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Environmental Surveillance and Compliance at Los Alamos during 1996

Los Alamos
NATIONAL LABORATORY

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Acknowledgments

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Hazardous and Solid Waste Group
Ecology Group

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Photo credit goes to Randy Balice for cover photograph. The front cover photo shows a purple fruit prickly pear (*Opuntia phaecantha*), flora native to the Los Alamos area.

Environmental Surveillance and Compliance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (the Laboratory), Environment, Safety, and Health Division, 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 comply 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.

The environmental data are organized by environmental media (Chapter 4, air; Chapter 5, water; and Chapter 6, soils and foodstuffs) in a format to meet the needs of a general and scientific audience. Chapter 1 provides an overview of the Laboratory's major environmental programs. Chapter 2 reports the Laboratory's compliance status for 1996. Chapter 3 provides a summary of the maximum radiological dose a member of the public could have potentially received from Laboratory operations. 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 booklet, *Overview of Environmental Surveillance and Compliance during 1996* that briefly explains important concepts, such as radiation, and provides a summary of the environmental programs, monitoring results, and regulatory compliance explained.

Inquiries or comments regarding these annual reports may be directed to the

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1. Environmental Programs Overview

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Abstract

This report presents environmental data that characterize environmental performance and addresses compliance with environmental standards and requirements at Los Alamos National Laboratory (LANL or the Laboratory) during 1996. The Laboratory routinely monitors for radiation and for radioactive and nonradioactive materials at Laboratory sites as well as in the surrounding region. LANL uses the monitoring results to determine compliance with appropriate standards and to identify potentially undesirable trends. Data were collected in 1996 to assess external penetrating radiation; quantities of airborne emissions; and concentrations of chemicals and radionuclides in ambient air, surface waters and groundwaters, the municipal water supply, soils and sediments, and foodstuffs. Using comparisons with standards and regulations, this report concludes that environmental effects from Laboratory operations are small and do not pose a demonstrable threat to the public, Laboratory employees, or the environment. Laboratory operations were in compliance with all major environmental regulations.

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 be completed by a hundred 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'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 is a multiprogram laboratory with the central mission of reducing the nuclear danger. The central mission at the Laboratory has evolved beyond nuclear weapons testing and development to include five major elements to reduce the nuclear danger:

- stockpile stewardship activities ensure that we keep safe, secure, and reliable those weapons that the nation needs;
- stockpile management projects provide capabilities ranging from the dismantlement to the recertification of existing nuclear weapons;
- nuclear materials management requires that we ensure the availability or safe disposition of plutonium, highly enriched uranium, and tritium;
- effective nonproliferation and counterproliferation technologies help us keep nuclear weapons, nuclear materials, and nuclear weapons knowledge out of the wrong hands; and
- environmental stewardship projects provide for the remediation and reduction of wastes from the nuclear weapons complex.

The Laboratory will continue its role in defense, particularly in nuclear weapons technology, and will increasingly use its multidisciplinary capabilities to solve important civilian problems (including initiatives in the areas of health, national infrastructure, energy, education, and the environment) and industrial collaborations (LANL 1996). The Laboratory is managed by the Regents of the University of California; the contract is administered through the Department of Energy (DOE) Los Alamos Area Office and the Albuquerque Operations Office.

1. Environmental Programs Overview

2. Geographic Setting

The Laboratory and the associated residential 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 43-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 intermittent streams. Mesa tops range in elevation from approximately 7,800 feet on the flanks of the Jemez Mountains to about 6,200 feet at their eastern termination above the Rio Grande Canyon.

Most Laboratory and community developments are confined to 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, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County. The Pueblo of San Ildefonso borders the Laboratory to the east.

The Laboratory is divided into technical areas (TAs) that are used for building sites, experimental areas, waste disposal locations, 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. Most land provides buffer areas for security and safety and is held in reserve for future use.

3. Geology and Hydrology

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. The tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet eastward above the Rio Grande. It was deposited as a result of major eruptions in the Jemez Mountains' volcanic center about 1.2 to 1.6 million years ago.

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. Chino Mesa 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 feet 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 upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the Laboratory site before they are 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 main aquifer of the Los Alamos area.

The main aquifer of the Los Alamos area is the only aquifer in the area capable of serving as a municipal water supply. Water in the main aquifer is under artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande (Purtymun and Johansen1974). The source of recharge to the aquifer is presently uncertain. Isotopic and chemical composition of some waters from wells near the Rio Grande suggest that the source of water underlying the eastern part of the Pajarito Plateau may be the Sangre de Cristo Mountains (Blake et al., 1995). Groundwater flow along the Rio Grande rift from the north is another possible recharge source. The main 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 to 5,500 acre feet annually from the aquifer.

4. Ecology and Cultural Resources

The Pajarito Plateau is a biologically diverse and archaeologically rich area. The plants and animals found on or near LANL property include approximately 500 plant species, 29 mammal species, 200 bird species, 19 reptile species, 8 amphibian species, and hundreds of insect species. Roughly 20 are designated as a threatened species, an endangered species, or a species of concern at the federal and/or state level.

Approximately 68.5% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and about 1,400 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 feet in elevation. Almost three-quarters of all ruins are found on mesa tops.

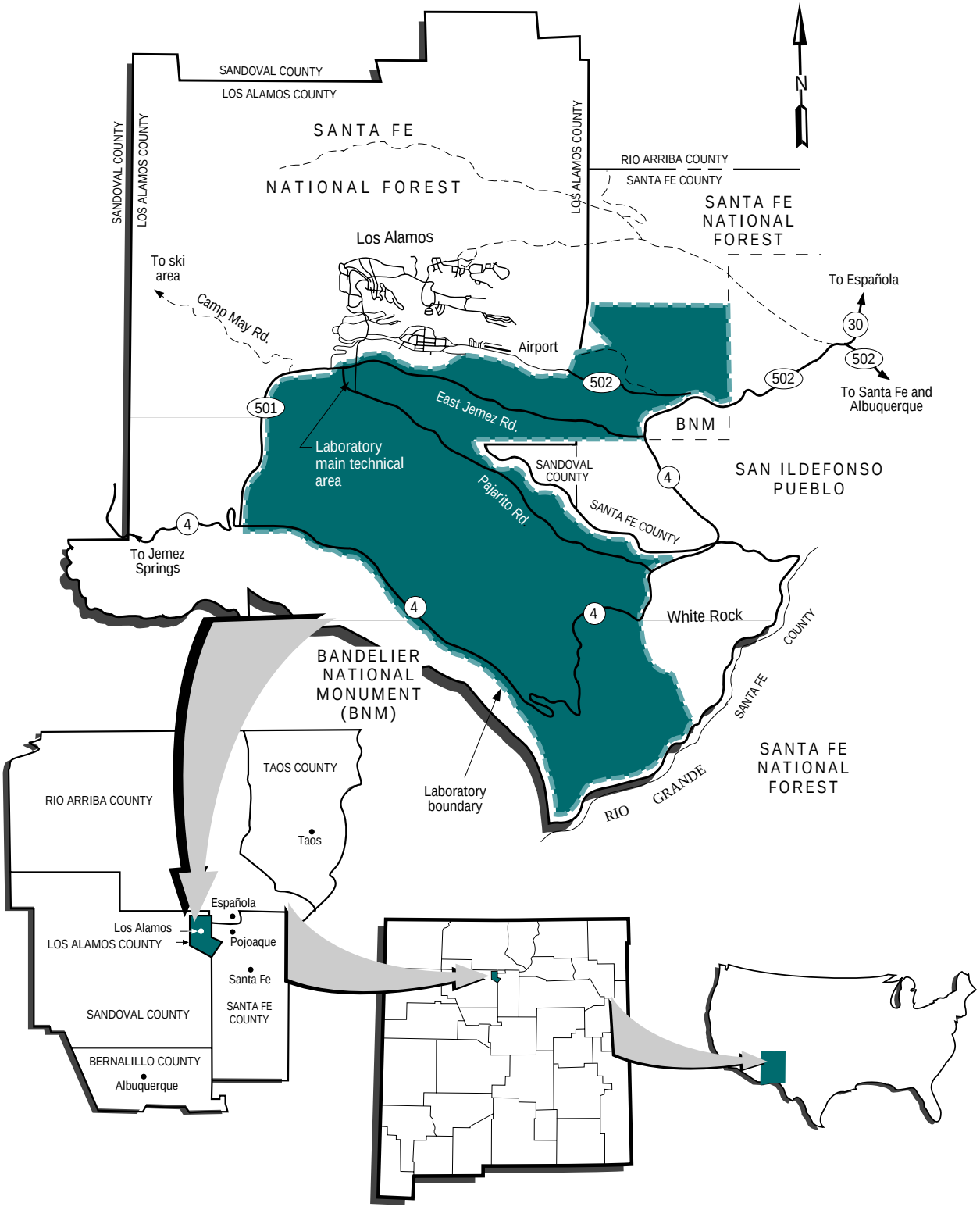

Figure 1-1. Regional location of Los Alamos National Laboratory.

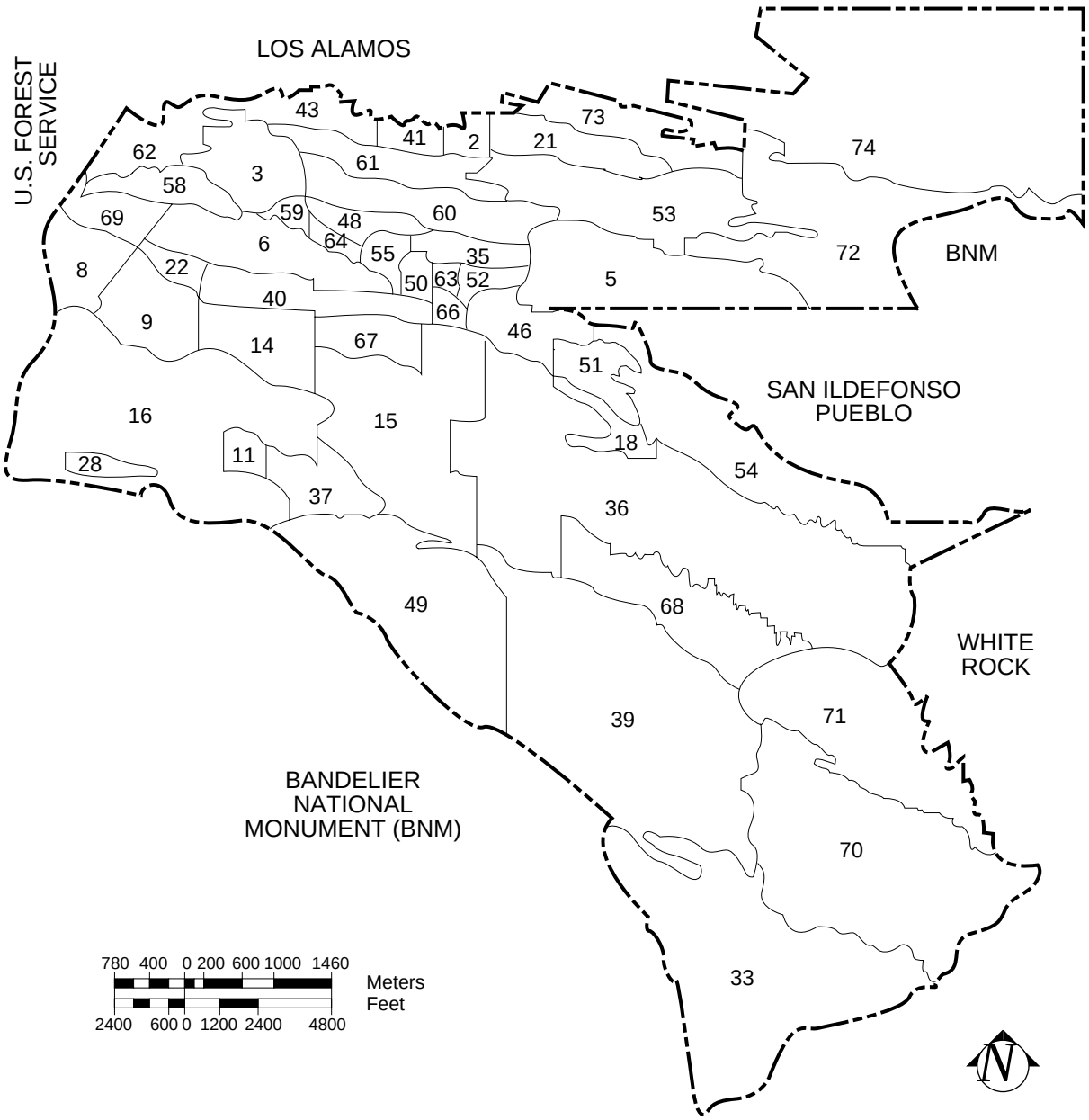

Figure 1-2. Technical areas of Los Alamos National Laboratory in relation to surrounding landholdings.

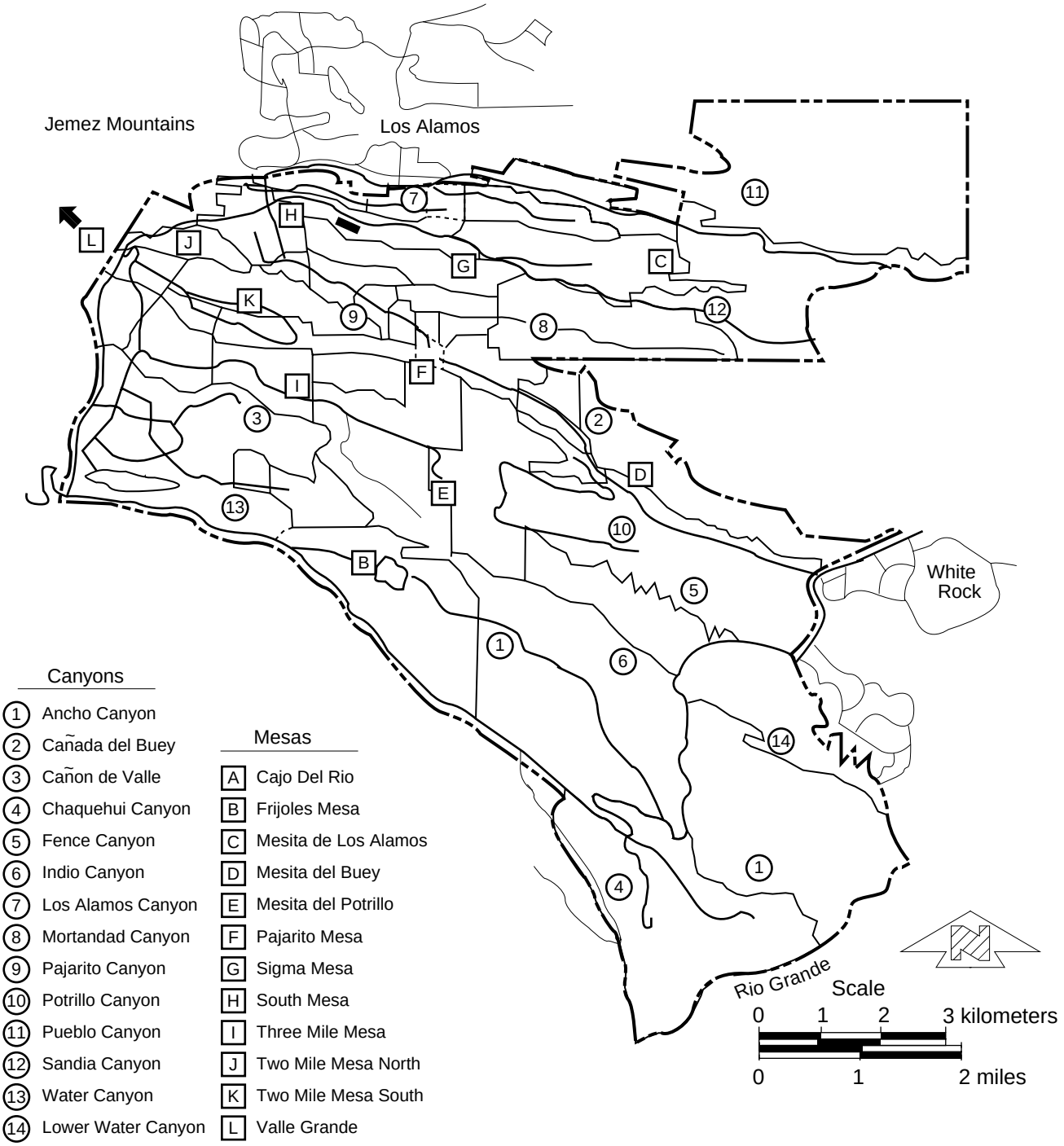

Figure 1-3. Major canyons and mesas.

B. Major Environmental Programs

1. Environmental Monitoring, Surveillance, and Compliance

The Environment, Safety, and Health (ESH) Division is in charge of performing environmental measurements and activities to help ensure that Laboratory operations do not adversely affect public health or the environment and that the Laboratory conforms with applicable environmental regulatory requirements as required by DOE Orders 5400.1 (DOE 1988) and 5400.5 (DOE 1990).

Although the Laboratory Director has primary responsibility for ESH management, ESH Division provides line managers with assistance in preparing and completing environmental documentation such as reports required by the National Environmental Policy Act (NEPA) of 1969 and the federal Resource Conservation and Recovery Act (RCRA) and its state counterpart, the New Mexico Hazardous Waste Act (HWA), as documented in Chapter 2 of this report. With assistance from the Laboratory Counsel, ESH Division helps to define and recommend Laboratory policies with regard to applicable federal and state environmental regulations and laws and DOE orders and directives. The ESH Division is responsible for communicating environmental policies to Laboratory employees and for ensuring that appropriate environmental training programs are available. Four groups in ESH Division—Air Quality (ESH-17), Water Quality and Hydrology (ESH-18), Hazardous and Solid Waste (ESH-19), and Ecology (ESH-20)—initiate and promote Laboratory programs for environmental assessment and are responsible for environmental surveillance and regulatory compliance.

Environmental measurements taken by these four groups are generally organized into two categories:

- Off-site locations include regional and perimeter stations.

  Regional stations are located within the five counties surrounding Los Alamos County (Figure 1-1) at distances up to 70 miles from the Laboratory.

  Perimeter stations are located within 2.5 miles of the Laboratory boundary, and many are in residential and community areas.

- On-site stations are within the Laboratory boundary, and many are in areas accessible only to employees during normal working hours.

More than 450 sampling locations are used for routine environmental monitoring. The general location of monitoring stations is presented in maps in the text of this report. Each year, approximately 200,000 analyses for chemical and radiochemical constituents are performed on more than 11,000 environmental samples. Samples of air particles and gases, water, soils, sediments, and foodstuffs are routinely collected at the monitoring stations and then analyzed. The results of these analyses help identify impacts of LANL operations on the environment. Additional samples are collected and analyzed to obtain information about particular events, such as major surface water runoff events, nonroutine releases, or special studies. Methods and procedures for acquiring, analyzing, and recording data are presented later in this document in Chapters 2, 3, 4, 5, and 6. Comprehensive information about environmental standards is presented in Appendix A.

a. Air Quality. ESH-17 personnel assist Laboratory organizations in their efforts to comply with federal and state air quality regulations. ESH-17 personnel report on the Laboratory's compliance with the air quality standards and regulations discussed in Chapter 2, including an overview of the status of National Emission Standards for Hazardous Air Pollutants (NESHAP) Federal Facility Compliance Agreement (FFCA). Various environmental surveillance programs are conducted to evaluate the potential impact of Laboratory emissions on the local environment and public health. These programs include measuring direct penetrating radiation, meteorological conditions, and stack emissions and sampling for ambient air contaminants. Chapter 4 contains a detailed exploration of the methodologies and results of the ESH-17 air monitoring and surveillance program for 1996, including trends from previous years. Personnel from ESH-17 monitor meteorological conditions to assess the transport of contaminants in airborne emissions to the environment and to aid in forecasting local weather conditions; Chapter 4 summarizes meteorological conditions during 1996 and provides a climatological overview of the Pajarito Plateau.

b. Dose Assessment. ESH-17 personnel are responsible for the radiation dose assessment that is presented in Chapter 3, including the methodology and assessments for specific pathways to the public and the environment; an analysis of the potential doses to the public and the environment is also included in Chapters 3, 4, 5, and 6.

c. Water Quality and Hydrology. Personnel from ESH-18 are responsible for providing environmental monitoring and activities to demonstrate regulatory compliance and to help ensure that Laboratory operations do not adversely affect public health or the environment.

ESH-18 provides technical and regulatory support to operating groups to achieve compliance with the following major state and federal regulations: Clean Water Act National Pollutant Discharge Elimination System (NPDES) outfall, storm water, spill control, and dredge and fill regulations; Safe Drinking Water Act and New Mexico Drinking Water Regulations; New Mexico Water Quality Control Commission Regulations; Federal Insecticide, Fungicide, and Rodenticide Act; and New Mexico Pesticide Control Act. Surveillance programs and activities include: groundwater, surface water, and sediments monitoring; water supply reporting for Los Alamos County; and the Groundwater Protection Management Program. Chapter 2 contains documentation on the Laboratory's compliance status with water quality regulations and includes an update of the NPDES FFCA. Chapter 5 presents the data analyzed by ESH-18 personnel from surveillance monitoring.

d. Hazardous and Solid Waste. ESH-19 personnel provide services in developing and monitoring permits under hazardous and solid waste rules, RCRA/HWA, Solid Waste Act (SWA), and letters of authorization for landfilling polychlorinated biphenyl (PCB) solids contaminated with radionuclides under the Toxic Substances Control Act (TSCA); providing technical support, regulatory interpretation, and Laboratory policy on hazardous, toxic, and solid waste issues and underground storage tank regulations to Laboratory customers; and documenting conditions at past waste sites. The Laboratory's compliance status with hazardous and solid waste regulations is presented in Chapter 2, including updates on the status of federal facility compliance agreements and orders on mixed waste and storage of radioactively contaminated PCB wastes.

e. Ecology. Personnel in ESH-20 investigate and document biological and cultural resources within the Laboratory boundaries; prepare environmental reports, including Environmental Assessments required under NEPA; and monitor the environmental impact of Laboratory operations on soil and foodstuffs. Chapter 2 documents the 1996 work in the areas of NEPA reviews and biological and archaeological reviews of proposed projects at the Laboratory. Chapter 6 contains information on the results of the soil, foodstuff, and biological monitoring programs at the Laboratory.

2. Overview of Environmental Quality Assurance Programs

Quality is the extent to which an item or activity meets or exceeds requirements. Quality assurance (QA) includes all the planned and systematic actions and activities necessary to provide adequate confidence that a facility, structure, system, component, or process will perform satisfactorily. The Quality Assurance Support Group (ESH-14) provides support for QA functions at the Laboratory. ESH-14 personnel perform QA and quality control audits and surveillance of Laboratory and subcontractor activities in accordance with the Quality Assurance Plan (QAP) for the Laboratory and for specific activities, as requested. The Laboratory's Internal Assessment Group (AA-2) manages an independent environmental appraisal and auditing program that verifies appropriate implementation of environmental requirements. The Quality and Planning Program Office provides management and coordination of the effort to become a customer-focused, unified Laboratory.

Each monitoring activity sponsored by the ESH Division has its own QAP or operating procedure. These plans and procedures are unique to activities but are guided by the need to establish policies, requirements, and guidelines for the effective implementation of regulatory requirements and to meet the requirements of DOE Orders 5400.1 (DOE 1988), 5400.5 (DOE 1990), and 5700.6C (DOE 1991). Each QAP must address the criteria for management, performance, and assessments. Monitoring activities for each environmental program performed by groups in ESH Division have been included in the current Environmental Monitoring Plan (EARE 1995).

3. Waste Management Program

Waste management activities are focused on minimizing the adverse effects of radioactive wastes on the environment, maintaining compliance with regulations and permits, and ensuring that wastes are managed safely. The Chemical Sciences and Technology (CST) Division at the Laboratory had responsibility for waste management activities until the latter part of 1996, when the Environmental Management Solid Waste Office took over these responsibilities.

1. Environmental Programs Overview

Wastes generated at the Laboratory are divided into categories based on the radioactive and chemical content. No high-level radioactive wastes are generated at the Laboratory. Major categories of waste managed at the Laboratory are presented below:

Low-Level Radioactive Waste. Low-level radioactive waste (LLW) at the Laboratory consists of solid waste or wastewater contaminated with radioactive materials, including plutonium, americium, uranium, or tritium from weapons design and test work; tracer and medical isotopes from scientific studies; mixed fission materials from nuclear energy work; and activation products from physics experiments. (Activation products are formed when a substance is struck by protons or neutrons. The atoms of the original substance are converted to another element that is unstable and, therefore, radioactive.)

LLW can include items such as equipment, paper, rags, radiation protective clothing, demolition debris from decontamination and decommissioning activities, and contaminated soils and debris from environmental cleanup activities. LLW managed at the Laboratory may require special handling and shielding to protect workers and the public. Most LLW generated at the Laboratory is disposed of on-site in pits and shafts designed and engineered for this purpose within TA-54, Area G.

Transuranic Waste. Transuranic (TRU) waste consists of rags, equipment, solidified wastewater treatment sludge, paper, and protective clothing that contain radioactive elements with atomic numbers greater than 92 and activities greater than 100 nCi/g. Radioactive contaminants at the Laboratory, such as plutonium and americium, have long half-lives.

Mixed Waste. Mixed waste contains LLW or TRU constituents mixed with nonradioactive hazardous waste regulated by RCRA. Low-level mixed waste (LLMW) at the Laboratory includes gases, liquids, and solids, such as gas cylinders of hydrogen with a tracer radioactive isotope; contaminated solvents and oils; spent solutions from electroplating operations; contaminated lead shielding; contaminated soils; or solid chemicals that react violently with water. Solid and liquid LLMW is stored on-site pending the availability of off-site DOE or commercial treatment or the development of technologies to treat those wastes that cannot be treated off-site. Currently, LANL plans to treat some limited quantities of newly generated LLMW at the generator's sites in order to reduce costs. No technology development is planned at this time to manage these wastes.

TRU mixed wastes at the Laboratory are solids. The major hazardous component is solvent contamination or the presence of heavy metals like cadmium or lead.

Hazardous Waste. Hazardous wastes are defined by regulations under RCRA and the HWA. (The State of New Mexico is authorized by the EPA to implement RCRA.) Hazardous wastes at the Laboratory include gases, liquids, and solids such as compressed gas cylinders containing combustible gases; acids, bases, and solvents; out-of-date laboratory chemicals; and lead bricks. At present, no disposal facility for hazardous wastes exists at the Laboratory. However, treatability studies, research development, and decommissioning projects are conducted. Hazardous wastes are shipped off-site for further treatment and disposal to facilities in accordance with RCRA/HWA requirements.

Nonhazardous Special Waste. Nonhazardous special waste is waste that does not fall under the technical definition of hazardous waste but still requires special handling. The SWA and other regulations, such as NESHAP, apply to some of these wastes, which include asbestos, infectious wastes, oils, coolants, and other materials that are controlled for reasons of health, safety, or security.

Today, DOE and the Laboratory conduct business in an atmosphere of sharply declining budgets and increasing public scrutiny, which mandate that operations become both more cost effective and environmentally sensitive. Incorporation of waste minimization methodologies into the daily conduct of operations can provide significant returns by avoiding waste management costs, both for the waste generating programs and the Laboratory Waste Management (WM) Program, as well as increases in employee productivity. Pollution prevention is an essential element of the LANL WM Program.

The Laboratory's Environmental Stewardship Office coordinates the integrated Laboratory pollution prevention program. Specific reductions in the generation rates of wastes and the amount of source material reduction and recycling are provided in Chapter 2.B.1.g. Other waste management activities that reduced waste generation include the following:

- continuation of financial incentives for waste reduction and innovative pollution prevention ideas,

- development of databases and automated procedures for purchases that could minimize waste or use recycled materials, and
- provision of pollution prevention expertise to Laboratory organizations in construction projects, site remediation, and decontamination and decommissioning projects.

The following list includes specific Laboratory research and development of new pollution prevention technologies in 1996:

- The Laboratory experimented with water soluble polymers that can extract metals from solution, and separate metal-laden polymers from the rest of the solution by ultrafilration for metal recycle and polymer reuse. The Laboratory is exploring the use of these polymers in various processes, including extracting radioactive metals like americium and plutonium from nuclear power reactor cooling water, extracting mercury from decontamination and decommissioning waste, extracting metals from mining and mineral processing wastes, extracting silver from photographic waste, and extracting metals from electroplating wastewaters.
- The Laboratory teamed with an industrial partner to develop small, portable, high-temperature superconducting systems in magnetic separators that can allow for the remediation of actinide-contaminated soils and liquids generated at facilities throughout the DOE complex. This technology reduces the amount of secondary waste generated by allowing the soils to be treated on-site.
- The Laboratory used a nonthermal plasma to successfully break down volatile organic compounds. The technology breaks down organic compounds into nonhazardous substances, such as carbon dioxide, water, and acids that can be neutralized. Many commonly used conventional waste treatment methods, such as incineration or carbon filtration, create secondary waste streams that are often as difficult to treat as the original contamination.
- The Laboratory developed a noninvasive chemical concentration analyzer to determine the concentrations of chemicals contained inside a pipe or small tank by using Fourier transform analysis of high-frequency acoustic signals from ultrasonic sensors. This noninvasive analysis technique greatly reduces worker risk, eliminates the need for sample preparation, and avoids secondary waste generation.
- The Laboratory is participating in a team effort to develop plasma source ion implantation. This technology has the potential to extend the useful life of manufacturing tools, such as draw dies for injection molding, metal punches, and stamping dies.

4. Environmental Restoration Project

The Environmental Restoration (ER) Project within the DOE Office of Environmental Management is responsible for assessing, cleaning up, decontaminating, and decommissioning sites at DOE facilities and sites formerly used by DOE. The objectives of the ER Project at the Laboratory meet the goals of environmental management and augment the Laboratory's environmental surveillance program by identifying and characterizing potential threats to human health and the environment from past Laboratory operations and by mitigating those threats through corrective actions that comply with applicable environmental regulations. The project is also responsible for decontaminating and decommissioning surplus facilities at the Laboratory. Corrective actions may include source containment to prevent contaminant migration, controls on future land use, and excavation and/or treatment of the source to remove or, at a minimum, reduce chemical and/or radiological hazards to acceptable human health and environmental levels.

The ER Project at the Laboratory responds to two primary laws: RCRA, which is the statutory basis for the ER Project at the Laboratory, and the Comprehensive Environmental Response, Compensation, and Liability Act, which offers a reference for remediating sites at the Laboratory that contain certain hazardous substances not covered by RCRA. The Hazardous and Solid Waste Amendments (HSWA) to RCRA mandate that certain facilities, including the Laboratory, that store, treat, and dispose of hazardous wastes operate under a formal permit system. The corrective action provisions of the RCRA permit are contained in Module VIII of the Laboratory's Hazardous Waste Permit. The Environmental Protection Agency and the New Mexico Environment Department (NMED) regulate the Laboratory's corrective action program under RCRA. The DOE has oversight for those sites

not subject to RCRA and for the decommissioning program.

A summary of ER Project activities completed in 1996 is presented in Section 2.B.1.i of this report.

C. Community Involvement

The Laboratory continues to encourage public access to information about environmental conditions and the environmental impact of operations at the Laboratory. Although the Community Involvement Office (CIO) has a responsibility to help coordinate activities between the Laboratory and northern New Mexico, many organizations at the Laboratory are active in working with the public. Frequently, the subject of these interactions are related to environmental issues because of concerns regarding the Laboratory's potential impact on local safety, health, and the environment.

Some examples of how the Laboratory distributes and makes environmental information available to the public are listed below:

Public Meetings

DOE is required to have public meetings and comment periods when it undertakes an activity that could have a significant impact on the environment. It is the Laboratory's responsibility to assist DOE in activities that relate to the LANL site. During 1996, the Laboratory assisted DOE in its work on the Site-Wide Environmental Impact Statement, on meetings on Transportation and Hazardous Materials Response, and on a meeting for Highly Enriched Uranium Vulnerability Assessment. Additionally, the Laboratory held other meetings as appropriate to address the publics' environmental concerns.

Outreach Centers

CIO opened an outreach center in Española in April 1996. The new center complements the two other outreach centers located in Los Alamos and Taos. These centers are prime repositories for environmental information. During 1996, the centers jointly served an average of 250 visitors a month, many of whom were interested in obtaining information about the environmental impact of Laboratory operations.

Speakers Bureau and Tours

Laboratory personnel make presentations to a variety of audiences on a variety of topics including environmental restoration, waste management, and human health. During 1996, approximately 1,000 citizens heard presentations on environmental topics, which were arranged by the Speakers Bureau. The CIO also helps coordinate tours of environmental interest.

Tribal Interactions

In 1996, the Laboratory signed a tribal cooperative agreement with Santa Clara Pueblo. Similar to the three agreements previously signed with Cochiti Pueblo, Jemez Pueblo, and the Pueblo of San Ildefonso, the Santa Clara agreement describes the Laboratory's intent to work with the Pueblos on environment, safety, and health issues, including providing help in evaluating potential impacts and providing technical expertise to the Pueblos.

Bradbury Science Museum

Because many of the Laboratory's facilities are closed to the public, the Bradbury Science Museum provides a way for the public to learn about the kinds of work the Laboratory does, whether it is tracking the path taken by an earth-orbiting satellite or investigating possible options for disposing of the plutonium taken from dismantled nuclear weapons. In 1996, the museum hosted more than 114,000 visitors.

The World Wide Web

In response to the ever-growing interest in using electronic communications media, the Laboratory has made information available on the World Wide Web. Pages are available to the community through *http://www.lanl.gov/Public/Community/Welcome.html* or through *http://www.lanl.gov/community/*, a page maintained by CIO. Search engines for Laboratory environmental information (as well as for other topics) are available through *http://www/lanl.gov/searches/*.

Inquiries

In 1996, CIO—with the assistance of a wide variety of Laboratory organizations—responded to 351 public inquiries, many of which had an environmental theme. These inquiries came to CIO by letter, phone, fax, e-mail, and personal visits. Addresses and phone/fax numbers for the various CIO facilities are listed below:

Community Involvement & Outreach Office
Los Alamos National Laboratory
P. O. Box 1663, Mail Stop A117
Los Alamos, NM 87545

Phone: (505) 665-4400 or 1-800-508-4400;
Fax: (505) 665-4411
cio@lanl.gov

Española Outreach Center
1002 N. Oñate
Española, NM 87532

Phone: (505) 753-3682; Fax: (505) 753-4679

Los Alamos Outreach Center
1350 Central, Suite 101
Los Alamos, NM 87544

Phone: (505) 665-2127 or 1-800-985-7232;
Fax: (505) 667-3111

Taos Outreach Center
630 Paseo del Pueblo Sur
Taos, NM 87571

Phone: (505) 751-3405; Fax: (505) 751-7150

Bradbury Science Museum
1350 Central Avenue
Los Alamos, NM 87544

Phone: (505) 667-4444; Fax: (505) 665-6932

D. Assessment Programs

1. Overview of University of California/ Department of Energy Performance Assessment Program

During 1996, the Laboratory was evaluated by the University of California and DOE based on mutually negotiated performance measures. The performance measure rating periods are from July to June. The environmental components of these performance measures include the following categories:

- radiation protection of workers;
- radiation protection of the public;
- release incidents;
- toxic chemical releases;
- permit exceedances;
- environmental violations, fines, and penalties;
- status of regulatory commitments and milestones; and
- waste minimization and pollution prevention.

Specific information on the categories and the assessment scoring can be obtained on the World Wide Web at *http://labs.ucop.edu/library.html*.

2. Department of Energy Audits and Assessments

The DOE Headquarters and Albuquerque Operations Office conducted three appraisals of the ESH Division environmental programs during 1996.

The DOE Office of Oversight, Environment, Safety, and Health, prepared a "Profile of Los Alamos National Laboratory" following an on-site comprehensive inspection appraisal that was conducted September 30 to October 11, 1996. The purpose of this evaluation was to determine how effectively DOE and Laboratory line management have implemented safety management and environment, safety, and health programs. Numerous aspects of ESH were evaluated, including portions of the environmental programs. The environmental programs covered by external regulations were determined to be effective. The Laboratory's profile can be accessed through the World Wide Web at *http://WWW.tis.eh.doe.gov/web/eh2/profiles/prof-lansp.html*.

The second assessment was the Independent Air Quality Compliance appraisal that was conducted October 30 to November 1, 1996. This assessment was specifically required by the NESHAP FFCA. The scope of the assessment included the program management used by ESH-17 for the Radioactive NESHAP FFCA. There were no findings, but the report did make eight recommendations, including roles and responsibilities of LANL-wide management toward the FFCA; complexity, reviews, and training of operating procedures; compliance with Laboratory standards; and a regulatory and public communications program.

The DOE Albuquerque Field Office prepares an annual update to the Pilot Assessment Matrix, DOE Albuquerque's overall evaluation of LANL ESH performance. The DOE Pilot Assessment Report can be obtained through the World Wide Web at *http://sw2aa.lanl.gov/pocs/verbage.htm#2*. Additional information on DOE audits and assessments of LANL ESH programs is found through the DOE Home Page on the World Wide Web.

3. Cooperative and Independent Monitoring

DOE and the Laboratory have signed agreements with the State of New Mexico and four surrounding Pueblos that enable independent environmental monitoring at and near the Laboratory. The main agreements are the following:

- **Agreement-In-Principle** between DOE and the State of New Mexico.
- **Accords** between the individual Pueblos of San Ildefonso, Cochiti, Jemez, and Santa Clara and DOE.
- **Cooperative Agreements** between the individual Pueblos of San Ildefonso, Cochiti, Jemez, and

Santa Clara and the University of California, as operator of the Los Alamos National Laboratory.

The main purposes of these agreements are to build more open and participatory relationships, to improve communications, and to cooperate on issues of mutual concern. For monitoring, the agreements have allowed access to monitoring locations and encouraged cooperative sampling activities. Improved data sharing and communications on technical subjects are occurring. The agreements also provide frameworks for grant support that allow development of independent monitoring programs such as that of the NMED's DOE Oversight Bureau (see Section 2.C.2 for more information). NMED regularly holds public meetings and publishes reports on their independent assessments of environmental quality at LANL.

In addition, environmental monitoring at and near the Laboratory involves other federal agencies such as the Defense Nuclear Facilities Safety Board, the Agency for Toxic Substances and Disease Registry, the Bureau of Indian Affairs, and the US Geological Survey.

At a level closer to the public, community groups have been working with the Laboratory and NMED in establishing the Neighborhood Environmental Watch Network (NEWNET) consisting of radiological monitors, some of which are managed by interested community individuals. Data from NEWNET monitors are recorded every fifteen minutes and can be accessed by anyone using the Internet.

F. References

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2. Compliance Summary

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Highlights from 1996

Los Alamos National Laboratory (LANL or the Laboratory) staff had frequent interactions during 1996 with regulatory personnel regarding Resource Conservation and Recovery Act and New Mexico Hazardous Waste Act requirements and compliance activities. On October 4, 1995, the State of New Mexico issued the Federal Facility Compliance Order to both the Department of Energy (DOE) and the University of California requiring compliance with the Site Treatment Plan. This terminated the Federal Facility Compliance Agreement for the storage of mixed waste generated at the Laboratory that had previously been in effect.

Laboratory operations were in compliance with all federal and state nonradiological air quality requirements. Radioactive emissions generated at the Laboratory during 1996 were in compliance with the Environmental Protection Agency's (EPA's) effective dose equivalent (EDE) limitation of less than 10 mrem/yr to members of the public from airborne emissions. The EDE is calculated to be 1.93 mrem using EPA-approved methods. During 1996, the terms of the National Emission Standards for Hazardous Air Pollutants (NESHAP) Federal Facility Compliance Agreement were met, and full compliance with the radionuclide NESHAP was achieved at LANL. In April 1996, the US District Court for the District of New Mexico issued a partial summary judgment against DOE and the Laboratory Director and directed them to attempt to reach an agreement with the Concerned Citizens for Nuclear Safety concerning their lawsuit filed under the Clean Air Act.

In 1996, the Laboratory was in compliance with its on-site liquid discharge requirements in 98.8% of the samples from its sanitary effluent outfalls and in 97.9% of the samples from its industrial effluent outfalls. Concentrations of chemical, microbiological, and radioactive constituents in the drinking water distribution system remained within federal and state drinking water supply standards.

All applicable Laboratory projects were reviewed for compliance with the National Environmental Policy Act (NEPA). Laboratory staff reviewed 272 proposed projects and in 1996 sent 42 DOE Environmental Checklists and 122 NEPA Review Forms to DOE. In addition, Laboratory archaeologists evaluated 947 proposed actions for possible effects on cultural resources, which required 31 intensive field surveys. Laboratory biologists reviewed more than 500 proposed actions for potential impacts to threatened and endangered species; over 80 of the actions required additional study.

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2. Compliance Summary

A. Introduction

Many activities and operations at Los Alamos National Laboratory (LANL or the Laboratory) involve or produce liquids, solids, and gases that contain radioactive and/or nonradioactive hazardous materials. Laboratory policy implements Department of Energy (DOE) requirements by directing its employees to protect the environment and meet compliance requirements of applicable federal and state environmental protection regulations.

Federal and state environmental laws address handling, transport, release, and disposal of contaminants, pollutants, and wastes, as well as protection of ecological, archaeological, historic, atmospheric, soil, and water resources. 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 regarding control of radionuclides. The environmental permits issued by these organizations and the specific operations and/or sites affected are presented in Table 2-1.

B. Compliance Status

1. Resource Conservation and Recovery Act

a. Introduction. The Laboratory produces a wide variety of hazardous wastes, most of which are produced 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, creates a comprehensive program to regulate hazardous wastes, from generation to ultimate disposal. The HSWA emphasize reducing the volume and toxicity of hazardous waste. Regulation 40 Code of Federal Regulations [CFR] 268 requires treatment of hazardous waste before land disposal.

EPA or an authorized state issues RCRA permits to specifically regulate the storage, treatment, or disposal of hazardous waste and the hazardous component of radioactive mixed waste that is stored, treated, or disposed of on-site. A RCRA Part A permit application identifies (1) facility location, (2) owner and operator, (3) hazardous or mixed wastes to be managed, and (4) hazardous waste management methods and units. A facility that has submitted a RCRA Part A permit application for an existing unit is allowed to manage hazardous or mixed wastes under transitional regulations known as the Interim Status Requirements pending issuance (or denial) of a RCRA Hazardous Waste Facility Permit. (Note: The term unit as it is used in this section refers to RCRA hazardous waste management areas). The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous or mixed waste management. The DOE and the University of California (UC) were issued a Hazardous Waste Facility Permit on November 8, 1989, from the State of New Mexico.

The operations at technical areas (TA) 50, 54, and 16, which are included in the RCRA Hazardous Waste Facility Permit, are due to be renewed. The 10-year permit expires in November 1999, and the Laboratory must submit the application for renewal six months in advance. Work on the renewal application will begin during fiscal year (FY) 1998.

The Hazardous and Solid Waste Group (ESH-19) submitted permit applications during 1996 to support compliance-related activities, to continue converting existing mixed waste management units to RCRA-permitted status, and to obtain new unit permits for ongoing project expansions. ESH-19 submitted permit applications and modifications to NMED using the permitting approach proposed in 1995 under which NMED intends to issue permits for the individual TAs where hazardous or mixed waste management activities are conducted.

LANL proposed that this process could be facilitated by the availability of a LANL General Part B Information submittal, subject to approval by NMED. The General Part B contains facility-wide information and procedures such as the contingency plan, training plan, and inspection plan. Its purpose is to provide common references for Laboratory documents that can be incorporated into permit modification packages without requiring repetitive NMED reviews. A proposed General Part B application was submitted to the Hazardous and Radioactive Materials Bureau of NMED in August 1996.

The Laboratory made progress on permit modifications necessary to meet compliance conditions in 1996. ESH-19 submitted an application to NMED for the retrieval of mixed transuranic (TRU) waste at TA-54, Area G, Pads 1, 2, and 4, and for related storage at Domes 229, 230, 231, and 232 pursuant to the December 10, 1993, Consent Agreement for Compliance Orders New Mexico Hazardous Waste Act (HWA) 93-01, 93-02, 93-03, and 93-04. This application was reviewed by NMED with subsequent infor-

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated in 1996

Category/Agency	Approved Activity	Issue Date	Expiration Date	Administering
RCRA Hazardous Waste Facility	Hazardous and mixed waste storage, and treatment permit	November 1989	November 1999	NMED
	RCRA mixed waste	Part A application submitted January 1991		NMED
		Revised Part A application submitted October 1993		NMED
HSWA	RCRA Corrective Activities	March 1990	December 1999	NMED
Polychlorinated biphenyls/TSCA[a]	Disposal of PCBs at TA-54, Area G	June 25, 1996	None	EPA
NPDES[b], Los Alamos	Discharge of industrial and sanitary liquid effluents	August 1, 1994	October 31, 1998	EPA
	Storm water associated with industrial activity	September 29, 1992	September 9, 1997	EPA
NPDES, Fenton Hill	Discharge of industrial liquid effluents	October 15, 1979	June 30, 1983[c]	EPA
Groundwater discharge plan, Fenton Hill	Discharge to groundwater	June 5, 1995	June 5, 2000	NMOCD[d]
Groundwater discharge plan, TA-46 SWSC Plant[e]	Discharge to groundwater	July 20, 1992	July 20, 1997	NMED
Groundwater discharge plan, Sanitary Sewage Sludge Land Application	Land application of dry sanitary sewage sludge	June 30, 1995	June 30, 2000	NMED
Groundwater discharge plan, TA-50, Radioactive Liquid Waste Treatment Facility	Discharge to groundwater	Approval pending		NMED
Air Quality (NESHAP)[f]	Construction and operation of four beryllium facilities	December 26, 1985; March 19, 1986; September 8, 1987; April 26, 1989	None	NMED

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated in 1996 (Cont.)

Category/Agency	Approved Activity	Issue Date	Expiration Date	Administering
Open Burning (20 NMAC[g] 2.60)	Burning of jet fuel and wood for ordance testing, TA-11	September 22, 1995 October 2, 1996	September 22, 1996 January 31, 1997	NMED NMED
Open Burning (20 NMAC 2.60)	Burning of HE-contaminated[h] materials, TA-14	January 9, 1996	December 20, 1996	NMED
Open Burning (20 NMAC 2.60)	Burning of HE-contaminated materials, TA-16	April 4, 1996	May 10, 1997	NMED
Open Burning (20 NMAC 2.60)	Burning of scrap wood from experiments, TA-36	October 22, 1996 November 1995	April 3, 1997 April 1996	NMED NMED
Open Burning (20 NMAC 2.60)	Fuel Fire Burn-Propane TA-16, Site 1409	October 3, 1996	April 3, 1997	NMED
Open Burning (20 NMAC 2.60)	Prescribed Open Burning TA-15, TA-16	October 3, 1996	December 31, 1996	NMED
Open Burning (20 NMAC 2.60)	Burning of HE-contaminated Materials, TA-31	August 10, 1995	August 10, 1996	NMED

[a]Toxic Substances Control Act.
[b]National Pollutant Discharge Elimination System.
[c]Permit administratively extended.
[d]New Mexico Oil Conservation Division.
[e]SanitaryWastewater System Consolidation.
[f]National Emission Standards for Hazardous Air Pollutants.
[g]New Mexico Administrative Code.
[h]High explosive.

mation requests. A suggested text revision package was sent to NMED in January 1996. LANL had not received an approval response by the end of 1996. Temporary waste storage areas for waste characterization activities in support of this project also went through this process in 1996. A new permit application was submitted in December 1996 for the TA-50 Radioactive Materials Research, Operations, and Demonstration Facility, a similar temporary storage area for a waste characterization project. A permit modification to allow mixed waste treatment residuals for wastes generated at LANL to be allowed back onto the LANL facility, if necessary for treatment, was submitted to NMED in November 1996 to support Site Treatment Plan (STP) requirements.

The Laboratory submitted permit modifications to NMED for existing hazardous and mixed waste management facilities. These included permit applications for the TA-55, Buildings 4 and 185 container storage areas and the TA-55-4 Cementation Unit submitted in June 1996, and for TA-14, 15, 36, and 39 Thermal Treatment Units, submitted in September 1996. A permit application for two mixed waste container storage areas in TA-3, Building 29, was also prepared in 1996.

One new RCRA Research, Development, and Demonstration permit application was submitted for NMED review. The application was for the proposed LANL Electrochemical Treatment Unit and was submitted September 6, 1996. The research objective of the work to be conducted under this permit was to experimentally define waste streams amenable for an electrochemical treatment process developed at LANL, to determine treatment conditions for these waste streams, and to assess the feasibility of processing batch waste quantities larger than allowed under RCRA treatability studies.

NMED requested a revision for TRU mixed waste characterization to the LANL hazardous waste analysis plan as a condition for approval of the Transuranic Waste Inspectable Storage Project (TWISP). The revised TRU mixed waste analysis plan was submitted to NMED on March 31, 1995. NMED issued a notice of deficiency (NOD) on May 24, 1996, requesting more information on specific waste characterization and certification procedures, which were provided by the Laboratory on July 12, 1996.

b. Resource Conservation and Recovery Act Closure Activities. Closure plans for three units were reviewed by NMED and implemented by LANL in 1996. A closure plan for an indoor and outdoor container storage area at TA-21, Building 61, was submitted to NMED in March 1996. Requests for further information were received from NMED for the closure of the TA-55 Oxygen Sparging Unit in May 1996, and the TA-50 Controlled Air Incinerator Closure Plan submitted in 1995 was approved by NMED on July 1, 1996.

In cooperation with NMED, an effort was initiated in 1996 to formally withdraw or delete waste management units that had been identified as such to NMED in previous years but had not operated as regulated units or actually been built. These submittals included withdrawals for several RCRA Research, Development, and Demonstration permits, the proposed TA-63 Hazardous Waste Treatment Facility, Chemical Plating Waste Treatment Skid, and the TA-53 south impoundment.

Several solid waste management units (SWMUs) are subject to both the HSWA Module VIII corrective action requirements and the closure provisions of RCRA. The corrective action process occurs concurrently with the closure process, thereby satisfying both sets of regulations. NMED is the lead regulatory agency for these sites. The history of RCRA closures is presented in previous environmental surveillance reports. The 1996 status of these sites is given below.

- TA-35 surface impoundments—An amended closure plan was approved by NMED on September 19, 1996. The Laboratory completed Phase VI verification sampling at TA-35 TSL-85 during July 1996. LANL submitted an amended closure certification report to NMED on September 30, 1996.

- TA-16, landfill at MDA-P—LANL received an NOD from NMED on March 28, 1996. LANL responded to the NMED on May 9, 1996. NMED had not approved the closure plan by the end of 1996.

- TA-53 surface impoundments—NMED notified LANL on July 18, 1996, that LANL must submit a Part B Application for the TA-53 RCRA Hazardous Waste Facility Permit or a closure plan application for closure under interim status. Discussions with NMED indicated that the TA-53 south surface impoundment may be removed from RCRA regulation because there is no evidence that the site ever received RCRA-regulated waste.

  On April 22, 1996, NMED sent an NOD to LANL on remaining deficiencies for the north surface impoundments. ESH-19 requested an

extension of the deadline for responding to the NOD until the land use/exposure scenario issue has been resolved with NMED, which was granted. The land use/exposure issue was still open as of the end of 1996.

c. Other Resource Conservation and Recovery Act Activities. TA-54, Area L, located on Mesita del Buey, was used for disposal of hazardous waste before the time such disposal became regulated under RCRA and HWA. TA-54, Area L is now used for storage of hazardous waste and some mixed waste. Area G, TA-54 is currently being used for storage of mixed wastes. Information on a groundwater monitoring waiver for both Areas L and G was submitted to NMED. Following the subsequent denial of this waiver, the Hydrogeologic Workplan was submitted to NMED to address Laboratory-wide groundwater concerns (see Section 2.B.10.a for more information on the workplan). Vadose zone monitoring is being conducted throughout Areas L and G to determine the extent of any releases from the disposal units. This type of monitoring is used to detect the presence of organic vapor in the vadose zone.

In 1996, EPA adopted new standards, under the authority of RCRA, as amended, and commonly called "Subpart CC" standards. These standards apply to air emissions from certain tanks, containers, less-than-90-day storage facilities, and surface impoundments used to manage hazardous waste capable of releasing volatile organic compounds (VOCs) at levels that can harm human health and the environment. LANL is developing implementation plans to address these new standards.

d. Resource Conservation and Recovery Act Compliance Inspection. NMED conducted its annual hazardous waste compliance inspection June 10 to 13, 1996 (Table 2-2). NMED inspectors visited hazardous and mixed waste satellite accumulation areas, less-than-90 day storage areas, and permitted and interim status storage and treatment facilities located throughout the Laboratory. On July 11, 1996, NMED sent DOE a Letter of Violation, an informal enforcement action, citing four violations that needed to be corrected. Those violations were satisfactorily addressed, and the inspection was closed out on August 15, 1996. No fines or penalties were assessed. In addition, LANL received a letter from the NMED Director noting LANL's improvement in hazardous waste regulatory compliance observed during the 1996 inspection.

e. Underground Storage Tanks. The Laboratory's underground storage tanks (USTs) are regulated under the New Mexico Administrative Code, Title 20, Chapter 5 (20 NMAC 5). At the end of calendar year (CY) 96, the Laboratory had 13 USTs in use. The Laboratory will close 12 of those 13 USTs by the end of CY98.

One UST was removed in CY96. UST TA-18-26 was discovered during the installation of a new natural gas line at TA-18. Best information indicates that the UST was used from 1946 to about June 1950, and was abandoned in place when the emergency generator that this UST supplied diesel fuel to was taken out of operation. The UST was removed on July 3, 1996. Upon removal, the UST was found to have leaked or been overfilled. LANL initiated a corrective action investigation and determined the extent of the diesel fuel contamination. LANL has determined that there has been no significant impact on the environment from the diesel fuel release. No highly contaminated soils were encountered during the subsurface investigation.

The Laboratory completed its investigation of the extent of contamination caused by UST TA-16-196, which was removed in 1987 (ESP 1996). This UST formerly held 4,000 gal. of leaded gasoline. Upon removal, it was observed that the UST was extensively corroded and leaking. Remediation actions involved the removal of several truckloads of contaminated soil from the site, but removal of all the soil containing lower levels of contamination was not completed. There has been no risk to the public because of this contaminated soil.

NMED did not conduct a UST inspection during 1996.

f. Solid Waste Disposal. The Laboratory has a commercial/special waste landfill located at TA-54, Area J, that is subject to New Mexico Solid Waste Act (SWA) regulations. In CY96, LANL/DOE completed the required Solid Waste Facility annual report for the previous year (CY95). In CY96, the TA-54, Area J landfill received and disposed 166 yd^3 of solid waste. Approximately 626 yd^3 of nonradioactive asbestos waste were shipped off-site from this facility to approved disposal sites. On October 10, 1996, the NMED Solid Waste Bureau conducted an inspection at the Laboratory's TA-54, Area J, special waste landfill. No violations of the New Mexico Solid Waste Management Regulations were found during the inspection. Radioactive asbestos and asbestos suspected of being contaminated with radioactive material continue to be disposed in a monofill-constructed disposal cell (a cell that receives only one type of waste) at TA-54, Area G.

LANL also disposes of sanitary solid waste (trash), concrete/rubble, and construction and demolition debris at the Los Alamos County landfill on East Jemez

Table 2-2. Environmental Inspections and Audits Conducted at the Laboratory in 1996

Date	Purpose	Performing Agency
February 21, 1996	PM-2 Discharge	NMED/AIP[a]
February 22, 1996	Otowi-4 Startup	NMED/AIP
March 14, 1996	Sandia Canyon Pipeline Crossing	NMED/AIP
April 26, 1996	Asbestos	NMED
May 17, 1996	DP Canyon	NMED/AIP
May 17, 1996	TA-9, Area M	NMED/AIP
May 22, 1996	Sanitary Survey of Drinking Water System	NMED
June 10-13, 1996	Hazardous Waste Facility Compliance	NMED
June 28, 1996	Waste Stream Characterization Program	EPA
July 2, 1996	TA-9, Area M	NMED/AIP
July 9, 1996	General Open Burn	NMED
July 15, 1996	Liquid Release Notifications	NMED/AIP
July 24, 1996	TA-15 Road Crossing	NMED/AIP
August 19, 1996	DOE Audit	DOE/Headquarters
September 16-17, 1996	Performance Audit Review (NPDES)	EPA
September 19, 1996	Road Crossing	NMED
October 10, 1996	TA-54, Area J, Special Waste Landfill	NMED
October 22, 1996	Beryllium Machining	NMED
October 30, 1996	Solvent Burn	NMED
November 1, 1996	Rad/NESHAP Management Effectiveness	NAU-CET-ITEP[b]
November 20, 1996	Prescribed Burn	NMED

[a]New Mexico Environment Department/Agreement in Principle: the DOE Oversight Bureau.
[b]Northern Arizona University College of Engineering & Technology Institute of Tribal Environmental Professionals.

Road, which is DOE property that is operated by Los Alamos County under a special use permit. Los Alamos County has day-to-day operating responsibility for this landfill and is responsible for obtaining all related permits for this activity from the state. LANL contributed 11% (2,263 tons) of the total volume of trash landfilled at this site during CY96, with the remainder contributed by Los Alamos County and the City of Española. LANL also sent 3,502 tons of concrete/rubble, 802 tons of construction and demolition debris, 145 tons of brush for composting, and 49 tons of metal for recycling.

g. Waste Minimization. In order to comply with the HSWA Module of the RCRA, RCRA Subtitle A, Superfund Amendments and Reauthorization Act (SARA) Subtitle 313, DOE Order 5400.1 and other regulations, the Laboratory must have a waste minimization and pollution prevention program.

Section 1003 of the Waste Disposal Act cites the minimization of the generation and land disposal of hazardous wastes as a national objective and policy. All hazardous waste must be handled in ways that minimize the present and future threat to human health and the environment. The act promotes process substitution; materials recovery, recycling, and reuse; and treatment as alternatives to land disposal of hazardous waste.

The amounts of routine, nonroutine, and total RCRA-hazardous and mixed low-level wastes generated by Laboratory operations during CY93, CY94, CY95, and CY96 are provided in Table 2-3.

Routine/normal waste generated at LANL includes those activities that occur regularly that generate a waste stream of a predictable quantity and characterization. Routine activities constitute the waste generation baseline that can be trended over an extended time period, provided the mission of the area did not change to the extent that it altered the waste-generating activities.

Nonroutine/off-normal waste generation at LANL can be identified as those waste-generating activities that occur on an unscheduled basis and/or that produce a waste stream of unpredictable quantity and/or charac-

terization. Because of the unpredictable schedule and/or characterization of the waste, waste generated from nonroutine/off-normal activities cannot be trended over an extended time period.

As evidenced in Table 2-3, LANL's generation of routine RCRA-hazardous wastes and mixed low-level wastes continue a downward trend. Nonroutine waste generation has generally increased for both waste types from the baseline year 1993, largely because of the increase in environmental restoration/decontamination and decommissioning activities occurring at LANL. Increased total mixed low-level waste generation in 1995 can also be explained by the moratorium on mixed low-level waste generation from May 8, 1992, to March 15, 1994. A full description of the moratorium is found in "Environmental Surveillance at Los Alamos during 1993" (ESP 1995).

In CY96, source reduction and recycling activities reduced the following amounts of waste:

Clean Air Act (chlorofluorocarbons)	265 lb
TRU waste:	138.4 m^3
Mixed TRU waste:	1.0 m^3
Low-level waste:	3,127.79 m^3
Mixed low-level waste:	29.04 m^3
RCRA-hazardous waste (chemicals, lead, lead acid batteries, solvents, etc.):	12,347,250 lb
Sanitary waste (paper, phone books, construction materials, rubble, electric cable, etc.):	18,459,929 lb
State-regulated waste (batteries, used tires, waste oil, etc. - not regulated by RCRA):	267,841 lb
Toxic Substances Control Act (TSCA) waste:	6,990 lb

h. Resource Conservation and Recovery Act Training. The RCRA training program, as described in the RCRA Hazardous Waste Facility Permit, is complete and only experienced minor modifications and revisions in 1996 to reflect regulatory, organizational, and/or programmatic changes.

During 1996, 87 workers completed RCRA Personnel Training, 249 workers completed RCRA Refresher Training, and 539 workers completed Waste Generation Overview. RCRA Refresher Training for treatment, storage, and disposal workers and for less-than-90-day-storage workers had previously been incorporated into Hazardous Waste Operations (HAZWOPER) Refresher Training. Of the 249 workers who required RCRA Refresher Training during 1996, approximately 195 met this requirement through completing the combined course.

The following RCRA courses were developed or revised by the Environment, Safety, and Health Training Group (ESH-13) during 1996:

- Environmental Issues for Managers (self-study)
- Environmental Regulations Overview (self-study)
- Pollution Prevention Overview (self-study)
- RCRA Refresher Training
- HAZWOPER: Refresher for Environmental Restoration Workers
- HAZWOPER: Refresher for Treatment, Storage, and Disposal Workers
- HMPT: Hazardous Materials Packaging and Transportation

The Radiological Controlled Area Waste Requirements course was developed and delivered to 168 workers, in response to a new Laboratory program

Table 2-3. Waste Generated by Laboratory Operations CY93–CY96

	RCRA-hazardous (lb)				Mixed low-level (m^3)			
	1993[a]	1994[a]	1995[a]	1996	1993[a]	1994[a]	1995[a]	1996
Routine	151,472	100,683	56,595	58,615	12.32	5.83	7.27	6.82
Nonroutine	33,111	327,582	2,494,231	1,965,544	11.75	65.07	79.58	58.19
Total	184,583	428,265	2,550,826	2,024,160	24.07	70.9	86.85	65.01

[a]More accurate data extraction methods were employed in CY96; therefore, CY93 to CY95 data have changed from the generation rates previously reported (ESP 1996).

for the management of waste generated in radiological controlled areas.

i. Hazardous and Solid Waste Amendments Compliance Activities. In 1996, the Environmental Restoration (ER) Project remained in compliance with Module VIII of the RCRA permit. One Class 3 permit modification proposal was submitted in September 1996, requesting removal of 42 SWMUs from the HSWA module list. The ER Project also recommended no-further-action for 84 areas of concern that are not on the HSWA module list. NMED has not yet approved this request.

During 1996, an additional 292 sites were proposed for no-further-action in 44 field investigation reports submitted to NMED. The ER Project also cleaned up 52 sites, including areas in the Los Alamos townsite. Depending on funding, the current projection for the completion of the characterization/remediation process at the Laboratory is between 2005 and 2006.

In 1996, the ER Project continued negotiations on a Document of Understanding (DOU) among the Laboratory, Sandia National Laboratory, DOE, EPA, and NMED. This DOU is intended to facilitate timely and cost-effective implementation of ER programs at the Laboratory and Sandia National Laboratory. It provides a basis for standardization in planning and execution of both programs. Additional annexes to the DOU are being written as applicable topics are identified.

j. Special Project: Ecological Risk Assessment. Work continued during 1996 on development of an ecological risk assessment methodology for use in assessing ecological risk at ER sites. This methodology follows guidance found in the US EPA "Framework for Ecological Risk Assessment" (EPA 1992, EPA 1996). It proposes a risk assessment approach based on an ecological exposure unit (EEU) concept, wherein EEUs are defined on the basis of ecological considerations—in this case primarily on the basis of habitat type. Each EEU may contain several to many potential release sites, and the risk assessment that is performed considers the contamination at all of the potential release sites as well as the uncontaminated area within the EEU.

Progress on six tasks was made during 1996.

Task 1: Develop Preliminary Contaminant of Potential Ecological Concern (COPEC) list.

Several criteria generally are used in developing a list of COPECs when performing an ecological risk assessment. They include the following:

- Contaminants that are known to have been used or known to be present at the site.
- Contaminants to which receptors are known to be sensitive.
- Contaminants identified as of concern during the human health assessment.
- Other factors, such as toxicity, persistence, exposure potential, bioavailabiltity, and potential for food chain transfer.

The preliminary COPEC list includes 17 inorganics, 5 semivolatile organic compounds (SVOCs), 3 VOCs, 4 high explosives, 8 radionuclides, and 6 pesticides. Additional chemicals can be added or deleted when there are reasons for doing so.

Task 2: Delineate Ecological Exposure Units.

Ecological Exposure Units are the ecologically defined units within which ecological risk assessments will be conducted. At LANL, EEUs will be defined on the basis of habitat and topography. The boundaries of the EEUs are coded into a geographical information system for use in preparing EEU maps.

Task 3: Define Food Webs.

The definition of food webs provides the primary basis for identifying trophic levels, appropriate receptors, and pathways of exposure. Species lists that are available for LANL (Hinojosa 1996) were broken down to sort species by habitat type, functional group, and trophic strategy.

Task 4: Define Pathways of Exposure.

This task is an assessment of the fate and transport of contaminants. It identifies sources, release mechanisms, transport pathways, points of exposure, and mechanisms of exposure. Generic conceptual models for terrestrial and aquatic pathways have been developed at the Laboratory. These generic models will be modified for specific EEUs, and potential transport pathways will be examined to ascertain whether significant contaminant transport might occur.

Task 5: Define Critical Ecosystem Functions.

Critical ecological attributes are those characteristics of the ecosystem that must be maintained in order to ensure biological diversity (ecosystem structure) and functional integrity (ecosystem function).

Task 6: Select Receptors and Assessment Endpoints.

The objective of selecting receptors is to select the minimum number of receptors that is necessary and sufficient to adequately assess the risk to the ecosystem. Receptors may represent more than one functional/trophic group. A preliminary list of receptors for the various habitat/community types at LANL has been compiled. For the purposes of screening at LANL, the assessment endpoints that are used are death, reproduction, and behavioral changes.

2. Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the SARA of 1986 mandates actions for certain releases of hazardous substances into the environment. The Laboratory is not listed on the EPA's National Priority List but follows the CERCLA guidelines for remediating ER Project sites that contain certain hazardous substances not covered by RCRA.

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

a. Introduction. Title III, Section 313, of the Emergency Planning and Community Right-to-Know Act (EPCRA), as modified by Executive Order 12856, requires all federal facilities to submit an annual Toxic Chemical Release Inventory report every July for the preceding calendar year.

Chlorine was the only chemical used in 1995 that met the reportable threshold limit of 10,000 lb. The 1996 Toxic Chemical Release Inventory reported that approximately 16,049 lb of chlorine were used in water purification operations involving noncontact cooling water, sewage treatment, and drinking water, which resulted in air emissions of 791 lb of chloroform and 2 lb of chlorine. An estimated 1,992 lb of chlorine were released with the discharged water.

b. Emergency Planning and Community Right-to-Know Act Summary. The Laboratory submits four reports each year in compliance with DOE guidance for EPCRA (see Table 2-4).

c. Emergency Planning. In accordance with DOE orders in the 5500 series, it is the Laboratory's policy to develop and maintain an emergency management system that includes emergency planning, emergency preparedness, and effective response capabilities for responding to and mitigating the consequences of an emergency. The Laboratory's Emergency Management Plan is a document that describes the entire process of planning, responding to, and mitigating the potential consequences of an emergency. The most recent revision of the plan was completed in January 1995; the plan will be updated in 1997.

4. Toxic Substances Control Act

Because the Laboratory's activities are in the realm of research and development and do not involve introducing chemicals into commerce, the polychlorinated biphenyl (PCB) regulations (40 CFR 761) have been the Laboratory's main concern under TSCA. Substances that are governed by the PCB regulations include but are not limited to dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, slurries, soils, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to transformers, capacitors, and other PCB items with concentrations above 50 ppm.

In 1996, the Laboratory replaced two PCB-contaminated (greater than 50 and less than 500 ppm) transformers with non-PCB transformers. The Laboratory still operates 16 PCB-contaminated transformers that will be replaced as funding becomes available. The Laboratory, through Johnson Controls, Inc. (JCI), completed its PCB survey in September 1996. In total, 2,023 structures were surveyed; 305 items were sampled for PCBs, and of those 305 items, 109 were identified by analysis as PCB items. The types of items surveyed include transformers, various pumps, oil-filled switches, light ballasts, generators, small transformers, and capacitors. If items are not in use or necessary for operations, they are recommended for disposal.

In 1996, the Laboratory had 16 off-site shipments of PCB waste. The total weight of PCBs in those shipments was 192,901 kg. PCB wastes are sent to EPA-permitted disposal and treatment facilities. The quantities of waste types disposed were 6 drums of capacitors, 13 drums of light ballasts, 2 transformers, 10 drums of water, 1,073 kg of PCB oil, and 171,186 kg of PCB-contaminated soil. All wastes are managed in accordance with 40 CFR 761 manifesting, record keeping, and disposal requirements. Light ballasts are sent off-site for recycling.

The Laboratory generates radioactively contaminated PCBs in both solid and liquid form. Liquid wastes are stored at the TA-54, Area L, TSCA storage facility. A total of 119 waste items in 73 drums are stored. Many of these items have exceeded TSCA's one-year storage limitation and are covered under the Federal Facility Compliance Agreement for Stored

Table 2-4. Compliance with Emergency Planning and Community Right-to-Know Act during 1996

Statute		Reporting Required		
		Yes	No	Not Required
EPCRA 302-303:	Planning Notification	×		
EPCRA 304:	Extremely Hazardous Substances Release Notification	×		
EPCRA 311-312:	Material Data Safety Sheet/ Chemical Inventory	×		
EPCRA 313:	Toxic Release Inventory Reporting	×		

Polychlorinated Biphenyls (PCB FFCAgreement) (see Section 2.C.1.b for a full discussion of the agreement). Nonliquid wastes containing greater than 50 ppm PCBs and radioactive constituents are disposed of at the Laboratory's EPA-authorized TSCA landfill located at TA-54, Area G. No nonliquid radioactive PCB wastes were disposed of on-site in 1996. The Laboratory received a new disposal approval for its PCB landfill on June 25, 1996.

The primary compliance documents related to 40 CFR 761.180 are the Annual PCB report submitted to EPA, Region 6, and an annual report submitted to DOE required by the PCB FFCAgreement. EPA did not conduct an audit of the Laboratory's PCB management program during 1996.

5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides, with requirements for registration, labeling, packaging, record keeping, distribution, worker protection, certification, experimental use, and tolerances in foods and feeds. Sections of this act that are applicable to the Laboratory include requirements for certification of workers who apply pesticides. The Laboratory is also regulated by the New Mexico Pesticide Control Act, administered by the New Mexico Department of Agriculture (NMDA). NMDA did not conduct an annual inspection of the Laboratory's pesticide application program during 1996.

6. Federal Clean Air Act

a. Federal Regulations. The Laboratory is subject to a number of federal air quality regulations. These include

- National Emission Standards for Hazardous Air Pollutants (NESHAP).
- National Ambient Air Quality Standards,
- New Source Performance Standards,
- Stratospheric Ozone Protection (SOP), and
- Operating Permit Program.

All of these requirements, except the NESHAP for radionuclides and provisions relating to SOP, have been adopted by the State of New Mexico as part of its State Implementation Plan. The requirements adopted by the State of New Mexico are discussed in Section 2.B.7, New Mexico Air Quality Control Act.

The 1990 amendments to the Clean Air Act (CAA) mandate new programs that may affect the Laboratory. The new requirements include control technology for hazardous air pollutants, enhanced monitoring, prevention of accidental releases, and chlorofluorocarbon replacement. The Laboratory will continue to track new regulations written to implement the act, determine their effects on Laboratory operations, and develop programs as needed.

b. Compliance Activities.

Radionuclide NESHAP. Under 40 CFR 61, Subpart H, EPA limits the effective dose equivalent to any member of the public from radioactive airborne releases from DOE facilities, including LANL, to 10 mrem/yr. The 1996 effective dose equivalent (as calculated using EPA-approved methods that do not allow the use of shielding factors) was 1.93 mrem/yr, primarily from the Los Alamos Neutron Science Center (LANSCE) operations. Any new construction or modifications undertaken at LANL that will increase

airborne radioactive emissions causing a potential increase in the dose of 0.1 mrem/yr must be approved by EPA. In 1996, approximately 60 projects were received by the Air Quality Group (ESH-17) for Laboratory review; none required EPA preconstruction approval.

Stratospheric Ozone Protection. Section 608 of the CAA, National Recycling and Emission Reduction Program, implemented by 40 CFR 82 Subpart F, prohibits individuals from knowingly venting ozone depleting substances (ODS) used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of air conditioning or refrigeration equipment. This regulation also established: (1) standards and requirements for recycling and recovery equipment used to maintain, service, repair, and dispose of ODS-containing appliances; (2) required practices that technicians must follow to maintain, service, repair, and dispose of air conditioning and refrigeration equipment; and (3) standards and requirements for training and certification of technicians who provide such services. Personnel performing refrigeration work at LANL are EPA-certified and use certified recovery and recycling equipment while maintaining, servicing, repairing, and disposing of air conditioning and refrigeration equipment at the Laboratory.

Section 609 of the CAA, Servicing of Motor Vehicle Air Conditioners, implemented by 40 CFR 82 Subpart B, established standards and requirements for recycling equipment used to service motor vehicle air conditioners and for training and certification of technicians who provide such services. In 1996, the Laboratory contracted with local automotive repair shops for most of LANL's automotive repair work. This work included service on motor vehicle air conditioning systems. JCI, which is in full compliance with these regulations, still provides limited service on some automotive air conditioning systems.

Section 611 of the CAA, Labeling of Products Using ODS, implemented by 40 CFR 82 Subpart E, established requirements to attach warning labels to products that contain Class I or II ODS and are introduced into interstate commerce. Laboratory groups that ship products containing ODS and ODS-containing waste off-site work with ESH-17 to ensure that, when required, the proper labeling requirements are met.

7. New Mexico Air Quality Control Act

a. State Regulations. The New Mexico Environmental Improvement Board (NMEIB), as provided by the New Mexico Air Quality Control Act, regulates air quality through a series of air quality control regulations in the NMAC. These regulations are administered by NMED. The NMACs relevant to Laboratory operations are discussed below.

b. Compliance Activities.

20 NMAC 2.07—Excess Emissions during Malfunction, Start-up, Shutdown, or Scheduled Maintenance. This provision allows for excess emissions from process equipment during malfunction, start-up, shutdown, or scheduled maintenance, provided the operator verbally notifies NMED either before or within 24 hours of the occurrence, followed by written notification within 10 days of the occurrence. No excess emissions were reported for 1996.

20 NMAC 2.11—Asphalt Process Equipment. Provisions of 20 NMAC 2.11 set emission standards according to process rate and require the control of emissions from asphalt-processing equipment. The asphalt concrete plant operated by JCI is subject to this regulation. The plant, which has a 60-ton/h capacity, is required to meet an emission limit of 33 lb/h of particulate matter.

20 NMAC 2.33—Gas Burning Equipment-Nitrogen Dioxide. Provisions of 20 NMAC 2.33 require gas burning equipment built before January 10, 1972, to meet an emission standard of 0.3 lb of nitrogen dioxide per million Btu when natural gas consumption exceeds 1×10^{12} Btu/yr/unit. The TA-3 steam/power plants have the capacity to operate at this level, although they never have. The Operating Permit Application would formalize compliance by setting voluntary federal enforceable terms to limit the operation of the units to less than 1×10^{12} Btu/yr/unit.

20 NMAC 2.34—Oil Burning Equipment-Nitrogen Dioxide. This regulation requires oil burning equipment built before January 10, 1972, to meet an emission standard of 0.3 lb of nitrogen dioxide per million Btu when the units operate at a heat input of greater than 1×10^{12} Btu/yr. The TA-3 steam/power plants have the capacity to operate at this level, although they never have. The Operating Permit Application would formalize compliance by proposing voluntary federally enforceable terms to limit the operation of these units to less than 1×10^{12} Btu/yr/unit.

20 NMAC 2.60—Regulation to Control Open Burning. This regulation controls the open burning of materials. Open burning of explosive materials is allowed when transport of these materials to other facilities may be dangerous. Research projects require open burning permits. In 1996, the Laboratory operated under seven open burning permits as listed in Table 2-1.

20 NMAC 2.61—Regulations to Control Smoke and Visible Emissions. This regulation limits visible emissions from various combustion sources, including the Laboratory boilers, to less than 20% opacity. Opacity is the degree to which emissions reduce the transmission of light and obscure the view of a background object. Because the Laboratory boilers are fueled by clean-burning natural gas, exceeding this standard is unlikely. However, oil is used as a backup fuel for the boilers. To ensure that the back-up system is working properly, the boilers must be periodically switched to oil. The Laboratory boilers can exceed the opacity standard while switching from gas to oil. An NMED-certified opacity observer reads the opacity while the switches are being made. If the Laboratory exceeds the opacity standard during the switch over, notification procedures, as required by 20 NMAC 2.07, are followed. There were no exceedances of these standards during 1996.

20 NMAC 2.70—Operating Permits. This regulation requires major sources of air pollution to obtain an operating permit from NMED. Because of LANL's large potential to emit regulated air pollutants (primarily NO_x from the steam/power plants), LANL is considered a major source. The permit application specifies the operational terms and limitations required to meet all federal and state air quality regulations. The Laboratory submitted its permit application to NMED in December 1995.

20 NMAC 2.71—Operating Permit Emissions Fees. As part of the new operating permit program, the State of New Mexico collects fees from emission sources that are required to obtain an operating permit. Fees depend on the allowable emission rates or the potential to emit. Laboratory fees for 1996 totaled $14,165.50.

20 NMAC 2.72—Construction Permits. Provisions of 20 NMAC 2.72 require permits for any new or modified source of air pollutants. The Laboratory reviews each new and modified source and makes conservative estimates of maximum hourly chemical usage and emissions. These estimates are compared with the applicable 20 NMAC 2.72 limits to determine if additional permits are required. During 1996, over 130 source reviews were conducted. None of these sources required permits under 20 NMAC 2.72.

20 NMAC 2.74—Prevention of Significant Deterioration. This regulation has stringent requirements that must be addressed before the construction of any new, large stationary emission source can begin. Wilderness areas, national parks, and national monuments receive special protection under this regulation. This impacts the Laboratory because of the proximity of Bandelier National Monument's Wilderness Area. Each new or modified source at the Laboratory is reviewed to determine whether this regulation applies; however, none of the new or modified sources in 1996 have resulted in emission increases considered "significant," and they therefore were not subject to this regulation.

20 NMAC 2.78—Emission Standards for Hazardous Air Pollutants. In this regulation, NMEIB adopted by reference all of the federal NESHAP, except those for radionuclides and residential wood heaters. The impact of each applicable NESHAP is discussed below:

Asbestos. Under the NESHAP for asbestos, the Laboratory must ensure that no visible asbestos emissions to the atmosphere are produced by asbestos removal operations at the Laboratory. During 1996, no Laboratory operation produced visible asbestos emissions. The Laboratory is also required to notify NMED of asbestos removal activities and disposal quantities. Such activities involving less than 15 m^2 (160 ft^2) or 80 lin m (260 lin ft) are covered by an annual small job notification to NMED. For projects involving greater than these amounts of asbestos, separate notification to NMED is required in advance of each project. NMED is notified of asbestos wastes (both small and large jobs) on a quarterly basis, which includes any material contaminated, or potentially contaminated, with radionuclides. Radioactively contaminated material is disposed of on-site in a designated radioactive asbestos burial area. Nonradioactive asbestos is transported off-site to designated asbestos disposal areas.

During 1996, LANL shipped off-site for disposal 53 m^3 of small job asbestos waste. There was 15 m^3 of asbestos waste buried at TA-54, Area G. Several large jobs generated 64 m^3 of waste that was buried at Area G and 1,926 m^3 that was transported off-site.

Beryllium. The beryllium NESHAP includes requirements for notification, emission limits, and stack performance testing for beryllium sources. The Laboratory has previously received four beryllium permits from NMED (Table 2-1) and has registered several additional facilities. The registered facilities do not require permits under the regulations because they existed before the adoption of the federal NESHAP. Exhaust air from each of the beryllium operations passes through air pollution control equipment before exiting from a stack. All beryllium operations meet the permitted emission limits set by NMED and have a negligible impact on ambient air quality.

8. Clean Water Act

a. National Pollutant Discharge Elimination System Program Overview. The primary goal of the

Clean Water Act (CWA) (33 U.S.C. 446 *et seq*.) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the National Pollutant Discharge Elimination System (NPDES) that requires permitting point-source effluent discharges to the nation's waters. The NPDES permits establish specific chemical, physical, and biological criteria that an effluent must meet before it is discharged. Although most of the Laboratory's effluent is discharged to normally dry arroyos, the Laboratory is required to meet effluent limitations under the NPDES permit program.

In 1996, LANL had 15 NPDES permits; 1 covering the effluent discharges at Los Alamos, 1 covering the Hot Dry Rock Geothermal Facility located 30 miles west of Los Alamos at Fenton Hill, and 13 covering storm water discharges (Tables 2-1 and 2-5). The UC and DOE are co-permittees of permits covering Laboratory operations. The permits are issued and enforced by EPA Region 6 in Dallas, Texas. However, NMED performs some compliance evaluation inspections and monitoring for EPA through a Section 106 water quality grant.

In January 1996, the Laboratory's NPDES outfall permit for Los Alamos included 2 sanitary wastewater treatment facilities and 95 industrial outfalls. By the end of 1996, the Laboratory had eliminated nine permitted industrial outfalls in the NPDES permit. The NPDES permit for the geothermal facility at Fenton Hill includes only one industrial outfall. This outfall did not discharge during 1996. Under the existing NPDES permit for LANL, samples are collected for analysis on a weekly basis, and results are reported to EPA and NMED at the end of the monitoring period for each respective outfall category. During 1996, effluent limits were exceeded 2 times in the 165 samples collected from the sanitary wastewater outfalls. Effluent limits were exceeded 32 times in the 1,559 samples collected from the industrial outfalls. Overall compliance for the sanitary and industrial waste discharges during 1996 was 98.8% and 97.9%, respectively. Water quality parameter's effluent limits were exceeded twice in 1996. A summary of these outfalls and a listing of present monitoring limits are presented in Tables A-4 and A-5.

b. 1996 National Pollutant Discharge Elimination System Permit Noncompliances and Corrective Actions. The following is a summary of the corrective actions taken by the Laboratory during 1996 to address permit noncompliances as presented in Tables 2-6 and 2-7.

TA-16, Building 260 (NPDES Outfall 05A056): There were eight oil and grease noncompliances at NPDES Outfall 05A056 between January 16, 1996, and November 21, 1996. Corrective actions for the remediation of the oil and grease noncompliances were addressed in the Laboratory's High Explosive (HE) Outfall Compliance Task Force, which in conjunction with the DOE/Los Alamos Area Office (LAAO) Project Management Office, was able to secure funding ahead of the compliance schedule (Administrative Order [AO] Docket No. VI-94-1242—see Section 2.C.1.c for additional information on the AO) to allow for early procurement of the HE wastewater treatment plant recirculation equipment. Corrective actions specific to TA-16, Building 260, included the installation of a Canatxx Filter System and oil-absorbing booms in the HE sumps. Upon completion of the recirculation system, the sumps were plugged and alarms were installed. On November 22, 1996, the discharge of HE wastewater to Outfall 05A056 was stopped. All effluent from TA-16, Building 260, is pumped and trucked to the TA-16 Burn Grounds Treatment Plant (NPDES Outfall 05A055) for further treatment.

TA-21, Sewage Treatment Plant (NPDES Outfall 05S): On February 6, 1996, excessive flow from a plugged toilet discharged into the TA-21 Sewage Treatment Plant holding tank and sand beds and resulted in an unplanned discharge of an estimated 175 gal. through NPDES Outfall 05S. The TA-21 Sewage Treatment Plant was not in operation, resulting in fecal coliform concentrations in excess of the permit limit. Vacuum trucks were used to pump out the contents of the holding tank. The outfall was plugged at the time of the discharge, but the plug was compromised. A high-level alarm and automatic dialer have been installed on the holding tank.

TA-53, Cooling Towers 62 and 64 (NPDES Outfalls 03A048 and 03A049): There were six arsenic noncompliances at TA-53 Cooling Towers 62 and 64 between April 16, 1996, and May 21, 1996. The Laboratory's short-term corrective actions included using untreated redwood in cooling tower repairs, operational sampling, and temporary cessations of the discharge. The long-term corrective action has been identified as replacement of the two wooden cooling towers with new units constructed of steel, fiberglass, and plastic. Design of these cooling towers has been started. The funding for the construction of the new cooling towers has not been identified. In addition, a stuck makeup valve caused the cooling tower basin to discharge through an overflow pipe that bypassed the

Table 2-5. Los Alamos National Laboratory National Pollutant Discharge Elimination System Storm Water General Permits Industrial and Construction Activity

Permit #	Location	Submittal	Type
NMR00A384	LANL Site	09/29/92	Industrial
NMR00A527	Tar Remnant Remediation	05/26/95	Industrial
NMR00A577	TA-32, -001, -002(a,b), -003, -004	03/11/96	Industrial
NMR00A650	DP Storage Area, 01027, -030(a)	04/26/96	Industrial
NMR00A652	Hot Shots, 1-001(s), -007(1)	05/23/96	Industrial
NMR10A064	TA-53 Sanitary Pipeline Project	10/01/92	Construction
NMR10A065	US West Communication Ductbank	10/01/92	Construction
NMR10A236	Dual Axis Radigraphic Hydrotest Facility Construction	05/20/94	Construction
NMR10A277	Small Arms Firing Range	08/18/94	Construction
NMR10A378	TRU Dome Project TWISP Facility Construction	02/28/95	Construction
NMR10A469	Steam System Upgrade TA-9, -16	09/01/95	Construction
NMR10A607	Radioactive Liquid Waste Cross Country Line Erosion Control Project	07/25/96	Construction
NMR10A622	Wildlands Fire Management Program	09/05/96	Construction

dechlorination system on December 2, 1996, causing two chlorine exceedances at NPDES Outfall 03A049. The operator turned off the blow-down and makeup valve to prevent further discharge to the outfall. The makeup valve was repaired.

TA-50, Building 1 (NPDES Outfall 051): Two chemical oxygen demand (COD) concentrations exceeded the permit limit of 125 mg/L on July 1, 1996, and September 25, 1996. Oxygen-requiring chemicals were improperly disposed of into the radioactive liquid waste line by unknown sources. TA-50, Building 1, Radioactive Liquid Waste Treatment Facility, operations have implemented an operational COD sampling program. The Radioactive and Industrial Wastewater Science Group (CST-13) contained all discharges until operational sampling demonstrated that COD concentrations were within permit limits.

TA-40, Building 23 (NPDES Outfall 06A099): Discharge pH values of 5.3, 4.7, and 5.7 occurred outside the permit range of 6.0 to 9.0 on July 12, November 4, and November 28, 1996, respectively. The investigation, including storm water sampling and leachability studies of roofing material, indicated that direct rainfall to Building 23 roof drains was the cause of the noncompliances. Results of less than 6.0 were also obtained from direct rainfall field measurements at TA-43-23. Additionally, pH results of less than 6.0 have been attained from rainfall field measurements taken at the National Atmospheric Deposition Program Network Station located at Bandelier National Monument. The photo processing equipment was not in operation at the time samples were collected on November 4 and November 28, 1996. Based on this information, EPA decided these were not permit exceedances. Rainfall was also believed to be the cause of the initial pH excursion on July 12, 1996; however, it could not be verified if the photo processing equipment was operating at the time of sampling so this permit noncompliance remained. Revised Discharge Monitoring Reports (DMRs) were submitted to EPA.

Table 2-6. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality at Sanitary Outfalls: Exceedances during 1996

Discharge Location (Category)	Date	Number of Permit Parameters	Exceedances
TA-21 (05S)	02/06/96	Fecal coliform bacteria	2
Sewage Treatment		COD[a]	0
Plant		BOD[b]	0
		TSS[c]	0
		pH	0
		Flow	0
TA-46 (13S)		Fecal coliform bacteria	0
SWSC		BOD[b]	0
Plant		TSS[c]	0
		pH	0
		Flow	0

[a]Chemical oxygen demand.
[b]Biochemical oxygen demand.
[c]Total suspended solids.

TA-8, Building 22 (NPDES Outfall 06A074): On August 14, 1996, two aluminum concentrations exceeded the daily average and daily maximum permit limits of 5.0 mg/L. The photo rinse water has been connected to the TA-46 Sanitary Wastewater Systems Consolidation (SWSC) plant and no longer discharges through NPDES Outfall 06A074.

Otowi Well #1 (NPDES Outfall 04A161): On September 11, 1996, six pH readings exceeded the maximum permit limit of 9.0 during a line disinfection operation conducted by JCI. The high pH readings were attributed to the addition of sodium thiosulfate to the discharge for dechlorination purposes. The entire discharge lasted approximately one hour. JCI has drafted and implemented new procedures for line disinfection discharge operations. The procedure documents the operating range for pH during the discharge. If the water quality exceeds the operating range for pH then the discharge will be shut off.

TA-3, Cooling Tower 285 (NPDES Outfall 03A027): There were two pH and two arsenic noncompliances between November 14 and November 18, 1996. The discharge from the TA-3-285 cooling tower (Outfall 03A027) was turned off, and there has not been a discharge from the outfall since November 21, 1996.

TA-35, Building 124 (NPDES Outfall 03A160): The total suspended solids (TSS) concentration of 54 mg/l exceeded the daily average permit limit of 30 mg/L on November 30, 1996. The condition was discovered during a manual discharge at the outfall. There will not be any further manual discharges to collect compliance samples from cooling towers.

TA-3, Building 187 (NPDES Outfall 03A024): On December 3, 1996, two arsenic concentrations exceeded the daily average and daily maximum permit limits of 0.04 mg/L. The cooling tower is currently off-line until corrective actions are implemented to address these exceedances.

c. Waste Stream Characterization Program and Corrections Project. The Water Quality and Hydrology Group (ESH-18) implemented the Waste Stream Corrections Project to correct Laboratory-wide noncomplying waste streams and potential unpermitted outfalls that discharge to the environment, as identified by the Waste Stream Characterization (WSC) Survey conducted from 1991 to 1994.

In March 1994, waste stream deficiencies identified by the WSC Survey were compiled into 83 reports that were finalized and distributed to the responsible division directors for facilities under their management. Correction of waste stream deficiencies is required for compliance with the CWA and NPDES

Table 2-7. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality at Industrial Outfalls: Exceedances during 1996

EPA ID	Technical Area	Date	Parameter		Results/Limit	
January						
05A056	TA-16-260	01/16/96	O & G[a]	(daily max)	36/15	mg/L
05A056	TA-16-260	01/16/96	O & G	(daily avg)	24.3/15	mg/L
February—No exceedances during monitoring period.						
March—No exceedances during monitoring period.						
April						
03A049	TA-53-64	04/16/99	As	(daily max)	0.068/0.04	mg/L
03A049	TA-53-64	04/16/96	As	(daily avg)	0.068/0.04	mg/L
May						
03A048	TA-53-62	05/15/96	As	(daily max)	0.066/0.04	mg/L
03A048	TA-53-62	05/15/96	As	(daily avg)	0.053/0.04	mg/L
03A048	TA-53-62	05/21/96	As	(daily max)	0.087/0.04	mg/L
03A048	TA-53-62	05/21/96	As	(daily avg)	0.062/0.04	mg/L
June—No exceedances during monitoring period.						
July						
051	TA-50-1	07/01/96	COD[b]	(daily max)	145/125	mg/L
06A099	TA-40-23	07/12/96	pH	(min)	5.3/6.0	s.u.
August—Annual Water Quality Parameter.						
06A074	TA-08-22	08/14/96	Al	(max)[c]	43.3/5.0	mg/L
06A074	TA-08-22	08/14/96	Al	(avg)[c]	21.7/5.0	mg/L
September						
04A161	TA-0	09/11/96	pH	(max)	9.1/9.0	s.u.
04A161	TA-0	09/11/96	pH	(max)	9.4/9.0	s.u.
04A161	TA-0	09/11/96	pH	(max)	9.3/9.0	s.u.
04A161	TA-0	09/11/96	pH	(max)	9.1/9.0	s.u.
04A161	TA-0	09/11/96	pH	(max)	9.1/9.0	s.u
04A161	TA-0	09/11/96	pH	(max)	9.1/9.0	s.u
051	TA-50-1	09/25/96	COD	(daily max)	130/125	mg/L
October						
05A056	TA-16-260	10/24/96	O & G	(daily max)	64/15	mg/L
05A056	TA-16-260	10/24/96	O & G	(daily avg)	64/15	mg/L
November						
05A056	TA-16-260	11/05/96	O & G	(daily max)	45/15	mg/L
05A056	TA-16-260	11/14/96	O & G	(daily max)	30/15	mg/L
05A056	TA-16-260	11/21/96	O & G	(daily max)	16/15	mg/L
05A056	TA-16-260	11/21/96	O & G	(daily avg)	30/15	mg/L
03A027	TA-03-285	11/14/96	pH	(max)	9.2/9.0	s.u.
03A027	TA-03-285	11/18/96	pH	(max)	9.1/9.0	s.u.
03A027	TA-03-285	11/14/96	As	(daily max)	0.10/0.04	mg/L
03A027	TA-03-285	11/14/96	As	(daily avg)	0.10/0.04	mg/L
03A160	TA-35-124	11/30/96	TSS[d]	(daily avg)	54/30	mg/L

Table 2-7. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality at Industrial Outfalls: Exceedances during 1996 (Cont.)

EPA ID	Technical Area	Date	Parameter	Results/Limit
December				
03A049	TA-53-64	12/02/96	Free Cl Available (daily max)	1.66/0.5 mg/L
03A049	TA-53-64	12/02/96	Free Cl Available (daily avg)[e]	0.71/0.2 mg/L
03A024	TA-03-187	12/03/96	As (daily max)	0.07/0.04 mg/L
03A024	TA-03-187	12/03/96	As (daily avg)	0.07/0.04 mg/L

[a]Oil and grease.
[b]Chemical oxygen demand.
[c]Yearly water quality parameter exceedance. Permit year 08/01/95 through 07/31/96.
[d]Total suspended solids.
[e]Average is based on all samples collected during the monitoring period.

permit regulations and with the schedule requirements set forth by EPA AO Docket No. VI-94-1242. The Laboratory met the AO Docket No. VI-94-1242 requirement to have 50% of the deficiencies corrected by September 30, 1995. On September 16, 1996, a new AO (Docket No. VI-96-1236) was issued by EPA in response to a request by UC to extend the completion date for the correction of the remaining deficiencies from September 30, 1996, to March 31, 1997. The request was necessary because of a Laboratory "Stop Work" directive that was issued on January 17, 1996, because of a serious electrical accident. The "Stop Work' directive resulted in a three-month delay on the Waste Stream Corrections Project. The Laboratory must now be in 100% compliance by March 31, 1997, pursuant to the new AO.

d. National Pollutant Discharge Elimination System Storm Water Program. Laboratory storm water discharges associated with "industrial activity" are covered under NPDES General Permits. The Laboratory has 13 NPDES General Permits for its storm water discharges (Table 2-5). One permit is for the Laboratory site and includes the following industrial activities: hazardous waste treatment, storage, and disposal facilities operating under interim status or a permit under Subtitle C of RCRA, (this category includes SWMUs); landfills, land application sites, and open dumps including those that are subject to regulation under Subtitle D of RCRA; and steam electric power generating facilities. Four permits are for the remediation of ER sites off of DOE property. The other eight permits are for construction activities that disturb more than five acres.

The conditions of the General Permit require the development and implementation of a Storm Water Pollution Prevention (SWPP) Plan. During 1996, the Laboratory developed and implemented 75 SWPP Plans for activities regulated under the NPDES General Permit for storm water discharges.

Under the General Permit, monitoring activities are required at landfills and EPCRA, Section 313, facilities. In 1996, monitoring was conducted at TA-54, Areas G and J, and at TA-55. These analytical data were submitted to EPA in the form of a DMR. The Laboratory submitted DMRs to EPA on October 28, 1996, for landfills and on January 27, 1997, for EPCRA, Section 313, facilities.

As part of the NPDES Storm Water Program, the Laboratory is operating stream monitoring stations on the canyons entering and leaving the Laboratory. In 1996, there were 19 stations on watercourses at the Laboratory. The discharge information for 1996 gathered by ESH-18 was published in separate reports (Shaull et al., 1996a and Shaull et al., 1996b).

e. National Pollutant Discharge Elimination System Compliance Inspection. A performance audit inspection was conducted by EPA on September 16-17, 1996. The Laboratory received a facility evaluation rating of 4: very reliable self-monitoring program. The EPA inspector documented that the overall NPDES

compliance program was superior. However, the Laboratory received an NOD for record keeping at the Radioactive Liquid Waste Treatment Facility (TA-50, Building 1). Corrective actions completed by the operating group included: pH calibration procedures were revised to provide a greater level of accountability and reliability; and the format of the daily logs was modified to ensure that all necessary information would be available for future inspections.

f. Spill Prevention Control and Countermeasures Program. The Laboratory's Spill Prevention Control and Countermeasures (SPCC) Plan is a comprehensive plan developed to meet the regulatory requirements of EPA and NMED that regulate water pollution from oil and hazardous chemical spills. The SPCC Plan, as required by the CWA, was developed in accordance with 40 CFR 112. The purpose of the SPCC Plan is to ensure that adequate prevention and response measures are provided to prevent oil spills from reaching a watercourse. Prevention measures include maintenance and inspection of facilities to ensure the integrity of the oil and chemical handling equipment, and proper operator training. Because of the wide variety of operating conditions at the Laboratory, the SPCC Plan has also diversified coverage with the implementation of a Group SPCC Implementation Plan approach.

In keeping with the site-specific Group SPCC Implementation Plan approach, the operating conditions for each location are addressed and, as these change, only the individual Group SPCC Implementation Plan is revised. In addition to requiring secondary containment provisions for all aboveground storage tanks, the plan also provides for spill control on drum and container storage, and transfer and loading/unloading areas. Training is provided for the operating group's designated Spill Coordinator on the requirements of the SPCC Plan. The Spill Coordinator plays the major role in implementation of the SPCC Plan at the group level.

g. Sanitary Sewage Sludge Management Program. In December 1992, the EPA promulgated 40 CFR Part 503: The Standards for Use or Disposal of Sewage Sludge. The purpose of these regulations is to establish numerical, management, and operational standards for the beneficial use or disposal of sewage sludge through land application or surface disposal. Under the Part 503 regulations, the Laboratory is required to collect representative samples of sewage sludge in order to demonstrate that it is not a hazardous waste and that it meets the minimum federal standards for pollutant concentrations. In addition, sewage sludge is monitored for radioactivity in order to demonstrate that it meets the standards set forth in the Laboratory's Administrative Requirement 3-5. During 1996, approximately 27 dry tons of sewage sludge were generated at the TA-46 SWSC plant as part of routine wastewater treatment operations. Although analytical monitoring of this sludge in 1996 demonstrated 100% compliance with the minimum federal and Laboratory standards for land application, the detection of low concentrations (less than or equal to 4.38 ppm) of PCBs in the sludge prompted the Laboratory to suspend all land application activities in May 1996. All sludge generated in 1996 is presently being stored on an asphalt pad at the SWSC plant while awaiting disposal.

9. Safe Drinking Water Act Program

a. Introduction. This program includes sampling from various points in the Laboratory, Los Alamos County, and Bandelier National Monument's water distribution systems and from the water supply wellheads to ensure compliance with the Safe Drinking Water Act (SDWA) (40 CFR 141). The DOE provides drinking water to Los Alamos County and Bandelier National Monument. The EPA has established maximum contaminant levels (MCLs) for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. These standards have been adopted by the state and are included in the New Mexico Drinking Water Regulations (NMEIB 1995). The NMED has been given authority by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

The particular locations within the water system where SDWA compliance samples are collected is specified in the regulations for each contaminant or group of contaminants. In 1996, the monitoring network for SDWA compliance sampling consisted of the following four location groups within the water system:

(1) wellhead sampling from the water supply wells in operation at the time of sampling (Guaje wells G-1, G-1A, G-2, G-4, G-5, G-6; Pajarito wells PM-1, PM-2, PM-3, PM-5; and Otowi well O-4).

(2) the five entry points into the distribution system (Pajarito Booster Station #2, Guaje Booster Station #2, PM-1 and PM-3 wellheads, and Los Alamos Booster Station #4).

(3) the six total trihalomethane (TTHM) sampling locations within the distribution system; and

(4) the 41 microbiological sampling sites located

throughout the Laboratory, Los Alamos County, and Bandelier National Monument.

The sampling program for drinking water quality is designed to meet or exceed regulatory requirements under the federal SDWA (see Table A-6) and the New Mexico Environmental Improvement Act. Sampling locations, frequencies, preservation, handling, and analyses follow the requirements specified in federal and state regulations. Chemical and radiological sampling is performed by Laboratory staff and submitted for analysis to the New Mexico Health Department's Scientific Laboratory Division (SLD) in Albuquerque. Microbiological sampling and analysis are performed by the JCI Environment (JENV) labora-tory. The JENV laboratory is certified by NMED for microbiological compliance analysis. Certification requirements include proficiency samples, maintenance of an approved quality assurance/quality control program, and periodic audits by NMED. The Laboratory and JENV staff are certified by NMED to perform drinking water compliance sampling.

All data collected from SDWA compliance testing is submitted to the NMED's Drinking Water Bureau for review and filing. The SLD and JENV laboratory report their analytical results directly to NMED. ESH-18 maintains both electronic and hard-copy files of all data collected from SDWA compliance testing.

b. Radiochemical Analytical Results. As required by the SDWA, in 1996, the Laboratory collected drinking water samples at the five entry points into the distribution system to determine the radiological quality of the drinking water. As shown in Table 2-8, the concentrations of gross alpha activity were less than the screening level of 5 pCi/L, and the concentrations of gross beta activity were less than the screening limit of 50 pCi/L. When gross alpha and beta activity measurements are below the screening limits, the Laboratory does not need to perform further isotopic analyses or perform dose calculations under the SDWA program. However, it should be noted that comprehensive monitoring of the water supply wells for radiochemical constituents is conducted by ESH-18 annually (see Table 5-22).

Radon is a naturally occurring radionuclide produced during the decay of geological sources of uranium. In 1996, radon sampling was performed at the 11 operating water supply wellheads and the 5 entry points into the distribution system. This sampling was done to collect information before the issuance of final EPA regulations governing radon in drinking water. As shown in Table 2-9, the radon concentrations ranged from 226 to 616 pCi/L. If the MCL is finalized at the proposed 300 pCi/L, waters from some well fields may need radon treatment.

c. Nonradiological Analytical Results. The analytical results for TTHMs, inorganic constituents, lead and copper, and VOCs in drinking water were all less than SDWA MCLs.

In 1996, TTHM samples were collected during each quarter from six locations in the Laboratory and Los Alamos County water distribution systems. As shown in Table 2-10, the annual average for TTHM samples in 1996 was 3.7 μg/L, less than the SDWA MCL of 100 μg/L.

In 1996, inorganic constituents in drinking water were sampled at the five entry points to the distribution system, with the exception of nitrates (NO_3-N) (nitrate as nitrogen), which were sampled at the 11 operating water supply wellheads. As shown in Table 2-11, all locations and all inorganic constituents were less than the MCLs.

In accordance with the requirements of the SDWA, the sampling program for lead and copper at residential taps that was initiated in 1992, was continued in 1996. There is currently no set MCL for lead or copper in drinking water. Instead, an action level has been set for each metal. SDWA regulations specify that if more than 10% of the samples from selected residential sites exceed the action level then water suppliers must take prescribed actions to monitor and control the corrosivity of the water supplied to the customers. Additionally, if 90% of the sample sites are below the action levels for lead and copper then the water system is in compliance without the need to implement corrosion controls. As is shown in Table 2-12, all 34 samples collected during 1996 were below EPA action levels for lead and copper. The Laboratory was in compliance with the SDWA regulations for lead and copper in drinking water during 1996.

In 1996, volatile organic compound (VOC) samples were collected at the five entry points to the distribution system. No VOCs were detected at any of the sampling locations.

In 1996, no synthetic organic compound (SOC) samples were collected. Sampling for SOCs will resume in 1997, as required by regulation.

d. Microbiological Analyses of Drinking Water. Each month during 1996, an average of 46 samples was collected from the Laboratory, Los Alamos County, and Bandelier National Monument's water distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the drinking water. Of the 547 samples analyzed during 1996, none indicated the presence of total coliforms or fecal coliforms.

Table 2-8. Radioactivity in Drinking Water (pCi/L) during 1996

	Gross Alpha			Gross Beta		
Sample Location	**Calibration Std.**	**Value**	**(Uncertainty)**	**Calibration Std.**	**Value**	**(Uncertainty)**
Entry Points:						
Pajarito Booster #2	^{241}Am	0.5	(0.3)	^{137}Cs	2.9	(1.0)
	Natural U	0.5	(0.4)	^{90}Sr, ^{90}Y	2.8	(1.0)
Guaje Booster #2	^{241}Am	1.2	(0.4)	^{137}Cs	3.4	(0.9)
	Natural U	1.3	(0.4)	^{90}Sr, ^{90}Y	3.4	(0.9)
Pajarito Well PM-1	^{241}Am	2.0	(0.6)	^{137}Cs	3.6	(0.9)
	Natural U	2.4	(0.6)	^{90}Sr, ^{90}Y	3.4	(0.8)
Pajarito Well PM-3	^{241}Am	1.6	(0.6)	^{137}Cs	3.4	(1.1)
	Natural U	1.9	(0.6)	^{90}Sr, ^{90}Y	3.2	(1.0)
Los Alamos Booster #4	^{241}Am	1.1	(0.5)	^{137}Cs	3.2	(1.1)
	Natural U	1.3	(0.5)	^{90}Sr, ^{90}Y	3.0	(1.1)
EPA Maximum Contaminant Level		15			none	
EPA Screening Level		5			50	

Noncoliform bacteria were present in 16 of the microbiological samples. Noncoliform bacteria are not regulated, but their presence in repeated samples may serve as indicators of biofilm growth in water pipes. A summary of the monthly analytical data is presented in Table 2-13.

e. Long-Term Trends. The Los Alamos water system has never incurred a violation for a SDWA regulated chemical or radiological contaminant. The water supply wells have, on occasion, exceeded proposed SDWA MCLs for arsenic and radon because of their natural occurrence in the main aquifer. Violations of the SDWA MCL for microbiological constituents occurred in 1993 and 1994. Both of these violations were attributed to localized contamination in the distribution system and not microbiological contamination of the main aquifer.

f. Drinking Water Inspection. On May 22, 1996, the District II Field Office of the NMED conducted an inspection of the drinking water system under the provisions of the New Mexico Drinking Water Regulations (NMEIB 1995). No deficiencies were found, and the inspectors reported that the system was well maintained and supervised.

10. Groundwater

a. Groundwater Protection Compliance Issues. Groundwater monitoring and protection efforts at the Laboratory have evolved from the early programs initiated by the US Geological Survey to present efforts. The major regulations, orders, and policies pertaining to groundwater are as follows.

DOE Order 5400.1 requires the Laboratory to prepare a Groundwater Protection Management Program Plan (GWPMPP). The program was required by the order to (1) document the groundwater regime with respect to quantity and quality; (2) design and implement a groundwater monitoring program to support resource management and comply with applicable environmental laws and regulations; (3) establish a management program for groundwater protection and remediation, including specific SDWA, RCRA and CERCLA actions; (4) summarize and identify areas that may be contaminated with hazardous substances; (5) develop strategies for controlling sources of these contaminants; (6) establish a remedial action program that is part of the decommissioning and other remedial programs contained in DOE directives. The GWPMPP focuses on protection of groundwater resources in and around the Los Alamos area and

Table 2-9. Radon in Drinking Water (pCi/L) during 1996

Sample Location	Value	(Uncertainty)
Entry Points:		
Pajarito Booster #2	520	(29)
Guaje Booster #2	226	(17)
Pajarito Well PM-1	278	(18)
Pajarito Well PM-3	357	(23)
Los Alamos Booster #4	491	(29)
Well Heads:		
Pajarito Well PM-1	278	(18)
Pajarito Well PM-2	616	(35)
Pajarito Well PM-3	357	(23)
Pajarito Well PM-5	446	(27)
Otowi Well O-4	512	(30)
Guaje Well G-1A	381	(23)
Guaje Well G-1	349	(22)
Guaje Well G-2	392	(24)
Guaje Well G-4	361	(23)
Guaje Well G-5	464	(28)
Guaje Well G-6	423	(25)
Proposed EPA Maximum Contaminant Level	300	

Table 2-10. Total Trihalomethanes in Drinking Water (μg/L) during 1996

	1996 Quarters			
Sample Location	**First**	**Second**	**Third**	**Fourth**
Distribution Sites:				
Los Alamos Airport	2.2	5.5	8.0	11.6
White Rock Fire Station	<0.5	<0.5	<0.5	<0.5
North Community Fire Station	2.3	7.0	5.7	4.2
TA-16, S-Site Fire Station	<0.5	<0.5	5.5	0.7
Barranca Mesa School	1.3	1.1	7.7	1.0
TA-33, Bldg. 114	2.4	7.5	NST[a]	NST
TA-39, Bldg. 02	NST	NST	NST	8.7
1996 Average of 3.7				
EPA Maximum Contaminant Level			100.0	
Sample Detection Limit			0.5	

[a] NST = No sample taken.

Table 2-11. Inorganic Constituents in Drinking Water (mg/L) during 1996

Sample Location	As	Ba	Be	Cd	Cr	F	CN	Hg	Ni	NO_3 (as N)	Se	Sb	Tl
Entry Points:													
Pajarito Booster #2	<0.002	<0.1	<0.002	<0.001	0.004	0.3	<0.02	<0.0002	<0.02		<0.005	<0.001	<0.001
Guaje Booster #2	0.012	<0.1	<0.001	<0.001	0.004	0.5	<0.02	<0.0002	<0.02		<0.010	<0.001	<0.001
Pajarito Well PM1	<0.002	<0.1	<0.002	<0.001	0.003	0.2	<0.02	<0.0002	<0.02		<0.005	<0.001	<0.001
Pajarito Well PM3	<0.002	<0.2	<0.002	<0.002	0.003	0.3	<0.02	<0.0002	<0.02		<0.005	<0.002	<0.002
Los Alamos Booster #4	<0.002	<0.1	<0.002	<0.001	0.003	0.3	<0.02	<0.0002	<0.02		<0.005	<0.001	<0.001
Wellheads:													
Pajarito Well PM-1										0.5			
Pajarito Well PM-2										0.3			
Pajarito Well PM-3										0.4			
Pajarito Well PM-5										0.3			
Otowi Well O-4										0.4			
Guaje Well G-1A										0.4			
Guaje Well G-1										0.4			
Guaje Well G-2										0.4			
Guaje Well G-4										0.6			
Guaje Well G-5										0.7			
Guaje Well G-6										0.5			
EPA Maximum Contaminant Levels	0.05[a]	2.0	0.004	0.005	0.1	4.0	0.2	0.002	0.1	10.0	0.05	0.006	0.002

[a] Proposed SDWA Primary Drinking Water Standard.

Table 2-12. Lead and Copper in Drinking Water at Residential Taps during 1996

Values	Lead	Copper
Values less than or equal to detection limit	33 samples	19 samples
Values detectable but less than action level	1 samples	15 samples
Values greater than action level	0 samples	0 samples
Total	34 samples	34 samples
Sample detection limit	5 µg/L	50 µg/L
90th percentile value	<5 µg/L	90 µg/L
EPA action level	15 µg/L	1,300 µg/L

ensures that all groundwater-related activities comply with the applicable federal and state regulations.

Module VIII of the RCRA Hazardous Waste Facility Permit, i.e., HSWA Module, Task III, requires the Laboratory to collect information to supplement and verify existing information on the environmental setting at the facility and collect analytical data on groundwater contamination. Historically, the groundwater monitoring requirements of RCRA (40 CFR 264 Subpart F) were not applied to the Laboratory's regulated units because DOE and LANL had submitted groundwater monitoring waiver demonstrations. However, as of May 30, 1995, the NMED denied the DOE/LANL groundwater monitoring waiver demonstrations, and groundwater monitoring program plans were requested for DOE/LANL to be in compliance with RCRA. In the denial letter, NMED recommended the development of a comprehensive groundwater monitoring program plan that addresses both site-specific and Laboratory-wide groundwater monitoring objectives. Under Task III, Section A.1, the Laboratory is required to conduct a program to evaluate hydrogeologic conditions. Under Task III, Section C.1, the Laboratory is required to conduct a groundwater investigation to characterize any plumes of contamination at the facility.

New Mexico Water Quality Control Commission (NMWQCC) regulations control liquid discharges onto or below the ground surface to protect all groundwater in the State of New Mexico. Under the provisions, a groundwater discharge plan must be submitted by the facility and approved by NMED or the Oil Conservation Division for energy/mineral extraction activities. Subsequent discharges must be consistent with the terms and conditions of the plan.

The Laboratory has three approved groundwater discharge plans to meet NMWQCC regulations (Table 2-1). One for TA-57 (Fenton Hill); one for the TA-46 SWSC plant; and one for the land application of dried sanitary sewage sludge from the TA-46 SWSC plant. At the request of NMED, on August 19, 1996, the Laboratory submitted a groundwater discharge plan application for the Radioactive Liquid Waste Treatment Facility at TA-50. As of December 31, 1996, approval of the plan by NMED was still pending.

b. Compliance Activities. The Laboratory's revised GWPMPP was approved by DOE in March 1996. The plan provides general management goals and direction to activities pertaining to groundwater quality and quantity.

In December 1996, the DOE/LANL submitted to NMED a proposed comprehensive hydrogeologic characterization and groundwater monitoring plan for the Laboratory. The plan was developed in response to NMED's denial of the Laboratory's RCRA groundwater monitoring waiver demonstrations. The plan proposes a major long-term drilling and hydrologic analysis program to broadly characterize the hydrogeology of the Pajarito Plateau and to assess in detail the potential for groundwater contamination to occur from individual waste disposal operations. The plan contains a prioritized list of activities and studies addressing the above.

The Laboratory continued an ongoing study of the hydrogeology and stratigraphy of the region, as required by the HSWA Module of the RCRA permit and DOE Order 5400.1. Studies by various Laboratory programs are integrated by the Groundwater Protection

Table 2-13. Bacteria in Drinking Water at Distribution System Taps during 1996

Month	No. of Samples Collected	No. of Positive Tests		
		Coliform	Fecal Coliform	Noncoliform
January	45	0	0	0
February	46	0	0	0
March	45	0	0	3
April	46	0	0	1
May	46	0	0	2
June	47	0	0	0
July	44	0	0	2
August	46	0	0	1
September	46	0	0	3
October	46	0	0	3
November	45	0	0	1
December	45	0	0	0
Total 1996	547	0	0	16
Maximum Contaminant Level (MCL)		[a]	[b]	[c]

[a]The MCL for coliforms is positive samples not to exceed 5% of the monthly total.
[b]The MCL for fecal coliforms is no coliform positive repeat samples following a fecal coliform positive sample.
[c]There is no MCL for noncoliforms.

Management Plan administered by ESH-18. Some key 1996 activities are listed as follows:

(1) The Waste Management Program prepared a series of reports in support of the Performance Assessment of TA-54, Area G. Critical geological, hydrological, and geochemical studies have been performed and formulated into a conceptual hydrogeologic model. Computer simulations forecast the long-term performance of the disposal area over 1,000 years.

(2) The ER Project has entered information from all significant drill holes into a computer based three-dimensional stratographic model of the Pajarito Plateau. This model will be continually updated during the ongoing hydrogeologic characterization of the Laboratory and will serve as a cornerstone for long-term numerical modeling efforts.

(3) The ER Project has prepared preliminary surface maps of key geologic units. Trends in the geologic surfaces have been analyzed to evaluate paleotopographic controls on groundwater flow.

(4) The ER Project and environmental surveillance projects continued evaluation of contaminant transport of sediments within critical drainage systems.

11. National Environmental Policy Act

a. Introduction. The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4331 et seq.) mandates that federal agencies consider the environmental impact of their proposed major actions and allow public input before making a final decision on what actions to take. The DOE is the sponsoring agency for most LANL activities, and it is DOE's responsibility to follow the letter and spirit of NEPA. DOE must comply with the regulations for implementing NEPA published by the Council on Environmental Quality at 40 CFR Parts 1500–1508 and its own NEPA Implementing Procedures as published at 10 CFR Part 1021. Under these regulations and DOE Order 451.1, DOE reviews proposed LANL activities and determines whether the activity qualifies for a categorical exclusion from the need to prepare further NEPA documentation based on previous agency

experience and analysis or whether to prepare the following:

- an Environmental Assessment (EA), evaluating environmental impacts should briefly provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or a Finding of No Significant Impact (FONSI) for the proposed action,
- an EIS, which is a detailed written statement of impacts.

If an EA or an EIS is required, the DOE is responsible for its preparation. In some situations, a LANL project may require an EA or EIS but, because the project is connected to another larger action requiring an EIS (e.g., the LANL Site-Wide EIS or a programmatic EIS done at the nationwide level), it may be included in the EIS analyzing the larger action or may later tier off the final programmatic EIS after a Record of Decision (ROD) is issued.

LANL project personnel initiate NEPA reviews by completing environment, safety, and health identification documents, which form the basis of a DOE NEPA Environmental Review Form formerly known as a DOE Environmental Checklist written by the LANL Ecology Group (ESH-20) using the streamlined format specified by the DOE/LAAO. In April, 1996, ESH-20 began to use the streamlined, shorter NEPA Review Form for projects that would receive a NEPA determination from the DOE/LAAO.

b. Compliance Activities. In 1996, LANL sent 42 DOE Environmental Checklists and 122 NEPA Review Forms to DOE for review. Also in 1996, DOE categorically excluded 155 actions and made a determination for 4 other actions. LANL applied previously so-called "umbrella" categorical exclusion determinations for 108 actions. DOE issued four FONSIs in 1996. Two project-specific analyses were drafted in 1996 for inclusion in the LANL Site-Wide EIS.

c. Environmental Assessments. The status of the Laboratory's EA-level NEPA documentation, and project descriptions follow.

TRU Waste Drum Staging Building. This action is designed to increase safety and minimize the volume of waste generated at the Laboratory's Plutonium Processing Facility at TA-55. This action consists of using a prefabricated, concrete-floored, metal building for temporary storage of drums of solid TRU waste that is pending certification and transport to a longer term storage area. Alternatives to the proposed action include constructing a new building or continuing operations under current conditions. Some of the potential environmental, safety, and health issues include air emissions, work safety, on-site TRU waste management, and TRU waste transportation. This action received a FONSI in February 1996.

Low-Energy Demonstration Accelerator. The proposed action is to design, build, and test critical components of a full-size prototype accelerator system for tritium production using a proton linear accelerator at LANL. The Low-Energy Demonstration Accelerator (LEDA) project would be divided into five separate stages that would develop and test an accelerator apparatus section by section over the next six years. Personnel at LANL would modify an existing proton accelerator facility at TA-53 and conduct component and prototype tests in order to verify equipment and prototype design and resolve related performance and production issues for future full-scale operation. The potential environmental, safety, and health issues for LEDA include utility demands, air emissions, environmental restoration, human health, and waste management. This action received a FONSI in April 1996.

In conjunction with the LEDA EA FONSI, DOE issued a Mitigation Action Plan (MAP) that defined a scope of activities that would be implemented to mitigate some of the potential impacts associated with the LEDA project. The LEDA MAP is being coordinated by DOE/LAAO, ESH-20, and LEDA project management.

As required by the MAP, an annual report (Rangel 1997) was written to report the status of the LEDA schedule and the action taken on the identified mitigation measures.

1996 was the first year of LEDA project development, but LEDA will only proceed to Stage III as allowed by the current safety analysis document. Because the Stage V development has been removed from the LEDA project schedule, large quantities of water and power use estimated in the final LEDA EA will no longer be required and generated. This affects the LEDA MAP because the land disturbance issue for utility line installation is removed and the quantity of water released into Sandia Canyon will be much less. As a result, no erosion is expected at the drainage channel of NPDES Outfall 03A113, and it is unlikely that a wetland will be created in Sandia Canyon although baseline biological data will continue to be collected in Sandia Canyon.

During FY96, planning was conducted for the remediation of a potential release site containing lead

shot (pellets) near Outfall 03A113. All of the necessary documentation and approvals for the cleanup by the LANL ER Project have been conducted; the cleanup is expected to take place in the spring of 1997.

Criticality Experiments. The proposed action is to consolidate certain nuclear materials and machines at the Los Alamos Critical Experiments Facility for the purpose of general purpose criticality experimentation and training. The proposed action consists of moving materials and machines from Hanford Site, Sandia National Laboratory, Oak Ridge National Laboratory, and Idaho National Engineering Laboratory to the Los Alamos Critical Experiments Facility. No new construction, operations, waste streams, or emissions were anticipated. Alternatives included (1) conducting criticality experiments and criticality training at an alternative DOE or LANL site and (2) receiving and storing materials at LANL or an alternative DOE site, but not conducting the criticality experiments or training. No adverse effects on environment and potentially only negligible effects on human health and transportation were identified. This action received a FONSI on May 22, 1996.

Effluent Reduction. The proposed action is to eliminate industrial effluent from approximately 27 outfalls at LANL through waste stream correction measures. These corrective measures are needed to comply with directives by EPA to DOE and UC requiring proper characterization of waste streams and ***c***ompliance with the discharge limitations specified in LANL's NPDES permit. In addition, effluent reduction provides proactive measures by the Laboratory to reduce pollution into the environment, reduce administrative and permitting costs, and minimize the number of NPDES exceedances. The proposed corrective actions include both simple and extensive plumbing modifications, which would result in the elimination of industrial effluent being released to the environment. The No Action alternative, which would maintain the status quo for LANL's outfalls, was also analyzed. One of the primary environmental effects of the proposed action would be an increase in compliance with LANL's NPDES permit limits. Other potential environmental, safety, and health issues for this project include changes in wetland vegetation, loss of wetland acreage, effects on fauna that drink water or use the areas near the outfalls, human health, waste management, and contaminant transport. This action received a FONSI in September 1996.

Expansion of TA-54, Area G. Routine activities at the Laboratory generate solid low-level radioactive wastes (LLWs) that are disposed of or stored at TA-54, Area G, which is currently a 63-acre site. For some types of waste, burial in pits or shafts is the only feasible disposal method that complies with all regulations. A draft project-specific analysis was in progress during the last quarter of CY96. The analysis for this project considers five alternatives for the management of LLWs: (1) using the active disposal area at Area G until it is full, (2) developing Zone 4 at TA-54, west of the active disposal area, (3) developing Zone 6 at TA-54, west of Area L and extending to Area J, (4) developing the North Site at TA-54, north of Zone 6, and (5) developing another location within the Laboratory, with TA-67 used as a representative undeveloped mesa site. Potential environmental, safety, and health issues include land use, air quality, ecological resources, soil, surface water, threatened and endangered species, cultural resources, and environmental restoration.

Enhancement of Pit Manufacturing Operations. The proposed action is to relocate or upgrade certain existing operations and to construct a new facility and access road to support plutonium pit (the central core of a nuclear weapon typically composed of plutonium-239 and/or highly enriched uranium) manufacturing operations at LANL. Essential operations at TA-55 and the Chemistry and Metallurgy Research (CMR) Building would be expanded and relocated between TA-55 and the CMR Building or upgraded in place. A new support building would be constructed at TA-55 as well as a controlled access road between TA-55 and the CMR Building. As a result of these upgrades and construction activities, LANL would be able to manufacture each type of pit required to support the enduring nuclear weapons stockpile. In addition, the Laboratory would be able to produce a maximum of up to 80 pits a year if required. Alternatives to the proposed action include an add-on configuration for using existing facilities as well as the construction of an all-new facility. Potential environmental, safety, and health issues include worker exposure to construction hazards as well as interruption to existing traffic patterns and minor increases in traffic volumes. The NEPA review for this project was initiated in 1996 for inclusion in the LANL Site-Wide EIS.

Radioactive Liquid Waste Treatment Facility—New Process Building. The NEPA review for this project was in progress during the last quarter of CY96. Because of the reduction in scope of this project in 1997, it is anticipated that this action will be categorically excluded from further NEPA review.

Chemical and Metallurgy Research Building Upgrades. The CMR Building was constructed as a major chemical research and analysis laboratory facility for radioactive materials in 1952. Despite

some repairs and upgrades since that time, the CMR Building does not meet current DOE regulations governing construction of a new nonreactor nuclear facility. LANL proposes to extend the life of the building 20 years by upgrading several major systems including seismic upgrades, ventilation system replacements and confinement zone separations, acid vents and drain lines replacements, and electrical system upgrades. The alternative action is not to upgrade the facility. Potential environmental, safety, and health issues include worker safety while the work is performed and LLW disposal. The EA for this proposed action was being prepared during 1996.

Transfer of the DP Road Tract to the County of Los Alamos. Under the proposed action, DOE intends to transfer ownership of a 28-acre tract of land located along DP Road, currently part of TA-21, to the County of Los Alamos. The transfer of this tract of land would result in a permanent change to the existing DOE property boundaries for TA-21. The county would develop the tract of vacant land for use as a business park or for light industrial use. The county specifically proposes to construct a new office building to house county employees, a new warehouse, garages, and a support building in order to transfer its equipment maintenance, school bus yard, and school supplies warehousing activities to the site. The alternative action is not to transfer the land and to continue to maintain government ownership of the tract. Potential environmental, safety, and health issues include worker and public exposure to construction hazards and nonradioactive air emissions from operations and from increased vehicular traffic. The proposed action could create approximately 450 new direct jobs and 585 indirect jobs. The EA for this action was under preparation during 1996.

d. Special Project: Dual Axis Radiographic Hydrodynamic Test Facility Mitigation Action Plan. In August 1995, DOE published a final EIS on the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility at LANL (DOE/EIS-0228, August 1995). DOE published a ROD on this final EIS in the Federal Register (60 FR 53588) on October 16, 1995. The DARHT ROD states that DOE has decided to complete and operate the DARHT facility while implementing a phased-containment program to conduct most tests inside steel containment vessels with containment to be phased-in over 10 years. The ROD further states that DOE must develop several mitigation measures to protect workers, soils, water, and biotic and cultural resources in and around the DARHT facility. In January 1996, DOE published a DARHT MAP, which identified potential impacts associated with the course of action selected in the ROD. The MAP also documents commitments and action plans that DOE considers necessary to mitigate these potential impacts. DOE has committed to reporting the status on MAP activities and commitments to the public.

The functions of the DARHT MAP are to (1) document potentially adverse environmental impacts of the Phased Containment Option delineated in the final EIS, (2) identify commitments made in the final EIS and ROD to mitigate those potential impacts, and (3) establish action plans to carry out each commitment.

In Section 6.C.8 of this report there is a description of DARHT Mitigation Action Plan activities of studies with mammals.

12. Cultural Resources

a. Introduction. The Cultural Resources Team in ESH-20 is responsible for maintaining a database of all cultural resources found on DOE land, supporting DOE's compliance requirements with appropriate cultural resource legislation as listed below, and providing appropriate information to the public on cultural resource management issues. Cultural resources are defined as archaeological sites, prehistoric or historic districts, sites, buildings, structures, traditional use areas, or objects included in, or eligible for inclusion in, the National Register of Historic Places. Artifacts, records, and remains related to and located within such properties are considered cultural resources.

b. Compliance Overview. Section 106 of the National Historic Preservation Act (implemented by 36 CFR 800, Public Law 89-665) requires agencies to evaluate the impact of all proposed actions on cultural resources and to consult with the State Historic Preservation Officer (SHPO) and/or National Advisory Council on Historic Preservation concerning possible effects to identified resources.

During 1996, Laboratory archaeologists evaluated 947 Laboratory proposed actions; 31 new field surveys were conducted to identify cultural resources. The results of 12 surveys were sent by DOE to the SHPO for concurrence in findings of effects and determinations of eligibility for National Register inclusion of any cultural resources located during the survey. Copies were also sent to the governors of the Pueblos of San Ildefonso, Santa Clara, Cochiti, Jemez, and to the President of the Mescalero Apache tribe for comment and identification of any traditional cultural properties which may be affected by a proposed action.

No adverse effects to prehistoric cultural resources were identified in 1996.

The American Indian Religious Freedom Act of 1978 (Public Law 95-341) stipulates that federal undertakings should not impact the practice of traditional religions. Notification must be given to tribal groups of possible alteration of traditional and sacred places. The Native American Grave Protection and Repatriation Act of 1990 (Public Law 101-601) states that if burials or cultural objects are inadvertently disturbed by federal activities, work must stop in that location for 30 days and the closest lineal descendent must be consulted for disposition of the remains.

The Archeological Resources Protection Act of 1979 (implemented by 43 CFR 7, Public Law 96-95, 16 USC 470) provides protection of cul-tural resources and sets penalties for their damage or removal from federal land without a permit. One illicit pot-hunting incident was discovered on DOE land in 1996. The site damaged, Laboratory of Anthropology 6787-A, is a low pueblo mound of approximately 10 rooms. This site was also illegally plundered in 1995. Security personnel from Bandelier National Monument were notified, but no suspects have been identified.

13. Biological Resources

a. Introduction. The DOE and the Laboratory must comply with the Endangered Species Act, the Migratory Bird Treaty Act, and the Bald Eagle Protection Act. The Laboratory also considers plant and animal species listed under the New Mexico Conservation Act and the Endangered Species Act.

b. Compliance Activities. During 1996, ESH-20 reviewed more than 500 proposed Laboratory actions for potential impact on threatened and endangered species. The Biology Team of ESH-20 identified more than 50 projects that required reconnaissance surveys. These surveys are designed to evaluate the amount of previous development or disturbance at the site and to determine the presence of any surface water or floodplains in the site area. The Biology Team also identified approximately 20 projects that required habitat evaluator surveys to assess if the appropriate habitat types and habitat parameters were present to support any threatened or endangered species. In addition, the Biology Team identified 11 projects that required a species-specific survey designed to determine the presence or absence of a threatened or endangered species at the project site. The Laboratory adhered to protocols set by the US Fish and Wildlife Service and permit requirements of the New Mexico State Game and Fish Department.

c. Biological Assessments. The Biology Team identified projects requiring a survey by first reviewing a literature database that compiles all habitat requirements of federal and state endangered, threatened, and candidate species. After the surveys were completed, the habitat characteristics of the surveyed sites were compared with the habitat requirements of the species in question. Biological evaluations are being prepared for projects that may influence threatened and endangered species that require consultation with US Fish and Wildlife for written concurrence of findings under the Endangered Species Act.

The Biology Team is currently preparing a threatened and endangered species habitat management plan as part of the DARHT MAP commitments by DOE. The plan should be completed in 1998 and will be used to further evaluate and manage the threatened and endangered species occupying LANL property.

14. Floodplain and Wetland Protection

a. Introduction. The Laboratory must comply with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands (EPA 1989) and Section 404 of the CWA.

b. Compliance Activities. During 1996, more than 500 proposed Laboratory actions were reviewed for their impact on floodplains and wetlands. Nine proposed projects required a floodplain and wetland review.

C. Current Issues and Actions

1. Compliance Agreements

a. Mixed Waste Federal Facility Compliance Order. DOE and the Laboratory are required by the Federal Facility Compliance Act of 1992 (section 3021[b] of RCRA) to prepare an STP describing the development of treatment capacities and technologies for treating mixed waste generated at LANL that is being stored beyond the one-year time frame provided for in the land disposal restrictions (Section 3004(j) of RCRA and 40 CFR Section 268.50). On October 4, 1995, the State of New Mexico issued the Federal Facility Compliance Order to both DOE and UC requiring compliance with the STP and thereby terminating the Federal Facility Compliance Agreement that had previously been in effect (ESP 1996).

b. Federal Facility Compliance Agreement on Storage of Polychlorinated Biphenyls. On August 8, 1996, DOE, the Naval Nuclear Propulsion Program, and EPA entered into a PCB FFCAgreement pertaining specifically to radioactive PCBs and PCB waste

containing RCRA wastes. The FFCAgreement is intended to be a compliance bridge from now until EPA's December 6, 1994, proposed rule updating the PCB regulations is final. The FFCAgreement also contains provisions to address the discrepancy created in the TSCA PCB regulations when the Department of Transportation changed its container specifications. The PCB FFCAgreement incorporates the proposed rule and provides regulatory relief for facilities now. When EPA makes the final decision, it will supersede the PCB FFCAgreement. The PCB FFCAgreement covers 29 facilities, including LANL, and the conditions of the agreement bind all the facilities together so that if one facility is noncompliant, all facilities are noncompliant. LANL has a total of 119 items that meet the criteria for inclusion in the PCB FFCAgreement.

The PCB FFCAgreement requires an annual report to be prepared by DOE and submitted to EPA. Each facility was required to compile the required information on its radioactive and mixed PCBs and submit it to DOE by November 13, 1996. LANL met that deadline.

c. National Pollutant Discharge Elimination System Federal Facility Compliance Agreement and Administrative Order. AO Docket No. VI-94-1242, issued to the Laboratory on June 15, 1994, incorporated the revised HE Wastewater Treatment Facility schedule and the new schedule for completion of the remaining corrective actions for the WSC project. The Laboratory met the September 30, 1995, deadline to complete 50% of the WSC corrective actions, as specified in the AO. A new Federal Facilities Compliance Agreement (FFCA) (Docket No. VI-96-1237) was issued to DOE by EPA on December 12, 1996, which corresponds to the Laboratory's AO Docket No. VI-96-1236 issued December 10, 1996.

The new TA-16 HE Wastewater Treatment Facility (NPDES Outfall 05A055) is also covered under AO VI-96-1236. The construction is currently ahead of schedule and is expected to be in compliance with final permit limits by October 1997, as required. All but two HE (05A) outfalls will be eliminated upon completion of this facility.

d. National Emission Standards for Hazardous Air Pollutants Federal Facility Compliance Agreement. In 1991 and 1992 the Laboratory received two Notices of Noncompliance (NONs) from the EPA for not meeting all provisions of 40 CFR 61, Subpart H. Specific findings of the NON included deficiencies in LANL's identification and evaluation of release sources, noncompliant stack monitoring equipment on all point release sources, incomplete quality assurance programs, and incomplete reporting. The 1992 NON stated that LANL had used a shielding factor without previous EPA approval and exceeded the 10 mrem/yr standard. As a result of the NON, the DOE negotiated a NESHAP FFCA with EPA Region 6, which was signed in June 1996. The Laboratory is meeting the terms of the NESHAP FFCA and had achieved full compliance in June 1996 with the radionuclide NESHAP, as defined by the FFCA.

2. Environmental Oversight and Monitoring Agreement

The Environmental Oversight and Monitoring Agreement—known as the Agreement in Principle (AIP)—between DOE and the State of New Mexico provides technical and financial support by DOE for state activities in environmental oversight, environmental surveys and sampling, site visits, and document review. The period for the current AIP is October 1, 1995, through September 30, 2000.

During 1996, the NMED/AIP staff conducted oversight of several of the Laboratory's environmental programs. This independent monitoring program allows the Laboratory's data to be verified. Highlights of these activities are presented below (NMED 1997).

External penetrating radiation dosimetry: The DOE Oversight Bureau maintains a network of thermoluminescent dosimeters (TLDs) for measuring the levels of gamma radiation present in the environment to assess the background baseline and any Laboratory-related gamma radiation anomalies. The data collected from the TLDs were at or below natural background radiation levels at all locations.

Ambient air: The values for plutonium, americium, and uranium measured by the DOE Oversight Bureau's stations, co-located with five of LANL's monitoring stations, are all approximately two to three orders of magnitude below DOE concentration guidelines.

Surface water and groundwater: The DOE Oversight Bureau expanded its routine oversight activities to include field explorations leading to the discovery of on- and off-site springs previously undocumented by the Laboratory and DOE. An analysis of data collected from several years shows that contaminants were detected within each of the four saturated zones in the Los Alamos area. The largest and most diverse concentrations of contaminants in groundwater are found within canyon alluvium.

Sediments, soils, vegetation, and foodstuffs: A preliminary comparison of historical radiological data for foodstuffs indicated that the data collected by the DOE Oversight Bureau are consistent with LANL's data.

Environmental Restoration: The DOE Oversight Bureau staff actively participated in the planning and expedited cleanup of TA-9, Area M, an abandoned dump site. Staff observed activities in the field throughout the cleanup process and evaluated the effectiveness of the cleanup. The bureau was instrumental in the formation of a Watershed Management Task Force to address the potential migration of contaminants into watercourses at the Laboratory from potential release areas, areas at the Laboratory that may require cleanup activities in the future. The bureau continued to work with EPA, DOE, and LANL to develop methods of evaluating potential release sites for risks to sensitive habitats or threatened or endangered species.

NEPA: The DOE Oversight Bureau reviewed and commented on six DOE NEPA documents for proposed activities at the Laboratory.

3. Significant Accomplishments

On August 30, 1996, the Laboratory received an Environmental Excellence Award from EPA for Wastewater Treatment Operations and Maintenance for the high level of success of the SWSC plant at TA-46 in a ceremony at the New Mexico State Capitol.

In addition, on September 8, 1996, the Laboratory received a 1995 Operator Award from the Rocky Mountain Section of the American Water Works Association for "the success of the Sanitary Wastewater Systems Consolidation plant consistently meeting established NPDES effluent limitations," and for "plant performance." The SWSC plant is operated and maintained by JCI.

The Laboratory received two Research & Development 100 Awards for environmentally responsive technologies in 1996

- Plasma Mechanical Cleaner for Silicon Wafer, which uses harmless inert gases to clean silicon wafers used in integrated circuits, and therefore produces no polluting byproducts and reduces the amount of water used by semiconductor manufacturers; and
- Transportable Remote Analyzer for Characterization and Environmental Remediation, which uses laser pulses to vaporize samples *in situ* to perform spectral analysis for various elements in a single sample. This procedure drastically reduces the amount of personal protective equipment required, eliminates sample preparation, and reduces analysis time to less than one minute.

The Laboratory received a "Best of What's New" award from Popular Science magazine for a system that replaces harsh dry cleaning chemicals with a liquid carbon dioxide cleaning process. The Laboratory shared the award with Hughes Environmental Systems, Inc., a subsidiary of Hughes Aircraft Company.

4. Significant Issues

a. Dome Fire. More than 16,000 acres of US Forest Service land southwest of the Laboratory burned during April 1996. Referred to as the Dome Fire, the blaze threatened archaeological sites, recreational sites, flora, and fauna in Bandelier National Monument, and research facilities on the southwestern perimeter of the Laboratory as it spread quickly because of extremely dry conditions.

The proximity of the fire and its potential to burn facilities that use radioactive materials raised public concerns about the potential for releases of radiation. NMED's DOE Oversight Bureau confirmed LANL's Neighborhood Environmental Watch Network (NEWNET) monitoring results that there had been no increases in radiation levels during or after the Dome Fire (NMED 1997).

After the Dome Fire, LANL formed the Interim Fire Management Team. The team is cochaired by the Deputy Group Leader of the Emergency Management and Response Group and the Group Leader of ESH-20. The team also includes members from the DOE, the US Forest Service, the Los Alamos Fire Department, the NMED DOE Oversight Bureau, the Pueblo of San Ildefonso, and Bandelier National Monument, along with Laboratory personnel involved with fire protection, environmental issues, storm water, archaeology, and site remediation.

The team has developed a list of precautionary measures to make the Laboratory safer from wildfire. Some immediate measures include improving fire roads, widening fire breaks, clearing vegetation beneath power lines, and conducting prescribed burns. The team will develop long-term measures in cooperation with Laboratory facility managers, the US Forest Service, the DOE, Bandelier National Monument, the Pueblo of San Ildefonso, and resource protection specialists.

b. Lawsuit. In 1994 a citizens' group, Concerned Citizens for Nuclear Safety (CCNS) sued DOE and the Laboratory Director under the CAA.

2. Compliance Summary

CCNS was concerned about the time it was taking to achieve compliance with 40 CFR 61 Subpart H at the Laboratory. In April 1996, the US District Court for the District of New Mexico issued a partial summary judgment against DOE and the Laboratory Director and directed the parties to attempt to reach a settlement. This agreement was finalized on March 25, 1997, following a period of public comment. The provisions of the agreement include:

- $150,000 payment to the US Treasury
- Independent comprehensive technical audits of the Laboratory's 40 CFR 61 Subpart H program in 1997 and 2000. A third audit in 2003 is required if recommended by the independent auditor
- 5-yr operation of 2 additional AIRNET stations to be located at TA-33 and in Santa Fe
- 5-yr operation of additional TLD stations to be located at 6 Laboratory technical areas and at AIRNET stations
- 5-yr operation of the northern New Mexico portion of NEWNET
- Quarterly ESH public meetings
- $450,000 payment to the University of New Mexico School of Medicine, Masters in Public Health program, for environmental health curriculum development
- 5-day course in radiation education for representatives of local and tribal governments surrounding Los Alamos
- Radiation monitoring equipment loan program for representatives of local and tribal governments who have participated in the radiation education training program.

D. References

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ESP 1996: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1995," Los Alamos National Laboratory report LA-13210-ENV (October 1996).

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Shaull et al., 1996a: D. A. Shaull, M. R. Alexander, and R. P. Reynolds, "Surface Water Data at Los Alamos National Laboratory: 1995 Water Year," Los Alamos National Laboratory report LA-13177-PR (August 1996).

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3. Environmental Radiological Dose Assessment

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Highlights from 1996

In the past, the maximum individual exposure from Los Alamos National Laboratory (the Laboratory) sources to a member of the public was calculated to be from an air pathway occurring near East Gate, north of the Los Alamos Neutron Science Center. For 1996, this is still the location of the maximum exposure for areas outside of Laboratory boundaries. In addition, another analysis was performed for individuals who are not Laboratory workers but are in transit within Laboratory boundaries. The maximum individual dose from this analysis is 8 mrem as calculated to occur near the Technical Area 18 criticality facility. This dose would be from direct radiation. The applicable regulatory dose limit for comparison purposes is 100 mrem, the allowed dose from all pathways (DOE 1990).

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A. Radiological Dose Equivalents

1. Overview of Radiological Dose Equivalents

Radiological dose equivalents are the potential doses received by individuals exposed to radioactivity in the environment. Dose equivalent refers to the quantity of radiation energy absorbed per unit mass (dose), multiplied by adjustment factors for the type of radiation absorbed. The effective dose equivalent (EDE), also referred to here as dose, is the principal measurement used in radiation protection. The EDE is a hypothetical whole-body dose equivalent that would equal the same risk of cancer mortality and serious genetic disorder as the sum of the weighted dose equivalents of those organs considered to be most seriously affected by the radionuclide in question. The EDE includes the committed effective dose equivalent (CEDE) from internal deposition of radionuclides and the EDE resulting from penetrating radiation from sources external to the body.

Federal government standards limit the EDE to the public (Department of Energy [DOE] Order 5400.5 [DOE 1990], 40 Code of Federal Regulations [CFR] Part 61). DOE's public dose limit (PDL) is 100 mrem/yr EDE received from all pathways (i.e., ways in which people can be exposed to radiation, such as inhalation, ingestion, and from airborne emissions of radionuclides); however, the dose received from airborne emissions of radionuclides is further restricted by the Environmental Protection Agency's (EPA's) effective dose standard of 10 mrem/yr (see Appendix A). These values are in addition to exposures from normal background, consumer products, and medical sources.

2. Methods for Dose Calculation

a. Introduction. Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, external exposure, and ingestion.

Two evaluations of releases are conducted: one to satisfy 40 CFR Part 61 requirements (emissions of radionuclides to air) and one for all sources and pathways. Results of environmental measurements are used as much as possible in assessing doses for all pathways. Calculations based on these measurements follow procedures recommended by federal agencies to determine radiation doses (DOE 1991, NRC 1977). Population and some individual doses attributable to Los Alamos National Laboratory (LANL or the Laboratory) activities are estimated through computer modeling.

b. Inhalation Dose. Annual average air concentrations of tritium; plutonium-238; plutonium-239,-240; uranium-234; uranium-235; uranium-238; and americium-241, determined by the Laboratory's air monitoring network (AIRNET), are corrected for background by subtracting the average concentrations measured at representative background stations. The

net air concentrations are then multiplied by a standard breathing rate and the 50-year CEDE for each radionuclide (DOE 1988a). To estimate a representative Los Alamos CEDE, AIRNET data from 13 stations in or near the townsite were averaged. The White Rock calculated dose is based on the data from four AIRNET stations in White Rock and Pajarito Acres.

This procedure for dose calculation assumes that exposure to the measured air concentration is continuous throughout the entire year (8,760 h).

c. External Radiation Dose. The Laboratory's largest contributor to the penetrating radiation environment is the Criticality Facility at Technical Area (TA) 18. Criticality experiments produce neutrons and photons, both of which contribute to the external penetrating radiation dose. During experiments that have the potential to produce a dose in excess of 1 mrem per operation, public access is restricted by closing Pajarito Road from White Rock to TA-51.

The other potentially significant contributor to penetrating radiation exposures is the Los Alamos Neutron Science Center (LANSCE) at TA-53. During experimentation at LANSCE, short-lived positron emitters are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential external radiation dose. Most of the emitters decay very quickly, and within a few hundred meters from LANSCE the dose is negligible. However, the dose at East Gate (the Laboratory boundary north-northeast of LANSCE) is elevated by these Laboratory emissions. The Laboratory's contribution to the penetrating radiation dose at East Gate is derived by modeling and environmental measurements. In one method, data from a high-pressure ion chamber (located very near East Gate) have been used to develop a direct evaluation of the penetrating radiation exposure rate. (In 1996, the measured data were not complete and so were not used.) In the other method, calculated or measured emissions from the stacks and buildings at LANSCE are input to CAP-88 to model the potential dose at East Gate. The modeling generally results in an overestimation of the Laboratory's contribution to the hypothetically exposed individual. Residential locations are also modeled to determine potential doses from LANSCE operations.

Environmental thermoluminescent dosimeters (TLDs) are used to estimate external penetrating radiation doses. The Laboratory has a network of TLDs (TLDNET) in fixed locations around the Laboratory and townsite (refer to Figure 4-1). The large variations in the natural background levels of penetrating radiation limit the ability of TLDs to discern the low-level Laboratory releases from natural background fluctuations. However, if there were a release of penetrating radiation significantly above background, TLDs could be used as an indicator of the magnitude and locations of the exposures. TLDs near the TA-18 facility have shown exposure levels above background as discussed further in Section 3.A.4.b. The Laboratory's TLDNET is not sensitive enough to reliably distinguish LANSCE emissions from background.

The TLDNET data are used to quantify the exposure from penetrating radiation in and around Los Alamos. The dose from self-irradiation, caused by natural radioactive emitters such as potassium-40 within the body, is about 40 mrem annually and is also factored into the calculation.

d. Ingestion Dose. Radioanalytical data from samples of foodstuffs are used to estimate the annual committed dose equivalent (CDE) to various tissues in the body and the total CEDE to the whole body for the maximum consumer of food products within the general population. The CEDE from food products is calculated by multiplying the CDE, representing the total dose which an organ or tissue of the body is expected to receive over the 50-year period following an intake of radioactive material, by the weighting factors for that tissue as given in the International Commission on Radiological Protection (ICRP) 26 (ICRP 1977). The CDE (and thus the CEDE) does not include contributions from exposures external to the body.

To calculate the CEDE, the radionuclide concentration in a particular foodstuff is multiplied by an estimated annual consumption rate to obtain the total adjusted intake for a particular radionuclide. The estimated annual consumption rates used for these calculations are presented in Table 3-1. Multiplication of this annual adjusted intake by the appropriate radionuclide dose conversion factor for a particular organ gives the estimated CDE to the organ and, similarly, the CEDE to the entire body [DOE 1988b]. To determine the Laboratory impacts, if any, on a particular foodstuff, the maximum CEDE (i.e., average CEDE + 2 sigma) at regional stations or other background stations is subtracted from the maximum CEDE at each monitoring location. Because one cannot have a "negative exposure to radiation," all negative values are set to zero leaving only the net positive differences between the sampling location of interest and the background stations. This net positive difference is summed over all the monitored radionuclides to obtain

Table 3-1. Annual Consumption Rates for Calculating the Committed Effective Dose Equivalent in Foodstuffs

Food Groups	Average Exposed Individuals	Maximum Exposed Individuals
Dairy Products	120 kg (0.3 L/d)[a]	300 kg (0.8 L/d)[a]
(Fresh Cow's Milk)	96 kg (0.25 L/d)[a]	190 kg (0.5 L/d)[a]
Beef		
Meat	95 kg (210 lbs)[b]	110 kg (243 lbs)[b]
Bone	23.8 kg (53 lbs)[d]	27.5 kg (61 lbs)[d]
Elk		
Meat	9.5 kg (21 lbs)[a]	23 kg (50 lbs)[c]
Bone	2.4 kg (5 lbs)[d]	5.7 kg (13 lbs)[d]
Fish (Fresh)	5.7 kg (13 lbs)[a]	21 kg (46 lbs)[b]
Fruits	17 kg (37 lbs)[e]	46 kg (102 lbs)[e]
Vegetables	42 kg (91 lbs)[e]	114 kg (250 lbs)[e]
Beverages		
(Tap Water)[h]	540 kg (1.5 L/d)[a]	730 kg (2.0 L/d)[f]
(Tea & Water Based Drinks)	421 kg (1.1 L/d)[a]	557 kg (1.5 L/d)[a]
Eggs	12 kg (34 g/d)[a]	20 kg (55 g/d)[g]
Honey	1.4 kg (3 lbs)[i]	5 kg (11 lbs)[i]

[a] EPA 1984.
[b] NRC 1977.
[c] Based on the consumption of one 233 kg elk (Meadows and Hakonson 1982) per year per 4.5 persons family.
[d] Based on the meat consumption rate and the weight distribution of elk tissue groups (Meadows and Hakonson 1982).
[e] Based on values from the NRC Regulatory Guide 1.109 (NRC 1977) with 22% fruit and 54% vegetables. The homegrown fraction is estimated at 40% (EPA 1989a).
[f] 40 CFR 141.
[g] EPA 1991.
[h] Modified to reflect the percent of water that a particular well contributed to the total amount of drinking water pumped in a year.
[i] Value used in previous years and/or based on professional judgment.

the total net positive difference, which is expressed in mrem. The total net positive difference is also reported as a percentage of the DOE's 100 mrem/yr PDL (DOE 1990), and can be used to calculate the risk of cancer fatalities from consuming a particular foodstuff.

3. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

Published EDE values from naturally occurring background radiation and from medical and dental uses provide a comparison with doses resulting from Laboratory operations. Global fallout doses resulting from atmospheric testing of nuclear weapons are only a small fraction of total environmental doses (<0.3% [NCRP 1987a]). Naturally occurring radiation dose is due primarily to exposure to the lungs from radon decay products and exposures from nonradon sources that affect the whole body.

External radiation comes from two sources of approximately equal magnitude: the cosmic radiation from space, and terrestrial gamma radiation from radionuclides in the environment. Estimates of natural radiation are based on a comprehensive report by the National Council on Radiation Protection and Measurements (NCRP 1987b) that uses 20% shielding by structures for high-energy cosmic radiation and 30% self-shielding by the body for terrestrial radiation.

Whole-body external dose is incurred from exposure to cosmic rays, external terrestrial radiation from naturally occurring radioactivity in the earth's

surface, and from global fallout. The EDE from internal radiation is due to radionuclides naturally present in the body and inhaled and ingested radionuclides of natural origin.

Annual external background radiation exposures for sources other than radon vary depending on factors such as snow cover and the fluctuations from solar radiation (NCRP 1975a). Estimates of background radiation in 1996 from nonradon sources are based on environmental dosimeter measurements of 160 mrem in Los Alamos and 140 mrem in White Rock using complete datasets only (i.e., measurements for all four quarters). The elevation difference between Los Alamos and White Rock accounts mainly for the difference between the two numbers. These measured doses were adjusted for structural shielding by reducing the cosmic ray component by 20%. The measured doses were also adjusted for self-shielding by the body by reducing the terrestrial component by 30%.

The neutron dose from cosmic radiation and the dose from self-irradiation (NCRP 1987b) were then included to obtain the whole-body environmental dose of 160 mrem at Los Alamos and 140 mrem at White Rock from sources other than radon. Uranium decay products occur naturally in soil and building construction materials. Inhalation of radon-222 produced by decay of radium-226, a member of the uranium series, results in a dose to the lung, which also must be considered. The EDE from radon-222 decay products is assumed to be equal to the national average, 200 mrem/yr. This estimate may be revised if a nationwide study of background levels of radon-222 in homes is undertaken. Such a national survey has been recommended by the NCRP (NCRP 1984, 1987a).

In 1996 the EDE to residents was 360 mrem at Los Alamos and 340 mrem at White Rock from all natural sources. The individual components of the background dose for Los Alamos and White Rock, and the average EDE of 53 mrem/yr to members of the US population from medical and dental uses of radiation (NCRP 1987a) are listed in Table 3-2.

Table 3-2. Calculation of Total Effective Dose Equivalent (mrem/yr) from Natural or Man-Made Sources

	Los Alamos	White Rock
Radon	200	200
Self-irradiation	40	40
Total External[a]	120	100
Total Effective Background Dose	360	340
Medical	53	53

[a] Includes correction for shielding.

4. Total Maximum Individual Dose to a Member of the Public or to Individuals Who are not Laboratory Workers

The 1.93 mrem dose reported in Chapter 2 is similar to the following reported doses but is derived solely from an EPA-approved air transport model. The doses in this chapter are based on actual measurements as well as transport modeling. Both methods of dose calculation are valid and are included here to provide a range for consideration.

a. Maximum Individual Dose—Off-Site Locations. The maximum effective dose equivalent (EDE or dose) was calculated at various locations to assess the maximum radiological impact from the Laboratory to areas inhabited by the public. The East Gate area was found to be the location of the maximum off-site dose. This maximum EDE is the total dose from all potential routes of radiation exposure and is based on data gathered by both the environmental surveillance program and radiological effluent monitoring program. The maximum dose, or the ninety-fifth percentile value, was 5.3 mrem and the median value (fiftieth percentile) for this estimate was 1.4 mrem.

b. Maximum Individual Dose—On-Site Locations. Potential doses that an individual who is not a Laboratory worker could have received while within the Laboratory boundary were calculated as 8.0 mrem for the maximum dose, or ninety-fifth percentile value, and 2.9 mrem for the median dose, or fiftieth percentile value. The location of the maximum potential exposure is a section of Pajarito Road near TA-18. The frequency and amount of time a member of the public may spend traveling this section of Pajarito Road, as well as the operational cycles of the TA-18 facility, were factored into the above dose calculations, which also used readings of external penetrating radiation measurements taken at TA-18 during the operation of criticality experiments. Potential doses to public members from TA-18 operations are limited using well-established principles of controlling exposure level, frequency, and duration. The section of Pajarito Road near TA-18 is closed during experiments when TA-18-generated doses may exceed one mrem. For experiments involving lower dose levels, the road is controlled so that public members may pass by but not remain near TA-18. The 8.0 mrem maximum dose is a

conservative estimate. An actual dose to an average public member who regularly commutes on Pajarito Road is estimated to be much lower.

c. Total Maximum Individual Combined Dose. By combining the calculated maximum off-site dose with the maximum on-site dose estimate, the maximum dose a member of the public could have received from the Laboratory during 1996 was estimated. The maximum dose, or the ninety-fifth percentile value, was equivalent to 13.3 mrem, or 13.3% of the DOE's annual public dose limit of 100 mrem EDE from all pathways. The median value (fiftieth percentile) for this dose estimate is 4.3 mrem; this dose is 1% of the total annual dose contribution from all sources of radiation (Figure 3-1). The contribution to the total maximum individual (median) dose via each pathway is presented in Figure 3-2.

5. Summary of Doses to Public Members of Nearby Residential Areas

Inhalation. The net CEDE resulting from the exposure, primarily through inhalation, to airborne emissions as measured by the AIRNET in 1996 for the townsites of Los Alamos and White Rock are 0.05 mrem and 0.04 mrem, respectively. These potential doses to the public are below the EPA standard of 10 mrem/yr for airborne emissions (EPA 1989b). Section 4.B.1.c provides further discussions on the CEDE by sampling locations as well as the radionuclides that contributed to this dose estimate.

External Exposure. For most environmental monitoring locations, no direct penetrating radiation dose equivalent to members of the public from Laboratory operations could be distinguished by measurements in 1996. The external penetrating radiation doses caused by Laboratory emissions of radionuclides to the air to residents of Los Alamos and White Rock were calculated to be 0.2 mrem and 0.01 mrem, respectively. However, higher-than-normal readings caused by external penetrating radiation sources at LANL were measured at one on-site location to which the public has access (Pajarito Road) and on-site locations to which individuals who are not Laboratory workers have some degree of access. For further discussion on additional potential individual exposures from Laboratory operations, see Sections 3.A.5.e below and 3.A.4.a above.

Ingestion Dose. Using the maximum consumption rate (see Table 3-1), the maximum difference between the total positive CEDE at sampling locations in the Los Alamos area and the regional background locations for each food group is as follows: fruits and vegetables, 0.77 mrem; milk, 0.083 mrem; honey, 0.036 mrem; eggs, 0.12 mrem; fish (bottom feeders), 0.083 mrem; fish (higher level feeders), 0.03 mrem; elk muscle, 0.011 mrem; elk bone, 1.4 mrem.; deer muscle, 0.013 mrem, deer bone, 1.1 mrem; and tea, 0.24 mrem. Assuming one individual consumed the total quantity for each food group (except bone tissue), the total net positive difference for the CEDE is 1.7 mrem. No LANL operation-caused radiation has been detected by analyzing the drinking water supply. Chapters 5 and 6 provide further discussions on the CEDE for other locations and for additional types of sample media.

Additional Public Exposure Scenarios and Doses from Laboratory Operations. In addition to the maximum individual dose presented in Sections 3.A.4.a and 3.A.4.b, hypothetical exposure scenarios are used to estimate the dose equivalents to individuals who walk, hike, or jog on certain parts Laboratory property. The scenarios considered in this section involve areas of Laboratory property to which the public is not technically granted access. However, these are areas where access is not designated as restricted by any means other than the generic Laboratory and/or federal government posting at the site boundary. The individuals within these scenarios are not authorized to be in these locations and would be trespassers. These scenarios are not expected to be realistic but were developed for informational purposes.

Exposure to TA-50 Effluent and Radioactive Liquid Waste Treatment Facility, Mortandad Canyon Stream Below National Pollutant Discharge Elimination System Outfall 051. Using radionuclide concentration and activity measurements from the TA-50 effluent and effluent from the stream below the Radioactive Liquid Waste Treatment Facility, National Pollutant Discharge Elimination System Outfall 051, the maximum CEDE using the maximum consumption rate of 16.1 L/yr is estimated at 19 mrem (19% of the DOE PDL) and 0.77 mrem (<0.8% of the DOE PDL), respectively. Using the average consumption rate of 5.7 L/yr, this annual CEDE decreases to 6.5 mrem and 0.27 mrem, respectively. Section 5.B.3.c provides further discussions on the assumptions used in this calculation.

Exposure to Sediments in Mortandad Canyon. Radioactivity in excess of background and fallout levels was measured in the Mortandad Canyon stream channel at four monitoring locations in 1996. The estimated maximum total effective dose equivalent (TEDE) (i.e., the total of the EDEs from all pathways plus twice the error term), using the dose modeling program RESRAD V5.61, to an individual frequenting

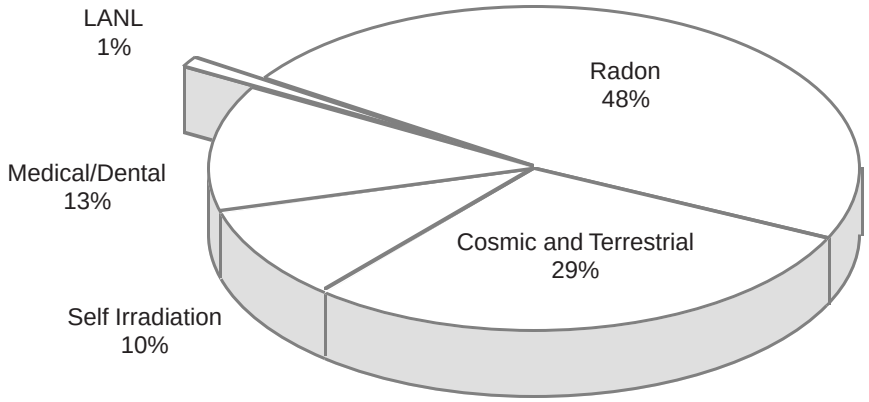

Figure 3-1. Total contributions to 1996 dose for the Laboratory's maximum exposed individual.

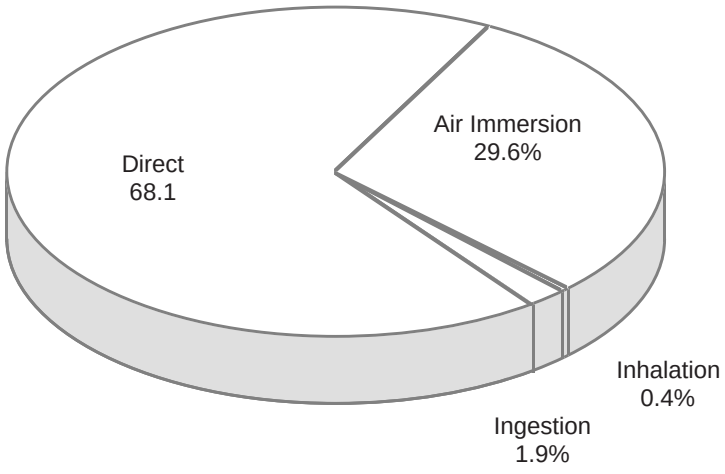

Figure 3-2. The Laboratory's contribution to dose by pathway for the Laboratory's maximum exposed individual.

the stream channel is 28 mrem/yr. However, because a hiking path exists approximately 3 m from the stream channel and the external penetrating radiation component (88% of the TEDE) falls off with increasing distance from the source, a more realistic estimated TEDE is approximately 6 mrem/yr. More detailed information on the calculations used to estimate this dose can be found in Section 5.C.3.a.

Exposure to Surface Contamination at Radioactive Waste Management Area T, TA-21. One of the monitoring locations at the waste management site, Area T, at TA-21 indicated a reading of 267 ± 10 mrem in 1996. This value is consistent with values observed at this location in the past and is attributed to cesium-137 on the ground. Applying the occupancy factor for industrial settings of 0.01 (Robinson and Thomas 1991) to the annual exposure rate, the maximum (i.e., the ninety-fifth percentile value) external penetrating dose to an individual frequenting the access road north of TA-21, Area T, for hiking or jogging is estimated at 2.9 mrem/yr. Additional information on the external penetrating measurements collected at TA-21 can be found in Section 4.C.5.b. (Low-Level Radioactive Waste Management Areas Network (WASTENET).

6. Population Distribution

The population distribution is used to calculate the collective dose resulting from 1996 Laboratory operations. In 1996, the estimated population of Los Alamos County was approximately 18,000 (BBER 1995). The two residential areas of Los Alamos townsite and White Rock and a few commercial areas exist in the county (Figure 1-1). The Los Alamos townsite (the original area of development) now includes residential areas known as Eastern Area, Western Area, North Community, Barranca Mesa, and North Mesa. The townsite had an estimated population of 12,000 residents in mid-1996. It is estimated that more than 246,000 persons lived within an 80-km (50-mi) radius of the Laboratory in mid-1996 (Table 3-3).

Table 3-3. Projected 1996/1997 Population within 80 km of Los Alamos National Laboratory[a]

	Distance from TA-53 (km)									
Direction	**0-1**	**1-2**	**2-4**	**4-8**	**8-15**	**15-20**	**20-30**	**30-40**	**40-60**	**60-80**
N	7	87	234	131	0	13	90	950	811	587
NNE	6	64	93	23	2	10	2,338	395	671	313
NE	3	11	0	0	1	1,181	14,743	2,536	2,457	3,591
ENE	1	0	0	0	559	1,499	4,546	3,585	1,416	1,601
E	0	0	0	1	316	1,332	4,096	386	22	413
ESE	0	0	0	0	9	10	669	8,017	727	2,240
SE	0	2	0	4,468	565	0	984	72,724	7,485	664
SSE	3	3	0	510	341	0	293	5,656	2,577	110
S	2	2	0	0	21	0	16	148	399	3,056
SSW	3	3	0	0	30	1	794	1,316	6,974	53,789
SW	3	10	0	1	4	1	0	0	2,249	188
WSW	1	16	27	0	7	0	32	387	2,474	5
W	0	3	119	173	0	7	66	291	64	72
WNW	2	14	1,007	5,839	0	0	26	30	63	2,622
NW	5	29	886	1,431	0	2	24	49	0	577
NNW	6	59	681	282	0	6	19	259	161	283
Total	42	303	3,047	12,859	1,855	4,062	28,736	96,729	28,550	70,111

[a]Total Population within 80 km of Los Alamos National Laboratory is 246,294.

7. Collective Dose

The collective EDE from Laboratory operations is the sum of the estimated dose received by each member of the population within an 80-km (50-mi) radius of LANL. Over 99% of this Laboratory operation dose is expected to have resulted from airborne radioactive emissions. As a result, the collective dose was estimated by modeling radioactive air emissions, their transport off-site, and the potential radiation exposures. The population distribution given in Table 3-3 was used in the dose calculation. The collective dose was calculated with the CAP-88 collection of computer programs. Airborne radioactive emissions from all types of releases were included in the analysis. The same exposure pathways that were evaluated for the maximum individual dose were also evaluated for the collective dose; these pathways include inhalation of radioactive materials, external radiation from materials present in the atmosphere and deposited on the ground, and ingestion of radionuclides in meat, produce, and dairy products. The 1996 collective EDE attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory was calculated to be 1.2 person-rem.

B. Risk to an Individual from Laboratory Operations

1. Estimating Risk

Health effects from radiation exposure (primarily cancer) are observed in humans only at doses in excess of 10 rem delivered at high dose rates (HPS 1996). In past environmental surveillance reports, our practice has been to use the risk estimates, also called risk factors, presented in the Committee on the Biological Effects of Ionizing Radiation (BEIR) documents (most recently, BEIR V 1990) to quantify the cancer risks from exposure to Laboratory contributions to local radiation levels. Although it is important to address the potential risk from these radiation doses, it is also important not to mislead the reader into concluding that small radiation doses are more hazardous than they actually are.

The risk estimates in BEIR V were developed by the National Academy of Sciences and were based primarily on the dose-risk effects produced in survivors close to the Hiroshima and Nagasaki atomic bomb blasts. These calculations, however, overestimate actual risk for low linear energy transfer (low-LET, primarily gamma) radiation, which is the source of more than 95% of the dose to the maximum exposed individual from Laboratory operations. Summarizing from the NCRP (1975b) risk estimates that are based on high doses and high-dose rates cannot provide realistic estimates of radiogenic cancers that might result from low-level doses received at low-dose rates. The fundamental shortcoming of the BEIR V risk estimates for determining low-level radiation effects is that they are based, primarily, on the effects of doses of tens or hundreds of rem received over periods of seconds. Extrapolating these data linearly downward to the mrem or fractions of mrem annual doses from Laboratory operations almost certainly results in a great overestimation of risk.

As early as the 1920s, investigators concluded that low levels of radiation could not cause the mutations and other effects assigned to such doses (Muller and Mott-Smith 1935). More recently, Billen (1990) concluded that radiation-induced DNA damage is a small contributor to the ongoing, spontaneous DNA damage that occurs in mammalian cells. In Billen's discussion, he suggests that an annual dose in the range of less than or equal to 100 mrem can be considered a "negligible dose." In terms of DNA damage, this dose is so small as to provide no effect that could be discerned from other causes. Other researchers conclude that there is no scientific basis for the low-dose risk estimates recommended by the EPA and BEIR V, and instead, propose new risk assessment methodologies that involve defining minimum significant risk (Seiler and Alvarez 1994 and 1996).

Radiation hormesis (the concept that small radiation doses in the range of a few rem annually may be beneficial) should also be considered when evaluating radiation-induced risk. The following discussion is paraphrased from Gollnick (1994). The descriptor *beneficial* means that a population exposed to small amounts of radiation will experience fewer cancer deaths than a similar, unexposed population. Among the claimed effects of small radiation doses, in addition to the potential for reduced cancer risk, are increased life span, growth, and fertility. Gollnick describes possible biochemical bases for these effects including elevated antibody levels in irradiated animals and differential sensitivity of different types of lymphocytes to radiation that effectively increases the body's ability to attack tumors. Some population studies support the radiation hormesis concept. Recently, Cohen (1997) compared cancer incidence to mean radon level in homes in the US. After adjusting for cigarette smoking, the data clearly indicate that at radon levels up to approximately 4 pCi/L (approximately equivalent to 1 rem), cancer incidence decreases with increasing radon level. This argues strongly against the conclusion that any small

increment of radiation implies an increment in cancer risk at low overall doses. Rather, the data indicate that low levels (<5 rem) of radiation may decrease cancer risk.

The Health Physics Society published a position statement on the risks of radiation exposures (HPS 1996). They concluded that below an individual dose of 5 rem in one year "risk estimates should not be used; expressions of risk should only be qualitative emphasizing the inability to detect any increased health detriment (i.e., zero health effects is the most likely outcome)."

Estimates range from 1 in 50 million excess risk of cancer death per mrem dose to a member of the public (EPA 1994) to a beneficial, although unquantified, risk as described above. We present the range of risk estimates in this section to allow readers to draw their own conclusions regarding the dangers of Laboratory radiation. If one chooses to use the BEIR or EPA risk estimates (factors) to calculate the potential excess cancer rates from a radiation dose, a sizable body of research indicates that the calculation will overestimate the actual risk. The potential excess cancer deaths may be calculated according to the following equation:

$R = D \times RF$ where

R = incremental (or decremental) risk of cancer death expected from a radiation dose to an individual,

D = effective dose equivalent (mrem), and

RF = risk factor (excess cancer deaths/mrem).

As noted previously, RFs range from 5×10^{-7}/mrem to negative, as yet unquantified values. In the following section, we do not report the potential risks associated with the reported doses, but the reader may calculate these according to the above equation, using whichever risk factors are believed to be appropriate.

2. Risk from Laboratory Operations

The risks calculated from natural background radiation and medical and dental radiation can be compared with the incremental risk caused by radiation from Laboratory operations. The average doses to individuals in Los Alamos and White Rock from 1996 Laboratory activities were 0.2 and 0.1 mrem, respectively. The exposure to Los Alamos County residents from Laboratory operations is well within variations in exposure of these people to natural cosmic and terrestrial sources and global fallout. For example, variation in the amount of snow cover and in the solar sunspot cycle can cause a 10-mrem difference from year to year (NCRP 1975a).

For Americans, the average lifetime risk is a 1-in-4 chance of contracting cancer and a 1-in-5 chance of dying of cancer (EPA 1979). Assuming one accepts the most conservative risk estimates (BEIR V 1990 and EPA 1994), the incremental risk from exposure to Laboratory operations is negligible.

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4. Air Surveillance

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Highlights from 1996

Los Alamos National Laboratory (LANL or the Laboratory) discontinued operation of 5 of its 58 air monitoring stations during 1996. The remaining 53 stations operated throughout 1996 and collected air samples that were analyzed for tritium, americium-241, plutonium-238, plutonium-239 ,-240, uranium-234, uranium-235, and uranium-238 to determine air concentrations of these radionuclides in the ambient air near the samplers. Air monitoring network (AIRNET) data indicate that at all locations, air concentrations were well below applicable guides and limits.

Air concentration data were analyzed to identify concentrations above those normally seen. These data analyses and follow-up assessments revealed an increasing trend in air concentrations of americium-241 and plutonium-239, -240 at one station location at TA-54, Area G, the waste disposal area at LANL. The air concentrations increased somewhat during the first quarter of 1995, and then again, to a significantly higher level during the second quarter of 1996. These increases were seen only at one station and suggested that the source of contamination was very small and very close to the station. A ground survey of the vicinity revealed a small area a few tens of meters from the station that had soil contaminated at levels about 100 times the average concentrations nearby.

We found that trenching had occurred next to the sampler during 1995 and 1996 and that the nearby road had been rerouted during early 1996. Our conclusion is that trenching or road work may have brought some contaminated material to the surface of the road and that heavy vehicle traffic associated with the Transuranic Waste Inspectable Storage Project operations provided an efficient mechanism to get the contamination airborne in the immediate vicinity. Because these concentrations were found to be localized and within a controlled area, a resulting dose would not have been experienced by a member of the public and are orders of magnitude below applicable exposure limits for workers.

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A. Ambient Air Sampling

1. Introduction

The radiological air sampling network at Los Alamos National Laboratory (LANL or the Laboratory) is designed to measure environmental levels of airborne radionuclides that may be released from Laboratory operations. Laboratory emissions include microcurie (μCi) quantities of plutonium and americium, millicurie (mCi) quantities of uranium, and curie (Ci) quantities of tritium and activation products. Each station collects both a total particulate matter sample and a water vapor sample for analysis.

Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by the Laboratory's air sampling program. Regional airborne radioactivity is largely composed of fallout from past atmospheric nuclear weapons tests by several countries, natural radioactive constituents from the decay of thorium and uranium attached to dust particles, and materials resulting from interactions with cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic radiation and stable water). Regional levels of radioactivity in the atmosphere, which are useful in interpreting air sampling data, are summarized in Table 4-1. Note that the measurements taken in Santa Fe by the US Environmental Protection Agency (EPA) are similar to those taken by the Laboratory as regional background values and are significantly lower than EPA concentration limits for the general public.

Particulate matter in the atmosphere is primarily caused by the resuspension of soil, which is dependent on meteorological conditions. Windy, dry days can increase the soil resuspension, but precipitation (rain or snow) can wash particulate matter out of the air. Consequently, there are often large daily and seasonal fluctuations in airborne radioactivity concentrations caused by changing meteorological conditions. The measured airborne concentrations are less than the EPA concentration limit for the general public. The EPA limit represents a concentration that would result in an annual dose of 10 mrem.

2. Air Monitoring Network

During 1996, ambient air sampling for airborne radioactivity was conducted at more than 50 locations. Stations are categorized as regional, pueblo, perimeter, or on-site. Three regional monitoring stations, 28 to 44 km (18 to 28 mi) from the Laboratory, are located in Española, Pojoaque, and Santa Fe. The data from these stations are used as reference points for determining regional background and fallout levels of atmospheric radioactivity. The pueblo monitoring stations are located at the Pueblos of San Ildefonso, Taos, and Jemez. There are now more than 20 perimeter stations located within 4 km (2.5 mi) of the Laboratory boundary (Figures 4-1 through 4-3).

Because maximum concentrations of airborne releases of radionuclides would most likely occur on-site, more than 30 stations are within the Laboratory boundary. For quality assurance (QA) purposes, two samplers are co-located as duplicate samplers, one at station #27 at Technical Area (TA) 54 and one at station #26 at TA-49. Also, there is a backup station located at East Gate. In addition to the three categories mentioned previously, stations can also be classified as being inside or outside a controlled area. A controlled area is defined as having possibly radioactive materials or elevated radiation fields and are clearly posted as such (DOE 1988). The active waste site TA-54 Area G is an example of a controlled area.

3. Sampling Procedures, Data Management, and Quality Assurance

a. Sampling Procedures. The Laboratory operates a network of more than 50 environmental air stations (called AIRNET) to sample radionuclides in ambient air (Figures 4-1 through 4-3). Each sampler is equipped with a filter to collect a particulate matter sample for gross alpha/beta and radiochemical determinations and a silica gel cartridge to collect moisture for tritium determination. The particulate filter and the gel cartridge are collected and are typically analyzed biweekly. To increase our ability to detect radionuclides, the particulate filters are accumulated for three months, composited, split, and then sent to commercial analytical laboratories for radiochemical analyses. Details about the sample collection, sample management, chemical analysis, and data management activities are provided in the project plan (ESH-17 1995) and in the numerous procedures through which the plan is implemented.

b. Data Management. The 1996 field data, including timer readings, readings for the flow in the sampling trains at the start and stop of the sampling period, and comments pertaining to these data, were recorded electronically in the field on a palm-top microcomputer. These data were later transferred to a table format within the ESH-17 AIRNET Microsoft Access database.

c. Analytical Chemistry. The 1996 particulate filters were analyzed biweekly by the Health Physics Measurements Group (ESH-4) Health Physics Analytical Laboratory (HPAL), using analytical procedures that meet the requirements of 40 Code of Federal Regulations (CFR) 61, Appendix B, Method 114, for gross alpha, gross beta, and tritium. A composite was prepared quarterly for each station by combining the filters from the six or seven sampling periods during the quarter. The composites (one for each station) were split, and the first half submitted to a commercial laboratory for analyses that conformed to EPA requirements. The second half of each composite was temporarily retained for reanalysis, if needed. Every two weeks, Air Quality Group (ESH-17) staff distilled the moisture from the silica gel cartridges and submitted the distillate to the ESH-4 HPAL for tritium determination by liquid scintillation spectrometry. A summary of the target miniumum detectable amount for the biweekly and quarterly samples is provided in the QA Project Plan for Radiological Air Sampling Network (ESH-17 1995).

d. Laboratory Quality Control Samples. For 1996, ESH-17 maintained a program of blank, spike, duplicate, and replicate analyses, which was designed to provide information on the quality of the data received from analytical chemistry suppliers. The chemistry met QA requirements for the Air Quality programs. Comprehensive data for the 1996 analytical quality assurance program are being prepared for publication in a separate report.

4. Radiochemical Analytical Results

a. Gross Alpha and Beta Radioactivity. Gross alpha and gross beta analyses are used primarily to

evaluate general radiological air quality and to identify potential trends. If gross activity in a sample is consistent with past observations and background, immediate special analyses for specific radionuclides are not necessary. If the gross analytical results appear to be elevated, then immediate analyses for specific radionuclides may be performed to investigate whether a problem, such as an unplanned release, has occurred. Gross alpha and beta activity in air exhibit considerable environmental, especially seasonal, variability as shown in Figures 4-4 and 4-5.

The National Council on Radiation Protection and Measurements (NCRP) estimated the average concentration of long-lived gross alpha activity in air to be 2.0 fCi/m^3. The primary alpha activity is due to polonium-210 (a decay product of radon gas) and other naturally occurring radionuclides (NCRP 1987). The NCRP also estimated average concentration levels of long-lived gross beta activity in air to be 20.0 fCi/m^3. This activity is primarily due to the presence of lead-210 and bismuth-210 (decay products of radon) and other naturally occurring radionuclides.

More than 1,000 air samples were collected in 1996 and analyzed for gross alpha and gross beta activity. As shown in Table 4-2, the annual averages for all of the stations were within two standard deviations of the NCRP's estimated average (2 fCi/m^3) for gross alpha concentrations. Gross alpha activity is almost entirely from the decay of natural radionuclides, primarily radon, and is dependent on variations in natural conditions such as atmospheric pressure, temperature, and soil moisture. The differences among the groups are most likely attributable to these factors (NCRP 1987).

Table 4-3 shows gross beta concentrations within and around the Laboratory. These data show variability similar to the gross alpha. All group averages are below 20 fCi/m^3, the NCRP estimated national average for gross beta concentrations.

b. Tritium. Laboratory operations released 680 curies of tritium during 1996. In addition, tritium is present in the environment as the result of nuclear weapons tests and is also produced naturally by the cosmogenic process (Kathern 1984). Sampling results are presented in Table 4-4. As a group, the perimeter stations seemed to show higher tritium concentrations than the regional or pueblo stations. The perimeter station average was 1.3 ± 1.2 pCi/m^3 compared to 0.3 ± 0.8 for the regional stations. The maximum off-site mean annual concentration of 2.2 pCi/m^3 was recorded at stations #8 and #16. The uncertainty (two standard deviations) of each perimeter, regional, and pueblo station is greater than the measured air concentration. The calculated gross tritium dose (no background subtraction) based on the mean air concentration at stations #8 and #16 was 0.15% of the EPA's public dose limit (PDL) of 10 mrem per year.

Elevated concentrations were observed at a number of on-site stations, with the highest maximum and annual mean concentration at station #35 (Area G). Elevated mean air concentrations were also seen at other Area G stations and one non-Area G station (#25). Station #35 is located at Area G in the TA-54 waste site (a radiological control area) near shafts where tritium-contaminated waste is disposed, and station #25 is located near a tritium facility. However, the annual mean gross (no background subtraction) concentration, which was observed at station #35, is approximately 0.002% of the Department of Energy (DOE) derived air concentration (DAC) for controlled areas (20×10^6 pCi/m^3). All annual mean concentrations were well below the applicable EPA and DOE guidelines.

c. Plutonium. Plutonium is released by the Laboratory in microcurie amounts. In addition, plutonium is present in the environment because of fallout from past nuclear weapons testing and, in some isolated cases, from natural sources (Kathern 1984).

Sampling results for plutonium-238 are presented in Table 4-5. The table shows that the highest group summary mean was for the category decontamination and decommissioning (D&D) stations at TA-21, with an annual mean of 6.5 ± 13.3 aCi/m^3. This corresponds to approximately 0.3% of the EPA public dose limit. The highest annual mean for an individual station was at station #27 on the north perimeter of TA-54, Area G, with an annual mean activity of 19.8 ± 10.0 aCi/m^3. This corresponds to approximately 0.94% of the EPA's public dose limit, or about 0.094 mrem. Analysis of data from this station indicates an increasing trend for this and other isotopes (plutonium-239) and radionuclides (americium-241) as discussed further below.

Sampling results for plutonium-239 are presented in Table 4-6. The regional, pueblo, and perimeter station group summaries all indicate annual means near zero, as we would expect. The highest annual mean at any off-site station occurred at Station #9, Los Alamos Airport and was 2.9 ± 1.4 aCi/m^3 of plutonium-239, -240. This annual mean concentration corresponds to approximately 0.15% of the EPA's public dose limit, or about 0.015 mrem (this is a gross dose with no background subtraction). The Los Alamos Airport is the nearest air monitoring station downwind of the decontamination and decommissioning operations at TA-21. The stations at TA-21 have an annual group mean that is higher than the other groups, with the exception of

the Area G stations discussed below. The somewhat elevated concentrations at TA-21 may have resulted from increased ground-level emissions associated with the demolition and related activities that occurred at this site during 1996.

The maximum on-site station mean (706.6 ± 369.9 aCi/m^3) was recorded at Station #27, TA-54, Area G. Station #27 was the highest on-site station last year also (ESP 1996), and we believe there has been a significant increase in the air concentration of plutonium-239 (and americium-241) at this location beginning during the second quarter of 1995 and continuing at least through the final quarter of 1996. The mean air concentration of plutonium isotopes at Station #30 (near Area G) appears to have been elevated because of high second quarter values as discussed further in Section 4.A.5.e.

d. Americium. Because americium often occurs along with plutonium, plutonium samples are also submitted for americium analysis. Results are presented in Table 4-7. As described for plutonium-238, americium is present in very low concentrations in the environment, and this is indicated by the low annual mean concentrations seen at the regional, pueblo, and perimeter station summaries. The elevated mean of 7.3 ± 27.1 aCi/m^3 for the on-site station group is due primarily to a single high value at station #30 (Pajarito Booster). The slightly elevated americium concentrations at the D&D sites (TA-21) may be due to increased ground-level emissions resulting from D&D activities. The elevated annual mean at the Area G stations is significant and is discussed in Section 4.A.5.

e. Uranium. Uranium is released from the Laboratory in microcurie amounts and occurs naturally in rocks and soil (please refer to a general discussion regarding uranium in the environment in a previous annual report [ESP 1995]). Tables 4-8, 4-9, and 4-10 present radioisotopic results for uranium-234, uranium-235, and uranium-238, respectively. The highest on- or off-site annual mean concentration for uranium-234 was at station #78, in the vicinity of firing sites where depleted uranium has been dispersed in explosive experiments. The maximum annual mean concentration at the perimeter stations was recorded at station #61; Los Alamos Hospital. The gross (not corrected for background) activity of 20.2 aCi/m^3 corresponds to approximately 0.036 mrem according to the EPA's PDL. The annual means of both the regional and the pueblo stations were higher than the on-site stations. This indicates the overwhelming importance of high background levels of natural uranium in the soils in these areas compared to Laboratory contributions. The highest uranium-235 concentration was at station #78. The maximum off-site value was 3.1 ± 2.3 aCi/m^3 at Española. All annual mean concentrations of uranium-238 were well below the applicable EPA and DOE guidelines.

In addition to releases of uranium from some Laboratory facilities, depleted uranium (consisting primarily of uranium-238) is dispersed by experiments that use conventional high explosives. About 176 kg of depleted uranium containing about 0.124 Ci of radioactivity was used in such experiments in 1996. Most of the debris from these experiments was deposited on the ground in the vicinity of the firing sites. Limited experimental data show that no more than about 10% of the uranium becomes airborne in a high-explosive test (Dahl and Johnson 1977). Dispersion calculations indicate that the resultant maximum airborne concentrations would be greater than concentrations attributable to the natural abundance of uranium that is resuspended in dust particles; however, the predicted values were not detected at on- or off-site stations.

5. Investigation of Elevated Air Concentration

In 1996, a number of air sampling values exceeded investigation levels established by ESH-17. A discussion of how investigation levels are determined can be found in the QA Plan for Radiological Air Sampling Network (ESH-17 1995). When a measured air concentration exceeds an investigation level, ESH-17 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 for the elevated concentrations. The following sections identify four incidences of elevated air concentrations that warrant further discussion.

a. Technical Area 54, Area G. Recently, the Laboratory initiated a formal ongoing review process of air monitoring data to assess whether ambient air concentrations of radionuclides are above what we have seen in recent history. As a result of that review, the Laboratory identified elevated air concentrations at station #27, on-site at Area G. By constructing a trend of the plutonium-239 and americium-241 concentrations since the first quarter of 1991, we determined that these are not isolated high values but, rather an increasing trend (Figure 4-6). Other radionuclides are not elevated significantly. None of the other air

monitoring stations at Area G showed evidence of this increasing trend, and neither did the nearby off-site stations, including those in White Rock.

Plutonium-239 and americium-241 increased somewhat during the first quarter of 1995. Before 1995, the average air concentrations of plutonium-239 and americium-241 were about 11 aCi/m^3. Beginning in the first quarter of 1995, plutonium-239 concentrations increased and remained at a plateau for approximately five quarters at an average concentration of 120 aCi/m^3 for plutonium-239 and 96 aCi/m^3 for americium-241. During the second quarter of 1996, a much larger increase occurred at both stations for the same radionuclides. A higher plateau was reached and the concentrations have remained at these elevated levels of 900 aCi/m^3 for plutonium-239 and 600 aCi/m^3 for americium-241 throughout the remainder of 1996.

The Laboratory performed a survey of the adjacent road area using a "Violinist" (a scintillation detector with a multiple channel analyzer that is capable of discriminating the low levels of gamma radiation associated with the decay of plutonium-239 and americium-241). The survey was completed during May 1997 and showed one small area (approximately 10 m $\times$ 15 m) of americium-241 and plutonium-239 contamination significantly higher than adjacent areas.

The entire road area in the vicinity of the air monitoring station had been moved and reworked over the past year. Additionally, trenching for waterlines along the northern edge of the road passed within a couple of meters of station #27. Although the survey results are still under evaluation, a preliminary summary and conclusions appear to be warranted. A first trenching operation occurred in February 1995 and appears to have been synchronous with the initial small rise in air concentrations. Another trenching operation and a complete reworking of the road surface was begun during the spring of 1996, closely matched in time with the much more significant increase in air concentrations. The road was actually moved in early 1996 and that move appears to have taken the road path directly over the contaminated area. Our preliminary conclusion is that trenching or the road work may have brought some contaminated material to the surface of the road and that heavy vehicle traffic associated with the Transuranic Waste Inspectable Storage Project operations has provided an efficient mechanism to get the contamination airborne in the immediate vicinity of station #27.

During 1997, the Laboratory should complete a remediation of the problem by covering the contamination with approximately 30 cubic yards of clean dirt. We are having biweekly AIRNET samples from station #27 radiochemically analyzed for americium and plutonium isotopes to assess whether airborne concentration levels have dropped as a result of the dirt cover. Additionally, surface surveys similar to the original survey that identified the contamination are planned to evaluate the effectiveness of this remediation.

b. Technical Area 16. We believe that elevated tritium results observed at the TA-16-450 station are related to increased tritium activities (stack and non-stack emissions) by the Weapons Engineering Tritium Facility at TA-16, which became fully operational during 1995. Stack effluents from TA-16 totaled 99 Ci, with 66% as tritium oxide. Using the air sampler data, non-stack emissions are estimated at 1 to 10 Ci per year of tritium oxide. The maximum dose resulting to a member of the public from the release of these effluents is calculated to be 0.003 mrem/yr to 0.004 mrem/yr.

c. Technical Area 21. Concentrations of transuranic radionuclides exceeding the investigation levels have been observed at TA-21 (stations #19, and #71 through #75) in the past and are thought to have resulted from increased ground-level emissions associated with D&D activities during 1996.

d. Firing Sites. Elevated concentrations of isotopes of uranium observed at firing site stations are attributed to open air explosive testing at TA-15-PHERMEX.

e. Station #30. This station, located at the turn-off at Pajarito Road to TA-54, recorded elevated readings of plutonium-239 and americium-241 for the second quarter of 1996. Results from other sample periods were examined to see if an undesirable trend was occurring; no trend was found. At this time, the cause of the elevated readings remains unknown.

6. Long-Term Trends

Investigation of long-term trends can provide information about long-term impacts of the Laboratory on the environment and help us to reduce such impacts. Last year (ESP 1996), we explored trends in tritium concentrations and concluded that ambient concentrations have decreased significantly compared to those in the 1970s and early 1980s.

In the current report, we have identified an ongoing situation at one Area G location where air concentrations of americium-241 and plutonium-239 have been increasing since early 1995. This increasing trend is discussed above. General review of our monitoring data does not indicate any other significant trends at

this time. We will continue to analyze these data and will report on significant trends as they emerge.

7. Dose Equivalents to Individuals from Ambient Air Monitoring Network

Inhalation dose resulting from exposure to airborne tritium (as tritiated water vapor); plutonium-238; plutonium-239, -240; americium-241; uranium-234; uranium-235; and uranium-238 was determined from samples collected by the AIRNET program. The background concentration values of these radionuclides, which includes natural radioactivity and worldwide fallout, were measured at selected locations and subtracted from the annual average concentrations values given in Tables 4-2 through Table 4-10 to determine net dose from LANL airborne effluents. The net dose measured by AIRNET in the townsites of Los Alamos and White Rock were 0.05 mrem and 0.04 mrem, respectively.

B. Stack Air Sampling for Radionuclides

1. Introduction

Radioactive materials are an integral part of many activities at the Laboratory, and some of these materials may be vented to the environment through a stack. These operations are evaluated 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 0.1 mrem in a year, this stack must be sampled in accordance with 40 CFR 61, subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (EPA 1989). As of the end of 1996, 28 stacks were identified as meeting this criterion. An additional four sampling systems were in place to meet DOE requirements for nuclear facilities prescribed in technical or operational safety requirements. Where sampling is not required, emissions are estimated using engineering calculations and radionuclide inventory information.

2. Sampling Methodology

As of the end of 1996, LANL was continuously sampling 32 stacks for the emission of radioactive material to the ambient air. LANL has identified four types of radioactive stack emissions: (1) particulate matter, (2) vaporous activation products (VAP), (3) tritium, and (4) gaseous/mixed air activation products (G/MAP). For each of these emission types, the Laboratory employs an appropriate sampling method.

3. Sampling Procedure and Data Management

a. Sampling and Analysis. Analytical methods were chosen for compliance with EPA requirements (40 CFR 61, Appendix B, [EPA 19] Method 114). These requirements were derived during 1995, as part of the development of QA project plans for tritium, particulate, and vapor sampling.

b. Laboratory Quality Control Performance. Groups of discrete samples were submitted to commercial laboratories for radiochemical analyses. For these analyses, the Laboratory maintained a program of blanks and spikes consistent with EPA guidelines (EPA 1991). These EPA guidelines call for a frequency of 1 blank and 1 duplicate for every 20 samples. For the tritium analyses for the stack program, the HPAL maintained a program of blanks and duplicates analyses that was more frequent than EPA guidelines. Comprehensive data for the 1996 analytical quality assurance program are being prepared for publication in a separate report.

4. Analytical Results

Measurements of Laboratory stack emissions during 1996 totaled 13,790 Ci. Of this total, tritium emissions comprised 680 Ci, and air activation products from the Los Alamos Neutron Science Center (LANSCE) contributed 13,110 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and particulate/vapor activation products were less than 0.5 Ci.

As in 1995, radioactive particulate source terms were developed using radionuclide specific analyses rather than process knowledge. In an effort to provide better data, the identities of radionuclides emitted from Laboratory stacks were determined through the use of radioanalytical chemistry in 1995 and 1996. For this reason, emissions of americium-241 are now presented separately from emissions of plutonium. Where sampling was discontinued or analyses were added during the year, calculated emissions are not representative of annual emissions. To account for this, incomplete emissions were scaled to reflect an entire year.

5. Long-Term Trends

Radioactive emissions from sampled Laboratory stacks are presented in Figures 4-7 through 4-10. These figures illustrate trends in measured emissions for plutonium, uranium, tritium, and G/MAP emissions, respectively. As the figures demonstrate, no increases in emissions from 1995 to 1996 were measured. The major decrease in emissions occurs for LANSCE. This decrease in emissions is primarily due

to the operation of the delay line (described below), a decreased run time, and to the facility configuration during 1996.

Figure 4-11 shows the total contribution of each of these emission types to the total Laboratory emissions. It clearly shows that G/MAP emissions and tritium emissions comprise the vast majority of radioactive stack emissions.

Because G/MAP emissions account for most of the airborne radioactivity, and because the FE-3 stack at LANSCE is the primary source of G/MAP isotopes, LANSCE operating personnel have developed and implemented a delay line to reduce these emissions. The delay line operates by removing a large part of the concentrated activated air from the production point at the LANSCE beam stop. This air is passed through a 1,200-m tube, allowing approximately 100 minutes of additional decay time (Fuehne 1996). Because of the short half-lives of the G/MAP isotopes, carbon-10 (19.5 s), carbon-11 (20 min), nitrogen-13 (10 min), nitrogen-16 (7 s), oxygen-14 (71 s), oxygen-15 (123 s), and argon-41 (1.8 h), this delay is sufficient to significantly reduce the total activity before returning the air to the stack. A recent study shows that, with the delay line operating, G/MAP emissions were reduced by 28.8%, as compared to similar operations without the benefit of the delay line (Fuehne 1996). Through such efforts, emissions of airborne radioactivity can be reduced while limiting the impact on the operating schedule.

C. Cosmic and Gamma Radiation Monitoring Program

1. Introduction

Naturally occurring external penetrating radiation originates from terrestrial and cosmic sources in the form of gamma rays, neutral particles, charged particles, and heavy nuclei. Man-made radiation consists of the same types of radioactive materials with the exception of the heavy nuclei. To evaluate natural and man-made radiation, the Laboratory's environmental monitoring program uses thermoluminescent dosimeters (TLDs) and a high-pressure ion chamber (HPIC) which is part of the Neighborhood Environmental Watch Network (NEWNET) community monitoring network operated by the Laboratory's Instrumentation and Control group. Because the natural background from terrestrial and cosmic sources are much larger than those from man-made sources, it is extremely difficult to distinguish man-made sources from the natural background. There are several environmental mechanisms that contribute to this difficulty.

The terrestrial component results primarily from naturally occurring potassium-40, the thorium and uranium decay chains, and radionuclides deposited as a result of nuclear atmospheric testing (e.g., strontium-90, cesium-137, and small amounts of plutonium). Terrestrial radiation varies diurnally, seasonally, and geographically. External penetrating radiation levels can vary from 15% to 25% at a given location because of changes in soil moisture and snow cover that reduces or blocks the radiation from terrestrial sources (NCRP 1975). There is also spatial variation that is a result of the soil type and the placement of the dosimeters. For example, those dosimeters that are placed in a narrow canyon will receive radiation from the sidewalls and the floor of the canyon as well as from the cosmic sources (ESP 1978).

Naturally occurring ionizing radiation from cosmic sources increases with elevation because of reduced atmospheric shielding. At sea level, cosmic sources yield between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km (1.4 mi), receives about 75 mrem/yr from cosmic sources. However, different locations in the region range in elevation from about 1.7 km (1.1 mi) at Española to 2.7 km (1.7 mi) at Fenton Hill, resulting in a corresponding range of 45 to 90 mrem/yr from cosmic sources. This component can also vary ±10% because of solar modulations (NCRP 1987). These fluctuations along with those from terrestrial sources make it difficult to detect an increase in radiation levels from man-made sources, especially when the increase is small relative to the magnitude of natural fluctuations.

2. Monitoring Network

a. Laboratory and Regional Areas (TLDNET). In an attempt to be able to distinguish any impact from Laboratory operations, 58 thermoluminescent dosimeter (TLD) stations are placed around the Laboratory and in the surrounding communities. This network of dosimeters is divided into three groups. (1) The off-site regional group has six locations ranging from 28 to 117 km (17 to 73 mi) from the Laboratory boundary. These regional stations are located at Fenton Hill and in the neighboring communities of Española, Pojoaque, Santa Fe, and the Pueblos of San Ildefonso and Jemez. Taos Pueblo was part of this network in 1995, but was dis-continued in 1996 because of repeated loss of measurements. (2) The off-site perimeter group has 25 locations within 4 km (2.5 mi) of the Laboratory boun-dary (see Figure 4-12). These stations are placed in residential areas surrounding the Laboratory and in locations where people work. (3) The on-site group has 27 locations

within Laboratory boundaries, generally around operations that may produce ionizing radiation. Four new on-site stations were added in 1996: East Gate (#56); TA-54 West at the TLD Lab (#57); TA-54 Lagoon on Pajarito Road (#58); and Los Alamos Canyon between the Ice Rink and TA-2 (#59).

b. Technical Area 53 Network (LANSCENET). To monitor external penetrating radiation from airborne gases, particles, and vapors resulting from LANSCE operations at TA-53, a network of 24 TLD stations is used. Twelve of these monitoring locations are approximately 800 m (0.5 mi) north of and downwind from the LANSCE stack. The other 12 TLD stations are located about 9 km (5.5 mi) from LANSCE, near the southern boundary of the Laboratory and are used as a background measurement. Both sets of 12 monitoring locations are placed at approximately the same elevations to help eliminate elevation effects from the cosmic component of the natural radiation.

c. Low-Level Radioactive Waste Management Areas Network (WASTENET). The Laboratory has 10 inactive and 1 active (TA-54, Area G) low-level radioactive waste management areas. To monitor any external penetrating radiation from these areas, 86 dosimeters are placed around the perimeter of these waste management areas. Of these 86 dosimeters, Area G at TA-54 has 25 dosimeters placed at strategic locations around the facility. All waste management areas are controlled-access areas and are not accessible to the general public. The average annual dose at each waste area is calculated from a set of TLDs located around each site.

d. High-Pressurized Ion Chamber. In addition to the LANSCENET, the Laboratory operates a HPIC-NEWNET station (#1707) at the Laboratory boundary immediately downwind from the LANSCE facility. In the past, station readings were used to estimate dose to a member of the public in the East Gate area. Two problems affecting the quality and usefulness of the data from the station occurred in 1996: (1) the detector's calibration period expired, and (2) the power failed in mid-November through the end of the year. An analysis of the data demonstrated that up until the time the station failed, useable data was being recorded despite the instrument being out of calibration. However, this data is not used to determine the dose equivalent at this location (see Section 3.A.4.a for an estimate of the dose equivalent for East Gate). More information about NEWNET and this station (#1707) is available on the World Wide Web at *http://newnet.jdola.lanl.gov/newnet.html*.

3. Sampling Procedures, Data Management, and Quality Assurance

Environmental TLDs used at the Laboratory are composed of natural lithium fluoride (LiF:Mg,Ti) crystals containing 7.4% lithium-6 in the form of 3.2-mm^2 by 0.9-mm-thick chips, referred to as TLD-100. After exposure to x- and gamma radiation, the TLD chips are collected and heated in a laboratory setting to measure the energy stored in the crystal. This stored energy is released in the form of light that is proportional to the amount of radiation absorbed by the TLD. The TLD-100 over responds to and is extremely sensitive to thermal neutrons, but is insensitive to fast or high energy neutrons. These neutrons must be moderated before they can be measured by TLD-100 chips.

A newly designed dosimeter was introduced for field monitoring in 1996 and was used for all monitoring locations except for the inactive material disposal areas in the WASTENET. This new dosimeter was used at TA-54, Area G. The dosimeter used in the previous years in the environmental TLD program were used at the inactive material disposal areas. This new dosimeter uses the same type of "acorn" holder as the old dosimeter, but utilizes five, 1/8 in. TLD-100 chips instead of the four, 1/4 in. TLD-100 chips used in the old dosimeter. (For a complete description of this dosimeter, see Archuleta 1997.) American National Standards Institute (ANSI) N545 performance testing of this newly designed dosimeter was accomplished in 1996, and the dosimeter passed all performance tests (ANSI 1966).

Procedures that outline the QA/quality control (QC) protocols; placement and retrieval of the dosimeters; reading of the dosimeters; and data handling, validation and tabulation can be found in operating procedures maintained by the Laboratory's Air Quality Group.

4. Analytical Results

a. Laboratory and Regional Areas (TLDNET). Results from the environmental monitoring networks are presented in Table 4-11. Some of the TLD stations are lacking one or more quarters of data as a result of dosimeter loss, animals damage, processing error, removal requests by the public, as well as new station installation after the beginning of the monitoring year.

The dose equivalent ranges observed in 1996 within each network are consistent with natural background radiation and the 1995 measurements. Only one offsite regional station, Pueblo of Jemez (station #54), had a complete set of data in 1996 (i.e., data for each

quarterly monitoring period) and had an annual dose equivalent of 119 mrem without any background subtraction. The average quarterly dose equivalents at the other off-site regional stations ranged from 27 to 35 mrem, corresponding to an approximate annual dose equivalent of 108 to 140 mrem. The annual measurements at off-site perimeter stations having complete data sets ranged from 95 to 176 mrem. Annual measurements at on-site stations ranged from 111 to 241 mrem. The 241 mrem measurement observed at station #28 (TA-18) is not representative of a dose to a member of the public because it contains operational exposures when public access was restricted. (See Section 4.C.5.b for an estimate of the maximum dose equivalent to a member of the public from TA-18 operations.)

b. Technical Area 53 Network (LANSCENET). The TLD measurements collected at the 12 stations located directly to the north of LANSCE were statistically compared to the 12 background stations located at TA-49. During the fourth quarter of 1996, two elevated measurements were observed at two separate locations at East Gate, north of LANSCE. After a thorough investigation of these elevated measurements, which included evaluation of LANSCE emissions, air monitoring data, radiographer activities for county utilities and a review of internal QC, a specific source of exposure to yield these high measurements could not be identified. In addition, DOE's Agreement in Principle program has a duplicate monitoring station near one of these monitoring locations. Their dosimeter did not indicate any increase in the ambient dose equivalent for the fourth quarter 1996. It is possible, however unlikely, that an irradiated field fade or a QC dosimeter may have inadvertently been placed at these monitoring locations. The reason for these elevated readings is not known, but they do not represent a valid dose to the public. The effective dose equivalent (EDE) as measured at East Gate with these two values eliminated is at 168 ± 36.8 mrem; whereas the background as measured at TA-49 is 164 ± 20.4 mrem. There is no significant difference ($p>.05$) between these TLD measurements observed at East Gate and those observed at the background locations. If the two values remain, the EDE at East Gate increases to 184 ± 86.8 mrem with TA-49 value remaining the same. Even with the two higher readings remaining, there is still no significant difference ($p>.05$) between the TLD measurements observed at East Gate and those observed at the background locations.

c. Low-Level Radioactive Waste Management Areas Network (WASTENET). Annual doses at the waste management areas are presented in Table 4-12. Among the sites with a complete data set, the annual average doses at all waste management areas during 1996 ranged from 119 to 173 mrem. Exposure data for TA-6, Area F, are not available for first and second quarters of 1995 because extensive and detailed geophysical sampling and characterization of the site disrupted the monitoring program. The 1995 annual dose for TA-50, Area C, does not include second quarter measurements because the data were lost due to an equipment malfunction.

The highest WASTENET annual average dose for 1996 was measured at TA-54, Area G, LANL's only active low-level radioactive waste area. The 25 environmental surveillance TLDs at TA-54, Area G, are located within the waste site and along the perimeter fence. The doses measured at this site are representative of storage and disposal operations that occur at the facility. Evaluation of this data is useful in minimizing occupational doses. However, this is a controlled-access area and these measurements are not representative of a potential public dose. One monitoring site at TA-21, Area T had an elevated reading of 267 ± 10 mrem in 1996. This value is consistent with values observed at this location in the past and is attributed to cesium-137 on the ground at that location. Discussions on potential dose equivalent to a member of the public from this location are discussed in Section 4.C.5.b below.

5. Dose Equivalents to Individuals from External Penetrating Radiation

a. Airborne Emissions. The major source of external penetrating radiation to an off-site location from LANL operations is airborne emissions from LANSCE. Nuclear reactions with air in the beam target areas at LANSCE (TA-53) cause the formation of air activation products, principally carbon-10, carbon-11, nitrogen-13, oxygen-14, and oxygen-15. These radioisotopes are positron emitters and have 19-s, 20-min, 10-min, 71-s, and 122-s half-lives, respectively. These radioisotopes are sources of penetrating radiation resulting from the formation of two 511 keV photons through positron-electron annihilation (oxygen-14 also emits a 2.4-MeV gamma ray). These air activation products are primarily released from a 30-m stack, but an additional small percentage of the releases occur as diffuse emissions from LANSCE buildings. An HPIC, located near of the maximum exposed individual (MEI) along the Laboratory boundary known as East Gate, is normally used to record the total external penetrating dose from

LANSCE operations. However, the HPIC did not provide reliable data and is not used for dose estimates in 1996. Dose contributions from LANSCE emissions are not distinguishable from natural background radiation levels detected by the TLDNET monitoring locations at East Gate, in Los Alamos, or in White Rock. For an estimate of the dose equivalent from airborne emissions, see Section 3.A.4.

b. Direct Radiation. Because the background is so large and variable, no direct penetrating radiation dose to the public from Laboratory operations could be distinguished by direct TLD measurements in 1996. However, there are three areas of concern involving direct penetrating radiation: (1) experiments conducted at the Los Alamos Critical Experiments Facility, TA-18, (2) exposure to an inadvertent visitor along TA-21, Area T, and (3) exposure to an inadvertent visitor from cesium-137 in the sediments of Mortandad Canyon.

Measurements collected by TLDs at TA-18 reflect background and operational activities when there was no public access to the facility and do not represent a dose to the public. TA-18 administrative controls require operations to be conducted after hours with the closure of Pajarito Road from TA-51 to White Rock whenever the potential dose to a member of the public exceeds 1 mrem. During such operations, the roadside dosimeters at TA-18, intended to measure public dose, are usually removed. During 1996, there were three operations at TA-18 when the road was closed to the public and the dosimeters were not removed.

For TA-18, potential exposure is to users of Pajarito Road at times when low-level experiments are being conducted (the road is closed for higher level experiments). Because Laboratory controls prevent public members from remaining continuously in front of TA-18, the frequency and amount of time a public member may spend in the area of exposure was factored into the dose calculation through use of the binomial distribution. This distribution assumes that the individual is either present during an operation at TA-18 and receives an exposure, or the person is not present during an operation at TA-18. One calculates a probability factor that is coupled to the number of operations conducted at TA-18 in a year to determine the number of potential exposures an individual could receive during the year. The estimated maximum dose equivalent for each SHEBA assembly operation is based on radiation measurements taken before 1996; however, the estimated maximum dose equivalent for each GODIVA assembly operation is based on measurements collected during 1996. Two scenarios were developed to estimate this probability factor involving a person passing over the 0.5 mile length of the roadway during the year:

(1) An individual drives past the facility while it is operating 10 times a day for 250 days per year at 40 mph. This scenario yields a probability factor of 0.0156 (i.e., .5 miles per pass at 40 mph times 10 passes per day times 250 days per year divided by the number of operating hours of TA-18 (2000 h); and

(2) An individual jogs past the facility twice per day (i.e., down to the lagoons and back up the hill) for 250 days/yr. This yields a probability factor of 0.0427 (i.e., 1.5 mi jog in 30 min, 5 days/wk, 50 wk/yr, divided by the number of operating hours of TA-18).

The maximum dose equivalent to a member of the public, at the 95% level of confidence, from TA-18 operations in 1996 is 7 mrem (7% of the DOE PDL) using the driving scenario and 8 mrem (8% of the DOE PDL) using the jogger scenario. Because the jogger scenario has a larger probability factor for a potential exposure and the dose equivalent for this scenario was slightly larger, it was selected as the maximum potential dose equivalent from TA-18 operations in 1996. Applying this same process to the 1995 operations, the maximum potential dose equivalent in 1995 to a member of the public from TA-18 operations is 2 mrem (2% of the DOE PDL) using the driving scenario and 5 mrem (5% of the DOE PDL) using the jogger scenario.

TA-21, Area T, is located behind a control-access fence; however, an inadvertent individual could pass by this material disposal area while walking or jogging on the roadway around TA-21. Because there are no residential areas along DP road near TA-21, this area can be considered to be within the industrial complex of the Laboratory. Because of this, an occupancy factor of 0.01 can be applied to this continuous radiation source (Robinson and Thomas 1991). This brings the maximum potential dose equivalent to an inadvertent occupant to 2.9 mrem in a year at this location.

Mortandad Canyon has several radionuclides in the stream channel sediments that could potentially expose an inadvertent occupant (See Chapter 5 for a more detailed discussion). There are no dosimeters in Mortandad Canyon near GS-1, MCO-5, MCO-7 and MCO-9 where this contamination is the most prevalent. The scenario used to model the dose equivalent to an inadvertent occupant, has this individual walking or jogging down the middle of the stream channel approximately 87 hours per year (i.e., the occupancy factor in

the canyon is 0.01 part of a year [Robinson and Thomas 1991]). Using this scenario, the estimated external penetrating dose equivalent as modeled with RESRAD, version 5.61, is 24 mrem with the majority of this exposure from cesium-137 in the stream channel sediments of the canyon. This can be modified because the walking or jogging path from the middle stream channel is approximately 3 meters away. Because penetrating radiation falls off with distance from the source, the estimated EDE at 3 meters from the stream channel is estimated at 2.7 mrem in a year. This EDE must be added to the CEDE presented in Section 5.C.3.a to obtain an estimated total EDE (TEDE) of 6 mrem in a year.

D. Nonradioactive Emissions Monitoring

1. Introduction

Emissions from 'industrial' sources are calculated annually because these sources are responsible for over 90% of all the nonradiological air pollutant emissions at the Laboratory. Research sources vary continuously and have very low emissions. As such, they are not calculated annually; instead, each new or modified research source is addressed in the new source review process.

Ambient monitoring for nonradioactive air pollutants was limited to particulate matter sampling as discussed below.

2. Particulate Matter Sampling

PM-10 samples (particles less than 10 μm in aerodynamic diameter) were collected for two events during 1996: the Dome Fire from April 26 through May 2 and a controlled burn on Laboratory property in November. The Dome Fire samples were collected at the TA-49 air monitoring compound near the entrance to Bandelier National Monument. The controlled burn samples were collected downwind from the fire in the northwest part of Pajarito Acres.

During the Dome Fire, the PM-10 concentrations averaged 17 $\mu g/m^3$. This concentration is well below the federal PM-10 ambient air quality standards given in Table A-3 of this report. The highest one-day concentration was 32 $\mu g/m^3$ which is well below the federal standard of 150 $\mu g/m^3$. These concentrations are typical values for the dry windy conditions present during the Dome Fire. Even though the fire was close to the monitoring site, the winds during the Dome Fire generally dispersed the smoke away from the sampler.

PM-10 samples were collected before, during, and after the controlled burn. The measured concentrations both before and after the fire were 12 $\mu g/m^3$. The sample collected during the fire was 30 $\mu g/m^3$. These data indicate that the fire seemed to have a measurable impact on local air quality. However, this value, which indicates that the fire did temporarily increase PM-10 concentrations, is still well below the federal 24-h standard of 150 $\mu g/m^3$.

3. Detonation and Burning of Explosives

The Laboratory conducts explosive testing by detonating explosives at firing sites operated by the Dynamic Testing Division. The Laboratory maintains monthly shot records that include the type of explosives used as well as other material expended at each mound. Table 4-13 summarizes the explosives detonations conducted at the Laboratory during 1996. The Laboratory also burns scrap and waste explosives because of treatment requirements and safety concerns. In 1996, the Laboratory burned 3,482 lb of high explosives.

4. Emissions Calculations

The 1996 estimated emissions are shown in Table 4-14. These are typical industrial-type sources. LANL nonradiological emissions from research operations are small when compared with these listed sources.

The NO_x emissions from the TA-3 power plant were calculated using an emissions factor of 163 lb/million cubic feet (MMCF), which was obtained from a stack test and is adjusted for 20% uncertainty. The particulate matter emission factor of 5 lb/MMCF for the asphalt plant represents the maximum emission factor listed in AP-42 (EPA 1995). For volatile organic compounds, an emission factor of 1.4 was used, which is corrected for 17% methane as specified in AP-42. The emission factor for SO_x is 0.6 lb/MMCF, as specified in AP-42.

The three power plants, the largest sources of nonradioactive emissions, are used to supply steam for heating. The steam plant at TA-3 also produces electricity when sufficient power from outside sources is not available; approximately one-third of the emissions from this steam plant results from electricity production. The plants are primarily operated on natural gas but can use fuel oil as a backup.

E. Meteorological Monitoring

1. Introduction

Meteorological data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, and engineering studies. To accommodate the broad

demands for weather data at the Laboratory, a wide variety of meteorological variables are measured across the network, including wind, temperature, pressure, relative humidity and dew point, and solar and terrestrial radiation. Details of the meteorological monitoring program are available through the World Wide Web at *http://weather.lanl.gov/monplan/mmp96.html* and are discussed in Stone et al., (1996).

2. Climatology

Los Alamos has a temperate, semiarid mountain climate. However, its climate is strongly influenced by elevation, and large temperature and precipitation differences are observed in the area because of the 300-m change in elevation across the site.

Four distinct seasons occur in Los Alamos. Winters are generally mild, but occasionally winter storms dump large snows and cause frigid temperatures. Spring is the windiest season of the year. Summer is the rainy season, when afternoon convective-type thunderstorms and associated hail and lightning are common. Fall marks the end of the rainy season and a return to drier, cooler, and calmer weather. The climate statistics given below summarize analyses given in Bowen (1990 and 1992).

Several factors influence the temperature in Los Alamos. An elevation of 7,400 ft helps to counter its southerly location, making for cooler summers than nearby locations at lower elevations. The sloping nature of the Pajarito Plateau causes cooled air to drain off the plateau at night; thus, nighttime temperatures on the plateau are often warmer than those at lower elevations. Also, the Sangre de Cristo mountains to the east act as a barrier to arctic air masses affecting the central United States. The temperature does occasionally drop well below freezing, however. Another factor affecting the temperature is the lack of moisture in the atmosphere. With less moisture, there is less cloud cover, which allows a significant amount of solar heating during the daytime and radiative cooling during the nighttime. This heating and cooling often causes a wide range of daily temperature (the average diurnal temperature range is 13˚C).

Winter temperatures range from –1˚C to 10˚C (30˚F to 50˚F) during the daytime, to –9˚C to –4˚C (15˚F to 25˚F) during the nighttime. The record low temperature recorded is –28˚C (–18˚F). Winter is usually not particularly windy, so extreme wind chills are uncommon.

Summer temperatures range from 21˚C to 31˚C (70˚F to 88˚F) during the daytime, to 10˚C to 15˚C (50˚F to 59˚F) during the nighttime. Temperatures occasionally will break 32˚C (90˚F). The highest temperature ever recorded is 35˚C (95˚F).

The average annual precipitation (including both rain and water equivalent of frozen precipitation) is 47.57 cm (18.73 in.). The average snowfall for a year is 149.6 cm (58.9 in.). Freezing rain and sleet are rare.

Winter precipitation in Los Alamos is often caused by storms entering the US from the Pacific Ocean, or by cyclones forming or intensifying in the lee of the Rockies. When these storms cause upslope flow over Los Alamos, large snowfalls can occur. The record snowfall for one day is 56 cm (22 in.), and the record snowfall in one season is 389 cm (153 in.). The snow is usually a dry, fluffy powder, with an average equivalent water to snowfall ratio of 1:20.

The summer rainy season accounts for 37% of the annual precipitation. During the July to August period, afternoon thunderstorms form as a result of the flow of moist air from the Gulf of Mexico and from the Pacific Ocean, and because of convection and the orographic uplift as air flows up the sides of the Jemez mountains. These thunderstorms can bring large downpours, but sometimes they only cause strong winds and dangerous lightning. Hail frequently occurs from these rainy-season thunderstorms.

Winds in Los Alamos are also affected by the complex topography, particularly in the absence of a large-scale disturbance affecting the area. Often a distinct daily cycle of the winds can be seen. During the daytime, upslope flow sometimes exists on the Pajarito Plateau, causing an southeasterly component to the winds on the plateau (see Figure 4-13). During the nighttime, as the mountain slopes and plateau cool, the flow becomes downslope, causing light westerly and northwesterly flow (see Figure 4-14). Cyclones moving through the area disturb and override the cycle. Flow within the canyons of the Pajarito Plateau is quite complex and very different from flow over the plateau.

3. Monitoring Network

A meteorological network of five towers was used to gather data at the Laboratory during 1996 (see Fig. 13.1 in the Meteorological Monitoring Plan [Stone et al., 1996] or access through the World Wide Web at *http://weather.lanl.gov/monplan/mmp96.html*). A sodar (sonic detection and ranging) and three precipitation measurement sites also supplemented the data collected. The towers are located at TA-6 (the official measurement site of the Laboratory), TA-49, TA-53, TA-54, and TA-41 (located in Los Alamos Canyon). The sodar is located at TA-6, and the precipitation measurement sites are located at TA-74, North Community in the Los Alamos townsite, and TA-16.

4. Sampling Procedures, Data Management, and Quality Assurance

Instruments in the meteorological network are located in areas where there is adequate exposure to the elements being measured and in open fields to avoid wake effects from trees and buildings on measurements of wind and precipitation. The open fields also provide an unobstructed view of the sky for the upward-directed radiometers that measure longwave radiation and solar radiation.

Temperature and wind are measured at multiple levels on open-lattice towers, with instruments positioned on west-pointing booms having a length of two times the tower width. The length of the boom helps to decrease wake effects from the tower, as do the west-pointing direction of the booms, because winds from the east are uncommon. The multiple levels give duplicate measurements for QA. Temperature sensors are shielded and aspirated with small fans to minimize radiative heating effects.

Most of the meteorological variables are sampled every 3 s, and the results are averaged every 15 min to give a sample size of 300 (for each of the 15-min periods). The data are stored by data loggers located at the tower sites and then fed to a Hewlett Packard worstation through telephone lines. At the workstation, automatic range checking is performed on the data, and data edits are automatically performed on variables falling outside of preset ranges. Next, time-series plots are constructed. These plots are used by a meteorologist to perform quality checking on the data. Daily statistical quantities are also included on the time-series plots (such as daily maximum and minimum temperature, total solar radiation, maximum wind gust, etc.) and are also checked for quality.

All meteorological instruments are audited twice a year. An internal audit is performed in the winter, and an external audit is conducted during the summer. All instrument calibrations are traceable to the National Institute of Standards and Technology standards. No significant problems were found during either audit in 1996 (Waldron 1996).

5. Analytical Results

A graphical summary of the weather at Los Alamos (TA-6) for 1996 is presented in Figure 4-15. This figure shows the average temperature range and precipitation by month, compared with the normals, which are averages based on a 30-year record (1961 to 1990). From this figure it can be seen that from January through June, temperatures were warmer than normal. May was unusually warm. The average temperature in May was 62.9˚F, which set a new record for the warmest May on record. Temperatures in July through December were near normal to below normal. For the year, temperatures were warmer than normal.

The total precipitation for the year was 95% of normal. Only 0.52 in. of precipitation fell during the spring (March to May), making it the driest spring on record. This dry spell was followed by a June precipitation total three times the normal amount, making it the fifth wettest June on record. October was also a wet month, with a total of more than two and a half times the normal value. December was quite dry, with only 0.09 in. of precipitation being recorded, or 8% of normal. The annual snowfall in 1996 was 57.6 in., which is 97% of normal. Spring snowfall totals were very low, but 21.2 in. of snow fell in October, setting a monthly snowfall record. Only 10% of normal snowfall fell during December. Precipitation data for 1996 for all recording sites are listed in Table 4-15.

Wind statistics based on 15-min average wind observations at the four towers on the Pajarito Plateau are shown in the form of wind roses Figures 4-13, 4-14, and 4-16. Wind roses show the percentage of the time the wind blows from each of 16 different wind directions. Also shown in the wind roses are the distributions of wind speed for each of the 16 directions; these are displayed by the shading of the wind rose barbs, as shown in the legend. For example, at TA-49 (Figure 4-13), the most frequent wind direction during the daytime is from the south, which occurs 18% of the time. The wind speed for that direction is most often in the 2.5 to 5.0 m/s category, followed by the 5.0 to 7.5 m/s category, the 0.5 to 2.5 m/s category, and the 7.5 + m/s category. Winds were calm 0.8% of the time at TA-49 during the daytime in 1996.

During the daytime (Figure 4-13), winds were predominately southerly at all four towers. Looking at the nighttime wind roses (Figure 4-14), it can be seen that the winds were more westerly and northwesterly, and that the winds are generally weaker. Wind roses for all times are given in Figure 4-16.

F. Quality Assurance Program in the Air Quality Group

1. Quality Assurance Program Development

During 1996, ESH-17 continued to maintain and to improve upon the QA program developed in recent years. This program includes a group quality management plan, project plans, and implementing procedures. QA plans for sampling systems follow the EPA QA-R/5 data quality objective process. Required elements of DOE QA programs are incorporated.

Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that ESH-17 processes perform satisfactorily. The following highlights of 1996 accomplishments are presented to demonstrate the vitality of the QA Program in the ESH-17, Air Quality Group.

Component:	Highlights
Documentation:	At the end of 1996, the ESH-17 QA document system included 8 QA Plans and 43 procedures, which are reviewed periodically to see if revision is needed. Of the plans, one was a new issue, and five QA Plans were updated. Of the 43 procedures, 16 were new procedures, and 13 were revised.
Distribution:	At the end of 1996, 40 persons had been issued QA binders with multiple plans and procedures. An additional 13 persons held 1 or more procedures or plans. Distribution details are maintained in a log by the custodian.
Training:	During 1996, ESH-17 implemented a computerized training database, which is maintained by the group training coordinator. Training plans are documented, training is logged as completed, and reminders are issued. Statistics compiled late in the year indicated that approximately 6 persons were trained to each plan or procedure, and the average person has completed training to 7 plans or procedures.
Assessments:	DOE completed an assessment of the Rad-NESHAP program and LANL considers itself in compliance with the Clean Air Act as of June of 1996. A management self-assessment was completed as an informal survey in October. The group leader used the information to improve the group management. In October, the Federal Facilities Compliance Agreement-required external assessment of Rad-NESHAP management systems was completed by a team from Northern Arizona University College of Engineering and Institute for Tribal Environmental Professionals. There were no findings. Responses or action plans have been written for the 8 recommendations made by the audit team and sent to DOE for EPA approval. An internal assessment of the group was conducted by a contractor employee in late 1996. The assessment evaluated the compliance with 40 CFR 61, Subpart H (Rad-NESHAP) and found the group in full compliance with the regulation. Several opportunities for improvement were identified. During 1996, ESH-17 teams (led by an ISO-9000 Certified Lead Assessor) performed assessments of the 3 laboratories that supply analytical data. One was a follow-up visit to verify that recommended improvements had been completed. After the visits, assessment reports were written that included quality improvement needs.
Quality Improvement:	The ESH-17 quality improvement system includes a computerized database used to track findings from internal and external assessments, and any equipment or process breakdowns that affect quality. In 1996, 49 reports of such deficiencies were made and 30 were closed out and verified.

2. Analytical Laboratory Assessments

During 1996, gross alpha, gross beta, and tritium analytical chemistry services were supplied by the Laboratory's HPAL. Analytical chemistry services for alpha-emitting isotopes (uranium, plutonium, and americium) on quarterly composite samples were provided by the Grand Junction Rust-GeoTech (now Wastran—Grand Junction) Project Office (GJPO) of Grand Junction, Colorado. Application of the data quality objective (DQO) process led to definition of analytical chemistry DQOs. These DQOs were summarized as purchase requirements in statements of work used for procurement of chemical analyses from the commercial laboratories. Before awarding the purchases, ESH-17 evaluated the lab procedures, quality plans, and national performance evaluation program results of these suppliers and found that they met purchase requirements. ESH-17 also performed formal on-site assessments at the Grand Junction and HPAL laboratories during 1996 and a follow-up reassessment at Paragon (formerly ATI). Quality control aspects of the analytical chemistry will be presented in later sections of this document.

Both Paragon and the Grand Junction analytical laboratory participated in national performance evaluation studies during 1996. Two federal agencies, EPA and DOE, sponsor intercomparison studies: the EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada, and the DOE Environmental Measurements Laboratory in New York, New York. The DOE laboratory sends spiked air filters twice a year to the participating laboratories. The EPA

laboratory sends one type of spiked media from one to three times a year that is of interest to ESH-17's QA program.

G. Special Studies

1. Comparison of Thermoluminescent Dosimeters

A special intercomparison study initiated in 1990 to compare results of the Laboratory's TLDs with TLDs obtained from a commercial vendor was concluded in 1996. Because the newly designed dosimeter passed the ANSI N545-1975 tests and performed well in the Eleventh International Intercom-parison for Environmental Dosimeter, the Laboratory did not feel the need to continue this intercomparison study. Intercomparisons are still being conducted with the New Mexico Environment Department (NMED) DOE Oversight Bureau that has duplicate dosimeters placed at select locations near Laboratory dosimeters (NMED 1997).

2. Eleventh International Intercomparison of Environmental Dosimeters

LANL participated in the Eleventh International Intercomparison of Environmental Dosimeters coordinated by the Environmental Measurements Laboratory (EML), US Department of Energy, in collaboration with the National Institute of Standards & Technology and Idaho State University. The purpose of the intercomparison program is to assess the performance of environmental dosimeters by comparing the overall distribution of results with reference measurements of the delivered doses and generally accepted performance standards. At the same time, this program furthers research in environmental dosimetry by giving participants an opportunity to evaluate their own performance or to test new dosimeters, and by incorporating special conditions designed to investigate problems associated with environmental dosimetry. It also provides useful data for performance standards under development. For the Eleventh International Intercomparison, participants submitted dosimeters for a three-month field test and for irradiations to americium-241 and cesium-137 in the laboratory.

Three dosimeters (1/4-in. LiF, 1/8-in. LiF, and Al_2O_3 dosimeters) used at various times for environmental monitoring at the Laboratory were submitted for this intercomparison. The results for the dosimeters containing the 1/4-in. TLD-100 chips was –25% for the field exposure, –28% for the americium-241 exposure, and –30% for the cesium-137 exposure. The new dosimeters with the 1/8 in. TLD-100 chips were –6%, –5% and –12% respectively. The Al_2O_3 dosimeter response was +7%, +58%, and +6%, respectively. The negative values indicate an under response, and positive values indicate an over response. The intercomparison confirmed much of what was suspected: the 1/4-in. TLD response was not as accurate as the newly designed 1/8-in. dosimeter. The newly designed dosimeters have a slight negative bias in their response when compared to an HPIC, and the Al_2O_3 dosimeter is not acceptable for environmental monitoring, especially because of their over response to the americium-241 exposure.

3. Performance Evaluation of Los Alamos National Laboratory's Environmental Dosimeter

The Laboratory's environmental dosimeter was tested against specific portions of the ANSI N545-1975 standard for environmental TLD applications. The dosimeters were evaluated for uniformity, reproducibility, energy response, angular response, light dependence, moisture dependence, an evaluation of the field fade, self-irradiation, lower limit of detection, and neutron response. In addition, before placing dosimeters in the field population, each dosimeter was evaluated against a stringent testing and acceptance process. Those dosimeters failing this acceptance testing were eliminated from the general field population. This field population was subjected to the performance testing protocols outlined in ANSI N545-1975. The newly designed environmental dosimeters satisfy all of the ANSI N545-1975 performance requirements for environmental radiation monitoring (Archuleta 1997).

4. Neighborhood Environmental Watch Network Community Monitoring Stations

NEWNET is a LANL Dynamic Experiment Division program focused on establishing a partnership with communities, state and tribal governments, and the DOE to address concerns about radiological monitoring in local communities. It establishes meteorological and external penetrating radiation monitoring stations in local communities and around radiological sources. These stations are the responsibility of a station manager from the local community. The stations have a local readout, and the data can be downloaded into a personal computer at the station if this process is coordinated with the station manager.

The data from these stations are transmitted via satellite communications to a downlink station at LANL. The data are converted to engineering units, checked and annotated for transmission errors or station problems, and stored in a public access database.

The data from all the stations are available to the public with, at most, a 24-h delay. Methods to decrease this period to near real time are being developed.

Station measurements include wind speed and wind direction, ambient temperature, relative humidity, barometric temperature, and gross gamma radiation using a pressurized ion chamber. The radiation sensors are sampled at 5-s intervals and averaged every 15 min. These values are transmitted every 4 h.

More information about NEWNET and the data is available on the World Wide Web at *http://newnet.jdola.lanl.gov/newnet.html*.

5. Compliance Program for 40 CFR 61, Subpart H, at Los Alamos National Laboratory

Effective on March 15, 1990, EPA established regulations controlling the emission of radionuclides to the air from DOE facilities to limit the dose to the public to 10 mrem/yr. These regulations are detailed in 40 CFR 61, Subpart H (EPA 1993). Part of these regulations require the operation of sampling systems on stacks meeting certain requirements. Although LANL has a long history of stack sampling, the systems in place at the time the regulation became effective did not meet the specific design requirements of the new regulation. In addition, certain specific program elements did not exist or were not adequately documented.

LANL has undertaken a major effort to upgrade its compliance program to meet these EPA requirements. This effort involved developing new and technically superior sampling methods and obtaining approval from the EPA for their use; negotiating specific methodologies with the EPA to implement certain requirements of the regulation; implementing a complete, quality assured, compliance program; and upgrading sampling systems. After several years of effort, the Laboratory sampling on stack emissions now meets all requirements of 40 CFR 61, Subpart H.

6. 1996 Los Alamos National Laboratory Radionuclide Air Emissions, Environmental Protection Agency Reporting

Information on radioactive effluents released to the air by the Laboratory is published in the DOE certified report "1996 LANL Radionuclide Air Emissions." This information is required under the Clean Air Act and is reported to the EPA. The EDE to a hypothetical MEI of the public was calculated, using procedures specified by the EPA and described in this report. That dose for 1996 was 1.93 mrem. Emissions of carbon-11, nitrogen-11, and oxygen-15 from a 1-mA, 800-MeV proton accelerator contributed over 92% of the EDE to LANL's MEI. Using CAP88, EPA's dose assessment model, more than 86% of the total dose received by the MEI was through the air immersion pathway.

H. Tables

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

	Units	Santa Fe (EPA)[a] 1990–1995	Northern New Mexico (LANL)[b] 1996	EPA Concentration Limit[c]
Gross Alpha	fCi/m^3	NA[d]	0.8	NA
Gross Beta	fCi/m^3	10	10.2	NA
^{234}U	aCi/m^3	14	35.6	7,700
^{235}U	aCi/m^3	0.6	2.2	7,100
^{238}U	aCi/m^3	13	24.7	8,300
^{238}Pu	aCi/m^3	0.2	0.1	2,100
$^{239,240}Pu$	aCi/m^3	0.3	0.7	2,000
Tritium	pCi/m^3	NA	0.3	1,500
^{241}Am	aCi/m^3	NA	2.1	1,900

[a] EPA (1991–1997), Reports 63 through 82. Data are from the EPA Santa Fe, New Mexico, sampling location and were taken from July 1990 through July 1995. Data for 1996 were not available at time of publication.
[b] Data from regional air sampling stations operated by LANL at Santa Fe, Pojoaque, and Española.
[c] Each EPA limit equals 10 mrem/yr.
[d] NA = not available.

Table 4-2. Airborne Long-Lived Gross Alpha Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s (fCi/m^3)
Regional Stations						
01 Española	26	0	2.8	0.2	0.9	1.2
02 Pojoaque	26	0	2.8	0.5	0.8	0.9
03 Santa Fe	26	0	2.7	0.3	0.8	1.1
Group Summary	78	0	2.8	0.2	0.8	0.0[a]
Pueblo Stations						
41 San Ildefonso Pueblo	26	0	3.4	0.3	0.8	1.1
42 Taos Pueblo	26	0	1.5	0.3	0.7	0.6
48 Jemez Pueblo-Riverside	26	0	2.0	0.2	0.7	0.7
Group Summary	78	0	3.4	0.2	0.7	0.1[a]
Perimeter Stations						
04 Barranca School	26	0	2.6	0.3	0.8	0.9
05 Urban Park	26	1	3.2	0.3	0.8	1.2
06 48th Street	26	2	1.4	0.3	0.6	0.6
07 Gulf/Exxon/Shell Station	26	1	4.6	0.2	1.0	1.7
08 McDonalds Restaurant	25	2	3.3	0.1	0.8	1.2
09 Los Alamos Airport	25	0	2.1	0.4	0.8	0.7
10 East Gate	26	3	4.4	0.0	0.8	1.7
11 Well PM-1 (E. Jemez Road)	26	1	2.2	0.2	0.7	0.8
12 Royal Crest Trailer Court	26	0	1.8	0.3	0.7	0.7
13 Piñon School	26	1	5.3	0.2	0.9	2.1
14 Pajarito Acres	24	2	2.9	0.2	0.7	1.0
15 White Rock Fire Station	25	0	4.0	0.3	1.0	1.6
16 White Rock Church of the Nazarene	26	1	1.2	0.2	0.7	0.6
17 Bandelier Entrance (Lookout) (Rim)	26	2	4.2	0.2	0.9	1.5
60 LA Canyon	26	1	1.7	0.2	0.7	0.6
61 LA Hospital	26	0	1.5	0.5	0.9	0.6
62 Trinity Bible Church	25	0	1.8	0.3	0.8	0.6
63 Monte Rey South	25	0	2.7	0.3	0.8	0.9
Group Summary	461	17	5.3	0.0	0.8	0.2[a]
On-Site Stations						
19 TA-21 DP Site	2	0	2.0	1.7	1.9	0.5
20 TA-21 Area B	26	0	2.7	0.3	0.9	0.9
21 TA-6	2	0	1.5	1.0	1.3	0.6
22 TA-53	2	0	1.5	0.8	1.1	0.9
23 TA-52 Beta Site	26	0	1.8	0.4	0.7	0.5
25 TA-16-450	26	0	1.3	0.3	0.6	0.5
26 TA-49	25	1	1.3	0.2	0.8	0.6
28 TA-33 HP Site	2	0	1.5	0.9	1.2	0.8
30 Pajarito Booster 2 (P-2)	26	2	3.8	0.1	1.0	1.4
31 TA-3	26	1	1.7	0.1	0.8	0.7
32 County Landfill	27	1	2.8	0.2	0.7	1.0
49 Pajarito Rd (TA-36) Sludge Pond	26	1	2.0	0.3	0.7	0.7
Group Summary	216	6	3.8	0.1	1.0	0.7[a]

Table 4-2. Airborne Long-Lived Gross Alpha Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s (fCi/m^3)
Area G Stations						
27 TA-54 Area G (by QA)	26	0	3.1	0.8	1.5	1.2
34 TA-54 Area G-1 (behind trailer)	26	0	1.7	0.3	0.8	0.6
35 TA-54 Area G-2 (back fence)	25	1	1.4	0.3	0.7	0.6
36 TA-54 Area G-3 (by office)	26	0	2.1	0.5	0.9	0.6
37 TA-54 Area G-4 (water tank)	20	1	1.7	0.2	0.8	0.6
45 Area G (Southeast Perimeter)	26	2	2.0	0.0	0.7	0.8
47 Area G (North Perimeter)	22	1	1.7	0.2	0.7	0.7
50 TA-54 Area G	26	0	2.4	0.4	0.8	0.8
51 TA-54 Area G	26	0	2.6	0.2	0.9	0.8
Group Summary	223	5	3.1	0.0	0.9	0.5[a]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	26	0	2.0	0.4	0.8	0.7
72 TA-21.02 (N Bldg. 344)	23	0	1.8	0.3	0.8	0.6
73 TA-21.03 (NE Bldg. 344)	25	1	2.3	0.0	0.7	0.9
74 TA-21.04 (SE Bldg. 344)	25	1	1.6	0.1	0.7	0.7
75 TA-21.05 (S Bldg. 344)	25	0	2.0	0.3	0.8	0.7
Group Summary	124	2	2.3	0.0	0.8	0.1[a]
TA-15 Firing Sites						
76 TA-15-NNW	25	0	1.3	0.2	0.6	0.5
77 TA-15-NNE	24	3	1.4	0.1	0.6	0.6
78 TA-15-N	26	2	5.1	0.2	0.9	2.5
Group Summary	75	5	5.1	0.1	0.7	0.4[a]

Concentration Guidelines are not available for gross alpha concentrations.

[a]This is two times the standard deviation of the mean value for the group.

Table 4-3. Airborne Long-Lived Gross Beta Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s (fCi/m^3)
Regional Stations						
01 Española	26	0	19.1	4.0	11.4	6.2
02 Pojoaque	26	0	15.2	3.5	10.2	6.2
03 Santa Fe	26	0	15.9	1.7	8.9	7.5
Group Summary	78	0	19.1	1.7	10.2	2.5[a]
Pueblo Stations						
41 San Ildefonso Pueblo	26	0	19.2	4.1	10.5	5.7
42 Taos Pueblo	26	0	16.1	5.8	10.5	5.4
48 Jemez Pueblo-Riverside	26	0	15.1	3.5	9.4	6.6
Group Summary	78	0	19.2	3.5	10.2	1.3[a]
Perimeter Stations						
04 Barranca School	26	0	19.3	2.5	10.4	6.3
05 Urban Park	26	2	17.0	1.4	9.0	6.1
06 48th Street	26	0	15.8	3.0	9.6	5.6
07 Gulf/Exxon/Shell Station	26	0	18.1	2.9	11.8	6.8
08 McDonalds Restaurant	26	2	19.4	1.1	9.8	7.3
09 Los Alamos Airport	26	0	19.3	3.5	10.9	6.3
10 East Gate	26	0	17.6	2.5	10.7	6.0
11 Well PM-1 (E. Jemez Road)	26	0	17.5	3.4	9.9	6.0
12 Royal Crest Trailer Court	26	0	16.5	2.0	9.5	5.6
13 Piñon School	26	0	19.1	3.5	10.3	6.5
14 Pajarito Acres	24	0	16.0	2.1	9.7	5.9
15 White Rock Fire Station	25	0	17.9	2.3	9.9	6.5
16 White Rock Church of the Nazarene	26	0	17.6	2.6	11.7	6.9
17 Bandelier Entrance (Lookout) (Rim)	26	0	20.2	3.8	12.0	6.4
60 LA Canyon	26	0	17.2	4.5	10.4	5.9
61 LA Hospital	26	0	22.4	4.9	12.4	7.9
62 Trinity Bible Church	25	0	19.9	4.0	10.8	6.6
63 Monte Rey South	25	0	20.8	5.1	11.9	7.7
Group Summary	463	4	22.4	1.1	10.6	2.0[a]
On-Site Stations						
19 TA-21 DP Site	2	0	7.3	3.6	5.4	5.3
20 TA-21 Area B	26	0	17.9	3.2	10.6	5.9
21 TA-6	2	0	3.5	2.2	2.9	1.9
22 TA-53	2	0	7.0	3.7	5.4	4.7
23 TA-52 Beta Site	26	0	17.5	3.1	9.9	5.9
25 TA-16-450	26	0	18.9	2.5	10.3	6.7
26 TA-49	26	0	15.1	2.8	10.7	6.1
28 TA-33 HP Site	2	0	7.5	2.3	4.9	7.3
30 Pajarito Booster 2 (P-2)	26	0	18.7	5.9	12.2	6.9
31 TA-3	26	0	22.8	2.3	10.3	9.2
32 County Landfill	27	0	43.9	2.9	10.8	14.1
49 Pajarito Rd (TA-36) Sludge Pond	26	0	21.1	4.0	11.9	6.7
Group Summary	217	0	43.9	2.2	8.8	6.4[a]

Table 4-3. Airborne Long-Lived Gross Beta Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s (fCi/m^3)
Area G Stations						
27 TA-54 Area G (by QA)	26	0	18.2	3.4	9.8	6.0
34 TA-54 Area G-1 (behind trailer)	26	0	17.5	4.2	10.5	5.1
35 TA-54 Area G-2 (back fence)	25	0	19.0	2.5	10.0	6.4
36 TA-54 Area G-3 (by office)	26	0	18.7	3.6	10.6	5.9
37 TA-54 Area G-4 (water tank)	20	0	18.7	2.4	10.0	6.6
45 Area G (Southeast Perimeter)	26	0	18.3	3.4	10.0	5.8
47 Area G (North Perimeter)	22	0	19.8	2.5	10.7	6.8
50 TA-54 Area G	26	0	17.4	2.3	9.6	6.7
51 TA-54 Area G	26	0	19.3	3.8	11.1	6.3
Group Summary	223	0	19.8	2.3	10.2	1.0[a]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	26	0	22.0	2.1	11.1	7.5
72 TA-21.02 (N Bldg. 344)	23	0	18.2	5.1	9.9	5.9
73 TA-21.03 (NE Bldg. 344)	25	0	18.8	5.2	10.6	5.7
74 TA-21.04 (SE Bldg. 344)	25	0	20.8	4.2	11.0	6.0
75 TA-21.05 (S Bldg. 344)	25	0	19.0	4.1	11.3	6.2
Group Summary	124	0	22.0	2.1	10.8	1.1[a]
TA-15 Firing Sites						
76 TA-15-NNW	25	0	17.2	3.6	10.2	5.8
77 TA-15-NNE	24	0	19.2	4.6	11.2	6.4
78 TA-15-N	26	0	15.5	3.0	10.1	5.9
Group Summary	75	0	19.2	3.0	10.5	1.2[a]

Concentration Guidelines are not available for gross beta concentrations.

[a]This is two times the standard deviation of the mean value for the group.

Table 4-4. Airborne Tritium as Tritiated Water Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	2s (pCi/m^3)
Regional Stations						
01 Española	26	21	11.0	–1.1[a]	0.8	4.7
02 Pojoaque	26	20	2.0	–1.7	0.3	1.6
03 Santa Fe	26	23	1.0	–1.3	0.0	1.1
Group Summary	78	64	11.0	–1.7	0.3	0.8[b]
Pueblo Stations						
41 San Ildefonso Pueblo	26	16	1.9	–0.4	0.5	1.1
42 Taos Pueblo	24	20	1.5	–0.3	0.3	0.8
48 Jemez Pueblo-Riverside	26	18	2.7	–0.8	0.4	1.5
Group Summary	76	54	2.7	–0.8	0.4	0.1[b]
Perimeter Stations						
04 Barranca School	26	19	3.4	–0.5	0.6	1.7
05 Urban Park	26	22	1.8	–1.1	0.2	1.3
06 48th Street	26	16	1.9	–0.3	0.5	1.1
07 Gulf/Exxon/Shell Station	26	15	2.7	–0.2	0.8	1.4
08 McDonalds Restaurant	26	7	7.5	–0.0	2.2	3.4
09 Los Alamos Airport	24	6	3.4	–0.4	1.4	1.7
10 East Gate	26	2	3.5	0.5	1.8	1.7
11 Well PM-1 (E. Jemez Road)	26	12	2.6	–0.6	0.9	1.9
12 Royal Crest Trailer Court	26	9	15.0	–0.6	1.5	5.7
13 Piñon School	26	10	5.4	–0.5	1.8	2.8
14 Pajarito Acres	25	11	6.5	–0.6	0.9	2.6
15 White Rock Fire Station	25	12	4.6	–0.1	1.2	2.3
16 White Rock Church of the Nazarene	26	5	5.7	0.3	2.2	2.7
17 Bandelier Entrance (Lookout) (Rim)	26	14	7.3	–0.6	1.1	3.1
60 LA Canyon	26	6	4.9	–0.2	1.7	2.5
61 LA Hospital	26	17	5.5	–0.7	1.1	2.7
62 Trinity Bible Church	26	11	12.4	–0.3	1.6	5.3
63 Monte Rey South	26	14	4.1	–0.9	1.0	2.5
Group Summary	459	208	15.0	–1.1	1.3	1.2[b]
On-Site Stations						
19 TA-21 DP Site	2	0	4.4	4.3	4.4	0.1
20 TA-21 Area B	26	5	4.5	0.4	1.8	2.0
21 TA-6	2	2	0.4	–0.4	0.0	1.2
22 TA-53	2	1	1.7	–0.2	0.8	2.6
23 TA-52 Beta Site	26	10	3.0	–1.1	1.1	1.8
25 TA-16-450	26	0	49.7	10.6	23.8	20.6
26 TA-49	26	11	9.1	–0.8	1.7	4.0
28 TA-33 HP Site	2	1	2.5	0.3	1.4	3.2
30 Pajarito Booster 2 (P-2)	26	14	13.6	–0.2	1.3	5.2
31 TA-3	26	7	3.2	0.3	1.3	1.5
32 County Landfill	27	12	6.9	0.0	1.3	2.8
49 Pajarito Rd (TA-36) Sludge Pond	26	13	7.5	–0.2	1.4	3.9
Group Summary	217	76	49.7	–1.1	3.4	13.0[b]

Table 4-4. Airborne Tritium as Tritiated Water Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	2s (pCi/m^3)
TA-54, Area G	21	1	57.6	1.7	18.4	31.2
27 TA-54 Area G (by QA)	26	0	52.3	3.2	18.5	26.2
34 TA-54 Area G-1 (behind trailer)	25	1	20.2	0.6	7.4	10.9
35 TA-54 Area G-2 (back fence)	25	0	1167.1	93.0	400.3	688.2
36 TA-54 Area G-3 (by office)	26	3	7.2	0.0	2.4	3.3
37 TA-54 Area G-4 (water tank)	20	0	12.6	1.1	5.5	5.8
45 Area G (Southeast Perimeter)	26	1	20.3	–0.6	7.7	9.1
47 Area G (North Perimeter)	20	1	28.3	0.7	12.2	18.0
50 TA-54 Area G	26	3	15.9	0.5	5.6	8.3
51 TA-54 Area G	26	6	7.5	0.3	2.6	3.3
Group Summary	220	15	1167.1	–0.6	51.4	261.9[b]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	25	4	5.1	–0.1	2.1	2.7
72 TA-21.02 (N Bldg. 344)	24	3	7.2	0.5	2.3	3.2
73 TA-21.03 (NE Bldg. 344)	26	0	12.5	1.0	4.0	5.5
74 TA-21.04 (SE Bldg. 344)	26	2	11.3	0.1	3.6	4.6
75 TA-21.05 (S Bldg. 344)	26	2	8.8	0.8	3.6	3.7
Group Summary	127	11	12.5	–0.1	3.1	1.8[b]
TA-15 Firing Sites						
76 TA-15-NNW	26	14	8.9	–0.8	1.3	4.0
77 TA-15-NNE	26	17	4.8	–1.4	0.8	2.5
78 TA-15-N	26	15	6.8	–0.6	0.9	2.8
Group Summary	78	46	8.9	–1.4	1.0	0.6[b]

Concentration Guidelines
Controlled Area DOE Derived Air Concentration Guide 20,000,000 pCi/m^3. See Appendix A.
Uncontrolled Area DOE Derived Air Concentration Guide 100,000 pCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 1,500 pCi/m^3.

[a] See Appendix B for an explanation of the presence of negative numbers.
[b] This is two times the standard deviation of the mean value for the group.

Table 4-5. Airborne Plutonium-238 Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Regional Stations						
01 Española	4	4	0.3	–0.4[a]	–0.1	0.3
02 Pojoaque	4	4	0.3	–0.2	0.0	0.2
03 Santa Fe	4	3	0.6	0.0	0.4	0.3
Group Summary	12	11	0.6	–0.4	0.1	0.5[b]
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	0.5	0.0	0.2	0.2
42 Taos Pueblo	4	3	1.2	–0.5	0.1	0.7
48 Jemez Pueblo-Riverside	4	4	0.7	–0.1	0.3	0.4
Group Summary	12	11	1.2	–0.5	0.2	0.1[b]
Perimeter Stations						
04 Barranca School	4	4	0.0	–0.3	–0.1	0.2
05 Urban Park	4	2	1.7	–0.3	0.7	0.8
06 48th Street	4	4	0.3	–0.6	–0.1	0.4
07 Gulf/Exxon/Shell Station	4	4	1.0	–0.5	0.3	0.7
08 McDonalds Restaurant	4	4	0.6	–0.3	0.1	0.5
09 Los Alamos Airport	4	4	0.2	0.0	0.2	0.1
10 East Gate	4	4	0.3	–0.1	0.1	0.2
11 Well PM-1 (E. Jemez Road)	4	4	0.4	–0.2	0.1	0.3
12 Royal Crest Trailer Court	4	3	2.8	0.1	1.0	1.2
13 Piñon School	4	3	0.7	–0.2	0.1	0.4
14 Pajarito Acres	4	4	0.1	–0.4	–0.2	0.2
15 White Rock Fire Station	4	4	0.5	–0.1	0.3	0.2
16 White Rock Church of the Nazarene	4	4	0.1	–0.5	–0.2	0.3
17 Bandelier Entrance (Lookout) (Rim)	4	4	0.2	–0.7	–0.1	0.4
60 LA Canyon	4	4	0.9	0.0	0.2	0.4
61 LA Hospital	4	3	1.5	–0.1	0.4	0.7
62 Trinity Bible Church	4	4	0.3	0.1	0.2	0.1
63 Monte Rey South	4	4	0.1	–0.1	0.0	0.1
Group Summary	72	67	2.8	–0.7	0.2	0.6[b]
On-Site Stations						
20 TA-21 Area B	4	3	1.2	0.1	0.6	0.5
23 TA-52 Beta Site	4	3	0.5	0.1	0.3	0.2
25 TA-16-450	4	4	0.4	–0.2	0.1	0.3
26 TA-49	4	3	1.2	0.2	0.6	0.4
30 Pajarito Booster 2 (P-2)	4	2	6.8	0.1	2.1	3.2
31 TA-3	4	2	5.2	0.1	1.7	2.4
32 County Landfill	4	3	3.0	–0.1	0.9	1.4
49 Pajarito Rd (TA-36) Sludge Pond	4	4	0.4	–0.1	0.2	0.2
Group Summary	32	24	6.8	–0.2	0.8	1.5[b]

Table 4-5. Airborne Plutonium-238 Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Area G Stations						
27 TA-54 Area G (by QA)	4	0	26.1	4.9	19.8	10.0
34 TA-54 Area G-1 (behind trailer)	4	2	3.7	0.2	1.8	1.6
35 TA-54 Area G-2 (back fence)	4	3	0.7	–0.1	0.2	0.4
36 TA-54 Area G-3 (by office)	4	4	0.7	0.0	0.3	0.3
37 TA-54 Area G-4 (water tank)	2	2	0.1	–0.3	–0.1	0.3
45 Area G (Southeast Perimeter)	4	4	0.4	–0.3	0.1	0.3
47 Area G (North Perimeter)	4	4	0.9	0.0	0.3	0.4
50 TA-54 Area G	4	3	0.7	0.3	0.5	0.2
51 TA-54 Area G	4	3	2.2	–0.3	0.8	1.0
Group Summary	34	25	26.1	–0.3	2.6	12.9[b]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	4	3	1.2	–0.6	0.4	0.8
72 TA-21.02 (N Bldg. 344)	4	1	33.2	1.0	11.2	14.9
73 TA-21.03 (NE Bldg. 344)	4	0	52.0	2.1	15.9	24.1
74 TA-21.04 (SE Bldg. 344)	4	2	6.3	0.7	2.2	2.7
75 TA-21.05 (S Bldg. 344)	4	2	8.6	0.8	3.0	3.7
Group Summary	20	8	52.0	–0.6	6.5	13.3[b]
TA-15 Firing Sites						
76 TA-15-NNW	4	3	2.2	–0.2	0.5	1.1
77 TA-15-NNE	4	4	0.2	–0.1	0.0	0.1
78 TA-15-N	4	4	0.3	–0.6	–0.0	0.4
Group Summary	12	11	2.2	–0.6	0.2	0.6[b]

Concentration Guidelines
Controlled Area DOE Derived Air Concentration Guide 3,000,000 aCi/m^3. See Appendix A.
Uncontrolled Area DOE Derived Air Concentration Guide 30,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 2,100 aCi/m^3.

[a] See Appendix B for an explanation of the presence of negative numbers.
[b] This is two times the standard deviation of the mean value for the group.

Table 4-6. Airborne Plutonium-239 Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Regional Stations						
01 Española	4	3	1.1	–0.4[a]	0.6	0.7
02 Pojoaque	4	4	0.7	–0.3	0.2	0.4
03 Santa Fe	4	3	2.2	0.4	1.2	0.8
Group Summary	12	10	2.2	–0.4	0.7	1.0[b]
Pueblo Stations						
41 San Ildefonso Pueblo	4	3	1.4	0.2	0.6	0.5
42 Taos Pueblo	4	4	1.6	–0.2	0.9	0.8
48 Jemez Pueblo-Riverside	4	3	1.7	0.4	1.0	0.6
Group Summary	12	10	1.7	–0.2	0.9	0.4[b]
Perimeter Stations						
04 Barranca School	4	4	1.1	0.4	0.7	0.3
05 Urban Park	4	2	2.1	–0.4	1.0	1.1
06 48th Street	4	4	0.7	–0.5	–0.1	0.5
07 Gulf/Exxon/Shell Station	4	3	2.0	–0.6	1.0	1.3
08 McDonalds Restaurant	4	3	2.9	0.1	1.1	1.2
09 Los Alamos Airport	4	1	4.0	0.8	2.9	1.4
10 East Gate	4	2	1.7	0.5	1.2	0.6
11 Well PM-1 (E. Jemez Road)	4	3	0.9	0.2	0.5	0.3
12 Royal Crest Trailer Court	4	2	2.3	0.2	1.5	0.9
13 Piñon School	4	3	2.0	0.3	1.1	0.7
14 Pajarito Acres	4	4	0.9	0.4	0.6	0.2
15 White Rock Fire Station	4	4	1.3	0.2	0.8	0.5
16 White Rock Church of the Nazarene	4	3	2.4	0.3	1.2	0.9
17 Bandelier Entrance (Lookout) (Rim)	4	2	1.7	0.1	0.8	0.7
60 LA Canyon	4	3	1.8	0.6	1.2	0.5
61 LA Hospital	4	3	1.0	0.1	0.6	0.4
62 Trinity Bible Church	4	3	1.9	0.3	1.0	0.7
63 Monte Rey South	4	3	0.9	0.3	0.5	0.3
Group Summary	72	52	4.0	–0.6	1.0	1.2[b]
On-Site Stations						
20 TA-21 Area B	4	2	1.9	1.3	1.6	0.3
23 TA-52 Beta Site	4	2	2.0	0.2	0.9	0.8
25 TA-16-450	4	4	0.8	–0.2	0.3	0.4
26 TA-49	4	2	14.6	0.5	4.6	6.7
30 Pajarito Booster 2 (P-2)	4	1	235.3	1.0	60.8	116.4
31 TA-3	4	3	1.9	0.6	1.0	0.6
32 County Landfill	4	0	6.9	3.6	5.0	1.6
49 Pajarito Rd (TA-36) Sludge Pond	4	3	1.2	0.7	1.0	0.2
Group Summary	32	17	235.3	–0.2	9.4	41.7[b]

Table 4-6. Airborne Plutonium-239 Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Area G Stations						
27 TA-54 Area G (by QA)	4	0	932.6	154.6	706.6	369.9
34 TA-54 Area G-1 (behind trailer)	4	1	8.3	1.4	3.6	3.2
35 TA-54 Area G-2 (back fence)	4	2	2.1	0.7	1.5	0.6
36 TA-54 Area G-3 (by office)	4	2	4.1	0.7	2.0	1.6
37 TA-54 Area G-4 (water tank)	2	1	1.0	0.9	0.9	0.1
45 Area G (Southeast Perimeter)	4	1	5.9	0.1	3.0	2.5
47 Area G (North Perimeter)	4	0	30.1	6.9	14.1	10.9
50 TA-54 Area G	4	1	11.0	1.2	4.4	4.4
51 TA-54 Area G	4	0	10.8	1.7	4.5	4.3
Group Summary	34	8	932.6	0.1	82.3	468.3[b]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	4	2	5.5	0.2	2.4	2.2
72 TA-21.02 (N Bldg. 344)	4	0	40.9	7.5	18.2	15.6
73 TA-21.03 (NE Bldg. 344)	4	0	34.5	7.0	19.4	11.8
74 TA-21.04 (SE Bldg. 344)	4	0	33.3	7.6	15.0	12.2
75 TA-21.05 (S Bldg. 344)	4	1	32.4	3.0	13.5	13.2
Group Summary	20	3	40.9	0.2	13.7	13.5[b]
TA-15 Firing Sites						
76 TA-15-NNW	4	2	3.5	0.3	1.4	1.5
77 TA-15-NNE	4	2	2.2	0.5	0.9	0.8
78 TA-15-N	4	3	2.4	0.0	0.9	1.0
Group Summary	12	7	3.5	0.0	1.1	0.6[b]

Concentration Guidelines
Controlled Area DOE Derived Air Concentration Guide 2,000,000 aCi/m^3. See Appendix A.
Uncontrolled Area DOE Derived Air Concentration Guide 20,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 1,900 aCi/m^3.

[a] See Appendix B for an explanation of the presence of negative numbers.
[b] This is two times the standard deviation of the mean value for the group.

Table 4-7. Airborne Americium-241 Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Regional Stations						
01 Española	4	1	4.2	1.2	2.3	1.3
02 Pojoaque	4	0	2.1	1.2	1.6	0.4
03 Santa Fe	4	1	3.3	1.5	2.5	0.8
Group Summary	12	2	4.2	1.2	2.1	1.0[a]
Pueblo Stations						
41 San Ildefonso Pueblo	4	0	2.2	1.4	1.7	0.3
42 Taos Pueblo	4	0	2.9	1.9	2.4	0.5
48 Jemez Pueblo-Riverside	4	2	2.2	1.1	1.7	0.5
Group Summary	12	2	2.9	1.1	2.0	0.8[a]
Perimeter Stations						
04 Barranca School	4	1	2.1	0.4	1.3	0.7
05 Urban Park	4	2	2.1	1.2	1.6	0.4
06 48th Street	4	1	2.3	0.7	1.6	0.7
07 Gulf/Exxon/Shell Station	4	2	2.5	1.0	1.6	0.7
08 McDonalds Restaurant	4	0	3.1	1.3	2.4	0.8
09 Los Alamos Airport	4	0	3.3	1.5	2.2	0.8
10 East Gate	4	1	2.2	1.0	1.8	0.6
11 Well PM-1 (E. Jemez Road)	4	1	3.1	0.6	1.8	1.1
12 Royal Crest Trailer Court	4	1	3.3	1.0	2.1	0.9
13 Piñon School	4	1	3.3	1.2	2.2	1.1
14 Pajarito Acres	4	0	2.7	0.7	1.9	0.8
15 White Rock Fire Station	4	0	2.6	1.9	2.3	0.3
16 White Rock Church of the Nazarene	4	1	1.9	1.1	1.7	0.4
17 Bandelier Entrance (Lookout) (Rim)	4	0	2.7	1.2	1.8	0.7
60 LA Canyon	4	1	2.2	1.3	1.7	0.5
61 LA Hospital	4	2	2.6	1.1	1.7	0.7
62 Trinity Bible Church	4	2	2.2	0.5	1.3	0.8
63 Monte Rey South	4	1	2.6	1.2	1.8	0.6
Group Summary	72	17	3.3	0.4	1.8	0.6[a]
On-Site Stations						
20 TA-21 Area B	4	0	2.8	1.9	2.3	0.4
23 TA-52 Beta Site	4	0	3.6	1.8	2.5	0.8
25 TA-16-450	4	0	2.8	1.2	1.8	0.7
26 TA-49	4	1	12.1	1.4	4.8	5.0
30 Pajarito Booster 2 (P-2)	4	1	153.0	1.8	40.7	74.9
31 TA-3	4	2	2.7	0.7	1.5	0.8
32 County Landfill	4	0	4.7	2.8	3.6	0.8
49 Pajarito Rd (TA-36) Sludge Pond	4	3	2.9	0.4	1.4	1.1
Group Summary	32	7	153.0	0.4	7.3	27[a]

Table 4-7. Airborne Americium-241 Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Area G Stations						
27 TA-54 Area G (by QA)	4	0	716.9	95.5	478.2	267.4
34 TA-54 Area G-1 (behind trailer)	4	0	7.2	2.3	4.2	2.1
35 TA-54 Area G-2 (back fence)	4	0	4.3	1.9	3.1	1.2
36 TA-54 Area G-3 (by office)	4	0	5.4	1.9	2.8	1.7
37 TA-54 Area G-4 (water tank)	2	1	2.1	1.0	1.6	0.8
45 Area G (Southeast Perimeter)	4	0	3.9	2.2	3.1	0.7
47 Area G (North Perimeter)	4	0	19.2	5.0	10.5	6.1
50 TA-54 Area G	4	0	3.9	1.9	2.5	0.9
51 TA-54 Area G	4	0	4.7	2.1	3.1	1.2
Group Summary	34	1	716.9	1.0	56.6	316.3[a]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	4	1	3.4	1.2	2.4	0.9
72 TA-21.02 (N Bldg. 344)	4	0	6.0	2.5	4.4	1.6
73 TA-21.03 (NE Bldg. 344)	4	0	14.8	4.0	9.0	4.4
74 TA-21.04 (SE Bldg. 344)	4	0	4.2	1.4	3.2	1.3
75 TA-21.05 (S Bldg. 344)	4	0	5.4	2.0	3.7	1.8
Group Summary	20	1	14.8	1.2	4.5	5.2[a]
TA-15 Firing Sites						
76 TA-15-NNW	4	2	2.7	1.2	1.6	0.7
77 TA-15-NNE	4	2	2.5	0.7	1.6	0.7
78 TA-15-N	4	0	4.0	1.7	2.9	0.9
Group Summary	12	4	4.0	0.7	2.0	1.5[a]

Concentration Guidelines
Controlled Area DOE Derived Air Concentration Guide 2,000,000 aCi/m^3. See Appendix A.
Uncontrolled Area DOE Derived Air Concentration Guide 20,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 1,900 aCi/m^3.

[a]This is two times the standard deviation of the mean value for the group.

Table 4-8. Airborne Uranium-234 Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Regional Stations						
01 Española	4	0	131.2	15.7	49.1	55.4
02 Pojoaque	4	0	43.4	18.1	28.6	11.8
03 Santa Fe	4	0	47.6	16.7	29.1	14.8
Group Summary	12	0	131.2	15.7	35.6	23.3[a]
Pueblo Stations						
41 San Ildefonso Pueblo	4	0	27.1	13.6	17.6	6.3
42 Taos Pueblo	4	0	42.8	15.0	25.9	12.0
48 Jemez Pueblo-Riverside	4	0	58.7	22.2	35.5	16.0
Group Summary	12	0	58.7	13.6	26.3	17.9[a]
Perimeter Stations						
04 Barranca School	4	0	21.0	5.6	11.8	6.5
05 Urban Park	4	2	14.1	2.6	7.3	5.4
06 48th Street	4	0	25.3	5.7	11.8	9.2
07 Gulf/Exxon/Shell Station	4	1	15.9	2.4	9.5	5.7
08 McDonalds Restaurant	4	1	14.5	2.9	8.9	4.9
09 Los Alamos Airport	4	0	12.3	7.4	10.1	2.1
10 East Gate	4	1	14.9	3.8	10.0	5.5
11 Well PM-1 (E. Jemez Road)	4	1	16.1	3.4	8.8	5.6
12 Royal Crest Trailer Court	4	0	14.4	7.4	9.3	3.4
13 Piñon School	4	0	14.9	5.6	10.1	3.8
14 Pajarito Acres	4	1	8.7	3.7	6.3	2.6
15 White Rock Fire Station	4	0	18.1	5.1	11.8	6.0
16 White Rock Church of the Nazarene	4	1	13.8	2.5	9.5	4.9
17 Bandelier Entrance (Lookout) (Rim)	4	1	12.1	3.8	8.0	3.5
60 LA Canyon	4	1	20.1	4.2	11.1	7.1
61 LA Hospital	4	0	27.7	14.4	20.2	5.9
62 Trinity Bible Church	4	1	17.6	4.3	10.7	5.4
63 Monte Rey South	4	0	11.7	4.0	8.0	3.2
Group Summary	72	11	27.7	2.4	10.2	5.9[a]
On-Site Stations						
20 TA-21 Area B	4	0	10.6	5.7	8.4	2.4
23 TA-52 Beta Site	4	0	36.5	10.4	26.7	11.3
25 TA-16-450	4	0	28.7	6.0	12.3	11.0
26 TA-49	3	0	14.9	11.2	12.7	1.9
30 Pajarito Booster 2 (P-2)	4	0	25.8	6.7	13.3	8.5
31 TA-3	4	0	16.3	7.2	11.8	3.8
32 County Landfill	4	0	67.0	28.6	43.6	17.7
49 Pajarito Rd (TA-36) Sludge Pond	4	0	29.2	4.3	20.0	10.9
Group Summary	31	0	67.0	4.3	18.6	23.2[a]

Table 4-8. Airborne Uranium-234 Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Area G Stations						
27 TA-54 Area G (by QA)	4	0	67.6	29.2	43.9	17.7
34 TA-54 Area G-1 (behind trailer)	4	0	40.7	7.3	19.6	15.3
35 TA-54 Area G-2 (back fence)	4	0	56.1	9.8	23.9	21.9
36 TA-54 Area G-3 (by office)	4	0	34.0	21.0	25.4	5.9
37 TA-54 Area G-4 (water tank)	2	1	21.9	3.3	12.6	13.2
45 Area G (Southeast Perimeter)	4	0	35.4	8.5	16.2	12.8
47 Area G (North Perimeter)	4	1	41.5	2.7	17.5	17.0
50 TA-54 Area G	4	0	112.6	23.5	50.8	41.7
51 TA-54 Area G	4	0	73.6	27.2	41.5	21.9
Group Summary	34	2	112.6	2.7	27.9	27.7[a]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	4	0	14.7	8.5	10.4	2.9
72 TA-21.02 (N Bldg. 344)	4	0	21.7	13.5	17.3	3.4
73 TA-21.03 (NE Bldg. 344)	4	0	20.3	8.2	13.5	5.0
74 TA-21.04 (SE Bldg. 344)	4	0	40.9	9.5	20.0	14.4
75 TA-21.05 (S Bldg. 344)	4	0	60.7	10.3	28.1	23.2
Group Summary	20	0	60.7	8.2	17.9	13.6[a]
TA-15 Firing Sites						
76 TA-15-NNW	4	1	15.6	3.8	11.4	5.4
77 TA-15-NNE	4	0	24.1	9.8	13.9	6.9
78 TA-15-N	4	0	235.7	4.1	64.5	114.2
Group Summary	12	1	235.7	3.8	30.0	59.9[a]

Concentration Guidelines
Controlled Area DOE Derived Air Concentration Guide 20,000,000 aCi/m^3.
Uncontrolled Area DOE Derived Air Concentration Guide 90,000 aCi/m^3.
EPA 40 CFR 61 Concentration Guide 7,700 aCi/m^3.

[a] This is two times the standard deviation of the mean value for the group.

Table 4-9. Airborne Uranium-235 Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Regional Stations						
01 Española	4	2	6.4	1.3	3.1	2.3
02 Pojoaque	4	3	3.5	–0.1[a]	2.0	1.6
03 Santa Fe	4	3	4.0	0.0	1.6	1.7
Group Summary	12	8	6.4	–0.1	2.2	1.6[b]
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	1.5	0.4	0.9	0.5
42 Taos Pueblo	4	2	2.3	1.5	1.8	0.4
48 Jemez Pueblo-Riverside	4	3	3.4	0.0	1.5	1.4
Group Summary	12	9	3.4	0.0	1.4	0.9[b]
Perimeter Stations						
04 Barranca School	4	4	3.0	–0.2	1.6	1.4
05 Urban Park	4	3	1.7	–1.5	0.4	1.5
06 48th Street	4	4	2.1	0.5	1.2	0.7
07 Gulf/Exxon/Shell Station	4	3	2.1	–0.5	1.0	1.1
08 McDonalds Restaurant	4	3	2.3	0.0	1.1	1.0
09 Los Alamos Airport	4	4	2.0	0.0	1.0	0.8
10 East Gate	4	4	1.9	0.0	0.9	1.0
11 Well PM-1 (E. Jemez Road)	4	4	0.9	0.0	0.5	0.4
12 Royal Crest Trailer Court	4	4	1.9	0.2	1.3	0.7
13 Piñon School	4	4	1.4	0.1	0.9	0.6
14 Pajarito Acres	4	4	2.4	0.1	1.0	1.1
15 White Rock Fire Station	4	4	1.3	–0.1	0.6	0.7
16 White Rock Church of the Nazarene	4	4	0.1	–0.3	–0.0	0.2
17 Bandelier Entrance (Lookout) (Rim)	4	4	1.5	–1.5	0.4	1.3
60 LA Canyon	4	4	1.8	1.1	1.4	0.3
61 LA Hospital	4	4	2.7	0.0	1.1	1.2
62 Trinity Bible Church	4	4	2.8	–0.7	0.7	1.5
63 Monte Rey South	4	4	1.1	0.0	0.7	0.5
Group Summary	72	69	3.0	–1.5	0.9	0.8[b]
On-Site Stations						
20 TA-21 Area B	4	4	1.6	–0.4	0.5	0.8
23 TA-52 Beta Site	4	2	3.0	0.0	1.8	1.3
25 TA-16-450	4	3	4.5	0.0	1.5	2.1
26 TA-49	3	3	1.5	0.1	0.6	0.8
30 Pajarito Booster 2 (P-2)	4	4	1.0	0.0	0.6	0.4
31 TA-3	4	3	2.7	–1.5	0.3	1.8
32 County Landfill	4	3	2.7	0.1	1.4	1.0
49 Pajarito Rd (TA-36) Sludge Pond	4	4	1.6	–0.1	0.9	0.8
Group Summary	31	26	4.5	–1.5	0.9	1.1[b]

Table 4-9. Airborne Uranium-235 Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Area G Stations						
27 TA-54 Area G (by QA)	4	3	3.4	1.4	2.4	1.1
34 TA-54 Area G-1 (behind trailer)	4	3	3.1	0.3	1.3	1.4
35 TA-54 Area G-2 (back fence)	4	4	1.5	0.7	1.0	0.3
36 TA-54 Area G-3 (by office)	4	4	1.5	1.1	1.3	0.2
37 TA-54 Area G-4 (water tank)	2	2	0.7	0.7	0.7	0.0
45 Area G (Southeast Perimeter)	4	3	2.2	0.0	1.1	1.0
47 Area G (North Perimeter)	4	3	4.2	0.2	1.7	1.8
50 TA-54 Area G	4	2	6.0	1.3	3.4	2.2
51 TA-54 Area G	4	2	4.1	1.2	2.6	1.5
Group Summary	34	26	6.0	0.0	1.7	1.8[b]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	4	3	1.2	–0.2	0.6	0.7
72 TA-21.02 (N Bldg. 344)	4	3	2.6	0.0	1.1	1.1
73 TA-21.03 (NE Bldg. 344)	4	4	1.4	0.0	1.0	0.7
74 TA-21.04 (SE Bldg. 344)	4	4	1.2	0.0	0.6	0.6
75 TA-21.05 (S Bldg. 344)	4	2	2.8	0.0	1.8	1.3
Group Summary	20	16	2.8	–0.2	1.0	1.0[b]
TA-15 Firing Sites						
76 TA-15-NNW	4	4	1.8	–0.1	1.1	0.8
77 TA-15-NNE	4	4	1.4	0.2	0.7	0.5
78 TA-15-N	4	3	12.6	0.0	3.7	6.0
Group Summary	12	11	12.6	–0.1	1.8	3.3[b]

Concentration Guidelines
Controlled Area DOE Derived Air Concentration Guide 20,000,000 aCi/m^3. See Appendix A.
Uncontrolled Area DOE Derived Air Concentration Guide 100,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 7,100 aCi/m^3.

[a] See Appendix B for an explanation of the presence of negative numbers.
[b] This is two times the standard deviation of the mean value for the group.

Table 4-10. Airborne Uranium-238 Concentrations for 1996

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Regional Stations						
01 Española	4	0	30.9	12.9	18.5	8.4
02 Pojoaque	4	0	38.4	16.8	28.6	11.0
03 Santa Fe	4	0	46.4	13.9	27.1	15.6
Group Summary	12	0	46.4	12.9	24.7	10.9[a]
Pueblo Stations						
41 San Ildefonso Pueblo	4	0	25.5	10.8	17.2	6.1
42 Taos Pueblo	4	0	42.9	16.5	26.4	12.5
48 Jemez Pueblo-Riverside	4	0	63.4	20.7	38.3	18.7
Group Summary	12	0	63.4	10.8	27.3	21.1[a]
Perimeter Stations						
4 Barranca School	4	0	19.9	8.2	12.8	5.1
5 Urban Park	4	0	16.5	3.9	8.5	5.5
6 48th Street	4	1	8.6	1.0	5.5	3.2
7 Gulf/Exxon/Shell Station	4	0	15.8	5.1	11.2	4.:
8 McDonalds Restaurant	4	0	17.1	4.6	10.7	5.6
9 Los Alamos Airport	4	0	19.6	5.9	12.2	5.6
10 East Gate	4	0	14.9	9.1	11.5	2.7
11 Well PM-1 (E. Jemez Road)	4	1	16.7	2.0	11.2	6.8
12 Royal Crest Trailer Court	4	0	16.6	3.3	8.5	5.7
13 Piñon School	4	0	14.7	8.7	10.9	2.7
14 Pajarito Acres	4	0	8.7	3.6	6.1	2.4
15 White Rock Fire Station	4	0	21.3	6.6	11.6	6.6
16 White Rock Church of the Nazarene	4	1	13.8	1.6	7.0	5.3
17 Bandelier Entrance (Lookout) (Rim)	4	0	19.2	3.7	10.4	6.7
60 LA Canyon	4	0	20.1	5.2	11.0	7.2
61 LA Hospital	4	0	29.1	7.4	19.0	9.1
62 Trinity Bible Church	4	0	18.1	4.3	12.4	5.9
63 Monte Rey South	4	1	11.7	3.1	8.8	3.9
Group Summary	72	4	29.1	1.0	10.5	6.0[a]
On-Site Stations						
20 TA-21 Area B	4	0	14.1	10.2	11.6	1.7
23 TA-52 Beta Site	4	0	34.9	11.9	27.5	10.6
25 TA-16-450	4	0	30.7	7.5	13.6	11.4
26 TA-49	3	0	12.0	9.8	11.0	1.1
30 Pajarito Booster 2 (P-2)	4	0	25.6	13.5	19.3	6.3
31 TA-3	4	0	13.3	10.0	11.0	1.5
32 County Landfill	4	0	68.9	26.8	44.7	17.9
49 Pajarito Rd (TA-36) Sludge Pond	4	0	30.5	9.8	16.2	9.6
Group Summary	31	0	68.9	7.5	19.3	23.4[a]

Table 4-10. Airborne Uranium-238 Concentrations for 1996 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s (aCi/m^3)
Area G Stations						
27 TA-54 Area G (by QA)	4	0	69.2	24.0	41.5	19.9
34 TA-54 Area G-1 (behind trailer)	4	0	45.6	4.7	19.5	18.8
35 TA-54 Area G-2 (back fence)	4	0	18.8	6.1	10.8	5.6
36 TA-54 Area G-3 (by office)	4	0	34.0	13.5	23.3	9.0
37 TA-54 Area G-4 (water tank)	2	0	19.1	5.5	12.3	9.6
45 Area G (Southeast Perimeter)	4	0	35.1	9.6	16.8	12.2
47 Area G (North Perimeter)	4	1	37.1	3.3	18.0	14.1
50 TA-54 Area G	4	0	104.2	28.2	50.6	36.1
51 TA-54 Area G	4	0	66.8	24.1	41.5	19.0
Group Summary	34	1	104.2	3.3	26.0	29.2[a]
Decontamination and Decommissioning						
71 TA-21.01 (NW Bldg. 344)	4	0	17.5	5.9	12.3	4.8
72 TA-21.02 (N Bldg. 344)	4	0	15.3	8.8	11.2	2.8
73 TA-21.03 (NE Bldg. 344)	4	0	13.7	4.5	10.4	4.1
74 TA-21.04 (SE Bldg. 344)	4	0	14.4	7.3	11.0	3.2
75 TA-21.05 (S Bldg. 344)	4	0	15.8	10.3	12.5	2.6
Group Summary	20	0	17.5	4.5	11.5	1.8[a]
TA-15 Firing Sites						
76 TA-15-NNW	4	0	18.5	6.3	11.9	5.1
77 TA-15-NNE	4	0	63.9	28.3	45.6	15.2
78 TA-15-N	4	0	20.8	4.3	11.6	7.8
Group Summary	12	0	63.9	4.3	23.0	39.0[a]

Concentration Guidelines
Controlled Area DOE Derived Air Concentration Guide 20,000,000 aCi/m^3.
Uncontrolled Area DOE Derived Air Concentration Guide 100,000 aCi/m^3.
EPA 40 CFR 61 Concentration Guide 8,300 aCi/m^3.

[a]This is two times the standard deviation of the mean value for the group.

Table 4-11. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 1994–1996

	TLD Station ID #	Location	1996 Annual Dose (mrem)[a]	1995 Annual Dose (mrem)	1994 Annual Dose (mrem)
Regional	01	Española	98 ± 11[c]	100 ± 12[b]	76 ± 13[b,c]
	02	Pojoaque	90 ± 9[c]	114 ± 10	118 ± 13
	03	Santa Fe	105 ± 9[c]	105 ± 10[c]	122 ± 13
	04	Fenton Hill (TA-57)	166 ± 10[c]	51 ± 9[d]	152 ± 13
	52	West Taos Pueblo	Discontinued	30 ± 10[e]	Not Operational
	53	Pueblo of San Ildefonso	82 ± 16[c]	104 ± 12	113 ± 13
	54	Jemez Pueblo	119 ± 11	114 ± 12	110 ± 13
Perimeter	05	Barranca School, Los Alamos	104 ± 10[c]	139 ± 10	118 ± 13
	06	Arkansas Avenue, Los Alamos	Discontinued 4th Quarter of 1992		
	07	Cumbres School, Los Alamos	130 ± 12	131 ± 10	125 ± 10
	08	48th Street, Los Alamos	144 ± 11	135 ± 8	132 ± 10
	09	Los Alamos Airport	131 ± 11	114 ± 9	110 ± 10
	10	Bayo Canyon, Los Alamos	170 ± 12	149 ± 11	145 ± 13
	11	Shell Station, Los Alamos	142 ± 11	137 ± 9	140 ± 10
	12	Royal Crest Trailer Court, Los Alamos	140 ± 11	127 ± 11	133 ± 13
	13	White Rock	134 ± 11	118 ± 9	124 ± 10
	14	Pajarito Acres, White Rock	130 ± 11	127 ± 11	122 ± 14
	15	Bandelier National Monument Lookout Station	149 ± 12	131 ± 9	143 ± 11
	16	Pajarito Ski Area	114 ± 10[c]	122 ± 12	118 ± 13
	20	Well PM-1 (SR4 and Truck Rt.)	167 ± 12	157 ± 12	148 ± 13
	41	McDonald's Restaurant, Los Alamos	78 ± 8[d]	134 ± 9	128 ± 10
	42	Los Alamos Airport-South	147 ± 11	125 ± 12	123 ± 13
	43	East Gate Business Park, Los Alamos	145 ± 11	126 ± 12	114 ± 13
	44	Big Rock Loop, Los Alamos	176 ± 12	142 ± 10	165 ± 13
	45	Cheyenne Street, Los Alamos	165 ± 12	83 ± 9[d]	160 ± 13
	46	Los Pueblos Street, Los Alamos	161 ± 12	156 ± 12	139 ± 13
	47	Urban Park, Los Alamos	144 ± 12	130 ± 11	135 ± 13
	48	Los Alamos County Landfill	135 ± 11	130 ± 12	122 ± 13
	49	Piñon School, White Rock	103 ± 10[c]	132 ± 12	124 ± 13
	50	White Rock Church of the Nazarene	95 ± 10	93 ± 12	101 ± 13
	51	Bayo Canyon Well, Los Alamos	162 ± 12	155 ± 10	103 ± 12
	55	Monte Rey South	128 ± 11	73 ± 8[d]	Not Operational
On-Site	17	TA-21 (DP West)	155 ± 12	142 ± 11	153 ± 10
	18	TA-6 (Two Mile Mesa)	142 ± 11	128 ± 9	134 ± 10
	19	TA-53 (LANSCE)	159 ± 12	142 ± 9	152 ± 12
	21	TA-16 (S-Site)	141 ± 11	140 ± 12	99 ± 12[c]
	22	Booster P-2	179 ± 12	185 ± 12	144 ± 13
	23	TA-3 East Gate of SM 43	125 ± 11	105 ± 12	132 ± 13
	24	State Highway 4	178 ± 13	135 ± 11	98 ± 11[c]
	25	TA-49 (Frijoles Mesa)	135 ± 11	135 ± 9	119 ± 10
	26	TA-2 (Omega Stack)	148 ± 12	168 ± 12	135 ± 13
	27	TA-2 (Omega Canyon)	173 ± 13	157 ± 12	159 ± 13
	28	TA-18 (Pajarito Site)	241 ± 13	378 ± 13[g]	127 ± 13
	29	TA-35 (Ten Site A)	92 ± 10	128 ± 12	114 ± 13

Table 4-11. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 1994–1996 (Cont.)

	TLD Station ID #	Location	1996 Annual Dose (mrem)[a]	1995 Annual Dose (mrem)	1994 Annual Dose (mrem)
On-Site (Cont.)	30	TA-35 (Ten Site B)	140 ± 12	98 ± 11[c]	140 ± 13
	31	TA-59 (Occupational Health Lab)	144 ± 12	128 ± 12	138 ± 13
	32	TA-3-16 (Van de Graaff)	153 ± 11	137 ± 12	145 ± 13
	33	TA-3-316 (Ion Beam Bldg.)	144 ± 12	118 ± 12	142 ± 13
	34	TA-3-440 (CAS)	113 ± 13	104 ± 11[c]	129 ± 13
	35	TA-3-420 (CMR Bldg. West Fence)	111 ± 11	123 ± 12	115 ± 13
	36	TA-3-102 (Shop)	115 ± 11	131 ± 12	119 ± 13
	37	TA-72 (Pistol Range)	142 ± 12	151 ± 12	146 ± 13
	38	TA-55 (Plutonium Facility South)	132 ± 14	107 ± 11[c]	133 ± 13
	39	TA-55 (Plutonium Facility West)	181 ± 12	160 ± 12	140 ± 14
	40	TA-55 (Plutonium Facility North)	154 ± 11	119 ± 11	135 ± 13
	56	East Gate Mid Station[f]	119 ± 10[c]	Not Operational	
	57	TA-54 West (TLD Lab)[f]	129 ± 11[c]	Not Operational	
	58	TA-54 Lagoon[f]	89 ± 9[d]	Not Operational	
	59	Los Alamos Canyon[f]	52 ± 8[e]	Not Operational	

[a] New environmental TLD system was introduced in second quarter 1996.
[b] The uncertainty of each measurement is the propagated error of the quarterly measurements.
[c] Annual dose is the sum of three quarters.
[d] Annual dose is the sum of two quarters.
[e] Data only available for one quarter.
[f] New stations placed into operation in 1996.
[g] Restricted-access operational measurements from quarter 2 were included in annual dose and does not reflect potential public dose resulting from controlled access.

Table 4-12. Waste Disposal Area Measured Dose

		Annual Dose (mrem)							
Waste Disposal Area	Number of TLD Locations	1996 Minimum	1996 Maximum	1996 Mean	1996 Uncertainty[a]	1995 Mean	1995 Uncertainty[a]	1994 Mean	1994 Uncertainty[a]
TA-21, Area A	5	114	127	119	9	133	11	129	13
TA-21, Area B	14	125	145	127	9	153	11	135	13
TA-50, Area C	10	125	140	132	10	118[b]	11	113	13
TA-33, Area E	4	132	143	138	9	147	11	139	13
TA-6, Area F	4	118	130	124	9	72[c]	9	N/A[d]	—
TA-54, Area G	25	124	222	173	10	161	12	160	13
TA-21, Area T	7	129	267	156	10	159	12	159	14
TA-21, Area U	4	127	136	132	9	128	11	131	14
TA-21, Area V	4	119	133	125	9	134	11	105	12
TA-35, Area W	3	114	138	123	9	125	11	110	13
TA-49, Area AB	10	112	138	126	10	141	12	126	13

[a]Uncertainty is the propagated error of the quarterly measurements.
[b]Annual Doses for only three quarters, second quarter data not available due to equipment malfunction.
[c]Only monitored 3rd & 4th quarter because of construction associated with a geophysical investigation.
[d]N/A = not available.

Table 4-13. Estimated Concentrations of Toxic Elements Released by Dynamic Experiments

Element[a]	Total Usage (kg)	Fraction Released (%)	Maximum Impact (2,767 m) ($\mu g/m^3$)	Nearest Public Access Point (1,500 m) ($\mu g/m^3$) 1 Hour Concentrations[b]	Nearest Off-Site Receptor (3,800 m) ($\mu g/m^3$)
Beryllium	.6	2	1×10^{-6}	6×10^{-7}	9×10^{-7}
Aluminum	430	100	4×10^{-2}	2×10^{-2}	3×10^{-2}
Tantalum	9.6	100	8×10^{-4}	5×10^{-4}	7×10^{-4}
Copper	505	100	4×10^{-2}	3×10^{-2}	4×10^{-2}
Molybdenum	.2	100	2×10^{-6}	1×10^{-5}	2×10^{-5}

[a]Usage and impact analysis performed on elements regulated under 20 NMAC 2.27 and 40 CFR 61, Subpart C.
[b]Currently, no impact standard exists for any of the elements detonated.

Table 4-14. Emissions by Source in 1996 (Tons)

Source	PM	CO	NO_X	SO_X	VOC
TA-3 Power Plant	1.5	11.7	47.5	.17	.40
TA-16 Power Plant	1.9	5.5	22.6	.08	.19
TA-21 Power Plant	.47	1.2	4.7	.02	.10
Asphalt Plant	.14	.07	.05	.001	.03
Total	3.01	18.47	74.85	.271	.73

Table 4-15. 1996 Precipitation (in.)

	North Community	TA-16	TA-6	TA-49	TA-53	TA-54	TA-74
January	1.05	1.35	1.29	0.97	1.09	0.80	0.86
February	0.59	0.76	0.69	0.55	0.49	0.46	0.46
March	0.57	0.47	0.39	0.21	0.23	0.15	0.17
April	0.10	0.18	0.11	0.07	0.08	0.07	0.05
May	0.03	0.00	0.02	0.00	0.00	0.00	0.07
June	3.35	4.07	3.83	3.77	2.97	3.32	2.95
July	2.64	4.91	2.96	3.01	2.52	3.52	2.26
August	3.63	3.39	2.25	2.33	2.06	1.50	2.34
September	1.38	3.86	2.20	2.06	1.49	1.36	1.37
October	3.26	4.17	3.37	4.02	3.26	3.62	3.09
November	0.71	0.76	0.64	0.55	0.52	0.53	0.43
December	0.12	0.10	0.09	0.06	0.02	0.01	0.01
Total	17.43	24.02	17.84	17.60	14.73	15.34	14.06

4. Air Surveillance

I. Figures

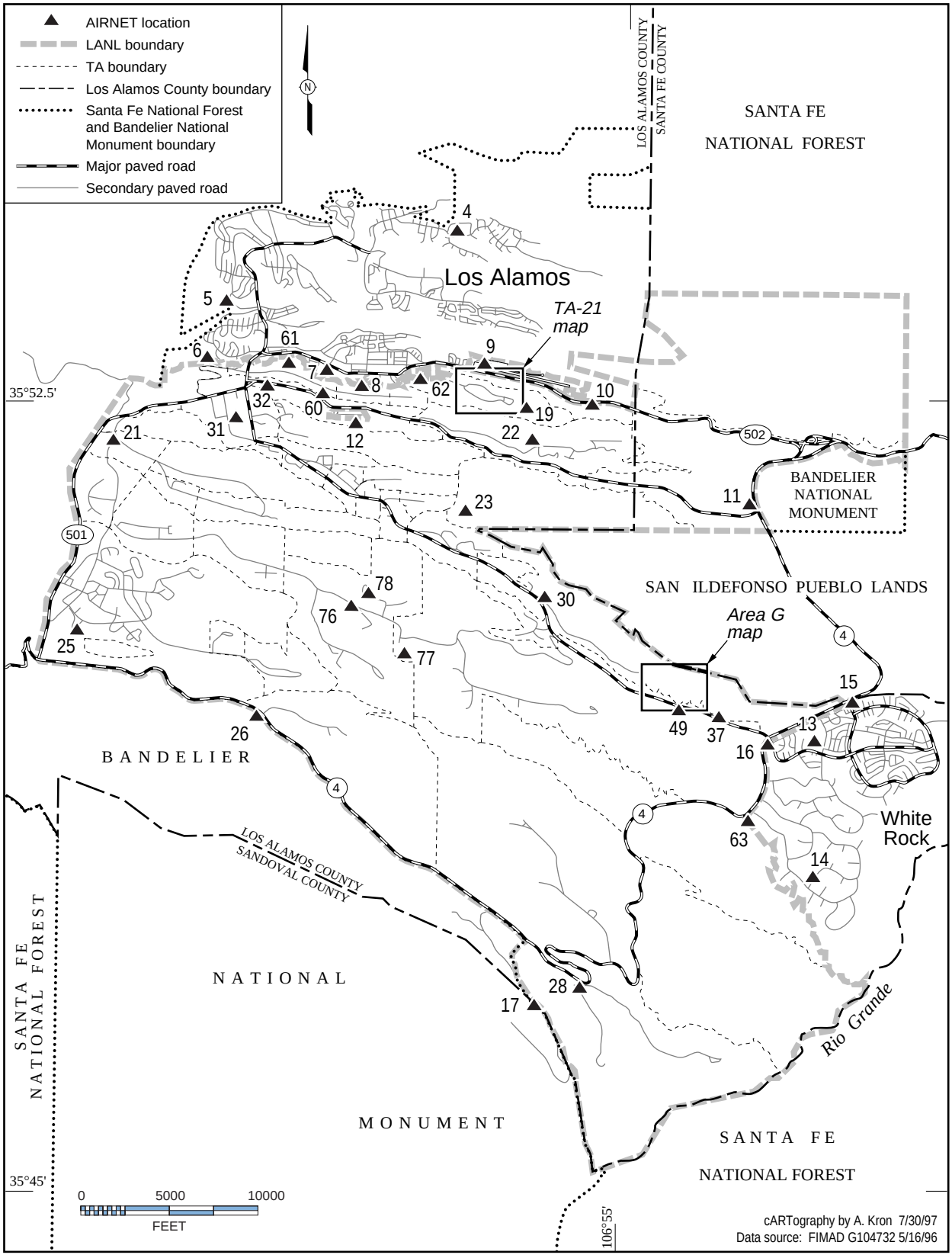

Figure 4-1. Off-site perimeter and on-site Laboratory AIRNET locations.

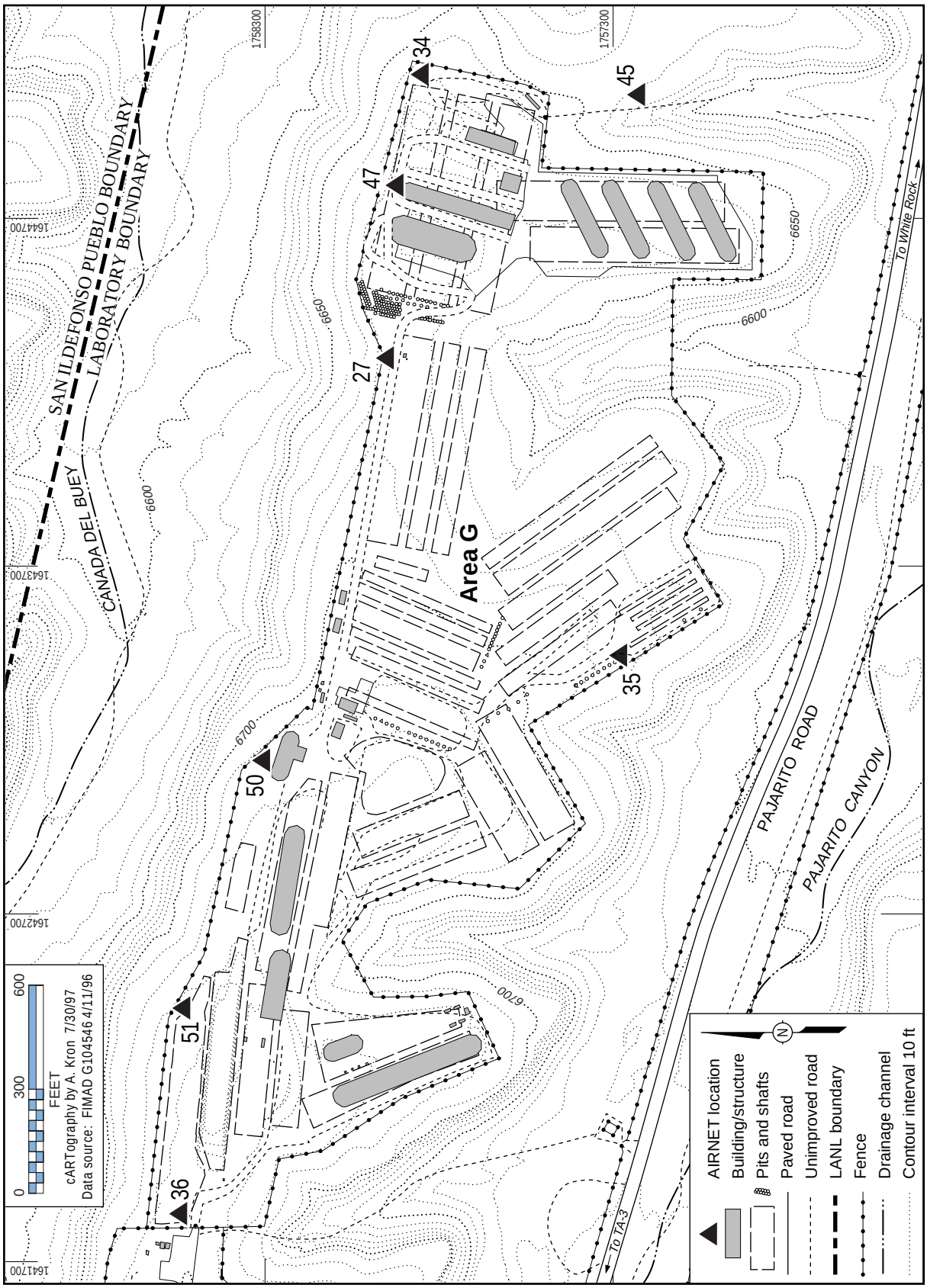

Figure 4-2. Technical Area 54, Area G map of AIRNET locations.

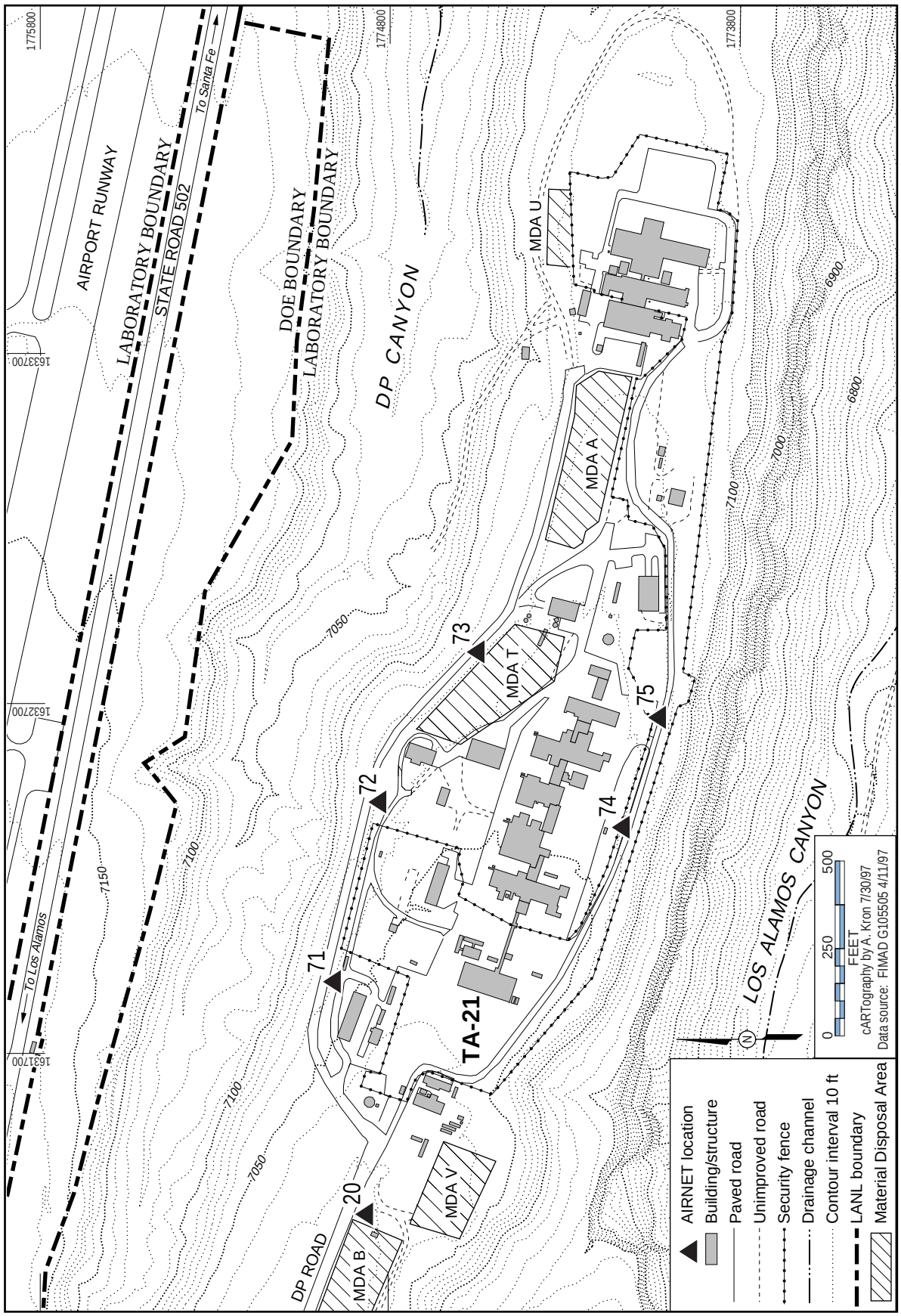

Figure 4-3. Technical Area 21 map of AIRNET locations.

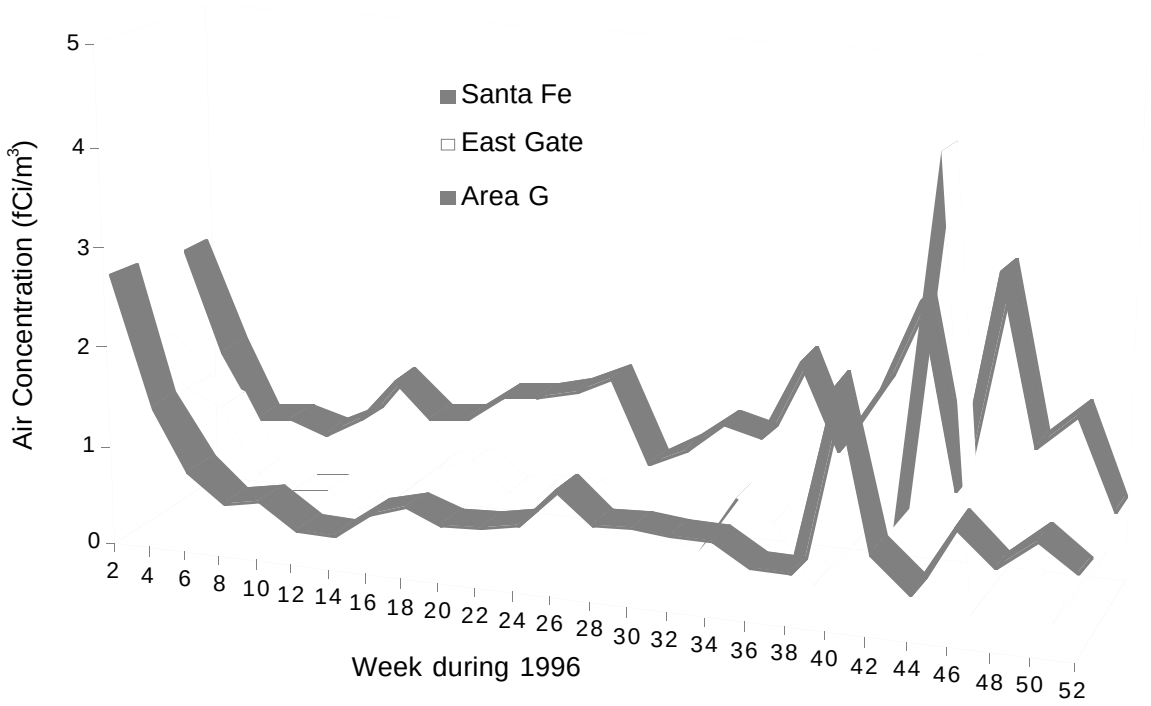

Figure 4-4. Comparison of gross alpha activity air concentrations at one regional, one perimeter, and one on-site station.

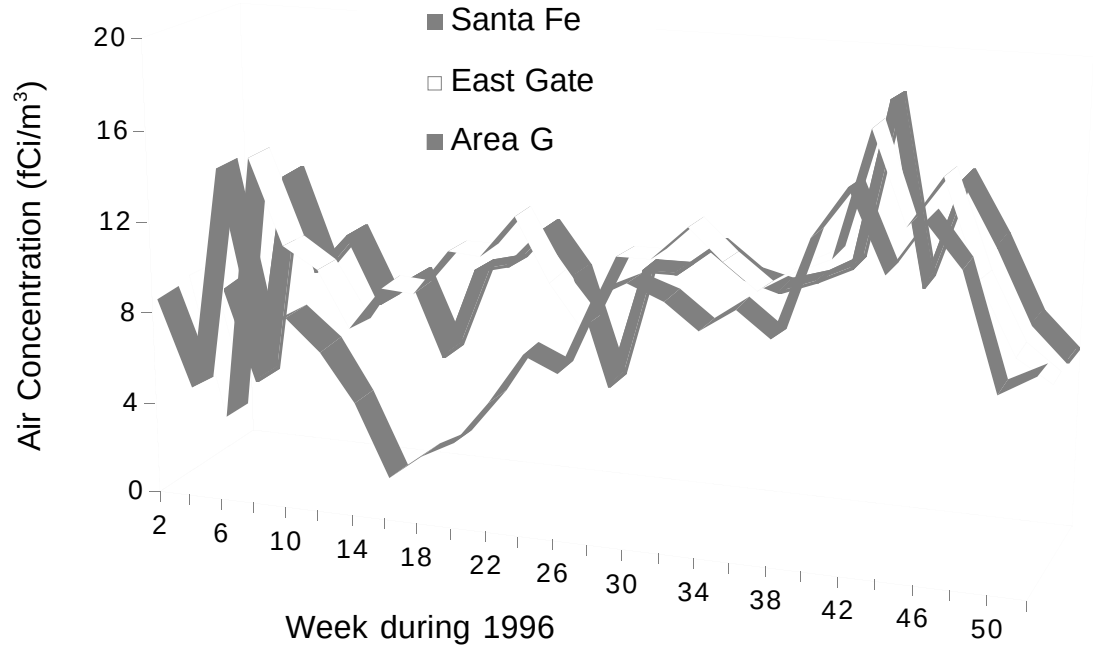

Figure 4-5. Comparison of gross beta activity air concentrations at one regional, one perimeter, and one on-site station.

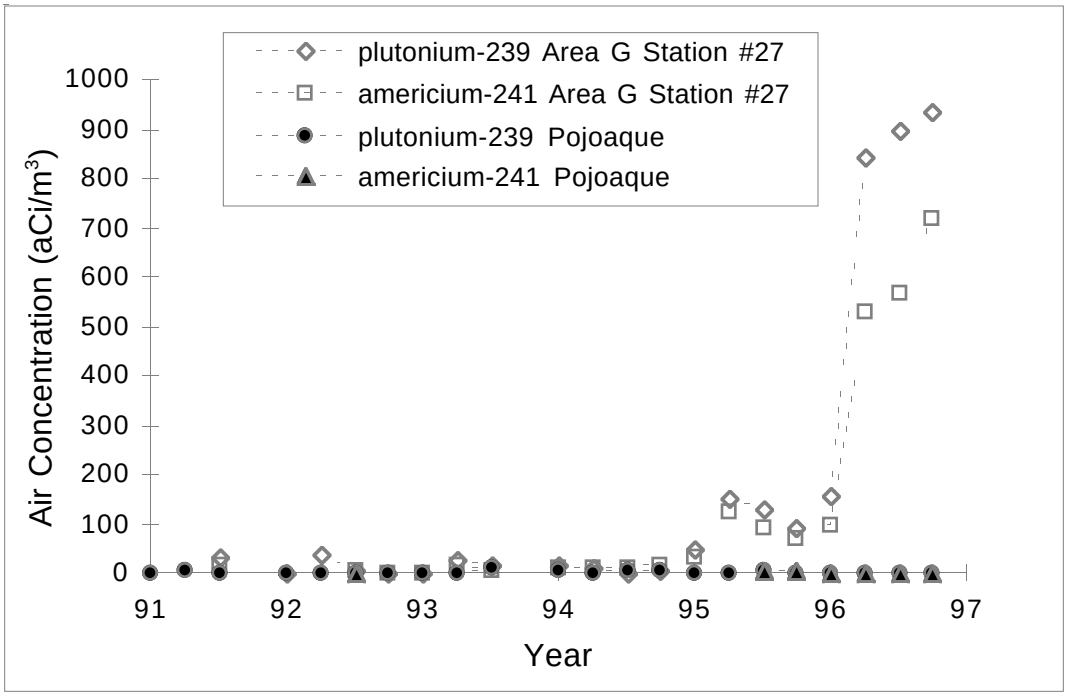

Figure 4-6. Comparison of plutonium-239 and americium-241 air concentrations at a regional station and Technical Area 54, Area G, Station #27.

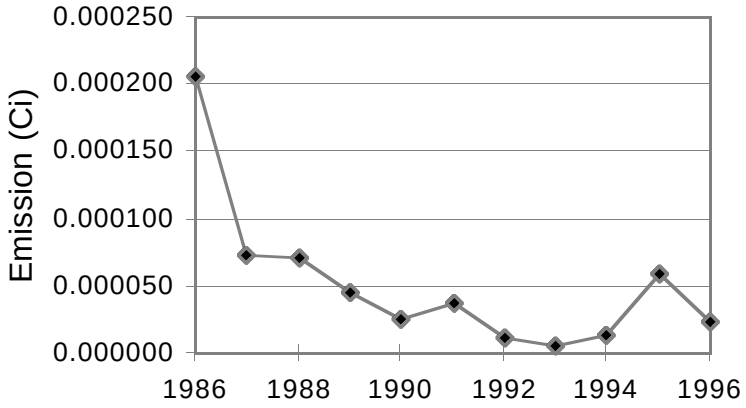

Figure 4-7. Plutonium emissions from Laboratory stacks since 1986.

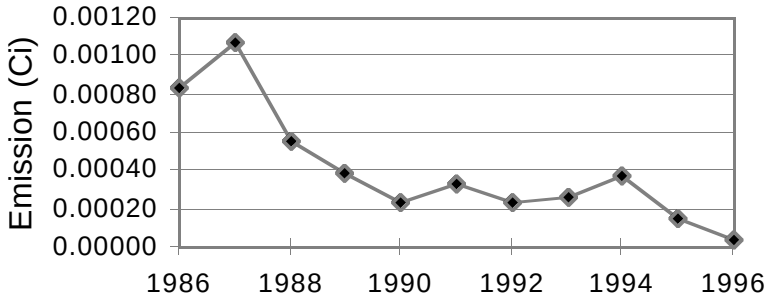

Figure 4-8. Uranium emissions from Laboratory stacks since 1986.

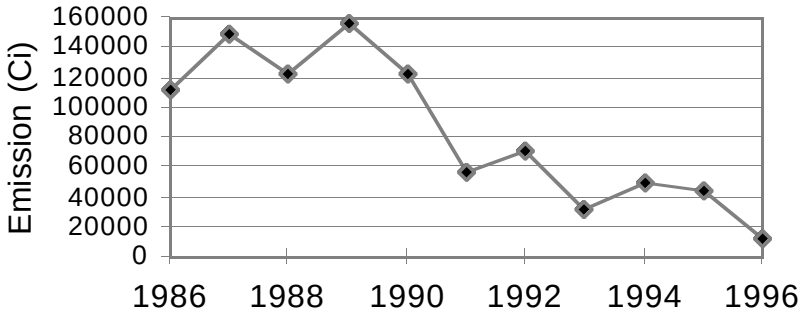

Figure 4-9. G/MAP emissions from Laboratory stacks since 1986.

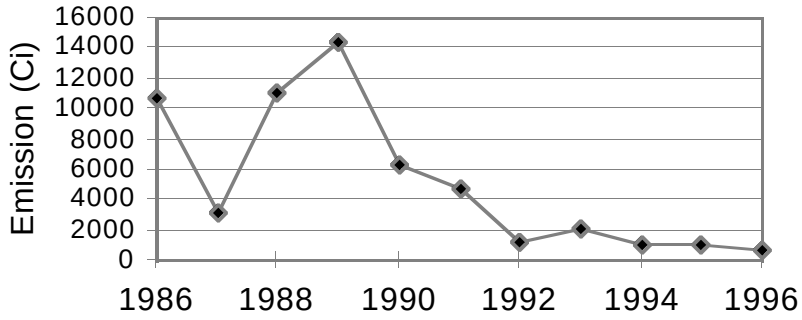

Figure 4-10. Tritium emissions from Laboratory stacks since 1986.

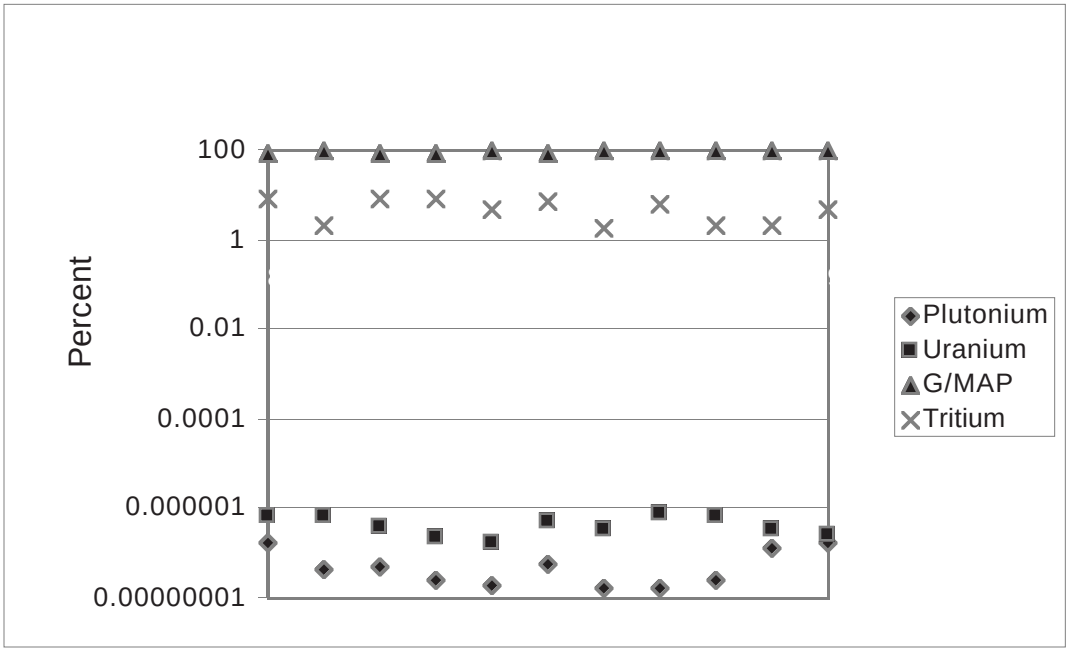

Figure 4-11. Percent of total emissions resulting from plutonium, uranium, tritium, and G/MAP.

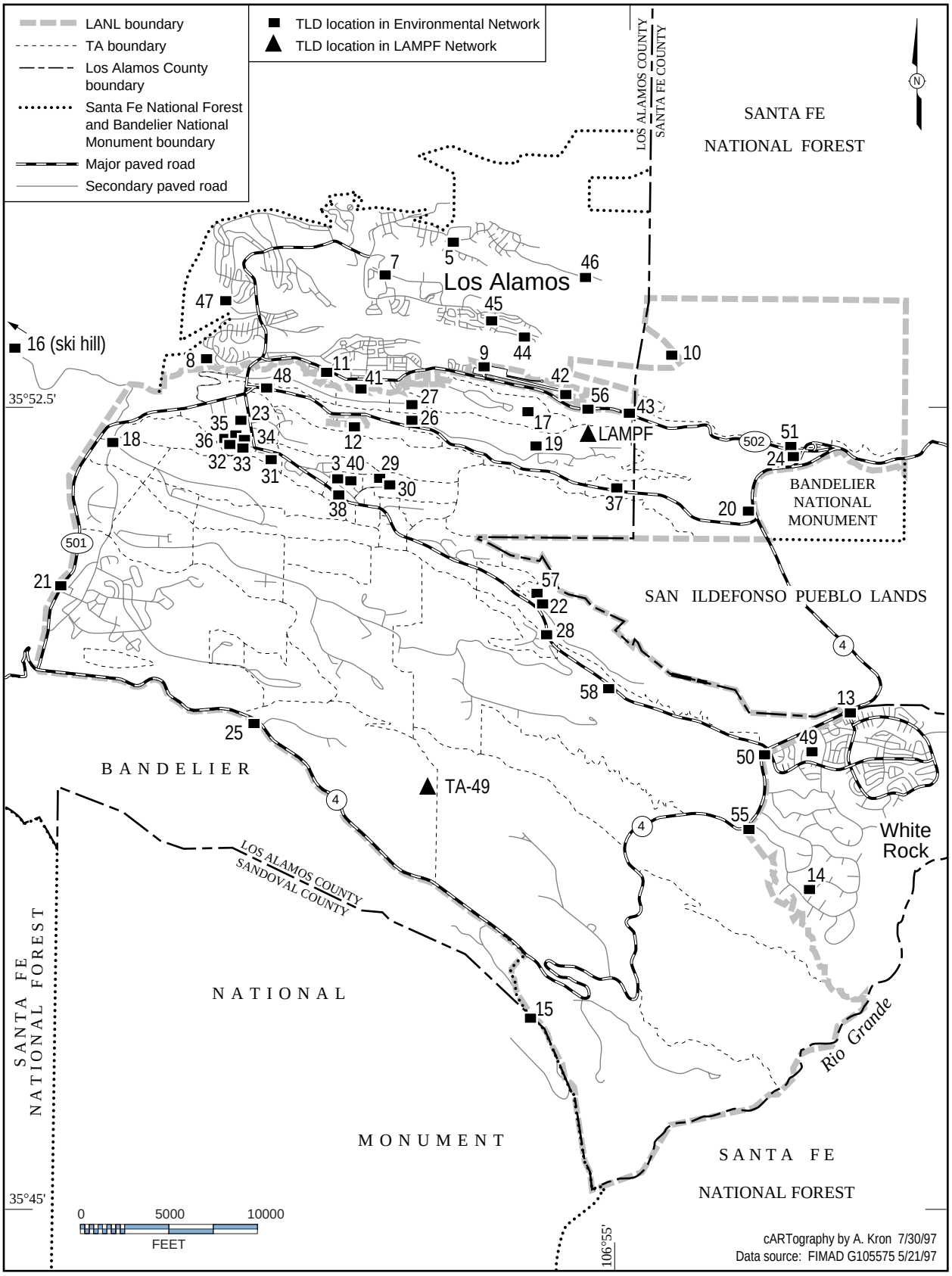

Figure 4-12. Off-site perimeter and on-site Laboratory TLD locations.

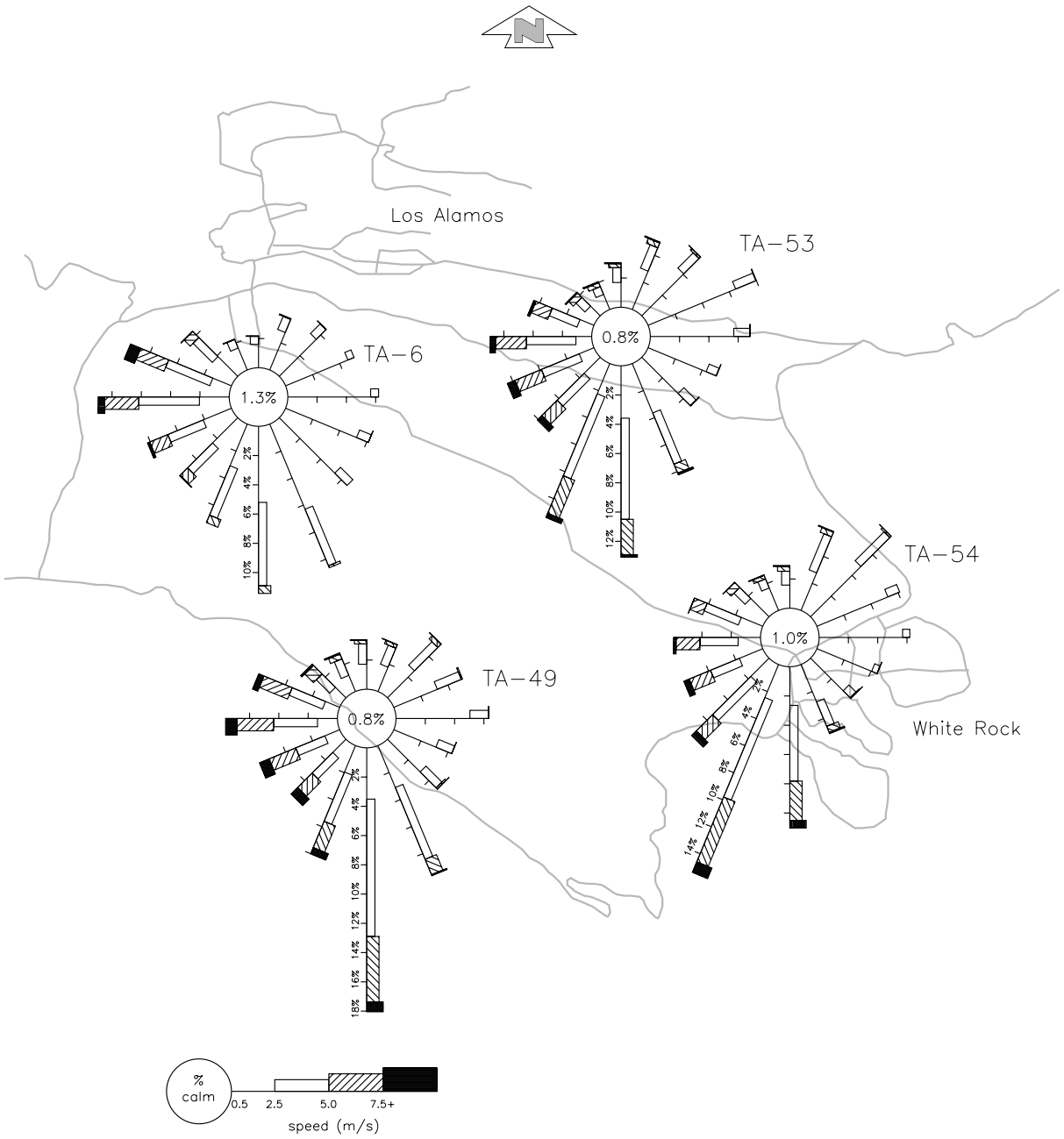

Figure 4-13. Wind roses for daytime winds observed at 11 m (36 ft) at TA-6, TA-49, TA-53, and TA-54 for 1996.

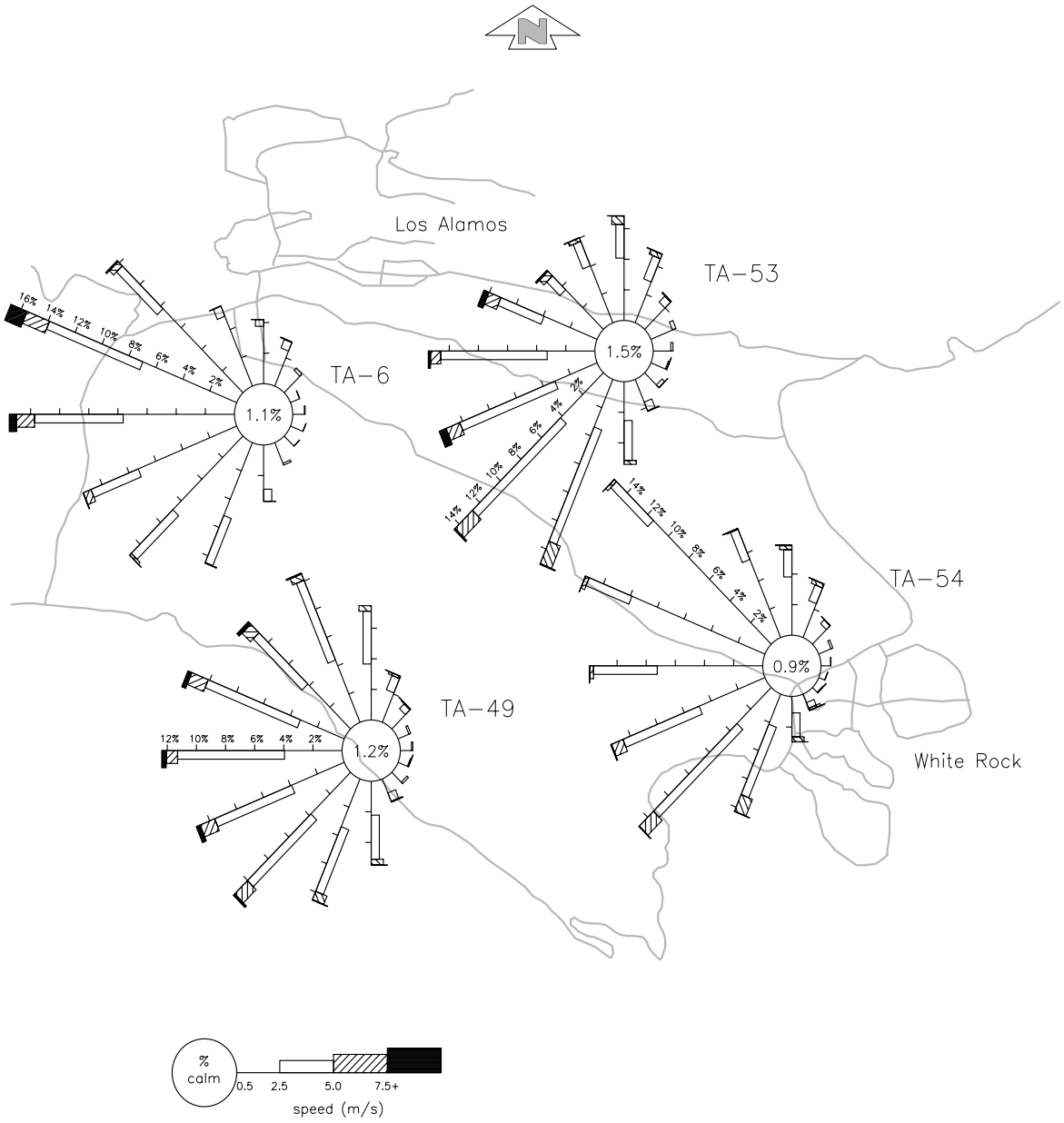

Figure 4-14. Wind roses for nighttime winds observed at 11 m (36 ft) at TA-6, TA-49, TA-53, and TA-54 for 1996.

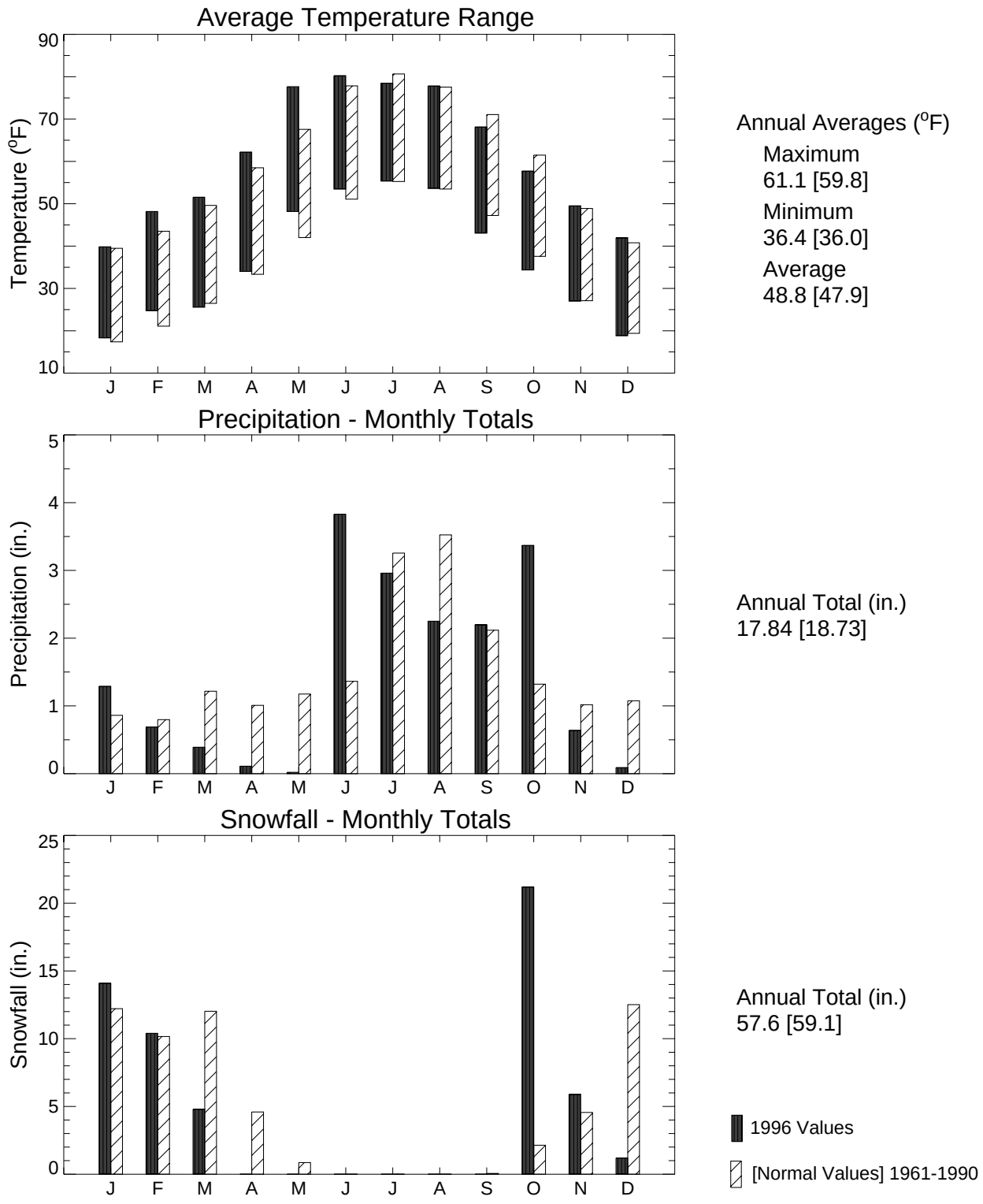

Figure 4-15. 1996 weather summary for Los Alamos (TA-6 station, elevation 7,424 ft.).

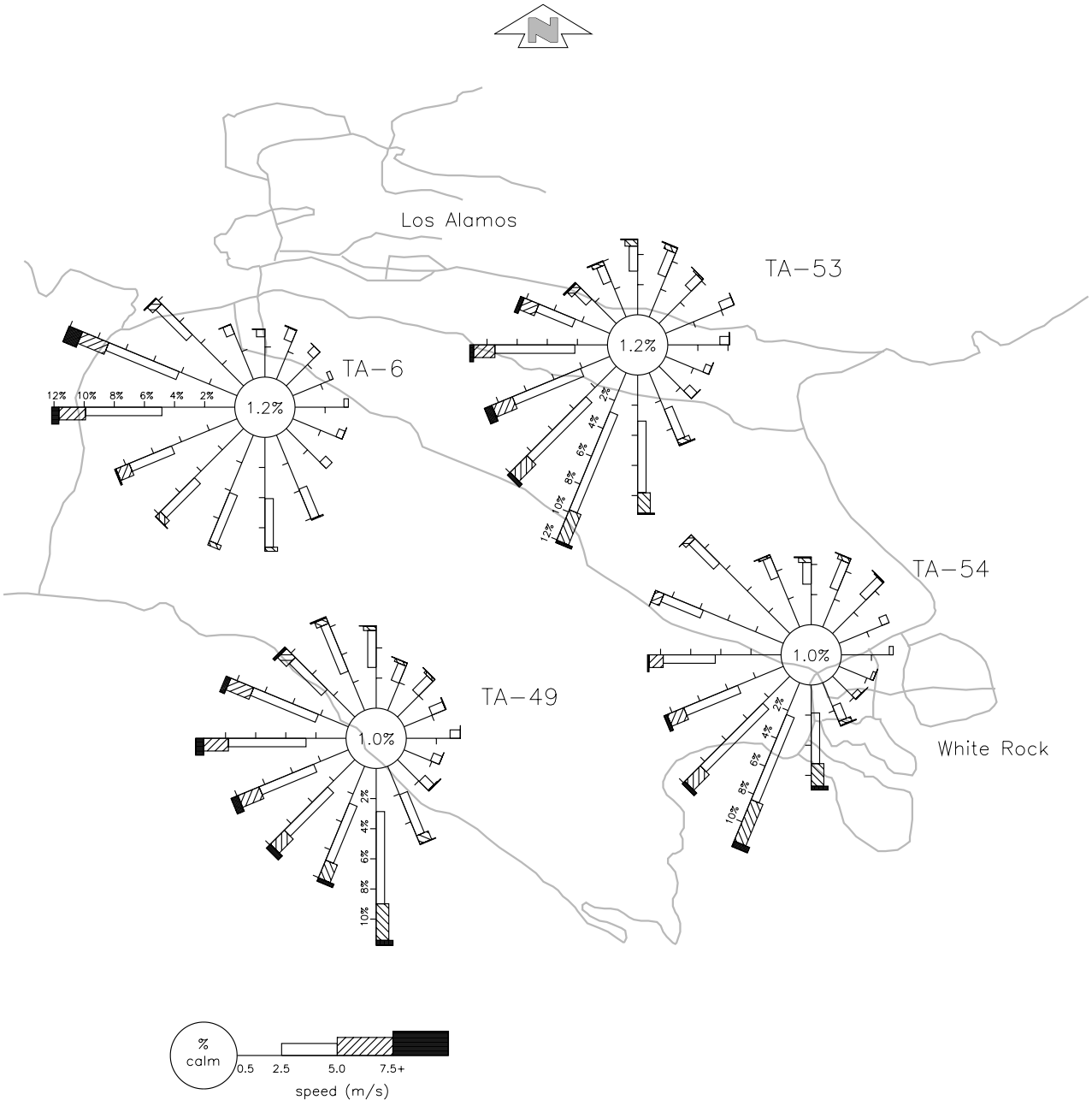

Figure 4-16. Wind roses for daytime and nighttime winds observed at 11 m (36 ft) at TA-6, TA-49, TA-53, and TA-54 for 1996.

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5. Surface Water, Groundwater, and Sediments

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Highlights from 1996

The 1996 analysis results for the surface water program are consistent with past findings. The most notable observation for 1996 was a finding of low levels of high explosives in Frijoles Canyon at the Bandelier National Monument Headquarters. High explosives were also detected in Water Canyon below Technical Area 16. Gaging stations with automated samplers have recently been installed at numerous locations around the Los Alamos National Laboratory (LANL or the Laboratory). Beginning in 1996, environmental surveillance runoff samples are collected using the automated samplers. The samplers are actuated when a significant precipitation event causes flow in a drainage crossing the Laboratory's eastern or western boundaries. The sample collected on October 11, 1996, from the bank at the Rio Grande at Otowi contained americium-241 and plutonium-238 at levels close to the detection limits. 1995 sampling results indicated low levels of americium-241 at this station. These samples may reflect the presence of flood plain deposits from Los Alamos Canyon north of the current channel. Storm water runoff samples collected at Cañada del Buey at White Rock and Ancho Canyon near Bandelier contained unusually high uranium levels. Most of the uranium was present in the suspended sediments. The concentration in the suspended sediments was within the range of background uranium in Bandelier Tuff.

Groundwater sample results from the main aquifer were consistent with previous years' results. Results from water supply wells are discussed separately. Trace levels of tritium are present in test wells in a few areas where former or present liquid waste discharges occurred, notably beneath Los Alamos, Pueblo, and Mortandad Canyons. The highest main aquifer tritium level is about 2% of the drinking water standard and poses no health risk according to the US Public Health Service. Continued special sampling of test wells in which possible strontium-90 detections occurred in 1994 shows no detectable levels, suggesting that the 1994 values may not have been true detections. Nitrate (as nitrogen) levels in a test well beneath Pueblo Canyon continue to be high, but in 1996 were only about half the drinking water standard. Analysis results for alluvial and intermediate depth groundwaters are similar to those of past years. Waters near former or present effluent discharge areas show the effects of these discharges; however, radionuclide activities are below Department of Energy dose concentration guidelines for public exposure.

Analytical results from the 1996 sediment samples are consistent with historical data. The majority of the sediment samples collected outside known radioactive effluent release areas were within background levels that reflect worldwide fallout. Many sediment samples from known radioactive effluent release areas, including Acid/Pueblo, DP/Los Alamos, and Mortandad Canyons, exceeded worldwide fallout levels for tritium, strontium-90, cesium-137, plutonium, and americium-241, and alpha, beta, and gamma activities. Sediments from Mortandad Canyon sampling stations at GS-1, MCO-5, and MCO-7 showed cesium-137 values that exceeded screening action levels; however, these results are consistent with previously reported values. Results of the radiochemical analyses of the large 1 kg samples collected in 1996 from Heron, El Vado, Abiquiu, Cochiti, and Rio Grande Reservoirs are also similar to those from previous years. All of these sample results were below their respective background levels except for some of the Cochiti Reservoir samples. Samples from the upper, middle, and lower sediment stations in Cochiti Reservoir showed possible detections of strontium-90; while the sample from the middle station showed elevated levels for cesium-137, plutonium-238, and plutonium-239, -240 radioactivity.

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5. Surface Water, Groundwater, and Sediments

A. Description of Monitoring Program

Studies related to development of groundwater supplies began at Los Alamos in 1945 and 1946 under the direction of the US Geological Survey (USGS). Studies specifically aimed at environmental monitoring and at protecting groundwater quality were initiated as joint efforts between the Atomic Energy Commission (AEC), the Los Alamos Scientific Laboratory, and the USGS in about 1949. These initial efforts were focused on Pueblo and DP/Los Alamos Canyons, which received radioactive industrial waste discharges in the early days of the Laboratory.

The current network of annual sampling stations for surface water and sediment surveillance includes a set of regional (or background) stations and a group of stations near or within the Los Alamos National Laboratory (LANL or the Laboratory) boundary. The regional stations are used to evaluate the background quantities of radionuclides and radioactivity derived from natural rock-forming minerals and from fallout affecting northern New Mexico and southern Colorado. Groundwater samples are taken from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo of San Ildefonso. The on-site stations are for the most part focused on areas of present or former radioactive waste disposal operations, particularly canyons (Figure 1-3). To provide context for discussion of monitoring results, the setting and operational history of currently monitored canyons that have received radioactive or other liquid discharges are briefly summarized below. These canyons have been the subject of numerous studies to evaluate environmental and health effects of Laboratory operations, as well as continual surveillance monitoring since the early days of the Laboratory, and are a high priority for remedial work by the Environmental Restoration (ER) Project. These descriptions are not intended as a complete inventory of past Laboratory discharges.

1. Acid Canyon, Pueblo Canyon, and Lower Los Alamos Canyon

Acid Canyon, a small tributary of Pueblo Canyon, was the original disposal site for liquid wastes generated by research on nuclear materials for the World War II Manhattan Engineer District atomic bomb project. Acid Canyon received untreated radioactive industrial effluent from 1943 to 1951. The Technical Area (TA) 45 treatment plant was completed in 1951, and from 1951 to 1964, discharged treated effluents that contained residual radionuclides. Most of the residual radioactivity from these releases is now associated with the sediments in Pueblo Canyon. Based on analysis of radiological sediment survey data using arithmetic means, the estimated total plutonium inventory in Acid Canyon, Pueblo Canyon, and Lower Los Alamos Canyon is about 630 ± 300 mCi; using geometric means, the value is 246 mCi (ESG 1981). The estimated plutonium releases were about 177 mCi, in satisfactory agreement with the plutonium inventory considering uncertainties in sampling and release estimates. About two-thirds of this total is in the Department of Energy (DOE)–owned portion of lower Pueblo Canyon. Several studies (ESG 1981, Ferenbaugh et al., 1994) have concluded that the plutonium does not present a health risk to the public.

Pueblo Canyon currently receives treated sanitary effluent from the Los Alamos County Bayo Sewage Treatment Plant in the middle reach of Pueblo Canyon. Water occurs seasonally in the alluvium, depending on the volume of surface flow from snowmelt, thunderstorm runoff, and sanitary effluents. Tritium, nitrate, and chloride, apparently derived from these industrial and municipal disposal operations, have infiltrated to the intermediate perched groundwater (at depths of 37 to 58 m [120 to 190 ft]) and the main aquifer (at a depth of 180 m [590 ft]) beneath the lower reach of Pueblo Canyon. Except for occasional nitrate values, levels of these constituents are a small fraction of the Environmental Protection Agency (EPA) drinking water standards.

Increased discharge of sanitary effluent from the county treatment plant, starting in 1990, resulted in nearly continual flow during most months except June and July in the lower reach of Pueblo Canyon and across DOE land into the lower reach of Los Alamos Canyon on Pueblo of San Ildefonso land. From mid-June through early August, higher evapotranspiration and the diversion of sanitary effluent for golf course irrigation eliminate flow from Pueblo Canyon into Los Alamos Canyon. Hamilton Bend Spring, which in the past discharged from alluvium in the lower reach of Pueblo Canyon, has been dry since 1990, probably because there was no discharge from the older, abandoned Los Alamos County Pueblo Sewage Treatment Plant. Farther east, the alluvium is continuously saturated, mainly because of infiltration of effluent from the Los Alamos County Bayo Sewage Treatment Plant. Effluent flow from Pueblo Canyon into Los Alamos Canyon generally extends to somewhere between the DOE/Pueblo of San Ildefonso boundary and the confluence of Guaje and Los Alamos canyons.

2. DP Canyon and Los Alamos Canyon

In the past, Los Alamos Canyon received treated and untreated industrial effluents containing some

radionuclides. In the upper reach of Los Alamos Canyon there were releases of treated and untreated radioactive effluents during the earliest Manhattan Project operations at TA-1 (late 1940s) and some release of water and radionuclides from the research reactors at TA-2. Los Alamos Canyon also received discharges containing radionuclides from the sanitary sewage lagoon system at the Los Alamos Neutron Science Center (LANSCE) at TA-53. The low-level radioactive waste stream was separated from the sanitary system at TA-53 in 1989 and directed into a total retention evaporation lagoon. An industrial liquid waste treatment plant that served the old plutonium processing facility at TA-21 discharged effluent containing radionuclides into DP Canyon, a tributary to Los Alamos Canyon, from 1952 to 1986.

The reach of Los Alamos Canyon within the Laboratory boundary presently carries flow from the Los Alamos Reservoir (west of the Laboratory), as well as National Pollutant Discharge Elimination System (NPDES)–permitted effluents from TA-2, TA-53, and TA-21. Infiltration of NPDES-permitted effluents and natural runoff from the stream channel maintains a shallow body of groundwater in the alluvium of Los Alamos Canyon within the Laboratory boundary west of State Road 4. Groundwater levels are highest in late spring from snowmelt runoff and in late summer from thundershowers. Water levels decline during the winter and early summer when runoff is at a minimum. Alluvial perched groundwater also occurs in the lower portion of Los Alamos Canyon on the Pueblo of San Ildefonso lands. This alluvium is not continuous with the alluvium within the Laboratory.

3. Sandia Canyon

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives water from the cooling tower at the TA-3 power plant and treated effluents from the TA-46 Sanitary Wastewater Systems Consolidation (SWSC) plant. These effluents support a continuous flow in a short reach of the upper part of the canyon, but only during summer thundershowers does stream flow reach the Laboratory boundary at State Road 4 and only during periods of heavy thunderstorms or snowmelt does surface flow from Sandia Canyon extend beyond the Laboratory boundary.

4. Mortandad Canyon

Mortandad Canyon has a small drainage area that heads at TA-3. Its drainage area presently receives inflow from natural precipitation and a number of NPDES-permitted effluents, including one from the radioactive Liquid Waste Treatment Facility at TA-50. The TA-50 facility began operations in 1963. The TA-50 effluents infiltrate the stream channel and maintain a saturated zone in the alluvium extending about 3.5 km (2.2 mi) downstream from the outfall. The easternmost extent of saturation is on-site, about 1.6 km (1 mi) west of the Laboratory boundary with the Pueblo of San Ildefonso. In addition to residual radionuclides, the effluent contains nitrates that often cause groundwater concentrations to exceed the New Mexico groundwater standard of 10 mg/L (nitrate as nitrogen). The groundwater standard applies because the TA-50 effluent infiltrates the alluvium in the canyon. In order to address these problems, the Laboratory is working to upgrade the TA-50 treatment process.

Continuous surface flow across the drainage has not reached the Pueblo of San Ildefonso boundary since observations began in the early 1960s (Stoker et al., 1991). Three sediment traps are located about 3 km (2 mi) downstream from the effluent discharge in Mortandad Canyon to dissipate the energy of major thunderstorm runoff events and settle out transported sediments. From the sediment traps, it is approximately another 2.3 km (1.4 mi) downstream to the Laboratory boundary with the Pueblo of San Ildefonso.

The alluvium is less than 1.5 m (5 ft) thick in the upper reach of Mortandad Canyon and thickens to about 23 m (75 ft) at the easternmost extent of saturation. The saturated portion of the alluvium is perched on weathered and unweathered tuff and is generally no more than 3 m (10 ft) thick. There is considerable seasonal variation in saturated thickness, depending on the amount of runoff experienced in any given year (Stoker et al., 1991). Velocity of water movement in the perched alluvial groundwater ranges from 18 m/day (59 ft/day) in the upper reach to about 2 m/day (7 ft/day) in the lower reach of the canyon (Purtymun 1974 and Purtymun et al., 1983). The top of the main aquifer is about 290 m (950 ft) below the perched alluvial groundwater.

5. Pajarito Canyon

In Pajarito Canyon, water in the alluvium is perched on the underlying tuff and is recharged mainly through snowmelt, thunderstorm runoff, and some NPDES-permitted effluents. Three shallow observation wells were constructed in 1985 as part of a compliance agreement 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; the alluvial perched groundwater was found

to be contained in the canyon bottom and did not extend under the mesa (Devaurs 1985).

6. Cañada del Buey

Cañada del Buey contains a shallow alluvial perched groundwater system of limited extent. The thickness of the alluvium ranges from 1.2 to 5 m (4 to 17 ft), but the underlying weathered tuff ranges in thickness from 3.7 to 12 m (12 to 40 ft). In 1992, saturation was found within only an 0.8-km (0.5-mi) long segment, and only two observation wells have ever contained water (ESP 1994). The apparent source of the saturation is purge water from nearby municipal water supply well PM-4, as the alluvium is dry upstream of the purge water entry point. Because treated effluent from the Laboratory's SWSC project 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 (ESP 1994). Construction of the SWSC project was completed in late 1992.

B. Surface Water Sampling

1. Introduction

Surface waters from regional and Pajarito Plateau stations are monitored to evaluate the environmental effects of LANL operations. There are no perennial surface water flows that extend completely across the Laboratory in any of the canyons. Periodic natural surface runoff occurs in two modes: (1) spring snowmelt runoff that occurs over highly variable periods of time (days to weeks) at a low discharge rate and sediment load, and (2) summer runoff from thunderstorms that occurs over a short period of time (hours) at a high discharge rate and sediment load. None of the surface waters within the Laboratory are a source of municipal, industrial, or irrigation water. The waters are used by wildlife. Concentrations of radionuclides in surface water samples may be compared to either the DOE-Derived Concentration Guides (DCGs) or the New Mexico Water Quality Control Commission (NMWQCC) stream standards, which reference the New Mexico Health and Environment Department Environmental Improvement Division's New Mexico Radiation Protection Regulations (part 4, Appendix A). However, New Mexico radiation levels are in general two orders of magnitude greater than the DOE DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC General, and Livestock Watering stream standards. The NMWQCC groundwater standards can also be applied in cases where groundwater discharge may affect stream water quality.

2. Monitoring Network

Two types of surface water samples are collected from regional stations and Pajarito Plateau stations surrounding the Laboratory. Surface water grab samples are collected annually from locations where effluent discharges or spring flows maintain stream flow. Runoff samples have historically been collected as grab samples during or shortly after precipitation events. As of 1996, runoff samples are collected using gaging stations with automated samplers (Shaull et al., 1996). Samples are collected when a significant precipitation event causes flow in a drainage crossing the Laboratory's eastern or western boundaries.

Regional surface water samples (Figure 5-1) were collected from five stations on the Rio Grande and the Jemez River. These waters provide background data from areas beyond the Laboratory boundary. Historically, samples have been collected at stations on the Rio Grande at Embudo, Otowi, Frijoles Canyon, Cochiti, and Bernalillo. In 1996, the stations on the Rio Grande at Embudo and Bernalillo and the station on the Rio Chama were not collected.

Surface water monitoring stations located on the Pajarito Plateau are shown in Figure 5-2. The stations monitor water quality effects of past or potential contaminant sources such as industrial or NPDES outfalls and effects of nonpoint sources, including possible soil contamination sites.

3. Radiochemical Analytical Results

The results of radiochemical analyses for surface water samples for 1996 are listed in Tables 5-1 and 5-2. All of these analytical results are below the DOE DCGs for public dose. The majority of the results are near or below the detection limits of the analytical methods used and are below the DOE DCGs for drinking water systems except for samples from Mortandad at GS-1 (plutonium-239, -240 and americium-241). Most of the measurements at or above detection limits are from locations with previously known contamination: Acid/Pueblo Canyon, DP/Los Alamos Canyon, and Mortandad Canyon.

Tables 5-3 and 5-4 contain lists of radionuclides detected in water samples and of possible detections, according to criteria discussed in Section 5.F.4. Because uranium, gross alpha, and gross beta are ubiquitous at detectable levels, occurrences of these

measurements above significant levels (chosen to be below the EPA maximum contaminant levels [MCLs] or screening levels) are reported. The specific values are 5 μg/L for uranium, 10 pCi/L for gross alpha, and 40 pCi/L for gross beta.

A few of the measurements at or above detection limits were from locations that do not typically show detectable activity. Detections from locations outside the known contaminated areas in Pueblo, DP/Los Alamos, and Mortandad Canyons are discussed below.

a. Radiochemical Analytical Results for Surface Water. In 1995 and 1996, samples collected at the Rio Grande at Otowi and the Rio Grande at Frijoles were collected from the bank and as a width integrated sample collected from a transect across the river. Historically, samples have only been collected from the bank. The bank samples have been collected from the western bank of the river. The Rio Grande at Otowi sample is taken upstream of Los Alamos Canyon and was expected to show no Laboratory-derived contamination. The analytical result from a water sample collected there on May 9, 1995, showed americium-241 at levels of 0.054 ± 0.017 pCi/L. A sample collected on September 15, 1995, at the same location contained americium-241 at 0.05 ± 0.03 pCi/L, a questionable result because of higher uncertainty. The sample collected on October 11, 1996, from the bank at the Rio Grande at Otowi contained americium-241 levels of 0.068 ± 0.028 pCi/L and plutonium-238 levels of 0.110 ± 0.027 pCi/L, both regarded as possible detections at 2.33 times the uncertainty (σ). (See Section 5.F.4. for an explanation of the 2.33 σ and 4.66 σ screening level.) Gross beta in the 1996 sample further suggests the presence of low levels of radionu-clides. With the exception of the gross beta value, these measurements are all very close to the detection limits, and none exceed any standards. None of these mea-surements meet the 4.66 σ detection criteria (except gross beta) but the repeated observation of contamina-tion suggests that there may be a low level source.

Graf (1993) indicates a flood plain deposit from Los Alamos Canyon just south of the Otowi Bridge along the west bank of the Rio Grande. The flood occurred in either 1958 or 1967. The presence of this deposit and the absence of radionuclides in the width-integrated sample are consistent with a LANL source. However, plutonium and americium are both present in worldwide fallout. The activities measured in these samples are so close to the detection limits that it is difficult to determine if these samples represent Laboratory influence, fallout, or random fluctuations in the detection limit.

Strontium-90 was a possible detection in the Jemez River at 3.2 ± 1.0 pCi/L. There is no obvious source of strontium-90 above this location except fallout. Past sampling at this location has shown no detections of strontium-90.

There were possible detections of americium-241 (0.056 ± 0.020 pCi/L) and plutonium-239, -240 (0.044 ± 0.016 pCi/L) at SCS-3 in Sandia Canyon and a detection of tritium (719 ± 80 pCi/L) at SCS-1. High gross gamma readings were also observed at SCS-2. Most of the values were very close to detection limits and were regarded as possible detections or detections because of low uncertainties associated with the measurements. There have been occasional detections of low levels of plutonium and americium in Sandia Canyon in the past.

Americium-241 was detected (0.055 ± 0.017) in surface water at Cañada del Buey in 1995. No sample was collected at this location in 1996 because there was no water at the station.

There was a detection of americium-241 at Frijoles Canyon at the Bandelier National Monument Head-quarters, slightly above the 4.66 σ level, (0.17 ± 0.035 pCi/L) from a sample collected on June 2, 1995. Two subsequent samples showed no detectable radiation.

b. Radiochemical Analytical Results for Runoff. Automated samplers were used to collect runoff samples whenever precipitation events caused significant runoff at the Laboratory boundaries. See Section 5.F.1 for a description of the runoff samplers and sampling protocols.

The distribution of contaminants between the dissolved and suspended phases was measured by filtering a sample and analyzing the filtrate and the portion retained by the filter. Total activity and the percent dissolved are reported at the bottom of Table 5-2. The total activity is the sum of dissolved activity and the suspended concentration. The suspended activity is converted to a per volume activity using the suspended sediment value. The value reported as the percent dissolved represents the fraction of contami-nants that passed through a 0.45 micron filter. If more than one analysis was performed, the average of the values is reported for the total.

The samples collected at Los Alamos Canyon near Los Alamos were inadvertently analyzed unfiltered, and only the total activity is reported. The total activity includes the radionuclides associated with the suspended sediments. Possible detections of cesium-137; plutonium-238; and detectable levels of strontium-90; americium-241; and plutonium-239, -240 were observed in runoff in Los Alamos Canyon and were consistent with earlier findings.

In 1996, there was a possible detection of cesium-137 (3.3 ± 1.3 pCi/L) in the runoff sample collected at Ancho Canyon near Bandelier (Table 5-4). Strontium-90 was below detection limits in this sample but was detected (50.9 pCi/L) in runoff collected in 1995.

The total concentration of uranium in the runoff sample collected at Cañada del Buey near White Rock (25.3 ± 1.0 µg/L) exceeded the proposed EPA Primary Drinking Water Standard of 20 µg/L. The total concentration of uranium in the sample collected at Ancho Canyon near Bandelier (31.5 ± 1.1 µg/L) exceeded the proposed EPA Primary Drinking Water Standard (20 µg/L) and the DOE Drinking Water System DCG (30 µg/L). In these two samples, one and five percent, respectively, of the uranium was in the dissolved fraction. Both of these standards are established to protect potable water supplies and are not applicable to surface water runoff. The standards are mentioned here only to provide some perspective on the numbers. The levels of uranium in the dissolved fraction are well below standards.

Background concentrations of uranium in Bandelier Tuff range from 2 to 8 mg/kg (Longmire et al., 1996). The average concentrations of uranium in the runoff samples collected at Cañada del Buey near White Rock and Ancho Canyon near Bandelier were 2.8 and 6.5 mg/kg. This suggests that the uranium found in these samples may be naturally occurring in the Bandelier Tuff.

c. Technical Area 50 Discharges. The cumulative discharge of radionuclides from the TA-50 radioactive liquid waste treatment facility into Mortandad Canyon between 1963 and 1977, and yearly discharge data for 1994 through 1996 are given in Table 5-5. In addition to total annual activity released for 1994 through 1996, Table 5-5 also shows mean annual activities in effluent for each radionuclide, and the ratio of this activity to the DCG. In 1996 the DCG was exceeded for americium-241 and for plutonium-238. For 1996 the effluent nitrate concentration exceeded the New Mexico groundwater standard of 10 mg/L (nitrate as nitrogen).

d. Ingestion of Water from the Technical Area 50 Effluent and the Stream Below the Outfall. Table 5-6 presents the summary of the committed effective dose equivalent (CEDE) from the ingestion of water collected in 1996 from the TA-50 effluent. A surface water sample was collected at GS-1 in Mortandad Canyon and is used to estimate the CEDE for someone consuming water from the stream below the outfall. Because no water is derived from Mortandad Canyon for drinking, industrial, or agricultural purposes, comparisons with the standards for drinking water are inappropriate and were not made. The CEDEs provided below are based on a per liter of water intake and an exercise scenario where a jogger or hiker drinks from the TA-50 effluent or the stream directly below the outfall.

By providing the CEDE on a per liter basis, the reader is able to determine his or her own level of intake of water from these sources and multiply this intake by the CEDE figures provided in the table. The total CEDE on a per liter intake basis for these sources is 1.2 mrem and 0.048 mrem per liter of water consumed from the TA-50 effluent and the stream directly below the outfall, respectively. The radionuclides that contributed more than 5% to the CEDE are plutonium-238, plutonium-239, and americium-241.

Using an exercise scenario and an hourly intake rate of 0.3 ± 0.3 L/h (McNall 1974), the maximum amount of water consumed per year from each source is 16.1 L. The total CEDE for this scenario using this consumption rate is 19 mrem and 0.77 mrem for the TA-50 effluent and the stream directly below the outfall, respectively. The radionuclides that contributed more than 5% to these CEDEs are plutonium-238; plutonium-239, -240; and americium-241.

4. Nonradiochemical Analytical Results

a. Major Chemical Constituents. The results of major chemical constituents analyses in surface water and runoff samples for 1996 are listed in Tables 5-7 and 5-8, respectively. The results are generally consistent with those observed in previous years, with some variability. The measurements in waters from areas receiving effluents show the effects of these effluents. None of the results exceed standards except for some pH measurements above 8.5.

b. Trace Metals. The results of trace metal analyses on surface water and runoff samples for 1996 are listed in Tables 5-9 and 5-10, respectively. The levels are generally consistent with previous observations. As with the radiochemical samples, samples were collected from the bank and as width-integrated samples at the Rio Grande at Otowi and the Rio Grande at Frijoles.

In 1995, the EPA action level (15 µg/L) was exceeded for lead at the Rio Grande at Frijoles for the width-integrated sample. The sample collected from the bank showed a lead concentration a factor of three lower than the width-integrated sample. Both the width-integrated and the bank samples collected at the Rio Grande at Frijoles in 1996 were at or below the detection limits for lead.

In 1995, a barium concentration of 520 µg/L was measured in the sample collected at Water Canyon at Beta, compared to a NMWQCC groundwater limit of 1,000 µg/L. This sample also had an elevated level of nitrates. The presence of these contaminants and the proximity of the sample location to TA-16 suggested high explosives contamination. The sample collected at Water Canyon at Beta in 1996 also contains levels (about 400 mg/L) of barium that are higher than those normally observed in surface water on the Pajarito Plateau. Analyses confirm the presence of high explosives at Water Canyon at Beta (see discussion in Section 5.B.4.d).

In 1996, runoff samples collected at Cañada del Buey near White Rock and Ancho Canyon near Bandelier contained similarly high levels of barium (480 and 810 µg/L, respectively). No high explosives were detected in either of these samples.

In 1995, the NMWQCC groundwater limit was apparently exceeded for silver at all three stations in Sandia Canyon (SCS-1, SCS-2, and SCS-3), but high uncertainties associated with those measurements cast doubt on this conclusion. In 1996, no surface water samples exceeded standards for silver with all measurements below or near detection limits.

The analytical detection limit (0.2 µg/L) is not adequate to determine if mercury is present in excess of the New Mexico Wildlife Habitat stream standard of 0.012 µg/L. In 1996, mercury was not observed above the detection limit (0.2 µg/L) at any location with the exception of a measurement of 0.3 µg/L for one of two measurements in DP Canyon at DPS-4. The other measurement found the concentration to be below the detection limit.

Aluminum, iron, and manganese concentrations exceed EPA secondary drinking water standards at most locations. The results reflect the presence of suspended solids in the water samples. Because the metals analyses are performed on unfiltered water samples, the results are due to naturally occurring metals (e.g., aluminum, iron, and manganese), which comprise the suspended solids.

Lead values (17 and 45 µg/L) above the EPA action level (15 µg/L) were found in the runoff samples collected at Los Alamos Canyon near Los Alamos. This is the station just upstream of State Road 4 in Los Alamos Canyon. Because of a miscommunication with the analytical laboratory, both analyses were performed on turbid, unfiltered samples. The EPA action limit is not applicable to these sorts of samples but is provided here for perspective. A more appropriate standard, the New Mexico Livestock Watering Limit, is 100 µg/L.

Measurable selenium concentrations were reported for surface waters in 1996. Typically, selenium has not been detected in surface waters on the Pajarito Plateau. These selenium values are not attributed to analytical method changes. Selenium values exceeded the New Mexico Wildlife Habitat Stream Standard (2 µg/L) at numerous locations around the Laboratory. The highest selenium value (18 µg/L) was reported at Pueblo 3 below the Bayo Treatment Plant discharge (Table 5-9).

c. Organics. The locations where organics samples were collected in 1996 are summarized in Table 5-11. Table 5-12 summarizes the organic constituents detected in 1996. (See Section 5.F.2.c. for analytical methods and analytes.) Most of the organic compounds detected in surface waters were tentatively identified compounds (TICs). The number of TICs reported by the analytical laboratory are recorded on Table 5-11. The individual results for TICs are not reported. Phthalates were also measured at numerous locations. Phthalates are common analytical laboratory contaminants.

High explosives were detected at Water Canyon at Beta and at Frijoles at Bandelier Monument Headquarters.

5. Long-Term Trends

Long-term trends of the activity of tritium and total plutonium in surface water in Mortandad Canyon are depicted in Figure 5-3. These measurements were made on samples collected at the station Mortandad at GS-1, which is a short distance downstream of the TA-50 effluent discharge into Mortandad Canyon. Samples collected before 1996 were preserved in the field and filtered through a 0.45-micron filter in the laboratory. The 1996 measurements represented the total (unfiltered) activity. Plutonium values for 1962 to 1966 are for plutonium-239, -240 only. Plutonium-238 was not recorded for those years. If more than one sample is collected in a year, the average value for the year is plotted. In general, there has been a decrease in the combined levels of plutonium-238 and plutonium-239, -240 during the period. All plutonium values exceed the detection limit of 0.04 pCi/L; all tritium activities exceed the detection limit of 700 pCi/L except for a sample collected in April 1988.

C. Sediment Sampling

1. Introduction

Sediment transport associated with surface water runoff is a significant mechanism for contaminant

movement. Contaminants originating from airborne deposition, effluent discharges, or unplanned releases can become attached to soils or sediments by adsorption or ion exchange. Accordingly, sediments are sampled in all canyons that cross the Laboratory, including those with either perennial or ephemeral flows. Furthermore, sediments from five regional reservoirs are sampled annually. Routine laboratory analyses for sediment samples include measurements for radioactivity, trace metals, organic compounds, and high-explosive (HE) residuals.

There are no federal or state regulatory standards for soil or sediment contaminants that can be used for direct comparison with analytical surveillance data. Instead, contaminant levels in sediments may be interpreted in terms of toxicity to humans, assuming the contaminated particles are either ingested or inhaled. The data can also be compared to levels attributable to worldwide fallout or natural background levels. Results of radionuclide analyses of sediment samples from regional stations collected annually from 1974 through 1986 were used to establish statistical limits for worldwide fallout levels (Purtymun et al., 1987). In addition, natural background levels have been established for total uranium in northern New Mexico. Fallout levels of radioactivity in sediments have also been established for tritium; strontium-90; cesium-137; uranium; plutonium-238; plutonium-239, -240; americium-241; and for gross alpha, gross beta, and gross gamma activity for the period 1974 to 1996 (McLin and Lyons 1997). The average activity level for each analyte in these samples, plus twice its standard deviation, has been adopted as an indicator of the approximate upper limit for worldwide fallout or natural background activity.

Screening action levels (SALs) are used by the Laboratory's ER Project to identify the presence of contaminants at levels of concern. SAL values are derived from toxicity values and exposure parameters using data from the EPA. Both background activity and SAL values for sediments are listed in tables summarizing analytical results.

Sediments in portions of Pueblo, Los Alamos, and Mortandad Canyons have been affected to varying degrees by contaminant releases from the Laboratory. These canyons have activities of radioactivity in sediments at levels that are significantly higher than levels attributable to worldwide fallout or natural background sources. In Mortandad Canyon, the bulk of contaminated sediments have not moved off-site because three sediment traps have prevented sediments from moving towards the eastern Laboratory boundary. Some of these radionuclides, however, may have migrated off-site onto Pueblo of San Ildefonso lands. Some radioactivity associated with sediments from Pueblo and Los Alamos Canyons has also moved off-site into the Rio Grande.

2. Monitoring Network

Sediment samples are collected from regional stations and Pajarito Plateau stations surrounding the Laboratory. Regional sediment sampling stations (Figure 5-1) are located within northern New Mexico and southern Colorado at distances up to 200 km (124 mi) from the Laboratory. Samples from regional stations provide a basis for determining conditions beyond the influence of Laboratory operations, such as background radionuclide concentrations resulting from fallout. Stations on the Pajarito Plateau (Figures 5-4 and 5-5) are located within about 4 km (2.5 mi) of the Laboratory boundary. They document conditions in areas potentially affected by Laboratory operations.

During 1996, sediment samples were collected from 24 regional and 68 Pajarito Plateau stations. Of the 24 regional samples, 9 are from rivers and 15 from the upper, middle, and lower portions of 5 regional reservoirs. These regional reservoirs include El Vado, Heron, and Abiquiu Reservoirs on the Rio Chama; Cochiti Reservoir on the Rio Grande; and Rio Grande Reservoir on the Rio Grande in southern Colorado.

Of the 68 Pajarito Plateau samples, 21 are specifically related to waste storage sites. Many of the sediment sampling stations on the Pajarito Plateau are located within canyons to monitor sediment transport that is possibly related to past or present effluent release sites. Fifteen plateau samples were collected from San Ildefonso Pueblo.

Sediments from drainages around two radioactive solid waste management areas are sampled. Nine sampling stations were established in 1982 outside the perimeter fence at TA 54, Area G (Figure 5-5a) to monitor possible transport of radionuclides by sheet erosion from the active waste storage and disposal area. From 1959 to 1961, hydronuclear experiments were conducted in underground shafts beneath the surface of the mesa at TA-49, designated Solid Waste Management Area AB (Purtymun and Stoker 1987, ESP 1988). Eleven stations were established in 1972 to monitor surface sediments in drainages surrounding the experimental area at TA-49 (Figure 5-5b). Another station (AB-4A) was added in 1981 as the surface drainage changed.

3. Radiochemical Analytical Result and Dose Equivalents for Sediments

a. Radiochemical Analytical Results. The results of radiochemical analyses of sediment samples collected during 1996 are listed in Table 5-13. Individual analytes that met detection criteria and are above background levels are also summarized in Tables 5-14 and 5-15. Results from the 1996 sediment samples are consistent with previous years' results. The majority of the sediment samples collected outside known radioactive effluent release areas were within background levels that reflect worldwide fallout (Purtymun et al., 1987 and McLin and Lyons 1997a). Many sediment samples from known radioactive effluent release areas, including Acid/Pueblo, DP/Los Alamos, and Mortandad Canyons, exceeded worldwide fallout levels for numerous constituents, including tritium, strontium-90, cesium-137, plutonium, and americium-241 radioactivity, and alpha, beta, and gamma activities. These observed levels are consistent with historical data. Three sediment samples from stations GS-1, MCO-5, and MCO-7 in Mortandad Canyon showed cesium-137 concentration levels that exceeded the SAL value. During 1996, no other sediment samples showed any values that exceeded respective SAL values, although reported values from stations GS-1 and MCO-5 were relatively high for tritium; plutonium-238; plutonium-239, -240; and americium-241 (that is, more than 100 times greater than background levels). These elevated values for radionuclides are consistent with historical values and reflect TA-50 effluent discharges into Mortandad Canyon since 1963.

At TA-54, Area G, a number of stations exceeded background levels for plutonium-238 and plutonium-239, -240. At TA-49, Area AB, a number of sediment stations showed above-background values for cesium-137; plutonium-238; plutonium-239, -240; and americium-241. These areas are known Laboratory contamination areas, and all of the reported values are consistent with earlier observations from these same stations.

In the samples from the regional stations, the sample from the Rio Grande at Otowi showed a possible detection strontium-90 value above background. This reported value could have originated from Laboratory contaminated sediment deposits within lower Los Alamos Canyon. These deposits may have been redistributed during snowmelt runoff resulting from backwater flooding effects from the Rio Grande. In future sampling efforts, the sediment station on the Rio Grande at Otowi will be relocated farther upstream so that possible backwater contamination effects are eliminated. The sample from the Rio Grande at Frijoles also showed a possible elevated strontium-90 value. However, all of these variations are consistent with data from previous years. None of the other Rio Grande sediment stations located between Otowi Bridge and Frijoles Canyon were sampled during 1996.

None of the Pajarito Plateau stations that are outside known contamination areas showed values above background for tritium, total uranium, plutonium-238, americium-241 radioactivity or for gross alpha, gross beta, or gross gamma activity. However, the sediment stations for Mortandad at MCO-9 and Mortandad at MCO-13 (A-5) showed above-background values for cesium-137 and plutonium-239, -240. Finally, the sediments from stations located above Ancho Spring and Frijoles at the Rio Grande showed possible detection of strontium-90 values above background. Frijoles at the Rio Grande also showed detections of cesium-137 and total uranium values that were above background. This station may have also been subjected to backwater flooding effects from the Rio Grande during 1996; therefore, in the future, this station will be located farther upstream in Frijoles Canyon. All of these possible detection values may be related to multiple sources, including natural variability, atmospheric fallout, surface deposition from air stack emissions, or surface transport from various Laboratory sources.

Results of the radiochemical analyses of the large 1-kg samples collected in 1996 from Heron, El Vado, Abiquiu, Cochiti, and Rio Grande Reservoirs are similar to those from previous years. All of these sample results were below their respective background levels except for some of the Cochiti Reservoir samples. The upper, middle, and lower sediment stations in Cochiti Reservoir showed possible detections of strontium-90, but only the middle station showed elevated levels of cesium-137; plutonium-238; and plutonium-239, -240 radioactivity. None of the other reservoir sediment samples exceeded background levels for other radionuclides, as seen in Table 5-13.

The results of the reservoir analyses are best interpreted in conjunction with information from a study by Purtymun et al., (1987) and McLin and Lyons (1997), which provide a regional context for analyses of reservoir sediments. The conclusions of greatest significance for interpreting the current samples from the five reservoirs are: (1) the mean plutonium-238 concentrations from Cochiti Reservoir are significantly higher than corresponding values from Abiquiu, El Vado, Heron, and Rio Grande Reservoirs; (2) the mean plutonium-239, -240 concentrations from Cochiti

Reservoir are significantly higher than corresponding values from Abiquiu, El Vado, and Heron Reservoirs; and (3) Abiquiu and El Vado Reservoirs exhibit significantly lower mean concentrations for strontium-90 than corresponding values from Cochiti Reservoir. These results also suggest that radionuclide deposition from fallout is not homogeneous but varies with differences in weather, altitude, erosion, sediment transport conditions, grain size distribution, total organic content, and cation exchange capacity.

Summary data from reservoir sediment plutonium analyses are shown in a long-term context in Table 5-16. Abiquiu Reservoir historically has had some of the lowest plutonium concentration ranges and isotopic ratios observed, but Cochiti Reservoir has some of the highest. The other sampled reservoirs tend to fall between these two extremes. These data clearly suggest that mean plutonium-238 and plutonium-239, -240 concentration levels are significantly higher in Cochiti Reservoir than in Abiquiu Reservoir. An important question is raised here: Are these differences primarily a result of Laboratory releases or to natural variations in atmospheric fallout? To help answer this question, additional future sediment samples and analyses will be performed in all reservoirs. These samples will be analyzed for radionuclide and metal concentrations, grain size distribution, total organic carbon, cation exchange capacity, and sediment surface area. Small grain sizes and high values for the other parameters enhance the capacity of the sediments to adsorb plutonium and may help explain the large variability in plutonium concentration levels between reservoirs.

b. Dose Equivalents from Exposure to Sediments in Mortandad Canyon. Radioanalytical results for sediments collected from Mortandad Canyon in 1996 were modeled using the RESRAD model, version 5.61 (see Chapter 3). The pathways evaluated are the external gamma pathway from radioactive material deposited in the sediments, the inhalation pathway from materials resuspended by winds, and the soil ingestion pathway. Because water in the canyon is not used for drinking water or irrigation and there are no cattle grazing in the canyon or gardens in the canyon, the drinking water, meat ingestion, and fruit/vegetable ingestion pathways were not considered.

The RESRAD model was run for each sampled location and for the entire canyon system with 10 to 14 samples per analyte collected throughout the canyon. For modeling purposes, it is assumed that the area of interest around each monitored location is 100 m^2, the site is part of an industrial complex where access to the monitored location is somewhat limited and thus the amount of time a person spends in the canyon is limited to approximately 87 hours per year (Robinson and Thomas 1991), and there is no cover material over the site of interest that would reduce external exposure to radionuclides. The input parameters for the RESRAD model are summarized in Table 5-17. RESRAD calculates the daughter radionuclides based on the initial radionuclide concentrations and time since placement of material.

The total effective dose equivalent (TEDE) (i.e., the sum of the effective dose equivalents from the external gamma, and the inhalation and soil ingestion pathways) is presented in Table 5-18. For comparison, the 1995 TEDE for each monitoring location is also shown. The TEDE using the average concentration of all monitoring locations in Mortandad Canyon and using the RESRAD input parameters in Table 5-17 is 6.0 mrem. The error term associated with this average value is extremely large, indicating a high degree of variability in the concentrations throughout the canyon. In 1996, the maximum TEDE (average TEDE plus twice the error term) (Table 5-19) ranged from 0.19 mrem (<0.2% of the DOE 100 mrem public dose limit [PDL]) near the Chemical and Metallurgy Research (CMR) building to 27 mrem (27% of the DOE PDL) at the GS-1 sampling location. This compares to the 1995 range of 0.089 mrem at the A-10 sampling location and 43 mrem at the GS-1 sampling location. The maximum TEDE for monitoring sites surrounding the GS-1 site (i.e., west of GS-1, MCO-5, MCO-7, and MCO-9) increased in 1996 over the 1995 values. These five monitoring locations represent 96% of the 1996 maximum TEDE for the entire canyon system. The only radionuclide that contributed more than 5% to the TEDE at these locations is cesium-137 for each of the five sites. For the other monitoring locations (i.e., near the CMR building, MCO-13 (A-5), A-6, A-7, A-9, and A-11), the naturally occurring radionuclides of uranium, and strontium-90 and cesium-137 from nuclear atmospheric testing contributed more than 5% to the TEDE at these monitoring locations. Averaged over the entire canyon system, cesium-137 and americium-241 contributed more than 5% to the canyon TEDE. The external pathway contributed more than 88% (with the cesium-137 contribution being more than 86%) to the total TEDE for the entire canyon system. Because there is a pathway approximately 3 m from the stream channel and the external component falls off with distance from the source, the estimated TEDE is reduced to approximately 6 mrem in a year (i.e., 2.7 mrem from the external pathway and 3.3 mrem from all other pathways considered).

4. Nonradiochemical Analytical Results

a. Trace Metals. Beginning in 1992, sediments were analyzed for trace metals. Trace metal results for the sediment samples collected in 1996 are presented in Table 5-20. None of the results show any significant accumulations of metals, and results are comparable to previously collected data. Laboratory sample preparation methods for metals analyses changed in 1993. Therefore, the 1992 sediment metals data should not be compared to the 1993 to 1996 metals data because of these differences in laboratory procedures.

Reported detection limits for antimony, mercury, and molybdenum increased from 1992 to 1996 (that is, from about 0.05 to 0.2 mg/kg; 0.01 to 0.1 mg/kg; and 0.30 to 2.0 mg/kg, respectively). These differences were the result of changes in sample preparation procedures. In addition, there was a decrease in the typical channel sediment sample size from 250 mg in 1992 to 125 mg in 1996.

b. Organic Analyses. Beginning in 1993, sediments were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and polychlorinated biphenyls (PCBs). Starting in 1995, selected sediment samples were also analyzed for HE residuals. This HE analysis effort was expanded in 1996; these new sampling stations tend to be located within the Laboratory boundary immediately upstream of the intersection of State Route 4 and the respective stream channels. Lists of individual organic compound analytes were previously given. In 1996, sediment samples were analyzed for VOCs, SVOCs, PCBs, and HE residuals from about one-sixth of the regional and local stations. The analytical results showed that there were no VOC, SVOC, PCBs, or HE residuals detected above the respective limit of quantitation (LOQ) in any of the sediment samples collected during 1996. The sampled stations are listed in Table 5-21.

5. Long-Term Trends

The concentrations of radioactivity in sediments from Acid, Pueblo, and lower Los Alamos Canyons that may be transported off-site are fully documented (ESG 1981). The data indicate that concentrations of radionuclides in sediments from Acid, Pueblo, and lower Los Alamos Canyons have been relatively constant at each location since 1980, given some degree of yearly fluctuation in the data. The total plutonium concentrations (plutonium-238 plus plutonium-239, -240) observed since 1980 in sediments at four indicator locations are shown in Figure 5-6.

Figure 5-6 also depicts total plutonium concentrations at four sediment stations in Mortandad Canyon from 1980 to 1996. MCO-5 and MCO-7 are located downstream of the TA-50 discharge point and upstream of the sediment traps. MCO-9 and MCO-13 are between the sediment traps and the Pueblo of San Ildefonso boundary. Values of plutonium at MCO-5 and MCO-7 are above background values resulting from Laboratory discharges at TA-50, but values from stations MCO-9 and MCO-13 are at or near atmospheric fallout levels. These results suggest that there has been little or no transport of plutonium from TA-50 below the sediment traps in Mortandad Canyon. Analyses of sediments collected at station Mortandad A-6 show plutonium-239, -240 concentration levels that are at background levels and are consistent with historical data.

D. Groundwater Sampling

1. Introduction

Groundwater resource management and protection efforts at the Laboratory are focused on the main (or regional) aquifer underlying the region (see Section 1.A.3), but also consider groundwater found within canyon alluvium and above the regional aquifer at intermediate depths.

The early groundwater management efforts by the USGS evolved with the growth of the Laboratory's current Groundwater Protection Management Program, required by DOE Order 5400.1 (DOE 1988b), which addresses environmental monitoring, resource management, aquifer protection, and geohydrologic investigations. Formal documentation for the program, the "Groundwater Protection Management Program Plan," was issued in April 1990 and revised in 1996 (LANL 1996a). During 1996 the Laboratory developed and submitted an extended groundwater characterization plan to the New Mexico Environment Department (NMED) (LANL 1996b).

Concentrations of radionuclides in environmental water samples from the main aquifer, the alluvial perched groundwater in the canyons, and the intermediate-depth perched systems may be evaluated by comparison with DCGs for ingested water calculated from DOE's PDL (see Appendix A for a discussion of standards). The NMWQCC has established standards for groundwater quality (NMWQCC 1993). Concentrations of radioactivity in samples of water from the water supply wells completed in the Los Alamos main aquifer are also compared to New Mexico Environmental Improvement Board (NMEIB) and EPA MCLs or to the DOE DCGs applicable to radioactivity in

DOE drinking water systems, which are more restrictive in a few cases.

The concentrations of nonradioactive chemical quality parameters may be evaluated by comparing them to NMWQCC groundwater standards and to the NMEIB and EPA drinking water standards, even though these latter standards are only directly applicable to the public water supply. The supply wells in the main aquifer are the source of the Los Alamos public water supply. Although it is not a source of municipal or industrial water, shallow alluvial groundwater results in return flow to surface water and springs used by livestock and wildlife, and may be compared to the Standards for Groundwater or the Livestock and Wildlife Watering Stream Standards established by the NMWQCC (NMWQCC 1993, NMWQCC 1995). These standards are for the most part based on dissolved concentrations, but many of the results reported here include both dissolved and suspended solids concentrations, which may be higher.

2. Monitoring Network

Groundwater sampling locations are divided into three principal groups, related to the three modes of groundwater occurrence: the main (or regional) aquifer, perched alluvial groundwater in the canyons, and localized intermediate-depth perched groundwater systems. The sampling locations for the main aquifer and the intermediate-depth perched groundwater systems are shown in Figure 5-7. The sampling locations for the canyon alluvial perched groundwater systems are shown in Figure 5-8. The springs and wells are described by Purtymun (1995).

Sampling locations for the main aquifer include test wells, supply wells, and springs. Eight deep test wells, completed within the main aquifer, are routinely sampled. The Laboratory located the test wells to detect possible infiltration of contaminants from effluent disposal operations. These test wells were drilled by the USGS between 1949 and 1960 using the cable tool method. The wells penetrate only a few hundred feet into the upper part of the main aquifer, and the casings are not cemented, which would seal off surface infiltration.

Samples are collected from eleven deep water supply wells in three well fields that produce water for the Laboratory and community. The well fields include the Guaje Well Field and the on-site Pajarito and Otowi Well Fields. The Guaje Well Field, located northeast of the Laboratory, contains seven wells, five of which had significant production during 1996. The five wells of the Pajarito Well Field are located in Sandia and Pajarito Canyons and on mesa tops between those canyons. Otowi-1 and Otowi-4, the first wells in a new field designated as the Otowi Well Field, were completed in 1990. Otowi-4 resumed production in 1996 after pump problems were repaired. Otowi-1 had a new pump installed during 1996 and was being prepared for production at the end of the year. Additional main aquifer samples were taken from wells located on the Pueblo of San Ildefonso.

Numerous springs near the Rio Grande are sampled because they represent natural discharge from the main aquifer (Purtymun et al., 1980). As such, the springs serve to detect possible discharge of contaminated groundwater from beneath the Laboratory into the Rio Grande. Based on their chemistry, the springs in White Rock Canyon are divided into groups, three of which (I, II, and III) have similar, aquifer-related chemical quality. The chemical quality of springs in Group IV reflects local conditions in the aquifer, probably related to discharge through faults in volcanics. Two additional springs, Indian and Sacred Springs, are west of the river in lower Los Alamos Canyon.

Beginning in 1995, approximately half of the White Rock Canyon springs were sampled in each year. Larger springs and springs on Pueblo of San Ildefonso lands are sampled annually, with the remainder scheduled for alternate years.

The perched alluvial groundwater in five canyons (Pueblo, Los Alamos, Mortandad, and Pajarito Canyons, and Cañada del Buey) is sampled by means of shallow observation wells to determine the impact of NPDES and past industrial discharges on water quality. In any given year, some of these alluvial observation wells may be dry, and thus no water samples can be obtained. Observation wells in Water, Fence, and Sandia Canyons have been dry since their installation in 1989. Most of the wells in Cañada del Buey are dry.

Intermediate-depth perched groundwater of limited extent occurs in conglomerates and basalt at depths of several hundred feet beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia Canyons. Samples are obtained from two test wells and one spring. The well and spring locations were selected to monitor possible infiltration of effluents beneath Pueblo and Los Alamos Canyons.

Some perched water occurs in volcanics on the flanks of the Jemez Mountains 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. During the winter of 1996–97, a falling tree broke the connecting pipe, and the water now flows down the Water Canyon drainage.

3. Radiochemical Analytical Results for Groundwater

The results of radiochemical analyses of groundwater samples for 1996 are listed in Table 5-22. Tables 5-23 and 5-24 contain lists of radionuclides detected in water samples and of possible detections, according to criteria discussed in Section 5.F. Because uranium, gross alpha, and gross beta are ubiquitous at detectable levels, occurrences of these measurements above significant levels (chosen to be below the EPA MCLs or screening levels) are reported. The specific values are 5 μg/L for uranium, 10 pCi/L for gross alpha, and 40 pCi/L for gross beta. Discussion of the results will address the main aquifer, the canyon alluvial groundwater, and finally the intermediate perched groundwater system.

a. Radiochemical Constituents in the Main Aquifer. For samples from wells or springs in the main aquifer, most of the results for tritium; strontium-90; uranium; plutonium-238; plutonium-239, -240; americium-241; and gross beta were below the DOE DCGs or the EPA or New Mexico standards applicable to a drinking water system. The exceptions are discussed below. In addition, most of the results were near or below the detection limits of the analytical methods used. Dissolved uranium is a common constituent of groundwater (Hem 1989), so only occurrences close to the proposed EPA MCL of 20 μg/L are discussed here.

The 1994 surveillance sampling of three test wells, TW-3, TW-4, and TW-8, showed unexpected levels of strontium-90 (ESP 1996a). Several of the sampling results were suspect because there were no corroborating measurements such as correspondingly elevated gross beta measurements in some of the samples. Special time-series sampling was carried out in 1995 to evaluate possible aquifer contamination near these wells, during which no strontium-90 was detected (ESP 1996b). These wells were sampled four times during 1996, with no radionuclides detected, except naturally occurring uranium and trace levels of tritium. The tritium results are discussed in Section 5.D.3.c.

Test Well 1 had a tritium detection of 749 pCi/L. Tritium values in this range cannot be accurately quantified by the analytical method, but the result does indicate a detection of tritium. The results of previous low-detection-limit tritium measurements done by the University of Miami on samples from this well have ranged from 277 to 366 pCi/L (ESP 1995; ESP 1996b). Water supply well G-2 showed a possible americium-241 detection; however, the americium-241 values found at small levels this year are suspect because of similar levels found in field blank samples (see Section 5.F).

Strontium-90 was detected in Sandia Spring. Spring 5A showed evidence of plutonium-238. La Mesita Spring has a significant uranium concentration of 10 μg/L. Samples from springs in this area have always contained a relatively high concentration of natural uranium (Purtymun et al., 1980). However, the uranium concentration for La Mesita Spring is below the proposed EPA primary drinking water MCL of 20 μg/L. The spring also has a high gross alpha value of about 14 pCi/L, near the EPA primary drinking water standard of 15 pCi/L.

In 1995, water supply well G-1A had an apparent strontium-90 detection of 3.9 ± 0.7 pCi/L. This value is just above the strontium-90 detection limit of 3 pCi/L. Another 1995 analysis gave a result of 7.4 ± 3.5 pCi/L, which has a very high uncertainty, making interpretation of this result difficult. No previous strontium-90 data are available for this well for comparison. The results of 1996 samples indicate no trace of strontium-90 in samples from this well.

All cesium-137 measurements of samples from the main aquifer wells and springs for 1994 are less than 5% of the DCG applicable to DOE Drinking Water Systems and less than the detection limit of 4 pCi/L.

b. Total Committed Effective Dose Equivalent from the Ingestion of Drinking Water from Los Alamos and White Rock. Table 5-25 presents the summary of the CEDE from the ingestion of drinking water collected in 1996. The CEDE for 1995 is presented for comparison. Because drinking water aquifers are regional, there is no "background" drinking water source available to determine the total net positive CEDE between the monitored source and a "background" source. The total annual CEDEs (i.e., the annual CEDE, without any error term, summed over all radionuclides) for all drinking water samples collected from Los Alamos water distribution wells are below 4 mrem. No samples collected exceeded the radioactive MCLs for drinking water systems (EPA 1989). The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) using the two liters per day drinking water consumption rate for samples collected in 1996 is 0.12 mrem as modified by the percent contribution to the distribution system for each monitored well. The radionuclides that contributed to more than 5% of the total CEDE in 1996 are strontium-90, cesium-137, total uranium, plutonium-238, plutonium-239, and americium-241.

c. Tritium Sampling of Test Wells. The 1994 surveillance sampling of three test wells, TW-3, TW-4, and TW-8, showed unexpected levels of strontium-90 (ESP 1996a). Several of the sampling results were suspect, because there were no corroborating measurements such as corresponding elevated levels of gross beta in some of the samples. Special time-series sampling was carried out in 1995 to evaluate possible aquifer contamination near these wells, during which no strontium-90 was detected (ESP 1996b). These wells were sampled four times during 1996, with no radionuclides detected, except for trace levels of tritium and naturally occurring uranium. This section discusses the trace-level tritium results, with analyses done by the University of Miami Tritium Laboratory.

The following information provides a perspective on tritium levels occurring in New Mexico. Before atmospheric testing of nuclear weapons began, tritium levels in precipitation were about 20 pCi/L (Adams et al., 1995). This is 5 to 10 times the tritium levels detected in the Los Alamos public water supply wells, for example. By the mid-1960s, tritium in atmospheric water in northern New Mexico reached a peak level of about 6,500 pCi/L. At present, general atmospheric levels in northern New Mexico are about 30 pCi/L, and those in the Los Alamos vicinity range from 20 to 450 pCi/L (Adams et al., 1995). Groundwaters that contain between 16 and 65 pCi/L of tritium most likely show the effects of recent recharge, that is, within the last four decades (Blake et al., 1995). Waters with tritium concentrations below about 1.6 pCi/L are likely to be old: the ages of these waters are more than 3,000 years, but there may be large errors associated with small tritium concentrations. With a tritium concentration below 0.5 pCi/L, modeled ages are more than 10,000 years, but this is at the limit of tritium age determinations. Waters with tritium concentrations more than 1,000 pCi/L and collected after 1990 cannot have their ages modeled and can only be the result of contamination (Blake et al., 1995).

The 1995 time series results suggested that tritium is present in trace amounts in the aquifer at TW-3 and -8, but not at TW-4. Tritium has previously been observed in TW-8. The presence of tritium in TW-3 in 1995 was a new discovery, because tritium was not noted in this well during sampling in 1993. The level of tritium in these wells is far below the EPA tritium drinking water standard of 20,000 pCi/L and even below the detection limit of the EPA-specified analytical method for tritium, which is 700 pCi/L. Evaluation of tritium activities in this trace level range was carried out for purposes of evaluating flow paths and hydrological connections within groundwater flow systems.

The 1996 sampling results continue to show naturally occurring trace levels of tritium in TW-4 and slightly higher tritium levels in TW-3 and TW-8 that suggest some contribution of recent recharge from the surface (Table 5-26). The 1995 tritium values in TW-3 ranged from 53 pCi/L down to 0.2 pCi/L, compared to the 1996 range of 15 pCi/L to 0.2 pCi/L. For TW-8, the 1995 range was 16 pCi/L down to 5.2 pCi/L, compared to a 1996 range of 26 pCi/L to 5.5 pCi/L. Thus, the results suggest a continual presence of a small recharge contribution from the surface in the main aquifer at TW-3 and TW-8. Considering that past surface water tritium activities in DP Canyon (near TW-3) and Mortandad Canyon (above TW-8) have been in the range of up to 10^6 pCi/L as recently as the mid 1980s, the effect of surface water tritium levels on the regional aquifer at these locations has been minimal.

Several other test well samples were analyzed for tritium by low-detection-limit methods. Table 5-26 shows these results. Previous analytical results for tritium were published in ESP (1995). Test wells DT-9 and DT-10 both showed higher tritium values in 1995 than in previous years. The 1993 values for test wells DT-9 and DT-10 were 0.45 and 1.3 pCi/L, compared to 1995 values of 1.5 and 3.2 pCi/L. These tritium values fall into a possible age range between 40 and 3,000 years. Test well DT-5A had a 1993 value of 0.23 pCi/L. The 1996 results for DT-5A, DT-9, and DT-10 are at the low end of the ranges previously observed. These 1996 tritium levels suggest that the main aquifer is isolated from surface recharge in the area of these three wells.

d. Radiochemical Constituents in Alluvial Groundwaters. None of the radionuclide activities in alluvial groundwater are above the DOE DCGs for Public Dose for Ingestion of Environmental Water. Except for strontium-90 values in samples from Mortandad Canyon, none of the radionuclide activities exceed DOE DCGs applicable to a drinking water system. Levels of tritium; cesium-137; uranium; plutonium-238; plutonium-239, -240; strontium-90; and gross alpha, beta, and gamma are all within the range of values observed in recent years.

The samples of the alluvial groundwater in Los Alamos Canyon show residual contamination, as has been seen since the original installation of the monitoring wells in the 1960s. In particular, for LAO-2 and LAO-3A, the activity of strontium-90 exceeds the EPA Primary Drinking Water Standard MCL of 8 pCi/L. Plutonium-239, -240 was detected in LAO-0.7; cesium-137 was possibly detected at LAO-0.7; and

several of the wells showed gross alpha or beta activities exceeding drinking water standards.

The alluvial groundwater samples from Mortandad Canyon showed levels of radionuclides within the ranges observed previously. Tritium; strontium-90; plutonium-238; plutonium-239, -240; americium-241; gross alpha; and gross beta are either detected or possibly detected in many of the wells. Well MCO-4 was not in service, so samples from nearby well MCO-4B are used in its place. The radionuclide levels are in general highest at well MCO-4B, which is nearest to the TA-50 outfall, and are lower further down the canyon. The levels of tritium, strontium-90, gross alpha, and gross beta exceed EPA drinking water criteria in many of the wells. In some years the levels (except for tritium) exceed the DOE drinking water system DCGs; but the levels do not exceed the DOE DCGs for public dose for ingestion of environmental water. There are no EPA drinking water criteria for plutonium-238; plutonium-239, -240; or americium-241. The DOE Drinking Water System DCGs for these latter radionuclides were not exceeded in Mortandad Canyon alluvial groundwater.

Pueblo Canyon well APCO-1 had a 1996 plutonium-239, -240 level (.087 ± 0.02 pCi/L) above the detection limit, as was observed in 1994 and 1995. Only one well in Pajarito Canyon was sampled in 1996 because wells PCO-2 and PCO-3 were dry.

e. Radiochemical Constituents in Intermediate-Depth Perched Groundwater. Taken over time, the radionuclide activity measurements in samples from TW-1A, 2A, and Basalt Spring in the intermediate-depth perched zones in Pueblo Canyon indicate a connection with surface water and alluvial groundwaters in Pueblo Canyon. Intermediate-depth perched zone waters have long been known to be influenced by contaminated surface water in the canyon based on measurements of major inorganic ions. TW-2A, furthest upstream and closest to the historical discharge area in Acid Canyon, has shown the highest levels. The 1996 tritium measurement obtained by conventional methods was 2253 pCi/L. In previous years this has been confirmed by the low detection limit measurements of about 2,300 pCi/L (ESP 1996a). Neither TW-1A nor TW-2A had detectable plutonium-239, -240 levels, in contrast to 1995. Basalt Spring did show detectable plutonium-239, -240. Because the sample at Basalt Spring is collected in contact with the canyon soils, the source of the plutonium could be surface sediments rather than groundwater.

The sample from the Water Canyon gallery was consistent with previous results, showing no evidence of radionuclides from Los Alamos operations.

4. Nonradiochemical Analytical Results

The results of general chemical analyses of groundwater samples for 1995 are listed in Table 5-27, and results of total recoverable metal analyses are listed in Table 5-28. Discussion of the results will address the main aquifer, the canyon alluvial groundwaters, and the intermediate perched groundwater system. Finally, results of organic analyses will be discussed. Because of instrument problems on the part of the analytical laboratory, some of the trace metals were analyzed at detection limits higher than is ordinarily the case during 1996, particularly cadmium, lead, thallium, and antimony. This problem will be rectified for 1997 sampling.

a. Nonradiochemical Constituents in the Main Aquifer. Values for all parameters measured in the water supply wells were within drinking water limits, with the following exceptions. In 1995, a nitrate (as nitrogen) value of 9.9 mg/L was found in well G-1A; values of this size have never been observed previously in this well, and no such values were found in the regular Safe Drinking Water Act (SDWA) sampling. The 1996 results show a nitrate (as nitrogen) concentration of 0.48 mg/L, which is consistent with background levels. The pH values in wells G-1, G-1A, and Otowi-1 were above the EPA secondary standard limit of 8.5. Well Otowi-1 was being tested during this sample collection period and had not been connected to the water supply system. In well G-1, the silver value was 53 µg/L, compared to the NMWQCC groundwater limit of 50 µg/L; the thallium level was 6 µg/L compared to the EPA primary drinking water standard of 2 µg/L. For well G-2, the arsenic level was about 76% of the standard of 50 µg/L and was similar to previous measurements. The vanadium level in well G-2 of 84 µg/L is within the EPA health advisory range of 80 to 110 µg/L but is lower than the 1993 value of 260 µg/L. The lead level in Otowi-4 was 12 µg/L, compared to the EPA action level of 15 µg/L.

The test wells in the main aquifer showed levels of several constituents that approach or exceed standards for drinking water distribution systems. However, the test wells are used for monitoring purposes only and are not part of the water supply system. TW-1 had a nitrate value of 5.5 mg/L, below the EPA primary drinking water standard of 10 mg/L (nitrate as nitrogen). This test well has shown nitrate levels in the

range of about 5 to 20 mg/L (nitrate as nitrogen) since the early 1980s. The source of the nitrate might be infiltration from sewage treatment effluent discharged into Pueblo Canyon, or residual nitrates from the now decommissioned TA-45 radioactive liquid waste treatment plant that discharged effluents into upper Pueblo Canyon until 1964.

TW-2 had values of sodium, chloride, sulfate, arsenic, and boron that were about ten times the usual ranges for these values. The total dissolved solids and conductance for this sample were in the usual range. Thus, the total dissolved solids value contradicts the values reported for these other analytes because it is much smaller than the sum of the sodium, chloride, and sulfate values. The source of these discrepancies has not been discovered.

Levels of trace metals that approach water quality standards in some of the test wells are believed to be associated with the more than 40-yr-old steel casings and pump columns. In the last few years, iron, manganese, cadmium, nickel, antimony, and zinc have been high in several of the main aquifer test wells. These trace metal values represent total, rather than dissolved concentrations, in that they include the composition of any suspended sediment contained in the water samples. Several of the test wells have occasionally had elevated lead levels in previous years. In 1995, lead levels exceeded the EPA action level in TW-1, 2, 3, and 4. In 1996, TW-1 (at 62 µg/L) and TW-4 (at 57 µg/L) had lead levels above the 15 µg/L EPA action level. However, the higher detection limit used for many of the measurements may have been insufficient to define the lead levels in these wells. TW-3 had one lead measurement at 11 µg/L. The lead levels appear to be due to flaking from piping installed in the test wells and do not represent lead in solution in the water (ESP 1996a). There are no known sources of lead near these wells, and dissolved lead levels in natural waters of near neutral pH (pH ~7) are commonly extremely low (Hem 1989).

In general, trace metal levels in unfiltered samples for test well DT-5A were low. This well had the highest lead levels in 1993. One sample from this well had a chromium concentration of 63 µg/L, compared to the NMWQCC groundwater limit of 50 µg/L.

Samples collected for metals analysis from the White Rock Canyon springs were filtered in 1996. In recent years, samples from a few springs in White Rock Canyon showed aluminum, iron, and manganese levels that exceed NMWQCC Livestock and Wildlife Watering Standards or drinking water standards. These levels were total rather than dissolved concentrations and reflect the composition of suspended sediments. Many of the springs have very low flow rates, and samples are collected in small pools in contact with the surrounding soils. The 1996 samples from Sandia Spring, La Mesita Spring, and Spring 1 were unfiltered and showed levels of aluminum and iron that would exceed standards for drinking water systems. Of the filtered spring samples, Spring 3A had a cadmium level above the drinking water MCL.

b. Nonradiochemical Constituents in Alluvial Groundwater. Alluvial canyon groundwater in Pueblo, Los Alamos, and Mortandad Canyons, which receive effluents, showed the effects of those effluents because values of some constituents were elevated above natural levels. Mortandad Canyon alluvial ground-water samples exceeded or approached the NMWQCC Groundwater Standards for fluoride and nitrate. The nitrate source is nitric acid that is used in plutonium processing at TA-55 and enters the TA-50 waste stream. Improvements to the TA-50 treatment process are planned, so that the effluent will not exceed water quality standards in the future. Mortandad Canyon alluvial groundwater is also high in sodium. Only one well in Pajarito Canyon was sampled in 1996 because wells PCO-2 and PCO-3 were dry.

Overall, trace metal levels in alluvial groundwater samples were much lower than for 1993 and 1994. As with past samples from the White Rock Canyon Springs, several of the alluvial groundwater samples showed levels of aluminum, iron, and manganese that would exceed standards for drinking water systems. These metal concentrations reflect the presence of suspended sediment that had entered the well casings.

c. Nonradiochemical Constituents in Intermediate-Depth Perched Groundwater. In 1996, the nitrate values for TW-1A, 2A, and Basalt Spring were well below NMWQCC Groundwater and EPA Drinking Water Standards. These sample locations have occasionally shown higher nitrate values in recent years.

TW-2A had levels of iron, lead, manganese, and zinc approaching or exceeding water quality standards. Again, the detection of these metals in TW-2A probably reflects flaking of metals from pump hardware and the well casing rather than the existence of dissolved metals in the groundwater. TW-1A had iron, and Basalt Spring had aluminum and manganese concentrations approaching or exceeding water quality standards. Otherwise, the intermediate perched groundwater and the Water Canyon gallery did not show any concentrations of trace metals that are of concern.

d. Organic Constituents in Groundwater. Analyses for organic constituents were performed on selected springs and test wells in 1996. The stations sampled are listed in Table 5-29. Samples were analyzed for VOCs, SVOCs, and PCBs. Test wells and most springs were analyzed for HE constituents. The laboratory also reports tentatively identified organic compounds, reflecting measurements that do not correspond to any of the cataloged organic compounds that may not have been analyzed specifically. These compounds are not listed here although the number for each station is given. The samples where organics were detected above the analytical LOQ are listed in Table 5-30.

HE constituents were detected in Ancho Spring during 1995 sampling, but not in 1996. This spring is below the explosives testing sites in the southern portion of the Laboratory. The Water Quality and Hydrology Group (ESH-18) will conduct additional analyses for HE in this area. Most of the possible organic detections reported by the Organic Analysis Group (CST-12) were rejected because the compounds were either detected in method blanks (introduced during laboratory analysis) or detected in trip blanks.

There were three organic detections that were not rejected. Toluene was found at low concentrations in Test Well DT-5A. However, this compound was found in method blanks for numerous other samples, indicating that it had inadvertently been introduced during laboratory analysis, as was butanone [2-] which was found in Spring 1. The Otowi House well had a detection of trichloroethane [1,1,1-].

5. Long-Term Trends

a. Main Aquifer. The long-term trends of the water quality in the main aquifer have shown little impact resulting from Laboratory operations. Except for low levels of tritium contamination found at four locations in Los Alamos and Pueblo Canyons and one location in Mortandad Canyon, no concentrations of radionuclides above detection limits have been measured on water samples from the production wells or test wells that reach the main aquifer other than an occasional analytical outlier not confirmed by analysis of subsequent samples. The apparent detection of strontium-90 in TW-3 in 1994 (ESP 1996a) presently appears to be due to analytical error because the gross beta measurement does not support the strontium result. The apparent detection of strontium-90 in TW-4 in 1994 (ESP 1996a) has not been substantiated by previous or subsequent measurements.

Measurements of tritium by extremely low detection limit analytical methods (ESP 1995; ESP 1996a) show the presence of some recent recharge (meaning within the last four decades) in water samples from six wells into the main aquifer at Los Alamos. The levels measured range from less than 2% to less than a 0.01% of current drinking water standards and are all less than levels that could be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations. Recent detection of lead in the main aquifer test wells appears to have resulted from contamination by well casings, pumps, and monitoring devices (ESP 1995). Nitrate concentrations in TW-1 have been near the EPA MCL since 1980.

The long-term trends of water levels in the water supply and test wells in the main aquifer indicate that there is no major depletion of the resource as a result of pumping for the Los Alamos water supply (McLin et al., 1997).

b. Alluvial Perched Groundwater in Mortandad Canyon. Long-term trends of radionuclide concentrations in shallow alluvial perched groundwater in Mortandad Canyon (downstream from the NPDES-permitted outfall for the radioactive waste treatment facility at TA-50) are depicted in Figure 5-9. The samples are from observation well MCO-6 in the middle reach of the canyon. The combined total of plutonium-238 and plutonium-239, -240 activities has been relatively constant, fluctuating up and down in response to variations in the treatment plant effluent and storm runoff that causes some dilution in the shallow alluvial water. Note that the current plutonium detection limit of 0.04 pCi/L applies to the separate analyses of plutonium-238 and plutonium-239, -240, and might be doubled for the addition of these values because results are often at or near the detection limit. The tritium concentration has fluctuated almost in direct response (with a time lag of about one year) to the average annual concentration of tritium in the TA-50 effluent.

E. Groundwater and Sediment Sampling at the Pueblo of San Ildefonso

To document the potential impact of Laboratory operations on lands belonging to the Pueblo of San Ildefonso, 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. This section deals with hydrologic and sediment sampling. The groundwater,

surface water, and sediment stations sampled on the Pueblo of San Ildefonso are shown in Figures 5-10 and 5-11. Aside from stations listed in the accompanying tables, the Memorandum of Understanding also specifies collection and analysis of additional water and sediment samples from sites that have long been included in the routine environmental sampling program, as well as special sampling of storm runoff in Los Alamos Canyon. These locations are shown in Figures 5-1, 5-2, 5-4, and 5-7, and the results of analyses are discussed in previous sections.

1. Groundwater

Radiochemical analyses of the 1996 groundwater samples are shown in Table 5-22. Tables 5-23 and 5-24 contain lists of radionuclides detected in water samples and of possible detections, according to criteria discussed in Section 5.F.4. Because uranium, gross alpha, and gross beta are ubiquitous at detectable levels, occurrences of these measurements above significant levels (chosen to be below the EPA MCLs or screening levels) are reported. The specific values are 5 μg/L for uranium, 10 pCi/L for gross alpha, and 40 pCi/L for gross beta.

Most of the groundwater stations (wells and springs) listed in the Memorandum of Understanding are discussed in Section 5.D. The Bureau of Indian Affairs wellpoints were not sampled in 1996 because high water turbidity made the samples of questionable value and because the ER Project has installed several new wells in the vicinity as part of the Resource Conservation and Recovery Act Facility Investigation Workplan for Los Alamos and Pueblo Canyons. The present section focuses on the Pueblo of San Ildefonso water supply wells.

As in previous years, the groundwater data indicate the widespread presence of naturally occurring uranium at levels approaching or in excess of proposed EPA drinking water limits. Naturally occurring uranium concentrations approaching or many times above the proposed MCL of 20 μg/L are prevalent in well water throughout the Pojoaque area. The high gross alpha readings for these wells are related to uranium occurrence.

In previous years, the Pueblo of San Ildefonso water supply well data have suggested the occasional detection of trace levels of plutonium and americium. In most cases, these values are near the detection limit of the analytical method when it is uncertain whether or not a detection has occurred and when precise quantification of the amount detected is not possible. For 1995, detection limits for plutonium-238 and americium-241 were exceeded in several wells. The possibility that these were detections is in doubt for two reasons: there were high values for americium-241 in the trip blank, and values for plutonium-238 and americium-241 in the New Community well sample and a duplicate sample differed widely. These two observations emphasize the questionable precision of the laboratory analyses at these extremely low levels. For 1996 sampling, the only possible detection of radionuclides in the Pueblo of San Ildefonso water supply wells, other than uranium, was for plutonium-239, -240 in the Sanchez House well, at a value only slightly above the detection limit.

The 1995 Westside Artesian well sample had a strontium-90 value of 8.4 pCi/L. This value exceeded the EPA MCL of 8 pCi/L. This 1995 analysis should be viewed with caution: first, because of the possibility of analytical error, in light of the relatively high detection limit for strontium-90; and second, because strontium-90 has not been previously found in any of these wells. The 1996 sample analysis did not detect strontium-90.

The Westside Artesian and New Community wells had uranium concentrations near or exceeding the proposed EPA primary drinking water standard of 20 μg/L. Uranium concentrations at the Pajarito Pump 1 and Sanchez House wells were about half of the proposed EPA standard. These measurements are consistent with the levels in previous samples and with relatively high levels of naturally occurring uranium in other wells and springs in the area.

The gross alpha level in samples from the Westside Artesian, Pajarito Pump 1, Don Juan Playhouse, New Community, and Sanchez House wells approached or exceeded the EPA primary drinking water standard of 15 pCi/L. The gross alpha levels are apparently attributable to the presence of uranium.

The chemical quality of the groundwater, shown in Table 5-27, is consistent with previous observations. The samples from the Westside Artesian and Pajarito Pump wells exceeded or were near the drinking water standard for total dissolved solids; these levels are similar to those previously measured.

The fluoride values for some wells are near (Sanchez House) or greatly exceed (Westside Artesian and LA-1B) the NMWQCC Groundwater Standard of 1.6 mg/L, again similar to previous values. Several of the wells have alkaline pH values, above the EPA secondary standard range of 6.8 to 8.5; again, these values do not represent a change from those previously observed in the area. None of the sampled wells had nitrate values approaching drinking water limits of 10 mg/L (nitrate as nitrogen).

Trace metal analyses are shown in Table 5-28. Well LA-1B and Pajarito Pump 1 had much lower arsenic values in 1995 and again in 1996, compared to previous values of about 40 µg/L, just below the EPA drinking water standard of 50 µg/L. Boron values in two wells, Westside Artesian and Pajarito Pump 1, exceeded the NMWQCC groundwater limit of 750 µg/L. These values are similar to those of past years. Boron, arsenic, and fluoride are common constituents of water in volcanic areas or in thermal springs (Hem 1989). The thermal waters discharging from the Valles Caldera have been shown to discharge through the Jemez River drainage, and other wells and springs in the area have far higher boron, arsenic, and fluoride levels (Goff et al., 1988). The only other trace metal occurrence of note was antimony that was detected in the New Community well at 5 µg/L compared to the EPA Primary Drinking Water Standard of 6 µg/L.

Samples from Eastside Artesian, Halladay House, Pajarito Pump 1, Don Juan Playhouse, and the Otowi House wells were analyzed for VOCs, SVOCs, and PCBs (Table 5-29). The only sample in which there was a trace detection was the Otowi House well (Table 5-30). The compound detected is trichloroethane [1,1,1-] at 23 µg/L.

2. Total Committed Effective Dose Equivalent from the Ingestion of Drinking Water Collected at the Pueblo of San Ildefonso

Table 5-31 presents the summary of the CEDE from the ingestion of drinking water collected in 1996. The CEDE for 1995 is presented for comparison. Because the Federal Guidance Report #11 is "intended for general use in assessing average individual committed doses in any population. . ." (EPA 1988), the dose conversion factors listed in this report are used in assessing drinking water from non-DOE sources. Because drinking water aquifers are regional, there is no "background" drinking water source available to determine the total net positive CEDE between the monitored source and a "background" source.

The total annual CEDEs (i.e., the annual CEDE, without any error term, summed over all radionuclides) for all drinking water samples collected from the Pueblo of San Ildefonso ranged from 0.26 mrem from the Halla

day House to 3.1 mrem from the New Community well. For samples collected at the Pueblo, the uranium contribution to the total CEDE ranged from 34% from the Halladay House sample to 91% from the Westside Artesian sample. The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) using the 2 liters/day drinking water consumption rate for the samples collected in 1996 ranged from 0.66 mrem from the Halladay House sample to 4.1 mrem from the New Community Well sample.

3. Sediments

Sediments from Mortandad Canyon were collected in 1996 from seven permanent sampling stations, as seen in Figure 5-11. The results of these and other sediment sample analyses for radiochemicals and trace metals are shown in Tables 5-13, 5-14, 5-15, and 5-20. Related information is presented in Section 5.C. Results are comparable to sediment data collected from these same stations in previous years.

Data discussed in Section 5.C suggest that radionuclide concentrations in sediments on Laboratory land just upstream of the Pueblo of San Ildefonso boundary (near station MCO-13) are the result of worldwide fallout rather than of Laboratory operations. None of the Pueblo of San Ildefonso sediment stations in Mortandad Canyon showed levels of strontium-90, total uranium, americium-241, gross alpha, gross beta, or gross gamma that exceeded the background values attributed to fallout (or naturally occurring uranium) in northern New Mexico (Purtymun et al., 1987). This value is consistent with historical observations from this station.

Sediments from sampling stations in Los Alamos Canyon located on the Pueblo of San Ildefonso lands at Los Alamos at State Road 502, Los Alamos at Totavi, and Los Alamos at Otowi showed levels of cesium-137; plutonium-238; plutonium-239, -240; and americium-241 above background and are clearly from Laboratory sources. All of these levels are consistent with previous samples collected from these same stations (see Section 5.C).

Analytical results from the sediment sampling locations in Guaje, Bayo, and Sandia Canyons are all within the range of values expected from worldwide fallout. These findings are consistent with current and previous measurements of sediments from these canyons where they flow across State Road 502. Sediment samples collected from the Pueblo of San Ildefonso in 1996 were also analyzed for trace metals, as reported in Table 5-20. These results, which are all within the general ranges found in geologic materials from Pajarito Plateau, suggest natural origins for all trace metals, including total uranium (Longmire et al., 1996).

F. Sampling and Analytical Procedures, Data Management, and Quality Assurance

1. Sampling

Stoker (1990) is the basic document covering sampling procedures and quality assurance (QA). Detailed container and preservation requirements are documented in a handbook by Williams (1990). More focused guidance is provided in formal procedures developed to address sampling procedures for each sample matrix (Mullen and Naranjo 1996, 1997). All sampling is conducted using strict chain-of-custody procedures, as described in Gallaher (1993). The completed chain-of-custody form serves as an analytical request form and includes the requester or owner, sample barcode number, program code, date and time of sample collection, total number of bottles, the list of analytes to be measured, and the bottle sizes and preservatives for each analysis required. The Laboratory's samples are submitted to the Chemical Science and Technology (CST) analytical laboratory. Detailed analytical methods are published in Gautier (1995). Beginning in 1995, samples were submitted using blind sample numbers to prevent possible bias by the analyst through knowledge of the sampled location.

Samples collected at the White Rock Canyon springs were filtered in the field. The "Code" column on the tables of analytical results shows a "U" for unfiltered samples and an "F" for filtered samples. The White Rock Canyon Springs samples are collected to represent groundwater surfacing at the springs. These samples were filtered in the field to minimize the effects of surface contamination.

Runoff was collected using automated samplers located at recently installed gaging stations (Shaull et al., 1996). If adequate water was collected by the automated sampler, two sets of samples were then submitted to the analytical laboratory. One set was preserved when the samples were transferred from the automated sampler bottles to the sample bottles. The other set was submitted unfiltered and unpreserved. The analytical laboratory filtered the samples and preserved them. If insufficient water for two sample sets was collected by the automated sampler, only one set of unfiltered samples was submitted to the analytical laboratory. The analytical laboratory filtered the samples through a 0.45-micron filter. The filtrate (the dissolved portion that passes through the filter) was preserved and analyzed to quantify the dissolved constituents. The portion remaining on the filter (suspended solids) was analyzed separately to quantify the constituents associated with the suspended solids.

When the samples were transferred from the automated sampler bottles to the sample bottles, the contents of all the bottles collected by the automated sampler were first transferred to a churn splitter. The churn splitter agitates the samples to ensure that they are well mixed and that the sediments are suspended.

2. Analytical Procedures

a. Metals and Major Chemical Constituents. Metals and major chemical constituents are analyzed using EPA SW-846 methods. Filtering and digestion methods have changed over time. Before 1993, water samples were preserved in the field and filtered in the lab before digestion. From 1993 forward, water samples have not been filtered in the field or in the analytical laboratory, with the exception of the White Rock Spring samples as described above, and the results reported have been for total concentrations. As described in "Environmental Surveillance at Los Alamos during 1994" (ESP 1996a), from September of 1992 through the spring of 1994, SW-846 digestion method 3050 was used for sediments, and 3005 was used for waters. After the spring of 1994, digestion method 3051 was used for sediments, and 3015 was used for waters. The methods are considered equivalent. Methods 3015 and 3051 use microwave digestion, and 3005 and 3050 use a steam bath.

b. Radionuclides. Radiochemical analysis has been performed using the methods as updated in Gautier (1995). Sediment samples are screened through a Number 12 US Standard Testing sieve before digestion. The sieves are brass with seamless frames and soldered wire cloths meeting American Society for Testing and Materials E-11 specifications. This sieve screens out materials larger than 1.7 mm (0.066 in.). Ten-gram samples are analyzed from stream channels; 1,000-g samples are analyzed from reservoirs. There is a 10-fold improvement in detection limits of plutonium-238 and plutonium-239, -240 for reservoir samples.

Negative values are reported for some radiological measurements. Negative numbers occur because measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Consequently, individual measurement values can result in positive or negative numbers. Although negative values do not represent a physical reality they are reported as they are received from the analytical laboratory. Valid long-term averages can be obtained only if the values less than the detection limit and the negative values are included in the analytical results.

Water samples submitted for radiochemical analyses are preserved in the field by adding nitric acid to lower the pH of the sample to two or less. Before 1996, water samples were filtered shortly after the analytical laboratory received them. After filtering, the sample was digested before analysis. Samples collected in 1996 were preserved in the field as before but were digested without filtering. Except for the White Rock Canyon Springs and some surface water runoff, the analytical results reported in 1996 are for the total sample and include the radionuclides adsorbed to the sediments and those dissolved in solution. At the analytical laboratory, both water and sediment radiochemical samples are completely digested in a mixture of nitric and hydrofluoric acids.

When very accurate trace level tritium analyses are required, samples are shipped to the University of Miami Tritium Laboratory. These samples are collected and analyzed according to procedures described (Tritium Laboratory 1996).

c. Organics. Organics are analyzed for using SW-846 methods as shown on Table A-9. This table shows the number of analytes included in each analytical suite. The specific compounds that are analyzed in each suite are listed in Tables A-10 through A-13. All organic samples are collected in glass bottles, and the volatile organics sample is preserved with hydrochloric acid. A trip blank always accompanies the volatile organic sample.

3. Data Management and Quality Assurance

As analytical data are generated by the analysts in CST, they are transferred to the Analytical Services Group (CST-3), the sample management group. CST-3 transfers the data to ESH-18 as a hard copy. The data are also transferred electronically every week to the Facility for Information Management, Analysis, and Display (FIMAD). The electronic data are screened by FIMAD and stored in an Oracle database table. The table in FIMAD contains all the analytical data generated by CST for the current year. Data are extracted from the table and downloaded to ESH-18 using commercially available software. The sample location name, the sample barcode number, and the field data are stored in a separate table on ESH-18 personal computers and in FIMAD. This table provides the link for associating a blind sample barcode number with a location name.

Each analytical batch (20 samples or less) contains at least one blank, matrix spike, and a duplicate as dictated by SW-846 protocols. These samples are provided by CST-3 and submitted along with environmental surveillance samples. For water samples, ESH-18 also submits blanks and field-prepared duplicates. These samples are submitted blind and are identical to all other samples. CST participates in numerous interlaboratory quality assurance programs. The programs, laboratory results, and expected results are summarized quarterly in Gautier (1996).

Lead, antimony, and thallium are generally analyzed by inductively coupled plasma mass spectrometry (ICPMS) to provide detection limits below water quality standards. For part of the year, the analytical laboratories' ICPMS was not functional, and these analyses were performed by inductively coupled plasma emission spectroscopy (ICPES) with higher detection limits.

In addition to routine quality assurance samples, ESH-18 submitted blanks of deionized (DI) water and spiked samples as surveillance samples to the analytical laboratory. The analytical results are presented in Table 5-32. From the results in Table 5-32, it is apparent that there was a high bias in the americium-241 results for 1996. A plutonium-242 tracer is used in the americium-241 analysis. A small, but measurable, portion of the tracer had decayed to americium-241 resulting in slightly elevated levels of americium-241 in the analytical results. Tritium analyses also showed a high bias. This is probably due to the tritium present in the nitric acid used to preserve the sample collected for all the radionuclide analyses.

The DI blanks were submitted as regular samples, without any identification that they were blanks. They went through the same sample analysis process as the regular field samples. The DI blanks were measured with the same background contributions from reagents and biases as the surveillance samples and gave an estimate of background and systematic analytical errors. The DI blanks were used to correct the radiochemical sample analyses results by subtracting the average of the blanks from the reported sample value. The tables of detections of radionuclides present the corrected and uncorrected values. The sample value for the other radiochemical results may be recovered by adding the average blank value to the value reported in the tables.

Blanks submitted for trace metals and chemical quality were generally reported as less than detection limits with one exception. The analytical results for the blank submitted on September 8 showed strikingly high values for metals. The only explanation was that the digestion vessel was not adequately cleaned between analyses.

One sample of DI water was spiked and submitted as a surveillance sample. The analytical results were typically close to the amount spiked. A notable excep-

tion was the value of 6.8 ± 1.1 pCi/L reported for cesium-137. No cesium-137 was spiked in this sample. This result would be regarded as a detection at the 4.66 σ level. These examples emphasize that apparent detections should be confirmed by follow-up sampling.

The following compounds were commonly found in the organics trip blanks and DI blanks; bis(2-ethylhexyl)phthalate, acetone, butanone [2-], chloroethane, methylene chloride, toluene. Analytical results suggesting that these compounds were present in the sample should be viewed skeptically.

In 1996, increased emphasis was placed on reporting TICs. As a result more TICs were identified than in past years. TICs present in analytical laboratory blanks suggest that some TICs may have been introduced in the analytical laboratory.

4. Determination of Radiochemical Detections

Analytical uncertainties are reported in the tables for radiological data. These uncertainties are reported by the CST analyst for each radiological measurement. These numbers are predominantly counting uncertainties and represent the uncertainty associated with counting photon emissions from a blank and the sample. Counting uncertainties do not include the other sources of error in an analytical measurement.

Counting uncertainties vary with time and from one instrument to another. One standard deviation (one sigma) counting uncertainty is typically reported. Through 1995, the uncertainties reported for tritium in the tables have been identified as representing one standard deviation (one sigma). Recent communications with CST show that this value has been reported incorrectly. For tritium results, the value reported as the one sigma uncertainty should have been reported as a three sigma uncertainty.

CST has determined detection limits for each analytical method. Radiological detection limits are based on Currie's formula (Currie 1968). Detection limits are reported at the bottom of the tables summarizing the radiochemical analytical results. The CST detection limits include average uncertainties associated with the entire analytical method and include average counting uncertainties, sample preparation effects, digestion, dilutions, and spike recoveries. The CST detection limits, reported in 1995 and 1996, have been changed from those reported in previous years. Some detection limits were higher (plutonium and americium) and others lower (cesium). These changes reflect changes in aliquot sizes, recent evaluations of detector backgrounds and efficiencies, and evaluations of recoveries.

In 1995 (ESP 1996b) CST detection limits were compared to the counting uncertainties to evaluate the validity of the reported detection limits. In general, the comparison validated the detection limits reported by CST. The CST detection limits for cesium-137 in water and for tritium appeared to be too low. The evaluation conducted in 1995 suggested tritium detection limits as high as 2,000 pCi/L may be reasonable. The detection limits reported at the bottom of the tables summarizing radionuclide analytical results in 1995 (ESP 1996b) corresponded to the estimated detection limits calculated and not to the detection limits reported by CST.

To identify Laboratory impacts as early as possible, it is important to determine when contaminants are present in areas where contamination has not been identified previously. The Surface Water, Groundwater, and Sediments section of this report each contain tables identifying detections of radionuclides in two groups. Possible detections are defined as being above the detection limit and greater than 2.33 times the uncertainty (σ) but less than 4.66 σ. Detections are defined as being above the detection limit and greater than 4.66 σ. These tables are presented to focus on those cases where radionuclides were detected. The rationale for choosing these cutoff levels is described below.

There are two approaches to determining when an analyte is detected in a sample. For the purpose of this discussion a 95% confidence level is assumed. The lower level is often called the limit of detection (LOD) or critical level (L_C). This is the lowest level that is statistically different from a blank. When the LOD is used as a decision point, 5% of the analytical results will be falsely identified as containing the analyte of interest when it is not present (Keith 1991, Taylor 1987, Currie 1968). That is, 5% of the values exceeding L_C are false positives.

The reliable detection limit (RDL or L_D) is the level where there is little chance of failing to detect an analyte that is present at or above this concentration. When the RDL is used as a decision point, an analyte that is present at a concentration equal to the RDL will not be detected 5% of the time.

For radiological analyses, a background measurement is subtracted from the instrument reading generated by the sample. This corrects for background radiation, such as cosmic rays. The uncertainty in the background measurement must be included in the uncertainty for the sample measurement. For background corrected radiological measurements for one-tailed, paired observations at the 95% confidence level,

the LOD or L_C is 2.33 times the uncertainty (σ) and the RDL or L_D is 4.66 σ.

The LOQ (or L_Q) is the level where the true concentration of an analyte can be established. Using the same criteria as above (95% confidence, one-tailed, paired observations) the LOQ for radiological measurements is 14.1 σ. The importance of this number is demonstrated when analytical results are compared against standards; the analytical result should be greater than 14.1 σ for the comparison to be meaningful.

The uncertainties reported with our data are predominantly counting uncertainties. The detection limits reported by the analytical laboratory are found at the bottom of the tables of radiological results. These detection limits reflect a typical detection limit and allow for sources of error in addition to counting uncertainties. The criteria we used to determine if an analyte is present in a sample includes both the counting uncertainties and the detection limit. If the sample value reported by the analytical laboratory is greater than the detection limit and greater than 2.33 σ, the sample value is reported as detected above the LOD or as a possible detection. If the sample value reported by the analytical laboratory is greater than the detection limit and greater than 4.66 σ, the sample value is reported as detected.

G. Unplanned Releases

All unplanned releases were investigated by ESH-18. Upon cleanup, personnel from NMED-DOE/OB (Oversight Bureau) inspected the unplanned release site to ensure adequate cleanup. NMED-DOE/OB administratively closed 12 of the 26 unplanned releases that occurred in 1996. It is anticipated that the rest of the unplanned release investigations will be closed when NMED-DOE/OB personnel become available for inspections.

1. Radiochemical Liquid Materials

There was one unplanned radioactive release in 1996.

- Two gal. of mixed waste that consisted of chromium and 185 nCi/L of radioactivity at TA-35-2 on April 3, 1996.

2. Nonradiochemical Liquid Materials

There were 25 unplanned releases of nonradioactive liquid in 1996. The following is a summary of these discharges.

- Eight unplanned releases of noncontact cooling water and treated cooling water including 3,000 gal. at TA-16-410 on December 24, 1996; 100 gal. at TA-53-63 on December 20, 1996; 1,000 gal. at TA-21-150 on July 11, 1996; 9,000 gal. at TA-53-622 on June 23, 1996; 12,500 gal. at TA-3-127 on June 17, 1996; 2,800 gal. at TA-35-213 on April 16, 1996; 50 gal. at TA-53-60 on April 16, 1996; and 240 gal. at TA-21 on February 6, 1996.
- Seven releases of sanitary sewage (less than 1,000 gal. each) from the Laboratory's Sanitary Wastewater Systems Consolidation (SWSC) Plant.
- Three releases of potable water that originated from the line disinfection of wells, water lines, and other sources in the Los Alamos water supply system.
- Three releases of cement/mud slurry, fill material, and soil that were eroded into a watercourse.
- Two releases with oil sheen that originated from well-flushing activities.
- One release of diesel resulting from a leak in a storage tank.
- One release of 1-2 dichloroethane from a septic tank leach field.

H. Special Studies

1. Main Aquifer Hydrologic Properties Study: Water Production Records

Monthly water production records are provided to the State Engineer Office under State of New Mexico requirements specified in the water rights permit held by DOE for the Los Alamos municipal water supply system. During 1996, total water production from 14 wells in the Guaje, Pajarito, and Otowi municipal well fields, the Water Canyon Gallery, and Los Alamos and Guaje Reservoirs was 5.21 million m^3 (1,376 million gal., or 4,222 acre-ft). This total production amounts to 76.2% of the total water right of 6.8 million m^3 (5,541 acre-ft) that is available to DOE under its permit. Except for the Otowi-1 supply well, all other production wells were used during 1996 for municipal and industrial water supplies. The Otowi-1 well did not contribute to water supply during 1996. Details of the performance of the water supply wells and their operation are published in a series of separate reports.

The most recent report is entitled "Water Supply at Los Alamos during 1995" (McLin et al., 1997).

2. Main Aquifer Hydraulic Properties Study: Measurement of Main Aquifer Water Levels

In October 1992, the Laboratory began measuring and recording water level fluctuations in test wells completed into the main aquifer below Pajarito Plateau and in various other monitoring wells completed within intermediate and alluvial groundwaters located throughout the facility. These data are automatically recorded at hourly intervals using calibrated pressure transducers. Data are presented in the Laboratory report entitled "Water Supply at Los Alamos during 1995" (McLin et al., 1997), which summarizes the locations, start and end dates for data collection, and final water levels recorded during 1996.

3. Surface Water Data at Los Alamos National Laboratory: 1996 Water Year

Surface water discharge data were collected from 17 stream-gaging stations that cover most of the Laboratory. The data, published in the report "Surface Water Data at Los Alamos National Laboratory: 1996 Water Year" (Shaull et al., 1996), show less runoff than do data for the 1995 water year. Water chemistry data from larger storm events occurring at some stations are also published in that report.

The second annual water data report from LANL contains flow data. The data collection focused on the Laboratory's downstream boundary, close to State Road 4; the upstream boundary is approximated by State Road 501. Some of the gaging stations are within Laboratory boundaries and were originally installed to assist groups other than ESH-18 that also conduct site-specific earth science research.

Group ESH-18 developed and installed the stream-gaging network; the USGS Water Resources Division designed and installed the necessary data collection structures. The network is operated by the Storm Water Team of ESH-18.

Table 5-1. Radiochemical Analysis of Surface Waters for 1996 (pCi/L)

Station Name	Date	Code[a]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	^{239,240}Pu	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Regional Stations													
Rio Grande at Otowi (bank)	10/11	U	1	–239 ± 135[b]	0.3 ± 0.4	0.8 ± 3.0	3.0 ± 0.3	0.110 ± 0.027	0.002 ± 0.014	0.068 ± 0.028	7.2 ± 3.3	124.7 ± 14.0	193 ± 60
			2					–0.005 ± 0.004	0.004 ± 0.011				
			D1										43 ± 50
Rio Grande at Otowi (wdth intgrt)	10/11	U	1	–62 ± 136	0.9 ± 0.7	1.5 ± 4.0	2.7 ± 0.3	0.015 ± 0.014	0.010 ± 0.012	0.014 ± 0.025	1.6 ± 0.9	8.1 ± 1.0	223 ± 60
			2					–0.006 ± 0.002	–0.015 ± 0.006	–0.014 ± 0.011			
			D1			–1.8 ± 0.8							
			R1	–140 ± 136			2.7 ± 0.3	–0.003 ± 0.006	0.016 ± 0.013	–0.030 ± 0.009	4.7 ± 2.2	7.3 ± 0.9	
Rio Grande at Frijoles (bank)	10/09	F	1	562 ± 139	0.4 ± 0.3	–2.0 ± 0.8	2.8 ± 0.3	0.017 ± 0.009	0.020 ± 0.013	–0.009 ± 0.012	4.1 ± 2.1	5.9 ± 0.7	–68 ± 50
			R1								2.6 ± 1.3	6.1 ± 0.8	
Rio Grande at Frijoles (wdth intgrt)	10/09	F	1	92 ± 136	0.4 ± 0.3	–2.5 ± 0.8	3.0 ± 0.3	–0.001 ± 0.006	–0.002 ± 0.009	–0.012 ± 0.012	2.6 ± 1.3	8.4 ± 1.0	–98 ± 50
Rio Grande at Cochiti	12/24	U	1	28 ± 137	0.6 ± 0.3		3.8 ± 0.4	0.005 ± 0.009	0.000 ± 0.009	–0.023 ± 0.015	5.3 ± 2.8	10.5 ± 1.9	–78 ± 50
			R1	211 ± 139				–0.007 ± 0.012	–0.002 ± 0.010	–0.021 ± 0.014			
Jemez River	11/14	U	1	–427 ± 138	3.2 ± 1.0	–1.8 ± 0.8	1.3 ± 0.1	–0.004 ± 0.005	0.005 ± 0.009	–0.021 ± 0.013	14.9 ± 7.0	15.7 ± 2.0	–18 ± 50
			R1										–18 ± 50
Jemez River at Pueblo Intakes	11/14	U	1	–246 ± 139	1.7 ± 0.9	2.5 ± 1.3	1.4 ± 0.1	–0.003 ± 0.006	0.013 ± 0.012	0.020 ± 0.023	9.7 ± 4.2	11.7 ± 1.0	–8 ± 50
Pajarito Plateau													
Guaje Canyon:													
Guaje Canyon	12/12	U	1	106 ± 143	–0.1 ± 0.4	–1.3 ± 0.8	0.1 ± 0.0	0.001 ± 0.006	–0.016 ± 0.003	–0.003 ± 0.013	0.9 ± 0.2	3.0 ± 0.4	–58 ± 50
			R1										–98 ± 50
Pueblo Canyon:													
Acid Weir	12/10		Insufficient water, sampled volatile organics only										
Pueblo 1	12/10		Insufficient water, sampled volatile organics only										
Pueblo 2	12/10		No Flow										
Pueblo 3	12/10	U	1	–214 ± 140	–0.3 ± 0.4	3.0 ± 0.9	0.6 ± 0.1	–0.007 ± 0.004	0.056 ± 0.016	0.000 ± 0.017	1.2 ± 0.7	21.3 ± 3.8	–68 ± 50
			D1			1.8 ± 0.8							
			R1								5.4 ± 3.4	23.7 ± 4.6	
DP/Los Alamos Canyon:													
Los Alamos Canyon Reservoir	12/12	U	1	–448 ± 139	–0.7 ± 1.1	0.0 ± 0.3	0.1 ± 0.0	–0.005 ± 0.006	–0.004 ± 0.008	–0.035 ± 0.010	0.8 ± 0.2	2.9 ± 0.4	–68 ± 50
			R1				0.1 ± 0.0						
DPS-1	07/09	U	1	369 ± 71	8.5 ± 0.8	2.9 ± 1.0	0.4 ± 0.0	0.016 ± 0.009	0.081 ± 0.019	0.263 ± 0.040	2.3 ± 0.8	30.9 ± 3.7	–108 ± 50
			D1			2.1 ± 0.9							
			R1					0.007 ± 0.008	0.113 ± 0.023	0.323 ± 0.050	2.0 ± 0.8	32.8 ± 4.0	
DPS-4	07/09	U	1	318 ± 71	31.0 ± 2.1	1.4 ± 3.8	0.5 ± 0.1	0.013 ± 0.010	0.078 ± 0.020	0.155 ± 0.034	1.3 ± 0.5	95.5 ± 11.5	–98 ± 50
			D1				0.5 ± 0.1						
			R1										–88 ± 50
Sandia Canyon:													
SCS-1	06/04	U	1	719 ± 80	–0.4 ± 0.2	–0.3 ± 1.3	0.3 ± 0.0	0.005 ± 0.007	0.008 ± 0.010	0.002 ± 0.013	1.2 ± 0.5	13.2 ± 1.6	–48 ± 50
			D1			–0.7 ± 0.8							
			R1	–172 ± 69									–88 ± 50

Table 5-1. Radiochemical Analysis of Surface Waters for 1996 (pCi/L) (Cont.)

Station Name	Date	Code[a]	^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Sandia Canyon (Cont.):												
SCS-2	06/04	U 1	–106 ± 70	0.0 ± 0.3	–1.7 ± 0.8	0.5 ± 0.1	–0.001 ± 0.006	0.001 ± 0.010	–0.029 ± 0.006	2.7 ± 1.2	21.0 ± 2.6	463 ± 80
		D1			0.0 ± 1.8					7.2 ± 3.0	18.5 ± 2.3	
		R1		0.2 ± 0.3								
SCS-3	06/04	U 1	149 ± 74	0.2 ± 0.3	–1.4 ± 0.8	0.5 ± 0.1	0.021 ± 0.011	0.044 ± 0.016	0.056 ± 0.020	–0.6 ± 0.2	17.9 ± 2.2	–18 ± 50
		R1					0.010 ± 0.009	0.025 ± 0.013	–0.004 ± 0.020			
		R2					0.010 ± 0.009	0.025 ± 0.013				
Mortandad Canyon:												
Mortandad at GS-1	08/05	U 1	13,281 ± 206	11.5 ± 1.4	30.6 ± 3.4	0.9 ± 0.1	2.673 ± 0.174	1.520 ± 0.115	2.190 ± 0.142	28.9 ± 11.0	123.7 ± 14.0	–78 ± 50
Mortandad at Rio Grande (A-11)	10/07	F 1	52 ± 135	0.6 ± 0.3	1.1 ± 3.5	1.8 ± 0.2	0.003 ± 0.007	–0.005 ± 0.006	–0.013 ± 0.014	0.4 ± 0.2	6.3 ± 0.8	23 ± 50
		D1										–118 ± 50
		R1								0.7 ± 0.3	6.1 ± 0.8	
Cañada del Buey:												
Cañada del Buey		No Water (6/4/96, 10/1/96, 12/17/96)										
Pajarito Canyon:												
Pajarito Canyon	12/11	U 1	–192 ± 140	1.1 ± 0.6	–0.8 ± 0.6	0.2 ± 0.0	0.006 ± 0.011	–0.007 ± 0.011	0.023 ± 0.020	1.4 ± 0.5	6.4 ± 0.9	–68 ± 50
		R1										–78 ± 50
Pajarito at Rio Grande	10/07	F 1	–50 ± 135	1.1 ± 0.4	–1.7 ± 0.8	1.2 ± 0.1	–0.006 ± 0.004	–0.002 ± 0.006	–0.008 ± 0.014	0.0 ± 0.0	3.8 ± 0.5	73 ± 50
Water Canyon:												
Water Canyon at Beta	11/08	U 1	145 ± 139	1.0 ± 0.9	–0.4 ± 1.2	0.6 ± 0.1	0.002 ± 0.009	0.007 ± 0.011	–0.028 ± 0.025	5.4 ± 2.0	7.6 ± 0.9	73 ± 50
		R1	–285 ± 136				0.006 ± 0.013	0.031 ± 0.021	–0.017 ± 0.011			
Ancho Canyon:												
Ancho at Rio Grande	10/08	F 1	–122 ± 134	1.0 ± 0.4	–0.1 ± 0.3	0.3 ± 0.0	0.010 ± 0.008	–0.007 ± 0.007	–0.017 ± 0.012	–0.4 ± 0.1	2.9 ± 0.4	–148 ± 50
Frijoles Canyon:												
Frijoles at Monument HQ	06/04	U 1	459 ± 77	–0.5 ± 0.2	–1.4 ± 0.8	0.1 ± 0.0	0.008 ± 0.016	0.007 ± 0.010	0.030 ± 0.024	0.6 ± 0.1	1.6 ± 0.2	–68 ± 50
		2					–0.006 ± 0.001	–0.001 ± 0.013	0.046 ± 0.020	±		
		D1				0.1 ± 0.0						
Frijoles at Rio Grande	10/09	F 1	233 ± 137	0.5 ± 0.3	–0.6 ± 0.9	0.1 ± 0.0	0.014 ± 0.011	0.009 ± 0.012	0.007 ± 0.018	0.9 ± 0.3	2.6 ± 0.3	–78 ± 50
Detection Limits			700	3	2	0.1	0.04	0.04	0.04	3	3	
Water Quality Standards[c]												
DOE DCG for Public Dose			2,000,000	1,000	3,000	800	40	30	30			
DOE Drinking Water System DCG			80,000	40	120	30	1.6	1.2	1.2			
EPA Primary Drinking Water Standard			20,000	8		20				15		
EPA Screening Level											50	
NM Livestock Watering Limit			20,000							15		
NMWQCC Groundwater Limit						5000						

[a] Codes: U–unfiltered, F–filtered, d–field duplicate, 1–primary analysis, 2–secondary analysis, R1–lab replicate, D1–lab duplicate.
[b] Radioactivity counting uncertainties (1 standard deviation) follow the ± sign.
[c] Standards given here for comparison only, see Appendix A.

Table 5-2. Radiochemical Analysis of Runoff Water Samples in 1996

Station Name	Date	Codes[b]	Flow (cfs)	^{3}H (pCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
Water													
LA Canyon near LA	08/22	U 1	2.2	−220 ± 136[b]	9.9 ± 1.3	4.1 ±1.0	0.79 ± 0.08	0.119 ± 0.032	1.074 ± 0.100	1.082 ± 0.084	24.9 ± 11.0	80.7 ± 10.0	−18 ± 50
		R1					0.34 ± 0.04	0.176 ± 0.040	1.578 ± 0.140	1.166 ± 0.090			−8 ± 50
LA Canyon near LA		U 1		94 ± 138	8.5 ± 1.4	3.7 ± 1.1	0.05 ± 0.01	0.122 ± 0.039	1.187 ± 0.120	1.316 ± 0.220	31.9 ± 13.0	60.7 ± 7.0	−48 ± 50
Cañada del Buey at WR	07/08	F 1	46	−232 ± 70	−0.3 ± 0.2	−1.3 ± 0.8	0.21 ± 0.02	−0.001 ± 0.004	0.010 ± 0.009	−0.012 ± 0.018	0.3 ± 0.1	5.4 ± 0.7	−68 ± 50
		D1				0.2 ± 2.1	0.20 ± 0.02						
		R1									0.1 0.0	5.3 0.6	−98 ± 50
Ancho Canyon near Bandelier	06/29	F 1	107	−41 ± 73	1.2 ± 0.4	1.0 ± 0.9	1.53 ± 0.15	0.002 ± 0.005	0.039 ± 0.013	−0.014 ± 0.020	1.4 ± 0.3	14.7 ± 1.8	−118 ± 50
		D1				0.5 ± 0.8	1.49 ± 0.15						
		R1									1.2 ± 0.3	13.3 ± 1.6	
Limits of Detection in Water Samples				700	3	2	0.1	0.04	0.04	0.04	3	3	

Station Name	Date	Codes[b]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	U (mg/kg)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
Suspended Solids											
Cañada del Buey at WR	07/08	1	0.0 ± 0.3	−0.5 ± 0.8	2.42 ± 0.24	0.003 ± 0.001	0.018 ± 0.002	0.007 ± 0.002	11.5 ± 0.2	5.6 ± 0.7	3.9 ± 0.5
		2				0.002 ± 0.001	0.024 ± 0.004	0.011 ± 0.008			
		D1		0.2 ± 0.2	3.09 ± 0.31						
		R1	0.3 ± 0.2						12.6 ± 4.2	7.1 ± 0.9	
Ancho Canyon near Bandelier	06/29	1	0.3 ± 0.2	0.6 ± 0.2	6.44 ± 0.64	0.004 ± 0.001	0.029 ± 0.003	0.008 ± 0.010	16.2 ± 7.5	11.5 ± 1.4	4.2 ± 0.5
		D1		0.5 ± 0.1	6.61 ± 0.66						
		R1	0.4 ± 0.3						13.1 ± 5.5	12.9 ± 1.6	
Limits of Detection in Sediment Samples			1	0.05	0.02	0.002	0.002	0.002	1.5	1.5	

Table 5-2. Radiochemical Analysis of Runoff Water Samples in 1996 (Cont.)

Station Name	Date	Codes[b]	Suspended Sediment (mg/L)	^{90}Sr Total[c] (pCi/L)	%D[d]	^{137}Cs Total (pCi/L)	%D	U Total (µg/L)	%D	^{238}Pu Total (pCi/L)	%D	^{239,240}Pu Total (pCi/L)	%D	^{241}Am Total (pCi/L)	%D	Gross Alpha (pCi/g)	%D	Gross Beta (pCi/g)	%D	Gross Gamma (pCi/g)	%D
Total in Solution and Percent Dissolved																					
LA Canyon near LA	08/22		680 ± 70	9.2	NA[e]	3.9	NA	0.39	NA	0.139	NA	1.280	NA	1.188	NA	28.4	NA	70.7	NA	–24.7	
Uncertainty in Total[f]				1.9		1.5		0.09		0.064		0.210		0.252		17.0		12.2		86.6	
Cañada del Buey at WR	07/08		9100 ± 900	1.1	0[g]	–1.9		25.28	1	0.022	0	0.201	5	0.070	0	109.9	0	63.1	8	–47.5	
Uncertainty in Total				1.0		2.6		0.98		0.900		0.900		0.900		4.3		1.7		70.7	
Ancho Canyon near Bandelier	06/29		4600 ± 500	2.8	42.7	3.3	22.9	31.53	5	0.020	10	0.172	23	0.023	–61	68.7	2	70.1	20	–98.7	120
Uncertainty in Total				0.7		1.3		1.07		0.500		0.500		0.500		9.3		3.3		50.0	
Water Quality Standards[h]																					
DOE DCG for Public Dose			2,000,000	1,000		3,000		800		40		30		30		30		1000			
DOE Drinking Water System DCG			80,000	40		120		30		1.6		1.2		1.2				40			
EPA Primary Drinking Water Standard			20,000	8				20								15					
EPA Screening level																		50			
NM Livestock Watering limit			20,000													15					
NMWQCC Groundwater Limit								5000													

[a]Codes: U—unfiltered, F—filtered, d—field duplicate, 1—primary analysis, 2–secondary analysis, R1—lab replicate, D1—lab duplicate.
[b]Radioactivity counting uncertainties (1 standard deviation) follow the ± sign.
[c]Total is the sum of dissolved and sediments corrected for total suspended solids. At LA Canyon near LA only unfiltered samples were analyzed and the average is reported for the total.
[d]Percent dissolved.
[e]NA–Not applicable; insufficient information to calculate percent dissolved.
[f]Propagated uncertainty for Total concentration.
[g]Value replaced by zero if % dissolved result is negative due to negative values for dissolved fraction.
[h]Standards given here for comparison only, see Appendix A.

Table 5-3. Detections of Radionuclides in Surface Water for 1996[a]

Station Name	Date	Code[b]		Analyte	Blank Corrected	Lab Value	Uncertainty (σ)	Units	Detection Limit
Rio Grande at Otowi (bank)	10/11	U	1	Beta	124.7	125.0	14.0	pCi/L	3
DPS-1	07/09	U	1	^{241}Am	0.263	0.307	0.040	pCi/L	0.04
			R1	^{241}Am	0.323	0.367	0.050	pCi/L	0.04
			R1	^{239,240}Pu	0.113	0.125	0.023	pCi/L	0.04
			1	^{90}Sr	8.5	8.6	0.8	pCi/L	3
DPS-4	07/09	U	1	Beta	95.5	95.8	11.5	pCi/L	3
			1	^{90}Sr	31.0	31.1	2.1	pCi/L	3
SCS-1	06/04	U	1	^{3}H	719	921	80	pCi/L	700
SCS-2	06/04	U	1	Gamma	463	580	80	pCi/L	120
Mortandad at GS-1	08/05	U	1	^{241}Am	2.190	2.234	0.142	pCi/L	0.04
			1	Beta	123.7	124.0	14.0	pCi/L	3
			1	^{137}CS	30.6	31.8	3.4	pCi/L	4
			1	^{3}H	13,281	13,483	206	pCi/L	700
			1	^{238}Pu	2.673	2.677	0.174	pCi/L	0.04
			1	^{239,240}Pu	1.520	1.532	0.115	pCi/L	0.04
			1	^{90}Sr	11.5	11.6	1.4	pCi/L	3
LA Canyon near LA	08/22	U	1	^{241}Am	1.082	1.126	0.084	pCi/L	0.04
			R1	^{241}Am	1.166	1.210	0.090	pCi/L	0.04
			1	Beta	80.7	81.0	10.0	pCi/L	3
			1	^{239,240}Pu	1.074	1.086	0.100	pCi/L	0.04
			R1	^{239,240}Pu	1.578	1.590	0.140	pCi/L	0.04
			1	^{90}Sr	9.9	10.0	1.3	pCi/L	3
LA Canyon near LA	08/22	U	1	^{241}Am	1.316	1.360	0.220	pCi/L	0.04
			1	Beta	60.7	61.0	7.0	pCi/L	3
			1	^{239,240}Pu	1.187	1.199	0.120	pCi/L	0.04
			1	^{90}Sr	8.5	8.6	1.4	pCi/L	3
Cañada del Buey at WR	07/08	T		Alpha	109.9		4.3	pCi/L	1.5
				Beta	63.1		1.7	pCi/L	1.5
				U	25.3		1.0	µg/L	0.1
Ancho Canyon near Bandelier	06/29	T		Alpha	68.7		9.3	pCi/L	1.5
				Beta	70.1		3.3	pCi/L	1.5
				U	31.5		1.1	µg/L	0.1

[a] Detection defined as sample value - average blank >4.66 σ and >detection limit, except values for Uranium > 5 µg/L, for Gross Beta >40 pCi/l, and for Gross Alpha >10 pCi/L.

[b] Codes: U–unfiltered, F–filtered, T–Total as calculated on Table 5-2, d–field duplicate; 1–primary analysis; R1–lab replicate; D1–lab duplicate.

Table 5-4. Possible Detections of Radionuclides in Surface Water for 1996[a]

Station Name	Date	Code[b]		Analyte	Blank Corrected[c]	Lab Value	Uncertainty (σ)	Units	Detection Limit
Rio Grande at Otowi (bank)	10/11	U	1	^{241}Am	0.068	0.112	0.028	pCi/L	0.04
			1	Gamma	193	310	60	pCi/L	120
			1	^{238}Pu	0.110	0.115	0.027	pCi/L	0.04
Rio Grande at Otowi (wdth intgrt)	10/11	U	1	Gamma	223	340	60	pCi/L	120
Jemez River	11/14	U	1	^{90}Sr	3.2	3.3	1.0	pCi/L	3
Pueblo 3	12/10	U	1	^{239,240}Pu	0.056	0.069	0.016	pCi/L	0.04
DPS-1	07/09	U	1	^{239,240}Pu	0.081	0.093	0.019	pCi/L	0.04
			1	^{90}Sr	8.5	8.6	0.8	pCi/L	3
DPS-4	07/09	U	1	^{241}Am	0.155	0.199	0.034	pCi/L	0.04
			1	^{239,240}Pu	0.078	0.090	0.020	pCi/L	0.04
SCS-3	06/04	U	1	^{241}Am	0.056	0.100	0.020	pCi/L	0.04
			1	^{239,240}Pu	0.044	0.056	0.016	pCi/L	0.04
Mortandad at GS-1	08/05	U	1	Alpha	28.9	29.0	11.0	pCi/L	3
LA Canyon near LA	08/22	U	1	^{137}Cs	4.1	5.2	1.0	pCi/L	2
			1	^{238}Pu	0.119	0.123	0.032	pCi/L	0.04
			R1	^{238}Pu	0.176	0.180	0.040	pCi/L	0.04
LA Canyon near LA	08/22	U	1	Alpha	31.9	32.0	13.0	pCi/L	3
			1	^{238}Pu	0.122	0.127	0.039	pCi/L	0.04
Ancho Canyon near Bandelier	06/29	T		^{137}Cs	3.3		1.3	pCi/L	2

[a] Possible detection defined as 2.33 σ < (sample value–average blank) < 4.66 σ and > detection limit, except values for Uranium >5 µg/L, for Gross Beta >40 pCi/L, and for Gross Alpha >10 pCi/L.

[b] Codes: U–unfiltered, F–filtered, T–Total as calculated on Table 5-2, d–field duplicate; 1–primary analysis; R1–lab replicate; D1–lab duplicate.

[c] Refer to Section 5.F.3.

Table 5-5. Summary of TA-50 Radionuclide and Nitrate Discharges[a]

	1963–1977	1994			1995			1996		
Radionuclide	Total Activity Released (mCi)[b]	Total Annual Activity (mCi)	Mean Activity (pCi/L)	Ratio of Activity to DCG	Total Annual Activity (mCi)	Mean Activity (pCi/L)	Ratio of Activity to DCG	Total Annual Activity (mCi)	Mean Activity (pCi/L)	Ratio of Activity to DCG
^{3}H	25,150	2,230	107,000	0.05	731	41,400	0.02	1,020	61,700	0.03
^{241}Am	7	3.1	147	4.9	1.4	79.4	2.65	1.99	120	4.00
^{137}Cs	848	8.5	408	0.14	6.6	375	0.13	2.20	133	0.04
^{238}Pu	51	2.8	135	3.38	3.4	195	4.88	2.25	136	3.40
^{239}Pu	39	0.4	21.4	0.71	0.6	35.6	1.19	0.39	23.8	0.79
^{89}Sr	<1	2.0	9.4	0.005	0.1	6.9	0.0003	0.66	40.2	0.002
^{90}Sr	295	0.3	13.7	0.01	0.6	36.9	0.04	0.60	36.1	0.04
^{234}U	NA	0.1	5.6	0.01	0.2	14.3	0.03	0.19	11.7	0.02
^{235}U	2	0.01	0.72	.001	.009	0.53	0.0009	0.003	0.18	0.0003
Constituent		**Total Annual Mass (kg)**	**Mean Concentration (mg/L)**	**Ratio of Concentration MCL**	**Total Annual Mass (kg)**	**Mean Concentration (mg/L)**	**Ratio of Concentration to MCL**	**Total Annual Mass (kg)**	**Mean Concentration (mg/L)**	**Ratio of Concentration to MCL**
NO_3-N		947	45.5	4.5	718	35.6	3.5	1,260	76.4	7.6
Total effluent volume ($\times 10^7$ liters)		2.08			1.76			1.65		

[a]Compiled from Radioactive & Industrial Wastewater Science Group (CST-13) Annual Reports. Data for 1996 are preliminary.
[b]DOE, 1979; decay corrected through 12/77.

Table 5-6. Total Committed Effective Dose Equivalent (CEDE) from the Consumption of Water from the TA-50 Effluent and the Stream below the Outfall during 1996

Committed Effective Dose Equivalent (mrem/yr)[a]				
	1995		1996	
	TA-50 Effluent	Stream below Outfall	TA-50 Effluent	Stream below Outfall
Per Liter	1.3	0.49[b]	1.2	0.048[c]
Exercise Scenario[d]	21	7.8[b]	19	0.77[c]

[a] Based on DOE dose conversion factors (DOE 1988a).

[b] Instead of using the surface water result, the CEDE for 1995 was estimated using the average annual storm runoff into Mortandad Canyon to dilute the TA-50 effluent. [Purtymun et al., 1983].

[c] The average +2 sigma from sample collected at GS-1. The CEDE using the average annual storm runoff into Mortandad Canyon to dilute the TA-50 effluent results in an estimate that is approximately 10 times higher than actual stream measurements.

[d] Maximum consumption rate is 16.1 L/year (0.8 L/event). See text for assumptions.

Table 5-7. Chemical Quality of Surface Waters for 1996 (mg/L[a])

Station Name	Date	Code[b]		SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Regional Stations																					
Rio Grande at Otowi (bank)	10/11	U	1	17	44.8	8.6	2.3	21.8	7.9	71.4	<5[f]	110.0	0.4	0.1	0.0	<0.01	250.0	50.0	148.0	8.4	381
Rio Grande at Otowi (wdth intgrt)	10/11	U	1	17	45.0	8.4	2.4	21.7	7.9	72.8	<5	120.0	0.4	0.0	0.1	<0.01	260.0	61.0	147.0	8.5	378
Rio Grande at Frijoles (bank)	10/09	F	1	19	39.0	8.2	2.0	20.0	8.7	67.6	<5	116.0	0.4	<0.02	<0.02	<0.01	310.0	35.0	131.0	8.4	363
			R1						8.6	68.8											
Rio Grande at Frijoles (wdth intgrt)	10/09	F	1	19	49.0	10.0	3.0	24.0	9.0	71.9	<5	115.0	0.4	0.0	0.1	<0.01	310.0	110.0	164.0	7.7	619
Rio Grande at Cochiti	12/24	U	1	28	43.2	9.6	3.9	25.8	11.1	49.8	<5	130.0	0.5	<0.02	0.6	<0.01	230.0	46.0	147.0	8.2	365
			R1		41.5	8.7	3.9	24.6						<0.02	0.6				138.0		
Jemez River	11/14	U	1	44	33.0	3.9	6.4	43.5	53.7	10.7	<5	127.0	0.9	<0.02	0.1	<0.01	310.0	12.0	98.0	8.5	436
			R1										0.9								
Pajarito Plateau																					
Guaje Canyon:																					
Guaje Canyon	12/12	U	1	38	7.4	2.8	1.8	7.3	6.7	4.9	<5	43.0	0.1	0.1	0.5	<0.01	88.0	<1	30.0	7.7	14
			R1									44.0			0.5						
Pueblo Canyon:																					
Acid Weir	12/10	Insufficient water, sampled volatile organics only																			
Pueblo 1	12/10	Insufficient water, sampled volatile organics only																			
Pueblo 2	12/10	No Flow																			
Pueblo 3	12/10	U	1	85	21.3	6.4	12.3	65.8	42.0	25.8	<5	230.0	0.5	5.0	0.3	<0.01	360.0	87.0	79.5	7.4	614
DP/Los Alamos Canyon:																					
Los Alamos Canyon Reservoir	12/12	U	1	38	7.7	3.0	1.9	6.5	6.6	4.9	<5	44.0	0.1	0.1	0.1	<0.01	100.0	<1	31.2	7.7	13
DPS-1	07/09	U	1		16.9	1.3	4.1	21.0											48.0		
			R1		16.9	1.4	4.7	21.0													
DPS-4	07/09	U	1		12.5	1.5	6.4	19.6											37.0		
Sandia Canyon:																					
SCS-1	06/04	U	1	97	15.9	4.6	9.7	60.0	47.4	36.8	12.0	120.0	0.7	0.3	0.8	<0.01	370.0	13.0	58.7	8.6	459
			R1		15.8	4.5	10.1	61.2			7.0	114.0									
SCS-2	06/04	U	1	83	22.3	4.9	11.8	100.0	66.0	96.8	11.0	140.0	1.3	3.3	0.0	<0.01	500.0	11.0	75.9	8.9	668
SCS-3	06/04	U	1	83	22.2	5.0	11.7	100.0	64.0	90.2	<5	146.0	1.3	3.3	0.1	0.0	500.0	22.0	76.0	8.6	658
Mortandad Canyon:																					
Mortandad at GS-1	08/05	U	1	50	25.2	2.6	5.0	30.0	8.7	14.2	<3	107.0	0.7	0.1	3.0	<0.01	290.0	14.0	73.0	7.6	662
Mortandad at Rio Grande (A-11)	10/07	F	1	86	31.0	7.9	14.0	85.0	73.8	33.1	<5	134.0	1.1	5.3	6.5	<0.01	440.0	24.0	111.0	8.0	182
Cañada del Buey:																					
Cañada del Buey	No Flow (6/4/96, 10/1/96, 12/17/96)																				
Pajarito Canyon:																					
Pajarito Canyon	12/11	U	1	29	19.2	6.6	2.7	27.0	46.6	14.4	<5	57.0	0.1	<0.02	0.9	<0.01	180.0	41.0	75.0	6.8	295
			R1													<0.01	180.0				
Pajarito at Rio Grande	10/07	F	1	69	22.0	5.1	1.5	15.0	9.0	7.4	<5	84.0	0.5	0.0	0.8	<0.01	170.0	2.0	74.9	8.4	197

Table 5-7. Chemical Quality of Surface Waters for 1996 (mg/L[a]) (Cont.)

Station Name	Date	Code[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Water Canyon:																				
Water Canyon at Beta	11/08	U 1	35	11.7	4.5	3.9	17.0	17.7	6.9	<5	48.0	0.2	0.1	0.0	<0.01	190.0	3.8	47.7	7.5	163
		R1		10.8	4.2	3.5	15.5													
Ancho Canyon:																				
Ancho at Rio Grande	10/08	F 1	75	13.4	3.4	1.2	11.1	6.1	3.8	16.0	67.0	0.4	<0.02	0.0	<0.01	180.0	1.2	47.5	9.1	143
		R1										0.4					1.2			
Frijoles Canyon:																				
Frijoles at Monument HQ	06/04	U 1	62	<0.191	<0.044	0.6	<0.323	4.8	4.1	<5	62.0	0.2	0.1	0.6	<0.01	140.0	6.0	0.0	8.0	11
		R1	63					4.8	4.4			0.2	0.0	0.6	<0.01	130.0				
Frijoles at Rio Grande	10/09	F 1	63	808.0	3.2	1.2	10.4	6.3	3.6	<5	53.0	0.2	0.1	0.0	<0.01	130.0	2.8	35.2	8.4	36
Water Quality Standards[g]																				
EPA Primary Drinking Water Standard									500			4		10	0.2					
EPA Secondary Drinking Water Standard								250	250			2				500			6.8–8.5	
NMWQCC Groundwater Limit								250	600			1.6		10	0.2	1000			6-9	

[a] Except where noted.
[b] Codes: d–field duplicate, 1–primary analysis, R1–lab replicate, D1–lab duplicate.
[c] Total dissolved solids.
[d] Total suspended solids.
[e] Standard units.
[f] Less than symbol (<) means measurement was below the analytical uncertainty.
[g] Standards given here for comparison only, see Appendix A.

Table 5-8. Chemical Quality of Runoff for 1996

Station Name	Date	Code[b]		SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Waters (mg/L)																					
LA Canyon near LA	08/22	U	1	<10[f]	9.6	2.2	5.0	9.0	7.9	4.0	<5	35.0	0.2	0.1	0.6	<0.01	100.0	680.0	33.0	7.7	94
		U	1		11.8	2.9	6.2	9.6						0.2	0.5	<0.01			41.0		
Cañada del Buey at WR	07/08	U	1	18	11.0	1.2	<3.88	3.0	<0.5	2.5	<5	77.0	<0.1	0.6	1.3	<0.01	280.0	9100.0	32.4	8.4	
Ancho Canyon near Bandelier	06/29	U	1	15	7.3	2.2	4.8	5.0	8.3	8.7	<5	<5	0.3				1800.0	4600.0	27.0	6.9	
Suspended Solids (mg/kg)																					
Cañada del Buey at WR	07/08	U	1		7.1	5.1	5.2	0.3													
			R1		6.1	4.7	4.7	0.3													
Ancho Canyon near Bandelier	06/29	U	1		4.5	3.2	3.4	0.5													
Water Quality Standards[g] (mg/L)																					
EPA Primary Drinking Water Standard										500			4		10	0.2					
EPA Secondary Drinking Water Standard									250	250			2				500			6.8–8.5	
NMWQCC Groundwater Limit									250	600			1.6		10	0.2	1000			6–9	

[a] Except where noted.
[b] Codes: d–field duplicate, 1–primary analysis, R1–lab replicate, D1– lab duplicate.
[c] Total dissolved solids.
[d] Total suspended solids.
[e] Standard units.
[f] Less than symbol (<) means measurement was below the analytical uncertainty.
[g] Standards given here for comparison only, see Appendix A.

Table 5-9. Total Recoverable Trace Metals in Surface Waters for 1996 (μg/L)

Station Name	Date	Code[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Stations															
Rio Grande at Otowi (bank)	10/11	U	1	<4[b]	1,890	4	42	104	<3	<2	<6	<3	<10	1,340	<0.2
			R1												<0.2
Rio Grande at Otowi (wdth intgrt)	10/11	U	1	<4	1,350	4	37	102	<3	<2	<6	3	<10	1,060	<0.2
			R1												<0.2
Rio Grande at Frijoles (bank)	10/09	F	1	<4	1,970	5	51	97	<3	<2	<3	<3	<10	1,200	<0.2
			R1												<0.2
Rio Grande at Frijoles (wdth intgrt)	10/09	F	1	<4	4,030	5	57	140	<3	<2	4	4	<10	2,300	<0.2
			R1												<0.2
Rio Grande at Cochiti	12/24	U	1	<10	4,558	<3	66.1	106.4	<2	<10	<10	<15	<10	2,692	<0.2
			R1	<10	3,670	<2	66.7	99.8	<2	<8	<8	<7	<10	2,190	<0.2
Jemez River	11/14	U	1	<10	505	53	438	58.4	<2	<7	<8	<7	<10	399.7	<0.2
	11/14	U	R1												<0.2
Pajarito Plateau															
Guaje Canyon:															
Guaje Canyon	12/12	U	1	<10	<500	<4	<20	20.8	<2	<7	<8	<7	<10	281	<0.2
			R1												<0.2
Pueblo Canyon:															
Acid Weir	12/10			Insufficient water, sampled volatile organics only											
Pueblo 1	12/10			Insufficient water, sampled volatile organics only											
Pueblo 2	12/10			No Flow											
Pueblo 3			1	<10	1,884	7	299.9	53	<2	<7	<8	<8	42.6	1,150	<0.2
	12/10	U	R1												<0.2
DP/Los Alamos Canyon:															
Los Alamos Canyon Reservoir	12/12	U	1	<10	<500	<4	<20	21.4	<2	<7	<10	<10	<10	1,902	<0.5
			R1												<0.5
DPS-1	07/09	U	1	<10	1,410	<2	47	55	<1	<2	<30	<10	<13	803	<0.4
			R1	<2	1,890	<2	36	55	<1	<2	<3	<10	<13	1,090	<0.4
DPS-4	07/09	U	1	<2	3,850	3.7	44	53	<1	<2	<3	<10	<13	1,840	<0.2
			R1												0.3
Sandia Canyon:															
SCS-1	06/04	U	1	<3.9	231	5.3	59.5	26.1	<1	<2	<3	<10	13.9	279	<0.2
			R1	<3	194	5.3	54.1	26.4	<1	<2	<3	11.6	21.4	264	<0.2
SCS-2	06/04	U	1	3.6	682	6.5	75.7	33.3	<1	<2	<3	17.5	<13	700	<0.2
			R1												<0.2

Table 5-9. Total Recoverable Trace Metals in Surface Waters for 1996 (μg/L) (Cont.)

tation Name	Date	Code[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Sandia Canyon (Cont.):															
SCS-3	06/04	U	1	3.7	277	6.4	70.3	31	<1	<2	<3	13.8	<13	440	<0.2
			R1												<0.2
Mortandad Canyon:															
Mortandad at GS-1	08/05	U	1	<2	2,650	2	72	35	<1	<2	<3	<10	<13	1,490	<0.2
			R1												<0.2
Mortandad at Rio Grande (A-11)	10/07	F	1	<4	700	4	410	93	<3	<2	<3	3	20	450	<0.2
			R1												<0.2
Cañada del Buey:	No Flow (6/4/96, 10/1/96, 12/17/96)														
Pajarito Canyon:															
Pajarito Canyon	12/11	U	1	<4	959	<2	41.8	80.6	<3	<2	<3	<3	<10	704	<0.4
			R1			<2									<0.4
Pajarito at Rio Grande	10/07	F	1	6	<280	3	49	50	<3	2	<3	5	<10	120	<0.2
			R1												<0.2
Water Canyon:															
Water Canyon at Beta	11/08	U	1	<4	12,000	4	49	400	<3	3	<3	<10	<10	5,630	<0.2
			R1	<4	10,900	4	45	370	<3	<3	<3	<3	<10	5,120	<0.2
Ancho Canyon:															
Ancho at Rio Grande	10/08	F	1	<4	<280	4	27	32	<3	<2	<3	<3	<10	<100	<0.2
			R1												<0.2
Frijoles Canyon:															
Frijoles at Monument HQ	06/04	U	1	<2	<90	<2.7	<6	<1	<1	<2	<3	<10	<13	<47	<0.2
			R1												<0.2
Frijoles at Rio Grande	10/09	F	1	<4	340	3	17	16	<3	<2	3	<3	<10	270	<0.2
			R1												<0.2
Water Quality Standards[c]															
EPA Primary Drinking Water Standard						50		2,000	4	5		100			2
EPA Secondary Drinking Water Standard				100	50-200								1,000	300	
EPA Action Level													1,300		
NM Wildlife Habitat Stream Standard															0.012
NM Livestock Watering Limit					5,000	200	5,000			50	1,000	1,000	500		10
NMWQCC Groundwater Limit				50	5,000	100	750	1,000		10	50	50	1,000	1,000	2

Table 5-9. Total Recoverable Trace Metals in Surface Waters for 1996 (μg/L) (Cont.)

Station Name	Date	Code[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Regional Stations														
Rio Grande at Otowi (bank)	10/11	U	1	90	<15	<50	<3	<3	2	<20	390	<3	<6	<50
Rio Grande at Otowi (wdth intgrt)	10/11	U	1	90	<9	19	3	<3	2	<80	382	<3	5	52
Rio Grande at Frijoles (bank)	10/09	F	1	68	<9	<10	<3	<3	3	<20	350	<3	8	<50
Rio Grande at Frijoles (wdth intgrt)	10/09	F	1	110	<9	<30	3	<3	4	<40	430	<3	11	140
Rio Grande at Cochiti	12/24	U	1	122.6	<33	<32	6	<0.08	5	<83	351.8	<3	14.7	<50
			R1	117.7	<30	<20	4	<0.06	3	<30	342.5	<3	14.7	<50
Jemez River	11/14	U	1	26.2	<30	<20	<3	<3	<3	32.7	140	<3	14	<50
Pajarito Plateau														
Guaje Canyon:														
Guaje Canyon	12/12	U	1	35	<30	<20	<3	<3	6	<30	59.4	<3	<20	62.1
Pueblo Canyon:														
Acid Weir	12/10		Insufficient water, sampled volatile organics only											
Pueblo 1	12/10		Insufficient water, sampled volatile organics only											
Pueblo 2	12/10		No Flow											
Pueblo 3	12/10		1	64.3	<30	<20	5	<3	18	<130	106	<3	26	102
DP/Los Alamos Canyon:														
Los Alamos Canyon Reservoir	12/12	U	1	38.9	<30	<20	<3	<3	7	<30	61.1	<3	<8	98.4
DPS-1	07/09	U	1	54	<29	<38	6	<2	<1	<30	74	<2	<13	34
			R1	54	<5	<18	7	<2	<1	<56	74	<2	<10	76
DPS-4	07/09	U	1	16	<50	22	5	<2	1.3	<60	70	<2	<10	34
Sandia Canyon:														
SCS-1	06/04	U	1	33.3	223.1	<18	2	<10	2	<59	70.8	<10	8.1	65.7
			R1	33.3	226	<37	4	<10	3.4	<70	70.3	<10	8.7	121
SCS-2	06/04	U	1	17.8	225	<18	3	<10	3	<59	101	<10	11.6	72.2
SCS-3	06/04	U	1	14.3	217	<18	2	<10	3.1	<59	101	<10	8.7	56.2

Table 5-9. Total Recoverable Trace Metals in Surface Waters for 1996 (μg/L) (Cont.)

Station Name	Date	Code[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Mortandad Canyon:														
Mortandad at GS-1	08/05	U	1	18	380	<60	<3	0.6	1	<59	64.6	0.17	<2	23
			2				<46							
Mortandad at Rio Grande (A-11)	10/07	F	1	43	<9	<50	<3	<3	7	<30	156	<3	10	<50
Cañada del Buey:														
Cañada del Buey	No Flow (6/4/96, 10/1/96, 12/17/96)													
Pajarito Canyon:														
Pajarito Canyon	12/11	U	1	84.7	<9	<10	<3	<3	<2	<20	147.9	<3	<3	50.3
							<3	<3	<2			<3		
Pajarito at Rio Grande	10/07	F	1	3	<9	<10	<3	<3	3	<30	140	<3	12	120
Water Canyon:														
Water Canyon at Beta	11/08	U	1	27	<9	<30	3	<3	<3	<20	88	<3	8	<50
			R1	25	<9	<15	3	<3	<3	<20	82	<3	6.5	<50
Ancho Canyon:														
Ancho at Rio Grande	10/08	F	1	1	<9	<10	<3	<3	3	36	71	<3	6	75
Frijoles Canyon:														
Frijoles at Monument HQ	06/04	U	1	2	<5	<18	1	<10	3	<59	<1	<10	<2	<16
Frijoles at Rio Grande	10/09	F	1	6	<9	<10	<3	<3	2	35	59	<3	4	<50
Water Quality Standards[c]														
EPA Primary Drinking Water Standard							100	6	50			2		
EPA Secondary Drinking Water Standard				50										5,000
EPA Action Level							15							
NM Wildlife Habitat Stream Standard									2					
NM Livestock Watering Limit							100		50				100	25,000
NMWQCC Groundwater Limit				200	1,000	200	50		50					10,000

[a]Codes: U–unfiltered, F–filtered, d–field duplicate, 1–primary analysis, 2–secondary analysis, R1–lab replicate, D1–lab duplicate.
[b]Less than symbol (<) means measurement was below the analytical uncertainty.
[c]Standards given here for comparison only, see Appendix A. Note that New Mexico Wildlife and Groundwater limits are based on dissolved concentrations, while these analyses are of unfiltered samples, thus concentrations may include metals asscciated with the suspended sediments.

Table 5-10. Total Recoverable Trace Metals in Runoff Samples for 1996 (µg/L)

Station Name	Date	Code[a]		Flow (cfs)	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Waters (µg/L)																
LA Canyon near LA	08/22	U	1	2.2	<10[b]	10,000	4.8	16	68	<2	<0.7	4	10	<10	5,500	<0.2
			R1													<0.2
LA Canyon near LA	08/22	U	1		<2	13,800	<15	31	139	1	<2	5	10	15	7,900	<0.2
			R1													<0.2
Cañada del Buey at WR	070/8	F	1	46	<2	1,400	<2.4	54	480	<1	<30	<6	<10	<2	720	<0.2
			D1													<3
Ancho Canyon near Bandelier	06/29	F	1	107	<2	7,040	3	225	810	<1	<3	<3	7.7	<13	3,604	<0.2
			R1													<0.2
Suspended Solids (mg/kg)																
Cañada del Buey at WR	07/08		1		<0.25	29,762	2.7	10.5	265	1.95	<0.25	7.36	19.2	17.4	21,822	<0.2
			R1		<0.25	28,511	<0.31	4.73	231	1.73	<0.25	6.29	17.2		19,654	
			D1				<0.31									<0.2
			D2													<0.2
Ancho Canyon near Bandelier	06/29		1		<0.002	19,250	3.65	13.11	189.4	1.55	<3	5.73	16.5	16.8	16,777	0.127
			R1													0.107
			R2													0.101
Water Quality Standards[c]																
EPA Primary Drinking Water Standard							50		2,000	4	5		100			2
EPA Secondary Drinking Water Standard					100	50-200								1,000	300	
EPA Action Level														1,300		
NM Wildlife Habitat Stream Standard																0.012
NM Livestock Watering Limit						5,000	200	5,000			50	1,000	1,000	500		10
NMWQCC Groundwater Limit					50	5,000	100	750	1,000		10	50	50	1,000	1,000	2

Table 5-10. Total Recoverable Trace Metals in Runoff Samples for 1996 (μg/L) (Cont.)

Station Name	Date	Code[a]	Flow (cfs)	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Waters (μg/L)														
LA Canyon near LA	08/22	U 1	2.2	120	14	<20	17	1.2	<2	<30	49	0.59	20	48
LA Canyon near LA	08/22	U 1		390	18.1	22	45	2	<2	<59	64	0.43	22	120
Cañada del Buey at WR	07/08	F 1	46	12	<5	<16	<46	<10	<1.4	<73	49	<10	<16	30
		D1												
Ancho Canyon near Bandelier	06/29	F 1	107	135.3	<35	<44	<46	<10	1	<59	46.6	<10	11.2	228.7
Suspended Solids (mg/kg)														
Cañada del Buey at WR	07/08	1		495	<0.625	18	25	<1.24	<0.6	<7.38	49.2	<1.24	28.1	80
		R1		427	<0.62	14.5	21	<1.24		<7.38	43.1	<1.25	23	65
		D1							0.72					
Ancho Canyon near Bandelier	06/29	1		489	<0.625	13.2	21.6	<1.25	0.69	<7.38	40	<1.25	21.3	77.3
Water Quality Standards[c]														
EPA Primary Drinking Water Standard						100		6	50			2		
EPA Secondary Drinking Water Standard				50										5,000
EPA Action Level							15							
NM Wildlife Habitat Stream Standard									2					
NM Livestock Watering Limit							100		50				100	25,000
NMWQCC Groundwater Limit				200	1,000	200	50		50					1,000

[a] Codes: U–unfiltered, F–filtered, d–field duplicate, 1–primary analysis, R1–lab replicate, D1–lab duplicate.
[f] Less than symbol (<) means measurement was below the analytical uncertainty.
[c] Standards given here for comparison only, see Appendix A. Note that New Mexico Wildlife and Groundwater limits are based on dissolved concentrations, but these analyses are of unfiltered samples- thus concentrations may include metals assciated with the suspended sediments.

Table 5-11. Number of Results above the Analytical Limit of Quantitation for Organic Compounds in Surface Waters in 1996

Station Name	Date	Volatile	Semivolatile	PCB	High Explosives	TIC[a]
Number of Compounds Analyzed		59	69	4	14	
Acid Weir	12/11	0				
Pueblo 1	12/10	0				
Pueblo 3	12/10	1	0	0		15
Los Alamos Canyon Reservoir	12/12	0	1	0		5
DPS-1	07/09	1	3[b]			5
SCS-2	12/10	0	1	0		2
Pajarito Canyon	12/11	0	1	0		4
Pajarito at Rio Grande	10/07	0	0	0		2
Water Canyon at Beta	11/08	0	0	0	2	2
Ancho at Rio Grande	10/08	0	0	0	0	
Frijoles at Monument HQ	06/04	0	0	0	2	
Frijoles at Rio Grande	10/09	0		0		
LA Canyon near LA (filtered)	08/22				0	
LA Canyon near LA (unfiltered)	08/22				0	
Cañada del Buey at WR (water)	07/08				0	
Cañada del Buey at WR (suspended solids)	07/08				0	
Ancho Canyon near Bandelier (water)	06/29				0	
Ancho Canyon near Bandelier (suspended solids)	06/29				0	

[a]TIC—Tentatively identified compounds, TICs are run with all volatile and semivolatile analysis, all detected values reported, limit of quantitation not defined.
[b]Semivolitile sample collected on 12/31/96.

Table 5-12. Organics Found in Surface Waters in 1996 above the Limit of Quantitation

Station Name	Date	Analyte	Sample Value (µg/L)	Uncertainty (µg/L)	Analyte[a] Suite
Pueblo 3	12/10	Hexadecanoic acid	24		voa
Los Alamos Canyon Reservoir	12/12	Di-n-butyl phthalate	4	1.2	semivoa
DPS-1	07/09	Acetone	15	4.5	voa
		Benzoic acid	11	3.3	semivoa
		Di-n-butyl phthalate	7	2.1	semivoa
		Di-n-octyl phthalate	8	2.4	semivoa
SCS-2	12/10	Di-n-butyl phthalate	2	0.6	semivoa
Pajarito Canyon	12/11	Di-n-butyl phthalate	2	0.6	semivoa
Water Canyon at Beta	11/08	HMX	4.92	1.48	HE
		RDX	0.76	0.228	HE
Frijoles at Monument HQ	06/04	Dinitrotoluene [2,4-]	3.443	1.329	HE
		Trinitrotoluene [2,4,6-]	1.442	0.433	HE

[a]voa—volatile organics, semivoa—semivolatile organics, HE—high explosives.

Table 5–13. Radiochemical Analysis for Sediments in 1996 (pCi/g)[a]

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Regional Stations:												
Rio Chama at Chamita	05/09	1	0.000 (0.001)[d]	0.70 (0.30)	0.06 (0.02)	1.35 (0.14)	0.001 (0.001)	0.002 (0.001)	0.002 (0.001)	1.5 (0.4)	1.4 (0.2)	2.8 (0.3)
	05/09	R1	0.001 (0.000)				0.001 (0.001)	0.002 (0.001)	0.002 (0.002)			
Rio Grande at Embudo	05/09	1	0.001 (0.001)	0.30 (0.20)	0.07 (0.02)	2.03 (0.20)	0.001 (0.001)	0.003 (0.001)	0.003 (0.005)	3.5 (1.6)	2.4 (0.3)	1.7 (0.2)
	05/09	R1								2.9 (1.3)	2.3 (0.3)	
Rio Grande at Otowi (bank)	05/09	1	0.000 (0.001)	–0.10 (0.20)	0.05 (0.02)	1.10 (0.11)	0.001 (0.001)	0.000 (0.000)	0.000 (0.001)	1.5 (0.7)	2.4 (0.3)	1.9 (0.3)
	05/09	R1			0.05 (0.02)							1.3 (0.2)
	10/11	1	0.026 (0.069)	1.80 (0.80)	0.09 (0.03)	4.17 (0.42)	0.001 (0.000)	0.004 (0.001)	0.003 (0.001)	6.3 (1.9)	5.0 (0.6)	3.0 (0.4)
	10/11	D1	0.025 (0.069)	2.50 (0.90)		3.79 (0.38)	0.001 (0.000)	0.004 (0.001)		6.0 (1.8)	5.0 (0.6)	
Rio Grande at Otowi (wdth intgrt)	10/11	1	–0.018 (0.040)	0.40 (0.90)	0.07 (0.02)	1.81 (0.18)	0.000 (0.000)	0.002 (0.001)	0.003 (0.001)	2.8 (0.8)	2.1 (0.2)	2.7 (0.3)
	10/11	R1			0.09 (0.02)							2.6 (0.3)
Rio Grande at Frijoles (bank)	10/09	1	0.008 (0.049)	1.40 (0.50)	0.09 (0.03)	2.89 (0.29)	0.000 (0.000)	0.003 (0.001)	0.003 (0.001)	3.5 (0.9)	2.7 (0.3)	3.0 (0.4)
	10/09	D1		1.60 (0.50)								
Rio Grande at Bernalillo	05/09	1	0.001 (0.001)	0.00 (0.30)	0.02 (0.03)	1.44 (0.14)	0.000 (0.000)	0.003 (0.001)	0.003 (0.005)	2.4 (0.7)	1.4 (0.2)	1.3 (0.2)
	05/09	D1		0.20 (0.30)								
Jemez River	05/09	1	0.001 (0.001)	0.40 (0.20)	0.08 (0.03)	2.61 (0.26)	0.002 (0.001)	0.006 (0.001)	0.005 (0.002)	14.5 (6.6)	4.1 (0.5)	6.6 (0.7)
	05/09	D1				2.70 (0.27)						
Guaje Canyon:												
Guaje at SR–502	03/11	1	IM[e]	0.10 (0.30)	0.06 (0.03)	1.53 (0.15)	0.001 (0.001)	0.004 (0.001)	0.002 (0.001)	1.9 (0.2)	1.6 (0.2)	3.2 (0.4)
Bayo Canyon:												
Bayo at SR–502	03/11	1	0.004 (0.004)	0.30 (0.30)	0.07 (0.03)	0.93 (0.09)	–0.001 (0.001)	0.002 (0.002)	0.003 (0.001)	1.9 (0.3)	0.9 (0.1)	2.8 (0.3)
Acid/Pueblo Canyons:												
Acid Weir	12/10	1	0.103 (0.034)	0.40 (0.30)	0.27 (0.03)	1.38 (0.14)	0.031 (0.003)	5.340 (0.140)	0.531 (0.019)	2.2 (0.6)	0.7 (0.1)	2.7 (0.3)
	12/10	R1		0.70 (0.20)	0.24 (0.03)	1.30 (0.13)	0.044 (0.005)	8.500 (0.400)	0.420 (0.020)			2.5 (0.3)
Pueblo 1	12/10	1	0.056 (0.045)	0.20 (0.40)	0.17 (0.02)	1.44 (0.14)	0.001 (0.001)	0.006 (0.001)	0.004 (0.001)	5.5 (1.2)	3.7 (0.5)	3.3 (0.4)
Pueblo 2	12/10	1	0.072 (0.014)	0.20 (0.20)	0.15 (0.02)	1.53 (0.15)	0.001 (0.001)	0.003 (0.001)	0.002 (0.001)	3.2 (0.6)	2.0 (0.2)	2.7 (0.3)
	12/10	R1								3.4 (0.7)	2.3 (0.3)	
Hamilton Bend Spring	12/24	1	0.002 (0.000)	0.00 (0.20)	0.09 (0.01)	1.70 (0.17)	0.003 (0.001)	0.423 (0.015)	0.013 (0.002)	3.6 (0.8)	2.6 (0.3)	3.3 (0.4)
Pueblo 3	12/10	1	0.010 (0.011)	0.00 (0.20)	0.11 (0.02)	1.69 (0.17)	0.000 (0.000)	0.005 (0.001)	0.008 (0.003)	4.0 (1.1)	1.7 (0.1)	3.0 (0.4)
Pueblo at SR–502	05/07	1	0.234 (0.144)	0.00 (0.30)	0.07 (0.03)	1.81 (0.18)	0.009 (0.002)	0.769 (0.032)	0.034 (0.010)	4.1 (0.7)	1.2 (0.1)	3.3 (0.4)
	05/07	R1		0.10 (0.20)						4.2 (0.9)	1.8 (0.2)	
DP/Los Alamos Canyons:												
Los Alamos at Bridge	05/08	1	IM	0.10 (0.20)	0.11 (0.03)	1.60 (0.16)	0.002 (0.001)	0.003 (0.001)	0.005 (0.005)	2.7 (0.5)	1.6 (0.2)	2.3 (0.3)
Los Alamos at LAO–1	05/08	1	IM	0.10 (0.20)	0.15 (0.04)	1.65 (0.17)	0.001 (0.001)	0.346 (0.013)	0.010 (0.002)	1.9 (0.3)	1.0 (0.1)	2.4 (0.3)
Los Alamos at GS–1	05/08	1	IM	0.10 (0.20)	0.05 (0.02)	1.23 (0.12)	0.000 (0.001)	0.060 (0.005)	0.006 (0.001)	1.3 (0.2)	0.5 (0.1)	1.8 (0.3)
	05/08	R1					0.002 (0.001)	0.054 (0.005)	0.006 (0.013)			
DPS–1	05/08	1	IM	0.20 (0.20)	0.38 (0.06)	0.77 (0.08)	0.005 (0.001)	0.044 (0.004)	0.053 (0.004)	0.9 (0.1)	1.4 (0.2)	2.2 (0.3)
	05/08	D1				0.67 (0.07)						

Table 5–13. Radiochemical Analysis for Sediments in 1996 (pCi/g)[a] (Cont.)

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
DP/Los Alamos Canyons (Cont.):												
DPS–4	05/08	1	IM	0.90 (0.20)	3.17 (0.26)	1.35 (0.14)	0.049 (0.003)	0.221 (0.009)	0.460 (0.030)	3.0 (0.4)	4.8 (0.6)	5.3 (0.6)
Los Alamos at LAO–3	05/08	1	IM	0.40 (0.30)	1.19 (0.12)	0.84 (0.08)	0.022 (0.002)	0.124 (0.005)	0.198 (0.009)	1.3 (0.2)	1.6 (0.2)	3.0 (0.4)
	05/08	R1			1.63 (0.16)							3.6 (0.4)
Los Alamos at LAO–4.5	05/08	1	IM	0.20 (0.20)	0.82 (0.09)	0.91 (0.09)	0.011 (0.001)	0.088 (0.004)	0.092 (0.005)	0.8 (0.1)	0.9 (0.1)	2.6 (0.3)
	05/08	D1		0.30 (0.30)	0.75 (0.09)	0.99 (0.10)	0.007 (0.001)	0.122 (0.006)	0.111 (0.006)	1.1 (0.1)	1.2 (0.1)	2.6 (0.3)
Los Alamos at SR–4	05/02	1	0.000 (0.000)	0.10 (0.20)	0.06 (0.02)	1.09 (0.11)	0.001 (0.000)	0.088 (0.004)	0.014 (0.002)	1.2 (0.2)	0.7 (0.1)	2.5 (0.3)
Los Alamos at Totavi	08/15	1	0.008 (0.001)	0.10 (0.40)	0.16 (0.02)	2.97 (0.30)	0.000 (0.001)	0.026 (0.003)	0.004 (0.001)	6.1 (2.2)	5.1 (0.6)	3.8 (0.4)
	08/15	R1				2.78 (0.28)			0.011 (0.002)			
Los Alamos at Otowi	05/02	1	0.000 (0.000)	0.30 (0.20)	1.67 (0.16)	2.91 (0.29)	0.029 (0.003)	0.243 (0.009)	0.340 (0.020)	5.5 (1.2)	4.3 (0.5)	5.9 (0.6)
	05/02	D1		0.90 (0.40)	1.75 (0.17)	2.90 (0.29)	0.032 (0.003)	0.230 (0.010)	0.370 (0.020)	6.1 (1.3)	4.5 (0.5)	5.3 (0.6)
	08/15	1	–0.001 (0.000)	0.20 (0.40)	0.13 (0.02)	1.34 (0.13)	0.001 (0.001)	0.100 (0.006)	0.004 (0.001)	1.8 (0.3)	0.7 (0.1)	3.1 (0.4)
Sandia Canyon:												
Sandia at SR–4	03/11	1	IM	0.10 (0.30)	0.04 (0.02)	1.21 (0.12)	0.000 (0.001)	0.003 (0.001)	0.002 (0.001)	3.2 (0.6)	2.3 (0.3)	1.2 (0.2)
	03/11	R1			0.06 (0.02)							2.4 (0.3)
Mortandad Canyon:												
Mortandad near CMR Building	04/11	1	0.076 (0.009)	0.10 (0.20)	0.07 (0.03)	1.45 (0.15)	0.030 (0.003)	0.008 (0.001)	0.005 (0.002)	10.9 (4.4)	4.3 (0.5)	2.6 (0.3)
	04/11	D1		0.90 (0.20)	0.07 (0.03)	1.81 (0.18)	0.027 (0.003)	0.012 (0.002)	0.006 (0.001)	8.1 (1.7)	4.1 (0.5)	
Mortandad west of GS–1	04/11	1	0.171 (0.026)	0.00 (0.20)	2.30 (0.21)	1.77 (0.18)	0.009 (0.002)	0.205 (0.009)	0.039 (0.002)	17.7 (3.7)	29.4 (3.5)	4.7 (0.5)
	04/11	R1										2.6 (0.3)
Mortandad at GS–1	04/11	1	31.877 (0.392)	0.50 (0.20)	16.10 (1.20)	0.89 (0.09)	6.800 (0.350)	4.850 (0.250)	9.060 (0.280)	54.1 (8.2)	43.4 (5.0)	20.0 (2.0)
Mortandad at MCO–5	04/11	1	0.000 (0.000)	0.80 (0.20)	14.70 (1.10)	1.36 (0.14)	2.220 (0.110)	5.790 (0.280)	7.250 (0.250)	43.1 (6.4)	26.5 (3.1)	16.0 (2.0)
	04/11	R1							8.250 (0.330)			
Mortandad at MCO–7	04/11	1	0.000 (0.000)	0.40 (0.20)	6.06 (0.48)	0.72 (0.07)	1.000 (0.500)	3.220 (0.160)	2.070 (0.100)	30.5 (5.2)	16.9 (2.0)	7.1 (0.7)
	04/11	R1							2.180 (0.110)			
Mortandad at MCO–9	04/11	1	0.000 (0.000)	0.10 (0.40)	0.54 (0.07)	1.03 (0.10)	0.002 (0.002)	0.037 (0.005)	0.016 (0.002)	10.6 (2.1)	8.6 (1.0)	4.4 (0.5)
Mortandad at MCO–13 (A–5)	04/11	1	0.000 (0.000)	–0.10 (0.50)	0.44 (0.06)	1.24 (0.12)	0.002 (0.001)	0.026 (0.002)	0.007 (0.001)	11.0 (2.9)	7.6 (0.9)	3.8 (0.4)
Mortandad A–6	08/15	1	0.002 (0.000)	0.40 (0.40)	0.24 (0.03)	2.12 (0.21)	0.001 (0.000)	0.023 (0.002)	0.004 (0.001)	3.7 (0.9)	5.6 (0.7)	3.5 (0.4)
	08/15	R1		0.40 (0.40)						5.8 (1.9)	2.6 (0.3)	
Mortandad A–7	08/15	1	0.004 (0.000)	0.40 (0.20)	0.20 (0.02)	2.21 (0.22)	0.000 (0.000)	0.008 (0.001)	0.003 (0.001)	8.5 (3.1)	5.9 (0.7)	3.4 (0.4)
	08/15	R1					0.001 (0.001)	0.010 (0.002)				
Mortandad at SR–4 (A–9)	08/15	1	0.005 (0.001)	0.30 (0.20)	0.10 (0.01)	1.85 (0.19)	0.000 (0.001)	0.004 (0.001)	0.002 (0.001)	6.1 (2.6)	3.2 (0.4)	3.4 (0.4)
	08/15	R1			0.08 (0.01)							2.8 (0.3)
Mortandad at Rio Grande (A–11)	10/07	1	IM	0.30 (0.50)	0.06 (0.02)	1.63 (0.16)	0.001 (0.001)	0.002 (0.001)	0.004 (0.002)	2.2 (0.5)	2.6 (0.3)	2.6 (0.3)
	10/07	R1			0.02 (0.04)							2.6 (0.3)
Cañada del Buey:												
Cañada del Buey at SR–4	03/11	1	IM	0.10 (0.20)	0.12 (0.04)	0.84 (0.08)	0.001 (0.001)	0.003 (0.001)	0.000 (0.000)	1.9 (0.3)	1.4 (0.2)	2.8 (0.3)
	03/11	D1		0.00 (0.30)		0.61 (0.06)	0.001 (0.001)	0.003 (0.001)	0.003 (0.001)	2.4 (0.4)	1.2 (0.1)	

Table 5–13. Radiochemical Analysis for Sediments in 1996 (pCi/g)[a] (Cont.)

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
TA–54 Area G:												
G–1	03/22	1	0.004 (0.003)	0.10 (0.20)	0.09 (0.03)	0.77 (0.08)	0.001 (0.001)	0.003 (0.001)	0.005 (0.001)	2.4 (0.5)	1.1 (0.1)	2.6 (0.3)
	03/22	D1		0.30 (0.20)			0.000 (0.001)	0.025 (0.003)	0.003 (0.001)			
G–2	03/22	1	0.023 (0.006)	0.30 (0.30)	0.06 (0.02)	1.15 (0.12)	0.000 (0.001)	0.012 (0.003)	0.003 (0.001)	3.9 (0.8)	1.8 (0.2)	2.3 (0.3)
	03/22	R1					0.001 (0.001)	0.003 (0.001)	0.004 (0.002)			
G–3	03/22	1	0.243 (0.070)	0.10 (0.10)	0.20 (0.04)	1.07 (0.11)	0.004 (0.002)	0.030 (0.004)	0.007 (0.003)	3.5 (0.7)	2.4 (0.3)	2.7 (0.3)
	03/22	D1				0.76 (0.08)	0.002 (0.001)	0.012 (0.002)	0.012 (0.002)			
	03/22	R1					0.007 (0.002)	0.013 (0.002)	0.010 (0.002)			
	03/22	R2					0.004 (0.002)	0.021 (0.003)	0.015 (0.002)			
G–4	03/22	1	0.019 (0.006)	0.20 (0.20)	0.26 (0.05)	1.68 (0.17)	0.004 (0.002)	0.018 (0.003)	0.006 (0.001)	5.1 (1.0)	4.0 (0.5)	4.1 (0.5)
	03/22	R1					0.003 (0.001)	0.015 (0.003)	0.003 (0.001)	7.6 (1.8)	4.3 (0.5)	
G–5	03/22	1	0.031 (0.009)	0.20 (0.20)	0.16 (0.04)	1.58 (0.16)	0.021 (0.003)	0.040 (0.005)	0.014 (0.002)	5.3 (1.5)	3.1 (0.4)	3.8 (0.4)
	03/22	R1					0.017 (0.005)	0.043 (0.003)	0.014 (0.004)			
	03/22	R2					0.017 (0.002)	0.039 (0.007)				
G–6	03/22	1	0.038 (0.009)	0.10 (0.20)	0.12 (0.03)	2.55 (0.26)	0.018 (0.003)	0.226 (0.012)	0.035 (0.003)	7.2 (2.1)	2.5 (0.3)	3.2 (0.4)
	03/22	R1					0.012 (0.002)	0.139 (0.007)	0.049 (0.004)			
G–7	03/22	1	0.020 (0.005)	0.00 (0.20)	0.15 (0.03)	0.88 (0.09)	0.243 (0.014)	0.174 (0.011)	0.013 (0.002)	4.0 (0.7)	2.0 (0.2)	2.9 (0.3)
	03/22	R1					0.118 (0.007)	0.105 (0.007)	0.044 (0.006)			
G–8	03/22	1	0.016 (0.005)	0.30 (0.40)	0.38 (0.06)	1.36 (0.14)	0.119 (0.008)	0.150 (0.009)	0.014 (0.002)	4.0 (0.7)	3.2 (0.4)	3.9 (0.4)
	03/22	R1			0.33 (0.05)		0.084 (0.005)	0.063 (0.004)	0.014 (0.004)			3.0 (0.3)
G–9	03/22	1	0.017 (0.005)	0.00 (0.30)	0.18 (0.04)	1.77 (0.18)	0.031 (0.004)	0.040 (0.004)	0.021 (0.003)	4.5 (0.9)	2.0 (0.2)	3.5 (0.4)
	03/22	R1					0.091 (0.005)	0.030 (0.003)	0.013 (0.016)			
Pajarito Canyon:												
Two–mile at SR–501	03/12	1	0.003 (0.014)	0.20 (0.20)	0.28 (0.05)	1.09 (0.11)	0.001 (0.001)	0.007 (0.001)	0.003 (0.001)	3.7 (0.7)	2.5 (0.3)	3.4 (0.4)
Pajarito at SR–501	03/11	1	0.036 (0.063)	0.20 (0.20)	0.08 (0.03)	1.10 (0.11)	0.001 (0.001)	0.006 (0.001)	0.002 (0.001)	3.0 (0.8)	2.3 (0.3)	3.1 (0.4)
	03/11	R1	0.035 (0.063)									
Pajarito at SR–4	03/11	1	0.067 (0.106)	0.00 (0.30)	0.21 (0.05)	1.19 (0.12)	0.001 (0.001)	0.010 (0.001)	0.009 (0.002)	5.0 (1.3)	2.7 (0.3)	–0.1 (0.2)
Potrillo Canyon:												
Potrillo at SR–4	03/11	1	0.006 (0.017)	0.10 (0.30)	0.18 (0.05)	1.22 (0.12)	0.001 (0.001)	0.006 (0.001)	0.002 (0.002)	5.2 (1.1)	3.3 (0.4)	4.8 (0.5)
Fence Canyon:												
Fence at SR–4	03/11	1	0.001 (0.014)	0.30 (0.20)	0.40 (0.07)	1.79 (0.18)	0.001 (0.001)	0.011 (0.001)	0.007 (0.001)	4.8 (0.8)	3.5 (0.4)	6.0 (0.6)
Cañon de Valle:												
Cañon de Valle at SR–501	03/12	1	0.000 (0.003)	0.10 (0.20)	0.13 (0.03)	0.93 (0.09)	0.001 (0.001)	0.003 (0.001)	0.004 (0.001)	2.0 (0.4)	1.4 (0.2)	1.5 (0.2)
Water Canyon:												
Water at SR–501	03/11	1	IM	0.00 (0.20)	0.09 (0.03)	0.65 (0.07)	0.001 (0.001)	0.005 (0.002)	0.003 (0.002)	3.0 (0.5)	2.1 (0.2)	2.8 (0.3)
Water at SR–4	03/11	1	0.009 (0.014)	0.10 (0.30)	0.28 (0.05)	1.84 (0.18)	0.001 (0.001)	0.011 (0.002)	0.004 (0.001)	8.7 (3.0)	5.7 (0.7)	5.2 (0.6)

Table 5–13. Radiochemical Analysis for Sediments in 1996 (pCi/g)[a] (Cont.)

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Indio Canyon:												
Indio at SR–4	03/11	1	0.005 (0.009)	0.10 (0.40)	0.16 (0.05)	0.67 (0.07)	0.001 (0.001)	0.007 (0.002)	0.006 (0.003)	1.7 (0.3)	1.5 (0.2)	3.6 (0.4)
Ancho Canyon:												
Ancho at SR–4	03/11	1	IM	0.10 (0.20)	0.07 (0.03)	1.14 (0.11)	0.000 (0.001)	0.002 (0.001)	0.002 (0.001)	3.9 (0.8)	2.3 (0.3)	3.1 (0.4)
Above Ancho Spring	10/08	1	0.003 (0.025)	1.60 (0.50)	0.27 (0.04)	2.94 (0.29)	0.001 (0.000)	0.002 (0.001)	0.003 (0.001)	4.3 (1.9)	4.5 (0.5)	3.5 (0.4)
	10/08	R1							0.004 (0.004)			
Ancho at Rio Grande	10/08	1	0.056 (0.034)	0.50 (0.40)	0.15 (0.03)	1.43 (0.14)	0.001 (0.000)	0.002 (0.001)	0.003 (0.003)	1.4 (1.0)	2.5 (0.3)	2.9 (0.3)
	10/08	R1	0.096 (0.034)				0.000 (0.001)	0.003 (0.001)		11.9 (3.5)	3.3 (0.4)	
Chaquehui Canyon:												
Chaquehui at Rio Grande	10/09	1	–0.030 (0.025)	–0.10 (0.40)	0.06 (0.02)	1.28 (0.13)	0.000 (0.000)	0.002 (0.001)	0.003 (0.001)	6.3 (1.4)	1.4 (0.2)	1.7 (0.2)
TA–49 Area AB:												
AB–1	03/25	1	0.029 (0.037)	0.70 (1.20)	0.51 (0.06)	1.96 (0.20)	0.003 (0.002)	0.023 (0.004)	0.008 (0.002)	7.6 (2.8)	7.4 (0.9)	3.2 (0.4)
AB–2	03/25	1	0.060 (0.047)	0.40 (1.00)	0.31 (0.05)	1.43 (0.14)	0.003 (0.001)	0.076 (0.006)	0.020 (0.003)	7.6 (3.2)	7.2 (0.9)	2.9 (0.3)
	03/25	D1				1.40 (0.14)						
AB–3	03/25	1	0.098 (0.009)	0.30 (0.70)	0.23 (0.04)	1.11 (0.11)	0.029 (0.003)	1.668 (0.058)	0.402 (0.015)	5.7 (2.0)	6.9 (0.8)	2.5 (0.3)
	03/25	R1					0.035 (0.004)	1.727 (0.060)	0.420 (0.300)			
AB–4	03/25	1	0.068 (0.024)	0.50 (1.20)	0.35 (0.05)	1.57 (0.16)	0.003 (0.002)	0.014 (0.003)	0.007 (0.002)	6.0 (1.6)	5.4 (0.6)	3.3 (0.4)
AB–4A	03/25	1	–0.007 (0.086)	–0.90 (2.00)	0.25 (0.04)	1.62 (0.16)	0.003 (0.002)	0.013 (0.002)	0.004 (0.001)	4.6 (2.0)	4.8 (0.6)	2.5 (0.3)
	03/25	R1			0.22 (0.04)							2.7 (0.3)
AB–5	03/25	1	0.006 (0.011)	0.70 (1.10)	0.61 (0.08)	0.95 (0.10)	0.003 (0.002)	0.033 (0.005)	0.013 (0.002)	6.0 (2.0)	6.5 (0.8)	3.1 (0.4)
AB–6	03/25	1	0.002 (0.006)	0.10 (1.90)	0.28 (0.05)	1.42 (0.14)	0.001 (0.001)	0.012 (0.002)	0.007 (0.002)	5.7 (1.5)	3.6 (0.4)	2.6 (0.3)
	03/25	D1		0.60 (0.90)								
AB–7	03/25	1	0.076 (0.013)	0.10 (0.60)	0.13 (0.03)	0.72 (0.07)	–0.002 (0.001)	0.007 (0.003)	–0.002 (0.001)	3.6 (0.7)	2.3 (0.3)	2.1 (0.3)
AB–8	03/25	1	0.001 (0.003)	0.30 (0.70)	0.09 (0.03)	0.84 (0.08)	0.001 (0.001)	0.002 (0.001)	0.003 (0.001)	2.5 (0.5)	1.9 (0.2)	2.5 (0.3)
	03/25	R1								2.9 (0.6)	1.8 (0.2)	
AB–9	03/25	1	0.001 (0.004)	0.90 (1.00)	0.15 (0.04)	1.00 (0.10)	0.000 (0.001)	0.002 (0.001)	0.004 (0.001)	2.6 (0.5)	1.5 (0.2)	2.6 (0.3)
AB–10	03/25	1	0.000 (0.005)	0.50 (0.60)	0.14 (0.03)	0.45 (0.05)	0.000 (0.001)	0.003 (0.001)	0.001 (0.001)	3.2 (0.5)	2.0 (0.2)	1.6 (0.2)
AB–11	03/25	1	0.002 (0.004)	0.60 (0.60)	0.25 (0.05)	0.48 (0.05)	0.000 (0.001)	0.007 (0.002)	0.003 (0.001)	2.2 (0.4)	1.1 (0.1)	2.0 (0.3)
Frijoles Canyon:												
Frijoles at Monument HQ	08/20	1	0.420 (0.062)	0.10 (0.40)	0.12 (0.04)	2.38 (0.24)	0.000 (0.004)	0.004 (0.004)	0.007 (0.002)	0.4 (0.2)	1.3 (0.2)	3.0 (0.4)
	08/20	D1	0.176 (0.060)	0.20 (0.40)	0.11 (0.03)	2.40 (0.24)	0.001 (0.001)	0.004 (0.001)	0.006 (0.002)	0.4 (0.2)	1.4 (0.2)	3.5 (0.4)
Frijoles at Rio Grande	10/09	1	0.487 (0.251)	1.30 (0.50)	0.50 (0.06)	4.55 (0.46)	0.002 (0.001)	0.020 (0.002)	0.009 (0.002)	3.0 (0.7)	7.8 (0.9)	4.7 (0.5)
	10/09	R1				4.41 (0.44)						
Reservoirs on Rio Chama (New Mexico):												
Heron Upper	06/27	1	ND[f]	0.30 (0.20)	0.47 (0.06)	2.57 (0.26)	0.0003 (0.000)[g]	0.0093 (0.001)[g]	0.008 (0.002)	7.5 (3.4)	5.7 (0.7)	3.0 (0.4)
	06/27	R1										2.3 (0.3)
Heron Middle	06/27	1	ND	0.20 (0.30)	0.18 (0.27)	3.06 (0.31)	0.0001 (0.000)	0.0038 (0.000)	0.004 (0.003)	14.0 (6.0)	8.8 (1.1)	3.0 (0.3)

Table 5–13. Radiochemical Analysis for Sediments in 1996 (pCi/g)[a] (Cont.)

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Reservoirs on Rio Chama (New Mexico)(Cont.):												
Heron Lower	06/27	1	ND	0.30 (0.20)	0.45 (0.06)	2.26 (0.23)	0.0004 (0.000)	0.0120 (0.000)	0.000 (0.003)	1.8 (0.4)	1.3 (0.2)	2.4 (0.3)
	06/27	D1		0.20 (0.30)	0.53 (0.06)	2.73 (0.27)	0.0005 (0.000)	0.0127 (0.000)	0.009 (0.002)	9.7 (2.7)	6.4 (0.8)	2.4 (0.3)
El Vado Upper	06/26	1	ND	0.20 (0.30)	0.16 (0.03)	2.27 (0.23)	0.0002 (0.000)	0.0053 (0.000)	0.005 (0.001)	9.9 (4.2)	5.8 (0.7)	2.4 (0.3)
	06/26	R1					0.0002 (0.000)	0.0052 (0.000)				
El Vado Middle	06/26	1	ND	0.20 (0.30)	0.11 (0.16)	2.51 (0.25)	0.0001 (0.000)	0.0020 (0.000)	0.003 (0.001)	5.8 (2.6)	4.5 (0.6)	2.1 (0.3)
El Vado Lower	06/26	1	ND	0.40 (0.20)	0.23 (0.04)	2.32 (0.23)	0.0002 (0.000)	0.0067 (0.000)	0.001 (0.002)	11.0 (5.0)	8.7 (1.1)	2.7 (0.3)
Abiquiu Upper	06/25	1	ND	0.10 (0.20)	0.08 (0.13)	1.32 (0.13)	0.0001 (0.000)	0.0011 (0.000)	0.002 (0.001)	2.9 (0.7)	0.9 (0.1)	1.4 (0.2)
	06/25	D1					0.0002 (0.000)	0.0011 (0.000)		1.4 (0.2)	0.9 (0.1)	
Abiquiu Middle	06/28	1	ND	0.50 (0.20)	0.12 (0.03)	2.69 (0.27)	0.0002 (0.000)	0.0038 (0.000)	0.003 (0.003)	7.6 (3.0)	4.6 (0.6)	1.9 (0.3)
	06/28	D1			0.13 (0.03)							
Abiquiu Lower	06/28	1	ND	0.10 (0.20)	0.35 (0.05)	2.23 (0.22)	0.0003 (0.000)	0.0090 (0.001)	0.004 (0.001)	9.8 (3.8)	5.6 (0.7)	2.4 (0.3)
Reservoirs on Rio Grande (Colorado):												
Rio Grande Upper	09/21	1	–0.160 (0.131)	0.20 (0.30)	0.42 (0.04)	3.02 (0.30)	0.0007 (0.000)	0.0165 (0.001)	0.007 (0.002)	7.5 (3.1)	5.5 (0.6)	3.4 (0.4)
	09/21	R1	0.181 (0.133)	0.40 (0.20)		3.07 (0.31)				–1.8 (0.8)	6.4 (0.8)	
Rio Grande Middle	09/21	1	0.048 (0.137)	0.50 (0.30)	0.33 (0.03)	3.08 (0.31)	0.0006 (0.000)	0.0144 (0.000)	0.007 (0.002)	8.5 (1.5)	7.1 (0.8)	3.3 (0.4)
Rio Grande Lower	09/21	1	0.458 (0.158)	0.40 (0.40)	0.49 (0.04)	2.84 (0.28)	ND	ND	0.007 (0.002)	16.4 (6.1)	8.5 (1.0)	2.9 (0.3)
	09/21	D1			0.58 (0.05)				0.007 (0.002)			3.1 (0.4)
Reservoirs on Rio Grande (New Mexico):												
Cochiti Upper	10/16	1	0.000 (0.000)	1.60 (0.60)	0.43 (0.04)	2.86 (0.29)	0.0009 (0.000)	0.0166 (0.001)	0.007 (0.002)	8.1 (5.1)	8.1 (1.0)	3.4 (0.4)
	10/16	R1								9.7 (6.0)	7.9 (1.0)	
Cochiti Middle	10/16	1	0.000 (0.000)	2.70 (0.70)	0.70 (0.06)	3.13 (0.31)	0.0012 (0.000)	0.0238 (0.001)	0.009 (0.002)	16.1 (12.9)	11.4 (1.5)	4.4 (0.5)
Cochiti Lower	10/16	1	0.000 (0.000)	1.30 (0.50)	0.34 (0.03)	2.10 (0.21)	0.0006 (0.000)	0.0138 (0.001)	0.006 (0.001)	8.1 (3.0)	5.5 (0.6)	3.0 (0.4)
	10/16	R1				2.80 (0.28)						
Standardized Comparisons												
Average Detection Limits				1.00	0.05	0.20	0.002[g]	0.002[g]	0.002	1.5	1.5	0.8
Background (x + 2 s)[h]				0.87	0.44	4.40	0.006	0.023	0.090[i]	14.8[i]	12.0[i]	8.2[i]
SAL[j]				4.4	5.1	67	27	24	22			

[a] Except where noted.
[b] Sample sizes: stream channels—100 g; reservoirs—1000 g.
[c] Code: 1—primary analysis, D—lab duplicate, R—lab replicate.
[d] Radioactivity counting uncertainties are shown in parentheses (1 standard deviation); values are less than analytical uncertainties. Values less than 2 standard deviations are considered nondetections.
[e] IM—Insufficient moisture for tritium analysis.
[f] ND—No Data; laboratory analysis not performed.
[g] Limits of Detection for ^{238}Pu and $^{239,240}Pu$ reservoir analyses are 0.0001 pCi/g.
[h] Purtymun, 1987a; upper limit for background.
[i] Preliminary background value for channel sediments from 1974 to 1996 (McLin 1997).
[j] SAL—Screening Action Level; Environmental Restoration, 1997; see text for details.

Table 5-14. Detections of Above-Background Radionuclides in Sediments for 1996

Station Name[a]	Date	Codes[b]	Analyte	Value	Sigma[c]	Units	DL[d]	BG[e]
Acid Weir	12/10	1	^{238}Pu	0.031	0.003	pCi/g	0.005	0.006
	12/10	R1	^{238}Pu	0.044	0.005	pCi/g	0.005	0.006
	12/10	1	^{239}Pu	5.340	0.140	pCi/g	0.005	0.023
	12/10	R1	^{239}Pu	8.500	0.400	pCi/g	0.005	0.023
	12/10	1	^{241}Am	0.531	0.019	pCi/g	0.005	0.090
	12/10	R1	^{241}Am	0.420	0.020	pCi/g	0.005	0.090
Hamilton Bend Spring	12/24	1	^{239}Pu	0.423	0.015	pCi/g	0.005	0.023
Pueblo at SR-502	05/97	1	^{238}Pu	0.009	0.002	pCi/g	0.005	0.006
	05/97	1	^{239}Pu	0.769	0.032	pCi/g	0.005	0.023
Los Alamos at LAO-1	05/08	1	^{239}Pu	0.346	0.013	pCi/g	0.005	0.023
Los Alamos at GS-1	05/08	1	^{239}Pu	0.060	0.005	pCi/g	0.005	0.023
	05/08	R1	^{239}Pu	0.054	0.005	pCi/g	0.005	0.023
DPS-1	05/08	1	^{239}Pu	0.044	0.004	pCi/g	0.005	0.023
DPS-4	05/08	1	^{137}Cs	3.17	0.26	pCi/g	0.05	0.44
	05/08	1	^{238}Pu	0.049	0.003	pCi/g	0.005	0.006
	05/08	1	^{239}Pu	0.221	0.009	pCi/g	0.005	0.023
	05/08	1	^{241}Am	0.460	0.030	pCi/g	0.002	0.090
Los Alamos at LAO-3	05/08	1	^{137}Cs	1.19	0.12	pCi/g	0.05	0.44
	05/08	R1	^{137}Cs	1.63	0.16	pCi/g	0.05	0.44
	05/08	1	^{238}Pu	0.022	0.002	pCi/g	0.005	0.006
	05/08	1	^{239}Pu	0.124	0.005	pCi/g	0.005	0.023
	05/08	1	^{241}Am	0.198	0.009	pCi/g	0.005	0.090
Los Alamos at LAO-4.5	05/08	1	^{137}Cs	0.82	0.09	pCi/g	0.05	0.44
	05/08	D1	^{137}Cs	0.75	0.09	pCi/g	0.05	0.44
	05/08	1	^{238}Pu	0.011	0.001	pCi/g	0.005	0.006
	05/08	D1	^{238}Pu	0.007	0.001	pCi/g	0.005	0.006
	05/08	1	^{239}Pu	0.088	0.004	pCi/g	0.005	0.023
	05/08	D1	^{239}Pu	0.122	0.006	pCi/g	0.005	0.023
	05/08	1	^{241}Am	0.092	0.005	pCi/g	0.005	0.090
	05/08	D1	^{241}Am	0.111	0.006	pCi/g	0.005	0.090
Los Alamos at SR-4	05/02	1	^{239}Pu	0.088	0.004	pCi/g	0.005	0.023
Los Alamos at Totavi	08/15	1	^{239}Pu	0.026	0.003	pCi/g	0.005	0.023
Los Alamos at Otowi	05/02	1	^{137}Cs	1.67	0.16	pCi/g	0.05	0.44
	05/02	D1	^{137}Cs	1.75	0.17	pCi/g	0.05	0.44
	05/02	1	^{238}Pu	0.029	0.003	pCi/g	0.005	0.006
	05/02	D1	^{238}Pu	0.032	0.003	pCi/g	0.005	0.006
	05/02	1	^{239}Pu	0.243	0.009	pCi/g	0.005	0.023
	05/02	D1	^{239}Pu	0.230	0.010	pCi/g	0.005	0.023
	08/15	1	^{239}Pu	0.100	0.006	pCi/g	0.005	0.023
	05/02	1	^{241}Am	0.340	0.020	pCi/g	0.005	0.090
	05/02	D1	^{241}Am	0.370	0.020	pCi/g	0.005	0.090
Mortandad near CMR Building	04/11	1	^{238}Pu	0.030	0.003	pCi/g	0.005	0.006
	04/11	D1	^{238}Pu	0.027	0.003	pCi/g	0.005	0.006
Mortandad west of GS-1	04/11	1	^{137}Cs	2.30	0.21	pCi/g	0.05	0.44
	04/11	1	^{238}Pu	0.009	0.002	pCi/g	0.005	0.006
	04/11	1	^{239}Pu	0.205	0.009	pCi/g	0.005	0.023
	04/11	1	Alpha	17.7	3.7	pCi/g	1.5	14.8
	04/11	1	Beta	29.4	3.5	pCi/g	1.5	12.0

Table 5-14. Detections of Above-Background Radionuclides in Sediments for 1996 (Cont.)

Station Name[a]	Date	Codes[b]	Analyte	Value	Sigma[c]	Units	DL[d]	BG[e]
Mortandad at GS-1	04/11	1	Tritium	31.88	0.39	pCi/g		
	04/11	1	^{137}Cs	16.10	1.20	pCi/g	0.05	0.44
	04/11	1	^{238}Pu	6.800	0.350	pCi/g	0.005	0.006
	04/11	1	^{239}Pu	4.850	0.250	pCi/g	0.005	0.023
	04/11	1	^{241}Am	9.060	0.280	pCi/g	0.005	0.090
	04/11	1	Alpha	54.1	8.2	pCi/g	1.5	14.8
	04/11	1	Beta	43.4	5.0	pCi/g	1.5	12.0
	04/11	1	Gamma	20.0	2.0	pCi/g	0.8	8.2
Mortandad at MCO-5	04/11	1	^{137}Cs	14.70	1.10	pCi/g	0.05	0.44
	04/11	1	^{238}Pu	2.220	0.110	pCi/g	0.005	0.006
	04/11	1	^{239}Pu	5.790	0.280	pCi/g	0.005	0.023
	04/11	1	^{241}Am	7.250	0.250	pCi/g	0.005	0.090
	04/11	R1	^{241}Am	8.250	0.330	pCi/g	0.005	0.090
	04/11	1	Alpha	43.1	6.4	pCi/g	1.5	14.8
	04/11	1	Beta	26.5	3.1	pCi/g	1.5	12.0
	04/11	1	Gamma	16.0	2.0	pCi/g	0.8	8.2
Mortandad at MCO-7	04/11	1	^{137}Cs	6.06	0.48	pCi/g	0.05	0.44
	04/11	1	^{239}Pu	3.220	0.160	pCi/g	0.005	0.023
	04/11	1	^{241}Am	2.070	0.100	pCi/g	0.005	0.090
	04/11	R1	^{241}Am	2.180	0.110	pCi/g	0.005	0.090
	04/11	1	Alpha	30.5	5.2	pCi/g	1.5	14.8
	04/11	1	Beta	16.9	2.0	pCi/g	1.5	12.0
Mortandad at MCO-9	04/11	1	^{137}Cs	0.54	0.07	pCi/g	0.05	0.44
	04/11	1	^{239}Pu	0.037	0.005	pCi/g	0.005	0.023
Mortandad at MCO-13 (A-5)	04/11	1	^{137}Cs	0.44	0.06	pCi/g	0.05	0.44
	04/11	1	^{239}Pu	0.026	0.002	pCi/g	0.005	0.023
Mortandad A-6	08/15	1	^{239}Pu	0.023	0.002	pCi/g	0.005	0.023
G-1	03/22	D1	^{239}Pu	0.025	0.003	pCi/g	0.005	0.023
G-3	03/22	1	^{239}Pu	0.030	0.004	pCi/g	0.005	0.023
G-5	03/22	1	^{238}Pu	0.021	0.003	pCi/g	0.005	0.006
	03/22	R2	^{238}Pu	0.017	0.002	pCi/g	0.005	0.006
	03/22	1	^{239}Pu	0.040	0.005	pCi/g	0.005	0.023
	03/22	R1	^{239}Pu	0.043	0.003	pCi/g	0.005	0.023
	03/22	R2	^{239}Pu	0.039	0.007	pCi/g	0.005	0.023
G-6	03/22	1	^{238}Pu	0.018	0.003	pCi/g	0.005	0.006
	03/22	R1	^{238}Pu	0.012	0.002	pCi/g	0.005	0.006
	03/22	1	^{239}Pu	0.226	0.012	pCi/g	0.005	0.023
	03/22	R1	^{239}Pu	0.139	0.007	pCi/g	0.005	0.023
G-7	03/22	1	^{238}Pu	0.243	0.014	pCi/g	0.005	0.006
	03/22	R1	^{238}Pu	0.118	0.007	pCi/g	0.005	0.006
	03/22	1	^{239}Pu	0.174	0.011	pCi/g	0.005	0.023
	03/22	R1	^{239}Pu	0.105	0.007	pCi/g	0.005	0.023
G-8	03/22	1	^{238}Pu	0.119	0.008	pCi/g	0.005	0.006
	03/22	R1	^{238}Pu	0.084	0.005	pCi/g	0.005	0.006
	03/22	1	^{239}Pu	0.150	0.009	pCi/g	0.005	0.023
	03/22	R1	^{239}Pu	0.063	0.004	pCi/g	0.005	0.023
G-9	03/22	1	^{238}Pu	0.031	0.004	pCi/g	0.005	0.006
	03/22	R1	^{238}Pu	0.091	0.005	pCi/g	0.005	0.006
	03/22	1	^{239}Pu	0.040	0.004	pCi/g	0.005	0.023
	03/22	R1	^{239}Pu	0.030	0.003	pCi/g	0.005	0.023

Table 5-14. Detections of Above-Background Radionuclides in Sediments for 1996 (Cont.)

Station Name[a]	Date	Codes[b]	Analyte	Value	Sigma[c]	Units	DL[d]	BG[e]
AB-1	03/25	1	^{137}Cs	0.51	0.06	pCi/g	0.05	0.44
	03/25	1	^{239}Pu	0.023	0.004	pCi/g	0.005	0.023
AB-2	03/25	1	^{239}Pu	0.076	0.006	pCi/g	0.005	0.023
AB-3	03/25	1	^{238}Pu	0.029	0.003	pCi/g	0.005	0.006
	03/25	R1	^{238}Pu	0.035	0.004	pCi/g	0.005	0.006
	03/25	1	^{239}Pu	1.668	0.058	pCi/g	0.005	0.023
	03/25	R1	^{239}Pu	1.727	0.060	pCi/g	0.005	0.023
	03/25	1	^{241}Am	0.402	0.015	pCi/g	0.005	0.090
AB-5	03/25	1	^{137}Cs	0.61	0.08	pCi/g	0.05	0.44
	03/25	1	^{239}Pu	0.033	0.005	pCi/g	0.005	0.023
Frijoles at Rio Grande	10/09	1	^{137}Cs	0.50	0.06	pCi/g	0.05	0.44
	10/09	1	Total U	4.55	0.46	mg/kg	0.25	4.40
	10/09	R1	Total U	4.41	0.44	mg/kg	0.25	4.40
Cochiti Middle	10/16	1	^{137}Cs	0.70	0.06	pCi/g	0.05	0.44
	10/16	1	^{238}Pu	0.0012	0.0001	pCi/g	0.0001	0.006
	10/16	1	^{239}Pu	0.0238	0.0010	pCi/g	0.0001	0.023

[a]Selection Criteria: (1) Value ≥ 4.66*Sigma; (2) Value ≥ DL; and (3) Value ≥ BG.
[b]Code: 1—primary analysis, D—lab duplicate, R—lab replicate.
[c]Sigma is the analytical counting uncertainity (1 standard deviation).
[d]DL = Detection Limit (average) for analytical method.
[e]BG = Purtymun et al., 1987 and McLin and Lyons 1997; upper limit for background.

Table 5-15. Possible Detections of Above-Background Radionuclides in Sediments for 1996

Station Name[a]	Date	Codes[b]	Analyte	Value	Sigma[c]	Units	DL[d]	BG[e]
Rio Grande at Otowi (bank)	10/11	D1	^{90}Sr	2.5	0.9	pCi/g	1.00	0.87
Rio Grande at Frijoles (bank)	10/09	1	^{90}Sr	1.4	0.5	pCi/g	1.00	0.87
	10/09	D1	^{90}Sr	1.6	0.5	pCi/g	1.00	0.87
Pueblo at SR-502	05/07	1	^{238}Pu	0.009	0.002	pCi/g	0.005	0.006
Mortandad west of GS-1	04/11	1	^{238}Pu	0.009	0.002	pCi/g	0.005	0.006
G-3	03/22	R1	^{238}Pu	0.007	0.002	pCi/g	0.005	0.006
G-5	03/22	R1	^{238}Pu	0.017	0.005	pCi/g	0.005	0.006
Above Ancho Spring	10/08	1	^{90}Sr	1.6	0.5	pCi/g	1.00	0.87
Frijoles at Rio Grande	10/09	1	^{90}Sr	1.3	0.5	pCi/g	1.00	0.87
Rio Grande Lower	09/21	1	Alpha	16.4	6.1	pCi/g	1.5	14.8
Cochiti Upper	10/16	1	^{90}Sr	1.6	0.6	pCi/g	1.00	0.87
Cochiti Middle	10/16	1	^{90}Sr	2.7	0.7	pCi/g	1.00	0.87
Cochiti Lower	10/16	1	^{90}Sr	1.3	0.5	pCi/g	1.00	0.87

[a]Selection Criteria: (1) 2.33*Sigma ≤ Value ≤ 4.66*Sigma; (2) Value ≥ DL; and (3) Value ≥ BG.
[b]Code: 1—primary analysis, D—lab duplicate, R—lab replicate.
[c]Sigma is the analytical counting uncertainity (1 standard deviation).
[d]DL = Detection Limit (average) for analytical method.
[e]BG = Purtymun et al., 1987 and McLin and Lyons 1997; upper limit for background.

Table 5-16. Plutonium Analyses of Sediments in Reservoirs on the Rio Chama and Rio Grande

Year[a]	Location[b]	^{238}Pu (fCi/g)	Sigma[c]	^{239,240}Pu (fCi/g)	Sigma[c]	Ratio (^{239,240}Pu/^{238}Pu)
Abiquiu Reservoir (Rio Chama)[d]						
1984	Mean	0.7	0.2	12.7	1.1	18.1
1985	Mean	0.7	0.2	8.8	0.8	12.6
1986	Mean	0.3	0.1	7.5	0.3	25.0
1987	Mean	0.2	0.0	3.7	0.2	18.5
1988	Mean	0.3	0.1	7.4	0.3	24.7
1989	Mean	0.4	0.1	3.7	0.2	9.3
1990	Mean	0.1	0.1	2.6	0.2	26.0
1991	Mean	0.3	0.2	7.2	0.4	24.0
1992	Mean	0.1	0.0	0.8	0.0	8.0
1993	Mean	0.2	0.1	5.1	0.4	25.5
1994	Mean	0.2	0.1	0.5	0.2	2.5
1995[e]	Mean	13.7	1.7	8.0	1.3	0.6
1996	Upper	0.2	0.0	1.1	0.1	5.5
	Middle	0.2	0.0	3.8	0.1	19.0
	Lower	0.3	0.1	9.0	0.9	30.0
1996	Mean	0.2	0.0	4.6	0.4	19.9
1984–96	Mean	0.3	0.1	5.4	0.4	17.8
1984–96	StDev	0.2	0.1	3.5	0.3	8.0
1984–96	Count	12	12	12	12	12
Cochiti Reservoir (Rio Chama)[d]						
1984	Mean[c]	0.7	0.1	19.7	1.1	28.1
1985	Mean	1.6	0.3	24.1	0.8	15.1
1986	Mean	1.3	0.1	21.6	0.3	16.6
1987	Mean	0.8	0.1	17.5	0.2	21.9
1988	Mean	1.7	0.2	12.1	0.3	7.1
1989	Mean	2.5	0.2	49.3	0.2	19.7
1990	Mean	3.2	0.1	17.6	0.2	5.5
1991	Mean	0.2	0.1	4.1	0.4	20.5
1992	Mean	1.9	0.2	13.4	0.0	7.1
1993	Mean	4.1	0.4	30.5	0.4	7.4
1994	Mean	0.4	0.1	9.3	0.4	23.3
1995[e]	Mean	7.6	1.4	12.5	1.8	1.6
1996	Upper	0.9	0.1	16.6	0.5	18.4
	Middle	1.2	0.1	23.8	1.0	19.8
	Lower	0.6	0.1	13.8	0.9	23.0
1996	Mean	0.9	0.1	18.1	0.8	20.1
1984–96	Mean	1.6	0.2	19.8	0.4	16.0
1984–96	StDev	1.2	0.1	11.6	0.3	7.6
1984–96	Count	12	12	12	12	12

[a] Year sampled.
[b] Sample location within reservoir: Upper, Middle, or Lower end; or mean of all three sample locations.
[c] Sigma is the analytical counting uncertainity (1 standard deviation).
[d] Samples were collected June 25, 1996, at Abiquiu Reservoir; and October 16, 1996, at Cochiti Reservoir.
[e] Uncertainties for 1995 data were not within quality control specifications; data not used for long-term statistics.

Table 5-17. RESRAD Input Parameters for Mortandad Canyon Sediments Collected in 1996

Parameter	Value	Comments
Area of Contaminated Zone	10,000 m^2 [a]	RESRAD default value; a larger area maximizes exposure via external gamma, inhalation and ingestion pathways
Thickness of Contaminated Zone	3 m	Based on mesa top conditions (Fresquez et al., 1996)
Time since placement of material	0 yr	Assumes current year (i.e., no radioactive decay) and minimal weathering
Cover Depth	0 m	Assumption of no cover maximizes dose
Density of contaminated zone	1.6 g/cm^3	Based on previous models (Buhl 1989) and mesa top conditions (Fresquez et al., 1996)
Contaminated zone erosion rate	0.001 m/yr	RESRAD default value
Contaminated zone total porosity	0.5	Average from several samples in Mortandad Canyon (Stoker et al., 1991)
Contaminated zone effective porosity	0.3	Table 3.2 in data handbook (Yu et al., 1993)
Contaminated zone hydraulic conductivity	440 m/yr	An average value for soil (not tuff) (Nyhan et al., 1978)
Contaminated zone b parameter	4.05	Mortandad Canyon consists of two units, the top most unit being sand (Purtymun et al., 1983) and Table 13.1 in the data handbook (Yu 1993)
Humidity in air	4.8 g/cm^3	Average value from Los Alamos Climatology (Bowen 1990)
Evapotranspirations Coefficient	0.85	Based on tritium oxide tracers in Mortandad Canyon (Penrose et al., 1990)
Precipitation	0.48 m/yr	Average value from Los Alamos Climatology (Bowen 1990)
Irrigation rate	0 m/yr	Water in Mortandad Canyon is not used.
Runoff Coefficient	0.52	Based on mesa top conditions (Fresquez et al., 1996)
Inhalation rate	8400 m^3/yr	RESRAD default value
Mass loading for inhalation	5.53×10^{-3} g/m^3	Factor used for benchmarking against several codes (Faillace et al., 1993)
Exposure duration	1 year	Assumes current year exposure only
Dilution length for airborne dust	3 m	RESRAD default value
Shielding factor, inhalation	0.4	RESRAD default value
Shielding factor, external gamma	0.7	RESRAD default value
Fraction of time spent indoors each year	0.7	Based on 18 h/d (Fresquez et al., 1996)
Fraction of time spent outdoors	0.01	Assumes an industrial scenario where access to site is somewhat limited. (Robinson and Thomas 1991)
Shape factor	1	Corresponds to a contaminated area larger than a circular area of 1200 m^2.
Depth of soil mixing layer	0.15 m	RESRAD default value.
Soil ingestion rate	44 g/yr	Calculated based on 100 mg/d for 24 yr (adult) and 200 mg/d for 6 yr (child) (Fresquez et al., 1996)

[a] For each sampling location, the area of the contaminated zone was assumed to be 100 m^2.

Table 5-18. Total Effective Dose Equivalent[a] for Mortandad Canyon (mrem)

Location	1996		1995	
Near CMR Building	0.16	(± 0.032)[b]	0.10	(± 0.14)[b]
West of GS-1	3.3	(± 0.60)[b]	0.17	(± 0.081)[b]
GS-1	24	(± 3.4)[b]	37	(± 5.9)[b]
MCO-5	21	(± 3.2)[b]	19	(± 3.3)[b]
MCO-7	8.8	(± 1.4)[b]	4.3	(± 0.95)[b]
MCO-9	0.78	(± 0.21)[b]	0.62	(± 0.20)[b]
MCO-13 (A-5)	0.65	(± 0.19)[b]	0.43	(± 1.1)[b]
A-6	0.41	(± 0.097)[b]	0.79	(± 1.2)[b]
A-7	0.36	(± 0.072)[b]	0.19	(± 0.10)[b]
A-8		—[c]	0.30	(± 0.15)[b]
SR-4 (A-9)	0.19	(± 0.057)[b]	0.17	(± 0.088)[b]
A-10		—[c]	0.061	(± 0.028)[b]
Rio Grande (A-11)	0.16	(± 0.12)[b]	0.10	(± 0.054)[b]
Average for entire Mortandad Canyon	6.0	(± 22)[b]	6.8	(± 30)[b]

[a]Based on results from RESRAD version 5.61 using input parameters listed in Table 1 and three exposure pathways: ingestion, inhalation, and external.
[b]±2 sigma in parenthesis; to convert to µSv multiply by 10.
[c]No sample collected at these locations in 1996.

Table 5-19. Maximum Total Effective Dose Equivalent

	Average + 2 Sigma (mrem/yr)	
Location	1996	1995
Near CMR Building	0.19	0.24
West of GS-1	3.8	0.25
GS-1	27	43
MCO-5	25	22
MCO-7	10	5.3
MCO-9	0.99	0.82
MCO-13 (A-5)	0.84	1.5
A-6	0.51	2.0
A-7	0.43	0.29
A-8	—[a]	0.45
SR-4 (A-9)	0.25	0.26
A-10	—[a]	0.089
Rio Grande (A-11)	0.29	0.15
Average for entire Mortandad Canyon	28	37

[a]No sample collected at these locations in 1996.

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg)

Station Name[a,b]	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Stations														
Rio Chama at Chamita	05/09	1	<0.25[d]	1,900	1.07	<0.75	38.00	0.18	<0.25	1.27	2.71	<1.63	3,223	<0.010
	05/09	R1	<0.25	1,700	1.18	<0.80	34.00	0.17	0.33	1.33	2.56	<1.63	3,014	<0.010
	05/09	R2												0.031
Rio Grande at Embudo	05/09	1	<0.25	738	<0.34	<0.75	13.70	<0.12	<0.25	0.88	1.29	<1.60	1,511	<0.010
	05/09	R1												<0.010
	05/09	R2												0.011
Rio Grande at Otowi (bank)	05/09	1	<0.25	<11	0.41	<0.75	<0.12	<0.12	0.31	<0.37	<1.25	<1.63	<6	<0.010
	05/09	R1												<0.010
	10/11	2	<0.40	11,815	4.80	<1.30	227.00	0.68	<0.27	6.20	13.50	9.22	13,110	<0.050
	10/11	R1	<0.40	11,335	4.70	<0.70	223.00	0.65	<0.30	6.30	13.10	8.80	12,975	<0.050
Rio Grande at Otowi (wdth intgrt)	10/11	3	<0.40	3,799	2.00	<3.00	75.00	0.24	<0.30	2.83	6.49	2.24	6,510	<0.050
	10/11	R1												<0.05
Rio Grande at Frijoles (bank)	10/09	1	<0.40	6,112	3.20	<3.00	163.00	0.52	<0.30	4.47	8.65	6.30	9,133	<0.060
	10/09	R1												<0.060
Rio Grande at Bernalillo	05/09	1	<0.25	1,302	1.31	<0.75	35.40	0.10	<0.25	1.24	2.10	3.30	2,803	<0.010
	05/09	R1												<0.010
Jemez River	05/09	1	<0.30	5,404	5.25	1.19	58.50	0.63	0.29	3.90	7.54	4.68	<1,243	<0.010
	05/09	R1												0.010
Guaje Canyon:														
Guaje at SR-502	03/11	1	<0.25	1,680	0.50	<0.75	20.90	<0.12	0.32	2.20	5.44	<1.63	6,600	<0.010
	03/11	R1												<0.010
Bayo Canyon:														
Bayo at SR-502	03/11	1	<0.25	1,520	0.40	<0.74	39.60	<0.12	0.39	1.09	3.56	1.79	3,250	<0.010
	03/11	R1												<0.010
Acid/Pueblo Canyons:														
Acid Weir	12/10	1	<0.40	1,354	1.60	<3.00	25.70	0.23	<0.30	1.56	1.53	2.73	4,602	<0.050
	12/10	R1												<0.050
Pueblo 1	12/10	1	<0.40	1,198	1.10	<3.00	17.26	0.16	<0.30	1.83	1.94	1.72	3,503	<0.050
	12/10	R1												<0.050
Pueblo 2	12/10	1	<0.40	1,476	0.40	<3.00	18.59	<0.15	<0.30	1.23	1.95	1.84	2,345	<0.050
	12/10	R1												<0.050
Hamilton Bend Spring	12/24	1	<0.09	1,638	0.50	<0.54	16.40	0.12	<0.30	<1.30	1.56	1.82	3,053	<0.050
	12/24	R1	<0.09	1,119	<0.40	<0.70	9.99	<0.06	<0.24	0.63	<1.32	4.00	1,875	<0.050

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Acid/Pueblo Canyons (Cont.):														
Pueblo 3	12/10	1	<0.40	1,580	0.40	<3.00	23.47	<0.15	<0.30	1.58	1.71	1.32	2,071	<0.050
	12/10	R1												<0.050
Pueblo at SR-502	05/07	1	3.40	1,930	0.60	<0.80	24.00	<0.12	<0.25	4.60	6.00	3.20	18,600	<0.010
	05/07	R1												<0.010
DP/Los Alamos Canyons:														
Los Alamos at Bridge	05/08	1	<0.25	3,134	1.30	<0.76	40.00	0.34	<0.25	1.80	4.60	5.20	6,170	0.023
	05/08	R1												0.031
	05/08	R2												0.017
Los Alamos at LAO-1	05/08	1	<0.25	2,040	2.30	<0.70	264.00	0.20	<0.25	1.80	3.70	2.40	7,394	0.106
	05/08	R1												0.065
	05/08	R2												0.056
Los Alamos at GS-1	05/08	1	<0.20	1,575	1.00	<0.70	20.00	0.17	<0.24	1.50	3.10	2.70	4,900	0.0200
	05/08	R1	<0.25	1,160	0.90	<0.70	18.00	0.18	<0.25	1.30	3.90	2.50	3,700	<0.010
DPS-1	05/08	1	<0.25	1,370	0.95	<0.74	23.00	0.14	<0.25	2.90	3.70	1.80	3,172	0.022
	05/08	R1												<0.010
DPS-4	05/08	1	<0.25	1,380	0.63	<0.74	14.00	0.17	<0.25	0.87	2.00	1.70	3,476	<0.010
	05/08	R1												0.014
Los Alamos at LAO-3	05/08	1	0.35	776	0.57	<0.75	16.00	<0.13	<0.25	0.80	1.30	2.20	1,600	<0.010
	05/08	R1												<0.010
Los Alamos at LAO-4.5	05/08	1	<0.25	854	0.64	<0.74	11.00	<0.12	<0.25	0.79	1.50	<1.60	2,963	<0.010
	05/08	R1												<0.010
	05/08	2	<0.25	2,320	1.10	<0.75	23.00	0.31	<0.25	1.70	3.60	2.90	5,387	0.016
	05/08	R1												0.011
Los Alamos at SR-4	05/02	1	<0.25	3,020	1.07	<0.75	39.00	0.44	<0.25	1.50	4.10	4.30	4,600	0.036
	05/02	R1												0.046
	05/02	R2												0.039
Los Alamos at Totavi	08/15	1	<0.40	1,268	<0.40	<0.70	17.00	<0.15	<0.30	1.08	1.65	1.46	2,920	0.118
	08/15	R1												<0.100
Los Alamos at Otowi	05/02	1	<0.25	1,000	0.61	<0.75	19.00	0.13	<0.25	1.05	1.90	2.06	2,510	<0.016
	05/02	R1												<0.016
	08/15	2	<0.40	2,465	<0.40	1.45	24.00	<0.15	<0.30	1.47	1.67	1.70	3,057	<0.2000
	08/15	R1												<0.200

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Sandia Canyon:														
Sandia at SR-4	03/11	1	<0.24	2,520	1.10	<0.72	27.00	0.18	0.30	1.07	2.54	<1.56	3,170	
Mortandad Canyon:														
Mortandad near CMR Building	04/11	1	0.53	4,384	1.30	<0.75	48.10	0.54	0.18	2.42	4.50	7.11	7,504	<0.010
	04/11	R1	<0.25	5,945	1.50	<1.09	48.00	0.61	<0.25	2.55	5.76	6.00	8,808	0.016
	04/11	R2												<0.010
Mortandad west of GS-1	04/11	1	<0.25	6,643	2.40	<0.75	93.00	0.45	<0.25	2.97	5.24	8.56	8,219	0.020
	04/11	R1												0.023
	04/11	R2												0.018
Mortandad at GS-1	04/11	1	<0.25	1,830	0.76	<0.75	13.80	0.45	<0.25	1.24	2.63	4.39	5,429	<0.010
	04/11	R1												<0.010
Mortandad at MCO-5	04/11	1	<0.25	848	<0.30	<0.75	9.78	0.23	<0.25	0.91	1.42	2.67	2,085	<0.010
	04/11	R1												<0.010
Mortandad at MCO-7	04/11	1	<0.25	951	0.51	<0.75	11.60	0.24	<0.25	1.59	1.54	<1.63	7,190	<0.010
	04/11	R1												0.010
	04/11	R2												<0.010
Mortandad at MCO-9	04/11	1	<0.25	2,272	1.20	<0.75	43.40	0.48	<0.25	2.21	2.02	3.57	4,481	<0.010
	04/11	R1												<0.010
Mortandad at MCO-13 (A-5)	04/11	1	<0.25	2,029	0.50	<0.75	20.30	0.32	<0.25	1.29	1.89	<1.63	2,810	<0.010
	04/11	R1												<0.010
Mortandad A-6	08/15	1	<0.40	1,584	<0.40	1.70	15.30	<0.15	<0.30	<0.72	0.81	0.99	1,979	<0.010
	08/15	R1	<0.40	1,483	<0.40	<0.70	17.00	<0.15	<0.30	0.92	1.07	1.41	1,745	<0.200
Mortandad A-7	08/15	1	<0.40	2,176	<0.40	<0.70	17.60	<0.15	<0.30	0.92	1.22	1.28	4,890	<0.010
	08/15	R1												<0.010
Mortandad at SR-4 (A-9)	08/15	1	<0.40	5,095	1.10	<0.90	59.00	0.17	<0.30	2.80	3.64	2.10	5,899	<0.200
	08/15	R1												<0.200
Mortandad at Rio Grande (A-11)	10/07	1	<0.40	3,098	1.10	<0.70	51.00	0.26	<0.30	4.31	4.86	3.73	6,972	<0.050
	10/07	R1												<0.050
Cañada del Buey:														
Cañada del Buey at SR-4	03/11	1	<0.24	2,110	0.70	<0.70	25.30	<0.12	0.37	1.81	2.54	0.67	5,020	<0.010
	03/11	R1	<0.25	2,220	0.40	<0.74	27.20	0.15	0.58	1.84	2.55	<1.59	4,745	<0.010

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
TA-54 Area G:														
G-1	03/22	1	<0.25	2,150	1.30	7.67	19.30	0.16	<0.25	0.95	1.59	<1.62	3,767	<0.010
	03/22	R1	<0.25	2,090	0.80	7.27	23.30	0.13	<0.25	0.86	1.65	<1.62	3,775	<0.010
G-2	03/22	1	<0.24	3,920	1.32	2.96	45.70	0.27	<0.24	1.75	3.09	2.42	6,640	<0.010
	03/22	R1												0.012
G-3	03/22	1	<0.25	4,090	1.08	3.03	54.80	0.24	<0.66	2.77	8.51	4.63	6,750	<0.010
	03/22	R1												<0.010
G-4	03/22	1	<0.25	2,485	0.78	3.04	27.50	0.30	0.20	0.88	2.06	1.93	5,000	<0.010
	03/22	R1												0.016
G-5	03/22	1	<0.26	4,920	1.64	3.05	67.90	0.49	0.26	2.20	4.27	2.82	5,960	<0.010
	03/22	R1												0.048
	03/22	R2												0.058
G-6	03/22	1	<0.25	6,620	1.84	2.78	65.70	0.46	<0.25	2.36	5.46	2.51	7,670	0.019
	03/22	R1												<0.010
	03/22	R2												0.016
G-7	03/22	1	<0.25	2,040	0.65	2.29	20.20	<0.12	0.25	0.52	1.39	1.69	3,290	<0.010
	03/22	R1												<0.010
G-8	03/22	1	<0.25	4,680	1.25	2.21	36.60	0.33	0.20	1.47	3.82	2.68	6,260	<0.010
	03/22	R1												<0.010
G-9	03/22	1	<0.25	2,240	0.56	2.85	20.60	<0.12	<0.12	0.73	1.92	<1.60	2,690	<0.010
	03/22	R1												<0.010
	03/22	R2												0.033
Pajarito Canyon:														
Twomile at SR-501	03/12	1	<0.24	2,770	1.20	<0.71	38.10	<0.12	0.50	1.45	2.65	2.35	4,240	<0.010
	03/12	R1												<0.010
Pajarito at SR-501	03/11	1	<0.24	2,650	1.20	<0.70	21.80	<0.12	0.34	2.11	2.94	1.97	5,380	<0.010
	03/11	R1												<0.010
	03/11	1	<0.24	3,300	0.80	<0.71	25.00	0.12	0.46	1.66	3.03	1.50	8,270	0.010
	03/11	R1												0.010
Potrillo Canyon:														
Potrillo at SR-4	03/11	1	<0.24	1,012	0.60	<0.71	15.20	<1.18	0.47	0.65	<1.18	<1.53	1,968	<0.010
	03/11	R1												<0.010

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Fence Canyon:														
Fence at SR-4	03/11	1	<0.24	5,000	1.60	<0.71	67.40	0.27	0.54	2.03	3.13	3.22	5,900	<0.010
	03/11	R1												<0.010
Cañon de Valle:														
Cañon de Valle at SR-501	03/12	1	<0.24	664	0.50	<0.73	13.60	<0.12	<0.24	<0.36	2.04	1.59	2,700	0.010
	03/12	R1												0.010
Water Canyon:														
Water at SR-501	03/11	1	<0.24	2,930	0.40	<0.73	35.20	0.17	<0.24	1.56	2.39	1.66	3,980	0.020
	03/11	R1												0.010
Water at SR-4	03/11	1	<0.25	4,895	1.50	<0.74	79.50	0.56	0.36	1.98	5.62	3.13	5,260	<0.010
	03/11	R1												<0.010
Indio Canyon:														
Indio at SR-4	03/11	1	<2.46	3,460	1.10	<0.74	25.00	0.18	0.42	1.94	3.61	<1.60	7,920	<0.010
	03/11	R1												<0.010
Ancho Canyon:														
Ancho at SR-4	03/11	1	<0.23	2,100	0.60	<0.70	16.10	<0.69	0.36	5.36	9.96	<1.51	26,600	<0.010
	03/11	R1												<0.010
Above Ancho Spring	10/08	1	<0.40	8,417	1.90	<3.00	83.73	0.65	<0.30	4.65	7.55	6.63	10,451	<0.050
	10/08	R1												<0.050
Ancho at Rio Grande	10/08	1	<0.40	2,907	1.80	<0.70	56.70	0.22	<0.30	2.31	4.68	2.17	5,872	<0.050
	10/08	R1												<0.050
Chaquehui Canyon:														
Chaquehui at Rio Grande	10/09	1	<0.40	1,762	1.70	<3.00	23.47	<0.15	<0.30	1.84	2.75	2.97	3,379	<0.050
	10/09	R1												<0.050
TA-49 Area AB:														
AB-1	03/25	1	<0.25	13,761	3.99	<0.75	145.00	<0.13	<0.25	6.93	8.65	9.76	13,153	<0.010
	03/25	R1	<0.25	14,632	3.69	<0.75	41.00	<0.13	<0.25	4.40	9.42	6.77	13,251	<0.010
AB-2	03/25	1	<0.25	10,000	3.85	<0.75	118.00	<0.13	<0.25	7.03	7.34	5.34	12,687	<0.010
	03/25	R1												<0.010
AB-3	03/25	1	<0.25	3,063	1.27	<0.75	45.00	<0.13	<0.25	1.60	2.91	3.15	6,718	<0.010
	03/25	R1												<0.010
AB-4	03/25	1	<0.25	12,985	4.12	<0.75	150.00	<0.13	<0.25	4.40	8.63	5.88	11,742	<0.010
	03/25	R1												<0.010

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
TA-49 Area AB (Cont.):														
AB-4A	03/25	1	<0.25	19,130	3.80	<0.75	156.00	<0.13	<0.25	5.00	12.00	7.38	14,322	<0.010
	03/25	R1												<0.010
AB-5	03/25	1	<0.25	11,541	3.05	<0.75	117.00	<0.13	<0.25	4.30	7.95	5.66	10,055	<0.010
	03/25	R1												<0.010
AB-6	03/25	1	<0.25	6,934	2.80	<0.75	63.40	<0.13	<0.25	3.00	6.56	3.17	8,831	<0.010
	03/25	R1												<0.010
AB-7	03/25	1	<0.25	1,014	0.89	<0.75	29.00	<0.13	<0.25	<0.38	<1.25	2.76	2,009	<0.010
	03/25	R1												<0.010
AB-8	03/25	1	3.53	6,038	2.42	<0.75	50.00	<0.13	<0.25	1.90	4.39	4.09	8,608	<0.010
	03/25	R1												<0.010
AB-9	03/25	1	<0.25	4,669	1.72	<0.75	51.00	<0.13	<0.25	1.61	3.50	2.66	7,532	<0.010
	03/25	R1												<0.010
AB-10	03/25	1	<0.25	2,487	1.48	<0.75	28.70	<0.13	<0.25	<0.38	1.79	1.85	4,346	0.013
	03/25	R1												0.012
	03/25	R2												0.016
AB-11	03/25	1	<0.25	1,883	0.54	<0.75	17.40	<0.13	<0.25	<0.38	1.34	2.65	3,444	<0.010
	03/25	R1												<0.010
Frijoles Canyon:														
Frijoles at Monument HQ	08/20	1	<0.40	14,550	4.00	1.76	126.00	1.16	<0.30	5.28	10.90	8.84	11,920	<0.050
	08/20	R1												<0.050
Frijoles at Rio Grande	10/09	1	<0.40	10,335	2.90	0.86	85.30	0.93	0.22	3.97	8.20	5.89	9,860	<0.050
	10/09	R1												<0.050
Reservoirs on Rio Chama (New Mexico):														
Heron Upper	06/27	1	4.89	17,017	4.80	2.03	139.00	0.85	0.28	7.00	15.30	15.00	20,231	<0.035
	06/27	R1												<0.038
Heron Middle	06/27	1	<0.25	14,224	6.30	<5.50	144.00	0.86	<0.68	9.10	11.80	16.40	20,334	<0.030
	06/27	R1												<0.028
Heron Lower	06/27	1	<0.25	20,465	6.50	6.30	144.00	0.92	0.47	7.50	18.10	16.50	20,588	<0.043
	06/27	D1	<0.25	11,888	5.80	<3.80	115.00	0.69	<0.25	7.40	10.80	12.60	18,055	<0.050
	06/27	R1												<0.040
El Vado Upper	06/26	1	<0.25	10,405	7.30	0.86	122.50	0.78	0.65	8.40	16.50	15.40	17,889	<0.037
	06/26	R1												<0.042

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Reservoirs on Rio Chama (New Mexico) (Cont.):														
El Vado Middle	06/26	1	<0.25	11,956	6.40	<2.70	144.00	0.91	<0.25	10.50	13.60	14.80	24,333	<0.040
	06/26	R1												<0.038
El Vado Lower	06/26	1	<0.25	21,579	9.80	8.72	156.00	1.06	<0.25	9.26	22.10	13.80	23,359	<0.040
	06/26	R1												<0.036
Abiquiu Upper	06/25	1	<0.30	7,318	2.60	4.86	142.00	0.38	2.60	2.80	8.08	3.56	7,460	<0.044
	06/25	R1	<0.25	5,215	2.20	4.10	143.00	0.34	0.51	3.02	6.40	3.87	7,048	<0.040
Abiquiu Middle	06/28	1	<0.25	18,997	4.10	4.62	250.00	1.09	<0.25	9.81	18.00	13.70	20,160	<0.047
	06/28	R1												<0.042
Abiquiu Lower	06/28	1	<0.25	1,150	0.60	<2.48	29.50	<0.13	<0.25	1.45	1.25	<1.63	1,431	<0.042
	06/28	R1												<0.033
Reservoirs on Rio Grande (Colorado):														
Rio Grande Upper	09/21	1	<0.40	13,883	0.01	<0.70	213.30	0.58	0.32	8.65	5.51	11.40	21,568	<0.050
	09/21	R1	<0.40	11,050	0.01	<0.70	194.80	0.58	<0.30	8.11	5.02	10.50	19,945	<0.050
Rio Grande Middle	09/21	1	<0.40	16,386	0.01	<0.70	250.60	0.87	0.34	11.50	5.27	14.30	25,319	<0.050
	09/21	R1												<0.050
Rio Grande Lower	09/21	1	<0.40	16,564	0.01	<0.70	208.00	0.74	0.51	9.00	5.16	14.80	20,315	<0.050
	09/21	R1												<0.050
Reservoirs on Rio Grande (New Mexico):														
Cochiti Upper	10/16	1	<0.40	11,786	0.00	<0.70	208.00	0.82	<0.80	6.41	12.50	11.50	13,026	<0.050
	10/16	R1												<0.050
Cochiti Middle	10/16	1	<0.40	26,532	0.01	<0.70	254.00	1.60	<0.45	12.20	20.00	18.00	21,663	<0.050
	10/16	R1												<0.050
Cochiti Lower	10/16	1	<0.40	4,268	0.00	<0.70	55.40	0.29	<0.30	3.32	7.05	3.15	8,478	<0.050
	10/16	R1												<0.050
Standardized Comparisons														
Average Detection Limits			0.25	11	0.34	0.70	0.12	0.08	0.40	0.50	0.50	0.50	14	0.050
1996 Mean (x)[e]			0.42	5,538	1.72	1.60	68.63	0.35	0.33	3.09	5.27	4.66	7,939	0.031
1996 Standard Deviation (s)[f]			0.66	5,648	1.82	1.62	67.82	0.31	0.25	2.79	4.58	4.32	6,388	0.035
SAL[g]			380	77,000	BG[h]	5,900	5,300	BG	38	4,600	30[i]	2,800	NA[j]	23

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Regional Stations													
Rio Chama at Chamita	05/09	1	58.80	<0.62	<2.25	<5.75	<0.625	<0.17	<7.38	18.00	<0.625	5.97	24
	05/09	R1	57.00	<0.62	<2.25	<5.70	<0.625	<0.17	<7.40	16.60	<0.620	5.78	30
Rio Grande at Embudo	05/09	1	43.00	<0.62	<2.25	<5.75	<0.620	0.18	<7.38	4.65	<0.625	3.11	8
Rio Grande at Otowi (bank)	05/09	1	0.26	<0.62	<2.25	5.75	<0.625	<0.17	<7.38	<0.12	<0.625	<0.25	<2
	10/11	2	321.00	<0.75	10.80	9.70	<0.300	0.70	<3.00	149.00	<0.300	21.00	39
	10/11	R1	322.00	<0.50	12.00	9.50	<0.300	0.50	<3.50	148.00	<0.300	20.70	38
Rio Grande at Otowi (wdth intgrt)	10/11	3	148.00	<0.50	<4.86	3.80	<0.300	0.30	<3.00	28.50	<0.300	14.00	
	10/11	R1											38
Rio Grande at Frijoles (bank)	10/09	1	225.00	<0.50	7.19	7.10	<0.300	<0.70	<3.00	81.94	<0.300	16.01	29
Rio Grande at Bernalillo	05/09	1	80.80	<0.62	2.40	<5.75	<0.625	<0.17	<7.38	14.60	<0.625	5.59	17
Jemez River	05/09	1	205.00	<0.62	7.62	6.79	<0.625	<0.17	<7.38	28.20	<0.625	10.70	24
Guaje Canyon:													
Guaje at SR-502	03/11	1	107.00	<0.63	5.42	<5.72	<1.250	<0.13	<7.37	5.76	<0.600	14.20	21
Bayo Canyon:													
Bayo at SR-502	03/11	1	98.10	<0.62	<6.33	<5.66	<1.230	<0.13	<7.26	4.94	<0.620	5.63	12
Acid/Pueblo Canyons:													
Acid Weir	12/10	1	255.00	<0.50	<1.70	15.30	<0.300	<0.70	<3.00	3.73	<0.300	6.30	38
Pueblo 1	12/10	1	143.00	<0.50	<1.70	20.40	<0.300	<0.70	<3.00	5.97	<0.300	3.99	30
Pueblo 2	12/10	1	100.00	<0.50	<1.70	4.20	<0.300	<0.70	<3.00	2.93	<0.300	3.18	13
Hamilton Bend Spring	12/24	1	101.00	<1.10	<5.70	4.60	<0.300	<1.20	<3.60	3.04	<0.300	3.22	21
	12/24	R1	51.10	<0.66	<2.20	2.60	<0.300	<0.70	<10.50	1.93	<0.300	2.06	12
Pueblo 3	12/10	1	126.50	<0.50	<1.70	6.50	<0.300	<0.70	3.13	3.46	<0.300	2.69	18
Pueblo at SR-502	05/07	1	460.00	3.00	<3.00	5.31	<0.625	<0.20	<7.30	4.30	<0.625	17.00	109
DP/Los Alamos Canyons:													
Los Alamos at Bridge	05/08	1	205.00	<0.62	2.30	15.90	<0.625	<0.44	<7.40	11.00	<0.625	8.90	36
Los Alamos at LAO-1	05/08	1	186.00	<0.62	<2.20	12.90	<0.625	<0.85	<7.40	6.30	<0.625	7.70	43
Los Alamos at GS-1	05/08	1	160.00	<0.62	<2.20	10.90	<0.625	<0.17	<7.30	4.20	<0.625	4.70	23
	05/08	R1	133.00	<0.62	<2.20	11.70	<0.625	<0.17	<7.32	4.10	<0.625	3.80	20
DPS-1	05/08	1	145.00	<0.62	<2.20	20.90	<0.625	<0.29	<7.32	4.70	<0.625	4.20	26
DPS-4	05/08	1	99.00	<0.90	<2.20	9.33	<0.625	<0.80	<7.30	3.00	<0.625	4.20	24
Los Alamos at LAO-3	05/08	1	73.00	<0.62	<2.30	7.75	<0.625	<0.17	<7.40	3.50	<0.625	2.50	18
Los Alamos at LAO-4.5	05/08	1	87.00	<0.62	<2.20	6.67	<0.625	<0.17	<7.20	3.10	<0.625	3.20	20
	05/08	2	180.00	0.60	<2.30	17.00	<0.625	<0.17	<7.40	4.20	<0.625	5.80	42

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
DP/Los Alamos Canyons (Cont.):													
Los Alamos at SR-4	05/02	1	188.00	<0.62	<2.20	17.20	<5.500	0.19	<7.33	8.40	<20.60	5.50	44
Los Alamos at Totavi	08/15	1	62.00	<0.50	<6.00	2.50	<0.300	<0.30	<3.00	4.50	<0.300	5.24	11
Los Alamos at Otowi	05/02	1	68.00	<0.60	<2.20	<5.70	<5.500	<0.17	<7.30	5.50	<20.60	4.40	16
	08/15	2	69.00	<0.50	<2.70	3.10	<0.300	<0.30	<3.00	8.33	<0.300	5.50	13
Sandia Canyon:													
Sandia at SR-4	03/11	1	130.00	<0.60	2.73	<5.52	<1.200	<0.13	<7.10	4.17	8.200	3.29	21
Mortandad Canyon:													
Mortandad near CMR Building	04/11	1	257.00	1.55	6.82	10.70	<5.410	<0.55	<7.38	9.70	<20.60	8.30	109
	04/11	R1	268.00	2.00	5.00	11.10	<5.460	<0.55	<7.38	9.82	<20.60	10.10	103
Mortandad west of GS-1	04/11	1	462.00	<0.62	3.76	25.50	<5.410	<0.55	<7.38	24.70	<20.60	10.30	41
Mortandad at GS-1	04/11	1	246.00	1.65	<2.25	6.30	<5.460	<0.56	<7.38	2.21	<20.60	4.25	32
Mortandad at MCO-5	04/11	1	89.00	<0.62	<2.25	<5.70	<5.460	<0.56	<7.38	1.59	<20.60	1.71	16
Mortandad at MCO-7	04/11	1	160.00	0.89	<2.25	<5.66	<5.410	<0.55	<7.40	1.63	<20.60	5.23	44
Mortandad at MCO-9	04/11	1	242.80	<0.62	<2.25	9.40	<5.460	<0.55	<7.38	6.10	<20.60	4.43	29
Mortandad at MCO-13 (A-5)	04/11	1	113.00	<0.96	<2.25	<5.70	<5.460	<0.55	<7.38	3.00	<20.60	3.35	19
Mortandad A-6	08/15	1	79.70	<1.30	0.90	3.30	<0.300	<0.30	<3.00	2.41	<0.300	2.07	12
	08/15	R1	129.00	<0.50	2.00	5.30	<0.300	<0.30	<3.00	2.50	<0.300	2.30	27
Mortandad A-7	08/15	1	170.00	<0.50	0.90	5.90	<0.300	<0.30	<4.00	2.56	<0.300	3.33	39
Mortandad at SR-4 (A-9)	08/15	1	238.00	<0.50	3.39	6.70	<0.300	<0.30	<3.00	8.88	<0.300	8.99	25
Mortandad at Rio Grande (A-11)	10/07	1	159.00	<0.50	6.40	4.50	<0.300	<0.50	<3.00	11.40	<0.300	13.30	19
Cañada del Buey:													
Cañada del Buey at SR-4	03/11	1	149.00	<0.61	7.72	<5.61	<1.230	<0.13	<7.20	3.20	<0.610	7.60	19
	03/11	R1	196.00	<0.62	4.67	<5.66	<2.460	<0.13	<7.26	3.59	<1.230	6.67	18

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
TA-54 Area G:													
G-1	03/22	1	135.00	<0.62	5.86	4.20	<1.250	<0.13	<7.37	3.76	<0.630	3.95	25
	03/22	R1	132.00	<0.62	2.20	5.60	<1.270	<0.13	<7.37	4.89	<0.600	4.18	22
G-2	03/22	1	199.00	<0.61	3.76	8.50	<1.230	<0.12	<7.19	8.34	<0.610	7.10	31
G-3	03/22	1	211.00	<0.63	4.70	139.00	<1.260	0.18	<7.40	10.40	<0.630	10.20	386
G-4	03/22	1	206.00	<0.54	11.40	12.00	<1.300	<0.13	<7.37	4.14	<0.600	3.97	39
G-5	03/22	1	223.00	<0.64	3.40	10.00	<1.280	0.13	<7.55	12.20	<0.640	7.50	34
G-6	03/22	1	225.00	<0.62	4.71	10.00	<1.230	<0.25	<7.28	15.80	<0.620	10.50	35
G-7	03/22	1	102.00	<0.63	2.26	6.30	<1.260	<0.13	<7.41	3.72	<0.630	3.99	60
G-8	03/22	1	193.00	<0.61	4.18	9.20	<1.230	<0.12	<7.20	7.25	<0.610	6.89	35
G-9	03/22	1	96.50	<0.61	2.95	3.40	<1.230	<0.12	<7.23	3.22	<0.610	3.28	13
Pajarito Canyon:													
Twomile at SR-501	03/12	1	178.00	<0.59	2.97	9.75	<1.200	<0.13	<7.02	8.61	<0.600	5.08	28
Pajarito at SR-501	03/11	1	125.00	<0.59	4.14	<5.50	<1.190	<0.13	<7.02	5.14	<0.600	7.78	20
	03/11	1	192.00	<0.59	4.14	<5.43	<1.180	<0.13	<6.96	3.91	0.650	10.30	31
Potrillo Canyon:													
Potrillo at SR-4	03/11	1	70.10	<0.59	2.12	<5.43	<1.180	<0.13	<6.96	2.19	<0.590	1.82	9
Fence Canyon:													
Fence at SR-4	03/11	1	199.00	<0.59	4.02	5.70	<1.200	<0.13	<7.02	10.30	0.600	6.33	24
Cañon de Valle:													
Cañon de Valle at SR-501	03/12	1	43.10	<0.61	2.18	10.20	<1.220	<0.13	<7.14	3.27	<0.610	4.41	14
Water Canyon:													
Water at SR-501	03/11	1	147.00	<0.61	2.20	<5.57	<1.210	<0.13	<7.14	8.11	<0.610	5.35	18
Water at SR-4	03/11	1	154.00	<0.62	6.32	16.60	<2.490	<0.13	<7.32	12.00	<1.250	4.19	34
Indio Canyon:													
Indio at SR-4	03/11	1	208.00	<0.62	4.58	<5.66	<2.470	<0.13	<7.26	4.90	<1.230	8.48	43
Ancho Canyon:													
Ancho at SR-4	03/11	1	380.00	<0.58	6.95	<5.34	<1.170	<0.13	<6.84	3.06	<0.580	19.90	119
Above Ancho Spring	10/08	1	251.00	<0.50	6.95	9.70	<0.300	<1.00	<3.00	17.70	<0.300	14.30	60
Ancho at Rio Grande	10/08	1	122.00	<0.50	3.36	4.10	<0.300	0.50	<3.00	16.30	<0.300	12.10	18
Chaquehui Canyon:													
Chaquehui at Rio Grande	10/09	1	76.30	<0.50	1.70	2.30	<0.300	<0.70	<3.00	12.70	<0.300	6.71	11

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
TA-49 Area AB:													
AB-1	03/25	1	545.00	<0.63	6.52	19.50	<1.240	0.37	<7.38	23.50	<0.620	18.10	195
	03/25	R1	329.00	<0.63	6.28	16.00	<1.230	0.38	<7.38	22.00	<0.620	1.15	180
AB-2	03/25	1	494.00	<0.63	6.56	15.90	<1.250	0.39	<7.38	21.60	<0.630	22.70	59
								<7.38					
AB-3	03/25	1	133.00	<0.63	<2.25	5.80	<1.240	0.50	<7.38	6.10	<0.620	8.58	65
AB-4	03/25	1	292.00	<0.63	6.00	14.30	<1.230	0.53	<7.38	26.30	<0.610	17.30	24
AB-4A	03/25	1	287.00	<0.63	6.50	16.90	<1.250	0.48	<7.38	32.00	<0.630	21.00	32
AB-5	03/25	1	338.00	<0.63	8.38	13.30	<1.240	0.55	<7.38	24.20	<0.620	12.00	34
AB-6	03/25	1	231.00	<0.63	4.60	8.90	<1.250	0.32	<7.38	10.60	<0.620	14.00	21
AB-7	03/25	1	129.00	<0.63	0.25	4.10	<1.250	0.14	<7.38	3.80	<0.630	2.58	50
AB-8	03/25	1	118.00	<0.63	3.77	9.50	<1.220	0.34	<7.38	8.88	<0.610	9.51	25
AB-9	03/25	1	176.00	<0.63	3.20	6.70	<1.250	0.27	<7.38	9.06	<0.620	6.90	24
AB-10	03/25	1	152.00	<0.63	<2.25	3.50	<1.270	0.22	<7.38	3.68	<0.630	5.00	16
AB-11	03/25	1	86.90	<0.63	<2.25	2.70	<0.620	0.12	<7.38	3.35	<1.230	3.17	15
Frijoles Canyon:													
Frijoles at Monument HQ	08/20	1	640.00	<0.62	5.77	19.70	<0.300	1.10	4.50	40.30	0.300	23.30	66
Frijoles at Rio Grande	10/09	1	413.00	<1.30	6.11	14.90	<0.300	0.80	3.64	29.20	<0.300	16.90	46
Reservoirs on Rio Chama (New Mexico):													
Heron Upper	6/27	1	340.00	<0.62	18.50	15.00	<0.100	0.78	<7.38	36.60		25.00	70
Heron Middle	6/27	1	726.00	<0.62	21.10	14.00	<0.100	0.81	<7.38	78.50		17.20	74
Heron Lower	06/27	1	382.00	<0.63	18.40	17.70	<0.100	1.02	<7.38	45.70		30.00	84
	06/27	D1	339.00	<0.62	15.50	12.60	<0.100	0.88	<7.38	37.70		18.10	58
El Vado Upper	06/26	1	377.00	<0.62	17.60	11.70	<0.100	1.07	<7.38	70.00		30.20	75
El Vado Middle	06/26	1	741.00	<0.62	19.00	11.70	<0.100	0.81	<7.38	53.20		24.60	81
El Vado Lower	06/26	1	674.00	<0.63	21.50	15.90	0.100	1.08	<7.38	74.20		40.00	74
Abiquiu Upper	06/25	1	188.00	<0.63	5.78	5.20	<0.100	0.36	<0.18	52.30		15.10	26
	06/25	R1	194.00	<0.62	6.57	4.90	<0.100	0.32	<7.38	53.30		12.00	27
Abiquiu Middle	06/28	1	597.00	<1.17	19.10	15.40	<0.100	0.69	<0.18	97.00		19.00	62
Abiquiu Lower	06/28	1	63.70	<0.13	3.18	1.40	<0.100	<0.15	<8.85	10.00		<2.00	12

Table 5-20. Total Recoverable Trace Metals in Sediments for 1996 (mg/kg) (Cont.)

Station Name[a,b]	Date	Code[c]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Reservoirs on Rio Grande (Colorado):													
Rio Grande Upper	9/21	1	440.00	<0.50	13.20	14.00	<0.300	0.00	<3.00	64.50	0.300	40.00	103
	9/21	R1	447.00	<0.50	5.82	12.50	<0.300	<0.00	<3.00	61.10	<0.300	32.90	84
Rio Grande Middle	9/21	1	659.00	<0.50	7.63	15.80	<0.300	0.00	<3.00	59.80	0.300	28.40	86
Rio Grande Lower	9/21	1	420.30	<0.50	5.00	15.00	<0.300	0.00	<3.00	68.90	0.300	28.70	70
Reservoirs on Rio Grande (New Mexico):													
Cochiti Upper	10/16	1	349.00	<0.50	12.00	13.40	<0.300	0.00	<3.00	108.00	<0.300	20.00	44
Cochiti Middle	10/16	1	761.00	<0.50	17.50	22.50	<0.300	0.00	<3.00	139.00	0.300	24.30	66
Cochiti Lower	10/16	1	120.60	<0.12	5.40	6.50	<0.300	0.00	<3.00	26.00	<0.300	17.50	25
Standardized Comparisons													
Average Detection Limits			0.20	0.90	2.00	0.20	0.200	0.30	4.00	0.30	0.200	0.50	1
1996 Mean (x)[e]			227.85	0.67	5.51	10.54	1.195	0.37	6.12	21.89	2.769	10.56	43
1996 Standard Deviation (s)[f]			168.10	0.34	4.82	13.74	1.489	0.29	2.09	31.31	6.256	8.76	47
SAL[g]			3,200	380	1,500	400	31	380	46,000	46,000	5.40	540	23,000

[a] Sample sizes: stream channels—100 g ; reservoirs—1000 g.
[b] Analytical uncertainties are approximately 10% of reported values.
[c] Code: 1—primary analysis, 2—secondary analysis, D—lab duplicate, R—lab replicate.
[d] Actual value is less than (<) listed value.
[e] Mean value of all 1996 sample values; if censored data are present, the < sign was omitted and the reported value was used.
[f] Standard deviation of all 1996 sample values; if censored data are present, the < sign was omitted and the reported value was used.
[g] SAL—Screening Action Level; Environmental Restoration, March 1997 values; see text for details. All units are in mg/kg.
[h] SAL value is less than background; therefore use local background (BG) value for SAL value.
[i] SAL value for hexavalent chromium is listed; SAL value for trivalent or total chromium is 210 mg/kg.
[j] No SAL value has been established for iron.

Table 5-21. Number of Analyses above Analytical Limit of Quantitation for Organic Compounds in Sediment Samples for 1996

Station Name	Date	Code[a]	Volatile[b]	Semivolatile[c]	PCB[d]	HE[e]	TIC[f]
Number of Compounds Analyzed			59	69	4	14	
Regional Stations							
Rio Grande at Otowi (bank)	10/11	1	0	0	0		10
Rio Grande at Frijoles (bank)	10/09	1		0	0		11
Canyons Along SR-4 or SR-502							
Bayo at SR-502	03/11	1				0	0
Pueblo at SR-502	05/07	1				0	0
Los Alamos at SR-4	05/02	1				0	0
Los Alamos at Otowi	05/02	1				0	0
Sandia at SR-4	05/02	1	0	0	0	0	2
Cañada del Buey at SR-4	05/02	1				0	0
Pajarito at SR-4	05/02	1				0	0
Potrillo at SR-4	05/02	1				0	0
Fence at SR-4	05/02	1				0	0
Water at SR-4	05/02	1	0	0	0	0	5
Indio at SR-4	05/02	1				0	0
Ancho at SR-4	05/02	1		0	0	0	1
TA-54 Area G							
G-1	03/22	1		0	0		4
G-2	03/22	1		0	0		0
G-3	03/22	1		0	0		5
G-4	03/22	1		0	0		0
G-5	03/22	1		0	0		0
G-6	03/22	1		0	0		4
G-7	03/22	1		0	0		1
G-8	03/22	1		0	0		2
G-9	03/22	1		0	0		1

[a] Code: 1—primary analysis, D—lab duplicate, R—lab replicate.
[b] Volatile organic compounds.
[c] Semivolatile organic compounds.
[d] Polychlorinated biphenyl compounds.
[e] High explosive compounds.
[f] Tentatively identified compounds.

Table 5-22. Radiochemical Analyses of Groundwater for 1996 (pCi/L[a])

Station Name	Date	Codes[b]	^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Main Aquifer												
Test Wells:												
Test Well 1	08/01	u 1	749 (147[c])	–0.3 (.6)	.65 (.44)	2.04 (.21)	–.016 (.005)	.009 (.010)	–.038 (.010)	2.23 (.8)	4.75 (.6)	–37 (50)
Test Well 2	08/21	u 1	161 (136)	–0.1 (.5)	–.98 (.32)	–.01 (.01)	–.003 (.003)	.019 (.011)	–.022 (.009)	–.49 (.12)	1.35 (.18)	–57 (50)
		u R1				–.01 (.01)						
Test Well 3	01/29	u 1	52 (330)	0.5 (.8)	–.23 (.34)	.05 (.06)	.039 (.013)	.008 (.009)	–.014 (.030)	.44 (.26)	3.55 (.5)	243 (60)
		u 2					.039 (.013)	.008 (.009)				
		u R1					.013 (.010)	.005 (.010)	–.004 (.030)			
		u R2					.013 (.010)	.005 (.010)				
	07/03	u 1	544 (74)	0.1 (.3)	–.32 (1.31)	.11 (.01)	.004 (.007)	–.010 (.007)	–.013 (.012)	–.23 (.05)	2.15 (.3)	–87 (50)
		u D1			–2.01 (.80)							
		u R1							–.003 (.016)	–.51 (.12)	1.05 (.2)	–87 (50)
	09/30	u 1	–52 (136)	–0.2 (.4)	.29 (.33)	.33 (.03)	.017 (.012)	.004 (.010)	.011 (.016)	–.43 (.12)	2.25 (.3)	–27 (50)
		u R1	11 (137)									
	11/15	u 1	–336 (139)	–0.7 (.8)	.59 (2.67)	.62 (.06)	.010 (.007)	–.007 (.006)	.045 (.024)	1.13 (.4)	4.05 (.6)	–17 (50)
Test Well 4	01/23	u 1	–253 (178)	0.7 (1.0)	.03 (.41)	.12 (.12)	.004 (.007)	.006 (.009)	.036 (.040)	–.071 (.002)	2.65 (.4)	323 (70)
		u 2					.004 (.007)	.006 (.009)				
		u D1			–.16 (1.56)							
		u D2			–.16 (1.56)							
		u R1								–.057 (.004)	–.6 (.04)	
	07/03	u 1	530 (73)	–1.0 (.2)	–.43 (1.14)	.04 (.01)	.010 (.009)	.004 (.012)	.010 (.018)	–.37 (.07)	3.45 (.4)	–107 (50)
		u 2					–.007 (.001)	–.014 (.005)	–.004 (.014)			
		u D1		–0.5 (.2)		.04 (.01)						
		u R1	–298 (62)				.007 (.009)	–.011 (.001)				
	09/27	u 1	–179 (135)	1.3 (.4)	–.44 (1.12)	.15 (.02)	–.006 (.002)	–.017 (.002)	–.036 (.008)	–.28 (.07)	2.95 (.4)	43 (50)
	11/15	u 1	–278 (139)	–0.1 (.8)	.14 (2.00)	.66 (.07)	–.003 (.005)	.005 (.009)	.050 (.026)	.55 (.2)	4.15 (.6)	–37 (50)
		u R1				.67 (.07)						
Test Well 8	01/29	u 1	–241 (322)	1.2 (.8)	.48 (2.50)	.48 (.05)	–.003 (.006)	–.003 (.009)	.006 (.040)	8.93 (3.2)	12.45 (1.5)	–97 (50)
		u 2					–.003 (.006)	–.003 (.009)				
		u D1				.55 (.06)						
		u R1										–107 (50)
	07/23	u 1	–289 (144)	–0.6 (.2)	–1.87 (.80)	.48 (.05)	–.003 (.008)	.003 (.009)	–.017 (.016)	.11 (.05)	1.15 (.2)	3 (50)
		ud 1	–41 (140)	0.4 (.3)	–1.70 (.80)	.47 (.05)	.017 (.009)	.003 (.009)	.017 (.025)	1.23 (.3)	1.55 (.2)	–27 (50)
		ud 2					.020 (.013)	.033 (.015)	.009 (.016)			
		ud R1										–37 (50)

Table 5-22. Radiochemical Analyses of Groundwater for 1996 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[b]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Test Wells (Cont.):													
Test Well 8 (Cont.)	09/30	u	1	–99 (136)	–0.1 (.4)	.21 (.35)	.58 (.06)	.003 (.009)	.019 (.014)	–.020 (.010)	–1.47 (.5)	1.65 (.2)	–47 (50)
		u	R1				.58 (.06)	–.004 (.006)	.020 (.012)	–.019 (.011)			
	11/15	u	1	20 (141)	–0.5 (.8)	.89 (.70)	.68 (.07)	.008 (.013)	.000 (.017)	–.008 (.015)	1.33 (.4)	2.05 (.3)	–47 (50)
		u	R1					–.003 (.006)	–.007 (.007)	.049 (.024)			
Test Well DT-5A	11/27	u	1	–56 (141)	–0.1 (.3)	–1.87 (.80)	.33 (.03)	–.006 (.006)	.029 (.015)	–.015 (.016)	.71 (.19)	2.37 (.3)	–57 (50)
		u	R1				.32 (.03)	.000 (.007)	.003 (.009)	–.041 (.013)			–57 (50)
		u	1										–97 (50)
		u	R1										43 (50)
Test Well DT-9	09/18	u	1	–9 (133)	0.0 (.3)	–.40 (.26)	.41 (.04)	.016 (.010)	.016 (.011)	–.025 (.010)	.47 (.14)	.95 (.1)	–7 (50)
		u	D1			–.61 (.23)							
		u	R1	–267 (131)									
	12/05	u	1	–129 (139)	0.3 (.3)	–1.43 (.80)	.39 (.04)	.003 (.008)	–.001 (.008)	–.011 (.018)	.46 (.1)	1.85 (.3)	–197 (50)
		u	2	–129 (139)									
		u	R1		–0.1 (.3)								
Test Well DT-10	09/19		1	170 (135)	1.4 (.5)	.17 (.32)	.57 (.06)	.014 (.012)	.025 (.014)	–.020 (.020)	–1.97 (.5)	7.45 (.9)	–67 (50)
			R1								.81 (.25)	7.95 (.9)	
	12/06	u	1	211 (143)	–0.8 (.6)	–1.27 (.80)	.59 (.06)	–.003 (.004)	.014 (.011)	–.018 (.015)	1.33 (.3)	3.15 (.4)	–157 (50)
		u	R1					–.001 (.006)	.022 (.012)	.032 (.026)			–137 (50)
Water Supply Wells:													
O-1	12/17	u	1	–236 (140)	0.3 (.4)	–.79 (.60)	3.16 (.32)	.005 (.009)	–.002 (.009)	.018 (.019)	5.83 (3.2)	2.75 (.5)	–47 (50)
	12/18	u	1	–397 (139)	0.3 (.4)	.03 (1.83)	3.10 (.31)	–.008 (.002)	–.002 (.007)	–.022 (.012)	3.83 (2.2)	2.35 (.5)	–77 (50)
		u	R1	–652 (137)									
	12/19	u	1	–347 (140)	0.5 (1.0)	–.51 (1.01)	3.05 (.31)	–.012 (.003)	.006 (.010)	–.008 (.017)	3.83 (2.2)	2.75 (.5)	–97 (50)
		u	R1							.002 (.016)			
			1	–724 (137)	–0.1 (.4)	–.45 (1.12)	2.81 (.28)	.001 (.008)	.007 (.010)	–.007 (.015)	7.63 (4.1)	2.85 (.5)	–77 (50)
			1	–66 (136)	0.0 (.4)		1.71 (.17)	.020 (.018)	–.004 (.011)	–.026 (.014)			–7 (50)
			R1	–379 (133)				–.003 (.010)	–.007 (.009)	.032 (.027)			
O-4	12/16	u	1	–506 (138)	0.2 (.4)	–.04 (1.72)	.88 (.09)	.004 (.007)	–.005 (.009)	–.003 (.014)	2.13 (1)	5.45 (.9)	–77 (50)
PM-1	04/25	u	1	–105 (322)	0.2 (.9)	–1.29 (.80)	1.49 (.15)	.006 (.008)	.024 (.013)	–.006 (.016)	.33 (.2)	3.25 (.4)	–47 (50)
PM-2	04/25	u	1	3 (325)	–0.1 (.9)	–1.20 (.80)	.25 (.03)	–.003 (.005)	–.006 (.007)	–.026 (.009)	–.37 (.1)	7.95 (1)	–77 (50)
		u	2					–.005 (.001)	–.012 (.001)	.017 (.019)			
		u	R1										–67 (50)
PM-3	04/25	u	1	–270 (317)	–0.1 (.8)	1.84 (.73)	.81 (.08)	–.007 (.003)	.022 (.011)	–.021 (.014)	.13 (.1)	3.15 (.4)	–87 (50)
		u	D1	2.6	(.8)								
		u	D2	2.6	(.8)								

Table 5-22. Radiochemical Analyses of Groundwater for 1996 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[b]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Water Supply Wells (Cont.):													
PM-5	04/25	u	1	–273 (317)	0.1 (.9)	–.40 (.38)	.76 (.08)	.012 (.008)	.001 (.008)	–.023 (.012)	–.37 (.1)	1.55 (.2)	–77 (50)
G-1	09/09	u	1	145 (136)	–0.2 (.2)	–.07 (1.68)	.44 (.05)	–.001 (.006)	–.009 (.006)	.018 (.017)	–.32 (.08)	6.55 (.8)	33 (50)
		u	R1	194 (137)									
G-1A	09/08	u	1	–487 (132)	–0.2 (.2)	.53 (.78)	.41 (.04)	.020 (.012)	.009 (.011)	–.017 (.014)	1.03 (.4)	6.15 (.8)	83 (50)
		u	R1					–.015 (.010)	.009 (.011)	–.019 (.012)			
		u	1	–236 (134)	–0.4 (.2)	–.26 (1.40)	.41 (.04)	.000 (.010)	.000 (.008)	.022 (.016)	.65 (.26)	6.35 (.8)	13 (50)
		u	R1										13 (50)
G-2	04/25	u	1	–371 (314)	–0.3 (.7)	–1.05 (.22)	1.11 (.11)	–.005 (.003)	–.006 (.007)	–.027 (.021)	.53 (.3)	2.55 (.4)	–47 (50)
		u	2					.026 (.012)	.004 (.010)	.064 (.025)			
G-5	04/25	u	1	306 (333)	–0.1 (.7)	–.65 (.81)	1.09 (.11)	.017 (.010)	–.004 (.007)	–.029 (.010)	1.23 (.5)	1.75 (.2)	–87 (50)
		u	D1			–1.12 (.10)							
		u	R1								–.01 (.2)	1.85 (.3)	
G-6	04/25	u	1	13 (325)	–0.6 (1.0)	–.72 (.70)	.46 (.05)	.007 (.007)	.002 (.008)	.002 (.017)	.63 (.2)	1.65 (.2)	–57 (50)
		u	R1	–286 (317)									
		u	1	–230 (318)	–0.1 (.8)	–1.45 (.80)	.42 (.04)	.001 (.005)	–.003 (.006)	–.027 (.016)	.93 (.3)	2.85 (.4)	–47 (50)
		u	R1							–.023 (.014)			
Main Aquifer Springs													
White Rock Canyon Group I:													
Sandia Spring	08/29	u	1	244 (137)	3.6 (.3)	2.06 (4.88)	.86 (.09)	–.016 (.006)	.023 (.017)	–.029 (.009)	5.03 (1.7)	6.15 (.7)	–57 (50)
		u	D1			–.56 (.96)							
		u	R1								9.93 (3)	7.45 (.9)	
Spring 3A	10/07	f	1	56 (136)	–0.4 (.3)	–1.15 (.07)	1.27 (.13)	–.004 (.006)	.007 (.010)	–.019 (.036)	1.03 (.4)	3.85 (.5)	–47 (50)
		f	R1					.007 (.007)	.010 (.010)	–.006 (.015)			
Spring 4	10/07	f	1	–205 (134)	0.1 (.3)	–1.90 (.80)	1.15 (.12)	–.002 (.004)	–.009 (.005)	.008 (.017)	.2 (1)	3.35 (.4)	–37 (50)
Spring 4A	10/08	f	1	–157 (134)	0.7 (.3)	1.67 (4.29)	1.04 (.11)	.006 (.009)	.017 (.013)	–.030 (.013)	.9 (.36)	6.55 (.8)	–27 (50)
Ancho Spring	10/08	f	1	–119 (134)	0.8 (.3)	.48 (2.50)	.29 (.03)	.011 (.008)	.008 (.011)	–.008 (.030)	–.34 (.08)	2.15 (.3)	–137 (50)
White Rock Canyon Group II:													
Spring 5A	10/08	f	1	366 (138)	–0.8 (.3)	–.75 (.67)	2.11 (.21)	–.006 (.001)	.007 (.009)	–.014 (.015)	.93 (.5)	3.85 (.5)	–77 (50)
		fd	1	–186 (134)	0.0 (.3)	–.46 (1.10)	1.92 (.19)	–.006 (.003)	–.001 (.011)	–.006 (.040)	.73 (.36)	4.35 (.5)	–57 (50)
		fd	2					.141 (.027)	–.001 (.007)				
Spring 6	10/08	f	1	214 (137)	–0.3 (.3)	–1.56 (.80)	.36 (.04)	–.006 (.004)	–.001 (.007)	–.022 (.010)	.93 (.3)	1.95 (.2)	–117 (50)
		f	R1					.004 (.006)	.009 (.010)	–.022 (.010)			

Table 5-22. Radiochemical Analyses of Groundwater for 1996 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[b]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
White Rock Canyon Group II (Cont.):													
Spring 8	10/08	f	1	–97 (134)	–0.2 (.3)	–1.65 (.80)	1.43 (.14)	–.003 (.006)	.007 (.011)	–.029 (.012)	2.23 (.9)	3.75 (.5)	–87 (50)
Spring 8B	10/08	f	1	49 (135)	0.9 (.4)	–1.51 (.80)	1.81 (.18)	–.009 (.004)	–.002 (.008)	–.024 (.013)	.63 (.29)	3.85 (.5)	–127 (50)
Spring 9A	10/09	f	1	90 (136)	0.6 (.3)	–.91 (.42)	.25 (.03)	.004 (.008)	–.003 (.009)	–.032 (.010)	–.18 (.03)	2.25 (.3)	–107 (50)
		f	R1	–16 (135)			.25 (.03)						
Spring 9B	10/09	f	1	15 (135)	0.4 (.3)	–1.79 (.80)	.17 (.02)	.000 (.007)	–.004 (.008)	.002 (.014)	.3 (.1)	1.45 (.2)	–167 (50)
Doe Spring	10/08	f	1	–363 (132)	1.2 (.4)	–.58 (.92)	.27 (.03)	.007 (.007)	.002 (.008)	.004 (.017)	–1.02 (.31)	2.15 (.3)	–107 (50)
		f	R1							–.044 (.000)			
Spring 10	10/09	f	1	54 (136)	–0.7 (.3)	–.47 (1.09)	1.01 (.10)	–.009 (.002)	–.001 (.007)	–.017 (.011)	–.22 (.06)	1.75 (.2)	–67 (50)
		f	D1										–97 (50)
White Rock Canyon Group III:													
Spring 1	08/29	u	1	–777 (129)	0.6 (.3)	–.29 (1.35)	1.51 (.15)	.004 (.008)	–.005 (.008)	–.004 (.017)	2.93 (1.1)	2.95 (.4)	–67 (50)
White Rock Canyon Group IV:													
La Mesita Spring	08/14	u	1	638 (78)	–0.1 (.7)	–.33 (.50)	10.01 (1.00)	.035 (.015)	.004 (.010)	–.016 (.014)	14.03 (5.2)	5.95 (.7)	–47 (50)
		u	D1			.81 (3.00)							
		u	R1								13.63 (5)	7.95 (1)	
Sacred Spring	08/14	u	1	–48 (69)	0.6 (.6)	–1.33 (.79)	.59 (.06)	.002 (.007)	–.007 (.006)	–.006 (.017)	6.03 (2.4)	8.65 (1.1)	–17 (50)
		u	R1										–77 (50)
Alluvial Canyon Groundwater Systems													
Acid/Pueblo Canyons:													
APCO-1	10/17	u	1	–141 (136)	0.5 (.4)	–1.19 (.02)	.34 (.04)	–.003 (.005)	.087 (.020)	–.020 (.012)	–3.97 (1.6)	12.05 (1.4)	283 (60)
		u	R1	274 (139)			.32 (.03)	.000 (.008)	.066 (.020)	–.015 (.016)			
Cañada del Buey:													
CDBO-6	12/17	u	1	29 (142)	0.2 (.3)	–.62 (.86)	.27 (.03)	–.010 (.002)	–.008 (.008)	.034 (.026)	7.13 (3.5)	11.55 (2)	–87 (50)
DP/Los Alamos Canyons:													
LAO-C	07/10	u	1	–173 (139)	0.3 (.3)	–1.27 (.80)	.14 (.02)	.007 (.012)	.009 (.010)	.061 (.027)	1.13 (.3)	20.75 (2)	–27 (50)
		u	R1	–297 (138)									
LAO-0.7	07/29	u	1	46 (141)	0.2 (.3)	2.69 (.85)	.42 (.04)	–.011 (.006)	.304 (.043)	–.024 (.014)	20.93 (9)	23.75 (3)	–87 (50)
		u	R1					–.006 (.007)	.248 (.040)	–.023 (.012)			
LAO-1	07/29	u	1	502 (144)	7.1 (.7)	–.32 (1.31)	.17 (.02)	.008 (.011)	.025 (.013)	–.020 (.013)	.73 (.3)	27.75 (3)	43 (50)
		u	D1		6.9 (.7)								

Table 5-22. Radiochemical Analyses of Groundwater for 1996 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[b]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
DP/Los Alamos Canyons (Cont.):													
LAO-2	11/13	u	1	152 (139)	16.5 (1.8)	.37 (2.33)	.15 (.02)	–.006 (.006)	.017 (.013)	.001 (.016)	.26 (.17)	54.75 (7)	3 (50)
		u	R1	–117 (137)			.12 (.01)						–17 (50)
LAO-3A	07/10	u	1	–51 (140)	25.4 (1.9)	.22 (.32)	.30 (.03)	–.006 (.008)	.019 (.014)	–.014 (.020)	1.93 (.7)	112.75 (14)	–37 (50)
		u	D1				.29 (.03)						
LAO-4	07/29	u	1	79 (141)	3.1 (.5)	.23 (.32)	.22 (.02)	.011 (.009)	.033 (.014)	–.015 (.013)	.63 (.2)	16.75 (2)	–47 (50)
		u	D1			–.22 (1.45)							
		u	R1								.57 (.22)	17.75 (2)	
Mortandad Canyon:													
MCO-4B	03/05	u	1	18279 (600)	108.9 (6.8)	–.82 (.54)	4.00 (.40)	.003 (.005)	.051 (.014)	.486 (.110)	25.73 (9.4)	625.75 (76)	133 (50)
		u	D1		140.0 (8.8)								
MCO-5	08/09	u	1	22545 (237)	121.9 (8.0)	5.31 (9.75)	6.49 (.65)	.027 (.013)	.028 (.014)	.393 (.050)	111.93 (47)	561.75 (66)	13 (50)
		u	R1										–17 (50)
		ud	1	22722 (237)	99.7 (6.6)	4.81 (9.00)	6.47 (.65)	.021 (.013)	.030 (.014)	.423 (.052)	105.93 (47)	597.75 (71)	–47 (50)
		ud	R1					.058 (.018)	.019 (.013)	.410 (.051)			
MCO-6	08/06	u	1	24396 (242)	83.2 (5.7)	1.91 (.90)	5.42 (.54)	.004 (.009)	.020 (.013)	.433 (.052)	108.93 (48)	501.75 (59)	–17 (50)
		u	D1				5.68 (.57)						
MCO-7	08/06	u	1	18027 (223)	1.9 (.7)	2.56 (5.63)	2.69 (.27)	.009 (.009)	.010 (.011)	.253 (.040)	127.93 (50)	253.75 (29)	–67 (50)
Pajarito Canyon:													
PCO-1	07/30	u	1	577.71 (146)	0.3 (.7)	–1.75 (.79)	.05 (.01)	.013 (.013)	.019 (.014)	.010 (.020)	.72 (.31)	6.85 (.8)	23 (50)
		u	D1			–.04 (.29)					–.55 (.19)	7.45 (.9)	
Intermediate Perched Groundwater Systems													
Pueblo/Los Alamos Area Perched System in Conglomerates and Basalt:													
Test Well 1A	08/02	u	1	180 (143)	0.2 (.6)	.33 (.33)	.07 (.01)	–.015 (.007)	–.010 (.008)	–.030 (.029)	–.34 (.06)	5.65 (.7)	–27 (50)
		u	R1		0.6 (.7)								
Test Well 2A	08/21	u	1	2253 (150)	0.0 (.4)	–1.57 (.80)	.11 (.01)	.007 (.010)	.024 (.014)	–.013 (.014)	–.97 (.34)	1.15 (.2)	–47 (50)
		u	R1					.018 (.011)	.014 (.013)	–.018 (.012)			
Basalt Spring	08/14	u	1	–310 (63)	–0.3 (.5)	–2.50 (.81)	.58 (.06)	.012 (.008)	.138 (.023)	–.032 (.015)	3.53 (1.3)	13.15 (1.6)	–67 (50)
Perched Groundwater System in Volcanics:													
Water Canyon Gallery	12/16	u	1	–417 (139)	–0.2 (.5)	–.68 (.77)	.24 (.03)	–.001 (.007)	.014 (.012)	.021 (.019)	.37 (.1)	2.25 (.3)	–77 (50)

Table 5-22. Radiochemical Analyses of Groundwater for 1996 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[b]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Pueblo of San Ildefonso Water Supply Wells:													
LA-1B	08/27	u	1	22 (135)	–0.1 (.3)	1.00 (.76)	.05 (.01)	.011 (.008)	.023 (.012)	.026 (.018)	–1.17 (.4)	.65 (.11)	–67 (50)
		u	R1	–269 (133)									–77 (50)
LA-5	08/14	u	1	–75 (69)	0.0 (.5)	–.97 (.33)	1.18 (.12)	.009 (.010)	.034 (.016)	–.024 (.018)	.85 (.33)	2.95 (.4)	–47 (50)
		u	R1	361 (75)									
Westside Artesian Well	08/14	u	1	–107 (68)	–0.3 (.5)	–.61 (.86)	19.36 (1.94)	–.010 (.003)	.004 (.008)	–.028 (.013)	25.93 (9.7)	3.25 (.4)	–67 (50)
		u	D1				19.54 (1.96)						
Eastside Artesian Well	08/13	u	1	–184 (136)	0.1 (.5)	.16 (.32)	.19 (.02)	.011 (.013)	.001 (.010)	.002 (.017)	–.88 (.38)	–.49 (.03)	–117 (50)
		u	R1					.030 (.014)	.001 (.009)	.009 (.040)			
Halladay House Well	08/13	u	1	–190 (136)	0.5 (.6)	–.14 (1.58)	1.26 (.13)	–.015 (.005)	.011 (.010)	–.003 (.017)	.14 (.04)	–.85 (.1)	–67 (50)
		ud	1	–187 (136)	0.7 (.3)	–.40 (.27)	1.37 (.14)	–.014 (.009)	–.002 (.009)	–.020 (.018)	1.23 (.5)	.85 (.1)	–57 (50)
Pajarito Well (Pump 1)	08/13	u	1	–107 (137)	0.1 (.5)	3.81 (7.50)	9.23 (.92)	.024 (.012)	–.000 (.009)	.005 (.016)	15.03 (6.2)	4.35 (.5)	–77 (50)
Don Juan	08/13	u	1	–308 (135)	0.4 (.9)	–.38 (.27)	5.96 (.60)	–.004 (.008)	–.010 (.008)	–.025 (.013)	6.43 (2.8)	2.65 (.3)	–67 (50)
Playhouse Well		u	D1			.48 (.41)							
		u	R1								11.63 (5.4)	2.25 (.3)	
Otowi House Well	08/13	u	1	98 (138)	0.2 (.5)	1.61 (.76)	2.87 (.29)	–.007 (.010)	–.009 (.008)	–.019 (.016)	2.83 (.9)	4.35 (.5)	–27 (50)
		u	D1				2.70 (.27)						
New Community Well	08/13	u	1	–5 (137)	2.7 (.6)	.64 (2.76)	19.64 (1.97)	.012 (.012)	–.009 (.009)	–.039 (.012)	23.93 (11.3)	5.65 (.7)	–7 (50)
		u	R1	–154 (136)									–87 (50)
Sanchez House Well	08/13	u	1	–231 (136)	0.1 (.3)	3.22 (6.62)	9.66 (.97)	.026 (.016)	.043 (.018)	–.019 (.017)	10.63 (4.7)	3.65 (.5)	–107 (50)
Limits of Detection				700	3	2	0.1	0.04	0.04	0.04	3	3	
Water Quality Standards[d]													
DOE DCG for Public Dose				2,000,000	1,000	3,000	800	40	30	30	30	1,000	
DOE Drinking Water System DCG				80,000	40	120	30	1.6	1.2	1.2	1.2	40	
EPA Primary Drinking Water Standard				20,000	8		20				15		
EPA Screening Level												50	
NMWQCC Groundwater Limit							5,000						

[a]Except where noted.
[b]Codes: u—unfiltered, f—filtered, d—field duplicate, 1—primary analysis, 2—second analysis, R1—lab replicate, D1—lab duplicate.
[c]Radioactivity counting uncertainties (1 standard deviation) in parentheses. Radioactivity counting uncertainties may be less than analytical method uncertainties.
[d]Standards given here for comparison only, see Appendix A.

Table 5-23. Detections of Radionuclides in Groundwater for 1996

Station Name	Date	Codes[b]		Analyte	Blank Corrected Value	Lab Value	Uncertainty (σ)	Units	Detection Limit
Test Well 1	08/01	u	1	^{3}H	749	951	147	pCi/L	700
Sandia Spring	08/29	u	1	^{90}Sr	3.61	3.7	0.3	pCi/L	3
Spring 5A	10/08	fd	1	^{238}Pu	0.1412	0.1452	0.0272	pCi/L	0.04
La Mesita Spring	08/14	u	1	Alpha	14.03	14.1	5.2	pCi/L	3
		u	R1	Alpha	13.63	13.7	5	pCi/L	3
		u	1	U	10.01	10.02	1	µg/L	0.1
LAO-0.7	07/29	u	1	Alpha	20.93	21	9	pCi/L	3
		u	1	^{239}Pu	0.304	0.316	0.043	pCi/L	0.04
		u	R1	^{239}Pu	0.248	0.26	0.04	pCi/L	0.04
LAO-1	07/29	u	1	^{90}Sr	7.11	7.2	0.7	pCi/L	3
		u	D1	^{90}Sr	6.91	7	0.7	pCi/L	3
LAO-2	11/13	u	1	Beta	54.75	55	7	pCi/L	3
		u	1	^{90}Sr	16.51	16.6	1.8	pCi/L	3
LAO-3A	07/10	u	1	Beta	112.75	113	14	pCi/L	3
		u	1	^{90}Sr	25.41	25.5	1.9	pCi/L	3
LAO-4	07/29	u	1	^{90}Sr	3.11	3.2	0.5	pCi/L	3
MCO-4B	03/05	u	1	Alpha	25.73	25.8	9.4	pCi/L	3
		u	1	Beta	625.75	626	76	pCi/L	3
		u	1	^{3}H	18,279	18,481	600	pCi/L	700
		u	1	^{90}Sr	108.91	109	6.8	pCi/L	3
		u	D1	^{90}Sr	140.01	140.1	8.8	pCi/L	3
MCO-5	08/09	u	1	Alpha	111.93	112	47	pCi/L	3
		u	1	^{241}Am	0.3933	0.4373	0.0497	pCi/L	0.04
		u	1	Beta	561.75	562	66	pCi/L	3
		u	1	^{3}H	22,545	22,747	237	pCi/L	700
		u	1	^{90}Sr	121.91	122	8	pCi/L	3
		u	1	U	6.49	6.5	0.65	µg/L	0.1
		ud	1	Alpha	105.93	106	47	pCi/L	3
		ud	1	^{241}Am	0.4231	0.4671	0.0516	pCi/L	0.04
		ud	R1	^{241}Am	0.41	0.454	0.051	pCi/L	0.04
		ud	1	Beta	597.75	598	71	pCi/L	3
		ud	1	^{3}H	22,722	22,924	237	pCi/L	700
		ud	1	^{90}Sr	99.71	99.8	6.6	pCi/L	3
		ud	1	U	6.47	6.48	0.65	µg/L	0.1

Table 5-23. Detections of Radionuclides in Groundwater for 1996 (Cont.)

Station Name	Date	Codes[b]	Analyte	Blank Corrected Value	Lab Value	Uncertainty (σ)	Units	Detection Limit
MCO-6	08/06	u 1	Alpha	108.93	109	48	pCi/L	3
		u 1	^{241}Am	0.4329	0.4769	0.0519	pCi/L	0.04
		u 1	Beta	501.75	502	59	pCi/L	3
		u 1	^{3}H	24,396	24,598	242	pCi/L	700
		u 1	^{90}Sr	83.21	83.3	5.7	pCi/L	3
		u 1	U	5.42	5.43	0.54	µg/L	0.1
		u D1	U	5.68	5.69	0.57	µg/L	0.1
MCO-7	08/06	u 1	Alpha	127.93	128	50	pCi/L	3
		u 1	^{241}Am	0.2527	0.2967	0.0399	pCi/L	0.04
		u 1	Beta	253.75	254	29	pCi/L	3
		u 1	^{3}H	18,027	18,229	223	pCi/L	700
Test Well 2A	08/21	u 1	^{3}H	2,253	2,455	150	pCi/L	700
Basalt Spring	08/14	u 1	^{239}Pu	0.1384	0.1504	0.0226	pCi/L	0.04
Westside Artesian Well	08/14	u 1	Alpha	25.93	26	9.7	pCi/L	3
		u 1	U	19.36	19.37	1.94	µg/L	0.1
		u D1	U	19.54	19.55	1.96	µg/L	0.1
Pajarito Well (Pump 1)	08/13	u 1	Alpha	15.03	15.1	6.2	pCi/L	3
		u 1	U	9.23	9.24	0.92	µg/L	0.1
Don Juan Playhouse Well	08/13	u R1	Alpha	11.63	11.7	5.4	pCi/L	3
		u 1	U	5.96	5.97	0.6	µg/L	0.1
New Community Well	08/13	u 1	Alpha	23.93	24	11.3	pCi/L	3
		u 1	U	19.64	19.65	1.97	µg/L	0.1
Sanchez House Well	08/13	u 1	Alpha	10.63	10.7	4.7	pCi/L	3
		u 1	U	9.66	9.67	0.97	µg/L	0.1

[a] Detection defined as sample value – avg. blank ≥ 4.66 σ and ≥ detection limit, except values shown for Uranium ≥ 5 µg/L, for Gross Beta ≥ 40 pCi/L, and for Gross Alpha ≥ 10 pCi/L.

[b] Codes: u—unfiltered, f—filtered, d—field duplicate, 1—primary analysis, 2—second analysis, R1—lab replicate, D1—lab duplicate.

Table 5-24. Possible Detections[a] of Radionuclides in Groundwater for 1996

Station Name	Date	Codes[b]		Analyte	Blank Corrected Value	Lab Value	Uncertainty (σ)	Units	Detection Limit
G-2	04/25	u	1	^{241}Am	0.064	0.108	0.025	pCi/L	0.04
APCO-1	10/17	u	1	^{239}Pu	0.087	0.099	0.02	pCi/L	0.04
		u	R1	^{239}Pu	0.066	0.078	0.02	pCi/L	0.04
LAO-0.7	07/29	u	1	^{137}Cs	2.69	3.88	0.85	pCi/L	2
MCO-4B	03/05	u	1	^{241}Am	0.486	0.53	0.11	pCi/L	0.04
		u	1	^{239}Pu	0.051	0.063	0.014	pCi/L	0.04
MCO-5	08/09	ud	R1	^{238}Pu	0.058	0.062	0.018	pCi/L	0.04
Sanchez House Well	08/13	u	1	^{239}Pu	0.0429	0.0549	0.0177	pCi/L	0.04

[a]Possible detection defined as 2.33 σ ≤ (sample value minus avg. blank) ≤ 4.66 σ and (sample value minus avg. blank) ≥ detection limit.
[b]Codes: u—unfiltered, f—filtered, d—field duplicate, 1—primary analysis, 2—second analysis, R1—lab replicate, D1—lab duplicate.

Table 5-25. Total Committed Effective Dose Equivalent (CEDE) from the Ingestion of Two Liters Per Day Drinking Water Collected during 1996

	Total Committed Effective Dose Equivalent[a] (mrem/yr)	
Well or Water System	**1996**	**1995**
Los Alamos & White Rock[b]	0.071 (± 0.048)[c]	0.43 (± 0.12)[c]

[a]Based on DOE dose conversion factors (DOE 1988a).
[b]Doses based on the 2 liter/day maximum consumption rate (EPA 1989) and the percentage wells were pumped to the distribution system.
[c]±2 sigma in parenthesis; to convert to μSv multiply by 10.

Table 5-26. Trace-Level Tritium Measurements in Regional Aquifer Test Wells during 1996

Station	Date	TU[a]	ΔTU[b]	pCi/L	ΔpCi/L
DT-10	12/04	0.03	0.09	0.10	0.29
DT-5A	11/27	0.16	0.09	0.51	0.29
DT-9	09/18	–0.02	0.09	–0.06	0.29
DT-9	12/05	0.11	0.10	0.35	0.32
TW-3	01/29	4.77	0.16	15.23	0.51
TW-3	07/03	1.87	0.09	5.97	0.29
TW-3	09/30	1.53	0.09	4.89	0.29
TW-3	11/15	0.05	0.09	0.16	0.29
TW-4	01/23	0.32	0.09	1.02	0.29
TW-4	07/03	0.20	0.10	0.64	0.32
TW-4	09/27	0.04	0.10	0.13	0.32
TW-4	11/15	0.06	0.09	0.19	0.29
TW-8	01/29	8.20	0.27	26.18	0.86
TW-8	07/23	1.72	0.11	5.49	0.35
TW-8	09/30	6.09	0.20	19.45	0.64
TW-8	11/15	3.26	0.12	10.41	0.38

[a]The University of Miami detection limit for this set of samples is about 0.3 pCi/L (0.1 tritium unit (TU)).
1TU = 3.193 pCi/kg H_2O ~ 3.193 pCi/L H_2O.
[b]The Δ values represent one standard deviation of the uncertainty of measurement.

Table 5-27. Chemical Quality of Groundwater for 1996 (mg/L[a])

Station Name	Date	Codes[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Main Aquifer Test Wells:																				
Test Well 1	08/01	u 1	43	52	10.6	3.4	17.8	33	22.1	<5[f]	101	0.41	0.06	5.53	<.01	300	5.6	175	8.1	393
		u R1	44																	
Test Well 2	08/21	u 1	<10	2.1	0.1	2.9	135.4	55.9	19.7	<5	66	0.5	<.02	0.1	<.01	100	2	5.7	7.4	152
		u R1		2	0.1	2.5	135.3			<5	65							5.6		
Test Well 3	07/03	u 1	33	12.3	4	<3.0	10	5.6	3	<5	67	0.49			0.01	110	4	46.4	7.6	
		u R1		12.3	3.9	1.9	10			<5	61									
	09/30	u 1	55	14.7	4.5	1.3	11.4	5.7	<1.0	<5	86	0.47	0.05	0.4	<.01	160	6.4	55.2	7.8	161
		u R1						5.7	<1.0											
	11/15	u 1	84	15.4	5	1.6	11.2	5.2	4.6	<5	80	0.43	<.02	0.73	<.01	200	<1	59.1	8	176
		u R1								<5	79									
Test Well 4	07/03	u 1	<10	9.1	4.7	<2.0	9.3	4.6	<1.0	<5	64	0.18			0.01	70	<1	42	8.4	
	09/27	u 1	<10	9.9	5.1	1.6	10.3	4.8	<1.0	<5	79		0.02		<.01	86	26	45.7	8.6	137
		u R1								<5	75			0.26						
	11/15	u 1	72	10	5.6	1.9	10.1	4.2	2.2	<5	70	0.19	<.02	1.55	<.01	150	2	47.8	7.9	141
		u R1												1.64						
Test Well 8	07/23	u 1	66	12.2	4.2	2.2	9.9	4.6	3.5	<5	61	0.17	0.25	0.2	<.01	130	<1	47.8	7.5	
		u R1													<.01		<1			
		ud 1	66	12.2	4.2	2.2	10	4.6	3.6	<5	65	0.16	<.01	0.23	<.01	140	<1	47.8	7.7	
	09/30	u 1		11.5	3.9	0.8	10.3											44.8		
	11/15	u 1	76	12.7	4.5	<2.2	11.9	4.3	3.6	<5	62	0.16	<.02	0.35	<.01	160	<1	50.1	8	135
		u R1		11.5	4	1.7	10.5											45		
Test Well	11/27	u 1	76	9.5	2.8	1.7	12.3	4.1	3.2	<5	52	0.24	<.02	0.4	<.01	150	<1	35	7.9	110
DT-5A		u R1		9.7	2.9	2.4	12.7								<.01	150	<1	36		
Test Well	09/18	u 1	72	9.6	2.6	<.3	10	4	4	<5	58	0.29	<.02	0.41	0.01	150	<1	34.8	8	118
DT-9		u R1		9.8	2.7	<.3	10.5											35.6		
	12/05	u 1	73	9.3	2.6	<1.0	9.8	4.7	4.2	<5	52	0.3	<.02	0.35	<.01	150	<1	34	8.1	120
		u 2	73					4.7	4.2	<5	52	0.3	<.02	0.35	<.01	150	<1		8.1	120
		u R1		9.1	2.5	<1.0	9.5											33		
Test Well	09/19	1	67	11.3	3.4	<.6	10.5	4	4	<5	66	0.25	<.02	0.27	0.01	160	<1	42	8.3	132
DT-10		R1	67										<.02				<1	0		
	12/06	u 1	67	10.8	3.2	<1.0	9.9	4.7	4	<5	60	0.26	<.02	0.26	<.01	150	<1	40	8.3	130
		u 2	67					4.7	4	<5	60	0.26	<.02	0.26	<.01	150	<1		8.3	130
		u R1	70										<.02		<.01	150				
		u R2	70										<.02		<.01	150				

Table 5-27. Chemical Quality of Groundwater for 1996 (mg/L[a]) (Cont.)

Station Name	Date	Codes[b]		SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Main Aquifer																					
Water Supply Wells:																					
O-1	06/24	u	1		2.3	<.0	0.5	62						0.02	<.04				5.9		
		u	R1											<.02							
	12/17	u	1	32	2.3	0	<1.0	62.5	5.7	5.7	18	140	0.3	<.02	0.35	<.01	160	<1	5.7	9.3	273
		u	R1										0.29								
	12/18	u	1	32	2.5	0.2	<1.0	60.3	5.8	5.8	8	150	0.31	<.02	0.27	<.01	170	13	7.1	9	271
		u	R1											<.02		<.01	170	12			
	12/19	u	1	32	2.4	0.1	<1.0	61	5.8	5.9	17	150	0.31	0.08	0.28	<.01	160	6	6.3	9.1	275
			1	33	2.1	0.1	<1.0	61.2	5.9	6.1	15	150	0.32	<.02	0.34	<.01	160	2	5.7	9.1	270
			1	38	3.5	0.8	<1.0	63.8	6	6	5	144	0.35			<.01	224	17	12	8.7	285
			R1	39	3	0.3	<1.0	63.9					0.37			<.01	218	19	8.7		
O-4	12/16	u	1	91	19	7.7	2.6	18	8	6.6	<5	120	0.31	0.05	0.44	<.01	200	<1	79.2	7.7	242
PM-1	04/25	u	1	78	23.7	5.9	3.3	16.7	6.6	6.1	<5	114	0.24	0.03	0.47	<.01	242	<1	83	7.5	244
PM-2	04/25	u	1	84	12.3	3.9	2.4	13.1	2.7	3.2	<5	51	0.22	0.03	0.28	<.01	136	<1	46	7.2	114
PM-3	04/25	u	1	91	23.4	7.6	3.2	16.3	7	6.3	<5	140	0.3	0.03	0.42	<.01	250	<1	89	7.3	255
PM-5	04/25	u	1	89	11.8	4.6	2.2	11.6	3.6	4	<5	79	0.28	0.03	0.27	<.01	182	<1	48	7.4	153
G-1	09/09	u	1	83	12.3	0.6	<3.8	20.9			<5	82	0.41	<.02	0.49	<.01	180	<1	33	8.5	163
		u	R1									81	0.41	<.02			180				
G-1A	09/08	u	1	72	9.9	0.5	<2.1	28.4			<5	89	0.56	<.02	0.48	<.01	160	1	27	8.6	185
		u	1	72	9.6	0.5	2.2	27.7			<5	88	0.57	<.02	0.48	<.01	180	1.8	26	8.6	186
G-2	04/25	u	1	74	9.4	0.5	2.5	34	3.7	5.1	<5	97	0.84	0.03	0.47	<.01	198	<1	25	8	205
G-5	04/25	u	1	59	16.9	3.6	1.9	10.6	3.8	5.1	<5	72	0.29	0.03	0.64	<.01	142	<1	57	7.8	167
		u	R1	61					3.8	5	<5	81			0.64	<.01					
		u	R2	61					3.8	5	<5	81			0.64	<.01					
G-6	04/25	u	1	54	15.3	2.4	2.3	17.8	3.2	4.1	<5	71	0.27	0.03	0.45	<.01	140	<1	48	7.7	159
		u	R1										0.28								
		u	R2										0.28								
		u	1	54	12.8	2	2.1	16.2	3.2	4.1	<5	118	0.28	0.03	0.39	0.01	136	<1	40	7.8	150
		u	R1		12.9	2.1	2	16.3											40		
		u	R2		12.9	2.1	2	16.3											40		

Table 5-27. Chemical Quality of Groundwater for 1996 (mg/L[a]) (Cont.)

Station Name	Date	Codes[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Main Aquifer Springs																				
White Rock Canyon Group I:																				
Sandia Spring	08/29	u 1	47	30.4	2.5	4	16.4	4.6	5.5	<5	115	0.55	0.04	0.04	<.01	170	84	85	7.3	239
		u R1	47																	
Spring 3A	10/07	f 1	51	19	1.7	1.9	14	7.4	6.1	<5	77	0.43	0.1	0.94	<.01	140	1.2	<54	8.2	115
Spring 4	10/07	f 1	55	22	4.6	1.6	14	10.2	10.8	<5	78	0.49	<.02	1.63	<.01	190	1.2	73.1	7.6	206
		f R1						9.8	11.5					1.62						
Spring 4A	10/08	f 1	71	17.6	4.3	1.1	11.3	7.9	7.1	<5	81	0.46	0.02	1.02	<.01	160	<1	61.7	8.4	186
		f R1														160				
Ancho Spring	10/08	f 1	76	11.6	3	1	10.1	5.5	4.4	<5	59	0.35	<.02	0.43	<.01	120	<1	41.3	7.8	133
White Rock Canyon Group II:																				
Spring 5A	10/08	f 1	54	25	3	2.3	29	8.3	8.6	<5	107	0.37	<.02	0.58	<.01	230	<1	73.8	7.8	232
		f R1										0.37					<1			
		fd 1	74	20	2.4	1.6	23	6.9	9	<5	107	0.39	<.02	0.5	<.01	200	<1	59.3	7.6	237
		fd R1	74																	
Spring 6	10/08	f 1	75	11.3	3.4	1.1	10.1	5.6	4.4	<5	59	0.35	0.02	0.48	<.01	150	<1	42.2	8	135
Spring 8	10/08	f 1	75	16.3	3.4	1.9	18.4	6.4	8.1	<5	87	0.38	<.02	0.55	<.01	190	<1	54.7	7.3	194
Spring 8B	10/08	f 1	76	18	4	2.1	21.2	6.6	9.4	<5	102	0.4	0.02	0.59	<.01	200	<1	61.4	6.9	228
Spring 9A	10/09	f 1	75	10.6	3.3	0.5	11.7	5.5	3.7	<5	58	0.49	<.02	0.29	<.01	140	<1	40.1	8.3	128
		f R1	75																	
Spring 9B	10/09	f 1	72	0.4	<.3	9.4	<.2	5.5	4.2	<5	42	0.47	<.02	0.13	<.01	130	<1	0	8	117
		f R1														150				
Doe Spring	10/08	f 1	77	13.6	3.6	1.1	12.2	6.2	3.2	<5	77	0.53	0.02	0.07	<.01	150	1.4	49.8	8	150
		f R1								<5	73									
Spring 10	10/09	f 1	72	14.8	3	0.4	10.9	5.5	3.9	<5	82	0.5	<.02	0.6	<.01	150	<1	49.1	8	161
		f R1												0.6						
White Rock Canyon Group III:																				
Spring 1	08/29	u 1	33	15	1.5	<2.8	27.4	4.6	6.2	<5	106	0.53	0.1	0.37	<.01	210	10	44	7.9	214
		u R1										<1.05				210				
White Rock Canyon Springs Group IV:																				
La Mesita Spring	08/14	u 1	30	34	2.2	3.4	24	8.2	14.1	<5	122	0.24	0.07	2.79	<.01	260	21	93	8.3	299
Sacred Spring	08/14	u 1	22	<.4	<.2	<.5	<.3	4.5	5.6	<5	110	0.53	0.05	0.04	<.01	190	20	<1	7	224

Table 5-27. Chemical Quality of Groundwater for 1996 (mg/L[a]) (Cont.)

Station Name	Date	Codes[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Alluvial Canyon Groundwater Systems																				
Acid/Pueblo Canyons:																				
APCO-1	10/17	u 1	78	20.2	4.9	10.1	60.2	46.7	25.7	<5	120	0.49	4.3	4.6	<.01	300	2.4	70	7.2	480
Cañada del Buey:																				
CDBO-6	07/02	u 1												0.05						
		u R1												0.07						
	09/30	u 1												0.12						
		u 1												0.09						
	12/17	u 1	60	15	3.8	2.1	20.5	10.5	8.7	<5	78	0.2	0.35	0.07	<.01	150	46	53.1	9	218
		u R1	60																	
		u 1												0.11						
CDBO-7	07/02	u 1												<.04						
		u R1												<.04						
	09/30	u 1												0.12						
		u 1												0.09						
DP/Los Alamos Canyons:																				
LAO-C	07/10	u 1	39	17.4	4	4.5	50.6	85	6.9	<5	60	0.15	<.01	<.04	<.01	250	<1	59.8	7	
LAO-0.7	07/29	u 1	38	18.6	3.7	4.6	43.3	76.1	8.3	<5	66	0.18	0.08	<.04	<.01	250	70	61.6	6.5	
LAO-1	07/29	u 1	40	16.9	3.6	4.9	37.5	62	7.6	<5	56	0.26	<.01	0.11	<.01	220	<1	57	6.6	
LAO-2	11/13	u 1	50	19.5	5.2	7	31	45.4	8.4	<5	76	0.69	0.08	0.19	<.01	230	<1	70	6.6	316
		u R1		21.3	5.7	7.9	34.2						0.05	0.18	<.01	220				
LAO-3A	07/10	u 1	52	17	3.6	7.2	29.7	22.6	12.7	<5	77	1.03	0.08	1.1	<.01	220	2	57.4	6.9	
LAO-4	07/29	u 1	45	13	3.6	5.4	27	15.8	9.6	<5	84	0.66	<.01	0.16	<.01	190	<1	47.2	6.7	
		u R1	45									0.69	<.01	0.15		200				
Mortandad Canyon:																				
MCO-4B	03/05	u 1	41	58.5	4.3	24	108	22	24	<5	224	1.34	0.11	36.6	0.01	482	<1	170	8.6	830
		u R1										1.34								
MCO-5	08/09	u 1	37	73.3	7.1	26.3	119	28.8	27.3	<5	250	1.29	0.06	61	<.01	790	5.6	211	7.9	1,070
		ud 1	36	71.2	6.8	25.3	117	29.1	26.7	<5	251	1.26	0.06	62.5	<.01	790	1	205	7.4	1,087
		ud R1															1			
MCO-6	08/06	u 1	34	68.6	7.6	30	116	29.4	26.8	<5	214	1.21	0.08	63	<.01	780	7.6	203	7.4	1,060
MCO-7	08/06	u 1	38	24.2	6.4	16.9	90	19.6	19.3	<5	174	1.5	0.41	27.9	<.01	590	57	86	7.6	289
		u R1										1.49	0.38			610				

Table 5-27. Chemical Quality of Groundwater for 1996 (mg/L[a]) (Cont.)

Station Name	Date	Codes[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Alluvial Canyon Groundwater Systems (Cont.)																				
Pajarito Canyon:																				
PCO-1	07/30	u 1	39	30.2	8.7	4.2	27.8	30.7	49.7	<5	55	0.14	0.03	0.48	<.01	250	1	111	6.6	322
		u R1		30	8.6	4.8	27.7							0.48				110		
Intermediate Perched Groundwater Systems																				
Pueblo/Los Alamos Canyon:																				
Test Well 1A	08/02	u 1	<10	11.7	4.8	4.6	49.4	41.1	7.3	<5	73	0.66	0.35	<.04	<.01	190	11	50	7.9	284
Test Well 2A	08/21	u 1	30	29	5.5	1.6	17.9	4.6	<1.0	<5	68	0.22	<.02	0.09	<.01	300	7.6	95	7.1	330
Basalt Spring	08/14	u 1	81	20.2	4.9	10	52.2	38.7	20	<5	121	0.47	4.4	1.33	<.01	380	30	70	6.9	411
		u R1									128									
Perched Groundwater System in Volcanics:																				
Water Canyon Gallery	12/16	u 1	46	6.3	3	1.5	5.8	2.9	3.4	<5	42	0.06	<.02	0.26	<.01	80	2	28.1	8	81.4
Pueblo of San Ildefonso Water Supply Wells:																				
LA-1B	08/27	u 1	<10	2	0.1	1.4	137.8	18.4	27	35	277	3.01	<.02	<.04	<.01	380	<1	5.4	9.4	655
LA-5	08/14	u 1	41	19	0.8	<2.6	15.4	5.5	6.5	<5	88	0.49	<.02	0.2	<.01	180	<1	50	8.3	173
		u R1	41										<.02			170				
Westside Artesian Well	08/14	u 1	25	14	0.9	1.7	380	339	81	26	352	5.44	0.12	<.04	<.01	1100	2.8	38	8.5	1,910
		u R1								25	349									
Eastside Artesian Well	08/13	u 1	<10	3.1	0.2	<1.9	79	5.3	17.5	17	181	0.81	<.02	<.04	<.01	210	<1	9	9.4	385
Halladay HouseWell	08/13	u 1	29	4	<.2	<2.2	39	6.2	13.7	<5	84	0.52	<.02	0.75	<.01	130	<1	10	9	208
		u R1	29											0.75						
		ud 1	31	4.2	<.2	<2.3	41	6.1	13.9	<5	80	0.5	<.02	0.55	<.01	110	<1	11	9	207
		ud R1						6.2	13.7											
Pajarito Well (Pump 1)	08/13	u 1	39	56.1	5.7	4.5	300	201	53.5	15	511	0.58	<.02	0.22	<.01	1100	2	162	7.7	1,710
		u R1									512					1100				
Don Juan Playhouse Well	08/13	u 1	27	6.2	0.5	0.5	64	5.3	15.7	<5	133	0.61	<.02	1.97	<.01	180	<1	17	8.9	314
Otowi House Well	08/13	u 1	60	65	5.1	2.8	39	42.1	25.1	10	196	0.39	<.02	0.62	<.01	350	<1	182	7.3	547
New Community Well	08/13	u 1	27	16	1	1.6	77	9.4	30.5	<5	173	0.14	0.1	1.47	<.01	230	<1	44	8.5	436
Sanchez House Well	08/13	u 1	42	27	1.9	2.5	88	50.2	41.9	11	179	1.2	<.02	1.47	<.01	280	<1	75	8.2	573
		u R1											<.02							

Table 5-27. Chemical Quality of Groundwater for 1996 (mg/L[a]) (Cont.)

Station Name	Date	Codes[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Water Quality Standards[g]																				
EPA Primary Drinking Water Standard									500			4		10	0.2					
EPA Secondary Drinking Water Standard								250	250							500			6.8–8.5	
EPA Health Advisory							20													
NMWQCC Groundwater Limit								250	600			1.6		10	0.2	1,000			6–9	

[a]Except where noted.
[b]Codes: u—unfiltered, f—filtered, d—field duplicate, 1—primary analysis, R1—lab replicate, D—lab duplicate.
[c]Total dissolved solids.
[d]Total suspended solids.
[e]Standard units.
[f]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[g]Standards given here for comparison only, see Appendix A.

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Main Aquifer															
Test Wells:															
Test Well 1	08/01	u	1	<2[b]	<90	<2	62	91	<1	<2	<6	<10	<13	1220	<.2
		u	R1												<.2
Test Well 2	08/21	u	1	13	<500	12	304	20	<2	<7	<8	<30	<10	83	<.2
		u	R1	10	<500	13	304	19	<2	<7	<8	<7	<10	107	<.2
Test Well 3	07/03	u	1	<2	<90	<2	24	34	<1	<2	3.8	<10	<13	1,0700	<.4
		u	R1	<2	<90	<2	38.5	34.6	<1	<2	<3	<10	<15	1,0700	<.4
	09/30	u	1	<4	<50	<2	39	35	<3	<2	6	5	<10	5,850	<.2
		u	R1												<.2
	11/15	u	1	<10	<50	3	24.9	24.5	<2	<7	<8	<7	<10	69.4	<.2
		u	R1												<.2
Test Well 4	07/03	u	1	<2	<90	<2	<6	48	<1	<2	<3	<10	<13	1,250	<.4
		u	R1												<.4
	09/27	u	1	<4	146	<2	<24	68	<3	<2	<6	11	87	5,730	<.2
		u	R1												<.2
	11/15	u	1	<10	<50	2	<20	54.9	<2	<7	<8	<7	33.9	213	<.2
		u	R1												<.2
Test Well 8	07/23	u	1	<2	<90	<2.2	23	7	<1	<2	<3	<10	<13	71	<.1
		u	R1												<.1
		ud	1	<2	<90	<2.2	36	6.5	<1	<14	<3	<10	<13	64	0.078
		ud	R1												0.088
	09/30	u	1	<4	<50	2	18	7	<3	<2	<3	<9	<10	93	<.2
		u	R1												<.2
	11/15	u	1	<10	<500	2	<20	9.9	<2	<7	<8	<7	<10	154.7	<.2
		u	R1	<10	<500	3	<20	9	<2	<7	0.9	<10	33.9	220.6	<.2
Test Well DT-5A	11/27	u	1	<10	<500	3	<20	26.8	<2	<7	21.7	62.9	<10	1,140	<.2
		u	R1	<10	<500	2	<20	26.6	<2	<7	<8	<7	<10	104	<.2

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Main Aquifer															
Test Wells (Cont.):															
Test Well DT-9	09/18	u	1	<4	<190	<2	24	16	<3	<3	<3	<6	<10	<40	<.2
		u	R1	<4	<187	<2	24	16	<3	<3	<11	<3	<10	<40	<.2
	12/05	u	1	<10	<500	<4	25.6	15.3	<2	<7	<8	<7	<10	93.9	<.2
		u	2			<4									<.2
		u	R1	<10	<500	4	<20	14.5	<1	<7	<8	<7	<10	<20	<.2
		u	R2			4									<.2
Test Well DT-10	09/19	u	1	<4	<187	2	22	7	<3	<2	<3	<3	<10	45	<.2
		u	R1												<.2
	12/06	u	1	<10	<500	<4	<20	6.6	<2	<7	<8	<7	<10	138	<.2
		u	2			<4									<.2
		u	R1												<.2
		u	R2												<.2
Water Supply Wells:															
Otowi 1	06/24	u	1	<3	<90	4.3	70	3	<1	<2	<3	<10	70	24,000	<.2
		u	R1												<.2
	12/17	u	1	<10	<500	<4	63.6	32.6	<2	<7	<8	12.8	<10	514	<.5
		u	R1												<.5
	12/18	u	1	<10	543	4	73	17.6	<2	<7	<18	14.4	<10	3,145	<.3
		u	R1												<.3
	12/19	u	1	<10	<500	<4	99.8	21.9	<2	<7	<8	15.3	13.5	3,124	<.2
		u	R1												<.2
		u	1	<10	<500	<4	71.2	7.1	<2	<7	<8	<17	<10	586	<.4
		u	R1												<.4
		u	1	<10	1,000	6	71.2	33.5	<2	<7	<8	16.3	<10	4,483	<.3
		u	R1	<10	<500	6	71.1	30.2	<2	<7	<8	15.3	<10	4,104	<.3
O-4	12/16	u	1	<10	<500	<4	69.1	36.7	<2	<7	<8	<7	83	920.5	<.2
		u	R1												<.2
PM-1	04/25	u	1	2	130	2.9	41	71	<1	<2	3	<10	<13	70	
PM-2	04/25	u	1	11	280	3.7	24	36	1	<2	<3	30	18	<65	
PM-3	04/25	u	1	<2	<110	3.4	49	48	<1	<2	<3	<10	<13	<65	
PM-5	04/25	u	1	<2	140	3.5	16	30	1	<2	<3	<10	<13	<65	

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Main Aquifer															
Water Supply Wells (Cont.):															
G-1	09/09	u	1	53	<500	6	<70	57	<2	<20	<21	<20	<7	47	<.2
		u	2												
		u	R1												<.2
G-1A	09/08	u	1	47	<500	14	63	24	<2	<10	<8	<15	<10	240	<.2
		u	2												
		u	R1												<.2
		u	1	44	<500	13	60	23	<2	<7	<21	<15	<30	516	<.2
		u	2												
		u	R1												<.2
G-2	04/25	u	1	<2	<110	37.8	32	61	1	<2	<3	10	<13	<65	
G-5	04/25	u	1	<2	<110	3	12	13	<1	<2	<3	<10	<13	<65	
G-6	04/25	u	1	<2	110	4.5	22	8	<1	<2	<3	<10	13	<65	
		u	1	3	<110	4.2	19	7	<1	<2	<3	<10	10	<65	
		u	R1	<2	<110	4.5	20	8	<1	<2	<3	<10	<13	<65	
		u	R2	<2	<110	4.5	20	8	<1	<2	<3	<10	<13	<65	
Main Aquifer Springs															
White Rock Canyon Group I:															
Sandia Spring	08/29	u	1	21	2,490	<4	<120	118	<2	<7	<8	<7	<10	1,480	<.25
		u	2												
		u	R1												0.26
Spring 3A	10/07	f	1	<4	<280	4	48	68	<3	7	4	5	10	140	<.2
		f	R1												<.2
Spring 4	10/07	f	1	<4	<280	3	32	43	<3	2	<3	<3	<10	<100	<.2
		f	R1												<.2
Spring 4A	10/08	f	1	<4	<280	3	31	38	<3	<2	4	4	<10	<100	<.2
		f	R1												<.2
Ancho Spring	10/08	f	1	<4	<280	2	32	26	<3	<2	3	3	<10	<100	<.2
		f	R1												<.2

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Main Aquifer Springs (Cont.)															
White Rock Canyon Group II:															
Spring 5A	10/08	f	1	<4	<280	4	60	35	<3	<2	<3	3	10	<100	<.2
		f	R1												<.2
		fd	1	<4	<280	2	<12	28	<3	<2	<3	<3	<10	<100	<.2
		fd	R1												<.2
Spring 6	10/08	f	1	<4	<280	3	34	25	<3	<2	<3	3	<10	<100	<.2
		f	R1												<.2
Spring 8	10/08	f	1	<4	<280	3	31	41	<3	2	<3	<3	<10	<100	<.2
		f	R1												<.2
Spring 8B	10/08	f	1	<4	<280	4	38	41	<3	<2	<3	<3	<10	<100	<.2
		f	R1												<.2
Spring 9A	10/09	f	1	<4	<280	2	<12	30	<3	<2	3	<3	<10	<100	<.2
		f	R1												<.2
Spring 9B	10/09	f	1	<4	<280	2	<12	<1	<3	<2	<3	<3	<10	<100	<.2
		f	R1												<.2
Doe Spring	10/08	f	1	4	<280	3	45	19	<3	<2	<3	<3	<10	<100	<.2
		f	R1												<.2
Spring 10	10/09	f	1	4	<280	4	<12	25	<3	<2	3.5	<3	<10	<100	<.2
		f	R1												<.2
White Rock Canyon Group III:															
Spring 1	08/29	u	1	21	1,820	<9	<100	29	<2	<7	<8	<7	<10	970	<.2
		u	R1												0.218
White Rock Canyon Group IV:															
La Mesita Spring	08/14	u	1	<2	5,100	<3	59	157	<1	<2	10	10	<13	5,200	<.2
		u	R1												<.2
Sacred Spring	08/14	u	1	<2	<160	<3	<13	<1	<1	<2	<3	<10	<13	<47	<.2
		u	R1												<.2

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Alluvial Canyon Groundwater															
Acid/Pueblo Canyons:															
APCO-1	10/17	u	1	<4	130	8	234	45	<3	<2	<9	<3	<10	160	<.2
		u	R1												<.2
Cañada del Buey:															
CDBO-6	12/17	u	1	<10	4,747	5	46.5	121.4	<2	<7	<8	<7	<10	2,226	<.4
		u	R1												<.4
DP/Los Alamos Canyons:															
LAO-C	07/10	u	1	<2	418	<2.2	43	63	<1	<2	<10	<10	<13	256	<.24
		u	R1												0.3
LAO-0.7	07/29	u	1	<2	885	<2.2	43	145	<1	<2	7	<10	<20	780	0.17
		u	R1												0.11
LAO-1	07/29	u	1	<2	721	<2.2	42	45	<1	<6	<3	20	<13	377	<.27
		u	R1												<.27
LAO-2	11/13	u	1	<10	<500	3	50	59.2	<2	<7	<8	<7	<10	153	<.2
		u	R1	<10	<500	3	407.5	65.5	<2	<7	<8	<7	<10	170.2	<.2
LAO-3A	07/10	u	1	<2	1,650	2.3	70	50	<1	<9	<3	10	<13	747	0.14
		u	R1												0.174
LAO-4	07/29	u	1	<2	170	<2.2	59	43	<1	<2	<3	<10	<13	110	<.35
		u	R1												<.35
Mortandad Canyon:															
MCO-4B	03/05	u	1	14	220	<30	80	150	<1	<2	<3	10	<13	216	<.2
		u	R1												<.2
MCO-5	08/09	u	1	<2	97	<2	76	192	<1	<5	<3	<10	<13	89	<.2
		u	R1												<.2
		ud	1	<2	<90	2	62	187	<1	<2	<3	<10	<13	<47	<.2
		ud	R1												<.2
MCO-6	080/6	u	1	<2	191	<2	87	220	<1	<2	<3	<10	<13	108	<.2
		u	R1												<.2
MCO-7	08/06	u	1	<2	3,200	3	79	227	<1	<2	<3	<10	<15	1,640	<.2
		u	R1												<.2

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Alluvial Canyon Groundwater (Cont.)															
Pajarito Canyon:															
PCO-1	07/30	u	1	<2	157		58	154	<1	<2	<10	<10	<15	304	<.2
		u	R1	<2	147		<60	155	<1	<2	<10	<10	<13	303	
Intermediate Perched Groundwater															
Pueblo/Los Alamos Canyon:															
Test Well 1A	08/02	u	1	<2	<90	<2	203	41	<1	<2	<3	<10	<13	3,490	<.2
		u	R1												<.2
Test Well 2A	08/21	u	1	<10	<500	<4	97	32	<2	<7	<8	<7	<10	4,330	<.2
		u	2												
		u	R1												0.252
Basalt Spring	08/14	u	1	<2	240	3	260	105	<1	<2	15	<10	13	190	<.2
		u	R1												<.2
Perched Groundwater in Volcanics:															
Water Canyon Gallery	12/16	u	1	<10	1,169	<4	<20	14.7	<2	<7	<8	<7	<10	494	<.2
		u	R1												<.2
Pueblo of San Ildefonso															
Water Supply Wells:															
LA-1B	08/27	u	1	20	<500	11	295	18	<2	<7	<8	<7	<10	69	<.2
		u	R1												<.2
LA-5	08/14	u	1	<2	<160	<3	<51	61	<1	<2	<3	<10	<13	630	<.2
		u	R1												<.2
Westside Artesian Well	08/14	u	1	<2	<160	4	1,650	41	<1	<2	<3	<10	<13	270	<.2
		u	R1												<.2
Eastside Artesian Well	08/13	u	1	<2	<160	6	110	1	<1	<2	<3	10	<13	250	<1
		u	R1												<1

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Pueblo of San Ildefonso															
Water Supply Wells (Cont.):															
Halladay House Well	08/13	u	1	<2	<160	9	59	36	<1	<2	<3	20	<13	<53	<1
		u	R1												<1
		ud	1	<2	<160	11	82	38	<1	<2	4	20	<13	240	<1
		ud	R1												<1
Pajarito Well (Pump 1)	08/13	u	1	<2	<160	7	1,430	84	<1	<2	5	<10	<13	440	<1
		u	R1												<1
Don Juan PlayhouseWell	8/13	u	1	<2	<160	7	97	2	<1	<2	5	10	<13	<53	<1
		u	R1												<1
Otowi House Well	08/13	u	1	<2	<160	<3	74	290	<1	<2	<3	<10	15	100	<1
		u	R1												<1
New Community Well	08/13	u	1	<2	<160	<6	46	14	<1	<2	<3	<10	<13	<53	<1
		u	R1												<1
Sanchez House Well	08/13	u	1	<2	<160	15	230	80	<1	<2	<3	<10	22	220	<1
		u	R1												<1
Water Quality Standards[c]															
Water Quality Standards[c]															
EPA Primary Drinking Water Standard						50		2,000	4	5		100			2
EPA Secondary Drinking Water Standard					50–200									300	
EPA Action Level													1,300		
NMWQCC Livestock Watering Standard					5,000	200	5,000			50	1,000	1,000	500		10
NMWQCC Groundwater Limit				50	5,000	100	750	1,000		10	50	50	1,000	1,000	2

[a] Codes: u—unfiltered, f—filtered, d—field duplicate, 1—primary analysis, R1—lab replicate, D1—lab duplicate.

[b] Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.

[c] Standards given here for comparison only, see Appendix A. Note that New Mexico Wildlife and Groundwater limits are based on dissolved concentrations, while many of these analyses are of unfiltered samples—thus concentrations may include suspended sediment quantities.

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Main Aquifer														
Test Wells:														
Test Well 1	08/01	u	1	66	<5[b]	<18	<100	4.9	1	<117	295	0.23	<17	1,660
		u	2				62							
Test Well 2	08/21	u	1	13	<30	<40	<60	<3	<3	<60	60	<3	<8	<50
		u	2				<3							
		u	R1	15	<30	<20	<60	<3	<3	<30	60	<3		66
		u	R2				<3							
Test Well 3	07/03	u	1	92	<13	<21	<110	<10	<1.2	<59	56.9	<10	<20	790
		u	R1	90.6	<30	<18	<157	<10	<1.2	<59	56	<10	10.1	783
	09/30	u	1	67	<9	<24	11	<3	2	<60	68	<3	4	427
	11/15	u	1	5.4	<30	<20	<3	<3	<3	<30	74.6	<3	14.7	<50
Test Well 4	07/03	u	1	36.7	<59	<74	<46	<10	<1.2	<59	45	<10	<6	1,830
	09/27	u	1	83	<9	16	57	<3	<2	<60	52	<3	<3	1760
	11/15	u	1	26.2	<30	32.3	12	<3	<3	<30	52.5	<3	14.7	1,423
Test Well 8	07/23	u	1	4	720	<29	<46	<1	<1.3	<59	55	<1	<2	184
		ud	1	2.5	183	<18	<120	<1	1.4	<60	55	<1	6.4	190
	09/30	u	1	4	<9	23	5	<3	2	<40	54	<3	6	22
	11/15	u	1	<30	<30	<20	5	<3	<3	<100	63.4	<3	14.7	251
		u	R1	2.8	<30	<20	6	<3	<3	<90	56.4	<3	14.7	318
Test Well DT-5A	11/27	u	1	<30	<30	<20	4	<3	<3	<30	53.7	<3	14.9	392.9
		u	R1	6.3	<30	<20	3	<3	<3	<30	55	<3	14.7	410
Test Well DT-9	09/18	u	1	1	7	<10	6	<3	4	<20	49	<3	5	237
		u	R1	<1	<9	<10	5	<3	<4	<20	50	<3	5	210
	12/05	u	1	<2	<30	<20	4	<3	<3	<30	47.9	<3	<15	281
		u	2						<3					
		u	R1	<2	<30	<20	3	<3	<3	<30	46.4	<3	<30	178
		u	R2						<3					
Test Well DT-10	09/19	u	1	<9	<10	4	<3	2	<20	48	<3	<3	77	
		u	R1											
	12/06	u	1	<2	<30	<20	<3	<3	<3	<30	46.4	<3	<8	59.4
		u	2								<3			

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Main Aquifer														
Water Supply Wells:														
Otowi 1	06/24	u	1	230	<14	<27	<50	<10	3	<100	10		11	100
	12/17	u	1	35.1	<30	<20	3	<3	6	<30	12.3	<3	19.4	73.8
		u	R1											
	12/18	u	1	105	<28	<20	3	<3	12	<30	15.8	<3	26.7	68.2
		u	R1											
	12/19	u	1	185.8	<30	<20	<3	<3	<10	<100	14.9	<3	18.7	271.4
		u	R1											
		u	1	20.5	<30	<20	<3	<3	9	<30	10.1	<3	18.7	<50
		u	R1											
		u	1	300	<30	<20	3	<3	14	<30	26	<3	36.6	172
		u	R1	277	<30	<20	<3	<3	5	<30	23.9	<3	43.3	135
O-4	12/16	u	1	8.9	<30	<20	12	<3	10	<30	106.1	<3	10.7	65.4
		u	R1											
PM-1	04/25	u	1	1	<5	<18	<46	<44	<1.6	<59	145	<166	10	22
PM-2	04/25	u	1	69	<5	18	<46	<44	2	<59	59	<166	11	54
PM-3	04/25	u	1	<1	<5	<18	<46	<44	<1.6	<59	126	<166	13	24
PM-5	04/25	u	1	1	<5	<18	<46	<44	2.7	<59	58	<170	11	33
G-1	09/09	u	1	<6	<70	<20	<20	<3	<5	<170	98	6	<40	<50
		u	2				9							
G-1A	09/08	u	1	<2	<30	<20	<60	<3	<3	<90	73	<3	<39	<10
		u	2				<3							
		u	1	<6	30	<70	<60	3	<3	34	73	<3	35	<50
		u	2				3							
G-2	04/25	u	1	<1	<5	<18	<46	<40	2.3	<59	77	<166	84	<22
G-5	04/25	u	1	<1	<5	<18	<46	<44	1.7	<60	83	<166	12	<22
G-6	04/25	u	1	<1	<5	<18	<46	<44	<1.6	<59	77	<166	21	28
		u	1	1	<5	<18	<46	<44	<1.6	<59	65	<166	20	<22
		u	R1	1	<5	<18	<46	<44	<1.6	<59	65	<166	20	<22
		u	R2	1	<5	<18	<46	<44	<1.6	<59	65	<166	20	<22

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Main Aquifer Springs														
White Rock Canyon Group I:														
Sandia Spring	08/29	u	1	194	<30	<20	<60	<3	<3	<30	320	<3	<8	<50
		u	2				<3							
Spring 3A	10/07	f	1	3	<9	10	10.4	<3	3	28	222	<3	12	<50
Spring 4	10/07	f	1	1	<9	10	<3	<3	3	<20	143	<3	9	170
Spring 4A	10/08	f	1	<1	<9	<10	<3	<3	4	<20	95	<3	7	120
Ancho Spring	10/08	f	1	3	<1	<10	<3	<3	3	32	60	<3	7	130
White Rock Canyon Group II:														
Spring 5A	10/08	f	1	2	<9	<10	<3	<3	3	<60	208	<3	15	95
		fd	1	3	<9	<10	<3	<3	3	<40	166	<3	12	<50
Spring 6	10/08	f	1	<1	<9	<10	<3	<3	5	27	60	<3	7	<50
Spring 8	10/08	f	1	26	<9	11	<3	<3	4	<20	104	<3	11	130
Spring 8B	10/08	f	1	5	<9	<10	<3	<3	4	11	127	<3	11	59
Spring 9A	10/09	f	1	<9	1	<10	<3	<3	3	<20	55	<3	7	<50
Spring 9B	10/09	f	1	<1	<9	<10	<3	<3	2	<20	1	<3	<3	<50
Doe Spring	10/08	f	1	1	<9	<10	<3	<3	8	<20	71	<3	10	<50
Spring 10	10/09	f	1	11	4	<10	<3	<3	<3	30	68	<3	10	<50
White Rock Canyon Group III:														
Spring 1	08/29	u	1	23	<60	<20	<60	<3	<3	<30	189	<3	8	<50
		u	2				<3							
White Rock Canyon Group IV:														
La Mesita Spring	08/14	u	1	50	<5	<27	<50	0.6	<2	<59	760	0.05	12	<22
		u	2				3							
Sacred Spring	08/14	u	1	<1	<5	<27	<46	1	<2	<59	1	0.04	6	<22
		u	2				4							

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Alluvial Canyon Groundwater Systems														
Acid/Pueblo Canyon:														
APCO-1	10/17	u	1	980	<9	10	<3	<3	3	<30	120	<3	7	60
Cañada del Buey:														
CDBO-6	12/17	u	1	28.4	<30	<20	3	<3	5	<30	112.5	<3	14	<50
DP/Los Alamos Canyons:														
LAO-C	07/10	u	1	10.5	89	23	<46	<1	<1.3	<59	116	<1	<2	<16
LAO-0.7	07/29	u	1	788	<80	<18	<46	<1	<1.3	<60	133	<1	6	60
LAO-1	07/29	u	1	2	66	<50	<46	<1	<1.3	<59	121	<1	6	28
LAO-2	11/13	u	1	<3	287	<20	<3	<3	4	<30	140.9	<3	<8	<50
		u	R1	<3	320.9	<20	<3	<3	<3	<30	155.3	<3	<8	<50
LAO-3A	07/10	u	1	16	905	<18	<46	<1	<1.3	<59	104	<1	7	25
LAO-4	07/29	u	1	1	157	<45	<46	2	<1.3	<59	87	<1	2	64
Mortandad Canyon:														
MCO-4B	03/05	u	1	7	133	<18	<1	<2	<20	<59	206	<1	3	20
MCO-5	08/09	u	1	4	138	25	<46	1.1	2	<59	307	0.16	<2	47
		u	2				<3							
		ud	1	2	140	<60	<46	0.2	2	<60	297	0.04	<2	22
		ud	2				<3							
MCO-6	08/06	u	1	6.4	116	<18	<46	0.5	1	<59	312	0.04	<2	<16
		u	2				3							
MCO-7	08/06	u	1	29	<90	<24	<46	<.2	1	<59	159	0.05	<15	54
		u	2				3							
Pajarito Canyon:														
PCO-1	07/30	u	1	136	14	<37	<46	0.9		<59	212	0.09	<2	18
		u	2				<3							
		u	R1	134	<45	<18	<130	0.4		<59	210	0.06	<2	19

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Intermediate Perched Groundwater Systems													
Pueblo/Los Alamos Canyon:													
Test Well 1A	08/02	u 1	79	15	<30	<46	0.1	2	<59	79	1.1	<2	3,100
		u 2				9							
Test Well 2A	08/21	u 1	202	<30	<180	<90	<3	<3	<180	161	<3	<8	8,050
		u 2				45							
Basalt Spring	08/14	u 1	644	<18	34	<46	0.6	<2	<59	114	0.04	19	<22
		u 2				<3							
Perched Groundwater System in Volcanics:													
Water Canyon Gallery	12/16	u 1	2	<30	<20	<3	<3	4	<30	48.8	<3	<8	<50
Pueblo of San Ildefonso													
Water Supply Wells:													
LA-1B	08/27	u 1	15	<30	<20	<60	<3	<3	<130	60	<3	<8	<50
		u 2				<3							
LA-5	08/14	u 1	36	<5	<27	<46	0.3	<2	<59	210	0.04	17	150
		u 2				<3							
Westside Artesian Well	08/14	u 1	8	57	<27	<46	0.61	<2	<59	340	0.06	10	<22
		u 2				<3							
Eastside Artesian Well	08/13	u 1	5	5	<27	<3	1.6	<2	<59	42	0.12	7	<22
		u 2				<46							
Halladay House Well	08/13	u 1	<1	<5	<27	<46	0.5	<2	<59	120	0.03	32	<20
		u 2				<3							
		ud 1	2	<5	<40	<46	0.59	<2	<59	125	0.04	32	<22
		ud 2				<3							
Pajarito Well (Pump 1)	08/13	u 1	5	7	<27	<46	0.4	<2	<59	1300	0.07	12	35
		u 2				<3							
Don Juan	08/13	u 1	<1	<5	28	<3	0.9	<2	<59	87	0.06	14	<22
Playhouse Well		u 2				<46							
Otowi House Well	08/13	u 1	1	7	<27	<46	0.9	<2	<59	750	0.05	11	110
		u 2				<3							
New Community Well	08/13	u 1	<1	<5	<27	<3	5	2	<59	188	0.9	13	<22
		u 2				<46							
Sanchez House Well	08/13	u 1	3	9	<27	<3	0.37	<2	<59	26.8	0.05	20	23
		u 2				<46							

Table 5-28. Total Recoverable Trace Metals in Groundwater for 1996 (μg/L) (Cont.)

Station Name	Date	Codes[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Water Quality Standards[c]													
EPA Primary Drinking Water Standard					100		6	50			2		
EPA Secondary DrinkingWater Standard			50										5,000
EPA Action Level						15							
EPA Health Advisory										25,000–90,000		80–110	
NMWQCC Livestock Watering Standard						100		2				100	25,000
NMWQCC Groundwater Limit			200	1000	200	50		50					10,000

[a]Codes: u—unfiltered, f—filtered, d—field duplicate, 1—primary analysis, R1—lab replicate, D1—lab duplicate.
[b]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[c]Standards given here for comparison only, see Appendix A. Note that New Mexico Wildlife and Groundwater limits are based on dissolved concentrations, while many of these analyses are of unfiltered samples—thus concentrations may include suspended sediment quantities.

Table 5-29. Number of Results above the Analytical Limit of Quantitation for Organic Compounds in Groundwater for 1996

		Type of Organic Compound				
Station	**Date**	**Volatile**	**Semivolatile**	**PCB[a]**	**HE[b]**	**TIC[c]**
Number of Compounds Analyzed		59	69	4	14	
Test Well DT-5A	11/27	1	0	0	0	1
Test Well DT-9	09/18	0	0	0	0	0
	12/05	0	0	0	0	2
Test Well DT-10	09/19	0	0	0	0	0
	12/06	0	0	0	0	3
Sandia Spring	08/29	0	0	0		0
Spring 3A	10/07	0	0	0		4
Spring 4	10/07	0	0	0	0	3
Spring 4A	10/08	0	0	0	0	2
Ancho Spring	10/08	0	0	0	0	0
Spring 5A	10/08	0	0	0	0	2
Spring 6	10/08	0	0	0	0	1
Spring 8	10/08	0	0	0	0	6
Spring 8B	10/08	0	0	0	0	2
Spring 9	10/09				0	0
Spring 9A	10/09	0	0	0	0	2
Spring 9B	10/09	0	0	0	0	2
Doe Spring	10/08	0	0	0	0	2
Spring 10	10/09	0	0	0	0	2
Spring 1	08/29	1	0	0	0	0
La Mesita Spring	08/14	0	0	0		0
Sacred Spring	08/14	0	0	0		0
LA-1B	08/27	0	0	0		0
LA-5	08/14	0	0	0		0
Eastside Artesian Well	08/13	0	0	0		0
Halladay House Well	08/13	0	0	0		0
Halladay House Well Dup.	08/13	0	0	0		0
Pajarito Well (Pump 1)	08/13	0	0	0		0
Don Juan Playhouse Well	08/13	0	0	0		3
Otowi House Well	08/13	1	0	0		0

[a]Polychlorinated biphenyl.
[b]High explosives.
[c]Tentatively identified compounds (see text).

Table 5-30. Results above the Analytical Limit of Quantitation for Organic Compounds in Groundwater for 1996

Station	Date	Analyte	Value	Uncertainty	Units	Suite
Test Well DT-5A	11/27	Toluene	9	2.7	µg/L	voa
Spring 1	08/29	Butanone [2-]	23	6.9	µg/L	voa
Otowi House Well	08/13	Trichloroethane [1,1,1-]	23	6.9	µg/L	voa

Table 5-31. Total Committed Effective Dose Equivalent from the Ingestion of Two Liters Per Day Drinking Water Collected at the Pueblo of San Ildefonso during 1996.

	Total Committed Effective Dose Equivalent[a] (mrem/yr)	
Well or Water System	**1996**	**1995**
San Ildefonso Pueblo		
Westside Artesian	2.7 (± 0.83)[b]	3.9 (± 1.5)[b]
Halladay House	0.26 (± 0.40)[b]	1.4 (± 0.67)[b]
Pajarito Pump 1	1.5 (± 1.1)[b]	1.6 (± 0.67)[b]
Otowi House	0.47 (± 0.41)[b]	0.82 (± 0.52)[b]
New Community	3.1 (± 1.0)[b]	3.7 (± 1.7)[b]
Sanchez House	1.6 (± 1.1)[b]	1.8 (± 1.0)[b]

[a] CEDE for consumption of water collected from San Ildefonso are based on dose conversion factors listed in FGR#11 (EPA1988).
[b] ±2 sigma in parenthesis; to convert to µSv multiply by 10.

Table 5–32. Quality Assurance Sample Results for Radiochemical Analysis in 1996 (pCi/L[a])

Station Name	Date	Codes[b]		^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
DI Blank	01/23	1	W	–98 ± 178	0.5 ± 0.8	0.4 ± 0.7	0.02 ± 0.04	–0.003 ± 0.002	0.023 ± 0.010	0.100 ± 0.050	0.2 ± 0.3	0.7 ± 0.1	410 ± 60
		2	W					–0.003 ± 0.002	0.023 ± 0.010				
		D1	W		0.6 ± 0.9								
		R1	W	98 ± 321									
DI Blank	04/24	1	W	246 ± 326	0.9 ± 0.8	1.0 ± 1.5	0.00 ± 0.01	0.012 ± 0.007	0.003 ± 0.006	0.044 ± 0.017	–0.1 ± 0.0	0.1 ± 0.0	20 ± 50
DI Blank	08/09	1	W	462 ± 144	0.2 ± 0.6	1.2 ± 1.8	0.02 ± 0.00	–0.010 ± 0.010	0.002 ± 0.008	0.027 ± 0.018	–0.1 ± 0.0	0.2 ± 0.0	60 ± 50
		R1	W	555 ± 144									
DI Blank	08/14	1	W	406 ± 73	–0.2 ± 0.5	–0.1 ± 0.8	0.03 ± 0.00	0.011 ± 0.009	–0.003 ± 0.006	0.043 ± 0.020	–0.1 ± 0.0	0.3 ± 0.0	80 ± 50
		R1	W					0.003 ± 0.005	0.012 ± 0.008	0.007 ± 0.015			
DI Blank	08/29	1	W	24 ± 134	0.6 ± 0.5	0.7 ± 1.1	0.00 ± 0.01	0.009 ± 0.007	0.018 ± 0.009	0.048 ± 0.015	–0.2 ± 0.0	–0.2 ± 0.3	70 ± 50
DI Blank	09/08	1	W	437 ± 137	–0.5 ± 0.2	2.6 ± 0.9	0.00 ± 0.01	0.022 ± 0.016	0.011 ± 0.014	0.069 ± 0.036	–0.1 ± 0.0	0.7 ± 0.1	110 ± 50
		R1	W				0.00 ± 0.01						
DI Blank	10/10	1	W	105 ± 134	–1.2 ± 0.4	1.0 ± 0.4	0.00 ± 0.00	–0.002 ± 0.006	0.030 ± 0.013	0.028 ± 0.016	–0.2 ± 0.0	0.0 ± 0.0	150 ± 50
DI Blank	12/12	1	W	–218 ± 139	–0.1 ± 0.4	2.6 ± 0.5	0.00 ± 0.00	0.005 ± 0.006	0.005 ± 0.006	0.032 ± 0.014	1.0 ± 0.3	0.1 ± 0.0	40 ± 50
Average Blank value				202	0.0	1.2	0.00	0.004	0.012	0.044	0.0	0.2	118
Standard Deviation				260	0.7	1.0	0.01	0.009	0.011	0.027	0.4	0.3	125
Spiked Sample	12/17	1	W	–143 ± 139	17.1 ± 1.1	6.8 ± 1.1	0.00 ± 0.00	0.328 ± 0.038	0.441 ± 0.045	0.423 ± 0.049	3.5 ± 0.5	50.5 ± 5.7	40 ± 50
Spike values					20.0			0.400	0.400	0.400			

[a]Except where noted.
[b]Codes: 1—primary analysis, 2—secondary analysis, R1—lab replicate, D1—lab duplicate.

J. Figures

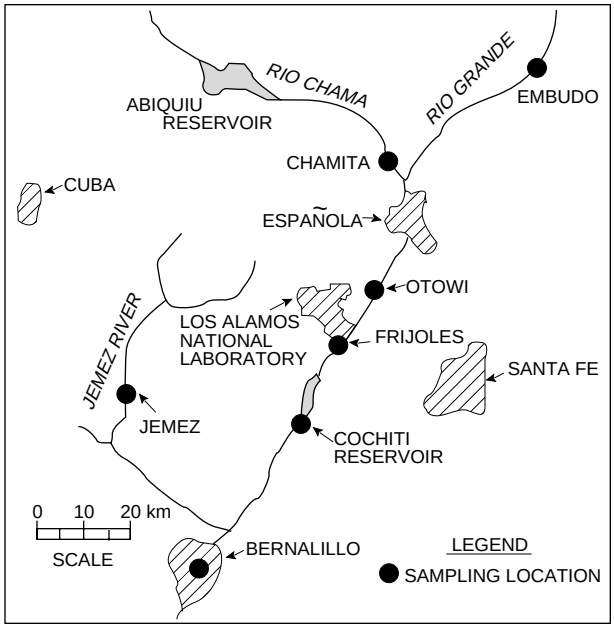

Figure 5-1. Regional surface water and sediment sampling locations.

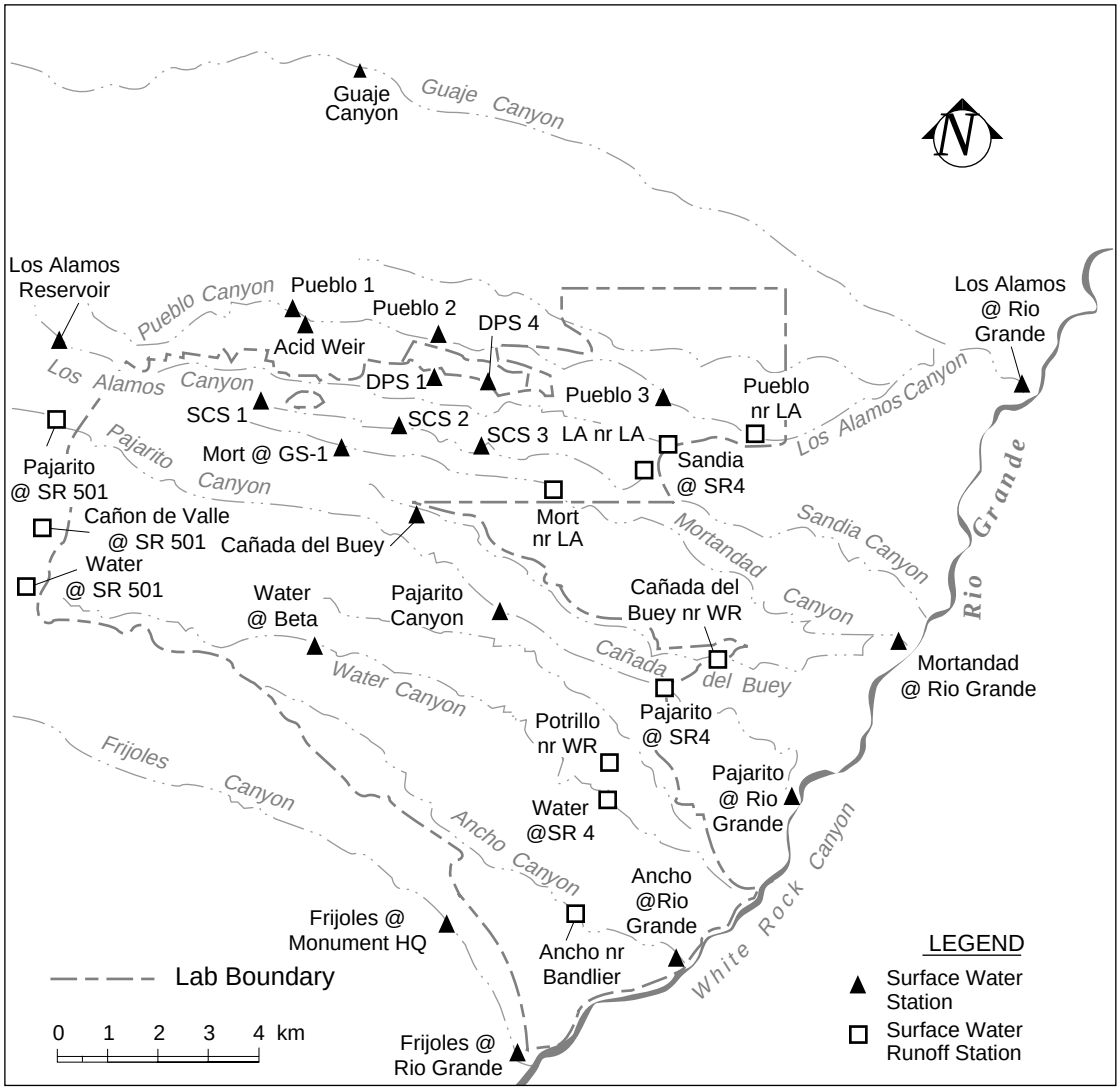

Figure 5-2. Surface water sampling locations in the vicinity of Los Alamos National Laboratory.

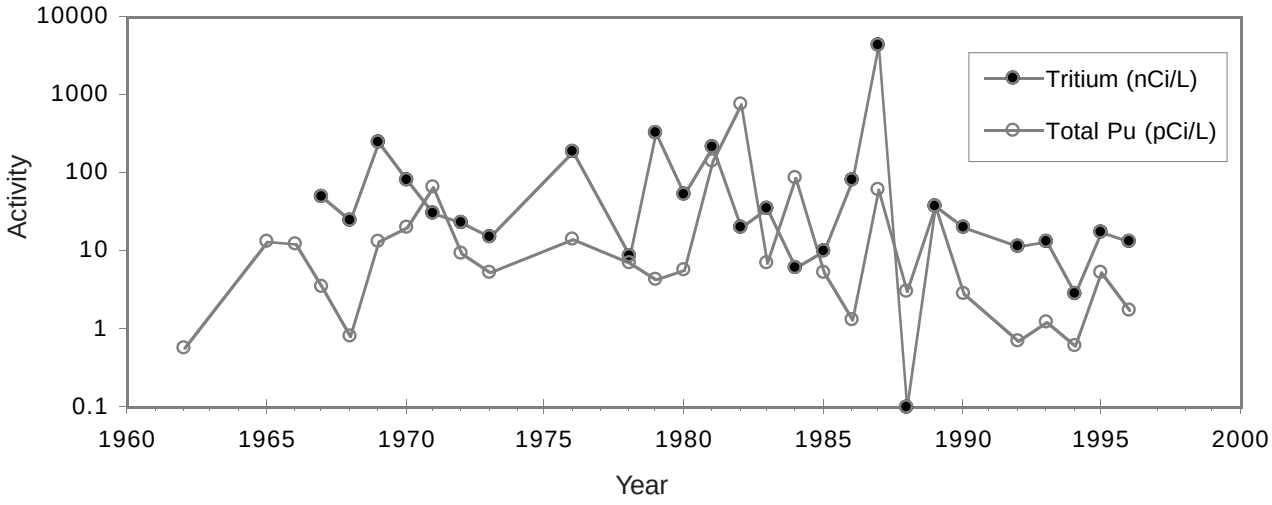

Figure 5-3. Tritium and plutonium activity at Mortandad Canyon at Gaging Station 1.

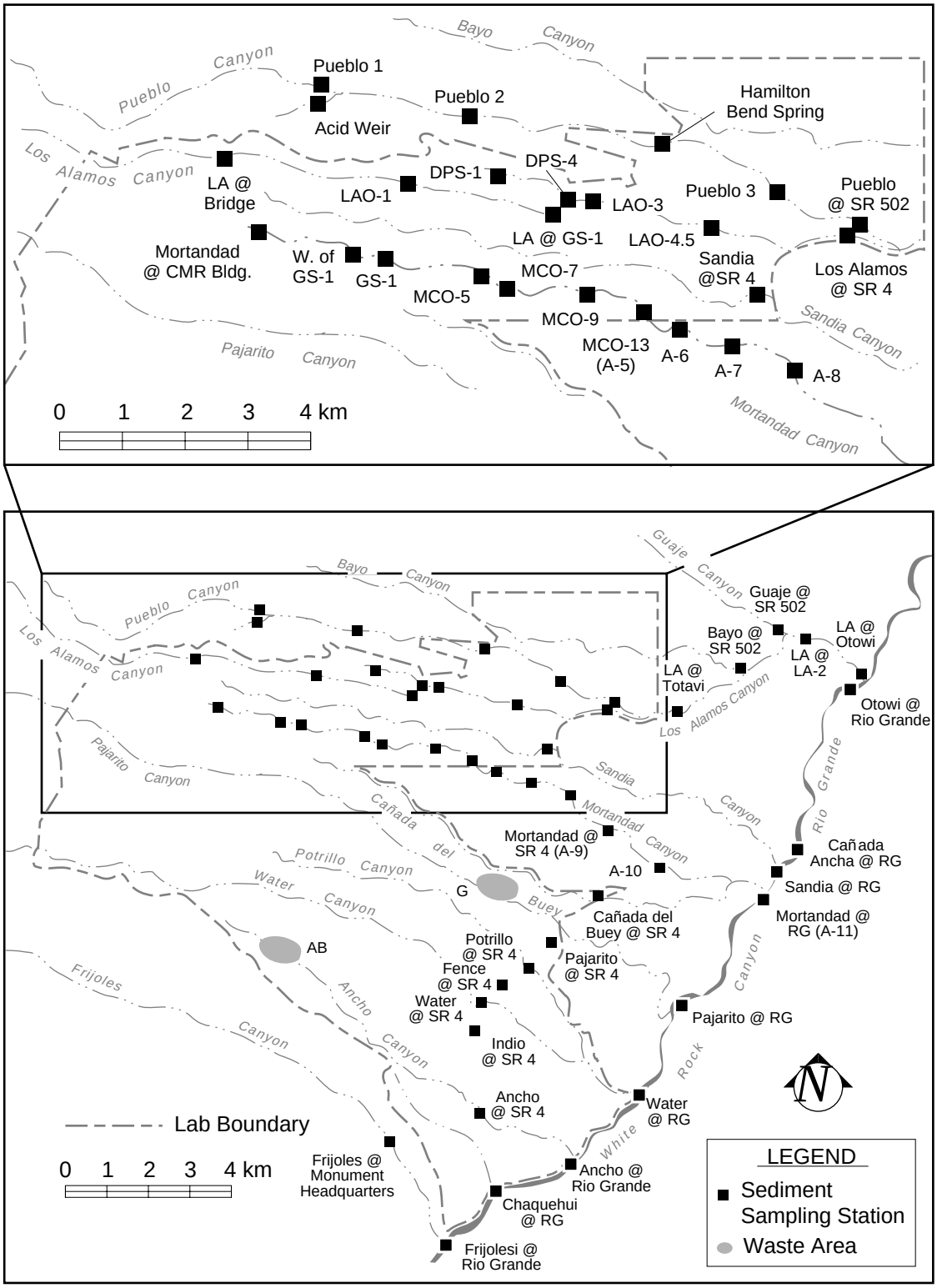

Figure 5-4. Sediment sampling stations on the Pajarito Plateau near Los Alamos National Laboratory. Solid waste management areas with multiple sampling locations are shown in Figure 5-5.

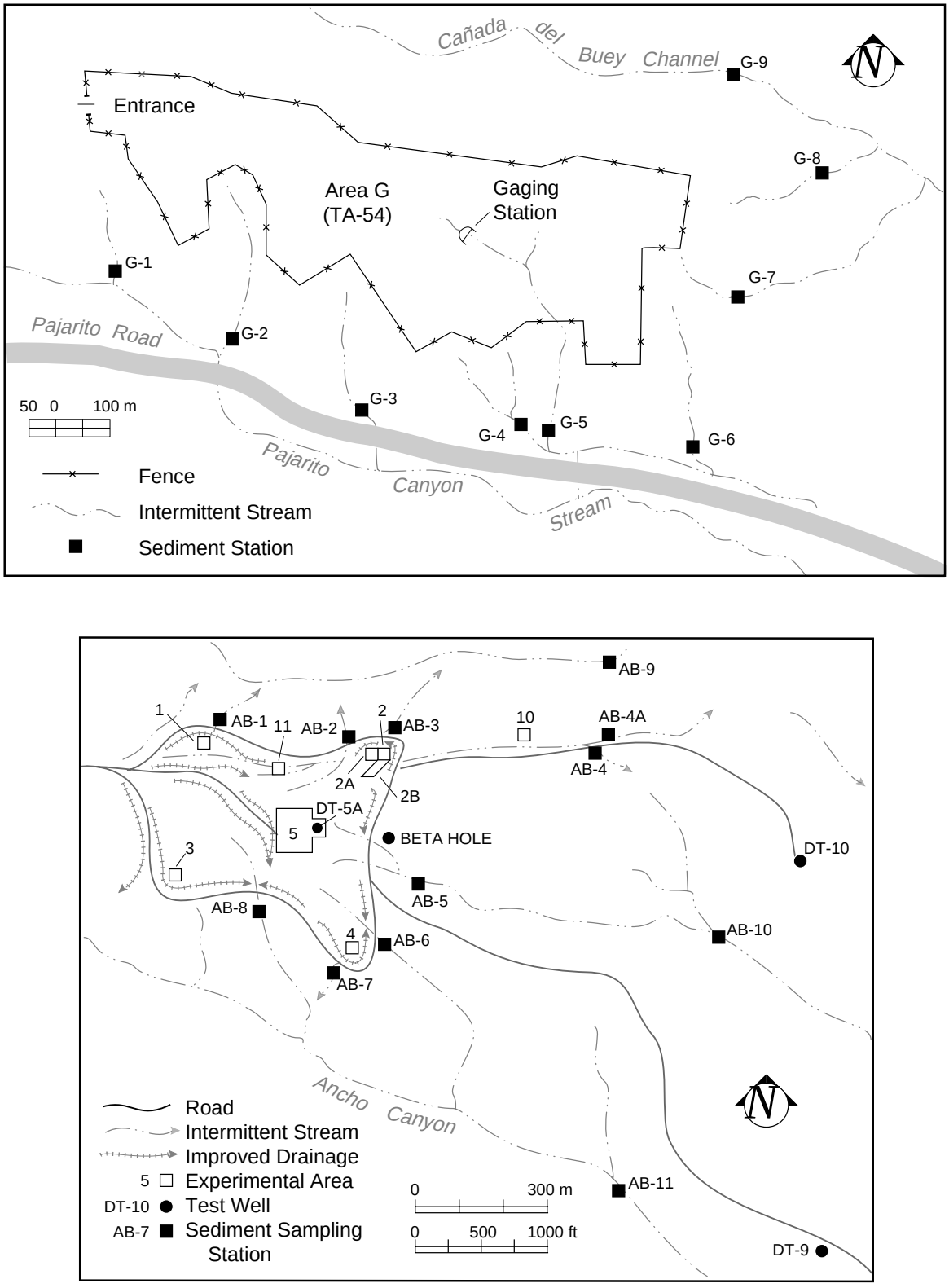

Figure 5-5. Sediment sampling stations at solid waste management areas.
a. Sampling stations at TA-54, Area G.
b. Sediment stations at TA-49, Area AB

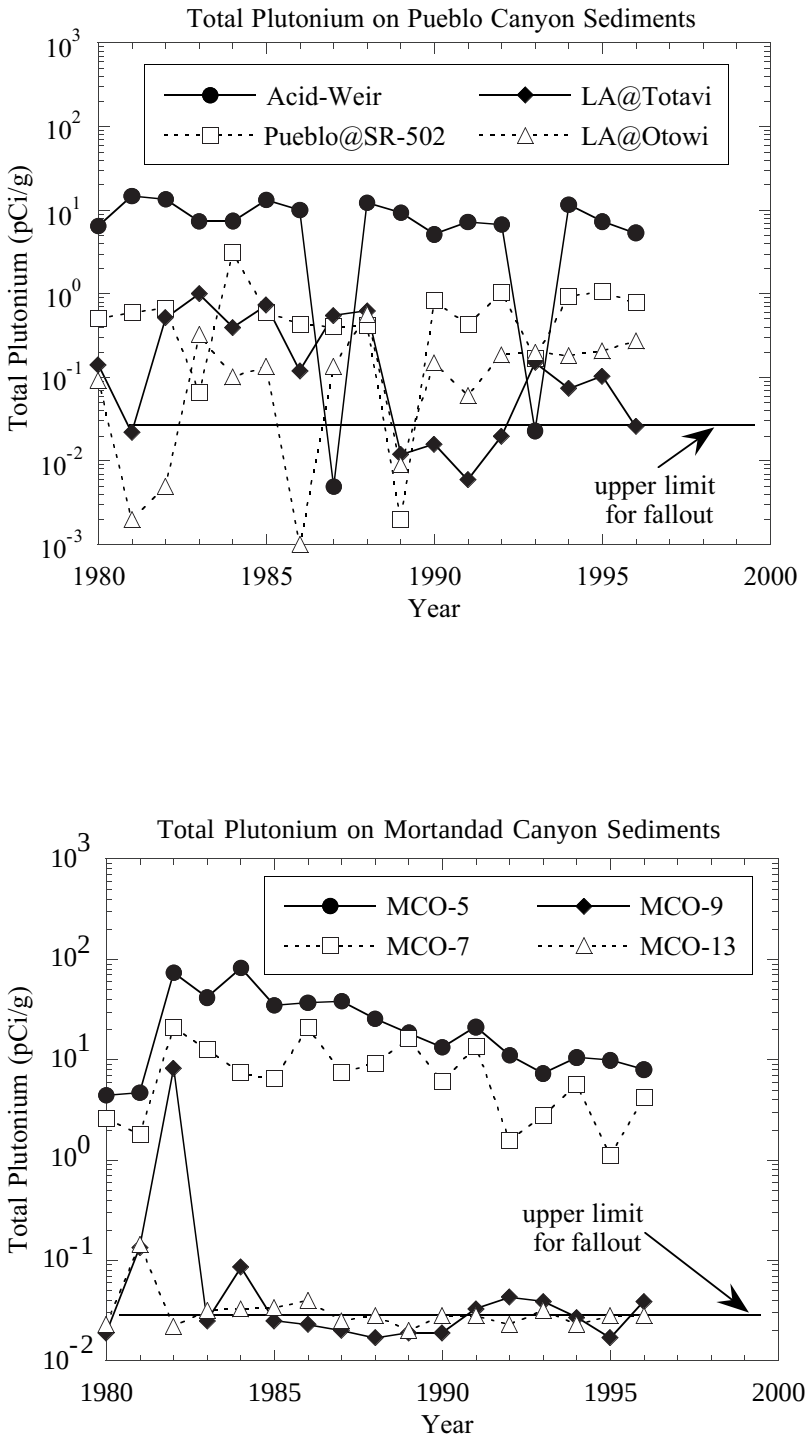

Figure 5-6. Total plutonium activity in Pueblo (top) and Mortandad (bottom) Canyon channel sediments.

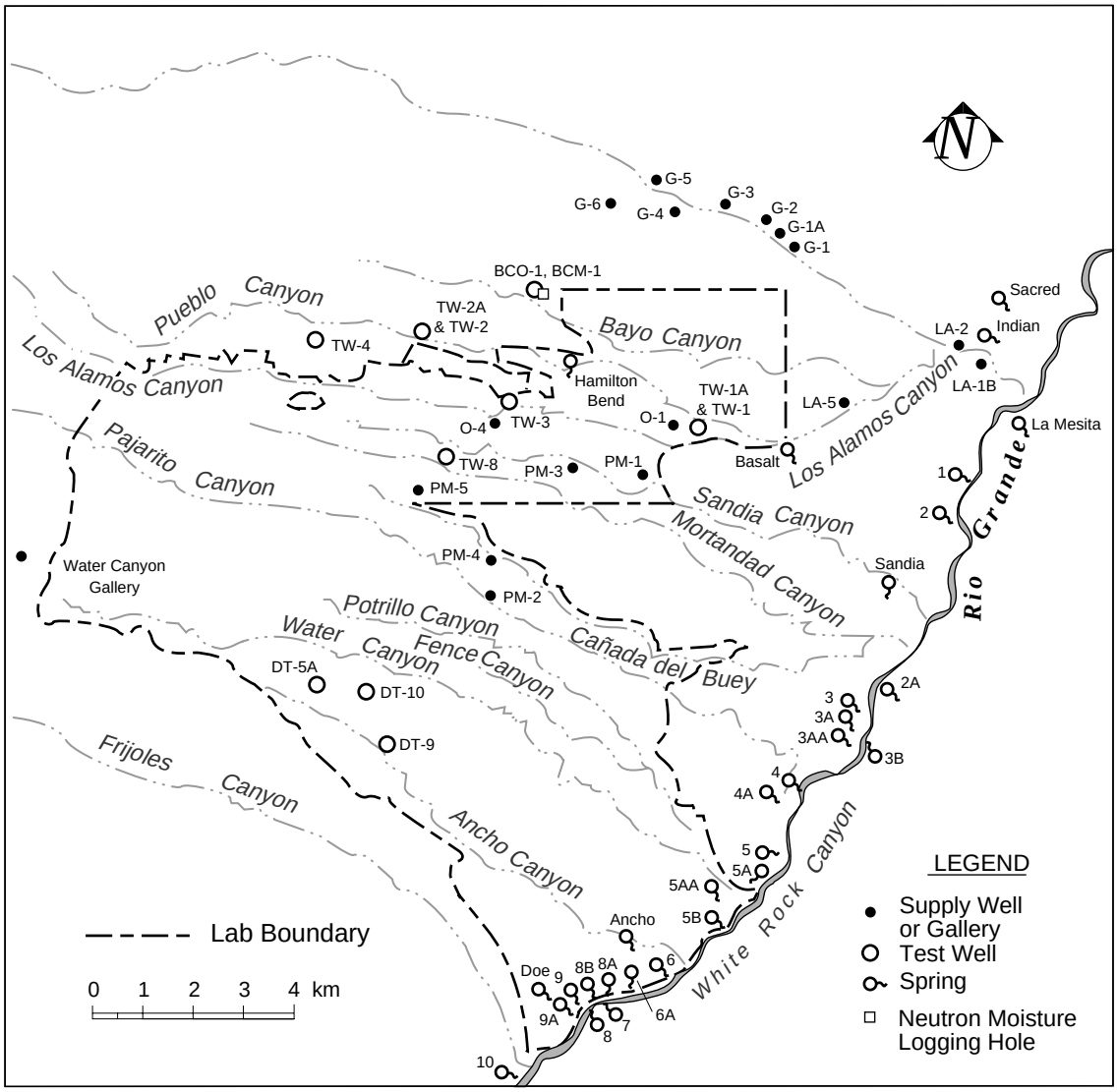

Figure 5-7. Springs and deep and intermediate wells used for groundwater sampling.

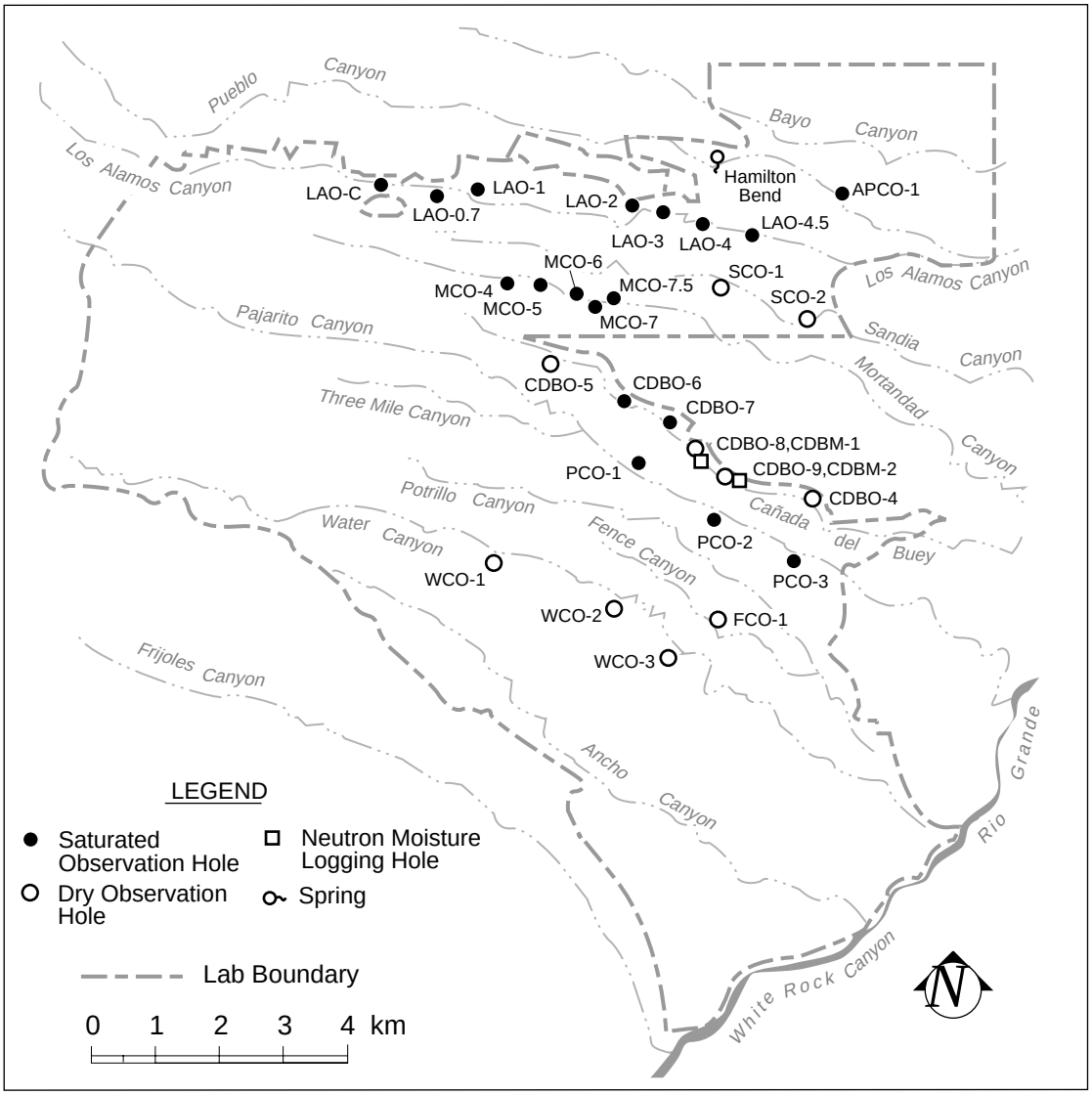

Figure 5-8. Observation wells and springs used for alluvial groundwater sampling and shallow neutron moisture holes.

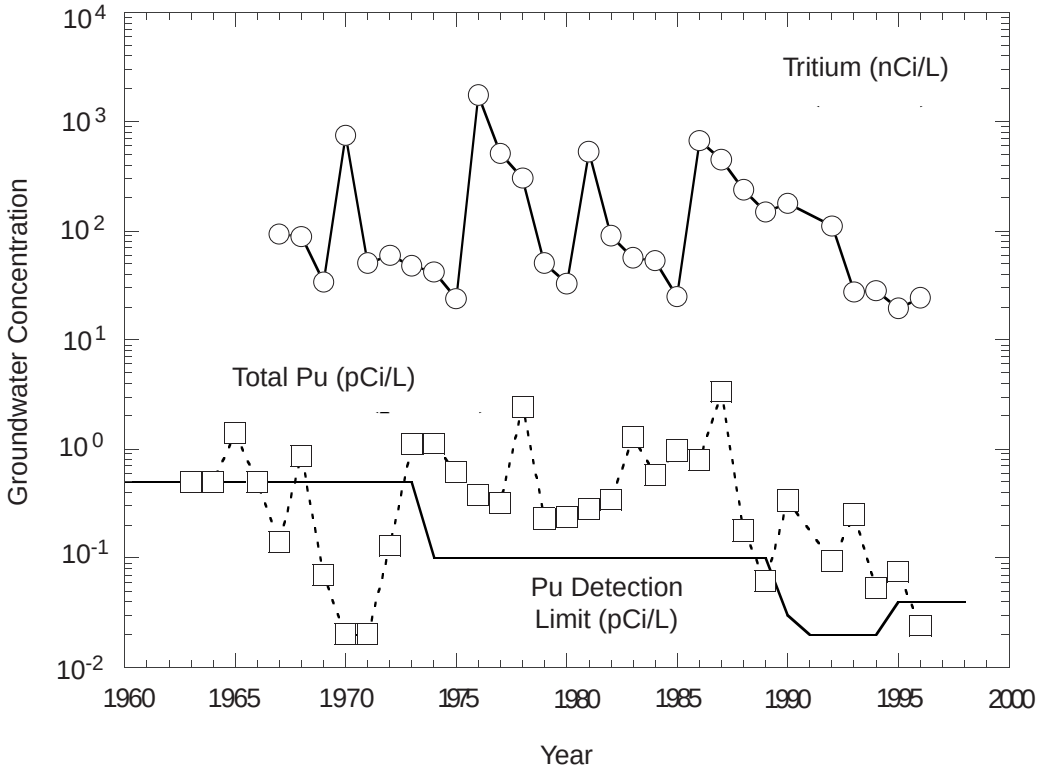

Figure 5-9. Tritium and plutonium concentrations in water samples from Mortandad Canyon Alluvial Observation Well MCO-6.

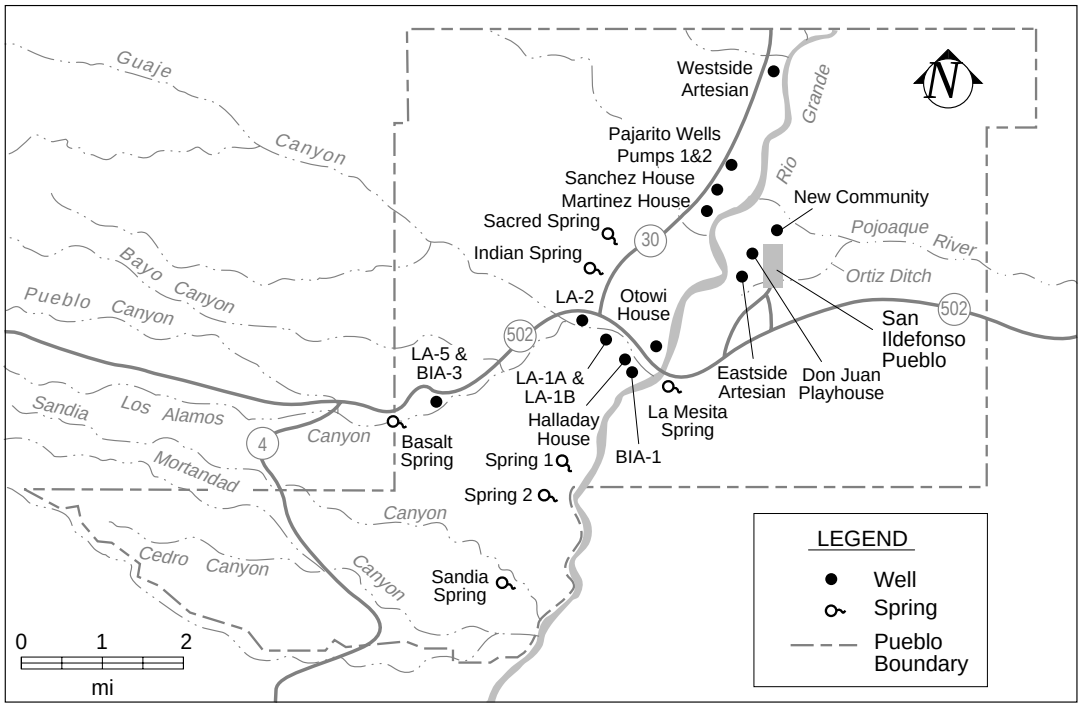

Figure 5-10. Springs and groundwater stations on or adjacent to the Pueblo of San Ildefonso land.

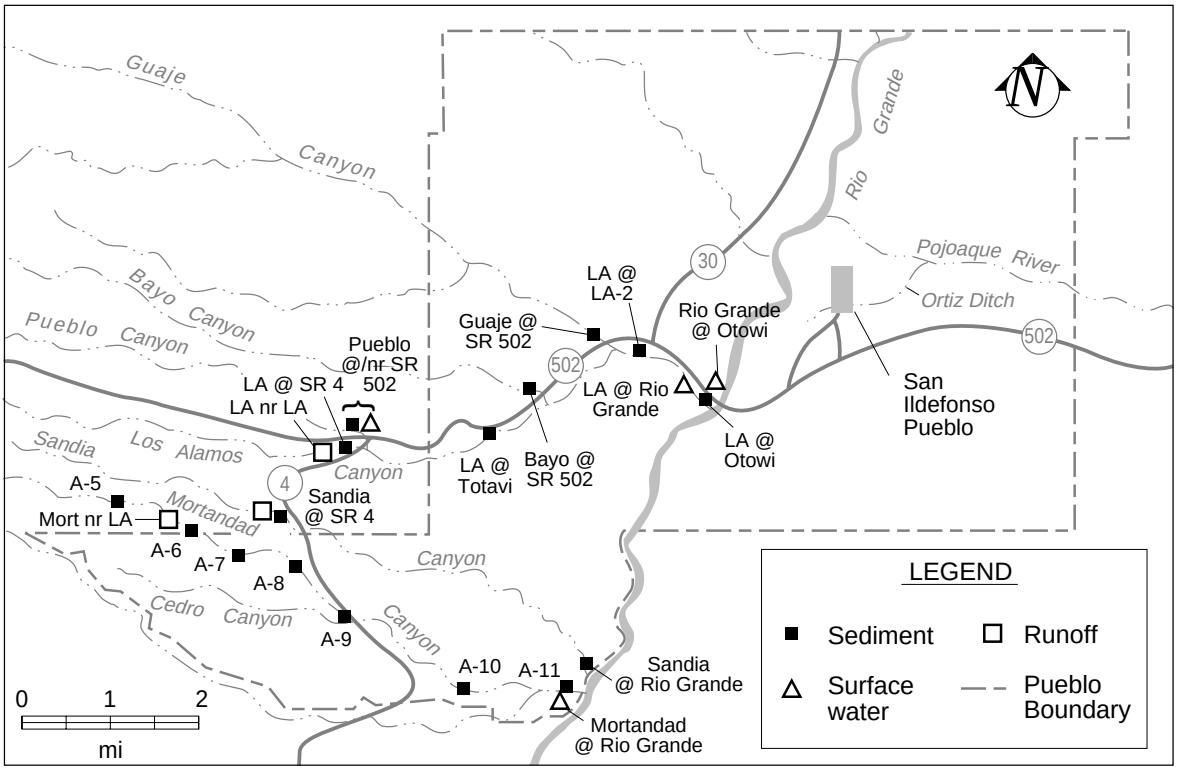

Figure 5-11. Sediment and surface water stations on or adjacent to the Pueblo of San Ildefonso land.

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6. Soil, Foodstuffs, and Associated Biota Monitoring

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Highlights from 1996

Soil Surveillance Program. *Soil samples were collected from 12 on-site (Los Alamos National Laboratory [LANL or the Laboratory]) and 10 perimeter areas around the Laboratory, analyzed for radiological and nonradiological constituents, and compared to regional (background) locations—radionuclides in soils collected from regional background areas are due to natural and/or to worldwide fallout. In general, most radionuclide concentrations in on-site and perimeter areas were within regional statistical reference levels (RSRLs) (i.e., the upper limit background concentration from data averaged from 1974 to 1994) and were far below LANL screening action levels (SALs). Trend analyses show that most radionuclides in soils from on-site and perimeter areas have been decreasing over time. These trends were especially apparent (i.e., significant at $p < 0.05$) for tritium and uranium in soils from on-site areas. Soils were also analyzed for trace and heavy metals, and most metals were within RSRLs and were well below LANL SALs.*

Foodstuffs and Associated Biota Surveillance Program. *Foodstuffs (milk, eggs, fruits, vegetables, honey, elk, deer, fish, herbal tea, and domestic livestock) were collected either from Laboratory and/or surrounding perimeter areas (including several Native American pueblo communities), to determine the impact of LANL operations on the human food chain. Most samples of foodstuffs from Laboratory and/or perimeter locations showed no radioactivity distinguishable from that attributable to natural sources and/or to worldwide fallout. Similarly, most heavy metal elements in produce from Laboratory and perimeter areas were within regional background concentrations.*

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A. Soil Monitoring

1. Introduction

A soil sampling and analysis program provides the most direct means of determining the concentration, inventory, and distribution of radionuclides and radioactivity around nuclear facilities (DOE 1991). This program is mandated by Department of Energy (DOE) Orders 5400.1 and 5400.5. Soil provides an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous effluents (e.g., air stack emissions) or indirectly from resuspension of on-site contamination (e.g., fugitive dust from solid waste management units [SWMUs]). Subsequently, the knowledge gained from a soil radiological sampling program is critical for providing information about potential pathways (e.g., soil ingestion, food crops, resuspension into the air, and contamination of groundwater) that may result in a radiation dose to humans (Fresquez et al., 1996a). This program evaluates radionuclide, radioactivity, and nonradionuclides (heavy metals) in soils collected from on-site (Los Alamos National Laboratory—LANL or the Laboratory), around the perimeter of the Laboratory, and regional (background) locations. On-site and perimeter areas are compared to regional background areas—these background areas are distant from the Laboratory, and their radionuclide and non-radionuclide contents are due to naturally occurring elements and/or to worldwide fallout.

2. Monitoring Network

Soil surface samples are collected from mesa tops that are relatively level, open, and undisturbed areas at regional (background) locations (6 sites), perimeter (10 sites), and LANL (12 sites) (Figure 6-1). LANL and perimeter areas are compared to soils collected from regional background locations where radionuclides, radioactivity, and heavy metals are due to natural and/or to worldwide fallout events.

a. Off-Site Regional (Background) Stations. The regional background stations for soils are located in northern New Mexico surrounding the Laboratory: Rio Chama, Rio Embudo, Cochiti Pueblo, Bernalillo, Jemez Pueblo, and Santa Cruz Lake. All are over 15

km (9 mi) from the Laboratory (DOE 1991) and are beyond the range of potential influence from normal Laboratory operations.

b. Off-Site Perimeter Stations. Ten soil sampling stations are located within 4 km (2.5 mi) of the Laboratory. These stations are located to reflect the soil conditions of the inhabited areas to the north (Los Alamos townsite area—four stations) and east (White Rock area and Pueblo of San Ildefonso lands—four stations) of the Laboratory. The other two stations, one located on Forest Service land to the west and the other located on Park Service land (Bandelier) to the southwest, provide additional coverage.

c. On-Site Stations. Soil samples from 12 on-site stations are collected. Areas sampled at LANL are not from SWMUs—any discernible site at which solid and/or liquid wastes have been routinely and systematically released (e.g., waste tanks, septic tanks, sumps, firing sites, burn pits, sumps, material disposal areas [such as TA-54, Area G, at LANL], and waste-water outfalls) (ESP 1995). Instead, the majority of on-site soil-sampling stations are located close to, and downwind from major facilities and/or operations at LANL in an effort to assess radionuclide, radioactivity, and heavy metals in soils that may have been contaminated as a result of air stack emissions and fugitive dust (e.g., the resuspension of dust from SWMUs).

3. Sampling Procedures, Data Management, and Quality Assurance

Collection of samples for chemical and radiochemical analyses follow a set procedure to ensure proper sample collection, documentation, submittal for chemical analyses, and posting of analytical results. Stations and samples are assigned a unique identifier to provide chain-of-custody control during the transfer of samples from the time of collection through analysis and reporting. All quality assurance/quality control (QA/QC) protocols, chemical analysis, and data handling, validation and tabulation can be found in the operating procedure (OP) entitled, "Soil Sampling for the Soil Monitoring Program," LANL-ESH-20-SF-OP-007, RO, 1997.

4. Radiochemical Analytical Results

Table 6-1 shows data from soils collected in 1996. Most radionuclide concentrations and radioactivity in soils collected from on-site and perimeter stations were within the long-term regional statistical reference level (RSRL). The RSRL is the average background concentration plus twice the standard deviation of the mean from data collected over a 21-yr period; data from 1974 through 1994 from regional background stations were used to establish the approximate upper limit background concentration for worldwide fallout of tritium, strontium-90; cesium-137; americium-241; plutonium-238; and plutonium-239, -240; and total uranium (Fresquez et al., 1996a). Some total uranium and plutonium-239, -240 values in some perimeter and on-site stations were above the RSRL but were far below LANL screening action levels (SALs). LANL SALs, developed by the Environmental Restoration Project at the Laboratory, are used to identify the presence of contaminants of concern and are derived from a risk assessment pathway using a 10-mrem/yr dose.

5. Nonradiochemical Analytical Results

Soils were also analyzed for trace and heavy metals. These data will be used to establish a database and are meaningful from a Laboratory operation/effects standpoint. The results of the 1996 soil sampling program can be found in Table 6-2.

Most concentrations of heavy metals measured in soils collected from perimeter and on-site areas were within RSRLs, and in fact, were within the range of metals normally encountered in the Los Alamos area (Ferenbaugh et al., 1990) and the continental United States (Shacklette and Boerngen 1984).

6. Total Effective Dose Equivalent from Living in Areas Where Soils Were Collected in 1996

A residential scenario (Fresquez et al., 1996a) was used in a computer model, RESRAD (version 5.61), to estimate the effective dose equivalent (EDE) from external radiation and the committed effective dose equivalent (CEDE) from internally deposited radiation (Yu et al., 1995). The EDE and CEDE are added together to provide an estimate of the total effective dose equivalent (TEDE). Table 6-3 presents a summary of this TEDE, based on the mean radioisotope concentrations, for a person living in the region, around the perimeter of the Laboratory, and on Laboratory property. The maximum TEDEs (i.e., the TEDE plus 2 sigma using the maximum consumption rate for fruits and vegetables) for samples collected during 1996 from the region, from the Laboratory's perimeter, and from on-site locations are 4.2 mrem, 5.1 mrem, and 4.2 mrem, respectively. The maximum net positive TEDE for the soils collected in 1996 after subtraction of soils collected from regional background locations show 0.78 mrem (<0.8% of the DOE public dose limit [PDL]) for perimeter soils, and 0.77 mrem (<0.8% of the DOE PDL) for on-site soils. The

radionuclides that contributed more than 5% to these maximum net positive TEDEs are cesium-137, plutonium-239, and uranium for perimeter soils; and cesium-137 and uranium for on-site soils.

7. Long-Term Trends

All soils collected from on-site and perimeter stations during 1974 through 1994 were subjected to a Mann-Kendal test for trend analysis (Fresquez et al., 1996a). Most radionuclides and radioactivity detected in LANL and perimeter soils, with the exception of plutonium-238 (increased at ≈96% of the sites) and gross alpha activity (increased at half of the sites), exhibited generally decreasing trends over time.

Activities of tritium, cesium-137, plutonium-239, and concentrations of uranium showed significantly decreasing ($p < 0.05$) trends over time in many soils collected from on-site and perimeter areas. Their decrease may be due in part to reductions in Laboratory operations, air stack emissions, and to better engineering controls employed by the Laboratory (ESP 1995), but is probably a result of (1) the cessation of above-ground nuclear weapons testing in the early 1960s, (2) weather conditions (wind, water erosion, and leaching), and (3) radioactive decay (half-life) (Rogowski and Tamura 1965, Wicker and Schultz 1982). Tritium, which has a half-life of about 12 years, exhibited the greatest decrease in activity over the 21 years in almost all of the soil sites studied, including regional locations.

Plutonium-238 and gross alpha activity generally increased over time in most on-site, perimeter, and even in regional background sites—all sites, however, were far from being statistically significant ($p < 0.05$). The source of most plutonium-238 detected in the environment is from nuclear weapons testing in the atmosphere (Klement 1965) and from the reentry burn-up of satellites containing a plutonium-238 power source (Perkins and Thomas 1980). Only a few gross alpha readings and a few gross beta readings showed significantly increasing trends ($p < 0.05$) over time. In these cases, however, the measurement period was both early and very short (1978 to 1981).

B. Foodstuffs and Associated Biota Monitoring

1. Introduction

There are many agriculturally important products that are grown and/or are harvested in the area surrounding LANL—and the ingestion of foodstuffs constitutes a critical pathway by which radionuclides can be transferred to humans (Wicker and Schultz 1982). Samples of milk, eggs, produce, fish, honey, herbal teas, domestic cattle, and elk and deer are collected annually from Laboratory and surrounding communities to determine the impact of Laboratory operations on the human food chain (Figure 6-2). This program is mandated by DOE Orders 5400.1 and 5400.5. The two main objectives of the Foodstuffs Monitoring Program are to (1) determine and compare radioactive and heavy metals constituents in foodstuffs between on-site LANL and perimeter areas with regional areas; and (2) calculate a maximum CEDE to surrounding area residents (e.g., Los Alamos townsite, White Rock/Pajarito Acres, the Pueblo of San Ildefonso, and Cochiti Pueblo) who may consume such foodstuffs.

2. Produce

a. Monitoring Network. Fruits, vegetables, and grains are collected each year from on-site (Laboratory), perimeter (Los Alamos townsite and White Rock/Pajarito Acres), and off-site regional (background) locations (Figure 6-2). Samples of produce are also collected from the Pueblos of Cochiti and San Ildefonso, which are located in the general vicinity of LANL. Produce from areas within and around the perimeter of LANL are compared to produce collected from regional (background) gardens more than 16 km (10 mi) from the Laboratory; these areas are located around the Española, Santa Fe, and Jemez areas. The regional sampling locations are sufficiently distant from the Laboratory to be unaffected by airborne emissions.

b. Sampling Procedures, Data Management, and Quality Assurance. Produce samples are collected from local gardens within and around the perimeter of the Laboratory in the summer and fall of each year (Salazar 1984). All QA/QC protocols, chemical analysis, and data handling, validation, and tabulation can be found in the OP entitled, "Produce Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-001, RO, 1997.

c. Radiochemical Analytical Results. Concentrations of radionuclides in produce collected from on-site, perimeter, and off-site regional (background) locations during the 1996 growing season can be found in Table 6-4. Most radionuclide concentrations in fruits and vegetables collected from on-site and perimeter areas were less than the RSRL. Strontium-90 concentrations, on the other hand, at most sites were higher than the RSRLs, although most values were not considered detectable values

(individual results were lower than two times the counting uncertainty). The causes of the higher concentrations of strontium-90 in produce samples collected from Los Alamos townsite, Cochiti Pueblo, Pueblo of San Ildefonso, and LANL sites, as compared to background are not completely known, but may be a reflection of analytical discrepancies and/or incomplete washing procedures rather than contamination effects by Laboratory operations.

d. Dose Equivalents to Individuals from Ingestion of Produce. Table 6-5 presents the summary of the CEDE from the ingestion of produce collected during the growing season in 1996, and for a comparison, the results for the 1995 growing season. The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) using the maximum consumption rate of 160 kg/yr (352 lb/yr) for produce is 3.3 mrem from the on-site sample, but the maximum annual CEDE for the regional background (Española, Santa Fe, and Jemez Pueblo) sample is 0.93 mrem. The maximum net positive CEDE from consuming produce collected from Cochiti Pueblo, White Rock, Los Alamos townsite, and the Pueblo of San Ildefonso is 0.086 mrem (<0.1% of the DOE PDL), 0.019 mrem (<0.02% of the DOE PDL), 0.77 mrem (<0.8% of the DOE PDL), and 2.2 mrem (2.2% of the DOE PDL), respectively. The radionuclides contributing more than 5% to this maximum net positive CEDE are natural uranium and plutonium-239 for the Cochiti Pueblo samples; plutonium-239 and americium-241 for the White Rock samples; and strontium-90, natural uranium, plutonium-239, and americium-241 for the Los Alamos townsite and the Pueblo of San Ildefonso samples. Because ingestion of produce collected on-site is not considered to be a significant pathway because of the small amount of edible material and the limited access to these foodstuffs, calculation of a total net positive CEDE and comparison to the DOE PDL is not appropriate. There is no significant difference ($p < 0.05$) between produce samples collected from background, perimeter, or on-site locations; and there is no significant difference ($p < 0.05$) between the 1995 and the 1996 CEDE.

e. Nonradiochemical Analytical Results. Most trace and heavy metal elements, particularly silver, arsenic, beryllium, cadmium, mercury, antimony, selenium, and thallium in produce from on-site, perimeter, and regional locations were below the limit of detection (Table 6-6). In those cases where produce samples contained some metals above the limit of detection (e.g., barium, chromium, nickel, and lead), only a few samples exceeded the RSRL. Lead, for example, was higher in concentration in two samples collected from the White Rock/Pajarito Acres area.

3. Honey

a. Monitoring Network. Beehives located within perimeter areas—Los Alamos townsite and White Rock/Pajarito Acres—are sampled on an annual basis for honey (Figure 6-2). Honey from these hives is compared to honey collected from regional background hives located in northern New Mexico (Fresquez et al., 1996b).

b. Sampling Procedures, Data Management, and Quality Assurance. Honey is collected by a professional (contract) bee keeper. All QA/QC protocols, chemical analysis, and data handling, validation, and tabulation can be found in the OP entitled, "Honey Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-004, RO, 1997.

c. Radiochemical Analytical Results. Results of the analysis of honey collected during the 1996 season are presented in Table 6-7. Most radionuclide concentrations in honey collected from perimeter hives were below RSRLs. A few radionuclides, principally actinium-228, cobalt-60, potassium-40, and strontium-90 observed in Los Alamos townsite and White Rock/Pajarito Acres samples, were in concentrations just above the RSRL; most levels, however, were small as compared to background.

d. Dose Equivalents to Individuals from Ingestion of Honey. Table 6-8 presents the summary of the CEDE from the ingestion of honey collected in 1996. The maximum CEDE (i.e., the CEDE plus 2 sigma) using the maximum consumption rate of 5 kg/yr (11 lb/yr) for all honey samples collected in 1996 is 0.075 mrem for the consumption of honey collected from around the Laboratory. The maximum net positive CEDE from consuming honey from Los Alamos townsite and White Rock and honey collected at a regional background station (i.e., San Pedro), using the maximum consumption rate, is 0.036 mrem (<0.04% of the DOE PDL) and 0.0030 mrem (<0.004% of the DOE PDL), respectively. The radionuclides that contributed more than 5% are potassium-40 for honey collected in Los Alamos; and strontium-90, cesium-137, and total uranium for honey collected in White Rock.

Because analyses of several more radionuclides were requested in 1996 as compared to previous years, a direct comparison of these results with previous years cannot be made. However, the 1996 results of analyses for tritium, strontium-90, cesium-137, uranium,

plutonium-238, plutonium-239, and americium-241 (the radionuclides requested in 1995) show the annual CEDE for the maximum consumption rate for samples collected from the background sample, White Rock, and Los Alamos townsite to be 0.0028 (±0.011), 0.0029 (±0.0012), and 0.0045 (±0.030) mrem, respectively. These dose equivalents can be directly compared with the previous year. The confidence intervals for the 1995 data set and this 1996 modified data set overlap, indicating that there is no difference between the 1995 and the 1996 calculated CEDEs for these sampling locations.

4. Eggs

a. Monitoring Network. Fresh eggs are collected from free-range chickens from the Los Alamos townsite area and from the Pueblo of San Ildefonso. These eggs are compared to eggs produced from free-range chickens located in the Española area.

b. Sampling Procedures, Data Management, and Quality Assurance. Approximately 24 medium sized eggs from Los Alamos townsite, Pueblo of San Ildefonso, and Española (background) were collected directly from the farmer, transported in Styrofoam containers to the Laboratory, and submitted to CST-9 for the analysis of tritium; total uranium; strontium-90; plutonium-238; plutonium-239, -240; americium-241; and cesium-137. All QA/QC protocols, chemical analysis, data handling, validation, and tabulation can be found in the OP entitled, "Egg Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-006, RO, 1997.

c. Radiochemical Analytical Results. Results of radionuclide concentrations detected in eggs collected from Los Alamos townsite and the Pueblo of San Ildefonso, as they compare to eggs collected from the Española area can be found in Table 6-9. Most radionuclide values in eggs collected from Los Alamos townsite and the Pueblo of San Ildefonso were less than the RSRLs. Although the cesium-137 activity in eggs collected from Los Alamos townsite was greater than the RSRL, the level was not considered a detectable hit because the concentration was lower than the counting uncertainty; and is, therefore, of no concern.

d. Dose Equivalents to Individuals from Ingestion of Eggs. Table 6-10 presents the summary of the CEDE from the ingestion of eggs collected near the Pueblo of San Ildefonso, Los Alamos townsite, and a regional background location near Española in 1996. The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) using the maximum consumption rate of 20 kg/yr (55 g/day) for eggs collected at Los Alamos townsite is 0.15 mrem. The maximum net positive CEDE for eggs collected from the Pueblo of San Ildefonso and from Los Alamos townsite and the regional background location is 0.002 mrem (<0.002% of the DOE PDL) and 0.12 mrem, respectively. Cesium-137 contributed greater than 99% of these dose equivalents. Because cesium-137 was not "detected" in any of the egg samples (i.e., the reported counting uncertainty is larger than the concentration measured), the contribution of this radionuclide to the maximum net positive dose appears to be from natural variability within the data set as a result of measuring low concentrations (i.e., near the detection limits of the instruments). There is no statistical difference ($p < 0.05$) between the maximum CEDE (i.e., average CEDE + 2 sigma) calculated for eggs collected from the Pueblo of San Ildefonso, Los Alamos townsite, and the regional background in the Española area.

5. Milk

a. Monitoring Network. There are no milk production facilities within 15 km (9 mi) of the Laboratory—the closest working dairy, located in the Pojoaque Valley, is approximately 40 km (24 mi) away. However, because milk is considered one of the most important and universally consumed foodstuffs, the analysis of milk may yield information as to the deposition of small amounts of radionuclides over a relatively large area. Accordingly, various radionuclides in milk from the Pojoaque Valley dairy were analyzed and compared to milk collected from a dairy (regional background location) located in Albuquerque.

b. Sampling Procedures, Data Management, and Quality Assurance. Milk is collected directly from the dairies in the Pojoaque Valley and from Albuquerque and submitted to CST-9 in the original containers for the analysis of tritium; uranium; strontium-90; plutonium-238; plutonium-239, -240; iodine-131; and cesium-137. All QA/QC protocols, chemical analysis, data handling, validation, and tabulation can be found in the OP entitled, "Milk/Tea Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-005, RO, 1997.

c. Radiochemical Analytical Results. The results of the radiochemical analysis performed on milk collected from the Pojoaque Valley and Albuquerque (background) during 1996 are summarized in Table 6-11. Most radionuclide concentrations in milk collected from the Pojoaque Valley, with the exception of total uranium, were less than

RSRLs and were similar to those obtained in previous years. Milk collected from both Pojoaque Valley and Albuquerque dairies contained detectable uranium concentrations; however, this fact was not unexpected because uranium is a natural element in all soils, and the degree to which it is found in milk depends on many factors, including the geology, mineralogy, vegetation, and meteorological (wind and rain) conditions of the area (Wicker and Schultz 1982).

d. Dose Equivalents to Individuals from Ingestion of Milk. Table 6-12 presents the summary of the CEDE from the ingestion of milk collected from the Pojoaque Valley for 1996. The results from 1994 and 1995 are also presented for comparison. The maximum CEDE (i.e., the CEDE plus 2 sigma) using the maximum consumption rate of 0.5 L/day for milk is 0.70 mrem from the regional background sample (Albuquerque). The maximum net positive CEDE from consuming milk from the Pojoaque Valley and from the regional background location is 0.083 mrem (<0.09% of the DOE PDL). The radionuclides contributing more than 5% to this total net positive difference are strontium-90 and uranium. There is no significant difference ($p < 0.05$) between the maximum CEDE (i.e., average CEDE + 2 sigma) calculated for milk samples collected from the Pojoaque Valley and the regional background. The confidence intervals for these data sets overlap, indicating that there is no difference between the 1994, 1995, and 1996 CEDEs.

6. Fish

a. Monitoring Network. Fish are collected annually upstream and downstream of the Laboratory (Figure 6-2). Cochiti Reservoir, a 10,690-acre flood and sediment control project, is located on the Rio Grande approximately five miles downstream from the Laboratory. Radionuclides in fish collected from Cochiti Reservoir are compared to fish collected from background reservoirs. Abiquiu, Heron, and El Vado Reservoirs are located on the Rio Chama, upstream from the confluence of the Rio Grande and intermittent streams that cross Laboratory lands (Fresquez et al., 1994a).

Two types of fish are collected: game (surface-feeders) and nongame (bottom-feeders). Game fish include Rainbow Trout (*Salmo gairdneri*), Brown Trout (*Salmo trutta*), Kokanee Salmon (*Oncorhynchus nerka*), Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieui*), White Crappie (*Pomixis annularis*), and Walleye (*Stizostedion vitreum*). Nongame fish include the White Sucker (*Catostomus commersone*), Channel Catfish (*Ictalurus penctatus*), Carp (*Cyprinus carpio*), and Carp Sucker (*Carpiodes carpio*).

b. Sampling Procedures, Data Management, and Quality Assurance. Fish are collected by hook and line, trot line, or gill nets (Salazar 1984). All QA/QC protocols, chemical analysis, data handling, validation, and tabulation can be found in the OP entitled, "Fish Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-002, RO, 1997.

c. Radiochemical Analytical Results. Concentration of radionuclides in game and nongame fish collected upstream and downstream of the Laboratory are presented in Table 6-13. In general, the concentrations of most radionuclides in game and nongame fish collected from Cochiti Reservoir before and after the Dome Fire were less than the RSRL from similar fish collected from Abiquiu, Heron, and El Vado Reservoirs. Uranium in fish from Cochiti Reservoir is from naturally occurring sources. The isotopic ratio of uranium-235 to uranium-238 in Cochiti Reservoir bottom-feeding fish collected during 1993 ($1.25 \times 1{,}013$ atoms uranium-235/ash g to $1.74 \times 1{,}015$ atoms uranium-238/ash g) and 1994 ($1.20 \times 1{,}013$ atoms uranium-235/ash g to 1.65×1015 atoms uranium-238/ash g), for example, were consistent with naturally occurring uranium (i.e., 0.0072 ratio) (Efurd 1993). In other words, there was no evidence of depleted uranium in fish samples collected from Cochiti Reservoir in past years. Depleted uranium, a by-product of uranium enrichment processes, has been used in dynamic weapons testing at LANL firing sites since the mid-1940s. Also, there was no evidence of uranium-236; this isotope does not occur in nature and is indicative of the presence of man-made uranium. These results compare well with radionuclide contents in crappie, trout, and salmon from comparable (background) reservoirs and lakes in Colorado (Wicker et al., 1972, Nelson and Wicker 1969).

d. Dose Equivalents to Individuals from Ingestion of Fish. Table 6-14 presents the summary of the CEDE from the ingestion of fish collected from upstream (Abiquiu, Heron, and El Vado Reservoirs) and downstream (Cochiti Reservoir) of the Laboratory before and after the 1996 Dome Fire. The maximum CEDE (i.e., the CEDE plus 2 sigma) using the maximum consumption rate of 21 kg/yr (46 lb/yr) for fish collected before the fire is 0.21 mrem from the Cochiti Reservoir bottom feeders, and the maximum CEDE for fish collected after the fire is 0.17 mrem. The maximum net positive CEDE for consuming fish from the

Cochiti Reservoir before the fire using the maximum consumption rate and subtracting the background from upstream of the Laboratory, is 0.12 mrem (<0.13% of the DOE PDL) for the bottom feeders and 0.052 mrem (<0.06% of the DOE PDL) for the higher level feeders. The maximum net positive CEDE for consuming fish from the Cochiti Reservoir after the 1996 Dome Fire using the maximum consumption rate and subtracting the background from upstream of the Laboratory, is 0.083 mrem (<0.09% of the DOE PDL) for the bottom feeders and 0.030 mrem (<0.04% of the DOE PDL) for the higher level feeders. The radionuclides contributing more than 5% to the maximum net positive CEDEs for samples collected before the Dome Fire are strontium-90, uranium, and americium-241 for bottom feeders and strontium-90, uranium, and plutonium-239 for the higher level feeders. The radionuclides contributing more than 5% to the total maximum net positive CEDEs for samples collected after the Dome Fire are strontium-90, uranium, and americium-241 for bottom feeders and strontium-90, cesium-137, uranium, plutonium-238, and americium-241 for the higher level feeders.

There is no significant difference ($p < 0.05$) between the maximum CEDE (i.e., average CEDE + 2 sigma) calculated for fish collected from upstream of the Laboratory and from Cochiti Reservoir before or after the Dome Fire. There is no significant difference ($p < 0.05$) between the 1995 CEDE and the 1996 CEDE calculated for the fish collected.

e. Long-Term Data Evaluation of Naturally Occurring Uranium in Surface- and Bottom-Feeding Fish Upstream and Downstream of the Laboratory. Fresquez et al., (1994a) conducted a summary and trend analysis of radionuclides in game and nongame fish collected from reservoirs upstream (Abiquiu, Heron, and El Vado Reservoirs) and downstream (Cochiti Reservoir) of LANL from 1981 to 1993. In general, the average levels of strontium-90, cesium-137, plutonium-238, and plutonium-239 in game and nongame fish collected from Cochiti Reservoir were not significantly different in fish collected from reservoirs upstream of the Laboratory. Total uranium was the only radionuclide that was found to be significantly higher in both game and nongame fish from Cochiti Reservoir as compared to fish from Abiquiu, Heron, and El Vado Reservoirs. Uranium concentrations in fish collected from Cochiti Reservoir, however, significantly ($p < 0.05$) decreased from 1981 to 1993, and no evidence of depleted uranium was found in fish samples collected from Cochiti Reservoir in 1993. Based on the average concentration of radionuclides over the years, the net positive CEDE from consuming 21 kg/yr (46 lb/yr) of game fish and nongame fish from Cochiti Reservoir after natural background has been subtracted was 0.005 and 0.009 mrem/yr, respectively. The highest dose was <0.01% of the DOE PDL (Fresquez and Armstrong 1996).

f. Nonradiological Analytical Results. The mean levels of all heavy metals in bottom-feeding fish collected from Cochiti Reservoir on June 3, 1996 (pre-Dome Fire) were within the RSRL (Table 6-15). In addition, all of these metals, particularly beryllium, mercury, and lead, were similar to values reported from 1991 to 1995. Mercury concentrations in fish occurring in lakes and reservoirs in New Mexico have been of significant concern to the public for several years. However, based on five years of data, mercury concentrations in fish upstream of LANL have been consistently higher, albeit slightly, than mercury concentrations downstream of the Laboratory.

Although some heavy metals, particularly silver, barium, beryllium, cadmium, chromium, and thallium in fish collected from Cochiti Reservoir on August 8, 1996, after the Dome Fire, were higher in concentrations than metals in fish collected upstream of LANL, they were less than the RSRL. The higher concentrations of these metals in fish from Cochiti Reservoir were probably a result of the fire on Forest Service and Bandelier National Park lands.

7. Game Animals (Elk and Deer)

a. Monitoring Network. Road kills of elk and deer are collected on an annual basis from within Laboratory boundaries, and the meat and bone are analyzed for various radionuclides. Three elk and five deer were collected during 1995 and 1996. These data, from meat and bone samples, were compared to radionuclide concentrations in meat and bone samples from elk and deer collected from regional background locations (Fresquez et al., 1994b).

b. Sampling Procedures, Data Management, and Quality Assurance. Elk and deer meat and bone tissue are collected from fresh road kills around the Laboratory. Background samples are collected from the New Mexico Department of Game and Fish during this same period of time. All QA/QC protocols, chemical analysis, data handling, validation, and tabulation can be found in the OP entitled, "Game Animal Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-003, RO, 1997.

c. Radiochemical Analytical Results. Results of road kill elk and deer collected during 1995 and 1996 can be found in Tables 6-16 and 6-17.

Most radionuclides in muscle and bone tissue of deer collected from LANL lands were less than RSRLs. Activities of cesium-137 and americium-241 in muscle and activities of tritium, strontium-90, and plutonium-238 in bone in some deer samples, however, were greater than the RSRL. And, three out of the five deer bone samples collected from LANL lands contained higher strontium-90 levels than background.

Most radionuclides, with the exception of total uranium, in muscle and bone tissue of elk collected within LANL lands were less than the RSRL. Only one sample, a leg bone sample from a cow elk collected on the Pueblo of San Ildefonso at State Road 4, contained detectable (where the analytical result was higher than two sigma) and higher concentrations of total uranium. The value was greater than the RSRL.

d. Dose Equivalents to Individuals from Ingestion of Game Animals. Table 6-18 presents the summary of the CEDE from the ingestion of elk collected during 1996. Because there were no regional background elk collected in 1994 or 1995 (ESP 1996), the 1993 data are also presented as a comparison (Fresquez et al., 1994b). The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) using the maximum consumption rate of 5.7 kg (13 lb) for elk bone and 23 kg/yr (50 lb) for elk muscle collected on-site in 1996 is 2.2 mrem and 0.042 mrem, respectively. For the regional sample, the maximum annual CEDE is 0.80 mrem for the consumption of elk bone and 0.044 mrem for the consumption of elk muscle. The maximum net positive CEDE from consuming bone and muscle from elk collected on-site and elk collected off-site in 1996 is 1.4 mrem (1.4% of the DOE PDL) for bone and 0.011 mrem (0.011% of the DOE PDL) for muscle. The radionuclides that contributed more than 5% to this maximum net positive dose is strontium-90 for bone and muscle. There is no significant difference ($p < 0.05$) between the maximum CEDE (i.e., average CEDE + 2 sigma) calculated in 1995 and 1996 or from 1996 on-site or off-site locations.

Table 6-19 presents the summary of the CEDE from the ingestion of deer collected during 1996. The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) using the maximum consumption rate of 4.8 kg/yr (11 lb/yr) for deer bone and 23 kg/yr (50 lb/yr) for deer muscle collected on-site in 1996 is 3.7 mrem and 0.16 mrem, respectively. For the regional sample, the maximum annual CEDE is 0.4 mrem for the consumption of deer bone and 0.05 mrem for the consumption of deer muscle. The maximum net positive CEDE from consuming bone and muscle from deer collected on-site and deer collected off-site in 1996 is 3.3 mrem (<3.5% of the DOE PDL) for bone and 0.13 mrem (<0.15% of the DOE PDL) for muscle. The radionuclides that contributed more than 5% to this total net positive dose is strontium-90 for bone and cesium-137 for muscle.

8. Domestic Animals.

a. Monitoring Network. Free-ranging cattle owned by residents of the Pueblo of San Ildefonso graze the boundaries of LANL on a regular basis and are offered by the Pueblo for sampling and analysis.

b. Sampling Procedures, Data Management, and Quality Assurance. All QA/QC protocols, chemical analyses, data handling, validation, and tabulation can be found in the OP entitled, "Game Animal Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-003, RO, 1997.

c. Radiochemical Analytical Results. Radionuclide concentrations in muscle and bone tissue of a domestic free-range steer collected from the Pueblo of San Ildefonso lands during the 1996 year can be found in Table 6-20. Results are compared to background elk samples—elk and cattle are both free-ranging grazers—collected during the same year. In general, most radionuclides, with the exception of total uranium, in muscle and bone tissue of a steer collected from the Pueblo of San Ildefonso were less than the RSRL. Total uranium in bone tissue, however, was detected at two times the levels commonly encountered in bone tissue of elk.

d. Dose Equivalents to Individuals from Ingestion of Domestic Animals. Table 6-21 presents the summary of the CEDE from the ingestion of a free-range steer collected from the Pueblo of San Ildefonso during 1996. Because this was the first year that a steer was sampled, there are no background samples with which to compare the 1996 results. In order to compare this CEDE to a background value, elk collected from the region from 1991 to the present were used. The maximum CEDE (i.e., the CEDE plus 2 sigma) using the maximum consumption rate of 110 kg/yr (243 lb/yr) for muscle and 275 kg/yr (61 lb/yr) for bone for steer collected from the Pueblo of San Ildefonso in 1996 is 2.3 mrem for the consumption of bone tissue and 0.17 mrem for the consumption of muscle tissue. The maximum net positive CEDE from consuming steer bone and muscle collected from Pueblo of San Ildefonso land, after the subtraction of elk CEDE from regional background, is 0.23 mrem

(<0.3% of the DOE PDL) and 0.057 mrem (<0.06% of the DOE PDL), respectively. The radionuclides that contributed more than 5% to this total maximum net positive dose are cesium-137, uranium, and americium-241 for bone; and strontium-90, uranium, and plutonium-239 for muscle. There is no significant difference ($p < 0.05$) between the maximum CEDE (i.e., average CEDE + 2 sigma) calculated for steer tissues collected from the Pueblo of San Ildefonso and elk tissue collected at regional background locations in 1996.

9. Herbs/Tea

a. Monitoring Network. Navajo Tea (Cota) was collected from three perimeter areas surrounding the Laboratory: Los Alamos townsite on the north, White Rock on the southeast, and Pueblo of San Ildefonso lands on the east. Tea was collected from the Española area as a background value.

b. Sampling Procedures, Data Management, and Quality Assurance. All QA/QC protocols, chemical analysis, data handling, validation, and tabulation can be found in the OP entitled, "Milk/Tea Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-005, RO, 1997.

c. Radiochemical Analytical Results. Results of the tea collected during the 1996 year can be found in Table 6-22. Tea collected from Los Alamos townsite, White Rock/Pajarito Acres, and the Pueblo of San Ildefonso contained detectable levels (where the analytical result was higher than two sigma) of plutonium-238, plutonium-239, and total uranium. These were greater than the RSRL. All other radionuclides were within background values.

d. Dose Equivalents to Individuals from Ingestion of Herbal Tea. Table 6-23 presents the summary of the CEDE from the ingestion of Navajo tea (Cota) collected in 1996. The maximum CEDE (i.e., the CEDE plus 2 sigma) using the maximum consumption rate of 1.5 L/day for all tea samples collected in 1996 is 1.9 mrem for the consumption of tea collected in the Pueblo of San Ildefonso. The maximum net positive CEDE from consuming tea from Los Alamos townsite, White Rock/Pajarito Acres, and the Pueblo of San Ildefonso and tea collected at a regional background station, using the maximum consumption rate, is 0.24 mrem (<0.3% of the DOE PDL), 0.27 mrem (<0.3% of the DOE PDL), and 0.92 mrem (<1.0% of the DOE PDL), respectively. The radionuclides that contributed more than 5% to these maximum net positive CEDEs are strontium-90, uranium, plutonium-238 and plutonium-239 for tea collected in Los Alamos; cesium-137, plutonium-238, and plutonium-239 for tea collected in White Rock, and cesium-137, uranium, and plutonium-238 for tea collected at the Pueblo of San Ildefonso. There is no significant difference ($p < 0.05$) between the maximum CEDE calculated for consuming tea from the sampling locations.

C. Special Studies, Including Long-Term Data Evaluations

1. Radionuclide Concentrations in Soils and Produce from Native American Pueblo Gardens in the Vicinity of Los Alamos National Laboratory

Radionuclide (tritium, strontium-90, cesium-137, plutonium-238, plutonium-239, and total uranium) concentrations were determined in soils and produce collected from gardens in the Pueblos of Cochiti, Jemez, Taos, and San Ildefonso. All radionuclides in soils from Pueblo areas were within or just above RSRL (natural and/or worldwide fallout). Similarly, the average levels of radionuclides in produce collected from gardens in the Pueblos of Cochiti, Jemez, Taos, and San Ildefonso were not significantly different in produce collected from regional (background) locations. The CEDE from consuming 160 kg (352 lb) of produce from the Pueblos of Cochiti, Jemez, Taos, and San Ildefonso, after the background value has been subtracted, was 0.036 (±0.016), 0.072 (±0.051), 0.012 (±0.027), and 0.110 (±0.102) mrem/yr, respectively. The highest calculated dose, based on the mean + 2 std dev (95% confidence level), was 0.314 mrem/yr; this was <0.4% of the International Commission on Radiological Protection (ICRP) permissible dose limit for members of the public (Fresquez et al., 1996c).

2. Radionuclide Concentrations in Elk and Deer from Los Alamos National Laboratory (1992–1995)

Rocky Mountain elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) are common inhabitants of LANL lands. Many of these animals forage over areas at LANL that may contain radioactivity above natural and/or worldwide fallout levels. A study was conducted to determine (1) radionuclide contents (tritium, cesium-137, strontium-90, plutonium-238, plutonium-239, americium-241, and total uranium) in muscle and bone from elk and deer collected from road kills on LANL lands from 1992 through 1995; and (2) the CEDE and the corresponding risk of excess cancer fatalities to people who consume meat and bone from these animals.

In general, most radionuclide concentrations in muscle and bone from elk and deer collected from LANL lands were either at less than detectable levels (where the analytical result was smaller than two counting uncertainties) or within upper limit background concentrations (the background mean + 2 std dev). Based on the long-term average, most radionuclides in muscle tissue from elk collected from LANL lands, with the exception of plutonium-239, were not significantly different ($p < 0.05$) from radionuclide concentrations in muscle from elk collected from background locations. Similarly, most radionuclides, with the exception of total uranium, were not significantly higher in bone from LANL elk as compared to bone from background elk. No significant differences resulted in any of the radionuclides measured in muscle and bone collected from LANL deer as compared to background deer. Overall, the maximum total net positive CEDE—based on the average concentration plus two standard deviations of all radionuclides measured over the years after the subtraction of background values—from the consumption of 51 lb of muscle and 13 lb of bone from LANL elk and deer were as follows: elk muscle = 0.029 mrem/yr, elk bone = 0.149 mrem/yr, deer muscle = 0.182 mrem/yr, and deer bone = 0.742 mrem/yr. All maximum total net positive CEDEs were well below the ICRP permissible dose limit of 100 mrem/yr from all pathways, and the highest CEDE (0.742 mrem/yr from deer bone) corresponds to a risk of excess cancer fatalities of 3.7×10^{-7} (<0.4 in a million). This risk was far below the EPA limit guideline of 10^{-4} (Fresquez et al., 1996d).

3. Radionuclides in Bees and Honey within and around Los Alamos National Laboratory

Honeybees are effective monitors of environmental pollution. LANL, in fact, has maintained a network of honeybee colonies within and around LANL for 17 years (1979 through 1995); the objectives for maintaining this honeybee network were to (1) determine the bioavailability of certain radionuclides in the environment with respect to LANL operations (tritium, cobalt-57, cobalt-60, europium-152, potassium-40, beryllium-7, sodium-22, manganese-54, rubidium-83, cesium-137, plutonium-238, plutonium-239, strontium-90, americium-241, and total uranium) and (2) estimate the CEDE and the corresponding risk of excess cancer fatalities to people who may consume honey from hives located around the perimeter of the Laboratory (Los Alamos and White Rock/Pajarito Acres). All other radionuclides, with the exception of tritium, in honey collected from perimeter hives around LANL were not significantly different from background. Overall, the maximum total net positive CEDE—based on the average concentration plus two std dev of all the radionuclides measured over the years after the subtraction of background values—from consuming 11 lb of honey collected from Los Alamos and White Rock/Pajarito Acres, was 0.031 mrem/yr and 0.006 mrem/yr, respectively. The highest CEDE was <0.04% of the ICRP permissible dose limit of 100 mrem/yr from all pathways and corresponds to a risk of excess cancer fatality of 1.6×10^{-8} (0.016 in a million)—far below the EPA's limit guideline of 10^{-4} (Fresquez et al., 1997a).

4. Radionuclide Concentrations in Pinto Beans, Sweet Corn, and Zucchini Squash Grown in Los Alamos Canyon at Los Alamos National Laboratory

Pinto beans (*Phaselous vulgaris*, var. Idaho 111), sweet corn (*Zea mays*, var. early sunglow), and zucchini squash (*Cucurbita pepo*, var. black beauty) were grown in a randomized complete block field/pot experiment at a site within Los Alamos Canyon at LANL. That site contained the highest levels of surface gross gamma radioactivity within that canyon bottom. Soils, as well as washed edible and nonedible (washed) crop tissues, were analyzed for various radionuclides (tritium, cesium-137, strontium-90, plutonium-238, plutonium-239, americium-241, total uranium, gross alpha, gross beta, and gross gamma) and heavy metals (arsenic, mercury, antimony, cadmium, chromium, lead, and zinc). Most radionuclides, with the exception of tritium and total uranium, in soil from Los Alamos Canyon were detected in significantly higher concentrations ($p < 0.01$) than in soil collected from regional background locations. Similarly, most radionuclides in edible crop portions of beans, squash, and corn were detected in significantly higher concentrations than regional background. Soil to plant concentration ratios for radionuclides and heavy metals in edible and nonedible crop tissues from Los Alamos Canyon were calculated. All heavy metals in soils, as well as edible and nonedible crop tissues grown in soils from Los Alamos Canyon, were within regional background concentrations. Overall, the maximum net positive CEDE—the CEDE plus two sigma for each radioisotope minus background and then all positive doses summed—to a hypothetical 50-year resident who ingested 160 kg [352 lb] of beans, corn, and squash from the region used in this study in equal proportions, was 74 mrem/yr. This dose was below the ICRP permissible dose limit of 100 mrem/yr from all pathways; however, the addition of other internal and

external exposure route factors may increase the overall dose over the PDL. The risk of an excess cancer fatality, based on 74 mrem/yr, was 3.7×10^{-5} (37 in a million); which is below the EPA's limit guideline of 10^{-4} (Fresquez et al., 1997b).

5. Sampling of Perimeter Surface Soils at Technical Area 54, Area G

During fiscal year (FY) 1996, 41 surface soil samples were collected from the perimeter of TA-54, Area G. Fewer samples were taken in FY96 than in previous years, and the locations sampled depended on historical data collected at Area G between FY93 and FY95. The locations for the FY96 surface soil samples were chosen on the basis that these were sites that could best indicate whether contaminants, under the influence of surface water runoff, were moving outside the TA-54, Area G perimeter. Each sampling point was located in an obvious (but small) drainage channel just outside the perimeter fence. These sampling locations were thus biased to best determine movement of contaminated soil being carried by surface water runoff from within the confines of Area G to beyond the Area G fence (Conrad 1997). The radioactive constituents measured in these surface soil samples included americium-241, cesium-137, isotopic plutonium, and tritium.

The analytical results of the surface soil sampling indicate that some perimeter soils at Area G continue to be elevated above background levels for tritium and plutonium. The most elevated concentrations of tritium in soils are prevalent in locations that are adjacent to the active tritium disposal shafts, and next to a series of inactive tritium shafts and the transuranic (TRU) waste storage pads. Isotopic plutonium and americium-241 activity are slightly elevated in perimeter surface soils located adjacent to the TRU pads. Cesium-137 is uniformly distributed in the perimeter soils. The perimeter soil samples were not analyzed for total uranium, but previous years' uranium data have show a uniform distribution in surface soils with no evidence of elevated levels over background.

No gross changes in radioactivity in surface soil samples were observed, and the samples collected in FY96 contain radioactivity similar to samples collected in FY95. No new locations where surface soils were elevated with radioactivity were defined by sampling. These findings are consistent with analogous measurements taken in FY93, FY94, and FY95. The Area G perimeter surface soil data indicate that very little radioactivity is moving outside of Area G under the influence of surface water runoff (Conrad 1997).

6. Dual Axis Radiographic Test Facility Mitigation Action Plan Activities

Elk are being collared in the vicinity of the Dual Axis Radiographic Test (DARHT) facility to effectively evaluate their current use of that area. Global positioning system (GPS) radio collars are put on elk in an attempt to gather data. These data are necessary to make clearer decisions associated with Laboratory projects that may affect elk, whether in a positive or negative manner. The data gathered and analyzed pertain primarily to habitat, water, and terrain use. This information aids in developing management strategies that can be used to alleviate the concerns associated with the DARHT project. The study objectives are to assess seasonal and daily activity use by elk of the DARHT project area to evaluate potential short and long term impacts of DARHT.

Information on large predators using the DARHT project area is also being collected. The study objectives are to determine the presence or absence of large predators (mountain lion, black bear) in the project area, and, if present, assess use of the project area by these species.

Collection and analysis of small mammal tissues is done to identify radionuclides present and monitor concentration amounts over time to obtain a trend analysis. The collection and sampling of small mammals in the vicinity of DARHT before operation of the facility provides a baseline of contaminant concentrations that can be compared to postoperational activities to determine if release of contaminants occurs. The information is used to identify radionuclide presence within surface and subsurface soils in adjacent canyons and to quantitatively estimate the amount of radionuclide uptake at the sampling locations by sampling carcasses of burrowing nocturnal small mammals.

In Chapter 2 of this report, there is a general description of the DARHT Mitigation Action Plan.

7. Environment, Safety, and Health Technology Development and Evaluation Applications Research Study

In 1996, ESH-20 initiated a research project involving the use of an advanced radiotelemetry system on elk studies at LANL. Project objectives included testing a new telemetry system, addressing important questions in contaminant transport and radionuclide concentrations in animals, providing information about elk and deer populations in the area, and providing data on animal diseases. Error rates were determined for a GPS collar associated with varying vegetation types and terrain types that can be applied to locational fixes

of animals following deployment of the collars in an applied field study. The error rates were calculated to be less than traditional telemetry devices and thus provides a more effective tool for wildlife studies. Habitat use patterns, water source use patterns, and movements based on human-induced barriers were identified. The GPS data were successfully interfaced with the geographical information system (GIS) to further advance the applications of the technology.

8. National Institutes of Health Hantavirus Grant

Beginning in 1994, the National Institutes of Health, through a collaborative research effort with the University of New Mexico School of Medicine, has funded the ESH-20 Biology Team to study the Sin Nombre hantavirus. Data are collected on small mammal populations, animal health, climatology, and food source use and availability at two locations in the Four Corners area. The objectives of this study are testing for correlations between population densities and concentrations of hantavirus; testing for correlations between ecological parameters, climatological conditions, and food source use or availability and concentrations of hantavirus; and determining seroprevalence rates in various species of rodents. The results of this study have shown a steady decrease in seroprevalence rates of infected animals.

In addition, monitoring of seroprevalence of hantavirus in rodent populations is occurring in Los Alamos County. The deer mouse was the most commonly captured species at all locations except one site where voles (*Microtus* spp.) were the most commonly captured species. Other species sampled included: harvest mice (*Reithrodontomys megalotis*), woodrats (*Neotoma* spp.), shrews (*Sorex* spp.), white-footed mice (*Peromyscus leucopus*), piñon mice (*Peromyscus trueii*), and brush mice (*Peromyscus boylii*). Results of the testing from 1993 to 1996 identified a total overall seroprevalence rate among deer mice of approximately 5.5%, 4.2%, 0%, and 0%, respectively. Several other species tested positive for the hantavirus, but it is uncertain if it is the Sin Nombre virus. Further studies will be necessary to quantify seroprevalence rates in those species. Testing has shown that seroprevalence rates for Los Alamos County were much lower than elsewhere in the region.

9. Technical Area 54, Area G, Enhanced Surveillance Activities—Small Mammal Contaminant Study

Small mammals were sampled at two waste burial sites at TA-54, Area G, and a control site within the proposed Area G expansion area. The purpose of these 1996 activities was to identify radionuclides that are present within surface and subsurface soils at waste burial sites, to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and to identify the primary mode of contamination to small mammals, either through surface contact, ingestion, or inhalation. Three composite samples of approximately five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for americium-241, strontium-90, plutonium-238, plutonium-239, total uranium, cesium-137, and tritium. Significantly higher (parametric t-test at $p < 0.05$) levels of total uranium, americium-241, plutonium-238, and plutonium-239 were detected in pelts as compared to the carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. Because of low capture rates at each site, no statistical analysis could be conducted to compare sites.

10. Fire Hazard Modeling

As a result of the La Mesa Fire in 1977 and the Dome Fire in 1996, ESH-20 initiated an ongoing effort to evaluate the potential for catastrophic wildland fires to occur in populated areas that are adjacent to LANL. The first step in this process is to inventory fuel levels in forests and woodlands on the Pajarito Plateau. This was done at 39 environmental surveillance plots, and the results are being used as inputs into fire behavior models. The outputs of these analyses will be used to prioritize areas and suggest methods for reducing the threats to populated areas from catastrophic fire.

The preliminary results of this inventory indicate that the greatest threat of catastrophic fire is in areas at higher elevations that are predominated by ponderosa pine forests and mixed conifer forests. Woodlands at lower elevations are less threatened by severe fires. ESH-20 is collaborating with the Los Alamos County Fire Department, the US Forest Service, and other emergency organizations to implement strategies for reducing the fire hazard near potentially affected residential and business districts.

11. Integration of a Custom FORTRAN Code and the Geographic Information System for Conducting a Spatially Dynamic Risk Assessment of Federally Protected Species

The Endangered Species Act of 1973 requires that the Department of Energy protect listed species at facilities such as the Los Alamos National Laboratory.

A preliminary risk assessment of the Mexican spotted owl (*Strix occidentalis lucida*) (Gallegos et al., 1997a), the American peregrine falcon (*Falco peregrinus*) (Gallegos et al., 1997b), and the bald eagle *(Haliaeetus leucocephalus*) was performed using a custom FORTRAN model, ECORSK5, and the geographic information system. Estimated doses from soil ingestion and food consumption contaminant pathways were compared against toxicity reference values to generate hazard indices that included a measure of cumulative effects from multiple contaminants (radionuclides, metals, and organic chemicals). The soil ingestion contaminant exposure pathway included a bioaccumulation component, and the food consumption contaminant pathway included a biomagnification component. Simulated foraging within scalable home ranges was weighted exponentially based on distance from randomly selected simulated nest sites. Other model variables included occupancy weighting, toxicity reference value adjustment, and home range sloping. Hazard indices for the most realistic foraging scenarios assessed were 0.73 (±0.23), 1.16 (±1.0) and 0.015 (±0.004) for the owl, falcon, and eagle, respectively. Hazard indices values below 1.0 were considered to be indicative of no unacceptable risk and generally require no further assessment. Information on risk by specific geographical location was generated for use in management of contaminated areas, species habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptably low levels.

Table 6.1. Radiochemical Analyses of Soils Collected in 1996

Location	^{3}H (pCi/mL)	^{90}Sr (pCi/g dry)	^{137}Cs (pCi/g dry)	Total Uranium (µg/g dry)	^{238}Pu (pCi/g dry)	^{239,240}Pu (pCi/g dry)	^{241}Am (pCi/g dry)	Gross Alpha (pCi/g dry)	Gross Beta (pCi/g dry)	Gross Gamma (pCi/g dry)
Off-Site Regional (Background) Stations:										
Rio Chama	0.4 (0.8)[a]	0.6 (0.4)	0.41 (0.12)	2.43 (0.48)	0.003 (0.004)	0.016 (0.006)	0.007 (0.004)	4.8 (4.0)	5.5 (1.4)	2.4 (0.6)
Embudo	0.3 (0.8)	0.4 (0.4)	0.40 (0.12)	1.91 (0.38)	0.002 (0.002)	0.014 (0.004)	0.005 (0.004)	5.4 (4.2)	5.7 (1.4)	2.6 (0.6)
Santa Cruz	0.3 (0.8)	–0.1 (0.6)[b]	0.11 (0.08)	2.18 (0.44)	0.001 (0.002)	0.008 (0.004)	0.004 (0.002)	5.3 (7.4)	5.8 (1.6)	2.8 (0.6)
Cochiti	0.2 (0.8)	0.3 (0.4)	0.26 (0.10)	1.88 (0.38)	0.001 (0.002)	0.006 (0.004)	0.005 (0.006)	2.6 (1.6)	3.8 (1.0)	2.3 (0.6)
Bernalillo	0.5 (0.8)	0.1 (0.4)	0.17 (0.08)	2.35 (0.48)	0.004 (0.004)	0.005 (0.004)	0.006 (0.004)	3.3 (3.6)	4.9 (1.2)	2.2 (0.6)
Jemez	0.5 (0.8)	0.1 (0.4)	0.26 (0.24)	3.18 (0.64)	0.002 (0.002)	0.012 (0.004)	0.006 (0.002)	5.0 (5.4)	4.3 (1.0)	3.8 (0.8)
Mean (±2SD)	0.4 (0.2)	0.2 (0.5)	0.27 (0.24)	2.32 (0.95)	0.002 (0.002)	0.010 (0.009)	0.006 (0.002)	4.4 (2.3)	5.0 (1.6)	2.7 (1.2)
RSRL[c]	6.34	0.82	1.13	4.05	0.008	0.028	0.208	35.3	13.6	7.3
SAL[d]	1,900[e]	4.4	5.1	29	27	24	22	NA[f]	NA	NA
Off-Site Perimeter Stations:										
Otowi	1.2 (0.8)	0.0 (0.4)	0.22 (0.08)	1.92 (0.38)	0.000 (0.002)	0.018 (0.006)	0.005 (0.002)	4.3 (3.6)	4.1 (1.0)	2.4 (0.6)
TA-8 (GT Site)	0.0 (0.8)	0.6 (0.4)	0.51 (0.16)	2.74 (0.54)	0.002 (0.002)	0.025 (0.004)	0.011 (0.004)	7.9 (5.2)	6.9 (1.6)	3.5 (0.8)
Near TA-49 (BNP)	0.3 (0.8)	0.2 (0.6)	0.58 (0.18)	4.44 (0.88)	0.000 (0.002)	0.022 (0.004)	0.008 (0.004)	7.0 (4.2)	7.8 (1.8)	3.7 (0.8)
East Airport	0.7 (0.8)	0.1 (0.4)	0.17 (0.10)	3.55 (0.72)	0.002 (0.002)	0.023 (0.004)	0.007 (0.004)	5.1 (2.0)	5.1 (1.2)	3.6 (0.8)
West Airport	0.5 (0.8)	0.3 (0.8)	0.33 (0.12)	4.13 (0.82)	0.004 (0.002)	0.275 (0.020)	0.048 (0.008)	2.9 (2.4)	8.0 (2.0)	3.5 (0.8)
North Mesa	0.4 (0.8)	0.6 (0.4)	0.47 (0.16)	3.91 (0.78)	0.002 (0.002)	0.026 (0.004)	0.010 (0.004)	7.8 (5.4)	5.6 (1.4)	4.0 (0.8)
Sportsman's Club	0.3 (0.8)	0.2 (0.6)	0.73 (0.20)	4.25 (0.86)	0.001 (0.002)	0.041 (0.006)	0.012 (0.100)	6.7 (3.0)	6.7 (1.6)	3.7 (0.8)
Tsankawi/ PM-1	0.6 (0.8)	0.1 (0.6)	0.25 (0.12)	4.36 (0.88)	0.001 (0.002)	0.009 (0.002)	0.008 (0.004)	7.4 (4.2)	4.8 (1.2)	4.6 (1.0)
White Rock (East)	0.3 (0.8)	0.3 (0.6)	0.23 (0.10)	2.77 (0.56)	0.001 (0.002)	0.007 (0.002)	0.004 (0.002)	6.3 (5.8)	5.6 (1.4)	3.5 (0.8)
San Ildefonso	0.6 (0.8)	0.1 (0.6)	0.25 (0.08)	2.36 (0.48)	0.002 (0.002)	0.015 (0.004)	0.006 (0.002)	–0.2 (0.0)	3.8 (0.8)	3.4 (0.8)
Mean (±2SD)	0.5 (0.6)	0.3 (0.4)	0.37 (0.37)	3.44 (1.84)	0.002 (0.002)	0.046 (0.162)	0.012 (0.026)	5.5 (5.2)	5.8 (2.9)	3.6 (1.1)
On-Site Stations:										
TA-16 (S-Site)	0.5 (0.8)	0.3 (0.4)	0.68 (0.18)	5.13 (1.02)	0.001 (0.002)	0.025 (0.004)	0.010 (0.004)	7.1 (4.6)	7.2 (1.8)	3.9 (0.8)
TA-21 (DP-Site)	0.7 (0.8)	0.1 (0.4)	0.08 (0.06)	2.55 (0.52)	0.004 (0.004)	0.015 (0.006)	0.007 (0.008)	6.5 (5.2)	5.5 (1.4)	2.9 (0.6)
Near TA-33	1.1 (0.8)	0.2 (0.4)	0.71 (0.18)	3.17 (0.64)	0.001 (0.002)	0.011 (0.002)	0.010 (0.004)	6.4 (4.4)	6.9 (1.6)	3.4 (0.8)
TA-50	0.8 (0.8)	0.2 (0.6)	0.25 (0.10)	3.64 (0.72)	0.004 (0.002)	0.097 (0.010)	0.019 (0.004)	4.5 (1.8)	3.9 (1.0)	3.2 (0.8)
TA-51	0.5 (0.8)	0.3 (0.4)	0.31 (0.10)	3.22 (0.64)	0.001 (0.002)	0.012 (0.004)	0.005 (0.002)	4.4 (2.4)	3.2 (0.8)	3.1 (0.8)
West of TA-53	0.5 (0.8)	0.3 (0.4)	0.19 (0.10)	3.26 (0.66)	0.001 (0.002)	0.026 (0.008)	0.004 (0.006)	7.0 (3.8)	5.2 (1.2)	3.1 (0.8)
East of TA-53	0.9 (0.8)	0.3 (0.4)	0.40 (0.12)	2.49 (0.50)	0.002 (0.002)	0.025 (0.006)	0.007 (0.002)	6.6 (3.0)	4.7 (1.2)	3.3 (0.8)
East of TA-54	2.8 (0.8)	0.3 (0.4)	0.45 (0.14)	2.44 (0.48)	0.004 (0.002)	0.053 (0.008)	0.016 (0.010)	2.4 (1.0)	2.5 (0.6)	3.8 (0.8)
Potrillo Drive/ TA-36	0.5 (0.8)	0.3 (0.4)	0.34 (0.10)	2.62 (0.52)	0.001 (0.002)	0.015 (0.004)	0.005 (0.002)	4.6 (2.0)	4.3 (1.0)	2.8 (0.6)
Near Test Well DT-9	0.4 (0.8)	0.0 (0.6)	0.42 (0.12)	2.63 (0.52)	0.002 (0.002)	0.013 (0.004)	0.008 (0.004)	3.4 (1.2)	3.1 (0.8)	3.3 (0.8)
R-Site Road East	0.6 (0.8)	0.5 (0.6)	0.34 (0.10)	4.42 (0.88)	0.000 (0.002)	0.012 (0.004)	0.003 (0.002)	4.5 (1.8)	4.4 (1.0)	2.9 (0.6)
Two-Mile Mesa	0.4 (0.8)	0.2 (0.4)	0.46 (0.14)	3.71 (0.74)	0.001 (0.002)	0.017 (0.004)	0.007 (0.004)	3.9 (2.2)	4.0 (1.0)	3.0 (0.8)
Mean (±2SD)	0.8 (1.3)	0.3 (0.2)	0.39 (0.36)	3.27 (1.68)	0.002 (0.003)	0.027 (0.050)	0.008 (0.010)	5.1 (3.1)	4.6 (2.9)	3.2 (0.7)

[a](±2 counting uncertainty); values are the uncertainty of the analytical result at the 95% confidence level.
[b]See Appendix B for an explanation of the presence of negative values.
[c]Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev) from Fresquez et al. (1996a).
[d]SAL (Los Alamos National Laboratory Screening Action Level) from Fresquez et al. (1996a).
[e]Equivalent to the SAL of 260 pCi/dry g soil at 12% moisture.
[f] NA = not applicable.

Table 6.2. Total Recoverable Trace and Heavy Metals (μg/g dry) in Soils Collected in 1996[a,b]

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb[c]	Se	Tl[c]
Off-Site Regional (Background) Stations:												
Rio Chama	0.13	2.3	60.3	0.32	0.13	7.43	0.03	5.23	11.60		0.4	
Embudo	0.13	1.7	103.0	0.46	0.13	8.59	0.03	6.87	7.21		0.3	
Santa Cruz	0.13	4.6	194.0	0.77	0.13	12.00	0.03	9.10	13.90		0.5	
Cochiti	0.13	3.0	103.0	0.43	0.13	6.55	0.03	5.59	8.32		0.4	
Bernalillo	0.13	4.1	145.0	0.55	0.13	7.78	0.03	7.99	10.90		0.4	
Jemez	0.13	5.7	108.6	0.46	0.13	6.93	0.03	5.52	6.96		0.5	
Mean(±2SD)	0.13 (0.0)	3.3 (3.1)	116 (84.8)	0.49 (0.28)	0.13 (0.0)	8.24 (3.63)	0.03 (0.0)	6.57 (2.96)	9.44 (5.42)		0.4 (0.2)	
RSRL[d]	2.09	6.04	194	0.74	0.20	14.8	0.02	10.9	14.40		0.6	
SAL[e]	400	6	5,600	0.9	80	400	24	1,600	500		400	
Off-Site Perimeter Stations:												
Otowi	0.13	1.8	97.0	0.435	0.13	8.37	0.03	5.69	7.20		0.3	
TA-8 (GT Site)	0.13	2.0	118.3	0.511	0.13	5.49	0.05	4.13	11.50		0.5	
TA-49 (BNP)	0.13	3.2	129.0	0.693	0.13	7.49	0.05	4.32	11.90		0.3	
East Airport	0.13	2.4	83.0	0.738	0.13	10.6	0.03	5.74	12.40		0.4	
West Airport	0.13	2.3	110.0	0.616	0.71	8.41	0.03	6.96	23.40		0.2	
North Mesa	0.13	2.9	99.1	0.655	0.13	10.0	0.03	5.52	11.70		0.4	
Sportsman's Club	0.13	3.9	91.5	0.515	0.13	7.79	0.03	4.28	10.10		0.4	
Tsankawi/ PM-1	0.13	2.1	64.4	0.906	0.13	5.41	0.03	3.82	15.50		0.5	
White Rock (East)	0.13	3.4	122.0	1.100	0.13	9.79	0.03	6.49	16.05		0.4	
San Ildefonso	0.13	1.7	41.7	0.471	0.13	4.36	0.03	2.85	7.28		0.2	
Mean (±2SD)	0.13 (0.0)	2.7 (1.5)	95.4 (57.5)	0.689 (0.409)	0.19 (0.39)	7.70 (4.47)	0.03 (0.02)	4.90 (2.7)	13.31 (9.20)		0.4 (0.2)	
On-Site Stations:												
TA-16 (S-Site)	0.13	1.6	187.0	0.825	0.13	5.72	0.03	4.45	9.31		0.4	
TA-21 (DP-Site)	0.13	3.1	100.0	0.827	0.13	4.41	0.03	6.18	38.90		0.3	
Near TA-33	0.13	2.4	101.0	0.818	0.13	9.58	0.03	7.99	15.00		0.3	
TA-50	0.13	2.1	77.1	0.470	0.13	4.03	0.03	3.86	10.30		0.3	
TA-51	0.13	3.2	111.0	0.606	0.13	6.96	0.03	5.32	13.70		0.3	
West of TA-53	0.13	2.7	96.0	0.651	0.13	8.12	0.03	6.39	11.10		0.4	
East of TA-53	0.13	2.1	46.8	0.452	0.13	3.95	0.03	2.88	10.00		0.3	
East of TA-54	0.13	1.6	47.2	0.520	0.13	3.46	0.03	2.63	8.85		0.1	
Potrillo Drive/ TA-36	0.13	2.5	73.6	0.463	0.13	5.95	0.02	5.34	9.32		0.5	
Near Test Well DT-9	0.13	2.1	118.0	0.873	0.13	7.57	0.03	6.40	10.10		0.4	
R-Site Road	0.13	3.1	135.5	0.869	0.13	10.01	0.03	5.46	12.00		0.5	
Two-Mile Mesa	0.13	4.2	47.3	0.499	0.13	3.38	0.03	1.98	8.95		0.4	
Mean (±2SD)	0.13 (0.0)	2.6 (1.5)	95.0 (82.3)	0.656 (0.349)	0.13 (0.0)	6.10 (4.70)	0.03 (0.01)	4.91 (3.59)	13.13 (16.68)		0.4 (0.2)	

[a] Analysis by EPA Method 3051 for total recoverable metals.
[b] All less-than values were reduced by one-half concentration. (Gilbert 1987).
[c] Sb and Tl were not analyzed in FY96.
[d] Regional Statistical Reference Level; this is the upper-limit background concentration (mean + 2 std dev) from Fresquez et al. (1996a).
[e] SAL (Los Alamos National Laboratory Screening Action Level).

Table 6-3. Total Effective Dose Equivalent (TEDE) from Living on Soils Collected in 1996

Total Effective Dose Equivalent[a] (mrem/yr)	
	Maximum Consumption[b]
Regional (Background)	1.6 (±2.6)[c]
Perimeter	2.4 (±2.7)[c]
On Site	2.4 (±1.8)[c]
1974–1996 Regional	2.4 (±3.6)[c]

[a] Based on RESRAD version 5.61 and residential scenario [Fresquez et al., 1996a].

[b] Maximum consumption rate is 160 kg/yr (352 lbs/yr) for fruits and vegetables (NRC 1977) and 44 g/yr for soil (Fresquez et al., 1996a).

[c] ±2 sigma in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

Table 6-4. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1996 Growing Season[a]

	^{3}H (pCi/mL)	^{137}Cs (10^{-3} pCi/dry g)	^{90}Sr (10^{-3} pCi/g dry)	^{tot}U (ng/g dry)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)	^{241}Am (10^{-5} pCi/g dry)
Off-Site Regional (Background) Stations							
Española/Santa Fe/Jemez:							
cucumbers	0.22 (0.28)[b]	50.5 (151.6)	66.7 (26.6)	2.7 (2.7)	4.0 (10.6)	25.3 (21.3)	70.5 (45.2)
tomatoes	0.36 (0.28)	–9.0 (48.0)[c]	0.0 (20.0)	1.0 (2.0)	0.4 (8.0)	14.0 (14.0)	10.0 (12.0)
corn	0.23 (0.28)	–9.6 (30.7)	6.4 (12.8)	1.3 (1.3)	–1.3 (3.8)	9.0 (7.7)	12.2 (10.2)
corn	–0.07 (0.28)	58.9 (175.4)	12.8 (12.8)	2.6 (1.3)	–3.8 (1.3)	4.5 (9.0)	16.6 (16.6)
corn	0.43 (0.28)	–22.4 (30.7)	38.4 (12.8)	3.8 (1.3)	1.3 (5.1)	3.8 (5.1)	3.8 (11.5)
cucumbers	0.18 (0.28)	46.6 (138.3)	66.5 (26.6)	10.6 (2.7)	–8.0 (2.7)	10.6 (13.3)	4.0 (21.3)
tomatoes	–0.27 (0.27)	–12.0 (48.0)	20.0 (40.0)	2.0 (2.0)	3.0 (8.0)	12.0 (14.0)	6.0 (18.0)
pinto bean	0.11 (0.14)	7.5 (11.0)	65.0 (10.0)	2.5 (0.5)	–0.5 (0.2)	1.0 (1.0)	7.0 (3.0)
squash	–0.30 (0.1)	43.5 (66.0)	15.0 (30.0)	6.0 (1.5)	–7.2 (2.7)	2.7 (3.6)	28.5 (10.5)
squash	–0.20 (0.1)	107.0 (27.0)	40.0 (30.0)	7.0 (1.0)	2.0 (4.0)	19.0 (8.0)	21.0 (10.0)
squash	–0.50 (0.1)	–31.2 (28.8)	36.0 (24.0)	6.0 (1.2)	5.0 (4.0)	10.0 (5.0)	18.0 (7.2)
squash	0.50 (0.1)	64.8 (97.2)	36.0 (24.0)	7.2 (1.2)	13.2 (7.7)	16.5 (8.8)	40.8 (28.8)
corn	–0.21 (0.14)	8.7 (3.0)	15.0 (12.0)	1.2 (0.3)	–0.3 (1.2)	1.2 (1.8)	9.0 (3.9)
corn	–0.24 (0.14)	13.8 (4.0)	14.0 (6.0)	0.8 (0.2)	0.3 (1.5)	5.7 (2.7)	3.2 (1.4)
corn	0.32 (0.14)	5.1 (7.5)	3.0 (6.0)	0.9 (0.3)	6.0 (2.7)	6.3 (2.4)	7.5 (2.7)
corn	0.49 (0.14)	11.1 (16.8)	33.0 (6.0)	0.9 (0.3)	5.1 (4.5)	–0.9 (1.5)	–3.3 (8.1)
Mean (±2 SD)	0.07 (0.64)[d]	20.8 (74.9)	29.2 (44.5)	3.5 (5.9)	1.2 (10.3)	8.8 (14.5)	15.9 (36.3)
RSRL[e]	16.9	690	75.6	38.2	35.4	67.9	52.2
Off-Site Perimeter Stations							
Los Alamos:							
squash	0.51 (0.28)	104.8 (55.0)	91.7 (26.2)	2.6 (2.6)	5.2 (13.1)	15.7 (18.3)	79.9 (55.0)
peaches	–0.32 (0.27)	–3.8 (36.5)	7.6 (15.2)	1.5 (1.5)	0.8 (4.6)	1.5 (6.1)	–1.5 (7.6)
tomatoes	0.01 (0.27)	24.0 (74.0)	10.0 (20.0)	1.0 (2.0)	–6.0 (10.0)	14.0 (18.0)	2.0 (24.0)
apples	0.05 (0.28)	–6.5 (17.3)	57.6 (21.6)	1.4 (0.7)	1.4 (5.8)	9.0 (7.9)	–1.1 (17.3)
squash	–0.18 (0.27)	95.6 (55.0)	52.4 (26.2)	2.6 (2.6)	5.2 (10.5)	7.9 (13.1)	13.1 (26.2)
lettuce	0.14 (0.28)	37.5 (115.0)	525.0 (100.0)	95.0 (20.0)	–2.5 (25.0)	195.0 (90.0)	587.5 (225.0)
squash	0.22 (0.28)	107.4 (52.4)	144.1 (26.2)	2.6 (2.6)	–2.6 (13.1)	28.8 (26.2)	369.4 (99.6)
Mean (±2 SD)	0.06 (0.54)	51.3 (100.9)	126.9 (363.6)	15.2 (70.4)	0.2 (8.4)	38.8 (138.8)	149.9 (469.7)

Table 6-4. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1996 Growing Season[a] (Cont.)

	^{3}H (pCi/mL)	^{137}Cs (10^{-3} pCi/dry g)	^{90}Sr (10^{-3} pCi/g dry)	^{tot}U (ng/g dry)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)	^{241}Am (10^{-5} pCi/g dry)
White Rock/Pajarito Acres:							
green beans	0.01 (0.28)	24.2 (15.6)	31.2 (31.2)	2.3 (1.6)	–3.9 (1.6)	1.6 (4.7)	58.5 (25.0)
squash	0.38 (0.28)	23.6 (70.7)	26.2 (52.4)	6.6 (2.6)	–5.2 (15.7)	24.9 (31.4)	56.3 (41.9)
squash	–0.12 (0.28)	34.1 (104.8)	39.3 (26.2)	3.9 (2.6)	–3.9 (2.6)	22.3 (21.0)	31.4 (23.6)
corn	0.30 (0.28)	12.2 (37.1)	0.0 (12.8)	2.6 (1.3)	–1.3 (3.8)	10.9 (9.0)	5.1 (12.8)
tomatoes	0.51 (0.28)	–12.0 (48.0)	10.0 (20.0)	1.0 (2.0)	2.0 (10.0)	15.0 (14.0)	26.0 (22.0)
green beans	0.25 (0.28)	6.2 (18.7)	7.8 (15.6)	2.3 (1.6)	0.3 (7.8)	6.2 (9.4)	20.3 (14.0)
tomatoes	–0.07 (0.28)	33.0 (20.0)	0.0 (20.0)	2.0 (2.0)	6.0 (8.0)	5.0 (8.0)	9.0 (10.0)
Mean (±2SD)	0.18 (0.48)	17.3 (32.9)	16.4 (31.5)	3.0 (3.6)	–0.9 (7.9)	12.3 (17.8)	29.5 (42.2)
Cochiti:							
cucumbers	0.32 (0.28)	27.9 (82.46)	305.9 (106.4)	78.5 (16.0)	9.3 (16.0)	13.3 (21.3)	57.2 (37.2)
squash	0.57 (0.29)	52.4 (157.2)	131.0 (183.4)	3.9 (2.6)	1.3 (5.2)	10.5 (13.1)	7.9 (36.7)
squash	0.58 (0.29)	65.5 (196.5)	–104.8 (104.8)	5.2 (2.6)	–7.9 (26.2)	24.9 (36.7)	23.6 (26.2)
tomatoes	0.26 (0.28)	3.0 (8.0)	190.0 (360.0)	2.0 (2.0)	3.0 (6.0)	18.0 (12.0)	20.0 (14.0)
green beans	0.46 (0.28)	12.5 (9.36)	156.0 (171.6)	3.1 (1.6)	1.6 (10.9)	22.6 (18.7)	27.3 (13.7)
corn	0.52 (0.28)	9.0 (26.88)	–19.2 (25.6)	2.6 (1.3)	1.9 (6.4)	5.8 (9.0)	41.0 (21.8)
Mean (±2SD)	0.45 (0.27)	28.4 (50.8)	109.8 (296.9)	15.9 (61.4)	1.5 (11.0)	15.9 (14.6)	29.5 (34.6)
Pueblo of San Ildefonso:							
parsley	0.35 (0.28)	48.4 (24.2)	242.0 (110.0)	27.5 (6.6)	15.4 (13.2)	86.9 (26.4)	72.6 (35.2)
cucumbers	–0.25 (0.27)	75.8 (228.96)	133.0 (160.0)	5.3 (2.7)	0.0 (10.6)	12.0 (13.3)	22.6 (21.3)
squash	0.45 (0.28)	128.4 (55.02)	170.3 (183.4)	9.2 (2.6)	3.9 (10.5)	2.6 (10.5)	27.3 (21.3)
tomatoes	0.17 (0.28)	65.0 (32.0)	10.0 (100.0)	2.0 (2.0)	–2.0 (10.0)	27.0 (20.0)	4.0 (20.0)
corn	–0.06 (0.28)	–3.2 (30.72)	115.2 (294.4)	1.3 (1.3)	2.6 (3.8)	3.2 (5.1)	6.4 (6.4)
lettuce	0.03 (0.28)	115.0 (350.0)	400.0 (250.0)	1.0 (0.5)	17.5 (25.0)	25.0 (35.0)	10.0 (20.0)
green beans	0.50 (0.28)	24.2 (71.76)	101.4 (62.4)	3.1 (1.6)	1.6 (9.4)	7.8 (9.4)	9.4 (12.5)
Mean (±2SD)	0.17 (0.56)	64.8 (93.9)	167.4 (248.6)	7.1 (18.9)	5.6 (15.4)	23.5 (59.2)	21.8 (48.0)

Table 6-4. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1996 Growing Season[a] (Cont.)

	^{3}H (pCi/mL)	^{137}Cs (10^{-3} pCi/dry g)		^{90}Sr (10^{-3} pCi/g dry)		^{tot}U (ng/g dry)		^{238}Pu (10^{-5} pCi/dry g)		$^{239,240}Pu$ (10^{-5} pCi/dry g)		^{241}Am (10^{-5} pCi/g dry)	
On-Site Stations													
LANL:													
apples	1.77 (0.30)	2.5	(2.88)	–7.2	(7.2)	0.4	(0.7)	1.1	(3.6)	4.3	(5.0)	16.9	(8.6)
peaches	0.31 (0.28)	2.3	(6.08)	38.0	(30.4)	2.3	(1.5)	0.8	(6.1)	17.5	(13.7)	27.4	(13.7)
peaches	2.61 (0.31)	36.5	(16.72)	7.6	(15.2)	1.5	(1.5)	1.5	(7.6)	–0.8	(7.6)	1.5	(7.6)
necterines	0.19 (0.28)	–1.6	(37.44)	15.6	(15.6)	0.8	(1.6)	–7.8	(78.0)	0.0	(39.0)	76.4	(48.4)
pears	0.38 (0.28)	–3.4	(14.88)	–6.2	(6.2)	0.9	(0.6)	0.0	(1.9)	1.9	(2.5)	25.1	(11.8)
crab apples	0.68 (0.29)	–4.4	(19.2)	612.0	(1016.0)	1.2	(0.8)	0.8	(2.4)	1.6	(2.4)	14.8	(8.8)
Mean (±2SD)	0.99 (1.96)	5.3	(31.1)	110.0	(493.0)	1.2	(1.3)	–0.6	(7.1)	4.1	(13.6)	27.0	(51.7)

[a]There are no concentration guides for produce; however, all mean radionuclide contents in produce collected from LANL, with the exception of ^{3}H, and perimeter areas were not significantly higher from regional background using a nonparametric Wilcoxon Rank Sum test at the 0.05 probability level (Gilbert 1987).
[b](±2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.
[c]See Appendix B, for an explanation of the presence of negative values.
[d](±2 standard deviation).
[e]Regional Statistical Reference Level; this is the upper-limit background concentration [mean + 2 std dev] from 1981 to 1994 data.

Table 6-5. Total Committed Effective Dose Equivalent and Maximum Annual CEDE[a] from the Ingestion of Produce Collected during 1995 and 1996

	1996		1995	
Background	**CEDE (mrem)**	**Max CEDE (mrem)**	**CEDE (mrem)**	**Max CEDE (mrem)**
Española, Santa Fe, Jemez				
# of Produce Samples	16		6	
Maximum Consumption[b]	0.19 (±0.74)[c]	0.93	0.38 (±0.86)[c]	1.2
Off-Site:				
Cochiti Pueblo				
# of Produce Samples	6		5	
Maximum Consumption[b]	0.24 (±0.56)[c]	0.80	0.20 (±0.45)[c]	0.65
White Rock/Pajarito Acres				
# of Produce Samples	7		6	
Maximum Consumption[b]	0.77 (±0.15)[c]	0.22	0.078 (±0.18)[c]	0.26
Los Alamos Townsite				
# of Produce Samples	7		6	
Maximum Consumption[b]	0.38 (±1.3)[c]	1.7	0.12 (±0.23)[c]	0.35
Pueblo of San Ildefonso				
# of Produce Samples	7		5	
Maximum Consumption[b]	0.81 (±2.3)[c]	3.2	0.31 (±0.54)[c]	0.85
On-Site:[d]				
# of Produce Samples	6		5	
Maximum Consumption[b]	0.61 (±2.7)[c]	3.3	0.54 (±1.6)[c]	2.2

[a] Based on DOE dose conversion factors (DOE 1988); maximum annual CEDE is the average CEDE + 2 sigma.
[b] Maximum consumption rate for produce is 160 kg/yr [NRC 1977].
[c] ±2 sigma of the data in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.
[d] Calculations presented here are for comparison purposes only. Produce grown on-site is not available for consumption.

Table 6-6. Total Recoverable Trace and Heavy Metals (μg/g dry) in Produce Collected in 1996[a]

	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl
Off-Site Regional (Background) Stations												
Española/Santa Fe/Jemez:												
cucumber	0.27[b]	1.10	18.40	0.06[b]	0.12[b]	0.48	0.05[b]	2.45	1.3	0.15[b]	0.2	0.15[b]
tomato	0.27[b]	0.10[b]	3.72	0.06[b]	0.32	4.35	0.05[b]	28.60	7.8	0.15[b]	0.1[b]	0.15[b]
corn	0.27[b]	0.10[b]	1.08	0.06[b]	0.12[b]	0.13[b]	0.05[b]	6.18	21.5	0.15[b]	0.1[b]	0.15[b]
corn	0.27[b]	0.10[b]	0.40	0.06[b]	0.12[b]	0.13[b]	0.05[b]	6.86	25.7	0.15[b]	0.1[b]	0.15[b]
corn	0.58	0.10[b]	0.35	0.06[b]	0.12[b]	0.13[b]	0.05[b]	4.02	26.4	0.15[b]	0.3	0.15[b]
cucumber	0.27[b]	0.10[b]	12.30	0.06[b]	0.12[b]	0.26	0.05[b]	0.36[b]	2.1	0.15[b]	0.4	0.15[b]
tomato	0.27[b]	0.10[b]	12.70	0.06[b]	0.12[b]	4.03	0.05[b]	20.60	3.6	0.15[b]	0.3	0.15[b]
Mean	0.31	0.24	6.99	0.06	0.15	1.36	0.05	9.87	12.6	0.15	0.2	0.15
(±2 std dev)	(0.23)	(0.76)	(14.70)	(0.00)	(0.15)	(3.88)	(0.00)	(21.11)	(22.9)	(0.00)	(0.2)	0.00
RSRL[c]	1.38	0.66	27.43	0.53	0.46	3.98	0.06	23.50	22.0	0.18	0.3	0.20
Off-Site Perimeter Stations												
Los Alamos Townsite:												
squash	0.27[b]	0.10[b]	13.70	0.06[b]	0.12[b]	0.52	0.05[b]	1.37	1.1	0.15[b]	0.1[b]	0.15[b]
peach	0.58	0.10[b]	1.91	0.06[b]	0.12[b]	1.51	0.05[b]	5.09	2.8	0.15[b]	0.1[b]	0.15[b]
tomato	0.27[b]	0.10[b]	3.28	0.06[b]	0.12[b]	2.06	0.05[b]	17.00	1.9	0.40	0.1[b]	0.15[b]
apple	0.27[b]	0.10[b]	2.27	0.06[b]	0.12[b]	0.50	0.05[b]	2.76	3.3	0.15[b]	0.1[b]	0.15[b]
squash	0.27[b]	0.10[b]	9.75	0.06[b]	0.13[b]	0.38	0.05[b]	7.50	0.6	0.15[b]	0.3	0.15[b]
lettuce	0.27[b]	0.10[b]	27.70	0.06[b]	0.12[b]	0.63	0.05[b]	1.36	1.4	0.15[b]	0.4	0.15[b]
squash	0.56	0.10[b]	12.80	0.06[b]	0.12[b]	0.13[b]	0.05[b]	2.49	1.8	0.15[b]	0.2	0.15[b]
Mean	0.36	0.10	10.20	0.06	0.12	0.82	0.05	5.37	1.8	0.19	0.2	0.15
(±2 std dev)	(0.29)	(0.00)	(18.35)	(0.00)	(0.01)	(1.39)	(0.00)	(11.17)	(1.9)	(0.19)	(0.2)	(0.00)
White Rock /Pajarito Acres:												
green bean	0.27[b]	0.10[b]	16.10	0.06[b]	0.12[b]	0.13[b]	0.05[b]	2.36	6.3	0.15[b]	0.2	0.15[b]
squash	0.27[b]	0.10[b]	10.00	0.06[b]	0.12[b]	0.13[b]	0.05[b]	3.66	1.6	0.15[b]	0.3	0.15[b]
squash	0.56	0.10[b]	7.10	0.06[b]	0.12[b]	0.33	0.05[b]	1.88	1.1	0.15[b]	0.4	0.15[b]
corn	0.27[b]	0.10[b]	0.26	0.06[b]	0.12[b]	0.37	0.05[b]	6.26	48.0	0.40	0.1[b]	0.15[b]
tomato	0.27[b]	0.10[b]	4.59	0.06[b]	0.12[b]	3.09	0.05[b]	16.30	32.7	0.15[b]	0.1[b]	0.15[b]
green bean	0.27[b]	0.10[b]	14.20	0.06[b]	0.12[b]	0.13[b]	0.05[b]	3.58	2.2	0.15[b]	0.2	0.15[b]
tomato	0.27[b]	0.10[b]	2.25	0.06[b]	0.12[b]	0.54	0.05[b]	3.93	5.1	0.15[b]	0.2	0.15[b]
Mean	0.31	0.10	7.79	0.06	0.12	0.67	0.05	5.42	13.9	0.19	0.2	0.15
(±2 std dev)	(0.22)	(0.00)	(11.92)	(0.00)	(0.00)	(2.15)	(0.00)	(10.00)	(37.4)	(0.19)	(0.2)	(0.00)

Table 6-6. Total Recoverable Trace and Heavy Metals (μg/g dry) in Produce Collected in 1996[a] (Cont.)

	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl
Cochiti/Peña Blanca/Santo Domingo:												
cucumber	0.16[b]	0.10[b]	7.40	0.06[b]	0.12[b]	0.23	0.05[b]	0.36[b]	2.9	0.15[b]	0.2	0.15[b]
squash	0.16[b]	0.10[b]	3.97	0.06[b]	0.12[b]	0.44	0.05[b]	0.36[b]	1.8	0.15[b]	0.3	0.15[b]
squash	0.16[b]	0.10[b]	3.55	0.06[b]	0.12[b]	0.78	0.05[b]	0.36[b]	1.3	0.15[b]	0.1[b]	0.15[b]
tomato	0.16[b]	0.10[b]	5.97	0.06[b]	0.12[b]	1.79	0.10	13.00	1.1	0.15[b]	0.1[b]	0.15[b]
green bean	0.16[b]	0.10[b]	8.22	0.06[b]	0.12[b]	0.17	0.05[b]	0.36[b]	4.4	0.15[b]	0.2	0.15[b]
corn	0.16[b]	0.10[b]	0.40	0.06[b]	0.12[b]	0.17	0.05[b]	0.36[b]	9.0	0.15[b]	0.4	0.15[b]
Mean	0.16	0.10	4.92	0.06	0.12	0.60	0.06	2.47	3.4	0.15	0.2	0.15
(±2 std dev)	(0.00)	(0.00)	(5.75)	(0.00)	(0.00)	(1.26)	(0.04)	(10.32)	(6.0)	(0.00)	(0.2)	(0.00)
Pueblo of San Ildefonso:												
parsley	0.16[b]	0.15[b]	29.90	0.06[b]	0.12[b]	0.08[b]	0.05[b]	0.36[b]	2.1	0.15[b]	0.3	0.15[b]
cucumber	0.16[b]	0.15[b]	18.10	0.06[b]	0.12[b]	0.08[b]	0.05[b]	0.36[b]	1.0	0.15[b]	0.3	0.15[b]
squash	0.16[b]	0.15[b]	8.70	0.06[b]	0.12[b]	0.23	0.05[b]	0.36[b]	1.5	0.15[b]	0.1[b]	0.15[b]
tomato	0.16[b]	0.15[b]	5.30	0.06[b]	0.12[b]	0.40	0.05[b]	1.50	2.4	0.15[b]	0.3	0.15[b]
corn	0.16[b]	0.40	0.82	0.06[b]	0.12[b]	0.08[b]	0.10	3.60	27.1	0.15[b]	0.7	0.15[b]
Mean	0.16	0.20	12.56	0.06	0.12	0.17	0.06	1.24	6.8	0.15	0.3	0.15
(±2 std dev)	(0.00)	(0.22)	(23.17)	(0.00)	(0.00)	(0.28)	(0.04)	(2.82)	(22.7)	(0.00)	(0.4)	(0.00)
On-Site Stations												
LANL:												
apple	0.16[b]	0.10[b]	3.33	0.06[b]	0.12[b]	0.08[b]	0.10	0.36[b]	6.2	0.15[b]	0.1[b]	0.15[b]
peach	0.16[b]	0.10[b]	2.49	0.06[b]	0.12[b]	0.22	0.05[b]	0.36[b]	4.3	0.15[b]	0.2	0.15[b]
peach	0.16[b]	0.10[b]	6.28	0.06[b]	0.12[b]	0.08[b]	0.05[b]	0.85	2.9	0.15[b]	0.1[b]	0.15[b]
nectarine	0.16[b]	0.50	4.82	0.06[b]	0.12[b]	0.08[b]	0.05[b]	1.43	4.4	0.15[b]	0.1[b]	0.15[b]
pear	0.16[b]	0.10[b]	6.58	0.06[b]	0.12[b]	0.08[b]	0.05[b]	1.03	11.6	0.15[b]	0.1[b]	0.15[b]
crab apple	0.16[b]	0.10[b]	16.70	0.06[b]	0.12[b]	0.08[b]	0.10	1.10	12.6	0.15[b]	0.3	0.15[b]
Mean	0.16	0.17	6.70	0.06	0.12	0.10	0.07	0.86	7.0	0.15	0.2	0.15
(±2 std dev)	(0.00)	(0.33)	(10.31)	(0.00)	(0.00)	(0.11)	(0.05)	(0.85)	(8.2)	(0.00)	(0.2)	(0.00)

[a] Analysis by EPA Method 3051 for total recoverable metals.
[b] Less than values were converted to one-half the concentration. (Gilbert 1987).
[c] Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev) from 1994, 1995, and 1996 data.

Table 6-7. Radionuclides in Honey Collected from Off-Site Perimeter and Regional (Background) Beehives during 1996

Radioisotope	Perimeter: Los Alamos Spruce St.	Perimeter: Los Alamos 42nd St.	Perimeter: Los Alamos Arizona St.	Perimeter: White Rock/Pajarito Acres	Regional (Background)	RSRL[e]
^{3}H (pCi/mL)[a]	0.03 (0.28)[b]	0.41 (0.28)	1.27 (0.38)	0.01 (0.26)	0.16 (0.30)	5.25
^{228}Ac (pCi/L)	8.4 (25.2)	26.0 (13.0)	1.72 (5.16)	34.9 (15.8)	15.1 (8.8)	23.90
^{57}Co (pCi/L)	–1.1 (1.52)[c]	–0.16 (1.52)	–0.16 (1.52)	0.46 (1.4)	2.5 (1.12)	154.68
^{58}Co (pCi/L)	–1.88 (1.52)	10.2 (30.6)	–4.6 (1.52)	–1.94 (1.52)	–1.66 (1.52)	–0.14
^{60}Co (pCi/L)	8.58 (4.16)	5.24 (3.0)	12.3 (5.2)	4.18 (2.64)	0.36 (1.08)	2.66
^{152}Eu (pCi/L)[d]						9.69
^{40}K (pCi/L)	524.0 (144.0)	922.0 (220.0)	960.0 (228.0)	499.0 (140.0)	499.0 (140.0)	740.00
^{7}Be (pCi/L)	64.1 (33.6)	48.8 (30.0)	70.0 (210.0)	49.4 (28.4)	53.3 (30.6)	887.27
^{214}Bi (pCi/L)	–4.8 (1.52)	–5.8 (1.52)	–3.4 (1.52)	–2.6 (1.52)	–4.8 (1.52)	–3.28
^{22}Na (pCi/L)[d]						70.12
^{54}Mn (pCi/L)	1.6 (0.0)	–0.02 (0.0)	1.74 (1.48)	–0.1 (0.0)	0.86 (0.0)	89.28
^{83}Rb (pCi/L)[d]						248.32
^{137}Cs (pCi/L)	4.8 (14.4)	–0.14 (1.6)	1.12 (3.36)	4.2 (12.6)	3.0 (9.0)	305.28
^{238}Pu (pCi/L)	0.001 (0.008)	–0.005 (0.022)	–0.004 (0.004)	0.004 (0.012)	0.042 (0.028)	0.07
^{239}Pu (pCi/L)	0.027 (0.022)	0.002 (0.012)	0.011 (0.018)	0.023 (0.020)	0.019 (0.020)	0.12
^{212}Pb (pCi/L)	5.66 (2.84)	–1.1 (0.0)	–1.22 (0.0)	–0.18 (0.0)	3.82 (2.16)	5.98
^{214}Pb (pCi/L)	2.0 (6.0)	–2.4 (1.52)	0.14 (0.44)	–1.86 (1.52)	0.58 (1.72)	2.30
^{241}Am (pCi/L)	0.004 (0.019)	0.044 (0.034)	0.025 (0.075)	0.016 (0.026)	0.019 (0.025)	0.05
^{90}Sr (pCi/L)	3.9 (2.8)	5.3 (3.0)	8.2 (3.8)	5.9 (5.8)	1.8 (4.4)	5.04
^{208}Tl (pCi/L)	–0.22 (0.0)	0.98 (0.0)	4.6 (0.0)	5.14 (2.64)	2.34 (1.68)	4.02
^{tot}U (µg/L)	1.13 (0.22)	0.27 (0.06)	0.41 (0.08)	0.92 (0.18)	0.49 (0.10)	4.99

[a] pCi/mL of honey moisture; honey contains approximately 18% water and has a density of 1,860 g/L.
[b] (±2 counting uncertainty); values are the uncertainty in the analytical result at the 95% confidence level.
[c] See Appendix B for an explanation of the presence of negative values.
[d] Lost in analysis.
[e] Regional Statistical Reference Level; this is the upper-limit background concentration (mean + 2 std dev) from Fresquez et al., 1996b.

Table 6-8. Total Committed Effective Dose Equivalent from the Ingestion of Honey Collected during 1996

Committed Effective Dose Equivalent[a] (mrem/yr)	
Background	**1996[b]**
# of Honey Samples	1
Maximum Consumption[c]	0.028 (±0.011)
Perimeter	
White Rock:	
# of Honey Samples	1
Maximum Consumption[c]	0.029 (±0.012)[d]
Los Alamos Townsite:	
# of Honey Samples	1
Maximum Consumption[c]	0.045 (±0.030)[d]

[a] Based on DOE dose conversion factors (DOE 1988).
[b] Analyses for 1996 included several radionuclides that were not requested in 1995. These numbers are not directly comparable to previous years.
[c] The maximum consumption rate for honey is 5 kg/yr (11 lb/yr).
[d] ±2 sigma in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

Table 6-9. Radionuclides in Eggs Collected in 1996

Radionuclide	Pueblo of San Ildefonso[a]		Los Alamos[a] Townsite		Española (Background)		RSRL[b]
^{238}Pu (pCi/L)[c]	0.002	(0.012)[d]	0.001	(0.008)	0.040	(0.022)	0.07
^{239}Pu (pCi/L)	–0.001[e]	(0.002)[e]	0.029	(0.018)	0.035	(0.022)	0.069
^{90}Sr (pCi/L)	0.0	(3.6)	2.1	(2.4)	1.6	(2.8)	3.2
Total U (μg/L)	0.07	(0.02)	0.06	(0.02)	0.05	(0.02)	0.06
Tritium (pCi/mL)	–0.5	(0.6)	0.2	(1.0)	–0.5	(0.6)	0.07
^{137}Cs (pCi/L)	3.8	(11.4)	38.0	(114.0)	3.1	(9.4)	9.04
^{241}Am (pCi/L)	0.012	(0.014)	0.020	(0.026)	0.026	(0.024)	0.05

[a] Most radionuclides in the Pueblo of San Ildefonso and Los Alamos townsite eggs, with the exception of uranium, were not detectable (where the analytical result was greater than two times the counting uncertainty) and higher than the RSRL.
[b] Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 counting uncertainties) based on 1995 to 1996 data.
[c] One liter (1L) is equal to approximately two dozen eggs (24 eggs) and the density of eggs is around 1,135 g/L.
[d] (±2 counting uncertainties); values are the uncertainty in the analytical results at the 95% confidence level.
[e] See Appendix B for an explanation of the presence of negative numbers.

Table 6-10. Total Committed Effective Dose Equivalent from the Ingestion of Eggs Collected during 1996

	Committed Effective Dose Equivalent (mrem/yr)[a]		
	Pueblo of San Ildefonso	Los Alamos Townsite	Regional Background
Maximum Consumption[b]	0.0040 (±0.021) [c]	0.043 (±0.11) [c]	0.014 (±0.021) [c]

[a] Based on DOE dose conversion factors (DOE 1988).
[b] The maximum consumption rate for eggs is 5 kg/yr or 55 g/day.
[c] ±2 sigma in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

Table 6-11. Radionuclides in Milk Collected in 1996

Radionuclide	Pojoaque Valley	Albuquerque (Background)	RSRL[a]
^{238}Pu (pCi/L)	0.000 (0.004)[b]	0.002 (0.004)	0.012
^{239}Pu (pCi/L)	0.001 (0.002)	0.005 (0.006)	0.010
^{90}Sr (pCi/L)	1.300 (0.6)	0.400 (0.6)	8
Total U (μg/L)	1.560 (0.32)	0.750 (0.16)	0.94
Tritium (pCi/mL)	0.000 (0.8)	–0.300 (0.8)	0.1
^{137}Cs (pCi/L)	12.000 (8)	14.000 (10)	21
^{131}I (pCi/L)	0.700 (2.2)	3.800 (11.4)	15.0

[a] Regional Statistical Reference Level; this is the upper limit background (mean + 2 std dev) from 1994–1996 data.
[b] (±2 counting uncertainties); values are the uncertainty in the analytical results at the 95% confidence level.
[c] See Appendix B for an explanation of the presence of negative numbers.

Table 6-12. Total Committed Effective Dose Equivalent from the Ingestion of Milk

	Committed Effective Dose Equivalent (mrem)[b]		
	1994	1995	1996
Pojoaque Valley[b]	0.14 (±0.49)[c]	0.26 (±0.50)[c]	0.31 (±0.21)[c]
Albuquerque Background[b]	0.20 (±0.55)[c]	0.48 (±0.40)[c]	0.32 (±0.38)[c]

[a] Based on DOE dose conversion factors (DOE 1988).
[b] Maximum annual consumption rate for milk is 199 kg/yr (0.5 L/day) (EPA 1984).
[c] ±2 sigma of the data in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

Table 6-13. Radionuclides in Game (Surface-Feeding) and Nongame (Bottom-Feeding) Fish Upstream and Downstream of Los Alamos National Laboratory during 1996

	^{3}H[a] pCi/mL		^{90}Sr 10^{-2} pCi/g dry		^{137}Cs 10^{-2} pCi/g dry		Total Uranium ng/g dry		^{238}Pu 10^{-5} pCig /dry		^{239}Pu 10^{-5} pCi/g dry		^{241}Am 10^{-5} pCi/g dry	
Game Fish/Surface Feeders														
Upstream (Abiquiu, Heron, and El Vado):														
trout/walleye	0.65	(0.29)	1.21	(2.42)	1.94	(0.73)	2.42	(0.48)	1.21	(4.84)	0.00	(2.42)	–2.42[b]	(2.42)
crappie	0.32	(0.28)	1.21	(2.42)	0.97	(0.48)	3.63	(0.73)	1.21	(2.42)	1.21	(2.42)	7.26	(9.68)
crappie	0.16	(0.28)	3.63	(2.42)	0.61	(0.24)	3.63	(0.73)	0.00	(2.42)	12.1	(0.00)	4.84	(7.26)
crappie	0.55	(0.29)	6.05	(4.84)	0.97	(0.48)	3.63	(0.73)	0.00	(4.84)	2.42	(4.84)	24.2	(24.2)
bass	0.30	(0.28)	2.42	(4.84)	0.61	(0.24)	3.63	(0.73)	4.84	(4.84)	2.42	(4.84)	12.1	(0.00)
Mean (±2 std dev)	0.40	(0.40)	2.90	(4.05)	1.02	(1.09)	3.39	(1.08)	1.45	(3.98)	3.63	(9.68)	9.20	(19.78)
RSRL	0.20		17.00		27.70		6.50		23.6		28.3		28.90	
Downstream (Cochiti):														
Pre Dome Fire (6-3-96)														
bass	0.22	(0.28)	3.63	(4.84)	1.94	(0.48)	4.84	(0.97)	–1.21	(2.42)	6.05	(7.26)	6.05	(7.26)
bass	LIA		13.31	(12.1)	1.94	(0.73)	6.05	(2.42)	–2.42	(2.42)	3.63	(4.84)	–2.42	(2.42)
crappie	LIA		4.84	(2.42)	1.94	(5.81)	7.26	(2.42)	1.21	(4.84)	12.1	(0.00)	18.15	(12.1)
crappie	LIA		6.05	(14.52)	2.30	(0.73)	6.05	(2.42)	3.63	(4.84)	2.42	(7.26)	6.05	(7.26)
pike	LIA		1.21	(2.42)	1.33	(0.48)	3.63	(0.73)	–1.21	(4.84)	24.2	(0.00)	24.2	(24.2)
pike	0.16	(0.28)	1.21	(4.84)	1.44	(4.60)	3.63	(0.73)	1.21	(2.42)	12.1	(0.00)	9.68	(7.26)
pike	0.04	(0.28)	0.00	(4.84)	1.57	(0.73)	3.63	(0.73)	4.84	(4.84)	2.42	(4.84)	4.84	(7.26)
Mean (±2 std dev)	0.14	(0.18)	4.32	(9.04)	1.78	(0.68)	5.01	(2.94)	0.86	(5.36)	8.99	(15.80)	9.51	(17.86)
Post Dome Fire (8-8-96)														
bass	–0.00	(0.28)	1.21	(14.52)	1.94	(1.45)	6.05	(2.42)	13.3	(26.6)	7.3	(16.9)	26.62	(41.14)
bass	0.84	(0.29)	4.84	(16.94)	2.54	(1.93)	6.05	(2.42)	0.00	(2.4)	0.0	(4.8)	20.57	(19.36)
bass	–0.32	(0.27)	4.84	(14.52)	1.45	(1.45)	7.26	(2.42)	0.00	(2.4)	0.0	(2.4)	8.47	(14.52)
bass	–0.03	(0.28)	3.63	(12.1)	2.30	(1.69)	6.05	(2.42)	1.20	(4.8)	2.4	(4.8)	10.89	(9.68)
bluegill	–0.02	(0.28)	6.05	(12.1)	1.82	(5.32)	9.68	(2.42)	1.20	(4.8)	10.9	(7.3)	36.30	(21.78)
walleye	0.05	(0.28)	–1.21	(12.1)	2.42	(1.93)	2.42	(0.48)	–1.20	(2.4)	2.4	(4.8)	10.89	(14.52)
Mean (±2 std dev)	0.09	(0.78)	3.23	(5.45)	2.08	(0.83)	6.25	(4.70)	2.42	(10.8)	3.8	(8.7)	18.96	(21.95)

Table 6-13. Radionuclides in Game (Surface-Feeding) and Nongame (Bottom-Feeding) Fish Upstream and Downstream of Los Alamos National Laboratory during 1996 (Cont.)

	^{3}H pCi/mL		^{90}Sr 10^{-2} pCi/g dry		^{137}Cs 10^{-2} pCi/g dry		Total Uranium ng/g dry		^{238}Pu 10^{-5} pCig /dry		^{239}Pu 10^{-5} pCi/g dry		^{241}Am 10^{-5} pCi/g dry	
Nongame Fish/Bottom Feeders														
Upstream (Abiquiu, Heron, and El Vado):														
sucker	0.09	(0.28)	2.85	(3.80)	1.14	(0.38)	2.85	(0.57)	3.80	(5.70)	9.50	(0.00)	0.00	(0.00)
sucker	0.58	(0.29)	4.75	(3.80)	0.48	(0.38)	3.80	(0.76)	0.95	(3.80)	0.95	(3.80)	9.50	(0.00)
carp sucker	–0.06	(0.28)	3.80	(3.80)	–0.48	(1.52)	6.65	(1.90)	0.00	(3.80)	9.50	(0.00)	0.00	(0.00)
carp sucker	0.26	(0.28)	5.70	(3.80)	1.52	(0.57)	9.50	(1.90)	1.90	(3.80)	1.90	(3.80)	9.50	(0.00)
catfish	–0.20	(0.28)	1.90	(1.90)	1.33	(0.57)	12.35	(1.90)	–0.95	(1.90)	0.95	(3.80)	9.50	(0.00)
catfish	0.18	(0.28)	0.95	(3.80)	1.14	(3.23)	9.50	(1.90)	9.50	(0.00)	–0.95	(0.00)	9.50	(0.00)
Mean (±2 std dev)	0.14	(0.54)	3.33	(3.56)	0.86	(1.48)	7.44	(7.35)	2.53	(7.57)	3.64	(9.26)	6.33	(9.81)
RSRL	0.20		13.20		26.90		16.20		9.80		19.20		16.14	
Downstream (Cochiti):														
Pre Dome Fire (6-3-96)														
carp	0.43	(0.28)	11.4	(1.90)	1.43	(0.57)	24.70	(5.70)	9.50	(0.00)	4.75	(3.80)	7.60	(7.60)
carp	0.16	(0.28)	2.85	(1.90)	1.62	(4.94)	3.80	(0.76)	1.90	(3.80)	9.50	(0.00)	–0.95	(1.90)
catfish	0.35	(0.28)	0.00	(1.90)	1.52	(0.57)	5.70	(1.90)	2.85	(5.70)	9.50	(0.00)	57.00	(19.00)
catfish	0.80	(0.29)	2.85	(1.90)	1.05	(0.38)	14.25	(3.80)	9.50	(19.00)	19.00	(19.00)	8.55	(7.60)
Mean (±2 std dev)	0.44	(0.54)	4.28	(9.87)	1.41	(0.50)	12.11	(19.08)	5.94	(8.26)	10.69	(11.95)	18.05	(52.63)

Table 6-13. Radionuclides in Game (Surface-Feeding) and Nongame (Bottom-Feeding) Fish Upstream and Downstream of Los Alamos National Laboratory during 1996 (Cont.)

	^{3}H pCi/mL		^{90}Sr 10^{-2} pCi/g dry		^{137}Cs 10^{-2} pCi/g dry		Total Uranium ng/g dry		^{238}Pu 10^{-5} pCig /dry		^{239}Pu 10^{-5} pCi/g dry		^{241}Am 10^{-5} pCi/g dry	
Downstream (Cochiti) (Cont.):														
Post Dome Fire (8-8-96)														
catfish	–0.09	(0.28)	2.85	(9.5)	2.47	(1.52)	12.35	(1.90)	1.0	(3.8)	3.8	(5.7)	8.55	(7.6)
catfish	0.24	(0.28)	0.00	(49.4)	1.14	(0.76)	8.55	(1.90)	–1.0	(1.9)	2.9	(3.8)	18.05	(13.3)
catfish	–0.25	(0.28)	2.85	(28.5)	2.47	(1.71)	11.40	(1.90)	–4.8	(3.8)	6.7	(7.6)	5.7	(19.0)
carp	–0.07	(0.28)	8.55	(34.2)	1.05	(0.95)	14.25	(3.80)	0.0	(0.8)	–1.0	(1.9)	6.65	(5.7)
carp	–0.28	(0.28)	14.25	(30.4)	0.48	(1.33)	20.90	(38.00)	1.0	(3.8)	1.0	(3.8)	11.4	(9.5)
carp sucker	–0.44	(0.41)	2.85	(13.3)	0.67	(0.76)	2.85	(1.90)	1.9	(5.7)	2.9	(5.7)	2.85	(5.7)
Mean (±2 std dev)	–0.15	(0.47)	5.23	(10.46)	1.38	(1.76)	11.72	(12.00)	–0.3	(4.8)	2.7	(5.2)	8.87	(10.66)

[a] mL of tissue moisture.
[b] See Appendix B for an explanation of the presence of negative values.
[c] (±2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.
[d] (±2 standard deviation).
[e] Regional Statistical Reference Level; this is the upper-limit background concentration (mean + 2 std dev) from Fresquez et al. (1994a).
[f] Detectable value (where the analytical result was higher than two times the counting uncertainty) and higher than the RSRL.

Table 6-14. Total Committed Effective Dose Equivalent from the Ingestion of Fish from Upstream and Downstream of the Laboratory for 1996

	Committed Effective Dose Equivalent (mrem/yr)[a]		
		Downstream (Cochiti)	
	Upstream (Abiquiu, Heron, El Vado)	Pre-Dome Fire	Post-Dome Fire
Bottom Feeders:			
# Fish Samples	6	7	6
Maximum Consumption[b]	0.042 (±0.051)[c]	0.067 (±0.14)[c]	0.064 (±0.11)[c]
Higher Level Feeders:			
# Fish Samples	5	6	4
Maximum Consumption[b]	0.034 (±0.050)[c]	0.049 (±0.085)[c]	0.049 (±0.065)[c]

[a]Based on DOE dose conversion factors (DOE 1988).
[b]The maximum consumption rate for fish is 21 kg/yr (46 lb/yr).
[c]±2 sigma of the data in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

Table 6-15. Mean (±2 std dev) Total Recoverable Trace and Heavy Metals in Bottom-Feeding Fish (μg/g wet) Collected in 1996

		Cochiti Reservoir		
Element	Abiquiu/Heron/El Vado Reservoirs (Background)[a]	Pre-Dome Fire (6-3-96)[a]	Post-Dome Fire (8-8-96)[b]	RSRL[c]
Ag	0.125 (0.00)	0.065 (0.11)	0.468 (0.17)	1.2
As	0.25 (0.00)	0.25 (0.00)	0.05 (0.07)	0.4
Ba	0.063 (0.00)	0.033 (0.06)	0.115 (0.04)	1.2
Be	0.053 (0.05)	0.033 (0.06)	0.348 (0.12)	1.3
Cd	0.105 (0.09)	0.055 (0.09)	0.233 (0.08)	0.3
Cr	0.625 (0.00)	0.324 (0.55)	9.624 (14.82)	1.5
Cu	0.815 (0.00)	0.421 (0.72)	1.978 (4.17)	1.4
Hg	0.342 (0.20)	0.208 (0.20)	0.287 (0.53)	0.4
Ni	1.125 (0.00)	0.582 (0.99)	1.162 (0.42)	1.5
Pb	1.25 (0.00)	1.25 (0.00)	0.05 (0.00)	4.0
Sb	1.25 (0.00)	1.25 (0.00)	0.05 (0.00)	2.1
Se	0.275 (0.00)	0.275 (0.00)	0.243 (0.23)	0.4
Tl	1.25 (0.00)	1.25 (0.00)	8.13 (2.85)	2.1
Zn	5.78 (3.35)	5.840 (2.05)	8.92 (11.19)	6.6

[a]The average of five bottom-feeding fish (mostly catfish, suckers, and carp).
[b]The average of six bottom-feeding fish (mostly catfish, suckers, and carp).
[c]Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev) from 1991 through 1996.

Table 6-16. Radionuclides in Muscle and Bone Tissues of Elk Collected from On-Site (LANL) and Off-Site (Background) Areas during 1995 and 1996

Location/Date/Sample	^{3}H (pCi/mL)[a]	Total U (ng/dry g)[a]	^{137}Cs (10^{-3} pCi/dry g)	^{90}Sr (10^{-3} pCi/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)	^{241}Am (10^{-5} pCi/dry g)
Muscle:							
LANL Elk							
TA-16/State Road 4/12-18-95/Bull	0.30 (0.60)	0.90 (0.20)	26.7 (13.2)	4.1 (16.4)	0.0 (3.3)	0.0 (3.3)	4.1 (3.3)
San Ildefonso/ State Road 4/6-18-96/Cow	0.30 (0.28)	0.10 (0.02)	11.2 (3.2)	–35.0 (16.0)	0.8 (2.4)	1.6 (1.6)	5.6 (5.6)
TA-16/State Road 501/6-25-96/Cow	0.14 (0.28)	0.10 (0.02)	8.8 (2.4)	–14.0 (8.0)	–0.8 (0.3)	2.0 (2.4)	2.0 (2.4)
Mean ±2 std dev	0.25 (0.18)	0.36 (0.92)	15.6 (19.4)	–15.0 (39.1)	0.0 (1.6)	1.2 (2.1)	3.9 (3.6)
Background Elk							
Chama, NM/1-9-96/Bull	0.30 (0.60)	0.50 (0.10)	48.4 (18.4)	4.0 (16.4)	0.0 (3.3)	0.0 (3.3)	4.1 (3.3)
RSRL[a]	0.90	3.06	577.9	3.9	0.0	0.0	7.4
Leg Bone:							
LANL Elk							
TA-16/State Road 4/12-18-95	0.30 (0.60)	0.50 (0.10)	5.3 (21.2)	2,173 (318)	53.0 (42.4)	0.0 (42.4)	53.0 (106.0)
San Ildefonso/ State Road 4/6-18-96/Cow	–0.04 (0.27)	5.30 (1.06)	–5.3 (254.4)	3,964 (636)	21.2 (42.4)	58.3 (63.6)	95.4 (116.6)
TA-16/State Road 501/6-25-96/Cow	0.15 (0.28)	1.10 (0.20)	–5.3 (254.4)	2,215 (318)	15.9 (31.8)	10.6 (21.2)	26.5 (137.8)
Mean ±2 std dev	0.14 (0.34)	2.3 (5.23)	–1.8 (12.24)	2,784 (2,044)	30.0 (40.1)	23.0 (62.1)	58.3 (69.5)
Background Elk							
Chama, NM/1-9-96/Bull	–0.40 (0.60)	0.40 (0.10)	30.1 (86.0)	1505 (172)	86.0 (86.0)	0.0 (34.4)	43.0 (34.4)
RSRL[a]	0.20	4.90	261.7	3477	120.6	80.0	77.4

[a]Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev) from long-term data.

Table 6-17. Radionuclides in Muscle and Bone Tissues of Deer Collected from On-Site (LANL) and Off-Site (Background) Areas during 1995 and 1996

Location/Date/Sample	^{3}H (pCi/mL)[a]	Total U (ng/dry g)[a]	^{137}Cs (10^{-3} pCi/dry g)	^{90}Sr (10^{-3} pCi/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)	^{241}Am (10^{-5} pCi/dry g)
Muscle:							
LANL Deer							
TA-16/State Road 4/8-7-95/Doe	0.00 (0.60)	0.36 (0.10)	18.5 (10.8)	4.5 (27.0)	0.0 (3.6)	4.5 (3.6)	—
TA-8/State Road 501/9-25-95/Buck	0.50 (0.60)	0.50 (0.10)	459.0 (90.0)	4.5 (27.0)	0.0 (3.6)	0.0 (3.6)	4.5 (3.6)
TA-21/State Road 502/10-17-95/Doe	0.80 (0.60)	0.63 (0.10)	10.4 (7.2)	0.0 (18.0)	4.5 (9.0)	0.0 (3.6)	4.5 (3.6)
TA-16/State Road 501/6-25-96/Doe	0.35 (0.28)	0.80 (0.20)	17.6 (6.4)	4.0 (16.0)	1.2 (2.4)	2.8 (3.2)	–1.2[b] (0.8)
TA-55/Pajarito Road/8-14-96/Buck	0.13 (0.27)	1.20 (0.24)	25.6 (8.0)	–24.4 (16.0)	0.2 (1.6)	0.8 (1.6)	1.2 (2.4)
Mean ±2 std dev	0.36 (0.63)	0.70 (0.65)	106.2 (394.6)	–2.3 (25.0)	1.2 (3.8)	1.6 (4.0)	2.3 (5.6)
Background Deer							
Cuba, NM/2-12-96/Doe	–0.10 (1.00)	0.50 (0.10)	21.2 (11.2)	0.0 (16.0)	0.0 (3.2)	0.0 (3.2)	0.0 (8.0)
El Vado, NM/3-19-96/Buck	0.40 (0.60)	1.00 (0.20)	15.5 (10.0)	20.0 (60.0)	–5.0 (2.0)	10.0 (10.0)	0.0 (4.0)
Mean ±2 std dev	0.15 (0.71)	0.75 (0.71)	18.4 (8.1)	10.0 (28.3)	–2.5 (7.1)	5.0 (14.1)	0.0 (0.0)
RSRL[a]	0.86	1.46	26.4	38.3	4.6	19.1	0.0
Leg Bone:							
LANL Deer							
TA-16/State Road 4/8-7-95/Doe	0.10 (0.60)	0.90 (0.90)	9.2 (9.2)	1,610 (276)	0.0 (92.0)	0.0 (36.8)	—
TA-8/State Road 501/9-25-95/Buck	0.30 (0.60)	1.30 (0.30)	8.5 (8.5)	1,399 (254)	127.2 (84.8)	0.0 (33.9)	254.4 (84.8)
TA-21/State Road 502/10-17-95/Doe	1.00 (0.60)	1.30 (0.30)	0.0 (206.0)	2,193 (258)	215.0 (86.0)	0.0 (34.4)	43.0 (34.4)
TA-16/State Road 501/6-25-96/Doe	–0.34 (0.27)	0.43 (0.09)	21.5 (34.4)	430 (172.0)	17.2 (25.8)	12.9 (25.8)	60.2 (68.8)
TA-55/Pajarito Road/8-14-96/Buck	0.12 (0.27)	0.86 (0.17)	12.9 (34.4)	8,824 (946)	30.1 (34.4)	8.6 (17.2)	60.2 (51.6)
Mean ±2std dev	0.24 (0.98)	0.96 (0.73)	10.4 (15.6)	3,212 (7,621)	77.9 (182.4)	4.3 (12.2)	104.5 (200.6)

Table 6-17. Radionuclides in Muscle and Bone Tissues of Deer Collected from On-Site (LANL) and Off-Site (Background) Areas during 1995 and 1996 (Cont.)

Location/Date/Sample	^{3}H (pCi/mL)[a]	Total U	^{137}Cs (ng/dry g)[a]	^{90}Sr (10^{-3} pCi/dry g)	^{238}Pu (10^{-3} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)	^{241}Am (10^{-5} pCi/dry g)	(10^{-5} pCi/dry g)
Background Deer								
Cuba, NM/2-12-96/Doe	–0.20 (1.20)	0.40	(0.40)	0.0 (206.4)	989 (172)	0.0 (34.4)	0.0 (34.4)	43.0 (86.0)
El Vado, NM/3-19-96/Buck	0.30 (0.60)	1.30	(0.30)	–8.6 (206.4)	946 (258)	0.0 (2.0)	0.0 (34.4)	43.0 (34.4)
Mean ±2 std dev	0.05 (0.71)	0.85	(1.27)	–4.3 (12.2)	968 (61)	0.0 (0.0)	0.0 (0.0)	43.0 (0.0)
RSRL[a]	0.76	2.12		7.9	1029	0.0	0.0	43

[a]Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev) from long-term data.
[b]See Appendix B for an explanation of the presence of negative numbers.

Table 6-18. Total Committed Effective Dose Equivalent and Maximum Annual CEDE from the Ingestion of Elk Muscle and Bone

	Total Committed Effective Dose Equivalent (mrem/yr)[a]		
	1996	**1994/1995**	**1993**
# Collected	3	4	3
Muscle[b]:			
On Site	0.0061 (±0.036)[d]	0.017 (±0.031)[d]	0.028 (±0.057)[d]
Off Site	0.021 (±0.023)[d]	—[c]	0.068 (±0.014)[d]
Bone[b]:			
On Site	1.3 (±0.94)[d]	0.82 (±0.52)[d]	0.35 (±0.42)[d]
Off Site	0.6 (±0.11)[d]	—[c]	0.81 (±0.95)[d]

	Maximum Annual CEDE (mrem)[a]		
	1996	**1994/1995**	**1993**
Muscle[b]:			
On Site	0.042	0.048	0.11
Off Site	0.044	—[c]	0.082
Bone[b]:			
On Site	2.2	1.3	0.99
Off Site	0.80	—[c]	1.8

[a] Based on DOE dose conversion factors (DOE 1988).

[b] Maximum consumption rate of 23 kg muscle and 5.7 kg bone per year is based on the meat consumption rate (NRC 1977) and the weight distribution of deer tissue groups (Meadows and Hakonson 1982).

[c] No off-site elk samples were collected in 1994/1995.

[d] ±2 sigma of the data in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

Table 6-19. Total Committed Effective Dose Equivalent and Maximum Annual CEDE from the Ingestion of Deer Collected during 1996

	Total Committed Effective Dose Equivalent (mrem/yr)[a]	
	On-Site	Off-Site
Muscle[b]	0.031 (±0.13)[c]	0.017 (±0.033)[c]
Bone[b]	1.1 (±2.6)[c]	0.37 (±0.025)[c]

	Maximum Annual Committed Effective Dose Equivalent (mrem)[a]	
	On-Site	Off-Site
Muscle[b]	0.16	0.05
Bone[b]	3.7	0.40

[a] Based on DOE dose conversion factors (DOE 1988).

[b] The maximum consumption rate of 23 kg/yr muscle and 4.8 kg/yr bone per year are based on the meat consumption rate (NRC 1977) and the weight distribution of deer tissue groups (Meadows and Hakonson 1982).

[c] ±2 sigma of the data in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

Table 6-20. Radionuclides in Muscle and Bone of a Free-Ranging Steer Collected from the Pueblo of San Ildefonso Lands in 1996

Tissue/Location	^{3}H (pCi/mL)[a]	Total U (ng/dry g)[a]	^{137}Cs (10^{-3} pCi/dry g)	^{90}Sr (10^{-3} pCi/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)	^{241}Am (10^{-5} pCi/dry g)
Muscle:							
San Ildefonso	–0.40 (0.60)[b]	1.48 (0.30)	14.4 (6.7)	11.1 (14.8)	0.0 (3.0)	7.4 (7.4)	3.7 (3.0)
Elk (Background)[c]	0.30 (0.60)	0.50 (0.10)	48.4 (18.4)	4.0 (16.4)	0.0 (3.3)	0.0 (3.3)	4.1 (3.3)
RSRL[d]	0.90	3.06	577.9	3.9	0.0	0.0	7.4
Leg Bone:							
San Ildefonso	–0.20 (0.60)	10.00 (2.00)	30.0 (90.0)	300.0 (200.0)	50.0 (40.0)	0.0 (40.0)	0.0 (40.0)
Elk (Background)	–0.40 (0.60)	0.40 (0.10)	30.1 (86.0)	1,505.0 (172.0)	86.0 (86.0)	0.0 (34.0)	43.0 (34.4)
RSRL	0.20	4.90	261.7	3,477.0	120.6	80.0	77.4

[a]pCi/mL of tissue moisture; the average dry/wet ratio for domestic cow muscle and bone was 0.27 and 0.72, respectively.
[b](±2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.
[c]Background from a Rocky Mountain elk collected in 1996; the dry/wet ratio for muscle and bone was 0.24 and 0.58, respectively.
[d]Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev) from elk collected from 1991 to present.

Table 6-21. Committed Effective Dose Equivalent from the Ingestion of Steer Muscle and Bone Collected during 1996

	Committed Effective Dose Equivalent (mrem/yr)[a]	
	Pueblo of San Ildefonso	Regional Background (Elk)[b]
Muscle:		
Maximum Consumption Rate[c]	0.081 (±0.085)[d]	0.086 (±0.18)[d]
Bone:		
Maximum Consumption Rate[c]	0.87 (±1.4)[e]	3.2 (±1.0)[d]

[a]Based on DOE dose conversion factors (DOE 1988).
[b]There were no background samples available for steer. Regional background for elk was used for background.
[c]The maximum consumption rate for steer muscle is 110 kg/yr and for steer bone is 275 kg/yr (NRC 1977) (Meadows and Hakonson 1982).
[d]±2 sigma of the data in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

Table 6-22. Radionuclides in Navajo Tea (Cota) Collected from Regional and Perimeter Locations in 1996

	^{3}H (pCi/mL)	^{90}Sr (pCi/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/L)	^{137}Cs (pCi/L)	^{tot}U (μg/L)	^{241}Am (pCi/L)
Off-Site Regional:							
Española	–0.22 (0.27)[a,b]	0.3 (0.8)	0.000 (0.004)	–0.001 (0.005)	13.5 (11.0)	0.32 (0.06)	0.180 (0.160)
RSRL	0.05	1.1	0.004	0.004	24.5	0.38	0.34
Off-Site Perimeter:							
Pueblo of San Ildefonso	–0.11 (0.27)	0.4 (0.8)	0.018 (0.010)	0.011 (0.010)	17.6 (35.2)	0.75 (0.16)	0.015 (0.058)
Los Alamos Townsite	–0.64 (0.26)	1.8 (0.8)	0.012 (0.007)	0.012 (0.007)	7.6 (15.2)	0.89 (0.18)	0.150 (0.100)
White Rock/Pajarito Acres	0.09 (0.27)	0.1 (0.8)	0.027 (0.013)	0.020 (0.012)	17.1 (11.6)	0.44 (0.08)	0.052 (0.056)

[a] See Appendix B for an explanation of the presence of negative numbers.
[b] (±2 counting uncertainty).

Table 6-23. Total Committed Effective Dose Equivalent from the Ingestion of Navajo (Cota) Tea Collected during 1996

Total Committed Effective Dose Equivalent (mrem/yr)[a]	
	Max Consumption[b]
Background	0.87 (±0.79)[c]
White Rock	0.75 (±0.59)[c]
Los Alamos	0.84 (±0.78)[c]
San Ildefonso	0.68 (±1.2)[c]

[a] Based on DOE dose conversion factors (DOE 1988).

[b] The maximum consumption rate for tea is 0.5 L/day.

[c] ±2 sigma in parenthesis; to convert to μSv, multiply by 10; values greater than 2 sigma show high variability and present questionable results.

E. Figures

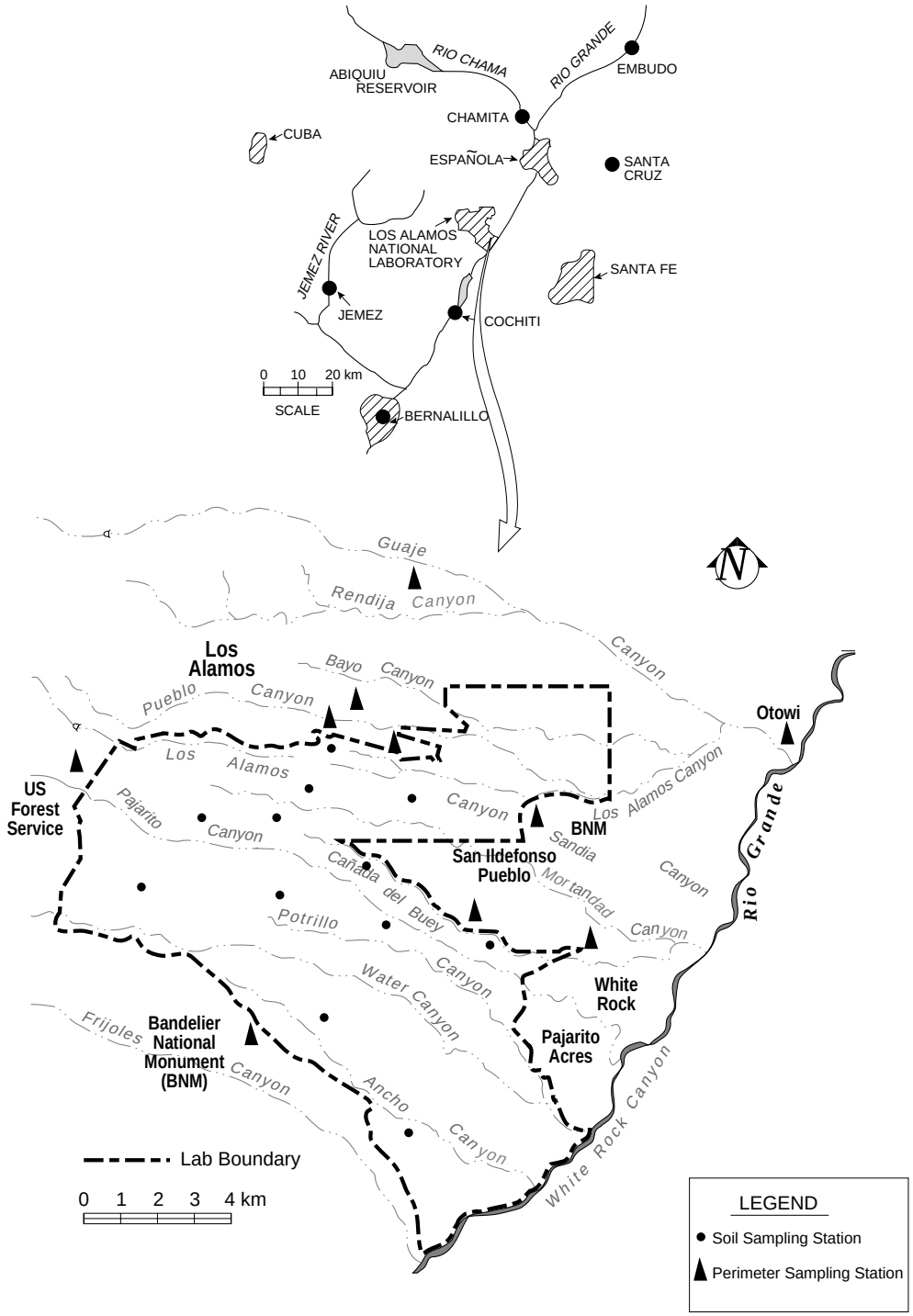

Figure 6-1. Off-site regional (top) and perimeter and on-site (bottom) Laboratory soil sampling locations.

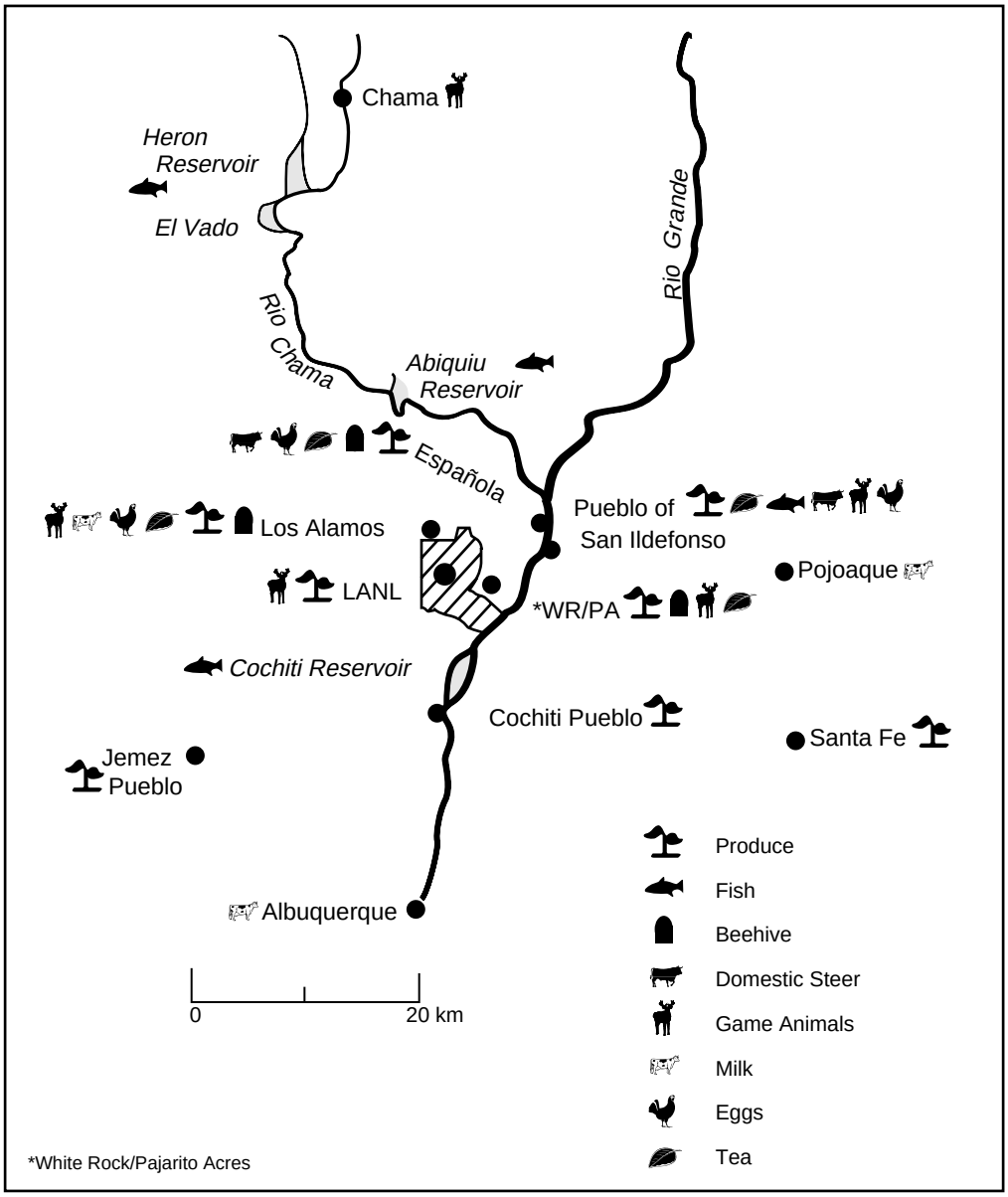

Figure 6-2. Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations. (Map denotes general locations only.)

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Standards for Environmental Contaminants

Throughout this report, concentrations of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, and 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;" 5480.1, "Environmental Protection, Safety, and Health Protection Standards;" 5480.11, "Requirements for Radiation Protection for Occupational Workers;" and 5484.1, "Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements," Chap. III, "Effluent and Environmental Monitoring Program Requirements."

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 adopted by DOE 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/yr. The PDLs and the DOE dose factors are based on recommendations of the ICRP and the National Council on Radiation Protection and Measurements (ICRP 1988 and 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 and water in uncontrolled areas measured by the Laboratory's environmental surveillance program are compared with DOE's derived air concentrations (DACs) and derived concentration guides (DCGs), respectively (Table A-2) (DOE 1990). These guides represent the smallest estimated concentrations in water or air, taken in continuously for a period of 50 years, that will result in annual EDEs equal to the PDL of 100 mrem in the fiftieth year of exposure.

In addition to the 100 mrem/yr effective dose PDL, exposures from the air pathway are also limited by the Environmental Protection Agency's (EPA's) standard of 10 mrem/yr EDE (EPA 1989a). To demonstrate compliance with these standards, doses from the air pathway are compared directly with the EPA dose limits.

Nonradioactive Air Quality Standards. Federal and state ambient air quality standards for nonradioactive pollutants are shown in Table A-3. New Mexico nonradiological standards are generally more stringent than national standards.

National Pollutant Discharge Elimination System. Table A-4 presents a summary of these outfalls and the types of monitoring required under National Pollutant Discharge Elimination System (NPDES). Table A-5 presents NPDES monitoring limits.

Drinking Water Standards. For chemical constituents in drinking water, regulations and standards are issued by EPA and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico Drinking Water Regulations (Table A-6) (NMEIB 1995). 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/L. Gross alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi/L.

A screening level of 5 pCi/L for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water (TableA-6) 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/yr, 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/yr. 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 to either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the New Mexico Health and Environment Improvement Division's New Mexico 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). (See Tables A-7 and A-8.) The NMWQCC groundwater stan-dards can also be applied in cases where groundwater discharges may affect stream water quality.

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-9. This table shows the number of analytes included in each analytical suite. The specific compounds analyzed in each suite are listed in Tables A-10 through A-13.

Table A-1. Department of Energy Public Dose Limits (PDL) for External and Internal Exposures

	EDE[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, 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 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 DOE Order 5480.11.

[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/yr.

[d] This level is from EPA's regulations issued under the Clean Air Act (40 CFR 61, Subpart H).

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

[a]Guides for uncontrolled areas are based on DOE's PDL for the general public (DOE 1990); those for controlled areas are based on occupational RPSs for DOE Order 5480.11. 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).
[c]Tritium in the HTO form.

Table A-3. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary
Sulfur dioxide	Annual arithmetic mean	ppm	0.02	0.03	
	24 hours[a]	ppm	0.10	0.14	
	3 hours[a]	ppm			0.5
Total suspended particulate matter	Annual geometric mean	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours[a]	$\mu g/m^3$	150		
PM_{10}[b]	Annual arithmetic mean	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
Carbon monoxide	8 hours[a]	ppm	8.7	9	
	1 hour[a]	ppm	13.1	35	
Ozone	1 hour[c]	ppm		0.12	0.12
Nitrogen dioxide	Annual arithmetic mean	ppm	0.05	0.053	0.053
	24 hours[a]	ppm	0.10		
Lead	Calendar quarter	$\mu g/m^3$		1.5	1.5
Hydrogen sulfide	1 hour	ppm	0.01		
Total reduced sulfur	1/2 hour	ppm	0.003		

[a] Maximum concentration, not to be exceeded more than once per year.
[b] Particles <10 μm in diameter.
[c] The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations is above the limit of ≤1.

Table A-4. Types of Discharges and Limits Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Sanitary Outfall Discharges

Discharge Category	Permit Parameter	Daily Average			Daily Maximum	
13S TA-46 SWSC Plant	BOD[a]	concentration	30	mg/L	45	mg/L
		loading limit	100	lb/day	N/A[b]	
	TSS[c]	concentration	30	mg/L	45	mg/L
		loading limit	100	lb/day	N/A	
	Fecal coliform bacteria[d]		500	org/100 mL	500	org/100 mL
	pH		6.0-9.0		6.0-9.0	
	Flow[e]		Report		Report	
05S TA-21 Sanitary Treatment Plant	BOD	concentration	30	mg/L	45	mg/L
		loading limit	0.5	lb/day	N/A	
	TSS	concentration	30	mg/L	45	mg/L
		loading limit	0.5	lb/day	N/A	
	COD[f]		125	mg/L	125	mg/L
			2.1	lb/day	N/A	
	Fecal coliform bacteria[d]		500	org/100 mL	500	org/100 mL
	pH		6.0-9.0		6.0-9.0	
	Flow[e]		Report		Report	

[a]Biochemical oxygen demand.
[b]Not applicable.
[c]Total suspended solids.
[d]Logarithmic mean.
[e]Discharge volumes are reported to EPA but are not subject to limits.
[f]Chemical oxygen demand.

NOTE: Sampling frequency for these sanitary outfalls varies from 1/week to once every 3 months, depending on the parameter.

Table A-5. Limits Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Industrial Outfall Discharges

Discharge Category	Number of Outfalls	Sampling Frequency	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
001 Power Plant	1	Monthly	TSS[a]	30	100	mg/L
			Free available CL_2	0.2	0.5	mg/L
			pH	6.0-9.0	6.0-9.0	
02A Boiler Blowdown	2	Every 3 months	TSS	30	100	mg/L
			Total Fe	10	40	mg/L
			Total Cu	1.0	1.0	mg/L
			Total P	20	40	mg/L
			Sulfite	35	70	mg/L
			Total Cr	1.0	1.0	mg/L
			pH	6.0-9.0	6.0-9.0	
03A Treated Cooling Water	26	Every 3 months	TSS	30	100	mg/L
			Free available Cl	0.2	0.5	mg/L
			Total P	20	40	mg/L
			Total As	0.04	0.04	mg/L
			pH	6.0-9.0	6.0-9.0	
04A Noncontact Cooling Water	32	Every 3 months	pH	6.0–9.0	6.0–9.0	
			Total residual CL_2	Report[b]	Report	mg/L
051 Radioactive Liquid Waste Treatment Facility (TA-50)	1	Variable: weekly to monthly	COD[c]	94	156	lb/day
			TSS	18.8	62.6	lb/day
			Total Cd	0.06	0.30	lb/day
			Total Cr	0.19	0.38	lb/day
			Total Cu	0.63	0.63	lb/day
			Total Fe	1.0	2.0	lb/day
			Total Pb	0.06	0.15	lb/day
			Total Hg	0.003	0.09	lb/day
			Total Zn	0.62	1.83	lb/day
			TTO[d]	1.0	1.0	mg/L
			Total Ni[b]	Report	Report	mg/L
			Total N[b]	Report	Report	mg/L
			NO_3-NO_2[b]	Report	Report	mg/L
			Ammonia (as N)[b]	Report	Report	mg/L
			pH	6.0-9.0	6.0-9.0	
			COD	125	125	mg/L
			^{226}Ra and ^{228}Ra	30.0	30.0	pCi/L
05A High Explosive	12	Every 3 months	Oil & Grease	15	15	mg/L
			COD	125	125	mg/L
			TSS	30.0	45.0	mg/L
			pH	6.0-9.0	6.0-9.0	
06A Photo Wastewater	12	Every 3 months	Total Ag	0.5	1.0	mg/L
			pH	6.0-9.0	6.0-9.0	

Table A-5. Limits Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Industrial Outfall Discharges (Cont.)

Discharge Category	Number of Outfalls	Sampling Frequency	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
All Outfall Categories: Annual Water Quality Parameters	88	Annually	Total Al	5.0	5.0	mg/L
			Total As	0.04	0.04	mg/L
			Total B	5.0	5.0	mg/L
			Total Cd	0.2	0.2	mg/L
			Total Cr	5.1	5.1	mg/L
			Total Co	1.0	1.0	mg/L
			Total Cu	1.6	1.6	mg/L
			Total Pb	0.4	0.4	mg/L
			Total Hg	0.01	0.01	mg/L
			Total Se	0.05	0.05	mg/L
			Total V	0.1	0.1	mg/L
			Total Zn	95.4	95.4	mg/L
			^{226}Ra and ^{228}Ra	30.0	30.0	pCi/L
			^{3}H[e]	3,000,000	3,000,000	pCi/L

[a]Total suspended solids.
[b]Concentrations are reported to EPA but are not subject to limits.
[c]Chemical oxygen demand.
[d]Total toxic organics.
[e]When accelerator produced.

Table A-6. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Radiochemicals, Inorganic Chemicals, and Microbiological Constituents

Contaminants	Level
Radiochemical:	**Maximum Contaminant Level**
Gross alpha	15 pCi/L[a]
Gross beta & photon	4 mrem/yr[a]
^{226}Ra & ^{228}Ra	5 pCi/L[a]
U	20 µg/L[a]
Radon	300 pCi/L[a]
	Screening Level
Gross alpha	5 pCi/L[a]
Gross beta	50 pCi/L[a]
Inorganic Chemical:	
Primary Standards	**Maximum Contaminant Level (mg/L)**
Asbestos	7 million fibers/L (longer than 10 µm)
As	0.05[a]
Ba	2
Be	0.004
Cd	0.005
CN	0.2
Cr	0.1
F	4.0
Hg	0.002
Ni	0.1
NO_3 (as N)	10
NO_2 (as N)	1
SO_4	500[a]
Se	0.05
Sb	0.006
Tl	0.002
	Action Levels (mg/L)
Pb	0.015
Cu	1.3
Secondary Standards	**(mg/L)**
Cl	250
Cu	1
Fe	0.3
Mn	0.05
Zn	5
Total Dissolved Solids	500
pH	6.5–8.5
Microbiological:	**Maximum Contaminant Level**
Presence of total coliforms	5% of samples/month
Presence of fecal coliforms or Escherichia coli	No coliform positive repeat samples following a fecal coliform positive sample

[a]Proposed.

Table A-7. Livestock Watering Standards

Livestock Contaminant	Concentration	
Dissolved Al	5	mg/L
Dissolved As	0.2	mg/L
Dissolved B	5	mg/L
Dissolved Cd	0.05	mg/L
Dissolved Cr	1	mg/L
Dissolved Co	1	mg/L
Dissolved Cu	0.5	mg/L
Dissolved Pb	0.1	mg/L
Total Hg	0.01	mg/L
Dissolved Se	0.05	mg/L
Dissolved V	0.1	mg/L
Dissolved Zn	25	mg/L
^{226}Ra and ^{228}Ra	30	pCi/L
^{3}H	20,000	pCi/L
Gross alpha	15	pCi/L

Table A-8. Wildlife Habitat Stream Standards

The following narrative standard shall apply:

1. Except as provided below in Paragraph 2 of this section, no discharge shall contain any substance, including, but not limited to selenium, DDT, PCBs, and dioxin, at a level which, when added to background concentrations, can lead to bioaccumulation to toxic levels in any animal species. In the absence of site-specific information, this requirement shall be interpreted as establishing a stream standard of 2 µg/l for total recoverable selenium and of 0.012 µg/l for total mercury.

2. The discharge of substances that bioaccumulate in excess of levels specified above in Paragraph 1, is allowed if, and only to the extent that, the substances are present in the intake waters which are diverted and utilized prior to discharge, and then only if the discharger utilizes best available treatment technology to reduce the amount of bioaccumulating substances which are discharged.

3. Discharges to waters which are designated for wildlife habitat uses, but not for fisheries uses, shall not contain levels of ammonia or chlorine in amounts which reduce biological productivity and/or species diversity to levels below those which occur naturally, and in no case shall contain chlorine in excess of 1 mg/L nor ammonia in excess of levels which can be accomplished through best reasonable operating practices at existing treatment facilities.

4. A discharge which contains any heavy metal at concentrations in excess of the concentrations set forth in Section 3101.J.1 of these standards shall not be permitted in an amount, measured by total mass, which exceeds by more than 5 percent the amount present in the intake waters which are diverted and utilized prior to the discharge, unless the discharger has taken steps (an approved program to require industrial pretreatment; or a corrosion program) appropriate to reduce influent concentration to the extent practicable.

Table A-9. Organic Analytical Methods

Test	SW-846 Method	Extraction Water	Extraction Sediments	Number of Analytes
Volatiles	8260A	E0730	E0720	59
Semivolatiles	8270B[a]	E0530	E0510	69
PCB[b]	8080A, 8081	E0430	E0410	4
HE[c]	8330			14

[a]Direct injection used for method 8270B.
[b]PCB = polychlorinated biphenyls.
[c]HE = high-explosive.

Table A-10. Volatile Organic Compounds

Analytes	Limit of Quantitation Water (μg/L)	Limit of Quantitation Sediments (mg/kg)
Acetone	25	0.025
Benzene	5	0.005
Bromobenzene	5	0.005
Bromochloromethane	5	0.005
Bromodichloromethane	5	0.005
Bromoform	5	0.005
Bromomethane	10	0.01
Butanone [2-]	25	0.025
Butylbenzene [n-]	5	0.005
Butylbenzene [sec-]	5	0.005
Butylbenzene [tert-]	5	0.005
Carbon disulfide	5	0.005
Carbon tetrachloride	5	0.005
Chlorobenzene	5	0.005
Chlorodibromomethane	5	0.005
Chloroethane	10	0.01
Chloroform	5	0.005
Chloromethane	10	0.01
Chlorotoluene [o-]	5	0.005
Chlorotoluene [p-]	5	0.005
Dibromo-3-chloropropane [1,2]	10	0.01
Dibromoethane [1,2-]	5	0.005
Dibromomethane	5	0.005
Dichlorobenzene [o-] (1,2)	5	0.005
Dichlorobenzene [m-] (1,3)	5	0.005
Dichlorobenzene [p-] (1,4)	5	0.005
Dichlorodifluoromethane	10	0.01

Table A-10. Volatile Organic Compounds (Cont.)

Analytes	Limit of Quantitation Water (μg/L)	Limit of Quantitation Sediments (mg/kg)
Dichloroethane [1,1-]	5	0.005
Dichloroethane [1,2-]	5	0.005
Dichloroethene [1,1-]	5	0.005
Dichloroethene [trans-1,2-]	5	0.005
Dichloroethylene [cis-1,2-]	5	0.005
Dichloropropane [1,2-]	5	0.005
Dichloropropane [1,3-]	5	0.005
Dichloropropane [2,2-]	5	0.005
Dichloropropene [1,1-]	5	0.005
Dichloropropene [cis-1,3-]	5	0.005
Dichloropropene [trans-1,3-]	5	0.005
Ethylbenzene	5	0.005
Hexanone [2-]	20	0.02
Isopropylbenzene	5	0.005
Isopropyltoluene [4-]	5	0.005
Methyl iodide	5	0.005
Methyl-2-pentanone [4-]	20	0.02
Methylene chloride	5	0.005
Propylbenzene	5	0.005
Styrene	5	0.005
Tetrachloroethane [1,1,1,2-]	5	0.005
Tetrachloroethane [1,1,2,2-]	5	0.005
Tetrachloroethylene	5	0.005
Toluene	5	0.005
Trichloroethane [1,1,1-]	5	0.005
Trichloroethane [1,1,2-]	5	0.005
Trichloroethene	5	0.005
Trichlorofluoromethane	5	0.005
Trichloropropane [1,2,3]	5	0.005
Trimethylbenzene [1,2,4-]	5	0.005
Trimethylbenzene [1,3,5-]	5	0.005
Vinyl chloride	10	0.01
Xylenes (o + m + p) [Mixed-]	5	0.005

Table A-11. Semivolatile Organic Compounds

Analytes	Limit of Quantitation Water (μg/L)	Limit of Quantitation Sediments (mg/kg)
Acenaphthylene	10	0.33
Aniline	10	0.33
Anthracene	10	0.33
Azobenzene	10	0.33
Benzidine [m-]	50	1.65
Benzo[a]anthracene	10	0.33
Benzo[a]pyrene	10	0.33
Benzo[b]fluoranthene	10	0.33
Benzo[g,h,i]perylene	10	0.33
Benzo[k]fluoranthene	10	0.33
Benzoic acid	50	1.65
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	0.33
Bromophenylphenyl ether [4-]	10	0.33
Butyl benzyl phthalate	10	0.33
Chloro-3-methylphenol [4-]	10	0.33
Chloroaniline [4-]	10	0.33
Chloronaphthalene [2-]	10	0.33
Chlorophenol [o-]	10	0.33
Chlorophenylphenyl ether [4-]	10	0.33
Chrysene	10	0.33
Di-n-butyl phthalate	10	0.33
Di-n-octyl phthalate	10	0.33
Dibenzo[a,h]anthracene	10	0.33
Dibenzofuran	10	0.33
Dichlorobenzene (1,2) [o-]	10	0.33
Dichlorobenzene (1,3) [m-]	10	0.33
Dichlorobenzene (1,4) [p-]	10	0.33
Dichlorobenzidine [3,3'-]	20	0.66
Dichlorophenol [2,4-]	10	0.33
Diethyl phthalate	10	0.33
Dimethyl phthalate	10	0.33
Dimethylphenol [2,4-]	10	0.33
Dinitrophenol [2,4-]	50	1.65
Dinitrotoluene [2,4-]	10	0.33
Dinitrotoluene [2,6-]	10	0.33
Fluoranthene	10	0.33
Fluorene	10	0.33
Hexachlorobenzene	10	0.33
Hexachlorobutadiene	50	1.65
Hexachlorocyclopentadiene	10	0.33
Hexachloroethane	10	0.33
Indeno[1,2,3-cd]pyrene	10	0.33
Isophorone	10	0.33

Table A-11. Semivolatile Organic Compounds (Cont.)

Analytes	Limit of Quantitation	
	Water (μg/L)	Sediments (mg/kg)
Methyl-4,6-dinitrophenol [2-]	50	1.65
Methylnaphthalene [2-]	10	0.33
Methylphenol [2-]	10	0.33
Methylphenol [4-]	10	0.33
Naphthalene	10	0.33
Nitroaniline [2-]	20	0.66
Nitroaniline [3-]	20	0.66
Nitroaniline [4-]	20	0.66
Nitrobenzene	10	0.33
Nitrophenol [2-]	10	0.33
Nitrophenol [4-]	50	1.65
Nitrosodi-n-propylamine [N-]	10	0.33
Nitrosodimethylamine [N-]	10	0.33
Nitrosodiphenylamine [N-]	10	0.33
Pentachlorophenol	50	1.65
Phenanthrene	10	0.33
Phenol	10	0.33
Picoline [2-]	10	0.33
Pyrene	50	1.65
Pyridine	10	0.33
Trichlorobenzene [1,2,4-]	10	0.33
Trichlorophenol [2,4,5-]	10	0.33
Trichlorophenol [2,4,6-]	10	0.33

Table A-12. Polychlorinated Biphenyls Analytes

	Detection Limits	
Analytes	**Water (μg/L)**	**Sediments (mg/kg)**
Aroclor [Mixed-]	0.05	0.06
Aroclor 1242	0.05	0.06
Aroclor 1254	0.05	0.06
Aroclor 1260	0.05	0.06

Table A-13. High Explosives Analytes

	Limit of Quantitation	
Analytes	**Water (μg/L)**	**Sediments (mg/kg)**
HMX	0.21	2.20
RDX	0.27	1.00
1,3,5-TNB	0.042	0.25
1,3-DNB	0.032	0.25
Tetryl	0.24	0.65
Nitrobenzene	0.13	0.26
2,4,6-TNT	0.068	0.25
4-A-2,6-DNT	0.046	0.25
2-A-4,6-DNT	0.046	0.25
2,6-DNT	0.085	0.25
2,4-DNT	0.085	0.25
2-NT	0.10	0.25
4-NT	0.12	0.25
3-NT	0.13	0.25

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).

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).

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 become 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 sutracted 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 following equation:

$$s = \sqrt{\frac{\sum_{i=1}^{N} \left(\bar{c} - c_i\right)^2}{(N-1)}},$$

where

c_i = sample i

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples comprising a station or group.

This value is reported as the uncertainty for the station and group means.

Tables

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 (km2)	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
gal.	gallon
in.	inch
kg	kilogram
kg/h	kilogram per hour
L	liter
lb	pound
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
$µg/m^3$	microgram per cubic meter
mL	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter

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

sq ft (ft^2)	square feet
μR	microroentgen
mCi	millicurie
mR	milliroentgen
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)
R	roentgen
std dev or σ	standard deviation
s.u.	standard unit
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 Labortories 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 ft^2 of leased space for training, support, architectural engineering design, and unclassified research and development in the Los Alamos townsite and White Rock. The publicly accessible Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos townsite.

TA-2, Omega Site: Omega West Reactor, an 8-MW nuclear research reactor, is located here. It was placed into a safe shutdown condition in 1993. It is currently being removed from the nuclear facilities list and will be transferred to the institution for placement into the decontamination and decommissioning (D&D) program during 1997.

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, and 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. A Van de Graaff accelerator was put on shutdown status in 1994.

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, Two-Mile 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 proposed site for DARHT (the dual-axis radiographic hydrotest facility) whose major feature is its intense high-resolution, dual-machine radiographic capability. 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 about half of the facility has been demolished. The programs conducted at DP West, primarily in inorganic and biochemistry, are being relocated during 1997 and the remainder of the site 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 and Center for Human Genome Studies: This site is adjacent to the Los Alamos Medical Center in the townsite. Research performed at this site includes structural, molecular, and cellular radiobiology, biophysics, mammalian radiobiology, mammalian metabolism, biochemistry, and genetics. The Department of Energy Los Alamos Area Office is also located within TA-43.

TA-46, WA Site: 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 will house research in inorganic and materials chemistry. The Sanitary Wastewater System Consolidation project 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 Bandalier 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 studied 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 Scattering Center: The Los Alamos Neutron Science Center (LANSCE), including the LANSCE linear proton accelerator, the Manuel Lujan Jr. Neutron Scattering Center (MLNSC), and a medical isotope production facility are located at this TA. Also located at TA-53 are the Accelerator Production of Tritium (APT) Project Office, including the Low-Energy Demonstration Accelerator (LEDA), 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 managing 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.

AT-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, and similar experiments are being planned.

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, Inc.

TA-64: This is the site of the Central Guard Facility and headquarters for the Laboratory Hazard 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.

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.

AEC Atomic Energy Commission**.** A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian applications. It was abolished by the Energy Reorganization Act of 1974 and was succeeded by the Energy Research and Development Administration (now part of the US Department of Energy (DOE) and the US Nuclear Regulatory Commission [NRC]).

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.

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.

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.

- ***absorbed dose*** — The energy imparted to matter by ionizing radiation per unit mass of irradiated material. (The unit of absorbed dose is the rad.)
- ***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, food-stuffs, 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 (subsurface water). Groundwater usually refers to a zone of complete water saturation containing no air.
^{3}H	Tritium.
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 Maximum 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 prior to 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 Clean Air Act; they set limits for such pollutants as beryllium and radionuclides.

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.

PCBs Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976.

PDL Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).

perched groundwater A groundwater body above a slow-permeablity rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.

person-rem The unit of population dose that expresses the sum of radiation exposures received by a population. For example, two persons, each with a 0.5 rem exposure, receive 1 person-rem, and 500 people, each with an exposure of 0.002 rem, also receive 1 person-rem.

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 due to a threat to health [see contamination]).

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.

R Roentgen. The roentgen is a unit for measuring exposure. It is defined only for the effect on air and applies only to gamma and x-rays in air. It does not relate biological effects of radiation to the human body.

1 roentgen = 1,000 milliroentgen (mR)

rad Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body.

1 rad = 1,000 millirad (mrad)

radionuclide An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

RCRA Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.

release Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.

rem Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) due to the different types of radiation.

rem = rad x 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 potassium-40; 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.

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.

uranium **Isotopic Abundance (atom %)**

	^{234}U	^{235}U	^{238}U
depleted	≤0.0055	<0.72	>99.2745
natural	0.0055	0.72	99.2745
enriched	≥0.0055	>0.72	<99.2745

Total uranium is the chemical abundance of uranium in the sample, regardless of its isotopic composition.

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.

AA-2	Internal Assessment Group (LANL)
AEC	Atomic Energy Commission
AIP	Agreement in Principle
AIRFA	American Indian Religious Freedom Act
AIRNET	Air Monitoring Network
AL	Albuquerque Operations Office (DOE)
AO	Administrative Order
AQCR	Air Quality Control Regulation (New Mexico)
ARPA	Archeological Resources Protection Act
BEIR	biological effects of ionizing radiation
BOD	biochemical/biological oxygen demand
Btu	British thermal unit
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAS	Connected Action Statement
CCNS	Concerned Citizens for Nuclear Safety
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIO	Community Involvement Office (LANL)
CMR	Chemistry and Metallurgy Research (LANL building)
CO	compliance order
COC	chain-of-custody
COD	chemical oxygen demand
CQI	continuous quality improvement
CST	Chemical Sciences and Technology (LANL division)
CST-3	Analytical Services Group (LANL)
CST-13	Radioisotopes and Industrial Wastewater Science Group (LANL)
CWA	Clean Water Act
CY	calendar year
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
D&D	decontamination and decommissioning
DEC	DOE Environmental Checklist
DOE	Department of Energy
DOE-EM	DOE, Environmental Management
DOU	Document of Understanding
EA	Environmental Assessment
EDE	effective dose equivalent
EEU	ecological exposure unit
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EO	Executive Order
EPA	Environmental Protection Agency

EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Restoration
ESH	Environment, Safety, & Health
ESH-4	Health Physics Measurements Group (LANL)
ESH-13	ESH Training Group (LANL)
ESH-14	Quality Assurance Support Group (LANL)
ESH-17	Air Quality Group (LANL)
ESH-18	Water Quality & Hydrology Group (LANL)
ESH-19	Hazardous & Solid Waste Group (LANL)
ESH-20	Ecology Group (LANL)
ESO	Environmental Stewardship Office (LANL)
EST	Ecological Studies Team (ESH-20)
FFCA	Federal Facilities Compliance Agreement
FFCAct	Federal Facilities Compliance Act
FFCAgreement	RCRA Federal Facility Compliance Agreement
FFCO	Federal Facility Compliance Order
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIMAD	Facility for Information Management, Analysis, and Display
FONSI	Finding of No Significant Impact
FY	fiscal year
GWPMPP	Groundwater Protection Management Program Plan
HAZWOPER	hazardous waste operations (training class)
HE	high-explosive
HMPT	Hazardous Materials Packaging and Transportation
HPAL	Health Physics Analytical Laboratory
HSWA	Hazardous and Solid Waste Amendments
HWA	Hazardous Waste Act (New Mexico)
HWMR	Hazardous Waste Management Regulations (New Mexico)
ICRP	International Commission on Radiological Protection
JCI	Johnson Controls, Inc.
JENV	JCI Environmental Laboratory
LAAO	Los Alamos Area Office (DOE)
LANSCE	Los Alamos Neutron Science Center
LANSCENET	LANSCE Network—TA-53 (for air monitoring)
LANL	Los Alamos National Laboratory (or the Laboratory)
LEDA	Low-Energy Demonstration Accelerator
LLW	low-level radioactive waste
LLMW	low-level mixed waste
LOQ	limit of quantitation
MAP	Mitigation Action Plan
MCL	maximum contaminant level
MDA	material disposal area
MEI	maximum exposed individual
NAGPRA	Native American Grave Protection and Repatriation Act
NCRP	National Council on Radiation Protection and Measurements

NEPA	National Environmental Policy Act
NERF	NEPA Review Form
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEWNET	Neighborhood Environmental Watch Network
NHPA	National Historic Preservation Act
NMDA	New Mexico Department of Agriculture
NMED	New Mexico Environment Department
NMEIB	New Mexico Environmental Improvement Board
NMWQCA	New Mexico Water Quality Control Act
NMWQCC	New Mexico Water Quality Control Commission
NOD	Notice of Deficiency
NON	Notice of Noncompliance
NPDES	National Pollutant Discharge Elimination System
NRC	US Nuclear Regulatory Commission
OB/OD	open burning/open detonation
ODS	ozone depleting substance
O&G	oil and grease
OHL	Occupational Health Laboratory (LANL)
OSHA	Occupational Safety and Health Act/Administration
PCB	polychlorinated biphenyl
PDL	public dose limit
PHERMEX	Pulsed high-energy radiographic machine emitting x-rays
ppb	parts per billion
ppm	parts per million
PWA	Process Waste Assessment
QA	quality assurance
QAP	Quality Assurance Program
QC	quality control
RCRA	Resource Conservation and Recovery Act
RD&D	research, development, and demonstration
RLWTF	Radioactive Liquid Waste Treatment Facility (LANL)
RSRL	regional statistical reference level
SAL	screening action level
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Officer (New Mexico)
SLD	Scientific Laboratory Division (New Mexico)
SOC	synthetic organic compound
SPCC	Spill Prevention Control and Countermeasures
SVOC	semivolatile organic compound
SWA	Solid Waste Act
SWPP	Storm Water Prevention Plan
SWMR	solid waste management regulations
SWMU	solid waste management unit
SWSC	Sanitary Wastewater Systems Consolidation

TA	Technical Area
TDS	total dissolved solids
TEDE	total effective dose equivalent
TIC	tentatively identified compound
TLD	thermoluminescent dosimeter
TLDNET	thermoluminescent dosimeter network
TRI	toxic chemical release inventory
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TTHM	trihalomethane
TWISP	Transuranic Waste Inspectable Storage Project
UC	University of California
USGS	United States Geological Survey
UST	underground storage tank
VAP	vaporous activation products
VOC	volatile organic compound
WASTENET	Waste Management Areas Network
WM	Waste Management (LANL)
WSC	Waste Stream Characterization
WQCC	Water Quality Control Commission
WWW	World Wide Web

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	NO_2
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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