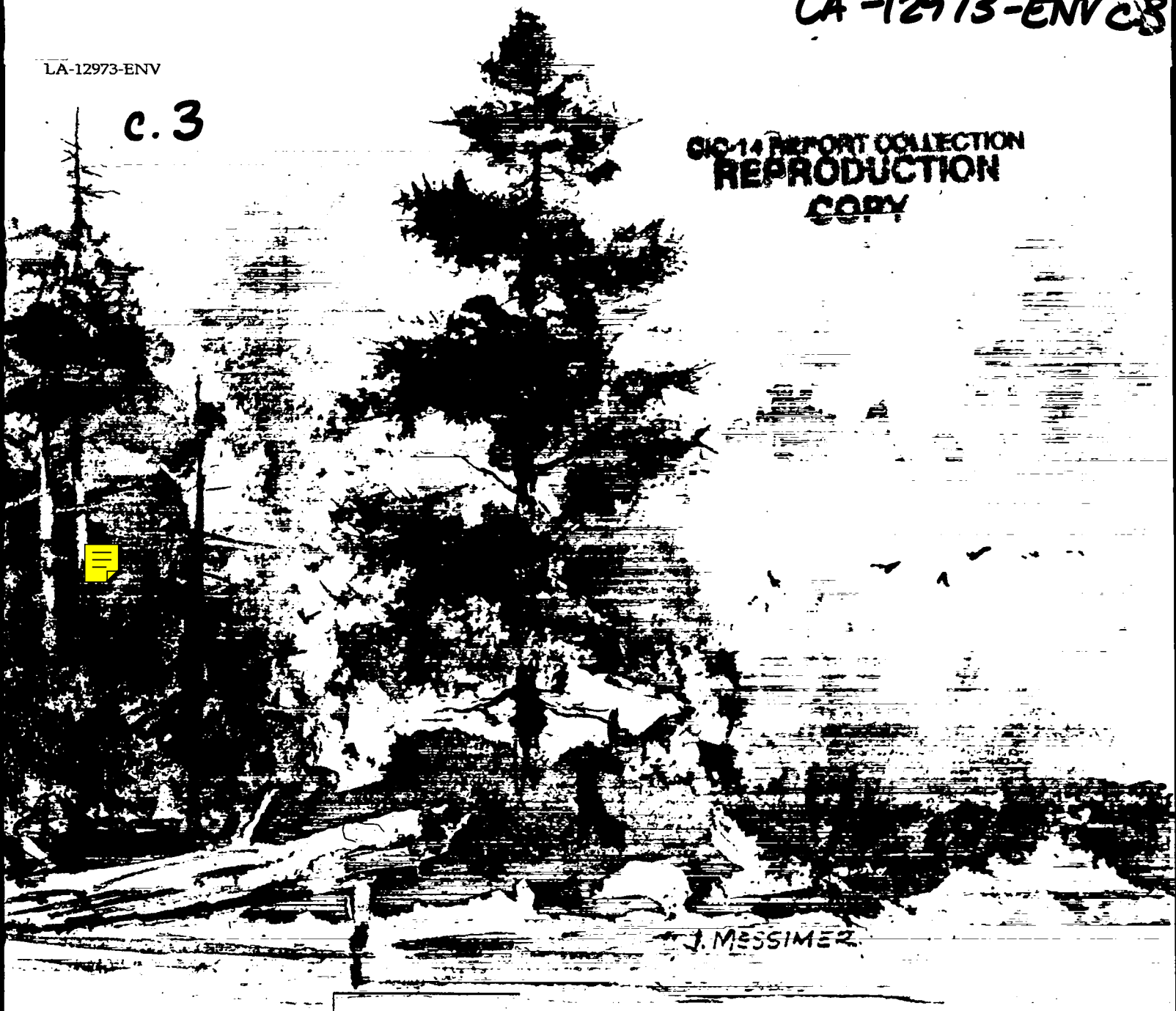

Environmental Surveillance at Los Alamos during 1993

Los Alamos
NATIONAL LABORATORY

Aerial view looking westward toward the Valle Grande in the Jemez Mountains. Extending eastward from the mountains, the Pajarito Plateau is cut into numerous narrow mesas divided by southeast-trending canyons. The Los Alamos townsite is on the mesas in the right half of the photograph and Los Alamos National Laboratory is on those in the left. The Laboratory's main technical area (TA-3) is in the top center, at the foot of the mountains, and the Los Alamos Meson Physics Facility (LAMPF) is in the lower center.

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Issued: October 1995

Environmental Surveillance at Los Alamos during 1993

Environmental Protection Group

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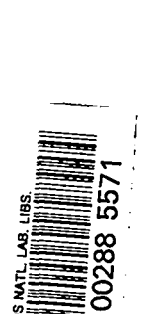

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ACKNOWLEDGMENTS

Karen Kohen, Linnea Wahl, and Julie Johnston compiled this report with contributions from members of the Environmental Protection Group (EM-8) in the Laboratory's Environmental Management Division. Personnel in EM-8 during 1993 include the following:

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Belinda Harrigan assembled this report and completed its layout. Louisa Lujan-Pacheco (CIC-1) edited the report. The following groups in the Laboratory's Environmental Management and Health & Safety Divisions provided environmental data: Waste Management (EM-7), Environmental Protection (EM-8), Environmental Chemistry (EM-9), Environmental Restoration (EM-13), Health Physics Measurements (HS-4), Risk Management Support (HS-3), and Health Physics Policy & Programs (HS-12).

PREFACE

"Environmental Surveillance at Los Alamos" reports are prepared annually by the Los Alamos National Laboratory (the Laboratory) as required by US Department of Energy Order 5400.1, entitled "General Environmental Protection Program."

These annual reports summarize environmental data that characterize the Laboratory's compliance with applicable federal, state, and local environmental laws and regulations, executive orders, and departmental policies. Additional data, beyond the minimum required, is 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.

These annual reports are written to be useful to the many individuals, organizations, and governmental entities interested in environmental monitoring at the Laboratory. Significant environmental efforts, special studies, and environmental quality trends of interest are highlighted. This year's report contains improved maps and new graphs designed to further clarify important issues. A glossary of terms, a listing of report contributors, and other supplementary information are included to aid the reader. Comments on how to improve the annual reports are encouraged.

This report is prepared by the Los Alamos National Laboratory, Environment, Safety, and Health Division, for the US Department of Energy.

Inquires or comments regarding these annual reports may be directed to the US Department of Energy, Office of Environment and Projects, 528 35th Street, Los Alamos, NM, 87544, or to the Los Alamos National Laboratory, Environment, Safety, and Health Division, P.O. Box 1663, MS-K491, Los Alamos, NM, 87545.

FOREWORD

Suggestions on How to Use This Report

This report was written for both the lay person and the scientist. Readers may have limited or comprehensive interest in this report. We have tried to make it accessible to all without compromising its scientific integrity. Following are directions advising each audience on how best to use this document.

1. Lay Person with Limited Interest. Read Section I, the Executive Summary, which describes the Laboratory's environmental monitoring programs for this year. The report emphasizes radiological emissions, dose calculations, and environmental regulatory compliance. A glossary and a list of acronyms and abbreviations in the back of the report define relevant terms and acronyms.

2. Lay Person with Comprehensive Interest. Follow directions for the "Lay Person with Limited Interest" given above. Summaries of each section of the report are in boldface type preceding the technical text; read summaries of those sections that interest you. Further details are provided in the text following each summary. Appendix A, Standards for Environmental Contaminants; Appendix B, Units of Measurement; and Appendix C, Description of Technical Areas and Their Associated Programs, may also be helpful.

3. Scientists with Limited Interest. Read Section I, the Executive Summary, to determine the parts of the Laboratory's environmental program that interest you. Then read the summaries and technical details of these sections in the body of the report. Sections IX and X contain lists of publications issued in 1993 and references, respectively.

4. Scientists with Comprehensive Interest. Read Section I, the Executive Summary, which describes the Laboratory's environmental programs this year. Read the major subdivisions of the report; detailed data tables are included in each section. Appendix D contains supplementary environmental information.

For further information about this report, contact the Los Alamos National Laboratory's Environmental Protection Group:

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The production of this report required the knowledge, skills, experience, and cooperation of many people and several organizations. The lead authors of the main sections are listed below. Their contributions and cooperation are gratefully acknowledged.

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I. Executive Summary	K. Kohen
II. Introduction	
A. Los Alamos National Laboratory	K. Kohen
B. Geographic Setting	A. Stoker
C. Geology and Hydrology	D. Rogers
D. Climatology	G. Stone
E. Ecology	T. Foxx
F. Cultural Resources	B. Larson
G. Population Distribution	K. Jacobson
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A. Introduction	K. Kohen
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C. Current Issues and Actions	S. Rae, J. McInnis, D. Stavert, K. Hargis, J. White, K. Jacobson, K. Kohen
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B. Environmental Assessments	P. Powers
C. Other Significant Environmental Activities at Los Alamos	R. Rangel, A. Adams (EES-1), F. Goff (EES-1), G. Stone, S. McLin, M. Maes, D. Rogers, L. Soholt (EM/ER), D. Armstrong, P. Fresquez, T. Foxx, P. Trujillo-Oviedo (PA-3), P. Josey (EM-DO), S. Fillas (HS-8)
V. Environmental Radiological Program Information	K. Jacobson, R. Rangel, B. Gallaher, S. McLin, P. Fresquez
VI. Environmental Nonradiological Program Information	J. Dewart
VII. Groundwater Protection Management Program	D. Rogers, S. McLin, A. Stoker
VIII. Quality Assurance And Sampling Procedures	K. Kohen, P. Gautier

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1993

ENVIRONMENTAL PROTECTION GROUP

ABSTRACT

This report describes the environmental surveillance program at Los Alamos National Laboratory during 1993. The Laboratory routinely monitors for radiation and for radioactive and nonradioactive materials at (or on) 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 1993 to assess external penetrating radiation; quantities of airborne emissions and liquid effluents; concentrations of chemicals and radionuclides in ambient air, surface waters and groundwaters, municipal water supply, soils and sediments, and foodstuffs; and environmental compliance. Using comparisons with standards, regulations, and background levels, 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.

I. EXECUTIVE SUMMARY

Los Alamos National Laboratory (LANL or the Laboratory) began as Project Y of the Manhattan Engineer District during World War II with the specific responsibility of developing the world's first nuclear weapon. The University of California (UC) manages the Laboratory for the Department of Energy (DOE). The Laboratory's focus has evolved over the years in response to changes in national policy. The Laboratory's vision is to be a world-class laboratory solving complex problems of national importance where science makes a difference; its mission is to apply science and technology to the nation's security and well-being.

The Laboratory's policy directs its employees to protect the public, employees, and the environment from harm that could be caused by Laboratory activities. Laboratory policy also directs us to reduce the environmental impact of our activities as much as is feasible. The DOE requires that we monitor the Laboratory site and the surrounding region for radiation, radioactive materials, and hazardous chemicals.

Our environmental surveillance program strives to fulfill these policies and requirements. Throughout the year, we routinely monitor the Laboratory's and surrounding region's air, water, and soil for radiation, radioactive materials, and hazardous chemicals. Every year, that data is summarized in an environmental surveillance report.

The Laboratory uses more than 450 sampling stations for routine monitoring of the environment. Table I-1 presents the number of each type of environmental monitoring station used in 1993. During 1993, more than 11,500 environmental samples were the subject of approximately 215,000 analyses for radioactive and nonradioactive constituents.

Estimated Doses and Risks from Radiation Exposure

Many of the activities that take place at the Laboratory involve handling radioactive materials and operating radiation-producing equipment. This report documents the monitoring results, which assess the potential exposures to the public from Laboratory-related radiation sources.

Table I-1. Number of Sampling Locations for Routine Monitoring of the Ambient Environment

	Off Site		On Site		
Type of Monitoring	**Regional**	**Perimeter**	**Laboratory**	**Waste Disposal Area**	**Total**
External radiation	4	23	51	88	166
Air	6[a]	14	23	9	52[b]
Surface waters[c,d]	6	10	12	0[e]	28
Groundwaters[c]	0	61	33	0[e]	94
Soils	7	6	9	1	23
Sediments	11	19	29	21	80
Foodstuffs	13	11	21	1	46
Meteorology	0	1	5	1	7

[a]Includes three pueblo monitoring locations.
[b]Includes three stations that monitor only nonradioactive air emissions.
[c]Samples from an additional 17 special surface water and groundwater stations related to the Fenton Hill Geothermal Program were also collected and analyzed as part of the monitoring program.
[d]Does not include National Pollutant Discharge Elimination System (NPDES) outfalls sampled to demonstrate regulatory compliance.
[e]Means not counted separately from on-site Laboratory locations.

Radiation Doses. Radiological doses are calculated in order to estimate the potential health impacts of any releases of radioactivity to the public. Standards exist which limit the maximum effective dose equivalent (EDE or simply "effective dose") to the public. The DOE's public dose limit (PDL) is 100 mrem/yr EDE received from all pathways, and the Environmental Protection Agency (EPA) restricts the EDE received by air to 10 mrem/yr. These values are in addition to those from normal background, consumer products, and medical sources. Both standards apply to locations of maximum probable exposure to an individual in an off-site, uncontrolled area.

In CY93, the estimated maximum EDE due to Laboratory operations was 3.1 mrem, taking into account shielding by buildings (30% reduction) and occupancy (100% for residences, 25% for businesses). It is 3.1% of DOE's 100 mrem/yr PDL for all pathways. This dose resulted mostly from external radiation from short-lived, airborne emissions from a linear particle accelerator at Los Alamos Meson Physics Facility (LAMPF). Figure I-1 presents a summary of the estimated maximum individual and maximum Laboratory boundary doses from external penetrating radiation generated by the Laboratory for the last 10 years. Table I-2 presents a summary of the annual EDEs attributable to 1993 Laboratory operations. The estimated maximum EDE from Laboratory operations is about 1% of the 342 mrem received from background radiation and radioactivity in Los Alamos during 1993 (Figure I-2).

The EPA-approved method of calculating EDE, which is used to demonstrate compliance with National Emissions Standards for Hazardous Air Pollutants (NESHAP) requirements, does not allow the Laboratory to take into account shielding or occupancy factors. In 1993, that EDE was 5.7 mrem, which is in compliance with EPA standards of 10 mrem/yr from the air pathway.

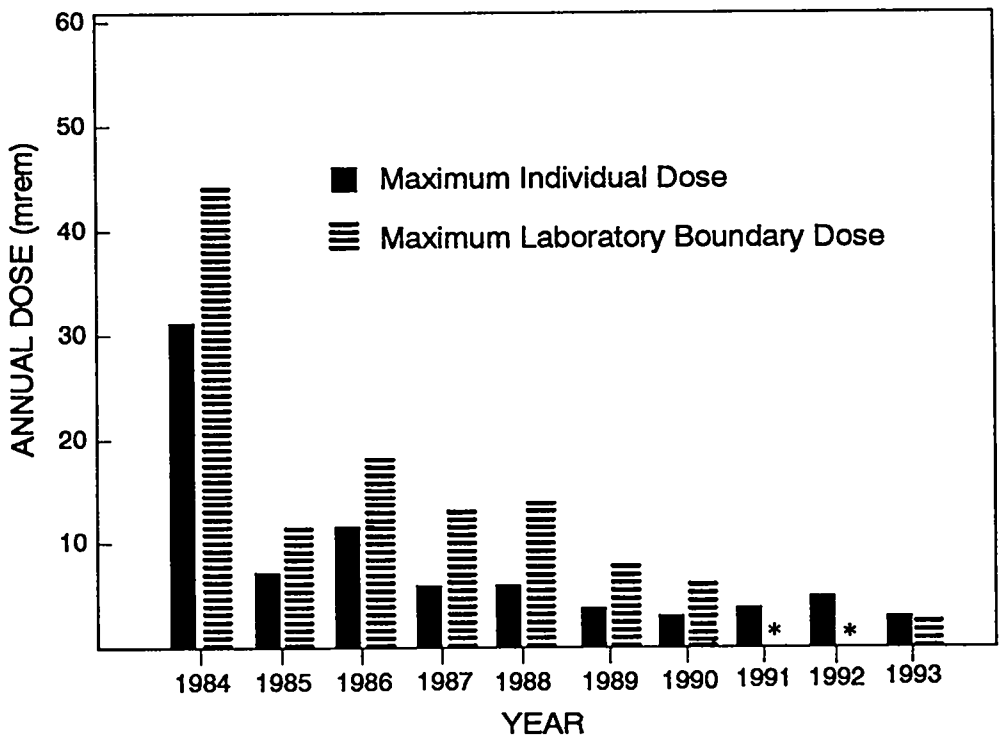


Figure I-1. Summary of estimated maximum individual and maximum Laboratory boundary doses from external penetrating radiation generated by Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources). Maximum individual dose calculated with DOE-approved methods that take building shielding and occupancy into account.

*No above-background Laboratory boundary doses, as measured by TLDs, were recorded during 1991 or 1992.

Table I-2. Summary of Annual Effective Dose Equivalents Attributable to 1993 Laboratory Operations

	Maximum Dose to an Individual[a,b]	Average Dose to Nearby Residents[b]		Collective Dose to Population within 80 km of the Laboratory[b]
		Los Alamos	White Rock	
Dose	3.1 mrem	0.15 mrem	0.03 mrem	3 person-rem
Location	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
Background	342 mrem	342 mrem	327 mrem	72,000 person-rem
DOE Public Dose Limit	100 mrem	—	—	—
Percentage of Public Dose Limit	3.1%	0.15%	0.03%	—
Percentage of Background	0.91%	0.044%	0.009%	0.004%

[a]Maximum individual dose is the dose to any individual at or outside the Laboratory where the highest dose rate occurs. Calculations take into account occupancy (the fraction of time a person is actually at that location), self-shielding, and shielding by buildings.

[b]Doses are reported at the 95% confidence level.

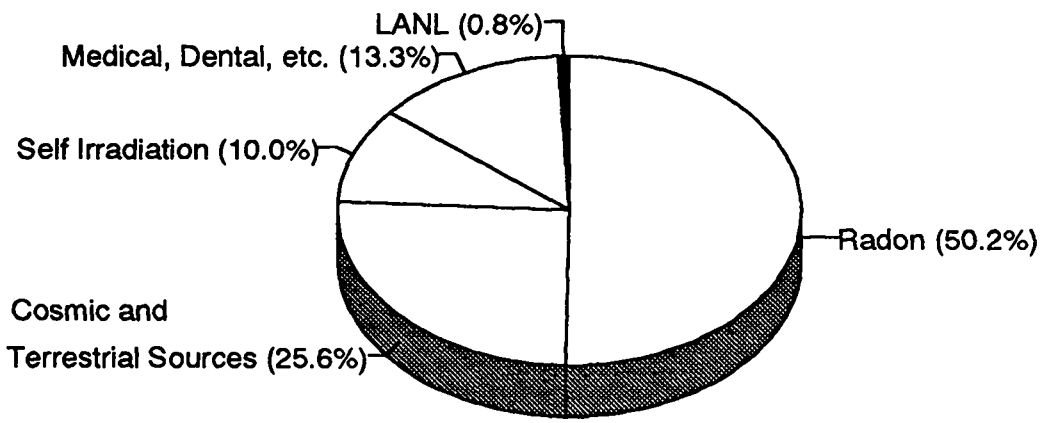


Figure I-2. Total contributions to 1993 dose at the Laboratory's maximum exposed individual location.

Risk Estimates. One way of understanding the effect of radiation released by Laboratory operations is by calculating the number of additional cases of cancer that will probably occur because of this radiation. In the US, the risk of contracting some form of cancer is 1 chance in 4. Because of the radiation released by 1993 operations, Los Alamos and White Rock residents have an added risk of contracting cancer. That additional risk is less than 1 chance in 1,000,000 (Table I-3).

Environmental Monitoring and Compliance Activities

External Penetrating Radiation Monitoring. LANL measures external penetrating radiation at 166 thermoluminescent dosimeters (TLDs) located both off and on site. Annual averages for the TLDs were generally the same in 1993 as in 1992, consistent with the variability in natural background radiation observed at the monitoring

Table I-3. Added Individual Lifetime Cancer Mortality Risks Attributable to 1993 Radiation Exposure

Exposure Source	EDE Used in Risk Estimate (mrem)	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.15	less than 1 in 1,000,000
White Rock area	0.03	less than 1 in 1,000,000
Natural Radiation		
Cosmic, terrestrial, self-irradiation, and radon exposure[a]		
Los Alamos	342	1 in 8,000[b]
White Rock	327	1 in 8,000
Medical X Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in 43,000

[a]An EDE of 200 mrem was used to estimate the risk from inhaling ^{222}Rn and its transformation products.

[b]The risks from natural radiation from non-radon sources were estimated to be 1 chance in 16,000 in Los Alamos and 1 chance in 18,000 for White Rock. The risk of lung cancer from radon exposure was estimated to be 1 chance in 14,000 for both locations. Risk estimates are derived from the NRC BEIR IV and BEIR V reports and the NCRP Report 93 (BEIR IV 1988, BEIR V 1990, NCRP 1987a).

stations. No radiation measurements above background were recorded at LAMPF in CY93. The current detection limit of the TLD system is 3.0 mrem.

Radioactive Air Monitoring. The sampling network for ambient airborne radioactivity consisted of more than 50 continuously operating air sampling stations in 1993. Ambient air is routinely sampled for tritium, plutonium, americium, uranium, iodine, and gross alpha and beta activity. Total radioactive airborne emissions during 1993 decreased significantly from those in 1992. Table I-4 presents both the 1992 and 1993 radionuclide releases from Laboratory operations.

Radionuclide National Emission Standards for Hazardous Air Pollutants. Under 40 CFR 61, Subpart H, EPA limits the EDE to any member of the public from radioactive airborne releases from any DOE facility, including LANL, to 10 mrem/yr. For 1993, the maximum dose to a member of the public of 5.7 mrem from airborne releases was calculated using the EPA-approved computer program CAP-88. More than 95% of the modeled 1993 EDE was due to gaseous activation products released from LAMPF. Air submersion was the primary pathway of exposure (versus inhalation or ground deposition).

In 1991, the EPA determined that LANL did not meet the requirements of 40 CFR 61, Subpart H, and issued LANL a Notice of Noncompliance (NON). Specific findings of the NON included deficiencies in LANL's identification and evaluation of release sources, lack of stack monitoring equipment on all point release sources, inadequate quality assurance programs, and incomplete reporting. All of these findings have been or are being addressed.

Unplanned Airborne Releases. There were two unplanned airborne radiological releases reported during 1993. Each EDE was less than 0.1% of DOE's PDL of 100 mrem/yr from all pathways and less than 1% of the EPA's 10 mrem/yr limit for the air pathway.

Nonradioactive Air Monitoring. The Laboratory operates monitors to routinely measure primary pollutants, beryllium, acid precipitation, and visibility.

Compliance with the Federal Clean Air Act and the New Mexico Air Quality Control Act. These acts establish ambient air quality standards, require the permits for new sources, and set acceptable emission limits. During 1993,

Table I-4. Comparison of 1992 and 1993 Releases of Radionuclides from Laboratory Operations

Airborne Emissions

Radionuclide	Units	Activity Released 1992	Activity Released 1993	Ratio 1993:1992
Tritium	Ci	1,298.00	1,410	1.1
Phosphorus-32	μCi	9.00	6	0.7
Uranium	μCi	242.00[b]	267[b]	1.1
Plutonium	μCi	12.00	6	0.5
Gaseous mixed activation products	Ci	71,950.00	32,100	0.4
Mixed fission products	μCi	2,750.00	1,360	0.5
Particulate/vapor activation products	Ci	0.73	13	18.0
Total	Ci	73,248.73	33,523	

Liquid Effluents

Radionuclide	Activity Released (mCi) 1992	Activity Released (mCi) 1993	Ratio 1993:1992
Tritium	10,630.00	2,660.00	0.25
Strontium-82,-85,-89,-90	17.00	7.64	0.45
Cesium-137	7.80[c]	8.17	1.04
Uranium-234	0.05	0.12	2.40
Plutonium-238,-239,-240	0.70	1.08	1.54
Americium-241	8.90[c]	11.20	1.26

[a]Detailed data are presented in Tables V-4 and V-5 for airborne emissions.
[b]Does not include dynamic testing.
[c]Corrected values from those listed in Environmental Surveillance at Los Alamos during 1992.

all of the Laboratory's existing operations remained in compliance with air quality regulations for nonradioactive emissions. One unplanned airborne nonradiological release was reported during 1993.

Surface Water and Groundwater Monitoring. The Laboratory monitors surface waters and groundwaters to detect potential or known transport of contaminants from the Laboratory. Measurable concentrations of radionuclides from Laboratory operations (primarily historical) are transported by surface water off site to Pueblo and Los Alamos canyons. The perched alluvial groundwater in off-site reaches of Pueblo and Los Alamos canyons also shows the influence of both industrial and sanitary effluents. The intermediate-depth perched groundwater beneath Pueblo Canyon at two locations (Test Well 2A on county land and Test Well 1A near the eastern Laboratory boundary) shows both radioactive and chemical quality influences from historical releases. The main aquifer shows the presence of recent recharge (less than 30 to 50 yr) at one location beneath Pueblo Canyon (Test Well 1).

Measurements of tritium by extremely low detection limit analytical methods 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 concentrations measured range from less than 2% to less than 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. Low concentrations of tritium were also detected at two wells and one spring associated with the intermediate-depth perched aquifer beneath Pueblo and Los Alamos canyons and at four household wells at the Pueblo of San Ildefonso.

Compliance with the Clean Water Act. The two primary programs at the Laboratory used to establish compliance with the Clean Water Act (CWA) are the National Pollutant Discharge Elimination System (NPDES) program and the Spill Prevention Control and Countermeasure (SPCC) program.

The Laboratory submitted an application for a new NPDES permit in September 1990. The Conditions of Certification for the NPDES permit required effluent limits based on water quality standards applicable to the Rio Grande rather than on water quality standards applicable to LANL's ephemeral streams. Subsequently, in October 1992, UC and DOE petitioned the New Mexico Water Quality Control Commission (NMWQCC) to review the New Mexico Environment Department's (NMED's) conditional certification of the NPDES permit limits. In September 1993, EPA issued a final NPDES permit for the Laboratory. However, review of the final permit revealed a few technical and typographical errors. Within the 30-day time period allowed, the Laboratory filed an Intent to Request an Evidentiary Hearing on the final permit in order to correct the errors. After discussions with EPA and NMED, it was agreed that the errors could be corrected by pursuing the modifications procedure in the CWA. A new final permit with error corrections was drafted by EPA in January 1994. This draft permit will go out for public comment and is expected to be issued sometime in 1994. In CY93, the Laboratory was in compliance with the NPDES permit in 100% of the analyses sampled at sanitary waste discharges and 99.1% at the industrial waste discharges.

The Laboratory has an SPCC Plan, as required by the CWA in 40 CFR 112. The plan is implemented by providing secondary containment for large tanks and other containers to control accidental oil spills and prevent them from entering watercourses.

Compliance with the Safe Drinking Water Act. Samples are collected and analyzed from the Laboratory and Los Alamos County water distribution systems on a routine basis in order to determine the levels of microbiological organisms, organic and inorganic chemical constituents, and radioactivity in the local drinking water. During 1993, all chemical parameters regulated under the Safe Drinking Water Act were in compliance with contaminant levels established by regulation. In August, there was a violation of bacteriological standards at TA-33 and TA-39.

Unplanned Liquid Releases. There were two unplanned radioactive liquid releases reported during 1993: TA-2 and TA-33. At TA-2, Omega West Reactor, there was a release of tritiated water. Less than 1,000 gal. of water overflowed from the three waste tanks onto the soil surrounding the tanks. Results of swipe samples of the floor in Omega 44 indicated minimum detectable activity or below for both alpha and beta. No water from the discharge reached a watercourse. The discharge was stopped by turning off the valve associated with the back flow preventer. At TA-33 approximately one gallon of tritiated water entered a floor drain. These facilities will be cleaned up under the Laboratory's decontamination and decommissioning program.

There were 28 unplanned nonradioactive liquid releases reported during 1993. Each of these releases was minor and was contained on Laboratory property; none was found to be of any threat to health or the environment.

Soils and Sediments Monitoring. Measurements of radioactivity and chemicals in samples of soils and sediments provide data on indirect pathways of exposure. Areas within Pueblo, Los Alamos, and Mortandad canyons all had concentrations of radioactivity in sediments at levels higher than those attributable to natural terrestrial sources or worldwide fallout. Cesium, plutonium, and strontium in Mortandad Canyon result from effluents from a liquid waste treatment plant. No runoff or sediment transport has been detected beyond the Laboratory boundary in Mortandad Canyon since effluent release into the canyon started. However, some radioactivity in sediments in Pueblo Canyon (from pre-1964 effluents) and Los Alamos Canyon (from post-1952 treated effluents) has been transported to the Rio Grande. Theoretical estimates confirmed by measurements show that the incremental effect on Rio Grande sediments is about 10% of the concentrations attributable to worldwide fallout in soils and sediments.

Surface runoff has transported some low-level contamination from the active waste disposal area and several of the inactive areas into canyons within the Laboratory boundary. Analyses of toxic metals in surface sediments in these canyons indicate that no constituents exceed EPA threshold criteria for determining hazardous waste.

Compliance with the Resource Conservation and Recovery Act (RCRA). This act regulates hazardous wastes from generation through disposal. The EPA has given full authority for administering the RCRA, with the exception of the *Hazardous and Solid Waste Amendments (HSWA) of 1984*, to NMED. LANL had frequent interactions with federal and state RCRA personnel during 1993. The Laboratory is currently out of compliance with RCRA requirements related to storage of certain hazardous and mixed wastes subject to the land disposal restrictions (LDRs) because of a lack of adequate or available treatment capacity. In June 1993, the DOE and LANL completed negotiations with the EPA on an Federal Facilities Compliance Agreement on mixed waste storage and treatment subject to LDRs. NMED conducted its annual waste compliance inspection the week of May 4, 1992; this

inspection resulted in the Laboratory receiving two Compliance Orders in January 1993 involving, among other matters, the management of mixed waste. Proposed fines totaled $1.6 million. A multi-media inspection was conducted by EPA and NMED in August 1993, which included NMED's annual RCRA compliance inspection.

Five underground storage tanks were removed during 1993. In 1993, the Laboratory's Environmental Restoration program submitted 10 of the required total of 24 RCRA facility investigation (RFI) work plans. Nine RFI workplans had previously been approved. Other legislation concerning hazardous waste disposal, storage, and treatment include

- ***Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act***
- ***Emergency Planning and Community Right-to-Know Act***
- ***Toxic Substances Control Act***
- ***Federal Insecticide, Fungicide, and Rodenticide Act***

Foodstuffs Monitoring. Most produce, fish, bee, and honey samples from Laboratory and perimeter locations showed no radioactivity distinguishable from that attributable to natural sources or worldwide fallout. Some produce samples from on-site locations had elevated tritium concentrations at levels <1% of DOE's guides for tritium in water (there are no concentration guides for produce). The range in tritium values in produce samples collected from Laboratory lands ranged in concentration from 0.10 to 4.70 pCi/mL.

Resource Assessments. In accordance with the ***National Environmental Policy Act (NEPA) of 1969***, federal agencies must consider the environmental impacts of proposed activities. In 1993, the Laboratory's Environmental Protection group reviewed 953 actions proposed to be undertaken at the Laboratory.

Other requirements concerning cultural and biological resources that are reviewed at the Laboratory include

- ***National Historic Preservation Act***
- ***Endangered Species Act***
- ***Executive Order 11988, Floodplain Management***
- ***Executive Order 11990, Protection of Wetlands***

II. INTRODUCTION

A. Los Alamos National Laboratory

In March 1943, a small group of scientists came to Los Alamos, located on a remote mesa high above the Rio Grande, northwest of Santa Fe 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.

Today, the Laboratory is a research and development (R&D) institution operated by the University of California (UC) for the Department of Energy (DOE). Managing the Laboratory since its inception in 1943, UC has maintained the tradition of free inquiry and debate that is essential to excellence in all scientific undertakings. The Laboratory is dedicated to developing world-class science and technology and applying them to the nation's security and well-being. The Laboratory will continue its special role in defense, particularly in nuclear weapons technology, and will increasingly use its multidisciplinary capabilities to solve important civilian problems.

In pursuing this mission, the Laboratory will maintain a safe and healthful work place and will protect the environment. No activity or operation will be carried out at the Laboratory unless it can be performed in a manner designed to protect employees, the public, and the environment (LANL 1992).

The operating cost of the Laboratory for fiscal year 1993 (FY93) was $1,100 million, with an additional $40 million for construction and $46 million for capital equipment. In FY93, 64% of the operating budget supported defense-related activities; 11% supported Department of Defense projects; 21% supported civilian R&D, predominantly research and technology development and programs supported by the nondefense programs within DOE; and 4% was classified as Work for Others, which includes work conducted for the Nuclear Regulatory Commission, National Institutes for Health, and the National Aeronautics and Space Administration. Approximately $184 million was spent on environmental restoration (ER), waste management, and environmental protection; this money represents 17% of the operating budget and 26% of the operating budget allotted to defense-related activities.

With about 8,400 employees, the Laboratory is the largest employer in northern New Mexico. More than 3,600 of these employees are technical staff members; the remainder are structured series employees. The Laboratory also employs more than 2,000 people in special programs such as work-study programs and as limited-term employees. In addition, more than 4,150 people are employed by contractors providing support services, protective force services, and specialized scientific and technical services.

The Laboratory contract is administered through the DOE Los Alamos Area Office and the Albuquerque Operations Office. The Laboratory Director is ultimately responsible for all Laboratory activities. However, technical and administrative responsibility and authority have been delegated to directorates and support offices. In 1993, the Director was supported by a Deputy Director, an Executive Staff Director, nine Associate Directors, the Controller, the Laboratory Counsel, the Director of Human Resources, and the Office of Public Affairs.

In 1993, the Environmental Management (EM) Division was the primary Laboratory support program for all environmental activities. EM Division initiates and promotes a comprehensive Laboratory program for environmental protection and has primary responsibility for environmental surveillance and regulatory compliance. As part of these duties, EM Division manages the Laboratory's waste management, corrective activities, environmental chemistry, environmental protection, and ER programs, and it maintains a record of Laboratory documents related to environmental matters. Although the Laboratory Director has primary responsibility for environment, safety, and health (ES&H) management, EM 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 Resource Conservation and Recovery Act. With assistance from the Laboratory Counsel, EM 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 Health and Safety Division is also key in implementing the Laboratory's environmental program. The division is responsible for tracking radiological airborne emissions from stacks around the Laboratory, for maintaining stack emission plans and quality assurance documentation, for preparing annual reports, and for communicating environmental policies to Laboratory employees and ensuring that appropriate environmental training programs are available.

Several committees provide environmental reviews for Laboratory operations. The Laboratory's ES&H Questionnaire Review Committee provides reviews of proposed projects to ensure that appropriate environmental, as well as health and safety, issues are properly addressed. In 1993, the committee reviewed 231 questionnaires. The Laboratory Environmental Review Committee reviews NEPA documentation for projects before submitting the documents to DOE. The ES&H Council provides senior management level oversight of environmental activities and policy development.

The Emergency Management Office is responsible for the Laboratory's Emergency Management Plan, which is designed for prompt mitigation of all incidents, including those with environmental impact, and provides the means for coordinating all Laboratory resources in the mitigation effort.

B. 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 100 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe (Figure II-1). The 111-km^2 (43-mi^2) Laboratory site is situated on Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west oriented canyons cut by intermittent streams (Figure II-2). Mesa tops range in elevation from approximately 2,400 m (7,800 ft) on the flanks of the Jemez Mountains to about 1,900 m (6,200 ft) at their eastern termination above the Rio Grande Canyon.

Most Laboratory and community developments are confined to mesa tops (see the inside front cover). The surrounding land is largely undeveloped, with large tracts of land north, west, and south of the Laboratory site being held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County (see the inside back cover). The Pueblo of San Ildefonso borders the Laboratory to the east.

The Laboratory is divided into technical areas that are used for building sites, experimental areas, waste disposal locations, roads, and utility rights-of-way (see Figure II-3 and Appendix C). 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.

DOE controls the area within Laboratory boundaries and has the option to completely restrict access. The public is allowed limited access to certain areas of the Laboratory. An area north of Ancho Canyon (see Figure II-4) between the Rio Grande and State Road 4 is open to hikers, rafters, and hunters, but woodcutting and vehicles are prohibited. Portions of Mortandad and Pueblo canyons are also open to the public. Archaeological sites at Otowi Tract northwest of State Road 502 near the White Rock Y and in Mortandad Canyon are open to the public, subject to restrictions protecting cultural resources.

In August 1977, the Laboratory site was dedicated as a National Environmental Research Park (NERP), a program managed by DOE in response to recommendations from environmental visionaries to set aside land for ecosystem preservation and study. In addition to Los Alamos, six other NERPs are located at DOE facilities and associated with national laboratories. The ultimate goal of programs associated with this regional facility is to encourage environmental research that will contribute to understanding how people can best live in balance with nature while enjoying the benefits of technology. Recent research at the park emphasizes understanding the fundamental processes governing the interaction of ecosystems and the hydrologic cycle on the Pajarito Plateau. The following specific data sets and database information have been developed as part of this program:

- Maps, including topographical and aerial photographs at several scales.

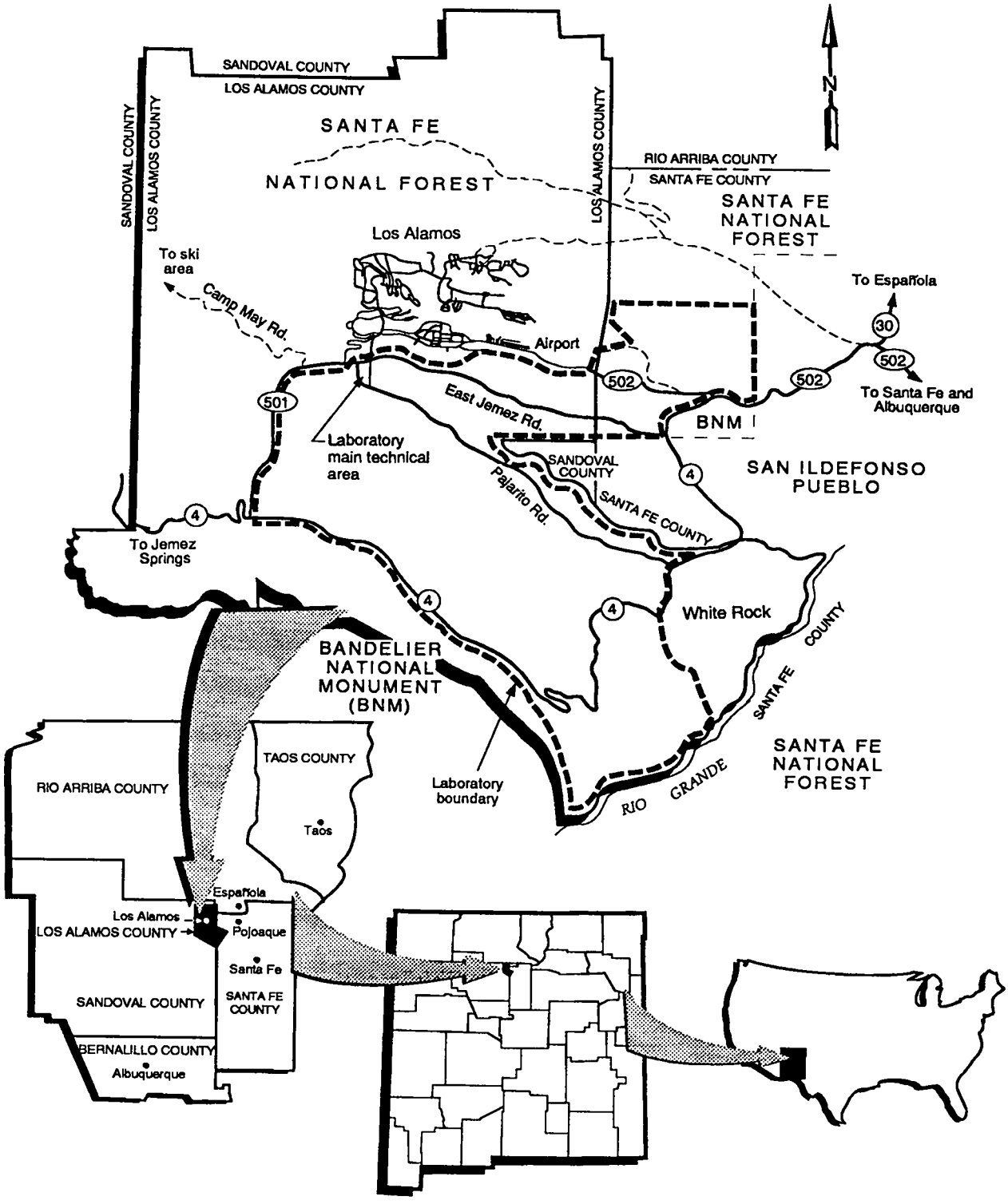


Figure II-1. Regional location of Los Alamos National Laboratory.

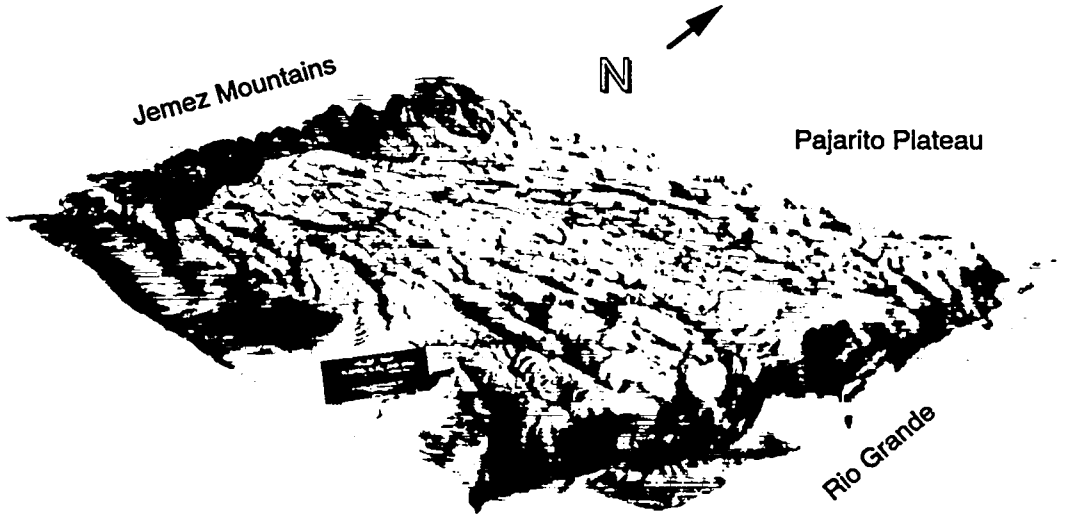


Figure II-2. Topography of the Los Alamos area.

- Habitat characterization/population dynamics, including lists of plant, fish, reptile, bird, and invertebrate species.
- Life history studies of Rocky Mountain mule deer, elk, and small mammals.
- Endangered species studies of the gramma grass cactus, peregrine falcon, and Jemez Mountain salamander.
- Fire ecology, including nutrient cycling and long-term fire succession.
- Long-term water and nutrient dynamics on piñon-juniper habitats.
- Computer-based interactive overlay mapping system.
- Climatology data, including 45 years of precipitation data and 23 years of wind data and solar radiation.
- Soil surveys.
- A long-term environmental surveillance database on radionuclides and stable elements in environmental media.
- Long-term vegetation map with species occurrences.
- Root distributions of native plants.

An Environmental Impact Statement (EIS) that assessed potential cumulative environmental impacts associated with then, known future, and continuing activities at the Laboratory was completed in 1979 (DOE 1979). The report provided environmental input for decisions regarding continuing activities at the Laboratory. It also provided more detailed information on the environment in and around Los Alamos. DOE will prepare a new site-wide EIS for the Laboratory within the next several years.

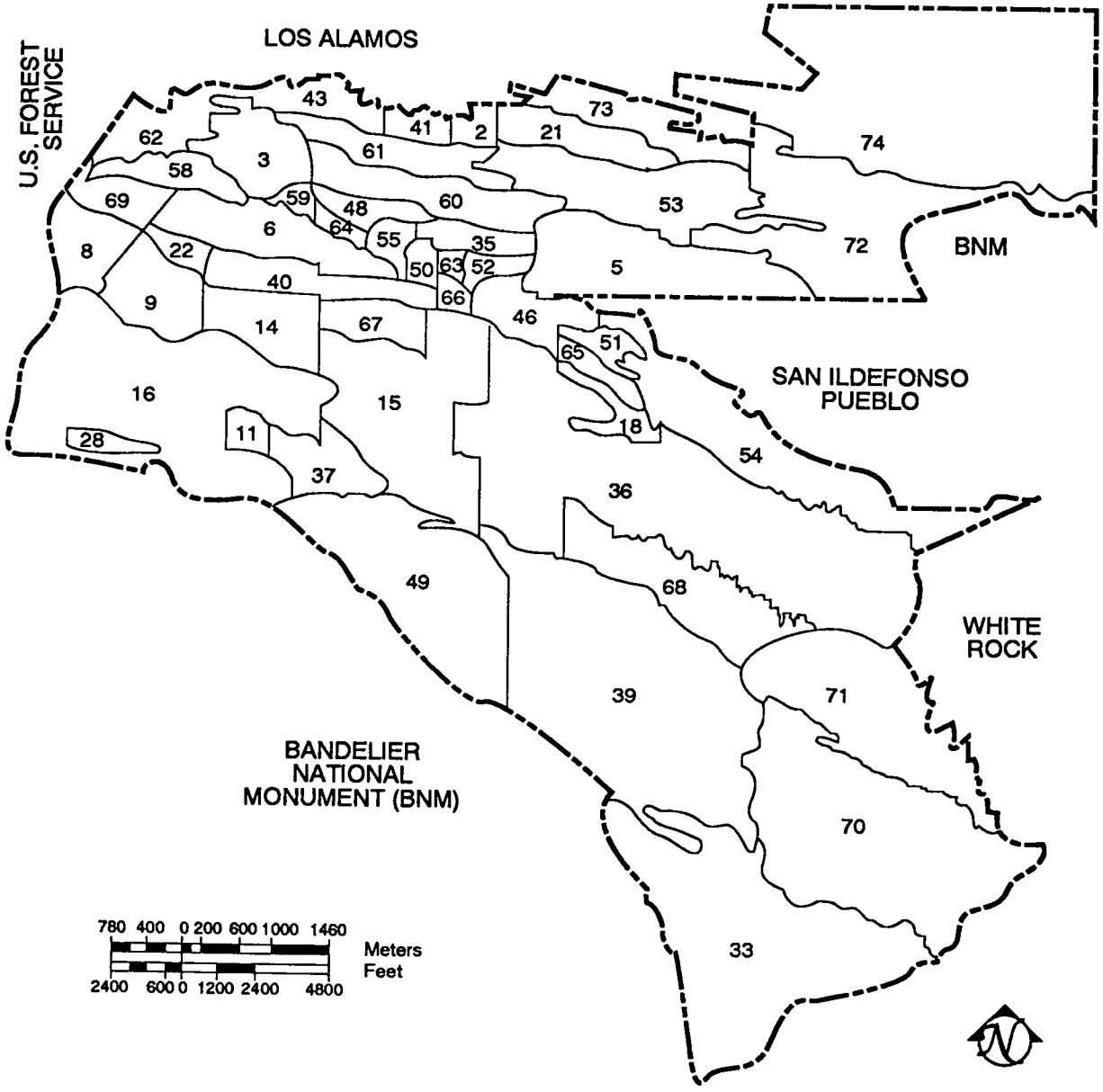
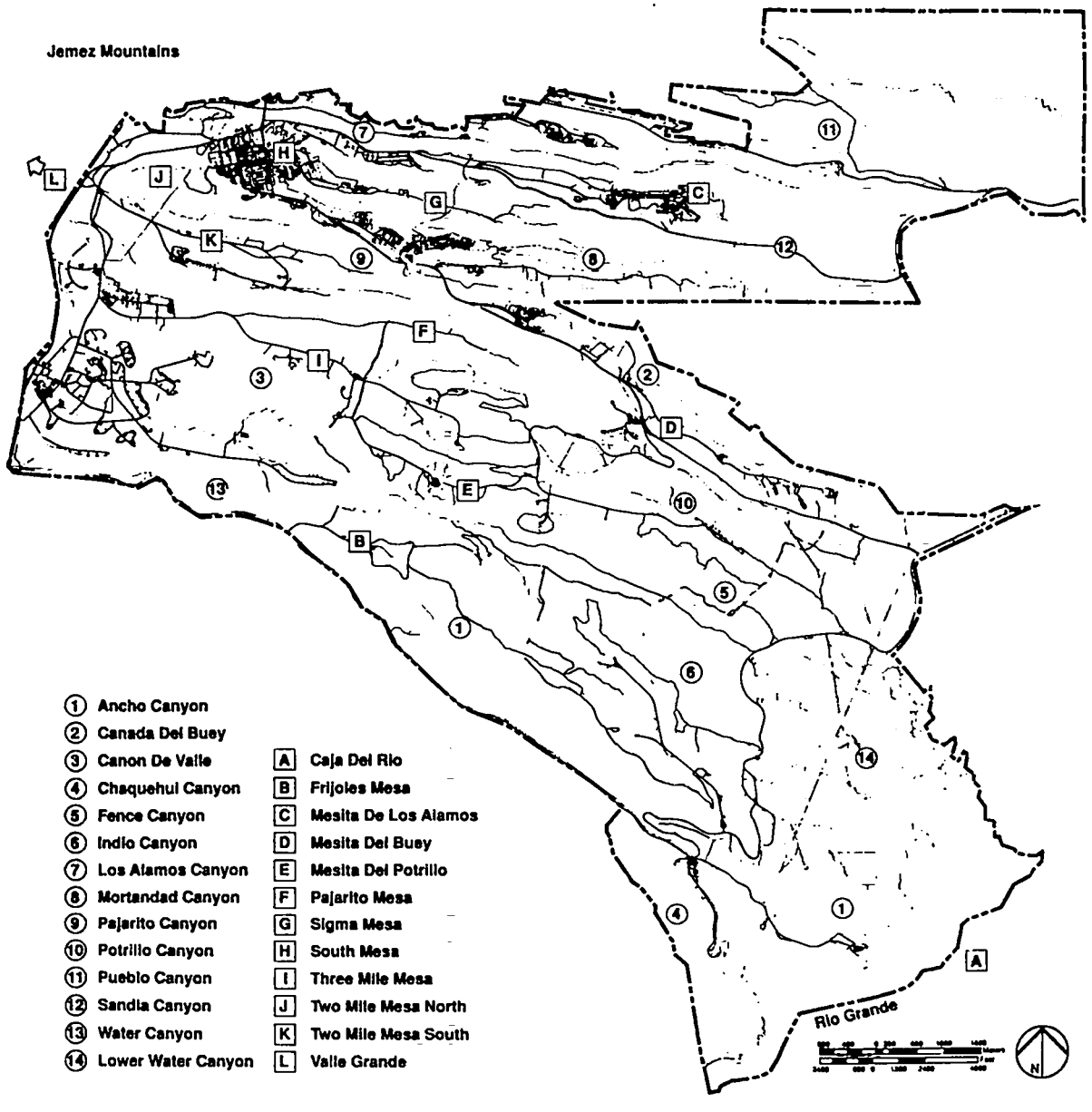


Figure II-3. Technical areas (TAs) of Los Alamos National Laboratory in relation to surrounding landholdings.



General Site Description

1990 Los Alamos National Laboratory Site Development Plan

Figure II-4. Major canyons and mesas.

C. Geology and Hydrology

Most of the finger-like mesas in the Los Alamos area are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff (Figure II-5). The tuff, ranging from nonwelded to welded, is over 300 m (1,000 ft) thick in the western part of the plateau and thins to about 80 m (260 ft) 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.

The 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 (Figure II-5) in the central and eastern edge along the Rio Grande. Chino Mesa basalts interfinger with the conglomerate along the river. These formations overlay the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 1,000 m (3,300 ft) thick. The Laboratory is bordered on the east by the Rio Grande, within the Rio Grande Rift. Because the rift is slowly widening, the area experiences frequent but minor seismic disturbances.

Surface water in the Los Alamos area occurs primarily as ephemeral 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. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande several times a year in some drainages. Effluents from sanitary sewage, industrial waste treatment plants, and cooling-tower blowdown enter some canyons at rates sufficient to maintain surface flows for varying distances.

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.

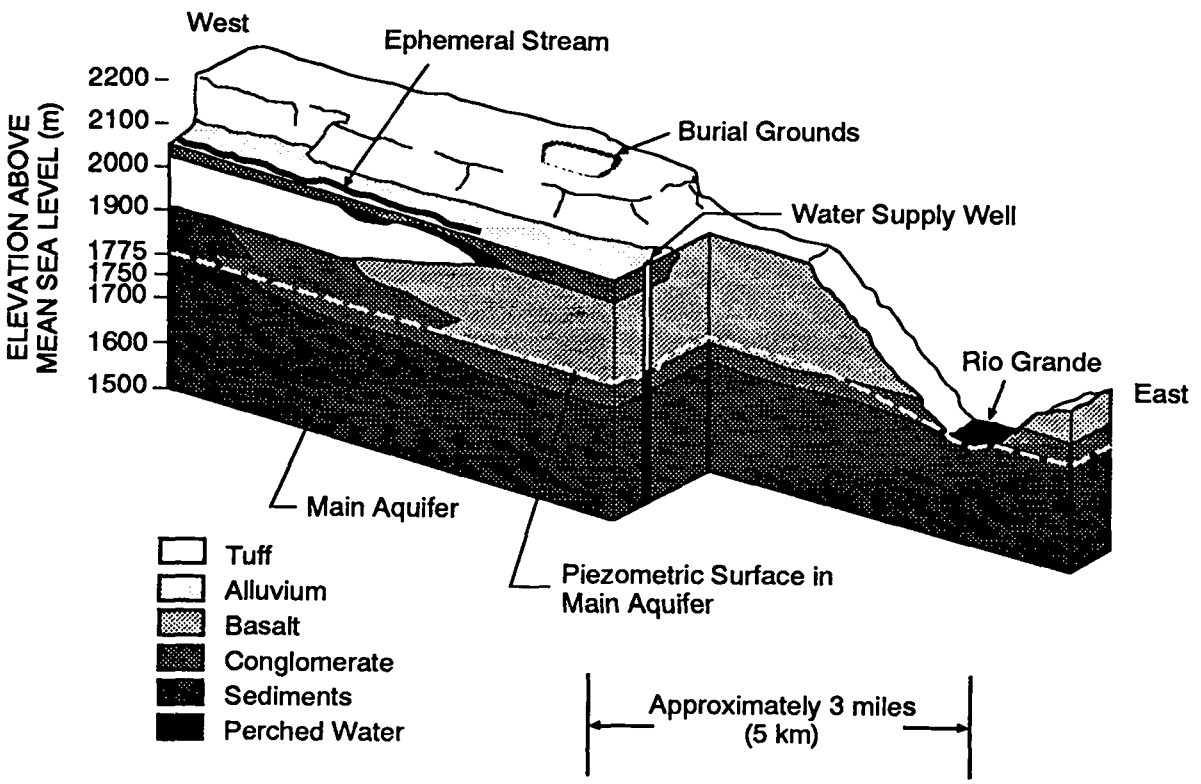


Figure II-5. Conceptual illustration of geologic and hydrologic relationship in Los Alamos area.

Ephemeral and interrupted streams have deposited alluvium that ranges from less than 1 m (3 ft) to as much as 30 m (100 ft) in thickness. Runoff in canyons infiltrates the alluvium until its downward movement is impeded by layers of weathered tuff and volcanic sediment that are less permeable than the alluvium. This creates shallow bodies of perched groundwater that move down gradient within the alluvium. As water in the alluvium moves down the canyon, it is depleted by evapotranspiration and movement into underlying volcanics (Purtymun 1977). The chemical quality of the perched alluvial groundwaters show the effects of discharges from the Laboratory.

Perched groundwater occurs at intermediate depths in conglomerates and basalts beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia canyons. It has been found at depths of about 37 m (120 ft) in the midreach of Pueblo Canyon, about 45 to 60 m (150 to 200 ft) beneath the surface in lower Pueblo and Los Alamos canyons near their confluence, in basalts in Los Alamos Canyon at 61 to 76 m (200 to 250 ft) (Figure II-5), and in Sandia Canyon near the eastern Laboratory boundary at a depth of about 137 m (450 ft). This intermediate-depth perched water has one known discharge point at Basalt Spring in Los Alamos Canyon. The intermediate-depth groundwaters communicate with the overlying perched alluvial groundwaters and show the effects of radioactive and inorganic contamination from Laboratory operations.

The main aquifer of the Los Alamos area is the only aquifer in the area capable of serving as a municipal water supply. The surface of the aquifer rises westward from the Rio Grande within the Tesuque Formation into the lower part of the Puye Formation beneath the central and western part of the plateau. Depth to the main aquifer is about 300 m (1,000 ft) beneath the mesa tops in the central part of the plateau. The main aquifer is separated from alluvial and perched waters by about 110 to 190 m (350 to 620 ft) of tuff and volcanic sediments with low (<10%) moisture content.

Water in the main aquifer is under artesian conditions near the Rio Grande (Purtymun 1974b). Continuously recorded data on water levels collected in test wells since fall 1992 indicate that the main aquifer exhibits confined aquifer response to barometric and earth tide effects at several locations across the plateau. Major recharge to the main aquifer is probably from the west because the piezometric surface slopes downward to the east. The main aquifer discharges into the Rio Grande through springs in White Rock Canyon. The 18.5-km (11.5-mi) reach of the river in White Rock Canyon between Otowi Bridge and the mouth of Rito de Frijoles receives an estimated 5.3 to 6.8×10^6 m^3 (4,300 to 5,500 ac-ft) annually from the aquifer.

D. Climatology

Climatological averages for atmospheric variables (temperature, pressure, winds, and the moisture content of the air) and precipitation are based on observations made at the official Los Alamos weather station from 1961 to 1993, as presented in Tables II-1 and II-2. Extremes are based on the 1911 to 1993 period. Although the location of the official weather station has changed over the years, all of the sites are within 30 m (100 ft) of each other in elevation and 5 km (3 mi) in distance. The meteorological conditions described here are representative of conditions on the Pajarito Plateau at an elevation of approximately 2,250 m (7,400 ft) above sea level.

Los Alamos has a temperate and semiarid climate; all four seasons are evident, but generally only small amounts of moisture are in the air. Spring is often the windiest season with stronger mean winds and wind gusts than at other times of the year. Summer is characterized by the onset of the "rainy" season, a period that is often referred to as a monsoon season (Lyons 1992). Lightning, hail, and active thunderstorms frequently occur during this period. Fall is typically characterized by the return of cooler and much dryer air from the northwest, with many days experiencing large swings of temperature. Winters in Los Alamos are generally not severe; occasionally, large snowfalls exceeding 1 m (3 ft) cause below freezing temperatures.

Temperatures range from a high of 35°C (95°F) to a low of -27.8°C (-18°F). In July, the average daily high temperature is 27.2°C (81°F), and the average nighttime low temperature is 12.8°C (55°F). The average January daily high is 4.4°C (40°F), and the average nighttime low is -8.3°C (17°F). The large daily range in temperature (approximately 13°C [23°F]) results from the site's relatively dry, clear atmosphere, which allows high insolation during the day and rapid radiative losses at night.

Table II-1. Los Alamos, New Mexico,[a] Climatological Summary (1911–1993), Temperature Means[b] and Extremes

	Temperature (°F)[c]										
	Normals			Extremes							
Month	Mean Maximum	Mean Minimum	Average	High Average	Year	Low Average	Year	High Daily Maximum	Date	Low Daily Minimum	Date
January	39.5	17.4	28.5	37.6	1986	20.9	1930	64	1/12/53	–18	1/13/63
February	43.5	21.1	32.3	41.5	1954	23.0	1939	69	2/25/86	–14	2/08/33
March	49.6	26.5	38.1	45.8	1972	31.5	1958	73	3/11/89	–3	3/11/48
April	58.4	33.3	45.9	54.3	1954	39.6	1973	80	4/23/50	5	4/09/28
May	67.6	42.0	54.8	60.5	1956	50.1	1957	93	5/10/34	24	5/01/76
June	77.8	51.1	64.5	69.6	1990	59.3	1941	95	6/22/81	28	6/03/19
July	80.6	55.3	68.0	71.9	1946	53.8	1918	95	7/11/35	37	7/07/24
August	77.5	53.5	65.5	70.3	1936	55.8	1918	92	8/10/37	31	8/31/87
September	71.1	47.2	59.2	65.8	1956	56.2	1965	94	9/11/34	23	9/29/36
October	61.5	37.6	49.6	57.7	1950	42.9	1984	84	10/01/80	6	10/30/93
November	48.9	27.1	38.0	44.4	1949	28.7	1929	72	11/01/50	–14	11/28/76
December	40.8	19.4	30.1	38.4	1980	23.8	1992	69	12/2/27	–13	12/09/78
Annual	59.7	36.0	47.9	52.0	1954	46.2	1932	95	6/22/81	–18	1/13/63

[a]Latitude 35°52′ north, longitude 106°19′ west; elevation 2263 m.

[b]Means are based on standard 30-year period: 1961–1990.

[c]Metric conversions: 1 in. = 2.5 cm; °F = 9/5°C + 32.

Table II-2. Los Alamos, New Mexico,[a] Climatological Summary (1911–1993), Precipitation Means[b] and Extremes

	Precipitation (in.)[c]										Mean Number of Days Per Year		
	Precipitation[d]					Snow						Max.	Min.
Month	Mean	Maximum	Year	Daily Maximum	Date	Mean	Maximum	Year	Daily Maximum	Date	Precip. ≥0.10 in.	Temp. ≥90°F	Temp. ≤32°F
January	0.86	6.75	1916	2.45	1/12/16	12.1	64.8	1987	22.0	1/15/87	2	0	29
February	0.80	2.78	1987	1.05	2/20/15	9.9	48.5	1987	20.0	2/19/87	2	0	27
March	1.22	4.11	1973	2.25	3/30/16	12.0	37.0	1973	18.0	3/30/16	3	0	24
April	1.01	4.64	1915	2.00	4/12/75	4.6	33.6	1958	20.0	4/12/75	3	0	14
May	1.17	4.47	1929	1.80	5/21/29	0.9	17.0	1917	12.0	5/02/78	3	0	3
June	1.36	5.64	1986	2.51	6/10/13	N/A[e]	N/A	N/A	N/A	N/A	3	1	0
July	3.26	7.98	1919	2.47	7/31/68	N/A	0.2	1925	0.2	7/23/25	8	1	N/A
August	3.52	11.18	1952	2.26	8/01/51	N/A	0.4	1957	0.4	8/23/57	8	0	N/A
September	2.12	5.79	1941	2.21	9/22/29	0.1	4.0	1936	4.0	9/28/36	5	0	0
October	1.30	6.77	1957	3.48	10/05/11	2.0	20.0	1984	9.0	10/31/72	3	0	7
November	1.02	6.60	1978	1.77	11/25/78	4.6	34.5	1957	14.0	11/22/31	2	0	22
December	1.08	3.72	1918	2.21	12/19/18	12.8	41.3	1967	22.0	12/06/78	3	0	30
Annual	18.72	30.34	1941	3.48	10/05/11	59.0	178.4	1987	22.0	1/15/87	46	3	156
Season							153.2	1986–87					

[a]Latitude 35°52′ north, longitude 106°19′ west; elevation 2263 m.

[b]Means are based on standard 30-year period: 1961–1990.

[c]Metric conversions: 1 in. = 2.5 cm; °F = 9/5°C + 32.

[d]Includes water equivalent of frozen precipitation.

[e]N/A = not applicable.

Although the dry atmosphere promotes rapid nighttime cooling near the ground, this cooling is somewhat counterbalanced by the flow of heat from above, generated by turbulence in the drainage flow. Therefore, the strong surface-based temperature inversions often observed in the valleys are not observed on the plateau. Inversions of 3°C (≅5°F) over 100 m (328 ft) are typical, and these are generally destroyed less than two hours after sunrise. Atmospheric pressure at the weather station averages 776 mbar (22.91 in. of mercury), which is about 76% of the standard pressure at sea level.

The Pajarito Plateau runs roughly from west to east and is situated between the Jemez Mountains to the west and the Sangre de Cristo Mountains to the east, separated by the Rio Grande Valley that runs roughly north to south and slopes downward from Colorado to New Mexico. The plateau slopes downward to the east at about a 4% grade, sufficient on occasion to promote both light drainage winds toward the Rio Grande at night and weaker upslope flows toward the Jemez Mountains by day if the synoptic (large-scale) winds are not too strong. Similarly, southward nocturnal drainage flows from Colorado are also observed.

Winds on the Pajarito Plateau at Los Alamos are typically quite light, with a climatological average at an elevation of 11.5 m (37 ft) of about 2.8 m/s (6.3 mi/h). The observed near-surface wind may reach up to 34.4 m/s (77 mi/h), but in the spring the observed mean winds can exceed 11 m/s (25 mi/h) and the associated gusts can exceed 22 m/s (50 mi/h). Generally there is little variability from year to year in the observed near-surface wind patterns. The strength and direction of these winds can change significantly, however, as the synoptic storm track shifts. The overall roughness and the complexity of the terrain near LANL combine to produce a large, but quite variable, degree of near-surface turbulence.

Monthly average values of the dew point temperature range from -9.4°C (15°F) in January to 8.9°C (48°F) in August, when moist subtropical air invades the region during the rainy season. Fog is rare in Los Alamos, occurring on fewer than five days a year.

The average annual precipitation (rainfall plus the water equivalent of frozen precipitation) is 47.6 cm (18.7 in.). However, the annual total varies approximately 25% from year to year. The lowest recorded annual precipitation is 17.3 cm (6.8 in.) and the highest is 77.1 cm (30.3 in.). The maximum precipitation recorded for a 24-h period is 8.8 cm (3.5 in.).

Approximately 36% of the precipitation over the plateau and surrounding regions is produced during the summer rainy season in July and August largely from shallow, convective precipitation events with rather small central rainshafts. This precipitation is often considered to be a random process, i.e., it is commonly stated in summertime forecasts that there is a certain percentage chance of recording rain during a given period.

Winter precipitation occurs mostly as snow; freezing rain is rare. Annual snowfall averages 150 cm (59 in.). The highest recorded snowfall for one season is 389 cm (153 in.), and the highest recorded snowfall for a 24-h period is 56 cm (22 in.). The snow is generally dry; on average, 20 units of snow is equivalent to 1 unit of water. The snowfall events are largely produced by frontal or frontal-related events. Often the largest snowfall amounts are associated with upslope flows from the east.

E. Ecology

The diversity of ecosystems in the Los Alamos area is due partly to the dramatic 1,500-m (5,000-ft) elevation gradient from the Rio Grande on the east to the Jemez Mountains 20 km (12 mi) to the west and partly to the many steep canyons that dissect the area. Six major vegetative complexes or community types are found in Los Alamos County: juniper-grassland, piñon-juniper, ponderosa pine, mixed conifer, spruce-fir, and subalpine grassland. The juniper-grassland community is found along the Rio Grande on the eastern border of the plateau and extends upward on the south-facing sides of canyons, at elevations between 1,700 and 1,900 m (5,600 to 6,200 ft). The piñon-juniper community, generally in the 1,900- to 2,100-m (6,200- to 6,900-ft) elevation range, covers large portions of the mesa tops and north-facing slopes at the lower elevations. Ponderosa pines are found in the western portion of the plateau in the 2,100- to 2,300-m (6,900- to 7,500-ft) elevation range. These three communities predominate, each occupying about one-third of the Laboratory site. The mixed conifer community, at an elevation of 2,300 to 2,900 m (7,500 to 9,500 ft), overlaps the ponderosa pine community in the deeper canyons and on north slopes and

extends from the higher mesas onto the slopes of the Jemez Mountains. The subalpine grassland community is mixed with the spruce-fir communities at higher elevations of 2,900 to 3,200 m (9,500 to 10,500 ft).

Because of the variety of complex, interlocking ecotones in the Los Alamos area, no single ecological structure of food webs can characterize all the associations of flora and fauna in the area. Food web relations for the biota of the Laboratory environs have been studied only enough to provide information for general descriptions and expectations. Generally, larger mammals and birds are wide ranging and utilize large habitats, from the dry mesa and canyon country at lower elevations to the high mountain tops west of the Laboratory. Smaller mammals, reptiles, invertebrates, and vegetation are more sensitive to variations in elevation and are thus confined to generally smaller habitats.

As a result of past and present use of the Laboratory environs, some areas of vegetation are undergoing secondary succession. This process has important consequences for natural systems. Farming by prehistoric Indians and by Spanish and Anglo settlers before establishment of the Laboratory created open, grassy areas on the mesas that have not yet returned to climax plant communities. These areas provide feeding areas for herbivores, especially deer and elk, and the adjacent timbered canyon slopes provide cover.

F. Cultural Resources

Approximately 60% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and close to 1,400 sites have been recorded. Over 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 1,760 and 2,150 m (5,800 and 7,100 ft) in elevation. Almost three-quarters of all ruins are found on mesa tops, which are also the preferred locations for development at the Laboratory today.

G. Population Distribution

In 1993, the estimated population of Los Alamos County was approximately 18,400 (USBC 1991). Two residential and a few commercial areas exist in the County (Figure II-1). The Los Alamos townsite (the original area of development, which now includes residential areas known as Eastern Area, Western Area, North Community, Barranca Mesa, and North Mesa) had an estimated population of 12,000. The White Rock area (including the residential areas of White Rock, La Senda, and Pajarito Acres) had about 6,400 residents. About 50% of the people employed by UC, DOE, and Laboratory contractors commute from outside Los Alamos County. It is estimated that approximately 219,000 persons lived within an 80-km (50-mi) radius of the Laboratory in 1993 (Table II-3).

Table II-3. 1993 Population within 80 km of Los Alamos National Laboratory[a,b]

	Distance from TA-53[c] (km)									
Direction	**0–1**	**1–2**	**2–4**	**4–8**	**8–15**	**15–20**	**20–30**	**30–40**	**40–60**	**60–80**
N	7	65	235	127	0	13	83	881	753	541
NNE	6	71	82	16	1	9	2,178	368	617	385
NE	4	7	0	0	1	1,109	13,409	2,307	2,251	3,370
ENE	0	0	0	0	508	1,386	4,022	3,254	1,305	1,440
E	0	0	0	1	294	1,208	3,612	339	20	375
ESE	0	0	0	0	7	9	610	6,949	649	2,032
SE	0	0	0	4,475	489	0	889	64,905	6,690	620
SSE	0	0	0	596	348	0	271	5,058	2,296	93
S	0	0	0	0	20	0	14	114	353	2,842
SSW	0	0	0	0	31	1	643	1,125	5,854	45,105
SW	0	0	0	0	4	1	0	0	1,843	150
WSW	0	0	0	0	0	0	23	322	2,117	3
W	0	0	85	212	0	5	56	245	52	61
WNW	0	0	969	6,060	0	0	22	25	54	2,194
NW	0	0	907	1,365	0	2	22	45	397	523
NNW	1	66	631	283	0	5	19	241	147	269
1993 Pop. Distribution	18	209	2,909	13,135	1,703	3,748	25,873	86,178	25,398	60,003

[a]Total population within 80 km of Los Alamos National Laboratory is 219,174.
[b]Please see Figure II-1 for more information on the location of the population.
[c]Please see Figure II-3 for the location of TA-53.

NOTE: The estimated population for 1993 is less than that reported in 1992. In 1993 LANL revised its method of estimating population by using the projections provided from the New Mexico Bureau of Business and Economic Research based on the 1990 census.

III. COMPLIANCE SUMMARY

Los Alamos National Laboratory (LANL or the Laboratory) operates under multiple federal and state environmental statutes, regulations, and permits that mandate compliance standards for environmental protection.

LANL had frequent interactions with federal and state Resource Conservation and Recovery Act (RCRA) personnel during 1993. The Department of Energy (DOE) and the Environmental Protection Agency (EPA) are finalizing negotiations on a Federal Facilities Compliance Agreement (FFCA) addressing mixed waste storage and treatment subject to land disposal restrictions (LDR). In January 1993, the New Mexico Environment Department (NMED) proposed fines totaling $1.6 million for various alleged violations of the New Mexico Hazardous Waste Act (NMHWA). NMED, DOE, and LANL negotiated and agreed to a compliance plan for the resolution of outstanding issues, and LANL paid fines totaling $700,000.

Five underground storage tanks were removed during the year. An annual inspection conducted by the NM Department of Agriculture (NMDA) found no deficiencies in the Laboratory's pesticide application program.

In 1993, the Laboratory was in compliance with its on-site liquid discharge requirements in 100% of the samples from its sanitary effluent outfalls and in 99.1% of the samples from its industrial effluent outfall samples. Concentrations of chemical constituents in the drinking water distribution system remained within federal and state water supply standards. In August, there was a violation of the Safe Drinking Water Act (SDWA) maximum contaminant levels for bacteria at Technical Area (TA) 39 and TA-33. The coliform contamination was eliminated by flushing and disinfecting the distribution systems serving these areas.

The Laboratory was in compliance with all federal nonradiological ambient air quality standards. The Laboratory's 1993 radioactive emissions were in compliance with EPA's effective dose equivalent (EDE) limitation of less than 10 mrem/yr to members of the public from airborne emissions. The EDE was 5.7 mrem calculated using EPA-approved methods that do not take into account building shielding and occupancy.

During 1993, 953 actions proposed to be undertaken at the Laboratory were reviewed for National Environmental Policy Act (NEPA) applicability, and 62 DOE Environmental Checklists (DECs) were submitted to DOE. In addition, Laboratory archaeologists evaluated 780 proposed actions for possible effects on cultural resources, which required 42 intensive field surveys. Laboratory biologists reviewed 410 proposed actions for potential impacts on threatened and endangered species; 49 actions required additional study. During 1993, 410 proposed actions were reviewed for effect on floodplains and wetlands. Four projects may be inside floodplain/wetland boundaries; floodplain or wetland assessments are being prepared for these projects.

A. Introduction

Many of the activities and operations at the Laboratory involve or produce liquids, solids, and gases that contain radioactive and/or nonradioactive hazardous materials. It is the policy of the Laboratory that operations shall be

performed in a manner that protects the environment and addresses compliance with applicable federal and state environmental protection regulations. This policy is in accordance with DOE requirements to protect the public, environment, and worker health and to comply with applicable environmental laws, regulations, and orders.

Federal and state environmental requirements address handling, transport, release, and disposal of contaminants, pollutants, and wastes, as well as protection of ecological, archaeological, historic, atmospheric, and aquatic resources. Regulations specify generic requirements and standards to ensure maintenance of environmental qualities. Table III-1 presents a list of the major environmental legislation that affects the activities of the Laboratory. The principal authorities administering the regulations implementing these laws are the EPA, DOE, and NMED. The environmental permits issued by these organizations and the specific operations and/or sites affected are presented in Table III-2.

B. Compliance Status

1. Resource Conservation and Recovery Act.

a. Introduction. The Laboratory produces a wide variety of hazardous wastes. The RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, mandates a comprehensive program to regulate hazardous wastes, from generation to ultimate disposal. The amendments emphasize reducing the volume and toxicity of hazardous waste. They require treatment of hazardous waste before land disposal. Table D-1 lists the hazardous waste management facilities at the Laboratory.

EPA or an authorized state grants RCRA permits to specifically regulate the treatment, storage, and disposal of hazardous waste and the hazardous component of radioactive mixed waste. 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. A facility that has submitted a RCRA Part A permit application is allowed to manage hazardous or mixed wastes under transitional regulations known as the Interim Status Requirements pending issuance of a RCRA Operating Permit. The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous or mixed waste management. DOE and the University of California (UC) or co-operator of LANL were granted a hazardous waste facility permit on November 8, 1989.

The EPA granted base RCRA authorization to New Mexico on January 25, 1985, transferring regulatory authority over hazardous wastes under RCRA to the NMED. State authority for hazardous waste regulation is found in the Hazardous Waste Act and Hazardous Waste Management Regulations (HWMR). However, NMED has not yet obtained authorization for implementing the majority of the 1984 HSWA. HWMR adopted the federal codification for regulations in effect on July 1, 1992, concerning the generation and management of hazardous waste. On July 25, 1990, the EPA authorized the State of New Mexico's Hazardous Waste Program to regulate mixed waste. A Part A permit application for mixed waste storage and treatment units throughout the Laboratory was submitted on January 25, 1991, within the required six-month period. Part B permit applications were submitted for three surface impoundments in July 1991. Negotiations on the submittal of modifications for the interim status units are continuing.

The Laboratory has currently negotiated a schedule for submittal of permit applications to NMED. These applications will address several categories of waste handling units, including the following: retrieval of mixed transuranic waste (TRU) from TA-54, Area G, storage pads 1, 2, and 4; development of new treatment capabilities and associated support units for compliance with the EPA FFCA; proposed new construction units to handle waste currently being generated; and proposed units under development for the handling of wastes generated by the Environmental Restoration (ER) program. Allocation of funding for these permitting activities is driven by compliance needs.

Current permitting issues include the acceptance and approval by NMED of permit modifications requested by LANL in April 1993. Permitting of the modified TRU pads 1, 2, and 4, TRU domes A, B, C, and D; subunits at the proposed Hazardous Waste Treatment Facility; and the Chemical Plating Waste Treatment Skids are also awaiting action by NMED. Applications for these units were submitted to NMED in October 1993. NMED action on the TRU domes and pads is expected in early 1994.

Table III-1. Major Environmental Acts under which the Laboratory Operated in 1993

Legislation	Regulatory Citation	Responsible Agency	Related Legislation and Regulations
Resource Conservation and Recovery Act	RCRA, 40 CFR 257, 258, 260–268, 270–272, 280, and 281	EPA/NMED	Hazardous and Solid Waste Amendments address releases of hazardous constituents, LDRs, etc. NM Hazardous Waste Act NM Hazardous Waste Management Regulations NM Solid Waste Act NM Solid Waste Regulations NM Groundwater Protection Act NM Underground Storage Tank Regulations
Comprehensive Environmental Response, Compensation, and Liability Act	CERCLA 40 CFR 300–311	EPA	Superfund Amendments and Reauthorization Act (SARA) NM Emergency Management Act
Emergency Planning and Community Right-to-Know Act	EPCRA 40 CFR 350–373	EPA	Executive Order 12856
Toxic Substances Control Act	TSCA 40 CFR 700–766	EPA	
Federal Insecticide, Fungicide, and Rodenticide Act	FIFRA 40 CFR 150–189	EPA/NM Department of Agriculture	NM Pest Control Act
Clean Water Act	CWA 40 CFR 121–136 40 CFR 400–424	EPA	National Pollutant Discharge Elimination System (NPDES) (40 CFR 122): two industrial and one storm water permits mandate specific monitoring and reporting conditions along with setting standards for effluent quality for Laboratory discharges to the environment.
		NMED/WQCC	NM Water Quality Control Commission Regulations NM Liquid Waste Disposal Regulations NM Oil Conservation Division - Groundwater Discharge Plan, Fenton Hill NM Water Quality Act Water Quality Standards for Interstate & Intrastate Streams in NM

Table III-1. (Cont.)

Legislation	Regulatory Citation	Responsible Agency	Related Legislation and Regulations
Safe Drinking Water Act	SDWA 40 CFR 141–148	EPA/NMED	NM Water Supply Regulations
Federal Clean Air Act	CAA 40 CFR 50–99	EPA/NMED	National Emission Standards for Hazardous Air Pollutants (NESHAP) for **Radionuclides** (40 CFR 61, Subpart H) requires that no member of the public receive more than 10 mrem/yr (effective dose equivalent), **Asbestos** (40 CFR 61, Subpart M) requires no visible asbestos emissions to the environment, and **Beryllium** (40 CFR 61, Subpart C) requires notification, emission limits, and stack performance testing. Ambient Air Quality Standards NM Air Quality Control Regulations
National Environmental Policy Act	NEPA, 40 CFR 1500–1508, 10 CFR 1021	Council on Environmental Quality/DOE	
National Historic Preservation Act	NHPA 36 CFR 800	State Historic Preservation Officer	NM Cultural Properties Act Archaeological Resources Protection Act Native American Graves Preservation and Repatriation Act American Indian Religious Freedom Act (AIRFA) Antiquities Act of 1906
Endangered Species Act	50 CFR 402	U.S. Fish and Wildlife/ NM Game and Fish	Fish and Wildlife Coordination Act NM Wildlife Conservation Act NM Endangered Plant Species Act
Floodplain Management	Executive Order 11988	DOE	10 CFR 1022
Protection of Wetlands	Executive Order 11990	DOE	10 CFR 1022 Clean Water Act, Section 404, Rivers and Harbors Act
Atomic Energy Act		Nuclear Regulatory Commission/DOE/EPA	

Table III-2. Environmental Permits or Approvals under which the Laboratory Operated in 1993

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA hazardous waste facility	Hazardous waste storage, treatment, and disposal	November 1989	November 1999	NMED
	Postclosure care	Application submitted September 1988		NMED
	RCRA Mixed Waste	Part A application submitted January 1991		NMED
		Part B application submitted (TA-53 Surface Impoundments [3]) July 1991	—	NMED
		October 1993	—	NMED
		Part A application submitted (TA-54 and TA-63 units)		
HSWA	RCRA Corrective Activities	March 1990	December 1999	EPA
PCBs[a]	Disposal of PCBs at TA-54, Area G	June 5, 1980	—	EPA
PCB oil	Incineration of PCB oils[b]	October 9, 1992	October 9, 1997	EPA
NPDES[c], Los Alamos	Discharge of industrial and sanitary liquid effluents	Modified permit January 30, 1990	March 1, 1991[d]	EPA
	Storm water associated with industrial activity	General Permit August 25, 1993	October 1, 1997	EPA
NPDES, Fenton Hill	Discharge of industrial liquid effluents	October 15, 1979	June 30, 1983[d]	EPA
NMLWD Regulations[e]	Discharge of sanitary effluents from septic tank systems into soil	[f]	—	NMED
Groundwater discharge plan, Fenton Hill	Discharge to groundwater	July 9, 1990	June 5, 1995	NMOCD[g]
Groundwater discharge plan, TA-46 Sanitary Wastewater Treatment Plant	Discharge to groundwater	July 20, 1992	July 20, 1997	NMED

Table III-2. (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality (NESHAP)[h]	Construction and operation of five beryllium facilities	December 26, 1985; March 19, 1986; September 8, 1987; April 26, 1989; November 25, 1992	—	NMED
Open Burning (AQCR 301)	Fuel fire for ordnance testing, TA-11	August 30, 1991	Testing completed in 1993	NMED
Open Burning (AQCR 301)	Burning of scrap wood from experiments, TA-36	June 14, 1993	June 14, 1993	NMED
Open Burning (AQCR 301)	Burning of HE-contaminated materials, TA-14	December 2, 1993	December 2, 1993	NMED
Open Burning (AQCR 301)	Burning of HE-contaminated materials, TA-16	December 2, 1993	December 2, 1993	NMED

[a]Polychlorinated biphenyls.

[b]No incineration occurred during 1993 even though the activity was permitted.

[c]National Pollutant Discharge Elimination System.

[d]Permit administratively extended while new permit is pending.

[e]New Mexico Liquid Waste Disposal Regulations.

[f]Dates vary depending on individual permits.

[g]New Mexico Oil Conservation Division.

[h]National Emission Standards for Hazardous Air Pollutants.

LANL is in the process of considering an application for a RCRA landfill that would be used primarily for the disposal of wastes generated by the ER program. The unit would consist of a landfill operation and associated storage. The current projection for completion of this permit application is late 1994. Because this is a new construction project, completion of an application will depend on the development of construction plans. Preliminary plans have recently been completed and final design plans are needed, at least in part, to finalize the application.

An application for an emergency permit to treat nitrated cheesecloth rags was submitted to NMED in 1993. LANL has responded to NMED's Notice of Deficiency (NOD) for this application. NMED is currently developing a draft permit for this activity.

The Laboratory submitted two Research, Development, and Demonstration (RD&D) permit applications to the NMED. The application for the packed bed reactor/silent discharge plasma unit was submitted in December 1992; the application for the hydrothermal unit was submitted in March 1993. During 1993, NMED completed administrative and technical completeness reviews for both applications. Additionally, the public comment period for the first draft RD&D permit was closed December 17, 1993. The public comment period for the second draft RD&D permit began in November 1993 and was scheduled to close during January 1994. If issued, the permits will allow the Laboratory to test new and innovative technologies for treatment of hazardous wastes. It is anticipated that the Laboratory will receive both permits sometime during the third quarter of FY94.

b. Solid Waste Disposal. The Laboratory has a Class D industrial solid waste landfill located at TA-54, Area J. The landfill is in compliance with the requirements in the New Mexico Solid Waste Management Regulations. LANL/DOE completed the required Solid Waste Facility Annual Report for calendar year (CY) 92. The TA-54, Area J landfill received 298 cu yd (228 m^3) of solid waste in 1993. The landfill is used as a staging area for nonradioactive asbestos (approximately 371 cu yd [284 m^3]) that is shipped off site to an approved commercial disposal site. Radioactive asbestos and asbestos suspected of being contaminated with radioactive material continue to be disposed into a monofill constructed at TA-54, Area G.

In February 1993, LANL submitted an annual solid waste management report to NMED for LANL's TA-54, Area J landfill. LANL/DOE was also required to submit a preliminary site assessment to the NMED for this landfill by June 30, 1993. The site assessment was sent to NMED on July 2, 1993. LANL also disposes of sanitary solid waste and rubble at the Los Alamos County landfill on East Jemez Road, DOE property that is operated under a special use permit with the county. Los Alamos County has day-to-day operating responsibility for the landfill and is responsible for obtaining all related permits for this activity with the state. LANL contributed approximately 27% of the total volume disposed of at this site during 1993 with the remainder contributed by Los Alamos County residents.

Table III-3 presents a summary of the materials recycled by Johnson Controls, Inc. (JCI), the Laboratory's support services subcontractor, in FY93. This effective waste minimization program, which continues to be expanded, conforms to RCRA Subtitle D.

c. RCRA Closure Activities. 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 closure of these sites. The status of these sites is given below:

TA-35, Surface Impoundments. Closure plans for the two surface impoundments for waste oil that are associated with Buildings 85 and 125 at TA-35 were submitted in October 1988, and oral approval to proceed with closure activities was subsequently received from the state. All contents of the impoundments and underlying soil were removed and disposed of as hazardous waste. Sampling to verify the removal of contaminants from the area was completed in October 1989. Preliminary results of the sampling effort revealed that the criteria for clean closure had been met. The impoundments were backfilled and revegetated at that time. Upon receipt of the final analytical results, it was found that the allowed sample holding times had been exceeded; consequently, the data could not be verified. The closure plan was modified to reflect the events of the field work that occurred and to include bore sampling to be used as the final verification of clean closure. Bore sampling performed in December 1990 determined that minimal amounts of contaminants remained. The levels of contamination found to remain after this cleanup effort did not exceed the EPA's health-based, risk-based cleanup levels. By achieving these

**Table III-3. Johnson Controls World Services, Inc.
FY93 Recycling Volumes**

Type	Volume	
Lead Acid Batteries	4,557 kg	(10,025 lbs)
Lead	1,057 kg	(2,325 lbs)
Waste Oil	35,462 L	(9,220 gals.)
Tires	11,682 kg	(25,700 lbs)
Aluminum	3,859 kg	(8,490 lbs)
Electric Cable	17,118 kg	(37,660 lbs)
Scrap Steel	304,880 kg	(670,735 lbs)
Stainless Steel	4,914 kg	(10,810 lbs)
Copper	13,773 kg	(30,300 lbs)
Brass	206 kg	(454 lbs)
Photographic Film	1,000 kg	(2,200 lbs)
Recycled Paper	351,818 kg	(774,000 lbs)
Phone Books	6,364 kg	(14,000 lbs)

cleanup levels, the Laboratory could still achieve clean closure status for these two units and no post-closure care would be necessary.

The closure report and closure certification letters for the TA-35-125 surface impoundment were completed as of July 31, 1991, and were submitted to NMED in August 1991. The closure report and closure certification letters for TA-35-85 were submitted on December 20, 1991. The NMED sent a NOD to DOE in July 1992 regarding the closure of surface impoundment TA-35-125. The NOD denied approval of clean closure of the unit for two reasons: (1) the Laboratory had failed to delineate the vertical extent of the contamination, and (2) the Laboratory had failed to demonstrate that releases from the unit to the surrounding soil or surface waters were below health-based risk levels. An amended closure plan was submitted to the state on September 4, 1992, to address these concerns. In accordance with this plan, the Laboratory and NMED split samples from Ten-Site Canyon. The sample results indicated that no contamination above health-based risk levels resulted from the release of contaminants to that canyon. The amended closure report was submitted to NMED in April 1993. The Laboratory received final regulatory approval from NMED in September 1993 on the TA-35-125 amended closure report. NMED indicated that the Laboratory met all of the requirements for closure by removal on TA-35-125. No further action is required for this surface impoundment.

An amended closure plan for TA-35-85 was submitted to NMED for approval on November 1, 1993. The plan proposed additional sampling and analysis or a revised technical approach with a schedule for the duration of each technical activity proposed. The Laboratory is still waiting for regulatory approval from NMED for the TA-35-85 closure.

TA-40, Scrap Detonation Site. On September 13, 1991, the NMED notified the Laboratory that the closure plan for the TA-40 Scrap Detonation Site had been approved. The start date of the closure plan was September 30, 1991. This closure is proceeding behind schedule because the original closure plan did not anticipate contamination, which was detected above action levels at several different locations during the sampling phase. The closure plan modification and clean closure equivalency demonstration included risk assessments for the areas where contamination was detected above action levels and was submitted to NMED in May 1993. The Notice of Intent (NOI) to close the site and terminate interim status was issued by NMED November 1, 1993, which started a 30-day period for receiving comments from the public.

TA-54, Waste Oil Storage Tanks. After discovering hazardous waste in six aboveground waste oil storage tanks, the Laboratory pumped and disposed of the contents as hazardous waste. The tanks were moved to TA-54, Area G to make room for needed facilities at TA-54, Area L. In April 1990, the Laboratory elected to pro-

ceed with the closure of these vessels before receiving an approved closure plan. After the tanks had been cleaned several times, the final decontamination was completed in August. A final closure plan/report that reflected the actual closure process of these units was submitted in June 1991. An addendum to the final closure plan was submitted in July 1992. NMED approved the plan in August 1992. Soil sampling at TA-54, Area L will be performed to demonstrate clean closure in conjunction with the HSWA permit corrective action investigations during 1994.

TA-16, Landfill at Material Disposal Area P. Closure and post-closure-care plans for the Area P landfill were submitted on November 25, 1985. In late 1987, these plans were modified to incorporate standards that this unit would be subject to once the Laboratory received its RCRA permit. Since that time, the ER Program Office, which oversees closures, has been established. The Laboratory requested an extension of the closure deadlines for this and other units that appear within the HSWA Module of the RCRA permit. An extension of the closure window would allow the ER program to incorporate the results of the RCRA facility investigation (RFI)/Corrective Measures Study into the closure process. The NMED rejected this approach and requested a revised closure plan by September 1993. The state indicated that it would allow an extension for evaluation of the outstanding issues.

The Laboratory submitted an amended closure plan on August 31, 1993, proposing additional sampling around the landfill to verify that there is no potential for migration of contaminants during snowmelt or storm events. Pending NMED approval, a lined surface water diversion channel around the landfill was constructed in November 1993. Sampling will commence upon NMED approval of the amended closure plan to be followed by final design and construction of a landfill cap.

TA-53, Surface Impoundments. A closure plan for two of the three surface impoundments located at TA-53 was submitted to NMED in February 1993. This plan was submitted as an alternative to permitting the units as mixed waste units. NMED's comments on the Laboratory closure plan proposing clean closure for the two TA-53 surface impoundments were addressed by the Laboratory in a January 14, 1994, submittal. Regulatory approval from NMED was still pending as of March 1994.

TA-50, Batch Waste Treatment Unit and Container Storage Area. Closure of this unit is proceeding pursuant to the closure plan as outlined in the 1989 NMED permit. This unit is located in Building 1 at TA-50 and consists of an enclosed 1,923 L (500 gal.) pressure vessel. The vessel has been removed from service and is presently in the process of internal and external wash downs as part of the closure process. Final closure activities and closure report submittals to NMED are scheduled for August 1994.

d. Underground Storage Tanks. Five underground storage tanks (USTs) were removed in CY93. Two of the USTs (TA-21-325 and TA-3-1255) met all New Mexico UST regulatory closure requirements. UST TA-21-325, with a 16,154 L (4,200 gal.) capacity, contained nitric acid and was removed in September 1993. UST TA-3-1255, with a 15,500 L (4,030 gal.) capacity contained diesel fuel and was removed in September 1993.

Other September 1993 UST removals are TA-55-17 and TA-16-205. UST TA-55-17 contained 11,569 L (3,008 gal.) of diesel fuel, and UST TA-16-205 contained 2,154 L (560 gal.) of diesel fuel. Both USTs are expected to meet all closure requirements by June 1994.

The final UST, TA-18-PL30, contained 2,154 L (560 gal.) of diesel fuel and was removed in September 1993. The UST is under corrective action for site contamination. The NMED, which has primacy for the EPA-UST program, has required the installation of two monitor wells at TA-18 to determine total petroleum hydrocarbon concentrations in a shallow perched aquifer of approximately 20-ft depth.

e. Other RCRA Activities. Area L, located at TA-54 on Mesita del Buey, had been used at one time for disposal of hazardous waste. Area G, also located at TA-54, has been used for the disposal of radioactive waste. Information on a groundwater monitoring waiver for both Areas L and G has been submitted to NMED. Vadose zone (the subsurface above the main aquifer) monitoring is being conducted quarterly throughout Areas L and G to identify any releases from the disposal units. This type of monitoring is used to detect the presence of organic vapor in the vadose zone.

A RCRA-permitted controlled air incinerator (CAI) for treating hazardous waste is located at TA-50-37. A trial burn was conducted in October 1986. The raw data were submitted to NMED in December 1986, and a final report for the test burn was submitted on March 5, 1987. These data and the report were used to support the Laboratory's

application for a hazardous waste permit for this facility. The permit was issued in November 1989. The CAI is currently not operating due to upgrades to improve its reliability so that waste can be routinely burned. A modification to the permit incorporating the upgrades must be approved before the facility can be restarted.

f. RCRA Compliance Inspection. NMED conducted an annual hazardous waste compliance inspection the week of May 4, 1992. EPA officials from Region 6 and the National Enforcement Investigations Center accompanied the state during the first three days of the inspection. On January 28, 1993, LANL received two Compliance Orders (COs) from NMED. The first CO (93-03) alleged violations involving the management of mixed waste in TRU pads 1, 2, and 4 and identified four findings of violation. CO 93-03 proposed fines of $1.28 million. The first three findings of CO 93-03 alleged deficiencies that could, according to the findings, lead to adverse impacts to human health and the environment if not addressed in a timely manner. The second CO (93-04) alleged deficiencies related to general Laboratory waste management practices (e.g., satellite/less than 90-day accumulation area requirements and operating records). Twenty counts were identified in this CO; CO 93-04 proposed fines of $350,000. All deficiencies in this CO were corrected within 30 days. DOE received nearly identical COs (CO93-01 and 93-02) except that, due to issues of sovereign immunity, no fines were proposed.

DOE began negotiations with NMED in February 1993 on a plan to bring the TRU pads into compliance with current RCRA storage requirements. A three-party Consent Agreement was signed by LANL, DOE, and NMED in December 1993. LANL paid a $700,000 fine in settlement of CO 93-03 and CO 93-04.

Environmental Protection Agency Multimedia Inspection. Between August 3 and 12, 1993, the EPA initiated a site-wide multimedia inspection of the Laboratory, which encompassed regulations promulgated pursuant to RCRA, Clean Water Act (CWA), SDWA, Clean Air Act, Toxic Substances Control Act (TSCA), and Emergency Planning and Community Right-to-Know Act (EPCRA) (see Table III-4). The EPA team was led by a representative of Region 6 and was staffed by personnel working for the EPA National Enforcement Investigations Center. The EPA team visited several satellite and less-than-90-day storage sites as well as long-term storage facilities at TA-3, TA-54, and TA-55, and treatment facilities at TA-14, TA-16, TA-36, TA-54, and TA-55. During the inspection outbriefing on August 12, EPA reported several RCRA noncompliances including mislabeled containers, open containers, inadequate training records, incomplete waste characterization, and missing notifications. None of the findings involved activities with direct impact on human health or the environment. The Laboratory did not receive any notification of violations during 1993.

g. RCRA Training. During 1993, EM-8 and HS-8 revised and updated the Laboratory's RCRA training program. The new training program, which incorporates requirements from the Laboratory's RCRA facility permit, interim status documents for mixed waste, and state and federal regulations, replaced all of the previous RCRA training courses and came on-line by September 1993.

In August 1993, RCRA Personnel Training (five hours) was added to the environmental training roster. This course was specifically designed to meet training requirements for treatment, storage, and disposal (TSD) and less-than-90-day storage area workers. Course content includes RCRA provisions, inspections, and the LANL Contingency Plan. One hundred and twenty people were trained in 1993. Two courses, Hazardous Waste Generator Training (1.5 hours) and Hazardous Waste Generator Requirements for Temporary Storage (1 hour) were replaced by Waste Generator Overview (4 hours) and Waste Documentation Forms (4 hours). The waste generator course covers a regulatory overview; waste characterization; Laboratory specifics on all types of waste management, with particular emphasis on hazardous and mixed waste; and temporary storage requirements. The Forms course is a "how to" on completion of the Laboratory's waste generation and disposal forms for hazardous, mixed, and radioactive wastes. Total number of workers trained in these courses during 1993 was 1,219.

All of these courses are based on general requirements in RCRA (40 CFR 262.34, 264.26, and 265.16). The revised training programs also allowed completion of DOE Tiger Team Action Plan C-EM-46.

During 1993, EM-8 and HS-8 also began developing a RCRA training workshop to be offered in January 1994. The workshop is directed at training coordinators in LANL organizations who have responsibility for hazardous or mixed waste TSD facilities. The workshop focuses on site- or unit-specific training requirements with emphasis on identification of overlapping requirements, development of on-the-job-training, documentation, and available Laboratory resources.

Table III-4. Environmental Inspections and Audits Conducted at the Laboratory in 1993

Date	Purpose	Performing Agency
December 1992–January 1993	NPDES permit program evaluation	DOE/LAAO
February 16–26, 1993	Agreement In Principle (AIP) evaluation	NMED/AIP
February 17–18, 1993	Observe beryllium machining operations and compliance stack test, TA-55, Bldg. 4	NMED
April 13, 1993	Spill cleanup evaluation	NMED/AIP
June 3, 1993	Spill cleanup evaluation	NMED/AIP
June 30, 1993	Observe quarterly HEPA filter challenge testing, TA-55, Bldg. 4	NMED
July 23, 1993	Site evaluation/NPDES permit review	San Ildefonso Pueblo
July 29, 1993	Annual pesticide certification and inspection	NMDA
August 2–12, 1993	RCRA compliance inspection of hazardous waste management activities	EPA/NMED
August 2–12, 1993	Multimedia audit TSCA inspection of permitted and registered beryllium machining operations	EPA/NMED
August 2–12, 1993	Multimedia audit of CWA activities	EPA/NMED
September 15, 1993	Spill cleanup evaluation	NMED/AIP
September 24, 1993	Spill cleanup evaluation	NMED/AIP
September 27, 1993	Spill cleanup evaluation	NMED/AIP
November 2, 1993	Spill cleanup evaluation	NMED/AIP
November 10, 1993	Spill cleanup evaluation	NMED/AIP

ES&H Manual. Administrative Requirement (AR) 10-3, Hazardous and Mixed Waste, was updated during 1993. Final distribution of the revised AR was completed in April 1993. The revised document incorporates new requirements on management of mixed wastes and radioactive materials. A new AR, 10-9, dealing with waste profile request forms and waste characterization was published simultaneously.

Generator Handbook. EM-8 began development of a regulatory handbook for hazardous waste generators. The handbook comprises a comprehensive set of flowcharts and supporting documentation and covers virtually every waste type generated at the Laboratory. Information includes waste identification and characterization, documentation, packaging, and shipping and directs generators to the proper Laboratory organization. The handbook will be completed and distributed to waste management coordinators and waste generators in 1994.

h. Waste Minimization. Subtitle A of RCRA states that the generation of hazardous waste is to be reduced or eliminated as soon as possible. All hazardous waste must be handled in ways that minimize the present and future threat to human health and the environment. The act promotes recovery, recycling, and treatment as alternatives to land disposal of hazardous wastes.

The Laboratory significantly reduced the rates of hazardous and mixed waste generation during 1993 in comparison to 1992. A total of 70,420 kg (154,924 lb) of hazardous waste was generated in 1993 versus 141,987 kg (312,371 lb) in 1992 (a 50% reduction). A total of 7,517 kg (16,537 lb) of mixed waste was generated in 1993 versus 91,650 kg (201,630 lb) in 1992 (a 92% reduction). LANL will continue its efforts to reduce the rates of hazardous and mixed waste generation because of DOE's participation in the draft mixed waste FFCA, which is expected to be finalized and then signed in early 1994.

i. HSWA Compliance Activities. In 1993, the ER program remained in compliance with Module VIII of the RCRA permit. During the year, 10 RFI work plans were submitted to EPA. In 1992, eight RFI work plans were submitted, and one work plan was submitted in 1991. These nine work plans have all been approved by EPA Region 6. Four RFI work plans will be submitted in 1994. Additionally, in 1995, work plans addressing the Canyons Operable Unit (OU) will be submitted.

The first permit modification request to Module VIII was submitted to EPA in February 1993. The request addressed some minor language changes, added dispute resolution language, added 483 Solid Waste Management Units, and staggered the submittal schedule for the 10 RFI work plans to be submitted during 1993. LANL anticipates all modifications will be made to the permit.

Field investigations will continue at all OUs for which a work plan has been submitted. A Phase Report for field investigations conducted at OU 1106 (TA-21) was submitted to EPA in December 1993. Also, the Installation Work Plan was revised and submitted to EPA in November 1993 as required by the permit.

Investigations at the Townsite (present day downtown Los Alamos) continue to be the ER program's highest priority. During July 1993, a septic tank was excavated and removed from private property. The materials removed were not hazardous waste but did have a radioactive component. The material was brought to LANL's TA-54, Area G, Pit 37 for disposal.

The ER program proposes to construct a Mixed Waste Landfill to dispose of mixed waste generated during the remediation process. The Conceptual Design Report was completed in 1992. The 100% Title I Design was completed in December 1993. A permit application for the facility is currently under preparation.

2. Comprehensive Environmental Response, Compensation, and Liability Act.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986 mandates actions for certain releases of substances into the environment. LANL has not been included on the EPA's National Priority List.

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

Title III, Section 313, of EPCRA exempts facilities not meeting certain Standard Industrial Classification (SIC) code criteria from reporting requirements. All research operations at the Laboratory are exempt under provisions of the regulation, and only pilot plants, production, or manufacturing operations at the Laboratory must report their releases. The Plutonium Processing Facility (TA-55) is the only operation at the Laboratory engaged in production activities and subject to Section 313. Nitric acid is the only regulated chemical that is used at the Plutonium Processing Facility in amounts greater than the Section 313 reporting thresholds.

A report describing the use of Section 313 chemicals must be submitted to EPA in July for the preceding CY. This report covered the releases of nitric acid during 1992. About 6,073 kg (13,360 lb) of nitric acid were used for plutonium processing with releases to the air of approximately 86 kg (190 lb). The amount of nitric acid released to the atmosphere was calculated using EPA emission factors and good engineering judgment. The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in the wastewater treatment operations. Only the air releases required reporting for 1992. Data on releases for CY93 will be reported under Section 313 in July 1994.

4. Toxic Substances Control Act.

The TSCA (15 U.S.C. 2601-2692) is administered by the EPA, which has authority to conduct premanufacture reviews of new chemicals before their introduction into the marketplace. This act requires testing of chemicals that

may present a significant risk to humans and the environment; establishes record-keeping and reporting requirements for new information regarding adverse health and environmental effects associated with chemicals; governs the manufacture, use, storage, handling, and disposal of polychlorinated biphenyl (PCB) equipment; and sets standards for PCB spill cleanups. Because the Laboratory's activities are in the realm of research and development, the 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, paints, slurries, dredge spoils, 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 a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to items with PCB concentrations of 50 ppm and greater. At the Laboratory, equipment and materials with greater than 500 ppm PCBs are transported off site for treatment and disposal, and those with 50 to 499 ppm PCBs are incinerated off site or disposed of at TA-54, Area G. Area G is approved by the EPA for disposal of PCB-contaminated materials.

Surveying of Laboratory TAs and facilities continued during 1993. Six hundred twenty-seven samples were submitted for analysis for PCBs. These samples were gathered in the process of surveying 258 structures at 6 Laboratory TAs. One hundred ten PCB capacitors and 14 miscellaneous PCB and PCB-contaminated items were added to the Laboratory's in-service inventory as a result of the 1993 PCB survey. As of December 31, 1993, PCB equipment in service at the Laboratory included 24 PCB transformers, 24 PCB-contaminated transformers, 456 PCB capacitors, and 18 miscellaneous PCB and PCB-contaminated equipment. Surveying of Laboratory TAs and facilities will continue in CY94. Table VI-19 presents data on the disposal of PCBs on and off site during 1993.

The Laboratory prepared a report to respond to EPA Region 6's requests for data and information regarding the hydrogeology of the TA-54, Area G landfill and disposal of PCB waste. This report will address the Laboratory's request for authorization renewal to continue disposal activities of PCB waste at the Area G landfill.

Also during 1993, DOE and EPA had several communications regarding the storage of PCB waste contaminated with radioactive constituents. In a meeting in October 1993, it was agreed to initiate negotiations on an FFCA to address this storage. Waste which currently cannot be disposed of within the one-year storage limit required by PCB regulations will be covered by this FFCA. To support this effort, a draft interim plan for the management and storage of Laboratory-generated radioactive PCB waste has been prepared and is currently undergoing review by DOE Los Alamos Area Office and the Laboratory.

From August 2 to 12, 1993, EPA Region 6 conducted a 10-day environmental multimedia audit at the Laboratory. This audit included inspection of the Laboratory's PCB management program. Deficiencies included the following:

1. Combustible materials located within five meters of seven PCB transformers located throughout the Laboratory.
2. Inaccuracies in the annual PCB document's inventories with respect to actual concentrations of PCBs in equipment, location of PCB equipment, discrepancies on manifests, and others.
3. One 55-gal. drum, located at TA-35-7, containing less than 2 gal. of an aqueous solution from a PCB spill cleanup had a date of February 1992 indicating that the one-year storage for disposal requirement had been exceeded.
4. Three PCB capacitors were found at TA-21-209 without PCB labels, which are required by regulation.

To date, no enforcement action has been taken by EPA Region 6 against the Laboratory regarding these PCB-related deficiencies.

5. Federal Insecticide, Fungicide, and Rodenticide Act.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides, with requirements on 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 recommended procedures for storage and disposal and requirements for certification of workers who apply

pesticides. The Laboratory is also regulated by the New Mexico Pest Control Act, administered by the NMDA, which regulates pesticide use, storage, and certification. NMDA conducts annual inspections of JCI's compliance with the act. The application, storage, disposal, and certification of these chemicals is conducted in compliance with these regulations. JCI applies pesticides under the direction of the Laboratory's Pest Control Program Administrator. A Laboratory Pest Management Plan, which includes programs for vegetation, insects, and small animals, was established in 1984 and is being revised by the Pest Control Oversight Committee, a committee established to review and recommend policy changes in the overall pest management program at the Laboratory.

An annual inspection conducted by the NMDA found no deficiencies in the Laboratory's pesticide application program and certified application equipment.

Table VI-20 presents data on the amount of herbicides, insecticides, and rodenticides used at the Laboratory during 1993.

6. Clean Water Act.

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

LANL has three NPDES permits, one covering the effluent discharges at Los Alamos, one covering the hot dry rock geothermal facility located 50 km (30 mi) west of Los Alamos at Fenton Hill, and one covering storm water discharges (Table III-2). The University of California (UC) and DOE are co-permittees on the permits covering Los Alamos. 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.

An application for a new NPDES permit was submitted to EPA by the Laboratory on September 4, 1990, in order to meet the 180-day submittal requirement before the old permit expired. The Laboratory's NPDES Permit No. NM0028355 expired on March 1, 1991, and was being continued under 40 CFR 122.6.

Between March and September 1992, EPA issued two different draft NPDES permits for public comment. During the comment periods for the draft permits, NMED informed EPA and LANL that the conditions for certification would require more stringent effluent limitations. Initially, the state applied standards based on the designated uses of stream segments No. 2-111 and No. 2-118 of the New Mexico Water Quality Standards for Interstate and Intrastate Streams in New Mexico. Later, the state decided to apply the general standard which applies to existing or attainable uses of these same stream segments. As a result, NMED ultimately issued two separate conditions of certification.

In October 1992, UC and DOE petitioned the New Mexico Water Quality Control Commission (NMWQCC) to review NMED's conditional certification of the NPDES permit limits. A hearing date, for presenting arguments to the NMWQCC, was set for March 1993. In January 1993, NMED and LANL requested a delay of the hearing until April 20, 1993. Settlement negotiations took place during the first quarter of 1993, and resulted in a settlement agreement with NMED wherein the Laboratory will fund a "use attainability" study of the receiving channels of the Laboratory's discharges in order to determine their correct use designations. NPDES permit effluent limits are based on the water quality standards for each use designation. In July 1993, EPA held a public hearing on the May 16, 1992, draft permit. In September 1993, EPA issued a final NPDES permit for the Laboratory. However, review of the final permit revealed a few technical and typographical errors. Within the 30-day time period allowed, the Laboratory filed an Intent to Request an Evidentiary Hearing on the final permit in order to rectify the errors. After discussions with EPA and NMED, it was agreed that the errors could be corrected by pursuing the modifications procedure set forth in the regulations. A new final permit with error corrections was drafted by EPA in January 1994. This draft permit will go out for public comment and is expected to be issued sometime in 1994.

During 1993, the Laboratory's NPDES permit for Los Alamos included 10 sanitary wastewater treatment facilities and 130 industrial outfalls. A summary of these outfalls is included in Table D-2. The NPDES permit for the geothermal facility at Fenton Hill includes only one industrial outfall. Under the Laboratory's existing NPDES

permit for Los Alamos, samples are collected for analysis on a weekly basis, and results are reported each month to EPA and NMED. During 1993, effluent limits were not exceeded in any of the 147 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 19 times in the 2,120 samples collected from the industrial outfalls. As shown in Figure III-1, overall compliance for the sanitary and industrial discharges during 1993 was 100% and 99.1%, respectively. Tables D-3 through D-6 present monitoring standards and Laboratory deviations from those standards. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1993.

In 1993, the Laboratory was under Administrative Order (AO) Docket No. VI-92-1306. The AO specified corrective activities and compliance schedules to bring the Laboratory into NPDES permit compliance.

All projects under the AO were completed as scheduled except for the High Explosive (HE) Wastewater Treatment Project (Outfall Category O5A). The AO contained a schedule for completion of the Laboratory's waste stream characterization field surveys. These were completed by September 30, 1993, except the survey of TA-55, which was delayed until October 8, 1993.

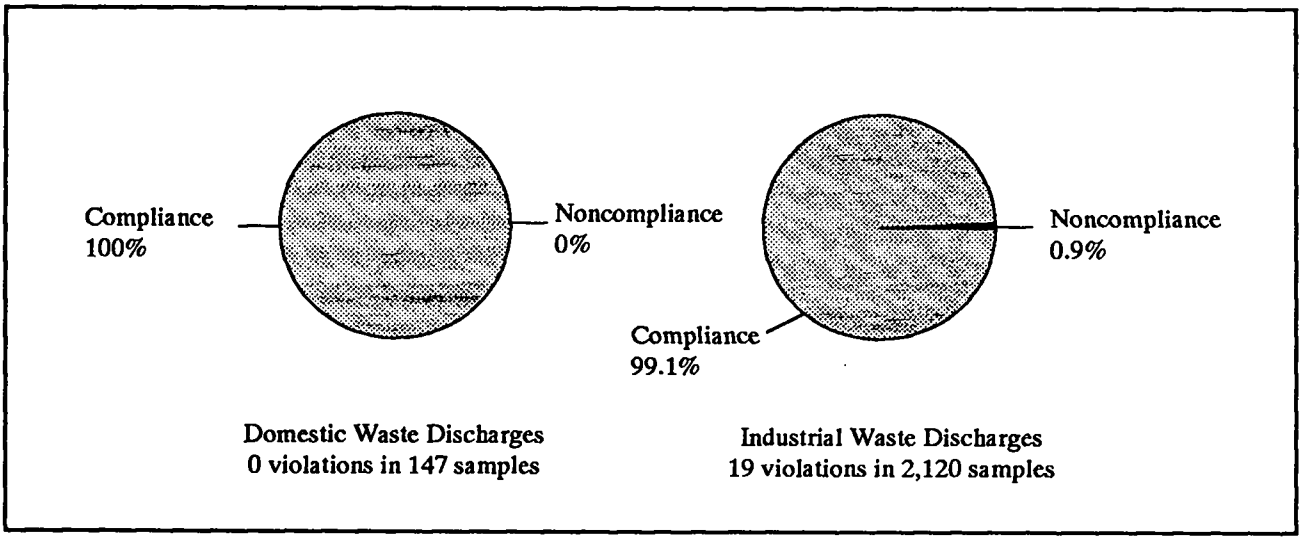


Figure III-1. Summary of Clean Water Act compliance in 1993, NPDES Permit NM0028355.

The interim date for the start of Title I Design for HE Wastewater Treatment Project was delayed from October 1993 to December 22, 1993, to allow for line-item funding to be approved. A delay in the construction start date and the construction completion date were recognized by the Laboratory. These delays were addressed under the new AO Docket No. VI-94-1210 issued to the Laboratory on December 6, 1993. The new AO incorporated the revised HE Wastewater Treatment project schedule and the remaining schedule for completion of the Waste Stream Characterization (WSC) Project corrective activities.

On May 28, 1993, the EPA issued AO Docket No. VI-93-0178 to the Laboratory for violations of categories O2A (boiler blowdown) and O3A (treated cooling water) between October 1992 and March 1993. The AO stipulated that the Laboratory come into compliance with the permit limitations within 30 days of issuance of the AO. The Laboratory also submitted a detailed report on specific corrective actions taken by the Laboratory to ensure future compliance at the two outfall categories.

b. Waste Stream Characterization. Group EM-8 continued the WSC program during 1993 in order to verify that each waste stream is correctly characterized and permitted under the proper outfall category. These studies consist of dye testing, interviews with user groups, and coordinating with other Laboratory organizations so that

sources, concentrations, and volumes of pollutants that enter waste streams, receive treatment and are discharged to the environment can be determined.

Field surveys for waste stream identification and characterization were completed for all facilities at the Laboratory except for TA-55 and TA-21 by July 31, 1993. Action plans for implementing corrective actions for TA-16 facilities were submitted by operating groups to EM-8 on March 11, 1993. These action plans include milestone dates to bring the facilities into compliance with the NPDES permit program. EM-8 has developed a WSC corrective action tracking database for tracking corrective actions and NOIs. An extension to the schedule for WSC surveys was requested until September 30, 1993, due to the extremely difficult access requirements and complicated drain systems at TA-21 and TA-55. An additional week, until October 8, 1993, was required to complete the survey work at TA-55 due to restricted access to this site.

EM-8 finalized 83 WSC reports by the revised AO Docket No. VI-94-1210 deadline of March 30, 1994. Corrective action plans to bring facilities into compliance with the Laboratory's NPDES permit will be requested from all operating groups.

c. Storm Water Discharges. On November 16, 1990, the EPA promulgated the final rule for NPDES Regulations for Storm Water Discharges and modified 40 CFR 122, 123, and 124. This rule was required to implement Section 402(p) of the CWA (added by Section 405 of the Water Quality Act of 1987).

NPDES General Permits for storm water discharges associated with industrial activity and storm water discharges from construction sites were finalized in September 1992. On September 29, 1992, LANL submitted an NOI to be covered under the General Permit for storm water discharges associated with industrial activity. On October 1, 1992, LANL submitted two NOIs to be covered under the General Permit for storm water discharges associated with industrial activities at construction sites. These sites are the TA-53 Lagoon Elimination project and the Los Alamos Integrated Communication System at TA-3.

As a condition of the General Permit, the facility manager for each Laboratory facility covered by the permit must prepare a Storm Water Pollution Prevention (SWPP) Plan by April 1, 1993. EM-8 identified 76 industrial facilities that must be included in a site-specific SWPP Plan. EM-8 developed "Guidelines for Preparing a Storm Water Pollution Prevention Plan" to assist LANL facility managers in preparing these plans. LANL did not meet the April 1, 1993, submittal deadline; most plans were completed by mid-June 1993. (SWMUs are considered to be facilities associated with industrial activities under the stormwater regulations and must have SWPP Plans as well. By the end of 1993, the Laboratory had not completed all SWPP Plans for SWMUs with point sources.)

Each plan must identify potential sources of pollution that may reasonably be expected to affect the quality of storm water discharge. In addition, the plan must describe and ensure implementation of practices used to reduce the pollutants in storm water discharge at the facility and to ensure compliance with the terms and conditions of the General Permit. SWMUs located on the facility site must be addressed. LANL did not meet the October 1, 1993, implementation deadline; implementation plans are expected to be completed in early 1994.

d. Spill Prevention Control. The Laboratory has a Spill Prevention Control and Countermeasures (SPCC) Plan, as required by the CWA in accordance with 40 CFR 112. This plan requires that secondary containment be provided for all aboveground storage tanks. There are approximately 40 major containment structures at the Laboratory. The plan also provides for spill control on drum and container storage, transfer, and loading/unloading areas. Training is provided for the user 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. The SPCC Plan completed its third revision in September 1993; a training course for Spill Coordinators is being developed and will be presented in spring 1994.

7. Safe Drinking Water Act, Municipal and Industrial Water Supplies.

This program includes sampling from various points in the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems to ensure compliance with the SDWA (40 CFR 141). The DOE provides drinking water to Los Alamos County and Bandelier National Monument. The EPA has established maximum contaminant levels 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 Water

Supply Regulations (NMEIB 1991). The NMED has been given authority by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

Compliance samples are analyzed for organic and inorganic constituents and for radioactivity at the New Mexico Health Department's Scientific Laboratory Division (SLD) in Albuquerque. The SLD reports the analytical results directly to NMED. The JCI Environmental (JENV) Laboratory also collects samples from the Laboratory, Los Alamos County, and Bandelier National Monument distribution systems and tests them for microorganisms. JENV Laboratory is certified by NMED for microbiological testing of drinking water.

During 1993, all chemical parameters regulated under the SDWA were in compliance with the maximum contaminant levels established by regulation. Tables VI-12, VI-13, and VI-14 present 1993 monitoring data on the chemical quality of drinking water. Tables V-21 and V-22 present radiological monitoring results in 1993.

Radon sampling was performed at points of entry of water from the three well fields into the distribution system. This sampling was done to collect information before the issuance of a final EPA regulation governing radon in drinking water. The sampling indicates that radon treatment may be required if EPA finalizes the radon standard with the same 300 pCi/L limit contained in the proposed rule. Depending on the final rule's provisions, waters from some well fields may need radon treatment by extended storage to allow radioactive decay or adsorption removal.

Each month an average of 50 microbiological samples was collected at designated sample taps in the distribution system. The microbiological samples were analyzed for residual chlorine concentration and the presence or absence of total coliform, fecal coliform, and noncoliform bacteria. Sample collection and analysis were performed by personnel of the JENV Laboratory. During 1993, of the total of 602 samples analyzed, 10 indicated the presence of total coliforms, and 4 indicated the presence of fecal coliforms. Noncoliforms were present in 49 of the microbiological samples. Monthly data for 1993 is presented in Table VI-15. Noncoliform bacteria are not regulated, but their presence in repeated samples may serve as indicators of biofilm growth in water pipes.

Coliforms are the standard indicators of sewage pollution because they inhabit the intestinal tract of humans and other animals and therefore may indicate the presence of sewage or animal waste in the water. They are generally easier and safer to culture than specific pathogens. Fecal coliforms are defined as a subclass of coliforms that can be cultured on specific media at an elevated temperature (44.5°C). The fecal coliform test methods are intended to select for bacteria that originate in the intestines of warm-blooded animals. Biofilms are colonies of bacteria that are normally present in drinking water pipes and that may include coliforms and noncoliforms, as well as other types of bacteria.

In August 1993, there was a violation of the SDWA maximum contaminant levels for bacteria at TA-39 and TA-33. From August 6 through August 9, drinking water samples taken at TA-39 showed the presence of total and fecal coliform bacteria. During the same four-day period total coliform bacteria were present in samples taken at TA-33. The fecal coliform were identified as to species by both JENV Laboratory and the SLD. Both Laboratories identified the fecal coliform bacteria as *Serratia rubidea*. According to Bergey's Manual of Systematic Bacteriology, *Serratia rubidea* can survive in a warm-blooded host or in the environment at ambient temperatures. *Serratia* species occur in plants, in the digestive tract of rodents, and in soil and water (Bergey 1984). *Serratia rubidea* is considered an opportunistic pathogen that may cause gastroenteric illness in immune-suppressed individuals. No such illnesses were reported by personnel who were exposed to *Serratia rubidea* at TA-39.

The source of the *Serratia rubidea* contamination is not known. No repairs or water line breaks that could have resulted in contamination were noted near TA-33 or TA-39 during the month before the August coliform event. Chlorine residuals were not detected in any of the coliform and fecal coliform samples taken during the August event. Water is delivered to TA-33 and TA-39 via a long dead-end main, which is susceptible to biofilm growth. The potential for biofilm growth is increased by the low water flows due to the small numbers of persons using the water at the sites. The presence of a 192,308 L (50,000 gal.) fire protection storage tank at TA-33 also increases the residence time of the water and biofilm growth potential. The *Serratia rubidea* may have been among the biofilm bacteria that colonized the interior of the TA-33/39 water pipes. Biofilm growth is controlled by disinfection with chlorine and by maintaining adequate flow in the mains. Warm summer conditions combined with inadequate chlorine residual and low water demand may have allowed the normal biofilm bacteria to multiply in the TA-33/39 line. The contamination was eliminated by flushing and disinfecting the distribution systems serving TA-33/39, including the fire tank. The Laboratory has improved its water quality control program by increasing minimum chlorine

residuals and by increasing the frequency of testing and flushing dead-end water lines to provide better control of biofilms. The Laboratory is also planning to install a chlorination station at the water tower serving TA-33/39. No other violations were noted in the Laboratory's municipal and industrial water supply program during 1993.

Programs conducted to protect the water supply system include the following:

a. Wellhead Inspection Program. Daily inspections of the wells were conducted by JCI Utilities to maintain pumping equipment and to identify any problem that might lead to a potential health hazard.

b. Disinfection Program for New Construction. Whenever new construction or repair work is required on the distribution or supply system, the pipe must be disinfected before it is put in service. This disinfection is accomplished by flushing the pipe and adding a high-strength chlorine solution to the piping. The chlorinated water is then removed, and a sample is taken during the flushing process by the JENV Laboratory and analyzed for the presence of coliform bacteria.

c. Cross Connection Survey Program. In 1992, the Laboratory began a comprehensive building-by-building survey of interior plumbing systems to identify and correct cross connections. Personnel from the Engineering Division Maintenance Group visually surveyed buildings looking for actual or potential cross connections between potable water systems and industrial, fire, cooling, or other nonpotable water supplies. The surveyors checked for the presence of adequate backflow prevention devices and labeled the piping and outlets where necessary.

Below is a synopsis of the types of findings that have been recorded by the survey team:

- No backflow prevention device at the building service entrance.
- No pressure regulating device at the building service entrance.
- No backflow prevention device where nonpotable water splits off for nonpotable uses.
- Emergency eye wash and showers served by nonpotable water.
- No vacuum breakers on industrial and potable water sinks.
- Lab sinks served by potable water and domestic use of nonpotable water by employees at lab sinks.
- Potable water usage from an unidentifiable water source.
- Dead legs of piping that house stagnant water.
- Improper labeling of piping.

Physical piping alterations were made in some cases and in other cases low hazard potential cross connections that presented little hazard were scheduled for piping modifications. Due to the labor intensive and detailed nature of these surveys, fewer than 10% of the Laboratory's approximately 2,400 buildings were surveyed in 1993. The survey and corrective action program will continue at least through 1994.

8. Federal Clean Air Act and the New Mexico Air Quality Control 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; and
- Stratospheric Ozone Protection (SOP).

All of the above requirements that are applicable to LANL, 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. Therefore, all of these regulations, except the radionuclide NESHAP and SOP, are discussed in Subsection b, State Regulations.

Radionuclide NESHAP. Under 40 CFR 61, Subpart H, the EPA limits the EDE to any member of the public from radioactive airborne releases from DOE facilities, including LANL, to 10 mrem/yr. For 1993, the maximum dose to a member of the public from airborne releases was calculated using the EPA-approved computer program CAP-88 to be 5.7 mrem. More than 95% of the modeled 1993 effective dose equivalent was due to gaseous activation products released from the Los Alamos Meson Physics Facility (LAMPF). Air immersion was the primary pathway of exposure (versus inhalation or ground deposition).

In 1991, the EPA determined that LANL did not meet the requirements of 40 CFR 61, Subpart H, and issued LANL a Notice of Noncompliance (NON). Specific findings of the NON included deficiencies in LANL's identification and evaluation of release sources, lack of stack monitoring equipment on all point release sources, inadequate quality assurance (QA) programs, and identification of the highest EDE. All of these findings have been or are being addressed.

- A comprehensive inventory of point release sources was completed. An inventory of diffuse (nonpoint) release sources was begun. These inventories identify and describe sources of radioactive air emissions. Both inventories are continually updated as new information is received and old information is revised.
- Stack monitoring equipment at LAMPF was upgraded, bringing the facility into compliance with 40 CFR 61, Subpart H, monitoring requirements. As scheduled, upgrades were begun on stack monitoring equipment at TA-33, TA-48, TA-50, and TA-55; these upgrades are in various stages of completion. Upgrades at other facilities throughout the Laboratory are scheduled to begin in 1994.
- For monitoring radioactive air emissions at LAMPF, a QA project plan was completed, approved by DOE, and implemented. This plan was later audited by DOE and found to be adequate. QA project plans were begun for monitoring radioactive air emissions at TA-55 and tritium facilities. In addition, an overall QA project plan was drafted for the management of radioactive air emissions; and necessary procedures were written, approved, and updated.
- Several reports of radioactive air emissions were prepared and submitted as scheduled in 1993. These included an annual Radioactive Effluent/Onsite Discharges/Unplanned Releases report to the DOE, annual and monthly (while LAMPF was operating) summaries of emissions (activities and doses) to the DOE and EPA, and annual and monthly summaries of emissions (activities only) to Laboratory personnel. In addition, quarterly progress reports were prepared and distributed to chronicle the activities of the Radioactive Air Emissions Management Group.

In addition, any construction or modifications undertaken at LANL that will increase airborne radioactive emissions require preconstruction approval from EPA. In 1993, 87 such projects were reviewed; only 2 of these were determined to require preconstruction approval.

The EPA audited LANL's NESHAP program in August 1992. Data gathered during the audit was used to support development of an FFCA between EPA and DOE. Building shielding factors previously used in estimating the dose to the maximum exposed individual without prior EPA approval were disallowed. These shielding factors account for the portion of time an individual spent indoors and wearing clothes. A second NON was issued to DOE on November 23, 1992, because the shielding factors were used and because Laboratory emissions exceeded the 10 mrem/yr standard during the 1990 reporting period when these factors were not used in the calculations. The terms of this NON are described in detail in Section III.C.1.d.

As a result of the second NON, DOE submitted monthly emissions and dose assessment reports in 1993, as specified in 40 CFR 61.94(c). To correct the findings in the NON, LANL stopped using shielding factors to calculate the effective dose equivalent, and it instituted an Emissions Management Plan for LAMPF to assure compliance with the standard.

Stratospheric Ozone Protection. Effective July 1, 1992, Section 608 (National Emission Reduction Program) of the Clean Air Act Amendments (CAAA) of 1990 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. JCI recovers and recycles all ODS during servicing and repair of all refrigeration equipment at the Laboratory and does not vent ODS to the atmosphere. Final regulations con-

cerning the type of recovery/recycling equipment to be used and the procedures for using this equipment became effective on July 13, 1993. Final regulations have yet to be adopted with regard to the certification requirements for personnel.

Section 609 (Servicing of Motor Vehicle Air Conditioners) of the CAAA established standards and requirements related to recycling equipment used in the servicing of motor vehicle air conditioners, and training and certification of technicians providing such services. JCI provides all servicing and maintenance relating to automotive air conditioning equipment at the Laboratory in full compliance with these regulations. Section 611 (Labeling of Products Using ODS) of the CAAA established requirements that no container containing Class I or II ODS or any product containing Class I ODS may be shipped across state lines unless it bears an appropriate warning label. This regulation came into effect on November 11, 1993. The Laboratory is currently working with groups that ship ODS products and ODS-containing waste off site to ensure that the proper labeling requirements are met.

b. State Regulations. The NMED preserves air quality through a series of Air Quality Control Regulations (AQCRs). The AQCRs relevant to Laboratory operations are discussed below.

AQCR 301 - Regulation to Control Open Burning. AQCR 301 regulates the open burning of materials. Under this regulation, open burning of explosive materials is permitted when transport of these materials to other facilities may be dangerous. Provisions of this regulation allow DOE and the Laboratory to burn waste explosives. Research projects require open burning permits. In 1993, the Laboratory had four open burning permits: one for the open burning of jet fuel for ordnance testing at TA-11, K Site; one for the open burning of explosive-contaminated materials at TA-14; one for the open burning of explosive-contaminated materials at TA-16; and one for burning explosive-contaminated wood at TA-36 (Table III-2).

AQCR 401 - Regulations to Control Smoke and Visible Emissions. AQCR 401 limits the visible emissions allowed from 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. It may, however, occur during start up with oil, the backup fuel for the boilers. Although oil is used infrequently, the boilers must be periodically switched to oil to ensure that the backup system is operating properly. No incidents of excess opacity were recorded in 1993.

AQCR 501 - Asphalt Process Equipment. Provisions of AQCR 501 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 68,162 kg/h (75 ton/h) capacity, is required to meet an emission limit of 15 kg (33 lb) of particulate matter per hour. A stack test of the asphalt plant in August 1992 indicated an average emission rate of 1.9 kg/h (4.2 lb/h) and a maximum rate of 2.3 kg/h (5.1 lb/h) over three tests (Kramer 1993a). Although the plant is old and is not required to, it meets NSPS stack emission limits for asphalt plants.

AQCR 507 - Oil Burning Equipment - Particulate Matter. This regulation applies to an oil burning unit having a rated heat capacity greater than 250 million British Thermal Units (Btu) per hour. Oil burning equipment of this capacity must emit less than 0.03 lb per million Btu of particulate. Although the Laboratory boilers utilize oil as a backup fuel, all have maximum rated heat capacities below this level; consequently, this regulation does not apply. The TA-3 Cogeneration Facility operates the three highest heat capacity boilers, each of which had an observed maximum capacity of 210 million Btu/h during the October 1993 stack tests at TA-3.

AQCR 604 - Gas Burning Equipment - Nitrogen Dioxide. Provisions of AQCR 604 require gas burning equipment built before January 10, 1972, to meet an emission standard of 0.3 lb of NO_2 per million Btu when natural gas consumption exceeds 10^{12} Btu/yr/unit. The TA-3 power plant meets the emission standard. The emission standard is equivalent to a flue gas concentration range of 146 to 253 ppm NO_2 depending on the air-to-fuel burning ratio; the measured flue gas concentration of the TA-3 boilers ranged from 68 to 110 ppm NO_2 during 1993 (Kramer 1993b).

AQCR 605 - Oil Burning Equipment - Sulfur Dioxide. This regulation applies to oil burning equipment having a heat input of greater than 1×10^{12} Btu/yr. Although the Laboratory utilizes oil as a backup fuel, no oil fired equipment exceeds this threshold heat input rate. Therefore, this regulation did not apply during 1993 to the Laboratory fuel burning equipment. Should such equipment operate above the heat input limit, emissions of sulfur dioxide would be required to be less than 0.34 lb per million Btu.

AQCR 606 - Oil Burning Equipment - Nitrogen Dioxide. This regulation applies to oil burning equipment having a heat input of greater than 1×10^{12} Btu/yr. Although the Laboratory utilizes oil as a backup fuel, no oil fired equipment exceeds this threshold heat input rate. Therefore, this regulation did not apply during 1993 to the Laboratory fuel burning equipment. Should such equipment operate above the heat input limit, emissions of nitrogen dioxide would be required to be less than 0.3 lb per million Btu.

AQCR 702 - Permits. Provisions of AQCR 702 require permits for any new or modified source of potentially harmful emissions if they exceed threshold emission rates. More than 500 toxic air pollutants are regulated, and each chemical's threshold hourly rate is based on its toxicity. 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 AQCR 702 limits to determine if additional permits are required. During 1993, over 100 source reviews were conducted. None of these sources required permits under AQCR 702.

AQCR 707 - Prevention of Significant Deterioration. These regulations have stringent requirements that must be addressed before the construction of any new, large stationary source can begin. Under this regulation, wilderness areas, national parks, and national monuments receive special protection. For the Laboratory, this mainly impacts 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 have resulted in emission increases considered "significant" and are therefore not subject to this regulation.

AQCR 751 - Emission Standards for Hazardous Air Pollutants. In this regulation, NMED adopts 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 1993, 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 sq ft) or 79 m (260 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 1993, JCI removed approximately 654 m (2,146 ft) of friable pipe insulation as part of individual small jobs. Large jobs resulted in 4.4 m^3 (157 cu ft) of friable and nonfriable potentially radionuclide-contaminated material being removed. A total of 13 m^2 (462 cu ft) of potentially radionuclide-contaminated material, both friable and nonfriable, was removed in 1993. A total of 650 m^2 (7,024 sq ft) of unregulated material, such as vinyl asbestos tile, transite board, siding and pipe, was also removed through small job activities. This resulted in approximately 79 m^3 (2,804 cu ft) of material for disposal.

Beryllium. The beryllium NESHAP includes requirements for notification, emission limits, and stack performance testing for beryllium sources. The Laboratory has previously received five beryllium permits from NMED (Table III-2) 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. One permitted beryllium processing operation, TA-3-35, has not yet been constructed, so the permit is not active. No new beryllium permits were issued to the Laboratory in 1993.

The EPA inspected all permitted and registered beryllium operations in August 1993. NMED was also present during some of these inspections. As a result of the inspection, the operations at TA-3-141, TA-35-213, and TA-3-102 were found to have emissions calculated using inaccurate filter control efficiencies. The beryllium operation at TA-3-39 had also previously been found to have an inaccurate filter control efficiency taken into account in its emissions calculations. Additionally, the EPA inspection revealed a beryllium drill press in TA-3-141 that had not been mentioned in the TA-3-141 beryllium permit. On August 19, 1993, a meeting was held with NMED to determine the appropriate actions required by the Laboratory to address these findings by EPA. It was agreed that no emission violation resulted from the control efficiency calculation errors as demonstrated by the stack tests. It

was also agreed that permit modifications would be submitted to correct these errors. Modifications to correct these errors in the permits will be submitted in 1994.

Exhaust air from each of the beryllium operations passes through air pollution control equipment before exiting from a stack. A fabric filter controls emissions from TA-3-39. The other operations use high-efficiency particle air (HEPA) filters to control emissions, with efficiencies of 99.95%. NMED was present during the June 1993 HEPA particle penetration challenge at TA-55-4. Source tests for the existing operations have demonstrated that all beryllium operations meet the permitted emission limits set by NMED and have a negligible impact on ambient air quality.

AQCR 770 - Operating Permits. The NMED program has been submitted to EPA for approval, as required by the CAAA enacted in 1993. When the regulation takes effect (expected effective date is November 1994), it will require that all major emission sources (as defined in AQCR 770) have permits that specify the operational terms and limitations required to meet all federal and state air quality regulations. In 1993, the Laboratory, a major source of NO_2, began to examine its emission sources to determine what applicable requirements will need to be included in its operating permit and is working with NMED to develop a plan to ensure compliance with the resulting operating permit conditions. The Laboratory's operating permit application may be required to be submitted in 1995, and the final operating permit is expected to be issued in late 1995.

AQCR 801 - 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 the NMED either prior to or within 24 hours of the occurrence, followed by written notification within 10 days of the occurrence. No incidences of excess particulate emissions were recorded in 1993. New training procedures initiated in 1993 reduced the likelihood of excess emissions from the testing of the oil fired backup system.

In addition to the existing federal programs, the CAAA of 1990 mandates new programs that may affect the Laboratory. The new requirements include control technology for hazardous air pollutants, prevention of accidental releases, and chlorofluorocarbon replacement. The Laboratory will track new regulations written to implement the act, determine their effects on Laboratory operations, and implement programs as needed.

9. National Environmental Policy Act.

a. Introduction. NEPA regulations mandate that federal agencies consider the environmental impact of their actions before making a final decision whether to proceed with those actions. NEPA establishes the national policy of creating and maintaining conditions under which man and nature can exist in productive and enjoyable harmony and fulfill the social, economic, and other requirements of present and future generations. Proposed activities are evaluated to determine whether they have the potential to affect the environment. The sponsoring agency, DOE for LANL activities, is responsible for preparation of NEPA documents, which include the following:

- a categorical exclusion, applied to specific types of activities that have been determined by DOE to have no significant environmental impacts and for which no additional NEPA documentation is required;
- an Environmental Assessment (EA), evaluating environmental impacts, leading to either a finding of no significant impact if the impacts are indeed found to be not significant or an Environmental Impact Statement (EIS) if the impacts are significant; and
- an EIS, in which impacts of proposed and alternative actions are evaluated and mitigation measures proposed, leading to a record of decision in which the agency discusses a decision on proceeding with the project.

NEPA provides specific protection to areas defined as unique resources (sensitive areas). Under NEPA review, proposed projects are evaluated for possible effects on cultural resources (archaeological sites or historic buildings), in accordance with the National Historic Preservation Act (NHPA) of 1966. In addition, proposed projects are evaluated for potential impact on threatened, endangered, or sensitive species, in accordance with the Endangered Species Act, and on floodplains or wetlands, in accordance with relevant executive orders (EO). A proposed project otherwise eligible for a categorical exclusion cannot be approved for such if it is determined that sensitive areas would be adversely affected.

b. Compliance Actions. LANL project personnel initiate NEPA reviews by completing ES&H Questionnaires, which form the basis of DECs that EM-8 then submits to DOE/LAAO. LAAO uses DECs for DOE/AL's requirement to prepare Environmental Checklists to assist DOE in determining the appropriate levels of NEPA documentation (categorical exclusions, EAs, or EISs) for LANL projects. Tables III-5, III-6, and III-7 present summary information on NEPA compliance actions taken during 1993. LANL also prepares broad scope DECs ("umbrellas") to cover a range of similar activities, such as routine maintenance, instrument calibration, etc. When DOE determines that the activities are categorically excluded from further NEPA review, these categorical exclusions serve as prior NEPA documentation to facilitate DOE review.

10. National Historic Preservation Act, Native American Graves Protection and Repatriation Act, and American Indian Religious Freedom Act.

As required by Section 106 of the NHPA, Laboratory activities are evaluated in consultation with the State Historic Preservation Officer (SHPO) for possible effects on cultural resources. During 1993, Laboratory archaeologists evaluated 780 actions, which resulted in 42 intensive field surveys. Most of these surveys were conducted on DOE property; however, several were on land owned by the US Forest Service, the Bureau of Land Management, the Navajo Nation, or the Pueblo of San Ildefonso, as well as on privately owned land.

Eight archaeological survey reports were submitted to the SHPO and Native American groups for review and concurrence. A plan for mitigation of adverse effects to one site, the historic Vigil y Montoya homestead, was reviewed and approved by the SHPO and National Advisory Council on Historic Preservation. In accordance with the approved plan, the site was excavated and a report is being prepared. Excavation of two prehistoric Anasazi sites, LA 4624 and LA 4626, was started; the mitigation plan calling for these excavations was approved by the SHPO and the Advisory Council in 1991.

Discussions with the San Ildefonso Pueblo Tribal Council concerning effects on cultural resources continued. Tribal representatives visited LA 71410, a small Anasazi structure that will be affected by construction of the Dual Axis Radiographic Hydrotest Facility at TA-15. The Tribal Council was asked to state their preference as to how impacts at the site should be mitigated.

As required by the National American Graves Protection and Repatriation Act, a summary list of cultural items excavated from archaeological sites by LANL was completed. Copies of this summary were sent to local Pueblos having ancestral ties to the Pajarito Plateau. This summary will be the basis for any future repatriation of cultural items to tribal governments.

Table III-5. Projects Reviewed by LANL NEPA Staff in 1993

	ESH Questionnaires	Other Sources	Total
Appendix A Activities	0	26	26
Umbrella Coverage			
Routine Maintenance	10	334	344
Environmental and Safety Improvements	19	63	82
Relocation of Structures	0	10	10
Support Structures	12	272	284
Workplace Habitability Improvements	0	34	34
Building/Equipment Instrumentation	3	18	21
Asbestos Removals	0	6	6
PCB Removals	0	5	5
Projects Cancelled	3	1	4
DOE Environmental Checklists Needed	135	2	137
Total Documents Reviewed	182	771	953

Table III-6. DOE Environmental Checklists

Categories of DOE Environmental Checklists Submitted in 1993	No. of Checklists
Environmental/Safety Improvements	4
Waste Management/Environmental Restoration	8
Bench/Pilot-Scale or Outdoor Research	37
Decontamination/Decommissioning Projects	4
Construction and Modification of Facilities	8
Waste Minimization Activities	1
Total Checklists Submitted	62
DOE Determinations in 1993	**No. of Checklists**
Umbrella Categorical Exclusions	
Routine Maintenance	1
Environmental and Safety Improvements	
Relocation of Structures	
Support Structures	
Workplace Habitability Improvements	
Building/Equipment Instrumentation	
Asbestos Removals	
PCB Removals	
Categorical Exclusions	43
Environmental Assessments	7
Prior NEPA, Continuing Operations	5
Total Project NEPA Determinations	56

Table III-7. Environmental Assessments

	No. of EAs
Findings of No Significant Impact	0
In Review/Being Revised	11
In Preparation or on Hold	6
Cancelled	3
EA determination rescinded	1

11. Endangered, Threatened, and Protected Species.

The DOE and the Laboratory must comply with the Endangered Species Act, New Mexico Wildlife Conservation Act, and the New Mexico Endangered Plant Species Act. During 1993, EM-8 reviewed 410 proposed Laboratory actions for potential impact on threatened and endangered species. Of these, 171 proposed actions were identified through the ES&H Questionnaire system. The Biological Resource Evaluations Team (BRET) of EM-8 identified 33 projects that required reconnaissance surveys (Level I 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. BRET also identified 12 projects that required quantitative surveys (Level II surveys) to determine if the appropriate habitat types and habitat parameters were present to support any threatened or endangered species. In addition, BRET identified four projects (Table III-8) that required an intensive survey designed to determine the presence or absence of a threatened or endangered species at the project site (Level III survey). The Laboratory adhered to protocols and permit requirements of the New Mexico State Game and Fish Department.

BRET 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 requiring a Level II or Level III survey, and consultation with US Fish and Wildlife for written concurrence of findings, as required under the Endangered Species Act, will be undertaken.

No species protected at state or federal level were confirmed within any of the proposed project sites surveyed in 1993. However, highly suitable habitat exists for many of these species (e.g., goshawk, Jemez Mountains salamander, meadow jumping mouse) within some project sites.

Table III-8. Projects Identified in 1993 that Require a Species Specific Survey

Project Name	Species Surveyed
RCRA Mixed Waste Disposal Facility, TA-67	Goshawk[a]
Site Characterization, OU 1182, TA-11, 13, 16, 24, 25, 28, & 37	Goshawk[a]
Site Characterization, OU 1086, TA-15	Goshawk[a]
Site Characterization, OU 1114, TA-3, 30, 59, 60, 61, and 64	Goshawk[a]
Site Characterization, OU 1157, TA-8, 9, 23, and 69	Goshawk[a]
Fire Protection Lines (Various TAs in the western portion of the Laboratory)	Goshawk
Site Characterization, OU 1146, TA-43	Jemez Mountains salamander
High-Explosive Wastewater Consolidation (TAs-16 and 9)	Goshawk
USGS Gaging Stations (on US Forest Service Land/West Jemez Road)	Jemez Mountains salamander

[a]Projects were identified in 1992; goshawk surveys were conducted in June 1993.

12. Floodplain and Wetland Protection.

Los Alamos National Laboratory must comply with EO 11988, Floodplain Management, and EO 11990, Protection of Wetlands (EPA 1989a). During 1993, 410 proposed Laboratory actions were reviewed for impact to floodplains and wetlands. Nine projects reviewed in 1993 may be located within floodplain or wetland boundaries. Floodplain and Wetland Assessments are being prepared for these projects. None of the nine proposed projects will affect a wetland area greater than one acre, and all affected wetlands were artificially created from Laboratory effluents. In compliance with 10 CFR 1022, a Floodplain and Wetland Notice of Involvement and Statement of Findings for these projects will be submitted to the DOE for publication in the Federal Register.

C. Current Issues and Actions

1. Compliance Agreements.

a. Mixed Waste Federal Facilities Compliance Agreement. On May 14, 1992, DOE/LAAO, with support from a Laboratory team, began negotiations with EPA Region 6 for an FFCA to ensure complete compliance with the LDR storage prohibition for mixed waste (hazardous and radioactive waste) as provided for in Section 3004(j) of the RCRA and 40 CFR Section 268.50. An agreement was reached on June 6, 1993, between DOE and EPA on

reached on June 6, 1993, between DOE and EPA on the terms and conditions of the FFCA. The draft FFCA was released for public review and comment on July 27, 1993. The review and comment period is now closed, and it is likely the FFCA will be signed by DOE and EPA before the end of March 1994. The FFCA provides a plan and schedule for the treatment of mixed wastes. Under a mandate in the Federal Facilities Compliance Act (FFCAct), DOE will be negotiating with the State of New Mexico issues similar to those negotiated in the FFCA. The Laboratory has been operating under a moratorium on the generation of mixed waste, pending negotiation and execution of the FFCA. Once the FFCA is executed, future direction on the generation of mixed waste will be forthcoming from the Laboratory.

b. New Mexico Environment Department Compliance Orders for Hazardous Waste Operations. In January 1993, NMED issued two COs against the Laboratory and two COs against DOE alleging various violations of the NMHWA. In addition to other requirements, the COs seek to require the Laboratory to develop a plan and schedule to retrieve and store TRU mixed wastes from TA-54, Area G, pads 1, 2, and 4 in compliance with RCRA and NMHWA. DOE and LANL negotiated a compliance agreement with NMED to resolve these matters. The Laboratory paid a total of $700,000 in fines. A Part B permit application was submitted in October 1993 that addressed storage areas in Area G.

c. National Pollutant Discharge Elimination System Federal Facilities Compliance Agreement and Administrative Order. In March 1993, EPA proposed an FFCA, Docket No. VI-92-1305, to DOE that eliminated the discrepancies between LANL's previous AO and the previous DOE FFCA (Docket No. VI-91-1328). The FFCA was reviewed by DOE and UC. However, the FFCA does not reflect the schedules for the new AO (Docket VI-94-1210). The schedules for completing projects required under the AO are presented in Table D-7.

In May 1993, EPA, Region 6, issued AO Docket No. VI-93-0178 to UC stipulating a 30-day compliance schedule for two categories of outfalls with effluent violations during the previous six-month period.

On December 6, 1993, EPA, Region 6, issued an AO, Docket No. VI-94-1210, to UC. The AO stated that LANL had failed to meet the HE Wastewater project schedule for outfall 05A. The AO included a revised compliance schedule and interim effluent limits for outfall category 05A and a revised schedule for completion of the WSC project.

d. National Emissions Standards for Hazardous Air Pollutants Federal Facilities Compliance Agreement. The radioactive air emissions at the Laboratory have been evaluated against DOE/EH-0173T, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance, and 40 CFR Part 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities. Based on off-site environmental monitoring results and on doses calculated from measured stack emissions, the off-site doses for 1993 were less than 10 mrem/yr, which is the standard given in 40 CFR 61.92.

On November 23, 1992, the EPA Region 6 issued a NON for the requirements of 40 CFR 61 to DOE. This notice was based on the results of an EPA audit of the Laboratory's radioactive NESHAP program in August 1992 and included the following findings:

- LANL, by using a shielding factor that reduces its calculated emission level by approximately 30%, is using "other procedures" without prior approval of EPA and is in violation of 40 CFR 61.93 (a).
- In 1990, LANL used this shielding factor to calculate emissions of radionuclides to the ambient air. As calculated using the specified methodology (without the shielding factor), an EDE of 11.5 mrem/yr may have been received by a member of the public, thereby violating 40 CFR 61.92.
- Because LANL violated the emission limits for CY90, it must immediately comply with the 40 CFR 61.94 and

  (1) report on a monthly basis all the information required by 40 CFR 61.94 (b);

(2) continue this monthly reporting until the requirement is either modified or ended by the Director of the Air, Pesticides, and Toxics Division, EPA Region 6; and

(3) include in each monthly report the additional information described in 40 CFR 61.94 (c)(1) and (2).

As a result of this and the 1991 NON, the DOE is currently negotiating an FFCA with EPA Region 6 that will include schedules for the Laboratory to follow so that it complies with radioactive stack monitoring requirements. A draft FFCA was initially submitted by DOE/LAAO to the EPA on March 12, 1992, and updated on November 29, 1993; review is proceeding, but the FFCA has not yet been finalized.

e. Environmental Oversight and Monitoring Agreement. The Environmental Oversight and Monitoring Agreement (known as the Agreement in Principle or AIP) between DOE and the State of New Mexico provides technical and financial support by DOE for state activities in environmental oversight, monitoring, access, and emergency response. The Agreement was signed in October 1990 and covers Los Alamos and Sandia National Laboratories, the Waste Isolation Pilot Project, and the Inhalation Toxicology Research Institute. NMED is the lead state agency under the Agreement. DOE and NMED are currently negotiating a five-year extension to this agreement.

During 1993, the NMED AIP staff conducted oversight of several of the Laboratory's environmental programs. Highlights of these activities are presented below.

Air Monitoring: NMED AIP staff concentrated on review of LANL's air monitoring and surveillance activities and review of the Laboratory's efforts to achieve compliance with 40 CFR 61 Subpart H requirements regarding NESHAP. LANL has been out of compliance with some of the procedures used to determine radioactive emissions from certain stacks, but worked with the EPA to implement measures to assure compliance. AIP staff reviewed LANL's monthly progress reports for NESHAP compliance and observed LANL's air monitoring procedures. Four ambient air monitors were co-located with LANL monitors at locations in Los Alamos and White Rock. These will be used to verify LANL measurements.

Sampling: Extensive sampling activities were conducted at LANL in 1993. Sampling is done in coordination with the LANL Environmental Surveillance Program in order to obtain split or duplicate samples. The activities included sampling of outfalls, groundwater, springs, stream bed sediment, snowmelt runoff, and locally grown vegetables. Split samples are submitted to SLD and independent laboratories for analysis.

Environmental Restoration: LANL staff at the radioactive wastewater treatment plant expressed concern that slanted borings that were planned to penetrate below the locations of existing waste management facilities might intercept subsurface structures and result in release of contaminated water. NMED AIP staff found this concern to be valid and recommended against the procedure.

Site visits by NMED AIP staff at TA-50 resulted in the determination that a liquid storage tank described as having never been used to store radioactive liquids had in fact been used for storage of both gamma and beta contaminated liquids.

NMED AIP staff recommended that potential ecological impacts be included in prioritization for future cleanups; this recommendation was incorporated by DOE in its rating system.

Releases and Corrective Actions: A release of primary cooling waste water into Los Alamos Canyon from the TA-2 Omega West Reactor was reported in January 1993. EM-8 staff sent water quality data to the NMED Surface Water Quality Bureau weekly. LANL submitted a corrective action and sampling plan for the remediation of SWMU #3-010 mercury release. LANL reported a release of mercury into a tributary of Pajarito Canyon according to NMWQCC Regulation 1-203 (spill reporting). Rains caused erosion to the water course. NMED Surface Water Quality Bureau staff attended meetings with DOE, LANL, and contractors regarding the corrective actions and sampling plan. Representatives of DOE/LAAO worked with NMED's site representative to determine the best means for providing NMED with information regarding the nature, quantities, and hazards associated with hazardous, mixed and radioactive waste produced, stored or disposed of at LANL.

2. Corrective Activities.

The Corrective Activities (CA) Program is managed by EM-8 personnel under guidance from DOE/HQ EM-30. Funding is provided through the Five-Year Plan, a planning process in which waste management activities are iden-

tified and budgeted for. The CA Program includes those activities designed to bring active or standby facilities into compliance with ambient air, water, and solid waste regulations and/or agreements.

CA projects that demonstrate efforts toward regulatory compliance include the following:

- *HE Wastewater Treatment System.* This project consists of two HE wastewater treatment facilities and a collection piping system to transfer HE-contaminated fluids from existing building sumps to treatment facilities. Conceptual design for the facility was completed in FY92; construction is planned for FY96. Upgrading the HE wastewater facilities is required under the Laboratory's NPDES FFCA and AO.
- *Water Supply and Cross Connection Controls (CCC) Survey.* The CCC Survey continued in 1993. As of the end of October 1993, 89 of the 363 Laboratory buildings with potable water service, or about 25%, had been surveyed. Over 95% of the surveyed buildings were found to have one or more potential cross connections or other identifiable plumbing deficiencies.
- *TA-53 Sanitary Lagoons Elimination Project.* In 1993, 100% of the TA-53 Sanitary Lagoons Elimination Project was completed, as required by the previous AO. The project involved closing out the sanitary lagoons at TA-53, in part by rerouting the sanitary waste to the new sanitary wastewater systems consolidation plant.
- *PCB Transformers and Capacitors.* This project consists of replacing and retrofilling PCB-contaminated transformers and disposal of PCB-contaminated capacitors and other equipment. This is an ongoing activity and is required to ensure compliance with the TSCA.
- *WSC Survey.* This survey of all Laboratory buildings is being conducted in order to identify and eliminate noncomplying wastewater discharges and to comply with NPDES permitting requirements. At the end of 1993, 100% of all Laboratory facilities had been surveyed.
- *Firing Site Characterization.* The Laboratory operates open burning and open detonation (OB/OD) units at TAs 14, 15, 16, 36, and 39 for treatment of waste HE. These units currently operate under interim status for hazardous waste treatment. Beginning in 1993 and continuing in 1994, EM-8 initiated a site characterization effort for OB/OD units, funded by the Laboratory's corrective activities program under the Five-Year Plan. Surface and near surface soil samples were collected from each of the firing sites and adjacent areas and analyzed for volatile and semivolatile organic compounds, trace metals, residual high explosives, and certain radionuclides. Data will be reviewed during 1994 to determine whether contaminants are present and the extent to which each site is contaminated.

3. 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 through emergency planning, through emergency preparedness, and with effective response capabilities is capable of responding to and mitigating the consequences resulting from emergencies. The Laboratory's Emergency Management Plan incorporates into one document a description of the entire process designed to plan for, respond to, and mitigate the potential consequences of an emergency. The most recent revision was distributed in July 1993; future revisions will be distributed on a varying, as needed, basis.

4. Waiver or Variance Requests.

Groundwater monitoring is required for all RCRA surface impoundments, landfills, waste piles, and treatment units. This requirement may be waived if it can be demonstrated that there is little or no potential for a release from the units to migrate to the uppermost aquifer, as has been demonstrated for several units located at TA-16, 35, 53, and 54. All but the demonstration at TA-53 have been provided to the state's Hazardous Waste Program for review.

5. Significant Accomplishments.

The Voluntary Corrective Actions (VCA) of the ER program at the Old Catholic Church property and at the ordnance impact areas were performed with appropriate safeguards, QA checks, and coordination with DOE. Good

working relations were maintained with property owners and other federal agencies while the VCAs were being performed.

LANL was proactive in supporting DOE in complying with FFCAct requirements and with completion of DOE's draft FFCA with EPA. LANL successfully developed documents that were both timely and complete to comply with the FFCAct.

LANL had a successful waste minimization effort and developed tools that will serve the Waste Minimization Program well. The Process Waste Assessment (PWA) modeling hardware and software were developed to help waste generators make waste assessments and evaluate potential waste minimization technologies. Included in the assessments are a complete mass balance to ensure that the process is being modeled completely, and it has a trackable history of selected wastes and cost, energy, and manpower considerations. LANL completed ten PWAs. Other tools that LANL developed are the Site Specific Plans tool and the External Chemical Recycling tool. In addition, tools that LANL started are the Best Available Technology Database and the Cost/Benefit tools.

EM-8 continued to identify all waste streams that may potentially enter NPDES outfalls and to verify that each is included in the proper outfall category. Implementation of this program has allowed the Laboratory to comply with its NPDES permit under the previous AO. Specific accomplishments of the Laboratory's WSC program include

- completion of all surveys at all Laboratory facilities on October 8, 1993;
- drafted 83 WSC reports documenting WSC findings; and
- finalizing 25 WSC reports for all facilities at Technical Areas 16, 2, 9, 33, 39, 49, 69, 6, 14, 11, 8, 15, 40, 61, 36, and 22, the TA-3 power plant, and the steam plants at TA-16 and 21.

6. Significant Problems.

a. Lawsuits. In 1991, a lawsuit, Lujan v. Regents of the University of California, was filed against the Laboratory. Plaintiffs claimed that they were injured by exposure to discharges and emissions of radioactive and hazardous materials from past operations of the Laboratory. Plaintiffs were seeking compensatory and punitive damages, as well as injunctive relief against certain ongoing operations of the Laboratory. All of the plaintiffs except for Sonja Lujan, in her capacity as personal representative for her deceased daughter, Kimberly Lujan, dismissed their claims voluntarily; the court gave summary judgment on Sonja Lujan's wrongful death claims for her daughter, dismissing those claims. She has appealed, and the appeal is pending in the US 10th Circuit Court of Appeals.

In February 1992, a lawsuit, Truelock v. Regents of the University of California, was filed against the Laboratory. Plaintiffs claimed that they were injured by exposure to discharges and emissions of radioactive materials from past operations of the Laboratory. Plaintiffs were seeking compensatory and punitive damages, as well as injunctive relief against certain ongoing operations of the Laboratory. This lawsuit was dismissed in 1993.

On April 15, 1992, a lawsuit, Mills-Garrison v. Regents of the University of California, was filed against the Laboratory. Plaintiffs claimed that they were injured by exposure to discharges and emissions of radioactive materials from past operations of the Laboratory. Plaintiffs were seeking compensatory and punitive damages, as well as injunctive relief against certain ongoing operations of the Laboratory. This lawsuit was dismissed in 1993.

On May 21, 1992, a lawsuit, Chavez v. Regents of the University of California, was filed against the Laboratory. Plaintiffs sought to represent a class of all persons who resided or worked in what is now Los Alamos County since the Laboratory opened in 1943, and they sought creation of a fund to finance medical monitoring of the class members, psychological services, and scientific studies, in addition to injunctive and other relief. They relied upon the same legal theories asserted in the other complaints, with the exception of wrongful death. The complaint in Chavez bore a close resemblance to the complaints filed in the other cases. In Chavez, however, the plaintiffs did not allege they suffered any specific physical injury, and so did not seek recovery for wrongful death or personal injury. This lawsuit was dismissed in 1993.

The case of United States of America and Regents of the University of California v. State of New Mexico involved three conditions the NMED placed on the Laboratory's RCRA permit for the CAI. The Laboratory and DOE believed these conditions improperly regulated radioactive emissions and therefore fell outside NMED juris-

diction. In August 1992, a federal District Court ruled in favor of NMED. The US Department of Justice has appealed the ruling on behalf of DOE; the Laboratory did not participate in the appeal.

b. Other Issues. During 1993, trace amounts of tritium were found in the deep aquifer that supplies the potable water systems of the county and Laboratory. Preliminary data from water supply wells in Los Alamos County showed levels of tritium thousands of times lower than drinking water standards. The tritium levels, which are due to naturally occurring tritium, do not represent any health risk. Higher tritium levels found in test wells (not part of the water supply system) do raise a concern about possible migration of contamination from the surface to the deep aquifer. The origin of these trace amounts is not currently known. Additional QA samples will be taken from all test and production wells to determine if the readings might have been the result of sample contamination during sampling, handling, transportation, or analysis. See sections VII.E.1.b and E.1.c.

In 1993, LANL twice discovered that low-level radioactive waste had been discarded into LANL's sanitary waste stream. On May 28, 1993, low-level phosphorous-32 contamination from the Health Research Laboratory (TA-43) and on June 11, 1993, low-level cobalt-60 contamination from TA-3-66 were deposited into the Los Alamos County landfill. The low-level radioactive waste was removed from the landfill and disposed at LANL's TA-54, Area G low-level radioactive waste landfill. Beginning immediately after the May 28, 1993 occurrence, the Laboratory initiated interim measures to better monitor and control sanitary waste. A DOE Class C investigation was initiated to review these low-level radioactive disposal occurrences. The Class C investigation was complete on October 4, 1993. The investigation concluded with 10 findings of facts and 10 judgments of needs.

During 1993, above-background levels of gross alpha and gross beta radiation were found in a sample collected from storm water runoff at TA-54, Area G. The drainage has not flowed since the sample was collected. The runoff will be resampled. EM-7, with assistance from EM-8, has prepared a SWPP Plan for TA-54, Area G. EM-8 has reviewed this plan and has recommended improvements. Movement of potential radioactive sediments down Cañada del Buey is also being addressed. Permanent monitoring stations are being planned around TA-54, Area G with automated samplers.

The Laboratory continued communications with EPA concerning implementation of an FFCA in response to the NON it received on air monitoring. LANL has made progress toward compliance. LAMPF, which emits airborne radionuclides that result in more than 95% of the EDE to the maximum exposed individual, was brought into full compliance in 1993.

7. Tiger Team Assessment.

The Tiger Team Assessment was conducted at LANL from September 23 to November 8, 1991, under the auspices of the Office of Special Projects, Office of the Assistant Secretary for Environment, Safety and Health, DOE Headquarters. The objectives of the Environmental Subteam of the Tiger Team were to assess the effectiveness of environmental programs and program management at the Laboratory, the Laboratory's compliance with applicable regulations, and the effectiveness of best management practices within specific technical disciplines.

The Tiger Team did not identify any environmental deficiencies that could be considered an immediate danger to worker or public health and safety. The Tiger Team identified individual findings within nine technical disciplines. These individual findings were evaluated to determine four key findings that summarize the most significant deficiencies in the Laboratory's environmental program. The key findings were

- inadequate site-wide programs for managing wastes;
- inadequate identification, monitoring, and control of effluent releases;
- inadequate strategies for and management of regulatory permits; and
- lack of oversight for environmental activities.

The Tiger Team also identified some positive aspects of the Laboratory's environmental programs. In particular, the Tiger Team identified the high quality of environmental professionals at the Laboratory and their dedicated efforts to provide adequate and defensible programs and to meet regulatory requirements.

The Laboratory prepared action plans to address the environmental deficiencies identified by the Tiger Team. The plans were submitted to DOE for review and approval on March 31, 1992. The Tiger Team Corrective Action Plan was signed by the Secretary of Energy on October 28, 1992.

Of the 49 action plans for which the Laboratory's EM Division is responsible, 29 are in the high-priority group, and 20 are low priority. The 49 action plans address 90 individual Tiger Team findings for which the Division has primary responsibility. In the EM Division, detailed Work Breakdown Structures are being applied in a project-management approach to this effort.

Because of limited indirect funding, a number of action plans that were initially designated as high-priority did not receive anticipated funding in FY93. On most of these, work did not progress in accordance with the original (unconstrained budget) schedule. Nevertheless, significant work was accomplished in 1993 (some considerably ahead of schedule), including resolution of several important compliance issues in the unfunded items. As of December 31, 1993, completion reports had been filed for 26 of the 90 EM Division findings. As part of the FY 1996-2000 ES&H Management Plan (formerly the Five-Year Plan), Tiger Team action plans are being incorporated into activity data sheets (ADSs) with other activities of similar nature and impact. The ADSs will be subjected to the Laboratory's multivariate attribute risk/cost-benefit prioritization process, which is expected to better support funding requests for important action plan activities. Work is continuing on the funded action plans, and critical portions of the unfunded items are being addressed where possible.

8. DOE/HQ Audits and Assessments.

The DOE Albuquerque Field Office prepares an Annual Performance Appraisal of Los Alamos at the end of each fiscal year. The FY93 report ranked the overall environmental management program at the Laboratory as "meets expectations." The Waste Minimization program exceeded expectations. The Waste Management program met expectations and was given high marks for improvements in management systems, budget execution, and programmatic efforts. The Environmental Protection program met expectations. The ER program needed improvement, due to DOE's observation that the program had difficulty providing documents in a timely manner, providing adequate support in the stakeholder involvement area, and providing adequate coordination among contractor organizational elements.

IV. ENVIRONMENTAL PROGRAM INFORMATION

The Los Alamos National Laboratory (LANL or the Laboratory) supports an ongoing environmental surveillance program that includes routine monitoring for radiation, radioactive materials, and hazardous chemical substances on the Laboratory site and in the surrounding area. Over 450 sampling locations are used for routine surveillance of the environment. In 1993, more than 11,500 environmental samples were analyzed.

The Waste Management Group (EM-7) managed approximately 3,077 m^3 (109,849 ft^3) of radioactive wastes, 135 m^3 (4,820 ft^3) of hazardous wastes, and 1,142 m^3 (40,769 ft^3) of nonhazardous wastes.

The Environmental Restoration (ER) program continued its mandate to identify the extent of contamination at the Laboratory and to determine appropriate means of cleaning it up under applicable laws and regulations.

The Laboratory drafted eight Environmental Assessments (EAs) in 1993 to evaluate environmental impacts of proposed activities. In addition to environmental routine surveillance activities, the Laboratory carried out a number of special studies during 1993, which provide valuable supplementary environmental information.

A. Major Environmental Programs

1. Environmental Protection Program

The Environmental Protection Group (EM-8) was in charge of performing environmental measurements and activities to help ensure that Laboratory operations did not adversely affect public health or the environment and that the Laboratory conformed with applicable environmental regulatory requirements as required by Department of Energy (DOE) Orders 5400.1 (DOE 1988a) and 5484.1 (DOE 1990a). The major objectives of EM-8 were to

(1) develop and implement institutional plans and programs for environmental protection in response to specific federal and state regulatory requirements;

(2) assist Laboratory organizations in complying with environmental regulatory requirements;

(3) measure, evaluate, and document effects of Laboratory operations on public health and the environment;

(4) provide emergency response support by evaluating and responding to releases of radioactive and toxic materials.

EM-8 was divided into six sections, including

Waste Site Studies: this section performed interim actions on Operable Units for the ER program and environmental sampling support for foodstuff monitoring, abandoned disposal sites, and decommissioning and decontamination activities;

Environmental Health Physics & Hydrology: this section was responsible for compliance with DOE orders regarding environmental surveillance; applications for Environmental Protection Agency (EPA) construction approvals for projects involving radioactive air emissions; groundwater, surface water, soil, and sediment monitoring; and characterization of hydrologic properties of surface and subsurface geology;

Air Quality & Meteorology: this section was responsible for air quality permit applications, ambient air quality monitoring, and air dispersion modeling for emergency operations and regulatory needs;

Water Quality & Toxics: this section was in charge of the National Pollutant Discharge Elimination System (NPDES) permit and related programs, groundwater discharge plans, drinking water program, and Polychlorinated Biphenyls and pesticides compliance.

Hazardous & Solid Waste: this section provided support for the Resource Conservation and Recovery Act (RCRA) hazardous waste permits, prepared mixed waste permit applications, samples for underground storage tank removals, and provided Hazardous and Solid Waste Amendments (HSWA) permit oversight.

Environmental Assessments & Resource Evaluations (EARE): this section prepared environmental assessments related to National Environmental Policy Act (NEPA), biological resources, and cultural resources.

Monitoring and sampling locations for various types of environmental measurements were organized into two groups:

- **Off-site** locations included
  Regional stations are located within the five counties surrounding Los Alamos County (Figure II-1) at distances up to 80 km (50 mi) from the Laboratory. They provided a basis for determining conditions beyond the range of potential influence from normal Laboratory operations.

  Perimeter stations were located within about 4 km (2.5 mi) of the Laboratory boundary, and many were in residential and community areas. They were used to document conditions in areas regularly occupied by the public and potentially affected by Laboratory operations.
- **On-site** stations were within the Laboratory boundary, and most were in areas accessible only to employees during normal working hours. They measured environmental conditions at the Laboratory where public access is limited.

The general location of all monitoring stations is presented in maps in the text. For off-site perimeter and on-site stations, specific location coordinates are presented in Appendix D.

Samples of air particles and gases, water, soils, sediments, and foodstuffs were routinely collected at the monitoring stations for subsequent analyses. External penetrating radiation from cosmic, terrestrial, and Laboratory sources was also measured. Meteorological conditions were continually monitored to assess the transport of contaminants in airborne emissions to the environment as well as to aid in forecasting local weather conditions. Over 450 sampling locations were used for routine environmental monitoring (Table IV-1).

Additional samples were collected and analyzed to obtain information about particular events, such as major surface runoff events, nonroutine releases, or special studies. Over 215,000 analyses for chemical and radiochemical constituents were conducted on more than 11,500 environmental samples during 1993. Data from these analyses

Table IV-1. Number of Sampling Locations for Routine Monitoring of the Ambient Environment

	Off Site		On Site		
Type of Monitoring	**Regional**	**Perimeter**	**Laboratory**	**Waste Disposal Area**	**Total**
External radiation	4	23	51	88	166
Air	6[a]	14	23	9	52[b]
Surface waters[c,d]	6	10	12	0[e]	28
Groundwaters[c]	0	61	33	0[e]	94
Soils	7	6	9	1	23
Sediments	11	19	29	21	80
Foodstuffs	13	11	21	1	46
Meteorology	0	1	5	1	7

[a]Includes three pueblo monitoring locations.
[b]Includes three stations that monitor only nonradioactive air emissions.
[c]Samples from an additional 17 special surface water and groundwater stations related to the Fenton Hill Geothermal Program were also collected and analyzed as part of the monitoring program.
[d]Does not include National Pollutant Discharge Elimination System (NPDES) outfalls sampled to demonstrate regulatory compliance.
[e]Means not counted separately from on-site Laboratory locations.

were used for dose calculations, comparisons with standards and background levels, and interpretations of the relative risks associated with Laboratory operations, as presented in Section V.

Methods and procedures for acquiring, analyzing, and recording data are presented in Section VIII. Comprehensive information about environmental regulatory standards is presented in Appendix A. Supplemental environmental data tables are given in Appendix D.

2. Waste Management Program

EM-7 was formed in 1948 as part of the Los Alamos Area Office of the Atomic Energy Commission. EM-7 was then responsible for the minimization of the adverse effects of liquid radioactive wastes on the environment. Since then, many other responsibilities have been added to its charter: treating and disposing of liquid chemical wastes, including plating solutions; managing solid radioactive wastes; investigating incineration for volume reduction of radioactive solids; and managing all chemical wastes.

Wastes generated at the Laboratory include transuranic (TRU) wastes, low-level radioactive wastes (LLW), accelerator-produced radioactive material, and hazardous chemical wastes. No high-level radioactive wastes are generated at Los Alamos.

LLW is the largest volume of radioactive waste generated at the Laboratory. In 1993, 2,767 m^3 (98,782 ft^3) of LLW were generated of which 54 m^3 (1,928 ft^3) were classified as mixed waste. Averages from the last several years indicate that approximately 90% of the total volume of radioactive solid waste is LLW and 10% is TRU wastes. In 1993 135 m^3 (4,820 ft^3) of chemical wastes were generated.

EM-7 is divided into four sections that relate to the various kinds of waste handled:

Radioactive Liquid Waste Treatment: the laboratories, accelerators, reactors, and shops at the Laboratory annually generate about 8 million gal. of dilute, low-level radioactive liquid waste and about 46,000 gal. of a slightly higher radioactive process liquid waste. This section uses special collection systems to transport radioactive liquid waste to the central processing area at TA-50 for treatment and disposal or for monitoring and storage;

Chemical Waste Treatment: this section collects chemical wastes at the sites where the waste is generated and transports them to TA-54, Area L, for sorting, treating, and packaging. Wastes are either stored or shipped to off-site disposal facilities;

Radioactive Solid Waste Treatment: this section manages disposal, storage, and volume reduction of low-level radioactive solid wastes and TRU wastes. The section also operates facilities for size reduction and inspection, conducts studies of waste management sites, and is revising a certification program for LLW; and

Technical Support: this section is dedicated to developing incineration as a way to reduce the volume of radioactive wastes. The Controlled Air Incinerator (CAI) is not currently in operation.

Group operations are administered, audited, and controlled in compliance with regulations, directives, and orders of DOE, EPA, the Occupational Safety and Health Agency (OSHA), the Department of Transportation, and the New Mexico Environment Department (NMED). Waste management regulations continue to become more stringent to ensure the protection of the public's health and safety and the environment.

3. Environmental Restoration Program

In 1989, DOE created the Office of Environmental Restoration and Waste Management whose goal is to implement the DOE's policy to ensure that its past, present, and future operations do not threaten human or environmental health and safety (DOE 1990b). The Environmental Restoration (ER) program was established to identify the extent of contamination at the Laboratory and the appropriate means of cleaning it up under applicable laws and regulations. The program provides formal and informal mechanisms through which all interested parties (e.g., DOE, EPA, NMED, and the public) can participate in the corrective action review process at the Laboratory.

The ER program at the Laboratory is regulated by RCRA, which governs the day-to-day operations of hazardous waste management treatment, storage, and disposal facilities; establishes a permitting system; and sets standards for

all hazardous waste-producing operations at these facilities. Under this law, the Laboratory must have a permit to operate its facilities. RCRA, as amended by HSWA in 1984, prescribes a specific corrective action process for all potentially contaminated sites. In accordance with these laws, the Laboratory's operating permits included provisions for mitigating releases from facilities currently in operation and for cleaning up inactive sites. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides a framework for remediating Laboratory sites containing radioactive materials not covered by RCRA.

The Laboratory is obligated to meet the hazardous waste management requirements of RCRA and HSWA; however, compliance with CERCLA is a voluntary measure on the part of DOE and the University of California, who recognize that contaminants not covered by RCRA are of concern and should not be separated from concerns about hazardous wastes.

The Laboratory follows a three-step corrective action process at all of its potential release sites (PRSs):

The RCRA facility investigation is designed to identify the nature and extent of contamination that could lead to exposure of human and environmental receptors. This step involves characterizing the extent of contamination in the detail necessary so that corrective measures, if any, that need to be taken can be determined. This approach focuses on answering only those questions relevant to determining further actions in a cost-effective manner. In certain circumstances, the Laboratory will take voluntary corrective action, which is an option for accelerated cleanup.

If investigation indicates that corrective measures are needed, a *corrective measures study* will evaluate cleanup alternatives to reduce risks to human and environmental health and safety in a cost-effective manner.

Corrective Measures Implementation carries out the chosen remedy, verifies its effectiveness, and establishes ongoing control and monitoring requirements.

The approach to the corrective action process at the Laboratory includes an approach to making decisions based on risk that takes into account the great variety of PRSs and the complexity of the natural environment of the Pajarito Plateau. Chapter 4 of the Installation Work Plan for Environmental Restoration at Los Alamos National Laboratory provides a detailed account of the process (IWP 1992).

In accordance with regulatory requirements, the RCRA facility investigations will be completed by approximately May 1995 and the corrective measures studies by approximately May 2000. Section III.B presents information on the accomplishments of the ER program during 1993.

B. Environmental Assessments

NEPA mandates that federal agencies consider the environmental impacts of their actions before final decision-making. NEPA establishes the national policy of creating and maintaining conditions where people and nature can exist in productive and enjoyable harmony and fulfill the social, economic, and other requirements of present and future generations. The sponsoring agency, DOE for LANL activities, is responsible for preparation of NEPA documents, which include the following:

- categorical exclusion—applies to specific types of activities that have been determined to have no adverse environmental impacts;
- environmental assessment (EA)—evaluates environmental impacts and leads to either a Finding of No Significant Impact (FONSI) if the impacts are found to be not significant or preparation of an Environmental Impact Statement (EIS) if the impacts could be significant; and
- EIS—evaluates impacts of proposed and alternative actions and proposes mitigation measures; an EIS leads to a record of decision in which the agency discusses the decision to proceed with an action.

The proposed activities documented in EAs submitted to DOE for review in 1993 and in EAs submitted earlier, but still being revised, during 1993 are summarized below. DOE reviews the analysis of environmental impacts for the actions presented in each EA. DOE submits draft EAs to the NMED and to potentially affected Native American tribes for review before taking final action, which is to issue a FONSI or directions to prepare an EIS.

After the decision has been made, DOE places copies of the EAs in public reading rooms in Los Alamos and Albuquerque.

Table IV-2 presents the status of the Laboratory's major NEPA documentation as of December 1993. The EAs described below are drafts submitted to DOE during 1992, which were either at DOE for review or were being revised according to DOE comments during 1993.

Deactivate, Disassemble, and Decontaminate the High Pressure Tritium Laboratory. The proposed action is to remove and dispose of all materials and equipment from the High Pressure Tritium Laboratory (HPTL), decontaminate it, and demolish the shell. All tritium repackaging activities in the HPTL were suspended in October

Table IV-2. Status of Environmental Documentation as of December 30, 1993

Environmental Assessments that Received FONSIs during 1993	None
EAs submitted to DOE in 1992, in revision during 1993	Decommission of Building 86 Expansion of Area G, TA-54 High Explosive Material Test Facility Los Alamos/Nevada Test Site Explosive Pulsed Power Experiment (SCYLLA)[a] LLW Drum Staging Facility TRU Waste Compactor/Drum Storage Facility
EAs submitted to DOE during 1993	Accelerator Prototype Lab Actinide Source-Term Waste Test Program (formerly C-H TRU Waste-Source Term Test Program) Hazardous Waste Treatment Facility and Mixed Waste Receiving and Storage Facility Isotope Separator Building[a] Medical Radioisotope Production Mixed Waste Disposal Facility Uranium Oxide Reduction[a] Weapons Component Testing Facility
EAs with DOE determination, not submitted during 1993	Chemical Metallurgy Research Building upgrades—Phase II Fire-Resistant Pit Program High Explosive Wastewater Treatment Facility Nuclear Material Storage Facility Upgrade New Sanitary Landfill[b] Fire Protection Line Improvements[c]
Expanded Operations at the CAI	
Status of Environmental Impact Statement	DOE determined that an EIS should be prepared for a proposed Radioactive Liquid Wastewater Treatment Facility. LANL drafted an Environmental Information Document on the proposed facility during 1993, which will be used by DOE's independent contractor to prepare an EIS.

[a]Project cancelled.
[b]Determination made, draft not initiated.
[c]Categorical exclusion issued.

1990 and were subsequently transferred to the new Weapons Engineering Tritium Facility (WETF). Since that time, the HPTL has been steadily emitting a small amount of tritiated water vapor to the air. Implementing the proposed action would eliminate one source of airborne contamination and the costs required to maintain and monitor the empty building. Alternative actions include leaving the building as is but continuing the maintenance and monitoring activities, delaying one or more steps for an indefinite period, and reusing the building after the equipment has been removed. Environmental issues include radiation doses and risk to individuals from the emissions of tritiated water vapor and the volume of solid LLW that would be disposed of.

Expansion of TA-54, Area G. Routine activities at the Laboratory generate solid LLWs that are disposed of or stored at TA-54, Area G. For some types of waste, burial is the only feasible disposal method that complies with all regulations. The useful lifetime of the existing TA-54, Area G, 63-acre site, which is limited by the area suitable for pit construction, is estimated to be one year. The proposed action is to expand TA-54, Area G onto adjacent acreage on Mesita del Buey in order to provide adequate facilities to accommodate disposal of solid LLW after the currently active part of TA-54, Area G has been filled. Alternatives to expanding TA-54, Area G include installing specialized aboveground storage structures at the existing TA-54, Area G site, developing an alternative disposal site within the Laboratory; or transporting future solid LLW off site. Potential environmental, safety, and health issues include operational safety, transportation, and ensuring environmental protection as part of long-term solid LLW management.

High Explosive Materials Test Facility. The proposed action is to consolidate mechanical testing of high explosive (HE) materials in a new facility to enhance process efficiency, increase operational safety, and decrease maintenance costs. Tests of HE components include measurement of mechanical properties (such as tensile strength), thermal properties, and high-speed machining. Alternatives to construction of a new facility include continued testing in buildings currently used for these activities or in buildings that would be upgraded for greater efficiency and operational safety. Potential environmental issues include operational safety, threatened and endangered species, and solid and liquid waste management.

Low-Level Waste Drum Staging Facility. The proposed action is to erect a 10-ft by 15-ft building adjacent to the WETF to hold several 55-gal. drums of solid waste contaminated with small amounts of tritium. Waste would be accumulated until several drums could be moved in a single truckload to LANL's on-site LLW disposal area at TA-54. The waste would consist of metal parts and other noncompactable equipment used in tritium experiments at the WETF. At present, this waste is placed in a drum in the WETF laboratory space. Due to the demands on that space, single drums must be trucked to TA-54 as they are filled. Implementing the proposed action would increase the efficiency of LLW transportation and make more of the WETF laboratory space usable for experiments. The alternative action is to not build the staging facility. Environmental issues include the very small quantity of tritium that would be emitted from the drum each time it is opened, either in the WETF laboratory work space or in the isolated staging facility. The tritium emissions to the environment would be the same for either alternative.

TRU Waste Compactor and Drum Storage Building. The proposed 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 two activities: (1) installing a 20-ton hydraulic press in an existing laboratory area to compact approximately 500 lb of TRU waste per week; and (2) 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. At DOE's request, LANL combined separate EAs for the TRU Waste Compactor and the Drum Storage Building into a single EA. Alternatives to the proposed actions include installing the waste compactor but not the drum storage building, constructing the drum storage building but not the waste compactor, or continuing operations under current conditions. Some of the potential environmental, safety, and health issues include air emissions, worker safety, on-site TRU waste management, and TRU waste transportation.

The EAs described below were submitted to DOE for the first time during 1993.

Accelerator Prototype Laboratory. The proposed action is to erect a 100-ft by 70-ft preengineered metal building that would contain a high bay area where physicists could conduct research and development of linear particle injection systems. A linear particle injection system is the first part of a linear particle accelerator. The next generation of higher power particle accelerators must have a higher flux of subatomic particles, or beam current,

supplied by an improved injection system, in order to operate. The linear particle injection systems to be developed would not create any radioactive wastes or air activation products; the energy would be dissipated in the form of heat and x-rays. Shielding inside the building would protect personnel from exposure from x-rays. Alternative actions include construction and operation at another location and not constructing nor operating the facility. Environmental issues include discharge of cooling water, land use, and personnel safety.

Actinide Source-Term Waste Test Program. The Actinide Source-Term Waste Test Program is a two- to five-year study designed to provide data on the behavior of actinide elements (chemically similar radioactive materials with atomic numbers ranging from 89-103) in actual TRU waste immersed in brine (highly concentrated salt water). The proposed study is required to fulfill EPA requirements for the Waste Isolation Pilot Plant (WIPP). The tests would be conducted in a controlled and enclosed environment within the basement of Wing 9 of the Chemistry and Metallurgy Research (CMR) Building in TA-3 at the Laboratory. Alternatives to the proposed action include taking no action (no testing), conducting tests at facilities outside LANL, and conducting the tests at other laboratories at LANL. Potential environmental, safety, and health issues include radioactive air emissions, radiation exposures to workers and the public, and generation and disposal of radioactive wastes.

Hazardous Waste Treatment Unit and Mixed Waste Receiving and Storage Facility. The proposed action is to construct a new Hazardous Waste Treatment Unit (HWTU) and a Mixed Waste Receiving and Storage Facility (MWRSF) within the Laboratory complex at TA-63. The construction and operation of these facilities have been identified as critical milestones in the RCRA Federal Facilities Compliance Agreement at LANL. The proposed HWTU would provide a central location for use of existing hazardous and mixed waste treatment processes and a location for development of alternative treatment processes for existing and future wastes that would otherwise be stored. The proposed MWRSF would complement the HWTU by providing a centralized location for receiving and storing wastes identified for treatment in the HWTU. Alternatives to building the HWTU and MWRSF include transporting untreated wastes off site, developing and utilizing alternative waste treatment processes at various sites throughout the Laboratory, and continuing to manage the waste using current treatment and storage procedures. Potential environmental, safety, and health issues include radioactive and hazardous air emissions, radioactive and hazardous effluents, transportation, and cumulative, long-term impacts associated with operation of the proposed facility.

Isotope Separator Facility. Extremely small quantities of material can be separated into individual isotopes, much as a prism separates light into the individual colors, by ionizing the sample and passing the ion stream between banks of electromagnets. The proposed action is to construct an addition to an existing building where magnetic isotope separation is now done that will extend the capabilities of the separation technique. In particular, more stable (nonradioactive) isotope separations could be done and actinide samples could be separated. Ultrapure (99.99%+) isotope material would be produced for analytical reference standards, tracers for various natural processes, and other research purposes. Alternative actions are to perform these isotope separations at another location or not to perform the separations. Environmental issues include radioactive emissions, liquid effluents, radioactive waste management, land use, and human health effects.

Medical Radioisotope Production. Molybdenum-99 and ^{125}I radioisotopes are extensively used in human medical diagnosis and treatment. Several radiopharmaceutical supply firms have asked DOE to provide a backup source of supply because only one reactor in Canada now supplies the entire needs of North America. The proposed action is for DOE to use the production technologies that are registered with the US Food and Drug Administration Master Drug File and produce these radioisotopes. Highly enriched ^{235}U would be electroplated inside target tubes in the CMR Building at TA-3. The sealed tubes would be irradiated in the Omega West Reactor and transferred back to CMR where the mixed fission products would be removed and the ^{99}Mo packaged for shipment to commercial radiopharmaceutical suppliers for final purification. Iodine-125 would be made in a closed loop process at Omega West Reactor. Xenon-124 would be pumped into a target area inside the reactor where it would be irradiated to form ^{125}Xe, which decays to ^{125}I. This would be pumped out and condensed in a cold trap. This material would also be shipped to radiopharmaceutical suppliers. Alternatives considered were production at other sites and no production. Environmental concerns include radioactive air emissions, liquid wastes, mixed fission product and other solid radioactive waste management, worker exposure to highly radioactive material, transportation, and public exposures.

Mixed Waste Disposal Facility. The ER program anticipates generating approximately 363,375 m^3 (475,000 yd^3) of mixed waste as a result of cleanup activities scheduled by DOE and EPA for the LANL site. LANL currently lacks a facility capable of treating and disposing this waste in a manner that complies with the RCRA Land Disposal Restrictions. The proposed Mixed Waste Disposal Facility would be located at TA-67 and would receive, treat, and dispose of ER program-generated mixed waste. This facility would include a large disposal pit area with several cells, three separate treatment units, and several facility support structures. Alternatives to the proposed action include no action, building the facility at another LANL site, and shipping the wastes off site for treatment and disposal. Potential environmental, safety, and health issues include radiation exposure to workers and the public, water and air quality impacts, loss of critical wildlife habitat, and transportation.

Uranium Oxide Reduction. Small nuclear reactors may be needed as power sources in some of the research programs that the US may pursue, such as to power an earth-orbiting station or a manned base on the moon. These reactors use uranium fuel rods as a long-term, safe, compact, and reliable source of heat from nuclear fission. Fuel composition requirements for the reactors are design-specific. The proposed project is to produce up to 75 kg (165 lb) of reduced uranium oxide fuel materials per year, enriched to any specifications needed, in the existing Plutonium Facility Building (PF-4). The alternatives considered are to produce the reduced uranium oxides at another facility and not to produce the materials at all. Environmental issues include radioactive air emissions, radioactive waste management, worker exposures, and public health.

Weapons Component Testing Facility Relocation. The Weapons Component Testing Facility (WCTF) is one of the primary component instrumentation, diagnostics, and testing laboratories at LANL. The proposed action is to relocate the WCTF from Building 450 to Building 207, both at TA-16. Relocation would allow the WCTF operations to become more efficient and productive by increasing the usable space, consolidating with similar testing operations, and increasing the testing capabilities for larger components. Increased efficiency and productivity would allow the WCTF to better fulfill a LANL programmatic responsibility to maintain weapons development capability and test stored weapons components. The alternative is to keep the WCTF operations at their existing location. No changes in current operations of the WCTF are anticipated as a result of the relocation; no new waste would be generated in the operations after the relocation. The relocation would not change the quantity of sanitary effluent.

The proposed projects described below were determined by DOE to require an EA, but drafts had not been submitted to DOE before the end of 1993.

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. Environmental issues include worker safety while the work is performed and LLW disposal.

Expanded Operations at the Controlled Air Incinerator. LANL proposes to expand the function of the CAI beyond R&D activities to treat wastes by incineration and to vitrify ash on a regular and continuing basis. Operation of the CAI in an expanded mode would permit LANL to treat mixed waste with an approved technology and to comply with EPA requirements for storage, treatment, and disposal of mixed waste. Alternatives to expanded CAI operation include incineration with limited ash vitrification, biodegradation or pressurized water oxidation followed by solids stabilization, and off-site shipment for treatment and disposal. The principal environmental issues to be considered include air quality and health impacts to workers and the public.

Fire-Resistant Pit Program. The proposed action is to determine the melting and neutron generation characteristics of a disarmed plutonium weapons device, called a pit, when it is exposed to high temperatures typical of a fire. Alternative actions include performing the research in other locations and not performing the research. Environmental issues include worker protection from the exposure to neutrons, possible air emissions, transportation impacts, and radioactive waste management. The plutonium would be stored; it would not be a waste product.

High-Explosive Wastewater Treatment Facility. LANL proposes to improve its current management of wastewater contaminated with HE residues and solvents. Improvements to existing wastewater management is necessary to ensure that discharges conform to LANL's NPDES permit. The proposed action consists of piping and trucking all HE-contaminated water to one of two new treatment facilities so that no untreated wastewater is released to the environment. The proposed treatment facilities would remove organic contaminants by passing the water through activated carbon filters. Alternatives include different technologies such as biodegradation and wet oxidation treatments. The principal issues include air and water quality, soils, wetlands, wildlife, and safety.

Nuclear Material Storage Facility Upgrade. The Nuclear Material Storage Facility was originally designed and constructed to consolidate radioactive materials needed for LANL mission objectives from several on-site storage vaults. The facility has not been used yet. The proposed action is to upgrade the heat load capability from the current 20 kW to 75 kW, so that the facility could store more material and/or material with a higher rate of heat production. Alternative ways to transfer heat to the environment and to not upgrade the facility are being considered. Environmental issues include radiation doses to workers and heat transfer.

New Sanitary Landfill. The proposed action is to construct and operate a new sanitary landfill for non-radioactive, nonhazardous waste. The existing landfill is jointly used by the Laboratory and Los Alamos County. At present, decisions are in flux about whether a new facility would be jointly used or for Laboratory use only.

Fire Protection Line Improvements, Laboratory-wide. The water supply lines for fire protection to all facilities should be in a loop configuration so that the water can be supplied from either direction in case of fire. Some facilities have a single supply line, and the sprinkler systems inside some buildings do not meet current standards. The proposed action would install new supply lines and upgrade the sprinkler systems in some buildings. The alternative action is not to put in the needed lines or sprinklers. Environmental issues include consideration of the terrain through which the supply lines might be run, areas that may contain cultural resources, habitat suitable for threatened and endangered species, and floodplains and wetlands.

C. Other Significant Environmental Activities at Los Alamos

1. Studies to Measure External Radiation.

In addition to the Laboratory's external penetrating radiation monitoring program, described in Section V.B.1., other special studies were conducted during 1993. One study is a continuation of work initiated in 1990 to evaluate Laboratory thermoluminescent dosimeters (TLDs) with TLDs obtained from a commercial contractor.

The study involves placing vendor environmental dosimeters next to Laboratory dosimeters. There are a total of 22 locations where the vendor TLDs are part of the TLD network. The vendor's TLDs are set out and collected following the vendor's placement specifications. No information is provided to the vendor regarding the TLD locations and possible environmental radiation fields. The TLDs provided to LANL are analyzed and processed by the commercial vendor following established TLD analytical procedures. The analytical results are later provided to LANL.

In previous surveillance reports, the Laboratory's TLD results were graphically compared with contract vendor's TLD results. The assumption being that if the response of the Lab TLDs was within the range of the values reasonably expected by a co-located TLD, then the two TLD programs were assumed to produce similar results. To more definitively compare the data, starting with this report, that graph has been omitted and the comparison of the program results was made by using a paired t-test, which is very sensitive to systematic differences in sample sets. To ensure that the full power of the paired t-test is utilized, the total 1993 TLD results from each program that were spatially and temporally comparable were used for the statistical test.

Another special TLD study was continued during 1993. The study was conducted during the LAMPF run cycle in an attempt to monitor the LAMPF plume. LANL has been testing a new type of highly sensitive dosimeter. The test TLDs are composed of Al_2O_3 and are located next to the regular TLDs at the Laboratory boundary north of LAMPF (Figure V-1). Preliminary results indicate that these new dosimeters are nearly 30 times more sensitive than the presently used LiF type. This TLD study is ongoing. Study results will continue to be reported as data are analyzed and compiled.

2. Tritium in Precipitation near Los Alamos. (Andrew Adams, CST-7 and Fraser Goff, EES-1)

In February 1990, the Geology and Geochemistry Group (EES-1) commenced a study to determine the background levels of tritium in precipitation near Los Alamos (Adams 1991). This study is one of the framework studies that supports the ER program at Los Alamos.

Figure IV-1 shows the weighted mean of all the 1993 samples. The station locations, elevations, and the calculated mean tritium values (shown in small boxes) are depicted on the figure. The wind roses in the upper corners represent the average wind directions for 1992 (EPG 1994). The wind rose on the left represents the daytime winds; the wind rose on the right represents the night winds. The tritium values are expressed in Tritium Units (TUs); each TU is equal to approximately 3.2 pCi/kg of water.

From examination of the tritium data of this study plus cold spring and creek data from other studies in the Jemez Mountains, it appears that any rainwater with greater than 20 TU must be contaminated to some degree by Laboratory activities (Vuataz 1986, Meeker 1990, Goff 1993). Assuming that the maximum value of background tritium in precipitation is 20 TU, then we have drawn a 20 TU contour through the data points for each sampling period. The exact position of the contour is approximate, but the results are clear; activities at LANL release tritium into the atmosphere. However, over the four month time periods represented by these samples, the average release is almost two orders of magnitude below EPA limits set for tritium in drinking water (about 6,200 TU).

There are three mechanisms that produce tritium in the rain observed in the Los Alamos region. First, there is a natural background level of tritium that is produced by cosmic rays bombarding water vapor in the atmosphere. This background level depends on several factors including latitude, season, and distance from the ocean. For the intercontinental US, this natural background, which was present before the era of nuclear weapons testing, is about 6 TU.

Second, there is a man-made tritium input to the atmosphere from aboveground nuclear testing, which ceased in 1963. The maximum mean tritium level in rain in the southwestern US was about 2,800 TU in 1963 (Vuataz 1986) but has decreased to about 11 TU in 1991 (Shevenell, in press).

Third, there is an additional man-made tritium input to rain within the Los Alamos region caused by activities at LANL. It is the third mechanism that is believed to produce the tritium anomalies centered over Los Alamos, which is depicted in Figure IV-1. The low-level tritium analyses performed on rain can detect very small amounts of released tritium. The magnitude of these concentrations is generally two orders of magnitude below EPA limits for tritium in drinking water.

3. Meteorological Monitoring. (Doug ReVelle, ESH-17)

During 1993, meteorological data were gathered at Los Alamos at four meteorological tower stations on the Pajarito Plateau (TA-6 [the Laboratory's official weather station], TA-53, TA-54, and TA-49), as shown on Figure IV-2. In late November 1993, a new 23-m (75-ft) tower site, similar in overall features to the other towers, became operational at TA-41 in Los Alamos Canyon about 100 m (328 ft) below the plateau. Because only one month of useful data was obtained in 1993, the implications of this new and unique data set will be discussed in future environmental surveillance reports.

Conditions such as temperature, precipitation, fluxes of momentum, pressure, moisture, relative humidity, etc., are routinely monitored at the towers about 1.5 m (5 ft) above the ground. Temperature, as well as the three-dimensional wind fields (speed, direction, turbulence properties, etc.) are recorded from 11 to 92 m (38 to 302 ft) aloft. In addition, a Doppler acoustical sodar continuously monitors the three dimensional winds and turbulence properties from 60 m (197 ft) to elevations up to 720 m (2,362 ft) in 30 m (98 ft) intervals. Short-term maximum gust strengths and associated directions are also logged. All data are stored as mean values over 15 min intervals and archived in the LANL CFS computerized database. A tabular summary of the observed variables that are monitored at TA-6 and at the other tower sites is presented in Tables D-8 and D-9.

Weather Highlights. An overall summary of the climatic conditions at Los Alamos, including the observed ranges of the mean temperature and of the mean precipitation based on over 80 years of data is presented in Tables II-1 and II-2.

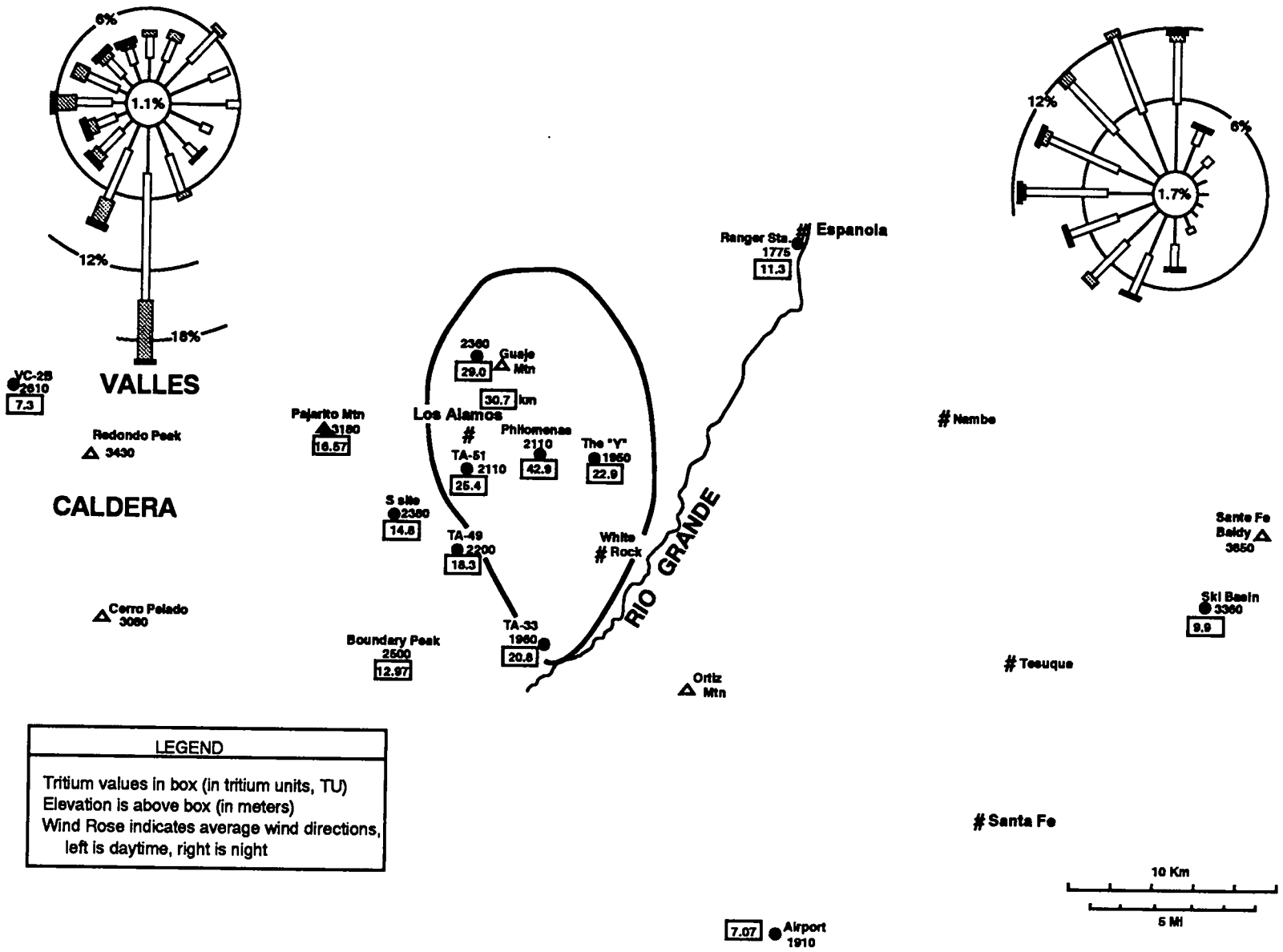


Figure IV-1. Weighted mean tritium values for precipitation in the Los Alamos region for 1993.

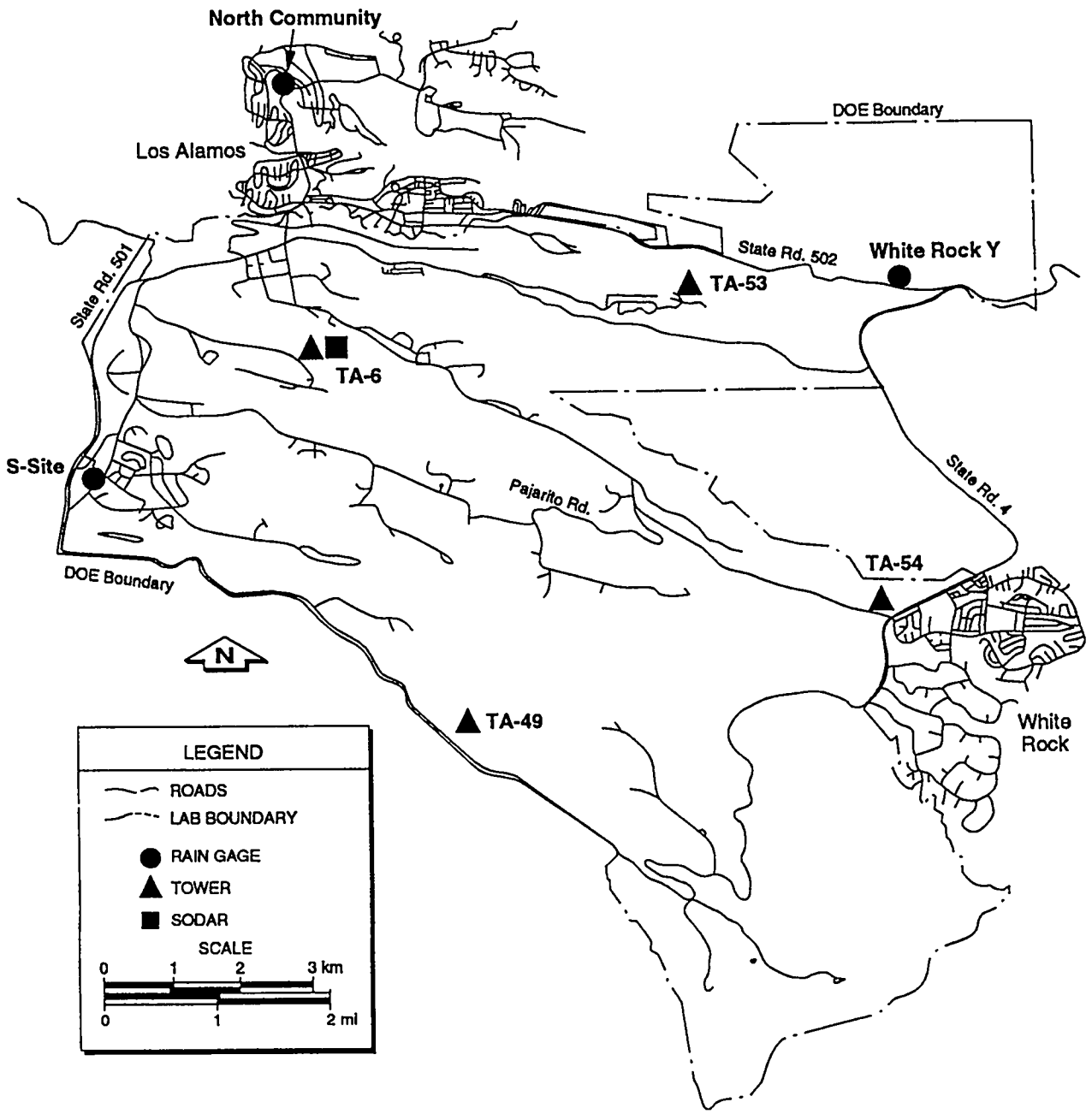


Figure IV-2. Off-site perimeter and on-site Laboratory meteorological monitoring locations.

The 1993 monthly mean temperatures at TA-6 are presented in Figure IV-3. The months of January, March, May through June, and September through December experienced significantly colder than average temperatures. Significantly warmer than average temperatures were recorded only in March through April and June. Figure IV-3 shows that 1993 was a wetter than average year with 53 cm (20.6 in.) total precipitation as compared to the average of 48 cm (18.7 in.) Snowfall amounts in January (84.6 cm [33.0 in.]) measured almost 3 times the average value of 31.3 cm (12.2 in.). March and December had significantly low snowfall amounts with the March deficit being more than a factor of two and the December deficit being more than a factor of four below the expected value.

Surprisingly, the strongest (61 mi/h) near-surface wind gust was recorded on December 12, 1993, at TA-6. The gust occurred during a storm that dropped 5 cm (2 in.) of snow. The next strongest (52 mi/h) gust was recorded in April, as might be expected.

Wind Roses. Mean wind data from 1993 for all the towers on the Pajarito Plateau are presented in Figures IV-4 and IV-5. These figures show the observed wind speeds and associated directions presented in the form of wind roses for each of the LANL meteorology towers (at 11.5 m [38 ft]) on the Pajarito Plateau. Both daytime and nighttime data are averaged over the year. In these figures, the length of each directional segment is proportional to the percentage of time that the wind came from the indicated direction; circles for 6% and 12% are included for reference. Each segment is further subdivided into speed categories that denote the percentage of time that the wind blew from the specified direction and maintained the indicated mean speed.

As can be seen in the figures, the winds at all the towers are stronger during the day than they are at night. Typically, daytime winds in Los Alamos have a strong southerly component. At night, the Pajarito Plateau drainage winds (downslope flow) are clearly evident because a weaker westerly component is typically observed. There is also distinct evidence for drainage flow effects from the Rio Grande Valley at TA-54 and TA-53, i.e., downslope flow at night from the north and east for approximately 5% to 6% of the observing time. During 1993, calm winds occurred 1% to 2% of the time at all the towers.

The sound, distance, and ranging (SODAR) data, available only at TA-6, is also presented on the wind roses in Figures IV-4 and IV-5. These upper level (510 m [1,673 ft]) winds are generally indicative of the undisturbed, prevailing synoptic scale flow. As can be seen, the winds aloft are generally much stronger than the near-surface level winds and are consistently from the southwest quadrant. In addition, the winds aloft tended to be stronger at night than they were during the day during 1993, a sharp contrast to wind patterns observed during 1992.

Evapotranspiration Measurements Summary. Additional measurements of evapotranspiration are now routinely taken at TA-6 as part of the overall surface energy budget monitoring program. Monthly mean summary results for 1992 and 1993 are presented in Figure IV-6. The evapotranspiration rate is basically a measure of the amount of water vapor evaporated from (or condensed onto) the ground, combined with the amount of water vapor transpired directly by the local vegetation and animal life during a given time interval. The evapotranspiration rate is very difficult to predict because of uncertainties in detailed modeling of plant properties; however, it is an integral determinant of the energy budget of the surface layer of the atmosphere.

As observed at TA-6, the monthly mean values of the observed magnitude of the evapotranspiration (the latent heat flux divided by the latent heat/mass of water for a phase change from gas to liquid) did not change significantly over almost two years of continuous records that are currently available (Figure IV-6). The summertime peaks, in excess of 5.8 cm (2.25 in.) during both years, are indicative of the fact that in semiarid climates the evapotranspiration rate (through the latent heat flux) is directly proportional to the observed amount of the total incoming solar radiation. We will continue to carefully monitor this quantity in future years, partly because it is of direct significance to the LANL hydrologists and partly because it is an integral part of an evaluation of the surface energy budget of the boundary layer.

4. Environmental Monitoring at the Fenton Hill Site. (Bruce Gallaher, Alan Stoker, Max Maes, and William Purtymun, ESH-18).

The Laboratory operates a program to evaluate the feasibility of extracting thermal energy from the hot dry rock geothermal reservoir at the Fenton Hill Geothermal Site (TA-57), which is located about 45 km (28 mi) west of Los Alamos on the southern edge of the Valles Caldera. The hot dry rock energy concept involves drilling two deep holes, connecting these holes by hydraulic fracturing, and bringing geothermal energy to the surface by circulating

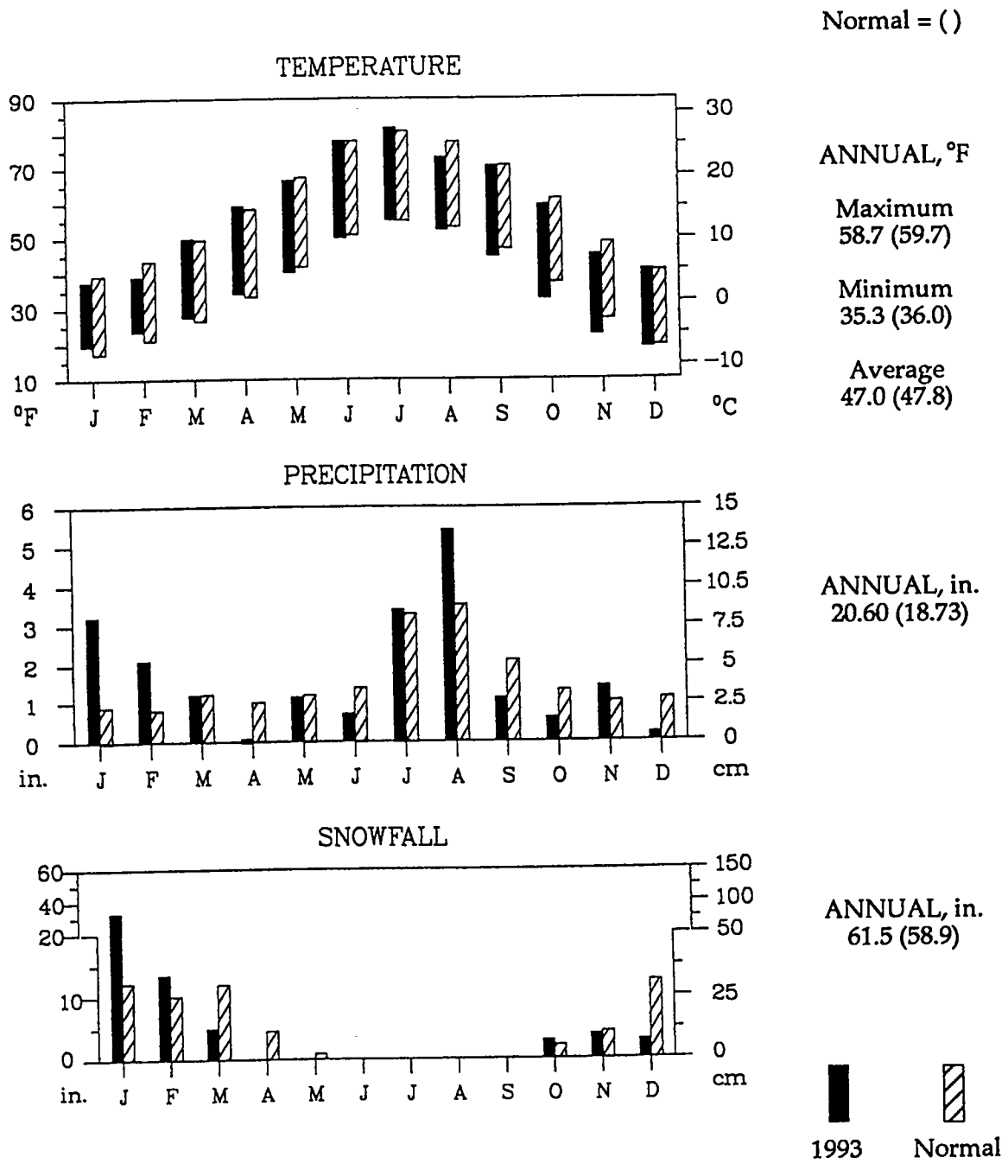


Figure IV-3. Temperature and precipitation for 1993.

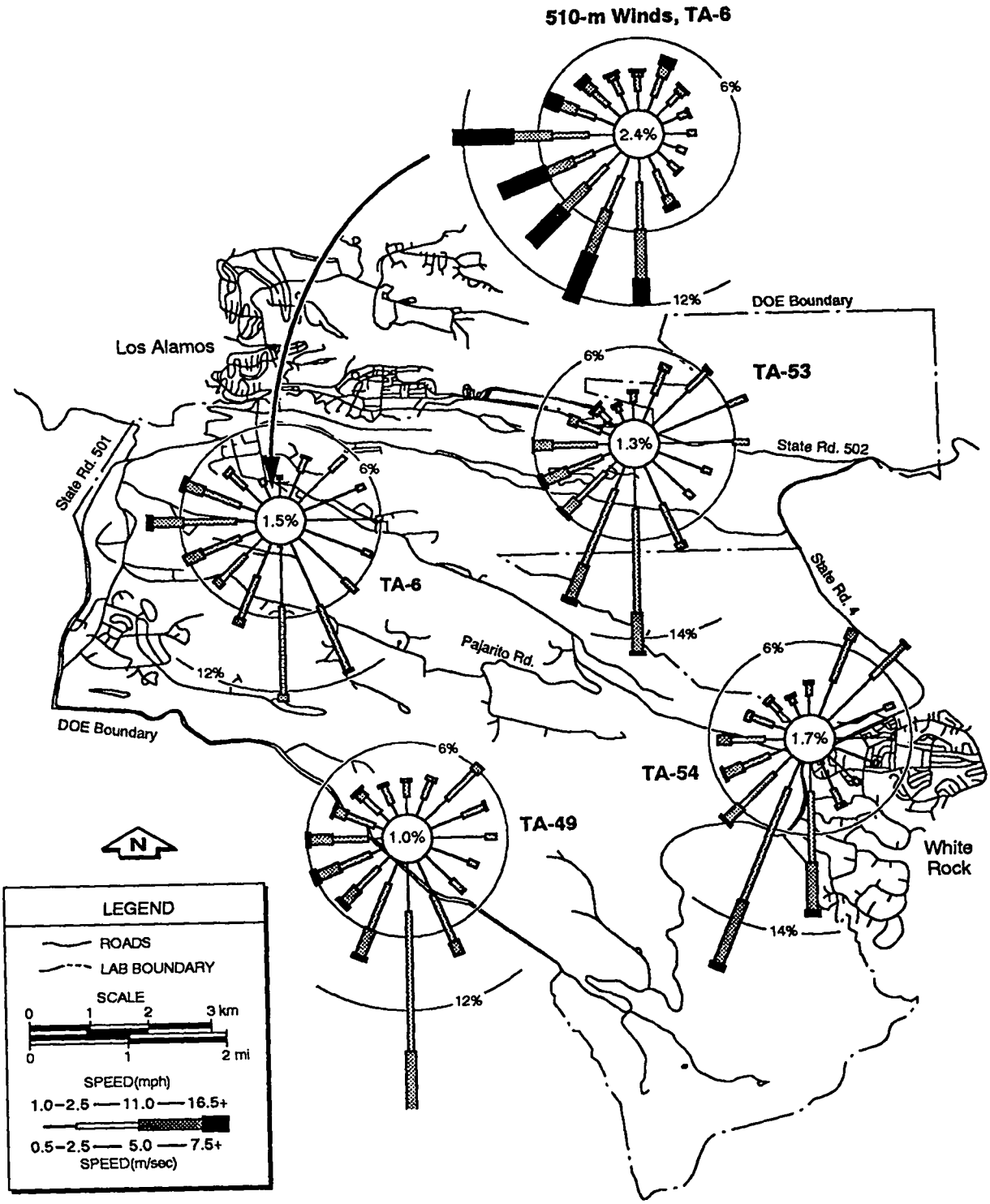


Figure IV-4. Wind roses for daytime winds observed at 11 m (36 ft) above the ground at the four towers. The rose at the top of the figure is for winds at 510 m (1,673 ft) above the ground (from SODAR measurements), for comparison.

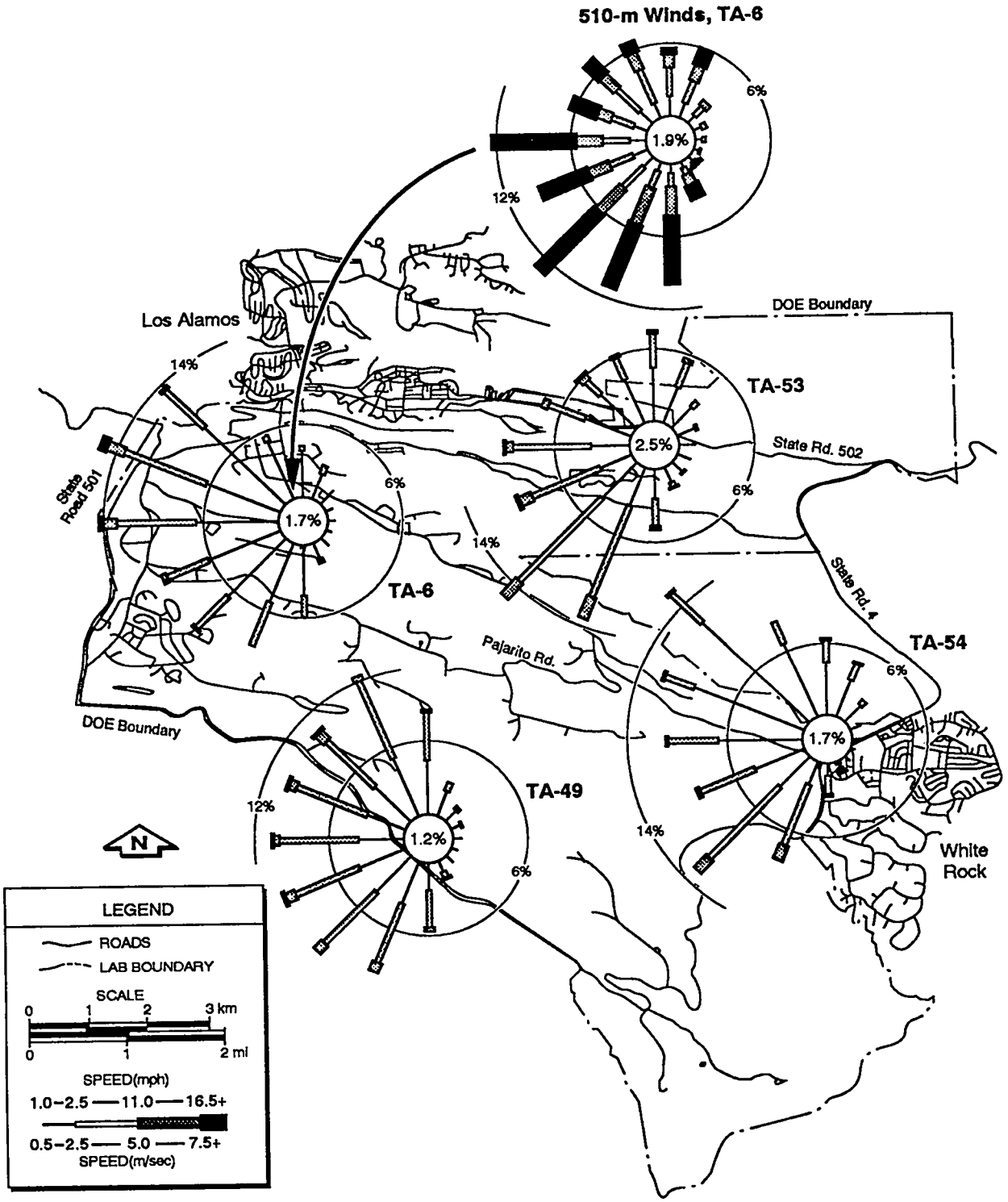


Figure IV-5. Wind roses for nighttime winds observed at 11 m (36 ft) above the ground at the four towers. The rose at the top of the figure is for winds at 510 m (1,673 ft) above the ground (from SODAR measurements), for comparison.

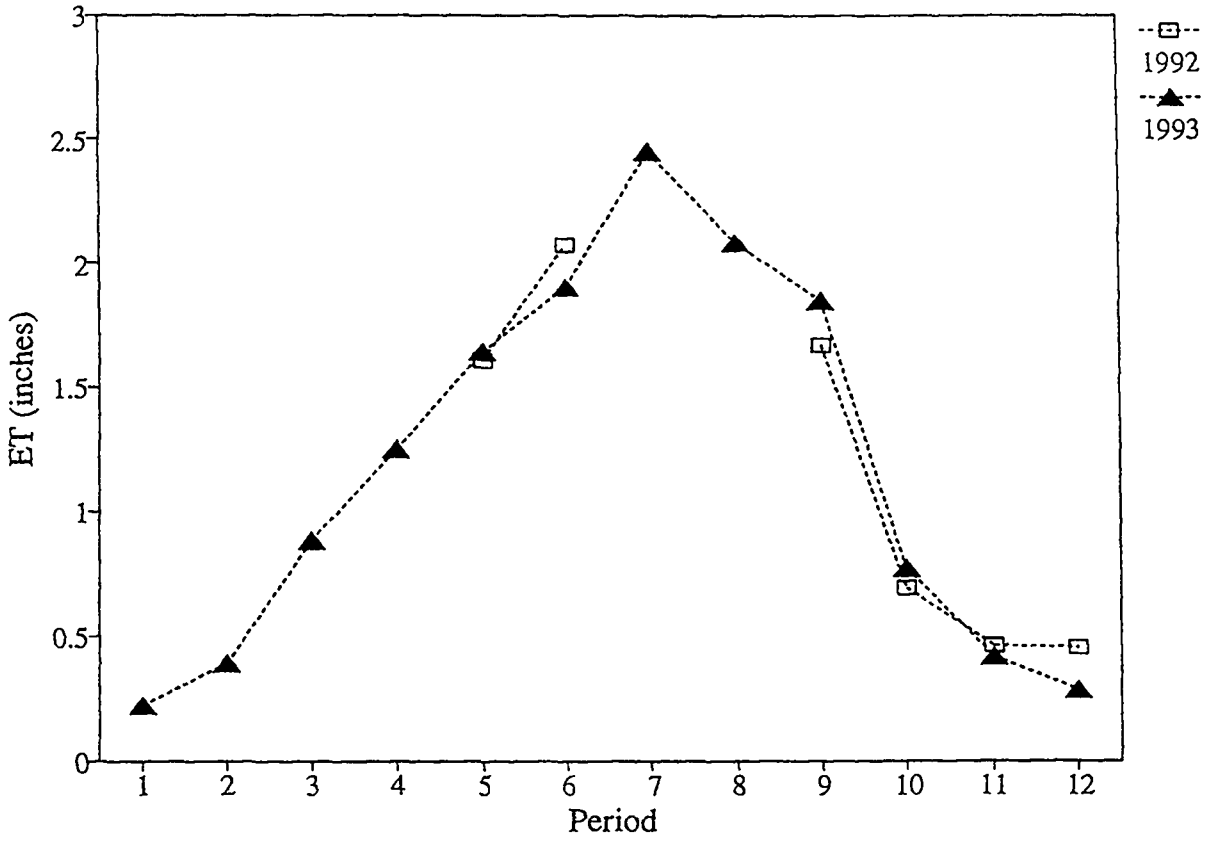


Figure IV-6. Monthly evaporation totals (inches).

Note: The units indicated are in. of water/month evaporated by the soil and by the associated vegetation throughout the year.

water through the system. Environmental monitoring is performed adjacent to the site to assess any impacts from the geothermal operations.

The chemical quality of surface water and groundwaters in the vicinity of TA-57 (Figure IV-7) has been monitored for use in geohydrologic and environmental studies. These water quality studies began before the construction and testing of the hot dry rock project (Purtymun 1974d).

Water samples from Fenton Hill have routinely been collected during periods of base flow (low surface water discharge) in late November or early December. In 1993 the samples were collected on November 1, 1993.

The results of the general chemical analyses are presented in Tables IV-3 and IV-4, and the results of trace metal analyses are presented in Tables IV-5 and IV-6. Radiological analyses, which are more extensive than routinely performed, are presented in Tables IV-7 and IV-8.

The chemical quality of surface waters and groundwaters among the individual stations varied slightly from data collected during previous years; however, these variations are within typical seasonal fluctuations observed in the past (Purtymun 1988a). Radiological levels were usually at or below the detection limit. Detectable levels of ^{241}Am were found in groundwater samples from the Jemez Canyon hot spring and from the Cold Springs locations. The levels are less than 1% of the DOE Derived Concentration Guides (DCGs). Americium-241 was detected at levels up to twice the detection limit in surface waters from the Jemez River at Battleship Rock and from Lake Fork.

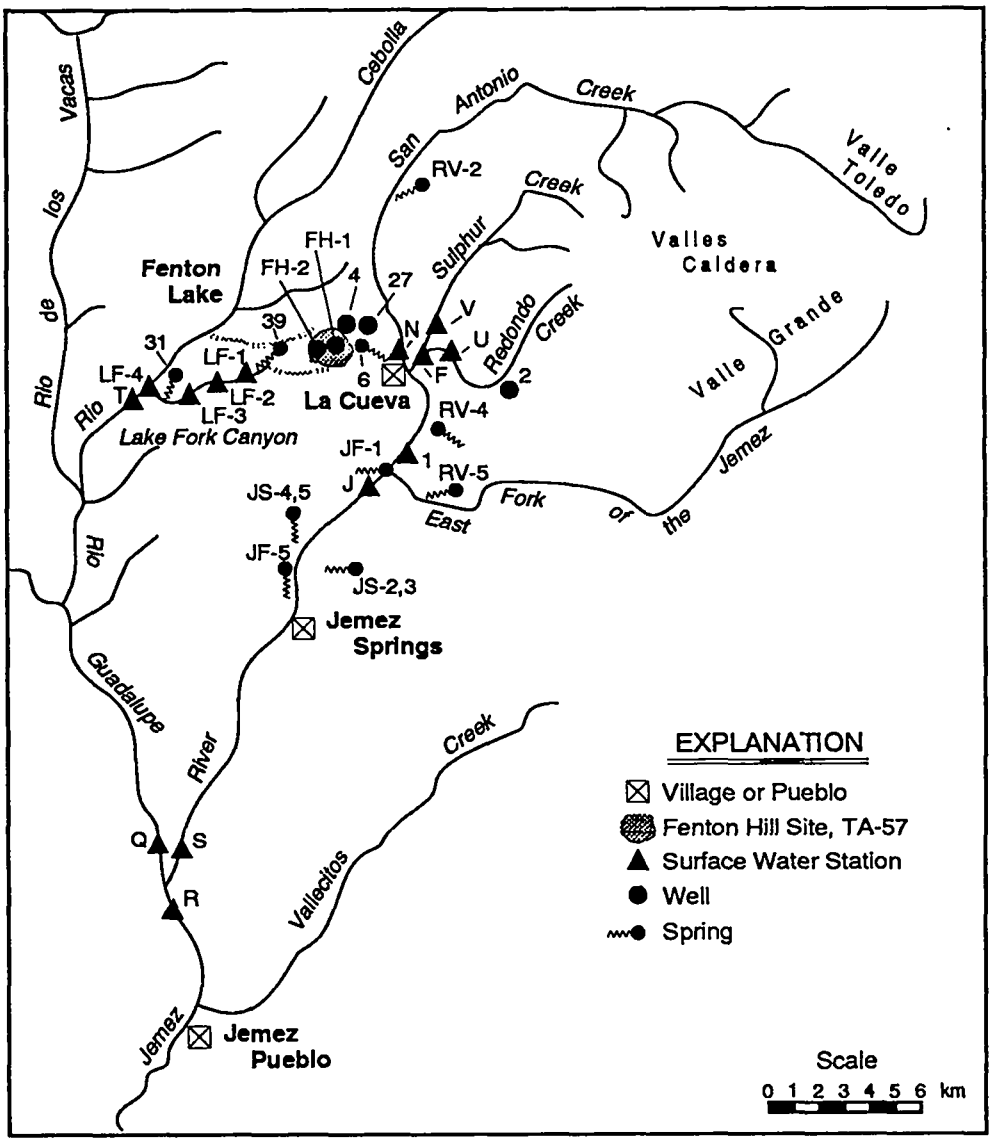


Figure IV-7. Sampling stations for surface water and groundwater near the Fenton Hill Site (TA-57). (Map denotes general locations only.)

There were no significant changes in the chemical quality of surface water and groundwater at the individual stations from previous years (Purtymun 1988a).

5. Environmental Studies at the Pueblo of San Ildefonso. (David Rogers, Stephen McLin, Max Maes, ESH-18, and Bill White [Bureau of Indian Affairs])

To document the potential impact of Laboratory operations on lands belonging to the Pueblo of San Ildefonso, DOE entered into a memorandum of understanding (MOU) with the Pueblo and the Bureau of Indian Affairs (BIA) to conduct environmental sampling on Pueblo land. The agreement, entitled "Memorandum of Understanding Among the Bureau of Indian Affairs, the Department of Energy, and the Pueblo of San Ildefonso Regarding Testing

Table IV-3. Chemical Quality of Groundwater near Fenton Hill for 1993 (mg/L)

Location		SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
JS-4,5	Jemez Village Spring Forest Service Office	78	32	5.1	4	46	20	1.0	<5[c]	161	0.0	11	0.19	<0.01	344	100	8.3	398
FH-1	Fenton Hill (Well)	78	73	7.8	6	24	47	<0.1	<5	201	<0.0	9	9.70	N/A[d]	394	239	7.8	622
JF-1	Jemez Canyon Hot Spring: Limestone Spring	47	280	23.0	71	1,900	825	1.3	<5	668	0.1	30	0.19	<0.01	2,200	790	7.3	3,670
JF-5	Jemez Canyon Hot Spring: Soda Dam	46	410	28.0	230	1,900	1,400	1.6	<5	1,190	0.0	32	0.09	<0.01	4,010	1,100	6.9	6,490
(4)	La Cueva Spring: Hofhein's House	82	12	2.5	2	16	5	0.2	<5	60	0.1	5	0.29	<0.01	192	40	8.0	151
(6)	La Cueva Spring: Little Shed	71	25	7.0	3	16	4	0.4	<5	92	0.3	6	0.07	<0.01	186	90	7.4	205
(RV-4)	Spence Hot Spring	65	12	3.4	3	92	8	0.7	<5	112	0.0	14	<0.04	<0.01	242	44	8.6	264
(31)	Cold Spring Lake Fork Canyon	51	25	3.8	6	15	6	1.0	<5	64	0.0	5	0.15	<0.01	164	77	7.6	158
(39)	Lake Fork Tank (Spring)	25	19	3.6	2	7	8	<0.1	<5	46	<0.0	14	0.12	<0.01	136	62	7.1	160
EPA Primary Drinking Water Standard								4					10	0.2				
EPA Secondary Drinking Water Standard												250			500		6.8-8.5	
EPA Health Advisory						20												
NMWQCC Groundwater Limit							250	1.6					10					

[a]Total dissolved solids.

[b]Standard Units.

[c]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

[d]N/A means analysis not performed, lost in analysis, or not completed.

Table IV-4. Chemical Quality of Surface Water near Fenton Hill for 1993 (mg/L)

Location		SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
J	Jemez River at Battleship Rock	52	14	2.8	3	15	5	0.9	< 5	67	0.0	12	0.18	<0.01	170	46	8.1	165
N	San Antonio Creek	55	14	2.1	3	14	4	1.1	< 5	56	0.1	10	<0.04	<0.01	716	43	7.7	144
Q	Rio Guadalupe	27	56	6.1	2	13	7	0.5	< 5	168	< 0.0	8	<0.04	<0.01	240	160	8.3	331
S	Jemez River above Rio Guadalupe	51	48	5.4	13	73	95	1.0	< 5	166	0.0	15	<0.04	<0.01	458	140	8.6	672
LF-1	Lake Fork 1	30	84	15.0	11	14	9	0.5	< 5	93	4.6	7	0.68	0.07	178	270	6.6	306
LF-2	Lake Fork 2	42	16	2.9	9	35	12	0.4	< 5	29	0.2	47	0.29	<0.01	216	51	6.3	240
LF-3	Lake Fork 3	58	14	2.3	3	13	4	1.0	< 5	64	0.4	5	0.28	<0.01	164	44	7.6	137
LF-4	Lake Fork 4	48	18	3.0	4	14	6	1.0	< 5	68	0.0	7	0.07	<0.01	176	57	7.3	168
EPA Primary Drinking Water Standard								4					10	0.2				
EPA Secondary Drinking Water Standard												250			500		6.8-8.5	
EPA Health Advisory						20												

[a]Total dissolved solids.
[b]Standard Units.

Table IV-5. Total Recoverable Trace Metals in Groundwater near Fenton Hill for 1993 (mg/L)

Location		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
JS-4,5	Jemez Village Spring Forest Service Office	<0.010 [a]	<0.20	0.028	0.170	0.038	<0.001	<0.003	<0.004	<0.004	0.006	<0.10	<0.0002
FH-1	Fenton Hill (Well)	<0.010	<0.10	<0.002	0.620	0.026	<0.001	<0.003	<0.004	<0.004	0.007	0.13	<0.0002
JF-1	Jemez Canyon Hot Spring Limestone Spring	<0.010	1.30	0.032	4.800	0.300	0.004	<0.003	<0.004	<0.004	<0.004	10.00	<0.0002
JF-5	Jemez Canyon Hot Spring Soda Dam	0.011	<0.20	1.500	10.000	0.450	0.005	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
(4)	La Cueva Spring Hofhein's House	<0.010	<0.20	<0.002	0.011	0.028	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
(6)	La Cueva Spring Little Shed	<0.010	0.57	0.006	0.017	0.098	<0.001	<0.003	<0.004	0.012	0.008	4.30	<0.0002
(RV-4)	Spence Hot Spring	<0.010	<0.20	0.125	0.170	0.004	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
(31)	Cold Spring Lake Fork Canyon	<0.010	6.70	0.003	0.036	0.083	0.005	<0.003	<0.004	<0.004	<0.004	6.30	<0.0002
(39)	Lake Fork Tank (Spring)	<0.010	<0.20	<0.002	0.015	0.027	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
EPA Primary Drinking Water Standard		0.05		0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard												0.3	
EPA Action Level											1.3		
Livestock Wildlife Watering Limit			5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01
NMWQCC Groundwater Limit		0.05		0.1		1.0		0.01		0.05			0.002

*Data on additional trace metals in groundwater near Fenton Hill is presented on page IV-22.

Table IV-5. (Cont.)

Location		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
JS-4,5	Jemez Village Spring Forest Service Office	<0.002	0.027	<0.02	<0.0010	0.001	<0.002	<0.03	0.180	<0.0010	<0.00	<0.02
FH-1	Fenton Hill (Well)	<0.002	<0.008	<0.02	0.0021	<0.002	<0.002	<0.03	0.270	0.0014	0.01	1.80
JF-1	Jemez Canyon Hot Spring Limestone Spring	0.840	<0.020	<0.02	<0.0010	<0.001	0.004	<0.03	1.600	<0.0010	0.01	<0.02
JF-5	Jemez Canyon Hot Spring Soda Dam	0.600	<0.020	<0.02	<0.0010	<0.001	0.005	<0.03	1.600	<0.0010	<0.00	<0.02
(4)	La Cueva Spring Hofhein's House	<0.002	<0.020	<0.02	<0.0010	<0.001	<0.002	<0.03	0.057	<0.0010	<0.00	<0.02
(6)	La Cueva Spring Little Shed	0.110	<0.020	<0.02	0.0015	<0.001	<0.002	<0.03	0.110	<0.0010	0.01	<0.02
(RV-4)	Spence Hot Spring	<0.002	0.110	<0.02	<0.0010	<0.001	<0.002	<0.03	0.054	<0.0010	<0.00	<0.02
(31)	Cold Spring Lake Fork Canyon	0.490	<0.020	<0.02	0.0045	<0.001	<0.002	<0.03	0.120	<0.0010	<0.00	<0.02
(39)	Lake Fork Tank (Spring)	<0.002	<0.020	<0.02	<0.0010	<0.001	<0.002	<0.03	0.100	<0.0010	<0.00	<0.02
EPA Primary Drinking Water Standard				0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard		0.05										5.0
EPA Action Level					0.015							
EPA Health Advisory									25-90		0.08-0.11	
Livestock Wildlife Watering Limit					0.1						0.1	25.0
NMWQCC Groundwater Limit					0.05		0.05					

[a]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Table IV-6. Total Recoverable Trace Metals in Surface Water near Fenton Hill for 1993 (mg/L)

Location		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
(J)	Jemez River at Battleship Rock	<0.01 [a]	0.90	0.006	0.023	0.029	<0.001	<0.003	<0.004	<0.004	<0.004	0.60	<0.0002
(N)	San Antonio Creek	<0.01	0.45	0.002	0.014	0.036	<0.001	<0.003	<0.004	<0.004	<0.004	0.43	<0.0002
(Q)	Rio Guadalupe	<0.01	<0.20	<0.002	0.035	0.100	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
(S)	Jemez River above Rio Guadalupe	<0.01	0.72	0.110	0.620	0.069	<0.001	<0.003	<0.004	<0.004	<0.004	0.44	<0.0002
(LF-1)	Lake Fork 1	<0.01	52.00	0.011	0.041	1.900	0.017	0.016	0.021	0.018	<0.004	150.00	0.0002
(LF-2)	Lake Fork 2	<0.01	0.21	<0.002	0.028	0.050	<0.001	0.026	<0.004	0.094	0.022	1.00	<0.0002
(LF-3)	Lake Fork 3	<0.01	1.10	<0.002	0.013	0.015	<0.001	<0.003	<0.004	<0.004	<0.004	0.82	<0.0002
(LF-4)	Lake Fork 4	<0.01	0.68	<0.002	0.016	0.033	<0.001	<0.003	<0.004	<0.004	<0.004	0.93	<0.0002
EPA Primary Drinking Water Standard		0.05		0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard												0.3	
EPA Action Level											1.3		
Livestock Wildlife Watering Limit			5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01

*Data on additional trace metals in surface water near Fenton Hill is presented on page IV-24.

Table IV-6. (Cont.)

Location		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
(J)	Jemez River at Battleship Rock	0.036	<0.02	<0.020	<0.001	<0.001	<0.002	<0.03	0.066	<0.001	<0.00	<0.02
(N)	San Antonio Creek	0.035	<0.02	<0.020	<0.001	<0.001	<0.002	<0.03	0.060	<0.001	<0.00	<0.02
(Q)	Rio Guadalupe	<0.002	<0.02	<0.020	<0.001	<0.001	<0.002	<0.03	0.200	<0.001	<0.00	<0.02
(S)	Jemez River above Rio Guadalupe	0.028	<0.02	<0.020	<0.001	<0.001	<0.002	<0.03	0.180	<0.001	<0.00	<0.02
(LF-1)	Lake Fork 1	3.100	<0.02	0.044	0.099	0.006	0.002	<0.03	0.460	<0.001	0.09	<0.02
(LF-2)	Lake Fork 2	1.100	<0.02	0.036	0.004	<0.001	<0.002	<0.03	0.073	<0.001	<0.00	<0.02
(LF-3)	Lake Fork 3	0.068	<0.02	<0.020	<0.001	<0.001	<0.002	<0.03	0.065	<0.001	<0.00	<0.02
(LF-4)	Lake Fork 4	0.066	<0.02	<0.020	<0.001	<0.001	<0.002	<0.03	0.092	<0.001	<0.00	<0.02
EPA Primary Drinking Water Standard				0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard		0.05										5.0
EPA Action Level					0.015							
EPA Health Advisory									25-90		0.08-0.11	
Livestock Wildlife Watering Limit					0.1						0.1	25.0

[a]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Table IV-7. Radiochemical Analysis of Groundwater near Fenton Hill for 1993

Location		^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA[a] (µg/L)	Total Uranium ICPES[b] (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)
JS-4,5	Jemez Village Spring Forest Service Office	0.2 (0.3)[c]	-0.2 (0.7)	1.1 (0.9)	0.3 (0.0)	N/A[d]	0.006 (0.030)	0.008 (0.020)	0.024 (0.030)	1 (1)	1 (0)	700 (100)
FH-1	Fenton Hill (Well)	-0.1 (0.3)	-1.6 (1.1)	2.38 (1.2)	N/A	5.0 (1.0)	-0.007 (0.007)	0.036 (0.016)	N/A	-3 (2)	6 (1)	50 (100)
JF-1	Jemez Canyon Hot Spring Limestone Spring	0.1 (0.3)	0.3 (0.7)	0.4 (0.9)	2.5 (0.3)	N/A	0.030 (0.030)	0.023 (0.020)	0.066 (0.030)	0 (1)	83 (8)	200 (90)
JF-5	Jemez Canyon Hot Spring Soda Dam	0.1 (0.3)	0.4 (0.7)	-0.8 (0.4)	0.6 (0.1)	N/A	-0.002 (0.030)	0.014 (0.020)	0.001 (0.030)	-6 (1)	450 (50)	1500 (200)
(4)	La Cueva Spring Hofhein's House	0.3 (0.3)	0.1 (0.7)	0.6 (1.2)	0.3 (0.0)	N/A	-0.003 (0.030)	0.006 (0.020)	0.038 (0.030)	1 (0)	3 (0)	1500 (200)
(6)	La Cueva Spring (Little Shed)	0.2 (0.3)	0.2 (0.7)	-0.9 (1.0)	0.9 (0.1)	N/A	0.016 (0.030)	0.005 (0.020)	0.040 (0.030)	2 (0)	5 (1)	-10 (90)
(RV-4)	Spence Hot Spring	0.1 (0.3)	-0.2 (0.7)	-1.1 (0.9)	0.3 (0.0)	N/A	0.009 (0.030)	0.003 (0.020)	0.017 (0.030)	1 (0)	2 (0)	2100 (200)
(31)	Cold Spring Lake Fork Canyon	0.1 (0.3)	0.8 (0.7)	-0.6 (0.6)	6.0 (0.6)	N/A	0.037 (0.030)	0.014 (0.020)	0.065 (0.030)	7 (1)	10 (1)	0 (90)
(39)	Lake Fork Tank (Spring)	0.4 (0.3)	0.8 (0.8)	-1.0 (0.3)	1.3 (0.2)	N/A	0.001 (0.030)	0.015 (0.020)	0.010 (0.030)	1 (0)	3 (0)	N/A
Limits of Detection		0.4	3	2	0.1	1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose		2,000	1,000	3,000	800	800	40	60	30			
DOE Drinking Water System DCG			120			1.6	1.2	1.2				
EPA Primary Drinking Water Standard		20	8		20	20				15	50	
EPA Screening Level NMWQCC Groundwater Limit				5,000	5,000							

[a]KPA = kinetic phosphorimetric analysis.

[b]ICPES = inductively coupled plasma emission spectrometry.

[c]Radioactivity counting uncertainties (±1 Standard Deviation) are shown in parentheses.

[d]N/A means analysis not performed, lost in analysis, or not completed.

Table IV-8. Radiochemical Analysis of Surface Water Near Fenton Hill for 1993

Location		^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA[a] (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)
(J)	Jemez River at Battleship Rock	0.6 (0.3)[b]	0.8 (0.7)	-0.8 (0.5)	0.2 (0.0)	0.010 (0.03)	0.024 (0.02)	0.040 (0.03)	1 (0)	2 (0)	1100 (100)
(N)	San Antonio Creek	0.5 (0.3)	0.3 (0.5)	-0.1 (1.1)	0.4 (0.0)	0.002 (0.03)	0.025 (0.02)	0.013 (0.03)	0 (0)	1 (0)	1000 (100)
(Q)	Rio Guadalupe	0.4 (0.3)	-0.2 (0.9)	0.8 (1.0)	4.4 (0.7)	0.008 (0.03)	0.029 (0.02)	0.010 (0.03)	5 (1)	3 (0)	260 (90)
(S)	Jemez River above Rio Guadalupe	0.2 (0.3)	-0.3 (0.8)	0.6 (1.0)	0.6 (0.1)	0.019 (0.03)	0.028 (0.02)	0.016 (0.03)	8 (2)	12 (1)	800 (100)
(LF-1)	Lake Fork 1	0.6 (0.3)	2.9 (0.9)	-0.5 (0.4)	N/A[c]	-0.002 (0.03)	0.012 (0.02)	0.069 (0.03)	-90 (20)	52 (5)	900 (100)
(LF-2)	Lake Fork 2	0.1 (0.3)	0.7 (0.8)	-0.3 (1.0)	0.9 (0.1)	0.003 (0.03)	0.008 (0.02)	0.043 (0.03)	0 (0)	10 (1)	190 (90)
(LF-3)	Lake Fork 3	0.1 (0.3)	0.3 (0.8)	0.3 (1.2)	0.1 (0.0)	0.020 (0.03)	0.012 (0.02)	0.025 (0.03)	1 (0)	3 (0)	-90 (90)
(LF-4)	Lake Fork 4	0.2 (0.3)	0.8 (0.8)	-0.4 (0.9)	0.8 (0.1)	-0.005 (0.03)	0.013 (0.02)	0.026 (0.03)	2 (0)	4 (1)	80 (90)
Limits of Detection		0.4	3	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose		2000	1000	3000	800	40	60	30			
DOE Drinking Water System DCG				120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard		20	8		20				15		
EPA Screening Level										50	

[a]KPA = kinetic phosphorimetric analysis.

[b]Counting uncertainties (±1 Standard Deviation) are shown in parentheses.

[c]N/A means analysis not performed, lost in analysis, or not completed.

for Radioactive and Chemical Contamination of Lands and Natural Resources Belonging to the Pueblo of San Ildefonso," No. DE-GM32-87AL37160, was concluded in June 1987. The agreement calls for both hydrologic pathway sampling (including water, soils, and sediments) and foodstuff sampling. This section deals with the hydrologic pathway. The foodstuff sampling results are presented in Section V.B.7 of this report. From 1987 to 1993, water, soil, and sediment samples were collected in accord with the agreement (Purtymun 1988b, ESG 1989, EPG 1990, EPG 1992, EPG 1993, EPG 1994). Additional information relating to groundwater age dating and trace-level tritium sampling results are presented in Sections VII.E.1.b and c of this report.

The Los Alamos Well Field, located on Pueblo of San Ildefonso lands east of the Laboratory in Los Alamos Canyon, is no longer used as the Los Alamos water supply. The last production of water from the Los Alamos Well Field was in September 1991. Three of the wells (Figure IV-8) have been turned over to the Pueblo of San Ildefonso: LA-1B (to be used cooperatively with the BIA as a long-term monitoring well), LA-2 (possible production well), and LA-5 (refitted with a smaller diameter casing and equipped with a pump to supply water to the houses at Totavi). The other wells in the field (LA-1, LA-3, LA-4, and LA-6 [these wells are not shown on Figure IV-8]) were plugged in 1993 in accordance with NM State Engineer Office regulations. Another well, LA-1A (also known as GT-1) is also used as an observation well. LA-1A was drilled in March 1946, to a depth of 122 m (400 ft), to evaluate water production potential for what became the Los Alamos Well Field (Purtymun 1995).

In 1993 special water samples were collected from 18 groundwater wells on Pueblo of San Ildefonso lands (Figure IV-8). Samples were collected by Laboratory personnel in the company of personnel from the San Ildefonso Pueblo Governor's Office and the BIA, on May 11 and 18. On May 11 water samples were taken from

- the New Community, Eastside Artesian, Don Juan Playhouse, Otowi House, and the Halladay House wells;
- alluvial observation wells BIA #1, BIA #2, and BIA #3;

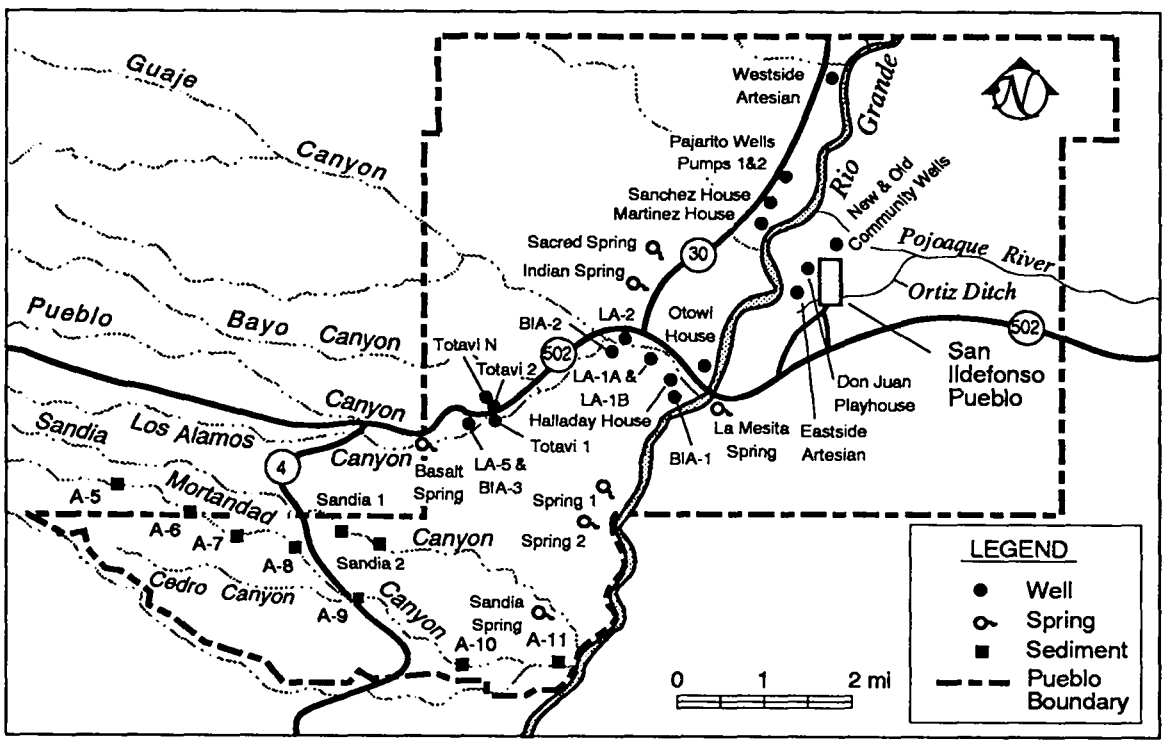


Figure IV-8. Groundwater and sediment stations on Pueblo of San Ildefonso land. (Map denotes general locations only; see Table IV-11 for cross-referencing to specific locations.)

- Los Alamos Well Field wells LA-2, LA-1B, and LA-5; and
- Sacred and Indian Springs.

On May 18 water samples were taken from

- the Westside Artesian, Sanchez House, Martinez House, and Pajarito Pump 2 wells;
- alluvial observation wells Totavi BIA North and Totavi BIA 2; and
- the Los Alamos Well Field well LA-1A.

The Totavi BIA alluvial groundwater monitoring wells were installed by the BIA to investigate leaks in an underground storage tank at the site of an old gasoline station at Totavi.

The BIA alluvial groundwater observation wells were installed to monitor water quality in the alluvium of lower Los Alamos Canyon. Each of the BIA wells is located near one of the three former Los Alamos Well Field wells LA-1B, LA-2, and LA-5. The BIA collected duplicate samples at 12 of these wells, which were analyzed by the BIA's own laboratory for inorganic chemicals and by a contract laboratory for radioactivity.

On May 11, 1993, special sediment samples were collected from five previously sampled locations on Pueblo of San Ildefonso lands in Mortandad Canyon, designated A-6, A-7, A-8, A-9, and A-10 (Figure IV-8). Sediment samples were also collected across a transect of the Mortandad stream channel below the Pueblo of San Ildefonso-Laboratory boundary. This transect is located between sediment sample stations A-7 and A-8 in Figure IV-8 and includes 11 separate locations centered in the ephemeral stream channel. These samples are identified as Station A through Station K in Tables IV-9 and IV-10. At each location a shallow sample was scooped along a line about 1 m (3.3 ft) long. Three additional locations in Sandia Canyon were also sampled for sediments. These locations were in the Sandia Canyon stream channel at the Pueblo of San Ildefonso-Bandelier National Monument boundary and a few hundred yards further east, identified as SSI-1, SSI-3, and SSI-4. An additional sample was also collected in Sandia Canyon at State Route 4. Finally, two sediment samples were also collected from Alexander and Froman Ponds on the Pueblo.

The MOU also specifies collection and analysis of 5 other water samples and 11 other 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 identified in Table IV-11 to permit cross-referencing with other sections of this report.

Groundwater. Radiochemical analyses of the 1993 groundwater samples are shown in Table IV-12. As reported for 1992 (EPG 1994), the major difference from previous results are the ^{137}Cs measurements, which are all much lower than reported before 1992. The ^{137}Cs measurements for 1992 and 1993 were all made using an improved method with a lower detection limit (See Section VIII.C on analytical chemistry methods and quality assurance for details). These results confirmed previous expectations that the levels of ^{137}Cs reported in the 1990 and 1991 surveillance reports (EPG 1992, EPG 1993) were artifacts of the older analytical method, which had a higher detection limit. None of the ^{137}Cs values measured in 1993 exceed the DOE DCG for water supply systems or the proposed EPA maximum contaminant level (MCL); all were less than 3% of the DCG of 120 pCi/L.

In 1992 analyses of several of the samples for plutonium and americium indicated that they contained levels exceeding the average detection limits of the analytical method (EPG 1994.) Those for Pajarito Pump 1, Pajarito Pump 2, Otowi House, Sanchez House, and Martinez House were as much as two to three times the detection limit, and those for the New Community Well and the Halladay House were up to 15 times the detection limit. The sampling or the analytical method were suspected of inaccuracies for two principal reasons: (1) none of the previously sampled locations had shown the presence of these isotopes, (2) results of BIA duplicate samples for 1993 sent to an independent laboratory did not confirm the results. With one exception, the results from the 1993 samples do not show levels much above detection limits (of 0.02 pCi/L) for samples taken at the same locations (all the same wells were sampled in May 1993 except Pajarito Pump 1, which was not operable). On the other hand, a very low amount of ^{238}Pu was detected in the Martinez House well, at twice the detection limit. This value of 0.042 pCi/L is just 3% of the DOE DCG of 1.6 pCi/L. The analytical uncertainty for this value is ±0.03 pCi/L.

Table IV-9. Radioactivity in Sediments on Pueblo of San Ildefonso Lands

Location	^{3}H (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
PERIMETER STATIONS (OFF SITE)										
DP-Los Alamos Canyons										
Los Alamos at Totavi	0.6 (0.3)[a]	0.3 (0.2)	0.4 (0.1)	2.2 (0.2)	0.014 (0.003)	0.200 (0.010)	0.030 (0.004)	3 (1)	3 (0)	8 (1)
Los Alamos at LA-2	0.4 (0.3)	0.0 (0.2)	0.4 (0.1)	1.7 (0.1)	0.025 (0.005)	0.278 (0.023)	0.028 (0.008)	3 (1)	1 (0)	5 (1)
Los Alamos at Otowi	0.3 (0.3)	0.1 (0.1)	0.3 (0.1)	1.3 (0.1)	0.004 (0.003)	0.279 (0.014)	0.016 (0.003)	2 (0)	1 (0)	1 (1)
Other Areas										
Alexander Pond	0.2 (0.3)	0.0 (0.3)	0.3 (0.1)	N/A[b]	0.006 (0.003)	0.017 (0.002)	0.004 (0.030)	19 (4)	5 (1)	5 (1)
Froman Pond	0.1 (0.3)	0.6 (0.2)	0.4 (0.2)	N/A	0.003 (0.003)	0.009 (0.002)	0.004 (0.030)	21 (5)	6 (1)	6 (1)
Sandia Canyon										
Station 1	1.8 (0.9)	0.3 (0.2)	0.0 (0.1)	1.7 (0.1)	0.005 (0.003)	0.003 (0.002)	0.001 (0.003)	3 (1)	2 (0)	4 (1)
Station 4	2.7 (1.1)	0.0 (0.2)	0.1 (0.1)	1.7 (0.1)	0.001 (0.003)	0.001 (0.002)	0.003 (0.003)	2 (0)	1 (0)	3 (1)
Station 3	0.3[c] (0.4)	0.1 (0.2)	0.3 (0.1)	2.0 (0.1)	0.001 (0.003)	0.004 (0.002)	0.005 (0.003)	2 (1)	1 (0)	4 (1)
Mortandad Canyon										
Mortandad A-6	2.1 (1.0)	0.1 (0.2)	0.8 (0.2)	1.4 (0.1)	0.001 (0.003)	0.006 (0.002)	0.004 (0.003)	3 (1)	4 (0)	4 (1)
Mortandad A-7	2.1 (1.0)	0.3 (0.2)	0.4 (0.1)	2.3 (0.2)	0.002 (0.003)	0.010 (0.002)	0.007 (0.003)	5 (1)	4 (0)	7 (1)
Mortandad A-7/8										
Transect Station A	1.2 (0.5)	0.0 (0.2)	0.2 (0.1)	2.5 (0.2)	0.002 (0.003)	0.014 (0.002)	0.003 (0.003)	6 (1)	4 (1)	9 (1)
Transect Station B	0.5 (0.3)	0.0 (0.3)	0.7 (0.1)	3.4 (0.2)	0.007 (0.003)	0.015 (0.002)	0.002 (0.003)	5 (1)	5 (1)	11 (1)
Transect Station C	0.6 (0.3)	0.0 (0.3)	1.1 (0.2)	4.9 (0.3)	0.002 (0.003)	0.031 (0.003)	0.009 (0.003)	10 (2)	8 (1)	13 (1)
Transect Station D	0.2 (0.3)	0.2 (0.2)	0.1 (0.1)	3.2 (0.2)	0.002 (0.003)	0.005 (0.002)	0.000 (0.003)	12 (3)	8 (1)	13 (1)
Transect Station E	0.4 (0.3)	0.2 (0.2)	0.2 (0.1)	3.5 (0.2)	0.002 (0.003)	0.006 (0.002)	0.001 (0.003)	7 (2)	6 (1)	11 (1)
Transect Station F	0.5 (0.3)	0.1 (0.2)	0.1 (0.1)	2.2 (0.2)	0.002 (0.003)	0.006 (0.002)	0.002 (0.003)	7 (2)	4 (1)	10 (1)
Transect Station G	0.4 (0.3)	0.2 (0.2)	0.0 (0.1)	4.7 (0.3)	0.001 (0.003)	0.003 (0.002)	0.000 (0.003)	5 (1)	3 (0)	9 (1)
Transect Station H	0.1 (0.3)	0.1 (0.2)	0.2 (0.1)	4.4 (0.3)	0.000 (0.003)	0.002 (0.002)	0.002 (0.003)	7 (2)	3 (0)	8 (1)
Transect Station I	0.4 (0.3)	0.0 (0.2)	-0.0 (0.1)	4.1 (0.3)	0.000 (0.003)	0.003 (0.002)	0.001 (0.003)	9 (2)	4 (1)	11 (1)
Transect Station J	0.6 (0.3)	0.1 (0.2)	0.4 (0.1)	4.4 (0.3)	0.007 (0.003)	0.007 (0.002)	0.006 (0.003)	5 (1)	4 (1)	11 (1)
Transect Station K	0.6 (0.3)	0.3 (0.4)	0.7 (0.1)	4.0 (0.3)	0.009 (0.003)	0.021 (0.002)	0.004 (0.003)	8 (2)	5 (1)	11 (1)
Mortandad A-8	1.2 (0.8)	0.2 (0.2)	0.2 (0.1)	3.0 (0.2)	0.001 (0.003)	0.004 (0.002)	0.001 (0.003)	4 (1)	3 (0)	7 (1)
Mortandad at SR-4 (A-9)	0.5 (0.5)	0.2 (0.3)	0.1 (0.1)	2.9 (0.2)	0.000 (0.003)	0.000 (0.002)	0.001 (0.003)	3 (1)	2 (0)	4 (1)
Mortandad A-10	1.5 (0.8)	0.1 (0.2)	0.2 (0.1)	2.0 (0.1)	0.001 (0.003)	0.002 (0.002)	0.001 (0.003)	3 (1)	3 (0)	6 (1)

Table IV-9. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
ON-SITE STATIONS										
DP-Los Alamos Canyons										
Los Alamos at SR-4	0.9 (0.3)	0.3 (0.2)	2.4 (0.4)	2.2 (0.2)	0.040 (0.004)	0.328 (0.015)	0.300 (0.027)	4 (1)	5 (1)	10 (1)
Other Canyons										
Sandia at SR-4	0.2 (0.3)	0.2 (0.2)	0.0 (0.1)	0.7 (0.1)	0.001 (0.003)	0.002 (0.002)	0.001 (0.003)	N/A	N/A	1 (1)
Background Statistical Limit[d]	—	0.87	0.44	4.4	0.006	0.023	—	—	—	7.9
S.A.L.[e]	20.0	5.9	4.0	95.0	20.0	18.0	17.0	—	—	—

[a]Radioactivity counting uncertainties (±1 Standard Deviation) are shown in parentheses.
[b]N/A means analysis not performed, lost in analysis, or not completed.
[c]Mean of multiple samples.
[d]Average plus 2 standard deviations of measurements in regional samples 1974–1986 (Purtymun 1987a)
[e]Screening Action Level, ER 1993.

Table IV-10. Total Recoverable Trace Metals[a] in Sediments on Pueblo of San Ildefonso Lands for 1993 (μg/g)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
PERIMETER STATIONS (OFF SITE)												
DP-Los Alamos Canyons												
Los Alamos at Totavi	7.5	4,500.0	1.30	<1.0[b]	50.0	0.55	<0.4	3.7	4.60	5.90	7,500.0	<0.1[c]
Los Alamos at LA-2	<1.0	3,300.0	0.82	<1.0	58.0	0.41	<0.4	4.4	5.40	3.80	9,100.0	<0.1[c]
Los Alamos at Otowi	<1.0	1,100.0	0.39	0.5	17.0	0.18	<0.4	2.3	1.90	1.80	2,200.0	<0.1[c]
Other Areas												
Alexander Pond	<1.0	14,000.0	7.10	5.4	288.0	0.75	<0.4	6.1	14.00	12.00	14,000.0	<0.1
Froman Pond	<1.0	18,000.0	6.70	6.0	300.0	1.20	<0.4	8.8	16.00	17.00	19,000.0	<0.1
Sandia Canyon												
Station 1	<1.0	2,500.0	1.23	<1.0	25.0	0.25	<0.4	0.8	7.40	1.80	4,200.0	N/A[d]
Station 4	<1.0	3,300.0	1.02	<1.0	37.0	0.31	<0.4	2.6	6.00	1.70	4,200.0	N/A
Station 3	2.8	2,600.0	0.86	<1.0	24.0	0.41	<0.4	2.1	6.30	1.60	4,200.0	N/A
Mortandad Canyon												
Mortandad A-6	<1.0	2,100.0	0.83	<1.0	14.0	0.18	<0.4	0.6	1.60	1.90	2,700.0	<0.1[c]
Mortandad A-7	<1.0	2,400.0	0.96	<1.0	19.0	0.28	<0.4	1.0	1.50	0.50	6,500.0	<0.1[c]
Mortandad A-7/8												
Transect Station A	<1.0	6,500.0	1.92	1.5	59.0	0.60	<0.4	2.2	4.00	2.60	8,100.0	<0.1[c]
Transect Station B	<1.0	9,100.0	2.81	3.0	85.0	0.98	<0.4	4.0	5.60	3.80	10,000.0	<0.1[c]
Transect Station C	<1.0	13,000.0	4.26	3.9	110.0	1.20	0.4	3.7	7.60	6.20	13,000.0	<0.1[c]
Transect Station D	<1.0	19,000.0	2.25	5.3	170.0	1.80	<0.4	5.5	11.00	7.80	18,000.0	<0.1[c]
Transect Station E	<1.0	12,000.0	3.34	2.9	100.0	1.10	<0.4	3.9	7.70	5.10	13,000.0	<0.1[c]
Transect Station F	<1.0	13,000.0	4.60	3.4	110.0	1.20	<0.4	3.7	7.40	5.00	13,000.0	<0.1[c]
Transect Station G	<1.0	9,900.0	3.12	2.8	87.0	0.92	<0.4	3.0	6.40	3.20	10,000.0	<0.1[c]
Transect Station H	<1.0	8,800.0	1.69	2.5	73.0	0.79	<0.4	2.6	5.40	2.30	9,500.0	<0.1[c]
Transect Station I	<1.0	11,000.0	1.90	2.8	95.0	1.10	<0.4	3.6	7.80	4.10	12,000.0	<0.1[c]
Transect Station J	<1.0	11,000.0	2.50	2.5	94.0	1.00	<0.4	3.2	6.90	4.20	12,000.0	<0.1[c]
Transect Station K	<1.0	9,600.0	2.14	2.8	86.0	0.89	<0.4	3.0	6.20	4.50	11,000.0	<0.1[c]
Mortandad A-8	<1.0	4,800.0	0.97	2.5	37.0	0.40	<0.4	2.2	2.70	1.50	6,600.0	<0.1[c]
Mortandad at SR-4 (A-9)	<1.0	3,600.0	1.26	<1.0	61.0	0.40	<4.0	3.6	4.70	1.30	8,800.0	<0.1[c]
Mortandad A-10	<1.0	5,300.0	1.50	<1.0	85.0	0.49	<0.4	2.6	4.60	2.50	6,900.0	<0.1[c]
ON-SITE STATIONS												
DP-Los Alamos Canyons												
Los Alamos at SR	6.5	2,700.0	1.01	<1.0	44.0	0.43	<0.4	3.4	5.40	5.30	6,300.0	<0.1[c]
Other Canyons												
Sandia at SR-4	5.1	2,000.0	0.93	<1.0	17.0	0.29	<0.4	2.5	4.20	1.70	3,100.0	<0.1[c]

*Additional data on trace metals in sediments from Pueblo of San Ildefonso land is presented on page IV-32.

Table IV-10. (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
PERIMETER STATIONS (OFF SITE)											
DP-Los Alamos Canyons											
Los Alamos at Totavi	230.0	<1.0	2.3	10.0	<0.10	<0.20	<4.0	11.0	<0.02	11.0	43.0
Los Alamos at LA-2	280.0	<1.0	3.5	6.0	<0.10	0.25	<4.0	9.0	<0.02	16.0	40.0
Los Alamos at Otowi	68.0	<1.0	<2.0	2.0	<0.10	<0.20	<4.0	5.5	<0.02	4.4	10.0
Other Areas											
Alexander Pond	390.0	1.5	12.0	18.0	<0.30	1.70	<4.0	180.0	0.30	44.0	45.0
Froman Pond	610.0	<1.0	17.0	22.0	<0.30	1.50	<4.0	150.0	0.30	36.0	75.0
Sandia Canyon											
Station 1	170.0	<1.0	2.5	11.0	<0.10	<0.20	<4.0	4.4	0.06	5.0	26.0
Station 4	190.0	<1.0	<2.0	7.0	<0.10	<0.20	<4.0	5.3	<0.02	5.5	22.0
Station 3	210.0	<1.0	<2.0	6.3	<0.10	<0.20	<4.0	4.3	<0.02	4.8	27.0
Mortandad Canyon											
Mortandad A-6	110.0	<1.0	<2.0	7.3	<0.10	<0.20	<4.0	1.7	<0.02	2.3	17.0
Mortandad A-7	280.0	<1.0	<2.0	1.0	<0.10	<0.20	<4.0	2.7	<0.02	3.7	38.0
Mortandad A-7/8											
Transect Station A	330.0	<1.0	4.0	11.0	<0.10	<0.20	<4.0	10.0	0.07	9.4	34.0
Transect Station B	380.0	<1.0	5.0	12.0	<0.10	<0.20	4.0	16.0	0.11	13.0	43.0
Transect Station C	470.0	<1.0	7.0	19.0	<0.10	<0.20	<4.0	20.0	0.16	17.0	57.0
Transect Station D	640.0	<1.0	11.0	19.0	<0.10	0.43	<4.0	32.0	0.22	24.0	67.0
Transect Station E	430.0	<1.0	5.0	13.0	<0.10	0.73	<4.0	20.0	0.11	17.0	50.0
Transect Station F	450.0	<1.0	6.8	14.0	<0.10	0.29	<4.0	22.0	0.14	18.0	51.0
Transect Station G	340.0	<1.0	4.7	9.2	<0.10	<0.20	<4.0	17.0	0.05	13.0	39.0
Transect Station H	330.0	<1.0	5.6	9.0	<0.02	<0.20	5.0	13.0	0.12	12.0	37.0
Transect Station I	460.0	<1.0	5.8	12.0	0.03	<0.20	35.0	16.0	0.14	16.0	47.0
Transect Station J	420.0	<1.0	6.0	12.0	0.03	<0.20	<4.0	17.0	0.15	16.0	50.0
Transect Station K	420.0	1.6	5.0	13.0	0.03	<0.20	<4.0	15.0	0.13	14.0	49.0
Mortandad A-8	280.0	1.8	3.4	6.0	<0.02	<0.20	<4.0	5.2	0.07	7.3	33.0
Mortandad at SR-4 (A-9)	360.0	<1.0	5.1	8.0	<0.02	<0.20	<4.0	7.2	0.09	15.0	33.0
Mortandad A-10	260.0	<1.0	10.0	7.0	<0.02	<0.20	<4.0	12.0	0.10	11.0	26.0
ON-SITE STATIONS											
DP-Los Alamos Canyons											
Los Alamos at SR-4	210.0	<1.0	<2.0	12.0	<0.10	<0.20	<4.0	6.2	<0.02	7.0	46.00
Other Canyons											
Sandia at SR-4	140.0	<1.0	<2.0	3.6	<0.10	<0.20	<4.0	2.6	<0.02	3.4	23.00

[a]EPA Analytical Procedure SW-846, Method 3050.

[b]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.

[c]Mean of multiple values.

[d]N/A means analysis not performed, lost in analysis, or not completed.

Table IV-11. Locations on Pueblo of San Ildefonso Lands for Water and Sediment Sampling that are Included in the Routine Monitoring Program

Station Identification	Map Designation	See this Table for Results
Water Sampling Locations		
Rio Grande		
Otowi	Figure V-13, No. 3	V-20, and VI-8, -9
Spring in Sandia Canyon		
Sandia Spring	Figure IV-8	VII-1, -2, -3
Springs in White Rock Canyon		
Spring 1	Figure IV-8	VII-1, -2, -3
Spring 2	Figure IV-8	VII-1, -2, -3
Sanitary Effluent Flow in Mortandad Canyon		
Mortandad at Rio Grande	Figure V-13, No. 38	IV-18, -19, -20
Sediment Sampling Locations		
Guaje at SR 502	Figure V-16, No. 12	IV-9, -10
Bayo at SR 502	Figure V-16, No. 13	IV-9, -10
Los Alamos Canyon		
Los Alamos at SR 4	Figure V-16, No. 35	IV-9, -10
Los Alamos at Totavi[a]	Figure V-16, No. 36	IV-9, -10
Los Alamos at LA-2[a]	Figure V-16, No. 37	IV-9, -10
Los Alamos at Otowi	Figure V-16, No. 38	IV-9, -10
Sandia Canyon		
Sandia at SR 4	Figure V-16, No. 14	IV-9, -10
Sandia at Rio Grande	Figure V-16, SANDIA	IV-9, -10
Mortandad Canyon		
Mortandad at MCO-13	Figure V-16, No. 45 (A-5)	IV-9, -10
Mortandad at SR 4	Figure V-16, No. 15 (A-9)	IV-9, -10
Mortandad at Rio Grande	Figure V-16, MORTANDAD	IV-9, -10

[a]Not required by MOU but routinely sampled and reported.

The analyses of samples from the three new alluvial observation wells (BIA #1, BIA #2, and BIA #3) shows a low, but not surprising, presence of americium, plutonium, and tritium. These wells sample water in the alluvium that is probably maintained by surface flow in Los Alamos Canyon. The maximum tritium level found was 0.7 nCi/L, compared to the EPA drinking water standard of 20 nCi/L. For wells BIA #1, BIA #2, and BIA #3, values ranged up to 0.09 pCi/L of ^{238}Pu, 0.737 pCi/L of $^{239,240}Pu$, and 0.565 pCi/L of ^{241}Am. These values are below the respective DOE drinking water system DCGs for these isotopes of 1.6 pCi/L, 1.2 pCi/L, and 1.2 pCi/L. Values for trace metals (discussed below) were also elevated for these wells. The high plutonium and americium values are most likely due to several factors: (1) the samples drawn from the recently-installed wells are likely to contain a high amount of suspended sediment, (2) the samples were not filtered before analysis, and (3) these elements (such as plutonium) are commonly adsorbed onto suspended sediments.

The uranium concentration observed for the alluvial observation well Totavi BIA North was 40.2 µg/L. The uranium concentrations were 28.1 µg/L for the New Community Well, 24.3 µg/L for Westside Artesian Well, and 20.0 µg/L for BIA Alluvial Observation Well #2. These values are either near or exceed the EPA primary drinking water standard (20 µg/L). The uranium values were determined using induction coupled plasma emission spectroscopy, which ordinarily gives elevated values for prepared standards and also gives values higher than the alternative kinetic phosphorimetric analysis method. Some of the spring analyses reported in Section VII, which have uranium results from both methods, bear this out. The Martinez and BIA #1 wells, La Mesita Spring, and Well

Table IV-12. Radiochemical Analysis of Groundwater on Pueblo of San Ildefonso Land for 1993

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium ICPES[a] (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)
San Ildefonso Wells										
Don Juan Playhouse Well	0.1 (0.3)[b]	0.0 (0.9)	2.3 (1.3)	7.0 (0.7)	0.000 (0.03)	0.000 (0.020)	0.036 (0.030)	0 (1)	2 (0)	150 (100)
Eastside Artesian Well	0.1 (0.3)	0.1 (0.8)	1.5 (1.3)	<1.0[c] (0.0)	-0.011 (0.03)	0.000 (0.020)	0.007 (0.030)	-2 (1)	2 (0)	80 (100)
Westside Artesian Well	0.4 (0.3)	0.1 (0.7)	2.7 (1.3)	24.3 (3.8)	0.009 (0.03)	0.004 (0.020)	0.019 (0.030)	14 (4)	6 (1)	300 (100)
Halladay Well	0.6 (0.3)	0.1 (0.8)	3.7 (1.3)	1.5 (0.1)	-0.005 (0.03)	0.019 (0.020)	0.022 (0.030)	-2 (1)	1 (0)	190 (100)
Martinez Well	0.3 (0.3)	0.5 (0.7)	1.5 (1.2)	13.4 (4.0)	0.042 (0.03)	-0.014 (0.020)	0.021 (0.030)	1 (1)	6 (1)	130 (100)
New Community Well	0.6 (0.3)	-1.1 (1.1)	0.9 (1.3)	28.1 (4.1)	0.005 (0.03)	0.005 (0.020)	0.008 (0.030)	-2 (1)	3 (1)	180 (100)
Otowi House Well	0.6 (0.3)	-0.1 (0.9)	-0.1 (1.2)	2.9 (0.4)	0.018 (0.03)	0.000 (0.020)	0.020 (0.030)	-3 (2)	3 (1)	120 (100)
Pajarito Well Pump 2	0.3 (0.3)	1.5 (0.9)	1.7 (1.2)	7.6 (1.0)	0.034 (0.03)	0.000 (0.020)	0.013 (0.030)	3 (2)	4 (1)	220 (100)
Sanchez House Well	0.6 (0.3)	0.0 (0.7)	-0.3 (1.2)	7.5 (1.2)	0.000 (0.03)	0.022 (0.020)	0.023 (0.030)	0 (1)	7 (1)	100 (100)
LA-1B	0.1 (0.3)	0.3 (0.6)	2.9 (1.3)	6.0 (1.0)	-0.005 (0.03)	0.018 (0.020)	0.013 (0.030)	3 (3)	5 (1)	80 (90)
LA-2	-0.2 (0.3)	-0.1 (0.9)	3.6 (1.4)	<1.0 (0.0)	0.000 (0.03)	0.000 (0.020)	0.036 (0.030)	-2 (1)	2 (1)	100 (100)
LA-5	-0.1 (0.3)	0.6 (0.7)	1.7 (1.2)	<1.0 (0.0)	-0.009 (0.03)	0.000 (0.020)	0.031 (0.030)	-2 (1)	2 (0)	130 (100)
LA-1A	0.4 (0.3)	0.8 (0.7)	2.4 (1.3)	16.5 (1.8)	-0.012 (0.03)	0.013 (0.020)	0.027 (0.030)	1 (1)	8 (1)	220 (100)
Springs										
Basalt Spring	0.2 (0.3)	0.4 (0.9)	3.0 (1.3)	2.1 (0.4)	0.013 (0.03)	0.063 (0.022)	0.000 (0.000)	-1 (1)	5 (1)	30 (90)
Indian Spring	-0.2 (0.3)	-0.4 (0.7)	2.8 (1.2)	2.0 (0.1)	0.023 (0.03)	0.000 (0.020)	0.014 (0.030)	-2 (1)	3 (1)	150 (100)
La Mesita Spring	0.3 (0.3)	-0.5 (1.0)	2.1 (1.2)	12.5 (2.4)	-0.005 (0.03)	0.010 (0.020)	0.000 (0.000)	0 (1)	7 (1)	80 (100)
Sacred Spring	0.5 (0.3)	0.3 (0.7)	1.3 (1.1)	2.0 (0.1)	0.004 (0.03)	0.004 (0.020)	0.024 (0.030)	-2 (1)	5 (1)	70 (90)
Los Alamos Canyon Alluvial Groundwater										
Totavi BIA Well North	0.3 (0.3)	0.6 (0.9)	1.7 (1.3)	40.2 (3.7)	0.025 (0.03)	0.015 (0.020)	0.028 (0.030)	2 (1)	17 (2)	120 (100)
Totavi BIA Observation Well 2	0.6 (0.3)	0.7 (0.6)	0.6 (1.2)	4.3 (0.4)	0.000 (0.03)	0.019 (0.020)	0.025 (0.030)	2 (1)	6 (1)	-40 (100)
BIA Well Point #1	0.5 (0.3)	0.5 (1.1)	2.7 (1.4)	10.5 (3.1)	0.005 (0.03)	0.206 (0.032)	0.413 (0.066)	0 (2)	10 (1)	190 (100)
BIA Well Point #2	0.7 (0.3)	1.5 (0.8)	0.9 (1.2)	20.0 (5.0)	0.095 (0.03)	0.360 (0.042)	0.298 (0.049)	8 (3)	18 (2)	10 (90)
BIA Well Point #3	0.7 (0.3)	1.5 (0.8)	1.6 (1.2)	1.0 (0.1)	-0.009 (0.03)	0.737 (0.067)	0.565 (0.070)	-1 (1)	13 (1)	0 (90)

Table IV-12. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium ICPES[a] (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)
Limits of Detection	0.4	3	2	1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose	2,000	1,000	3,000	800	40	60	30			
DOE Drinking Water System DCG			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard	20	8		20				15		
EPA Screening Level									50	
NMWQCC Groundwater Limit				5,000						

[a]ICPES = inductively coupled plasma emission spectrometry.
[b]Counting uncertainties (±1 standard deviation) are in parentheses.
[c]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method

LA-1A have significant uranium concentrations but are below the EPA drinking water standard. These measurements are consistent with the levels in previous samples and with relatively elevated levels of natural uranium in other wells in the area (EPG 1993, EPG 1994).

The gross alpha level in the sample from the Westside Artesian well is 14 pCi/L, just below the EPA primary drinking water standard of 15 pCi/L. Gross alpha levels in the samples from the BIA #2 and Westside Artesian wells are greater than the 5 pCi/L screening level, which would require analyses for radium if the levels could not be explained by correspondingly elevated levels of uranium.

With the exception of metal analyses (discussed below), the chemical quality of the groundwater, shown in Table IV-13, is consistent with previous observations. The samples from the Westside Artesian Well, Well LA-1B, and the Totavi BIA North alluvial observation well exceeded or were near the drinking water standard for total dissolved solids (TDS); the Westside Artesian Well and LA-1B levels are similar to those previously measured (EPG 1993, EPG 1994). Note that the TDS measurements are made by gravimetric measurements of filtered samples, and therefore do not reflect the elevated trace metal concentrations referred to below. The Martinez House Well nitrate value of 9.5 mg/L is near the EPA drinking water and NM ground water standards of 10 mg/L, similar to previous values (EPG 1994). The Sanchez House Well fluoride value of 1.5 mg/L is near the standard of 1.6 mg/L, again similar to previous values (EPG 1994). Several of the wells have alkaline pH values, above the EPA secondary standard range of 6.8-8.5; again, these values do not represent a change from those previously observed in the area (EPG 1993, EPG 1994).

Trace metal analyses are shown in Table IV-14. Several wells and springs show elevated values for trace metals, greatly exceeding values previously reported (EPG 1994). The elevated trace metal values are most likely due to several factors: (1) the samples drawn from the recently installed wells are likely to contain a elevated amount of suspended sediment, (2) the samples were not filtered before analysis, (3) the technique by which samples were prepared for analysis is for total recoverable metals, which partially digests the suspended sediment, and (4) these elements are commonly either adsorbed onto suspended sediments, or (5) several of these metals are constituents of the suspended sediment particles themselves.

In particular, the BIA and Totavi BIA alluvial observation wells may have had elevated suspended sediment levels, which along with the sample preparation technique, could contribute to a higher trace metal content. This supposition is supported by two other facts: (1) duplicates of these samples were filtered and analyzed independently by the BIA and show normal low levels of these trace metals; and (2) duplicate unfiltered samples of three alluvial observation wells in Pajarito Canyon were analyzed by the NMED and show elevated trace metal values similar to those we report for these wells in Section VII.

Some or all of the BIA and Totavi BIA observation wells exceeded the NM livestock, NM groundwater, or EPA drinking water primary or secondary standards for aluminum, arsenic, barium, beryllium, chromium, iron, manganese, nickel, lead, thallium, vanadium, and zinc. Aluminum, iron, and manganese are normal constituents of rock-forming minerals and are expected in suspended sediment materials. Barium and chromium are expected in higher-than-background concentrations as a result of releases into Los Alamos and Pueblo canyons from past operations at LANL. These results are consistent with the expectation that the alluvial water is maintained by surface flow from Los Alamos Canyon that carries treated sanitary effluents.

Well LA-1B had an arsenic value of 0.047 mg/L, just below the EPA drinking water standard of 0.05 mg/L, and slightly higher than the 1992 value of 0.03 mg/L (EPG 1994). Well LA-1A and Sacred Spring have elevated values of manganese and/or iron, which are also associated with suspended sediment.

The results of LANL's analyses were generally in agreement with results of chemical analyses of the duplicate samples collected by the BIA, except as noted above, where differences resulting from filtered vs. unfiltered analyses are expected. For the BIA and Totavi BIA alluvial observation wells, the BIA's analytical results for manganese and potassium were also much lower than reported here; again, these are normal constituents of rock-forming minerals and are expected in suspended sediment materials. In most of the analyses for which direct comparisons were possible (that is, for actual values rather than detection limits), most of the results agreed within 20%. Measurements with less consistently good agreement included those in carbonate, bicarbonate, and pH. These measurements are related to each other, and change with time after sample collection due to gain or loss of carbon dioxide gas from the sample; thus the differences may reflect whether field or laboratory measurements of alkalinity and pH were made.

Table IV-13. Chemical Quality of Surface Waters on Pueblo of San Ildefonso Lands for 1993 (mg/L)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µ/cm)
San Ildefonso Wells																	
Don Juan Playhouse Well	29	7	0.6	1	65	4	0.6	4	130	0.0	15	2.07	N/A[c]	268	19	8.6	285
Eastside Artesian Well	<1[d]	3	0.3	1	89	4	0.8	16	180	0.1	13	<0.04	N/A	272	9	9.1	372
Westside Artesian Well	27	14	0.9	2	400	341	5.2	2	353	<0.0	77	0.04	N/A	1100	38	8.7	1505
Halladay Well	31	5	0.1	1	41	4	0.5	3	79	0.1	13	0.61	N/A	174	12	8.3	162
Martinez Well	48	43	2.6	3	53	17	0.6	2	146	0.4	32	9.54	N/A	306	118	8.4	485
New Community Well	28	29	1.8	2	62	9	0.2	6	173	0.0	30	1.28	N/A	302	80	8.6	416
Otowi House Well	63	69	5.1	4	39	33	0.4	4	199	0.0	19	0.33	N/A	392	193	8.4	522
Pajarito Well Pump 2	42	29	2.0	2	120	58	1.0	2	235	0.1	24	1.49	N/A	428	81	8.4	711
Sanchez House Well	45	33	2.3	2	99	47	1.5	8	209	0.0	51	1.07	N/A	420	92	8.5	686
LA-1B	43	7	0.3	3	150	17	3.2	3	300	0.0	33	0.69	N/A	498	19	8.7	687
LA-2	34	11	0.2	2	28	3	0.7	3	74	0.0	7	0.51	N/A	158	28	8.4	131
LA-5	42	21	0.9	2	15	3	0.5	<1	68	0.0	6	0.45	N/A	144	56	8.2	123
LA-1A	37	30	0.4	2	70	12	0.2	2	195	<0.0	27	0.54	N/A	300	77	8.3	422
Springs																	
Basalt Spring	56	32	8.3	N/A	33	26	0.4	<5	97	1.7	21	2.27	N/A	302	111	7.4	384
Indian Spring	52	35	2.8	2	25	32	0.4	<1	92	0.0	8	0.88	N/A	256	99	8.3	295
La Mesita Spring	34	36	2.0	N/A	26	7	0.2	<5	116	0.1	14	2.91	N/A	218	90	8.2	285
Sacred Spring	33	24	0.7	3	21	3	0.5	<1	82	0.1	15	0.28	N/A	188	63	7.7	182
Los Alamos Canyon Alluvial Groundwater																	
Totavi BIA Well North	59	45	12.0	14	14	4	0.4	<1	110	<0.0	10	0.53	N/A	156	162	7.9	225
Totavi BIA Observation Well 1	61	38	6.1	5	59	57	0.4	<1	130	<0.0	22	4.01	N/A	530	120	7.6	544
BIA Well Point #1	60	73	19.0	14	38	25	0.5	<1	186	0.6	19	<0.04	N/A	370	260	7.4	470
BIA Well Point #2	61	85	47.0	33	39	27	0.4	<1	111	5.9	18	3.90	N/A	334	406	7.6	385
BIA Well Point #3	58	27	15.0	18	35	29	0.6	<1	66	2.9	10	0.16	N/A	276	129	7.1	261
EPA Primary Drinking Water Standard							4					10	0.2				
EPA Secondary Drinking Water Standard											250			500		6.8-8.5	
EPA Health Advisory					20												
NMWQCC Groundwater Limit						250	1.6					10					

[a]Total Dissolved Solids.

[b]Standard Units.

[c]N/A means analysis not performed, lost in analysis, or not completed.

[d]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.

Table IV-14. Total Recoverable Trace Metals in Groundwaters on Pueblo of San Ildefonso Lands for 1993 (mg/L)

Stations	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
San Ildefonso Wells												
Don Juan Playhouse Well	<0.010 [a]	0.140	0.0083	0.083	0.005	0.001	<0.003	<0.004	0.018	<0.004	<0.10	<0.0002
Eastside Artesian	<0.010	<0.100	<0.0020	0.036	0.009	<0.001	<0.003	<0.004	<0.004	<0.004	0.23	<0.0002
Westside Artesian	<0.010	<0.100	0.0060	1.600	0.037	<0.001	<0.003	<0.004	<0.004	0.013	0.33	<0.0002
Halladay Well	<0.010	<0.100	0.0114	0.059	0.042	<0.001	<0.003	<0.004	0.018	<0.004	<0.10	<0.0002
Martinez Well	<0.010	<0.100	0.0100	0.100	0.180	<0.001	<0.003	<0.004	<0.004	0.020	<0.10	<0.0002
New Community Well	<0.010	<0.100	0.0022	0.034	0.027	<0.001	<0.003	<0.004	0.005	<0.004	<0.10	<0.0002
Otowi House Well	<0.010	0.140	0.0035	0.045	0.290	<0.001	<0.003	<0.004	<0.004	0.005	0.10	<0.0002
Pajarito Well Pump 2	<0.010	<0.100	0.0130	0.410	0.110	<0.001	<0.003	<0.004	<0.004	0.028	0.07	N/A [b]
Sanchez House Well	<0.010	0.160	0.0134	0.270	0.110	<0.001	<0.003	<0.004	<0.004	0.120	<0.10	<0.0002
LA-1B	<0.010	<0.100	0.0473	0.370	0.046	0.001	<0.003	<0.004	0.039	<0.004	<0.10	<0.0002
LA-2	<0.010	<0.100	0.0058	0.048	0.092	<0.001	<0.003	<0.004	0.018	<0.004	0.22	<0.0002
LA-5	<0.010	0.062	0.0030	0.008	0.065	<0.001	<0.003	<0.004	0.008	<0.004	0.16	<0.0002
LA-1A	<0.010	0.420	<0.0020	0.180	0.220	<0.001	<0.003	<0.004	0.016	0.012	2.60	<0.0002
Springs												
Basalt Spring	<0.010	2.300	0.0060	0.110	0.080	<0.001	<0.003	<0.004	<0.004	0.000	1.50	<0.0002
Indian Spring	<0.010	<0.100	0.0041	0.034	0.100	<0.001	<0.003	<0.004	0.004	<0.004	<0.10	<0.0002
La Mesita Spring	<0.010	2.000	<0.0020	0.040	0.170	<0.001	<0.003	<0.004	0.005	<0.004	3.30	<0.0002
Sacred Spring	<0.010	1.000	0.0043	0.038	0.130	<0.001	<0.003	<0.004	<0.004	<0.001	1.00	<0.0002
Los Alamos Canyon Alluvial Groundwater												
Totavi BIA Well North	<0.010	34.000	0.0120	0.011	0.640	0.004	<0.003	0.015	0.028	0.004	34.00	<0.0002
Totavi BIA Observation Well 2	0.011	1.800	0.0104	0.200	0.130	<0.001	<0.003	<0.004	0.009	0.006	1.40	<0.0002
BIA Well Point #1	<0.010	84.000	0.0181	0.046	0.670	0.007	<0.003	0.024	0.059	0.065	58.00	<0.0002
BIA Well Point #2	0.021	220.000	0.0580	0.071	3.400	0.016	<0.003	0.080	0.140	0.130	150.00	<0.0002
BIA Well Point #3	0.016	74.000	<0.0020	0.064	0.450	0.006	<0.003	0.021	0.100	0.049	60.00	<0.0002
EPA Primary Drinking Water Standard	0.05		0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard											0.3	
EPA Action Level										1.3		
Livestock Wildlife Watering Limit		5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01
NMWQCC Groundwater Limit	0.05		0.1		1.0		0.01		0.05			0.002

*Additional data on trace metals in groundwaters on Pueblo of San Ildefonso lands is presented on page IV-39.

Table IV-14. (Cont.)

Stations	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
San Ildefonso Wells											
Don Juan Playhouse Well	0.005	<0.008	<0.010	<0.0010	<0.0010	0.0065	<0.03	0.094	<0.001	0.02	<0.010
Eastside Artesian Well	0.014	<0.008	<0.010	<0.0010	0.0015	0.0029	<0.03	0.042	<0.001	0.01	0.028
Westside Artesian Well	0.010	0.040	<0.020	<0.0010	0.0010	<0.0020	<0.03	0.350	<0.001	<0.01	<0.010
Halladay Well	0.004	<0.008	<0.010	<0.0010	<0.0010	0.0030	<0.03	0.130	<0.001	0.02	0.053
Martinez Well	<0.002	<0.008	<0.020	<0.0010	<0.0010	<0.0020	<0.03	0.600	<0.001	0.02	0.084
New Community Well	<0.002	<0.008	<0.010	<0.0010	<0.0010	0.0054	<0.03	0.340	<0.001	<0.00	0.016
Otowi House Well	0.020	<0.008	<0.010	<0.0010	<0.0010	0.0050	<0.03	0.780	<0.001	0.01	0.130
Pajarito Well Pump 2	0.006	<0.008	<0.020	<0.0010	<0.0010	<0.0020	<0.03	0.570	<0.001	0.03	0.019
Sanchez House Well	0.003	0.008	0.030	<0.0010	<0.0010	0.0034	<0.03	0.350	<0.001	0.02	0.150
LA-1B	0.016	0.023	0.023	<0.0060	<0.0010	0.0024	<0.03	0.160	<0.001	0.05	0.036
LA-2	0.009	<0.008	<0.010	<0.0060	<0.0010	0.0028	<0.03	0.240	<0.001	0.02	0.027
LA-5	0.010	<0.008	<0.010	<0.0060	<0.0010	0.0020	<0.03	0.230	<0.001	0.02	1.300
LA-1A	0.068	<0.008	<0.020	<0.0010	<0.0010	<0.0020	<0.03	0.830	<0.001	<0.01	0.010
Springs											
Basalt Spring	0.078	0.010	<0.010	0.0052	<0.0010	<0.0020	<0.03	0.190	<0.001	0.01	0.030
Indian Spring	<0.002	0.009	<0.010	<0.0060	<0.0010	0.0040	<0.03	0.420	<0.001	0.01	0.400
La Mesita Spring	0.058	<0.010	0.010	0.0010	<0.0010	<0.0020	<0.03	0.920	<0.001	0.01	0.030
Sacred Spring	0.035	<0.008	<0.010	<0.0060	<0.0010	0.0037	<0.03	0.510	<0.001	0.01	0.030
Los Alamos Canyon Alluvial Groundwater											
Totavi BIA Well North	0.730	<0.008	0.030	0.0344	<0.0010	<0.0020	<0.03	0.360	<0.001	0.10	0.130
Totavi BIA Observation Well 2	0.055	<0.008	0.012	<0.0010	0.0018	<0.0020	<0.03	0.190	<0.001	0.02	0.016
BIA Well Point #1	0.720	<0.008	0.060	0.0991	<0.0010	0.0067	<0.03	0.660	<0.001	0.18	1.700
BIA Well Point #2	29.000	0.009	0.240	0.1600	<0.0010	0.0046	<0.03	0.690	0.003	0.32	2.800
BIA Well Point #3	1.700	<0.008	0.074	0.0200	<0.0010	<0.0020	<0.03	0.190	<0.001	0.10	7.200
EPA Primary Drinking Water Standard			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard	0.05										5.0
EPA Action Level				0.015							
EPA Health Advisory								25-90		0.08-0.11	
Livestock Wildlife Watering Limit				0.1						0.1	25.0
NMWQCC Groundwater Limit				0.05		0.05					

[a]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.
[b]N/A means analysis not performed, lost in analysis, or not completed.

Sediments. The radioactive liquid waste treatment plant at TA-50 releases treated effluent into the upper reaches of Mortandad Canyon. The effluent, containing traces of radionuclides and other chemicals, infiltrates into the underlying alluvium and enters the shallow groundwater perched on the underlying tuff in the upper- and mid-reaches of the canyon within Laboratory boundaries. Most of the radionuclides present in the effluent when it is first released as surface flow are adsorbed or attached to the sediments in the stream channel; thus, the principal means of transport is through surface runoff. Because the headwaters of Mortandad Canyon are located on Pajarito Plateau within TA-3, the canyon has a small drainage area. The alluvium thickens in the middle and lower reaches of the canyon. The small drainage area and the thick section of unsaturated alluvium in the middle reach of the canyon have retained all the runoff affected by the effluent since 1963 when the treatment plant began operating.

In accordance with the MOU, sediments from Mortandad Canyon were collected on May 11, 1993, from seven permanent sampling stations. As seen in Figure IV-8, one of these sampling stations is located slightly west of the Pueblo of San Ildefonso-Laboratory boundary, and six locations are within the Pueblo. Samples were also collected at 11 new locations between Stations A-7 and A-8. The results of analyses for radiochemicals and trace metals in these samples are shown in Table IV-9 and Table IV-10; results from adjacent canyon stations are reported in Table V-23 and Figure V-18. The following discussion focuses on tabulated data from the Mortandad Canyon samples.

The tritium values for moisture in sediments collected at stations A-6, A-7, A-8, and A-10 in Mortandad Canyon, and at stations 1 and 4 in Sandia Canyon, are all somewhat elevated relative to the limit of detection for tritium in water (0.400 nCi/L), and the mean concentration value in natural rain waters (about 0.060 nCi/L). While these concentration values are well below the Laboratory's ER programs' screening action level (SAL), as seen in Table IV-9, the exact source of these slightly elevated values is unknown. For the interested reader, a more complete discussion of these SALs is presented in Section V.B.5.

The level of ^{137}Cs measured in samples from Station A-6 exceeded the statistically derived comparison value for fallout in soils and sediments in northern New Mexico by a factor of about two. In addition, the highest level of $^{239,240}Pu$ from previously sampled locations in Mortandad Canyon for 1993 was obtained at Station A-7 (located on Pueblo of San Ildefonso property adjacent to the boundary with the Laboratory). This sample contained less than one-half of the statistically derived $^{239,240}Pu$ comparison value for fallout in northern New Mexico. Hence, the plutonium isotope ratios ($^{239,240}Pu/^{238}Pu$) for these samples were not computed because individual isotope concentrations are at or below the respective limits of detection (see Table D-10), and this computation would not be sufficiently accurate.

Only one of the samples from the new 11-station transect located midway between stations A-7 and A-8 contained $^{239,240}Pu$ levels slightly exceeding the statistically derived levels from fallout in northern New Mexico, and 10 contained levels lower than that value. Only three of these special samples contained ^{238}Pu at levels that slightly exceeded that fallout reference level, while three samples contained ^{137}Cs concentration levels slightly above its reference level. Total uranium was slightly exceeded at two special stations. In all but three transect samples, the ratio of the plutonium isotopes ($^{239,240}Pu/^{238}Pu$) cannot be considered accurate because individual isotope concentrations are at or below the respective detection limits (see Table D-11). However, transect samples B, J, and K all show $^{239,240}Pu/^{238}Pu$ ratios below 2.3. Further upstream within the Laboratory boundary, and within the contaminated portion of Mortandad Canyon, this ratio is typically observed to be in the range of 2 to 4 (see stations MCO-5, MCO-7, and MCO-9 in Table V-23), while at uncontaminated sites this ratio typically exceeds 15. The low isotopic ratios at transects B, J, and K indicate the need for continued sediment monitoring in lower Mortandad Canyon to determine downstream plutonium migration potential. Currently, uncertainty about plutonium migration exists because of the small number of samples having elevated plutonium levels, concentrations in these samples being near detection limits, and sampling factors, such as the ratio of fine grain sizes to larger grain sizes in individual samples. In sediment samples dominated by worldwide fallout, considerable variability is expected because of different particle size distributions in grab samples (Purtymun 1990b). Samples with a large percentage of small particles typically exhibit higher mass concentrations of plutonium because of their high adsorption capacity. The sediments in this part of Mortandad Canyon are more like soils because there has been very little runoff to separate silt from the clay-size particles that typically show higher concentrations of plutonium.

Results of samples from the two new sediment sampling locations in Sandia Canyon are all within the range of values expected from worldwide fallout. The results do not indicate any presence of contaminants from Laboratory

operations. These findings are consistent with current and previous measurements of sediments from Sandia Canyon where it crosses the Laboratory boundary at State Road 502.

The samples of sediments collected from the Pueblo of San Ildefonso in 1993 were also analyzed for trace metals, as reported in Table IV-10. The results, which are within the general ranges expected for geologic materials, provide a basis for future comparisons.

6. Environmental Studies at the Pueblos of Jemez, Nambé, and Taos. (Bruce Gallaher, Alan Stoker, and Max Maes, ESH-18)

In response to requests from the Pueblos of Jemez, Nambé, and Taos, the Laboratory conducted limited special monitoring of waters, sediments, and soils on pueblo lands in late 1992 and 1993. Such special monitoring complements the Laboratory's long-term monitoring program in northern New Mexico and helps to collect information at locations of particular concern to the pueblos. Results of the special monitoring are presented in Tables IV-15 through IV-23.

At Jemez Pueblo, surface water samples were collected from the Jemez River at the pueblo intakes and from the Vallecitos Creek flowing through the center of the pueblo. The samples were analyzed for radioactivity and trace metals. The majority of the radioactivity results are near or below the average detection limits of the analytical methods used. Anomalous levels of ^{239,240}Pu were detected in the Jemez River at the pueblo intakes sample. The ^{239,240}Pu result exceeds detection limits by four times, but is less than 10% of the DOE limits for drinking water (Appendix A). This level is anomalous when compared with previous and other 1993 plutonium analyses of surface waters in the Jemez Mountains; the sampling or the analytical method are suspected of inaccuracies. Trace metal concentrations in the surface water samples are near or below the New Mexico standards for the protection of livestock and wildlife watering (NMWQCC 1991). The arsenic result from the Jemez River at the pueblo intakes is equal to the stream standard limit. Arsenic is often found in elevated levels within volcanic settings like the Jemez Mountains.

At Nambé Pueblo, water and sediment samples were collected within and around Nambé Lake and analyzed for radioactivity and trace metals. An additional water sample was collected from the Nambé Community Center water supply well and analyzed for trace metals and general chemical parameters. All results for radioactivity in Nambé Lake water samples are below the detection limits of the analytical methods used. None of the trace metal concentrations in surface water samples taken from the inlet and outlets exceed any limits for livestock and wildlife watering. Trace metal concentrations in sediments from the lake area are all within the range naturally found in soils and rocks. The Nambé Community Center water supply well meets all drinking water limits for metals and general secondary chemicals.

At Taos Pueblo, sampling was focused on the Rio Lucero and Rio Del Pueblo and on soils and a spring in the vicinity of the Pueblo landfill. Most of the radioactivity analyses of surface waters and all of the analyses of sediments are near or below the average detection limits of the analytical methods used. Surface water samples from the Rio Lucero and from Taos Pueblo East contained ^{239,240}Pu at levels above detection limits. The levels are less than 5% of the DOE drinking water limits. Water issuing from the Bison Pasture spring, located downgradient of the landfill, contains no detectable radionuclides and meets all drinking water limits for metals and general secondary chemicals. Radiochemical analyses of five soil samples from the Bison Pasture showed levels generally consistent with regional background conditions. Three results, however, significantly exceed regional levels: the ^{238}Pu result from one of the samples is nearly 7 times larger than background levels; the ^{137}Cs results from a different sampling location in the Bison Pasture is 15 times larger than background levels; a third sampling location is 2 times larger than background levels (Figure IV-9). The most plausible explanation for the elevated results is sampling and analytical method inaccuracies. It is noteworthy that (1) the other sampling results are at least three fold lower, and (2) the only known source of these radionuclides in this area is via atmospheric deposition that would typically result in more uniform levels within a pasture-sized plot of land. Trace metal concentrations in Bison Pasture soils are relatively uniform and within the range found naturally in soils and rocks.

7. Performance Assessments. (Dennis Armstrong, ESH-17)

DOE Order 5820.2A, Radioactive Waste Management, became effective in September 1988. Section III of this order established policies, guidelines, minimum requirements, and performance criteria for LLW and mixed waste

Table IV-15. Radiochemical Analysis of Surface Water near Jemez, Nambé, and Taos Pueblos for 1993

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA[a] (µg/L)	Total Uranium ICPES[b] (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)
Jemez Pueblo											
Jemez River at Pueblo Intakes	0.3 (0.3)[c]	0.4 (1.8)	1.4 (1.2)	N/A[d]	N/A	0.030 (0.030)	0.098 (0.022)	0.024 (0.030)	0 (1)	5 (1)	-40 (90)
Vallecitos Cr.	0.5 (0.3)	0.9 (1.3)	2.4 (1.3)	N/A	N/A	-0.004 (0.030)	0.018 (0.020)	0.000 (0.000)	-2 (2)	8 (1)	110 (100)
Nambé Pueblo											
Nambé Reservoir Inlet SW	0.3 (0.3)	N/A	N/A	N/A	N/A	0.005 (0.030)	0.011 (0.020)	N/A	7 (2)	13 (1)	50 (100)
Nambé Reservoir Outlet SW	0.2 (0.3)	N/A	N/A	N/A	N/A	0.006 (0.030)	0.000 (0.020)	N/A	2 (1)	2 (0)	20 (100)
Taos Pueblo											
Rio Lucero	0.6 (0.3)	0.7 (0.7)	-0.2[e] (33.3)	N/A	N/A	0.000 (0.030)	0.048 (0.020)	1.786[e] (33.300)	0 (1)	2 (0)	20 (90)
Rio Del Pueblo	0.4 (0.3)	0.2 (0.7)	13.1[e] (36.4)	N/A	N/A	0.072 (0.054)	0.024 (0.054)	-1.200[e] (33.500)	0 (1)	6 (1)	160 (90)
Taos Pueblo East	0.2 (0.3)	0.4 (0.8)	3.0 (1.3)	N/A	N/A	0.041 (0.052)	0.054 (0.038)	0.026 (0.030)	1 (1)	3 (1)	190 (100)
Limits of Detection	0.4	3	2		1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose	2000	1000	3000	800	800	40	60	30			
DOE Drinking Water System DCG			120			1.6	1.2	1.2			
EPA Primary Drinking Water Standard	20	8		20	20				15		
EPA Screening Level										50	

[a]KPA = kinetic phosphorimetric analysis.
[b]ICPES = inductively coupled plasma emission spectrometry.
[c]Counting uncertainties (±1 Standard Deviation) are shown in parentheses.
[d]N/A means analysis not performed, lost in analysis, or not completed.
[e]Mean of multiple samples.

Table IV-16. Radiochemical Analysis of Groundwater near Taos Pueblo

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA[a] (µg/L)	Total Uranium ICPES[b] (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)
Taos											
Bison Pasture Spring	0.3[c] (0.3)[d]	0.2 (0.7)	-10.7 (36.7)	N/A[e]	N/A	0.00 (0.03)	0.009 (0.020)	-12.035 (36.900)	1 (1)	2 (0)	160 (90)
Limits of Detection	0.4	3	2	0.1	1	0.02	0.02	0.02	3	3	
DOE Public Dose Limit	2000	1000	3000	800	800	40	60	30			
Drinking Water System DCG			120			1.6	1.2	1.2			
EPA Primary Standard	20	8		20	20				15	50	
EPA Secondary Screening Level											
NMWQC Groundwater Limit				5000	5000						

[a]KPA = kinetic phosphorimetric analysis.
[b]ICPES = inductively coupled plasma emission spectrometry.
[c]Mean of multiple samples.
[d]Counting uncertainties (±1 Standard Deviation) are shown in parentheses.
[e]N/A means analysis not performed, lost in analysis, or not completed.

Table IV-17. Chemical Quality of Surface Waters Near Jemez, Nambé and Taos Pueblos for 1993 (mg/L)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
Jemez Pueblo																	
Jemez River at Pueblo Intakes	30	33	3.6	N/A[c]	21	21	0.4	<5[d]	113	0.0	8	<0.04	N/A	220	98	8.4	294
Vallecitos Cr.	54	0	0.0	N/A	0	10	0.9	12	162	0.0	41	<0.04	N/A	300	114	9.1	423
Nambé Pueblo																	
Nambé Reservoir Inlet	16	5	1.6	1	1	1	<0.1	<5	13	0.1	4	0.08	N/A	68	20	7.0	36
Nambé Reservoir Outlet	19	5	1.2	1	2	1	<0.1	<5	12	0.0	4	<0.04	N/A	76	18	7.9	53
Taos Pueblo																	
Rio Lucero	7	19	1.6	<1	1	1	0.2	<5	57	N/A	8	0.20	N/A	138	55	7.9	95
Rio Del Pueblo	8	34	6.2	<1	3	2	<0.1	<5	98	N/A	20	<0.04	N/A	118	111	8.2	222
Taos Pueblo Landfill	18	19	2.9	2	2	2	0.1	<5	57	0.1	4	<0.04	N/A	92	59	7.8	126
EPA Primary Drinking Water Standard							4					10	0.2				
EPA Secondary Drinking Water Standard											250			500		6.8-8.5	
EPA Health Advisory					20												

[a]Total dissolved solids.

[b]Standard Units.

[c]N/A means analysis not performed, lost in analysis, or not completed.

[d]The less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Table IV-18. Chemical Quality of Groundwater at Taos and Nambé Pueblos for 1993 (mg/L)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
Taos Pueblo																	
Bison Pasture Spring	12	18	2.3	1	2	1	0.2	<5[c]	60	N/A[d]	7	0.06	N/A	30	55	7.0	96
Nambé Pueblo																	
Nambé Community Center Well	24	67	3.8	6	19	9	1.6	<5	202	0.0	11	0.91	N/A	288	183	7.7	432
EPA Primary Drinking Water Standard							4					10	0.2				
EPA Secondary Drinking Water Standard											250			500		6.8-8.5	
EPA Health Advisory					20												
NMWQCC Groundwater Limit						250	1.6					10					

[a]Total dissolved solids.
[b]Standard Units.
[c]The less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[d]N/A means analysis not performed, lost in analysis, or not completed.e

Table IV-19. Total Recoverable Trace Metals in Surface Water Near Jemez, Nambé, and Taos Pueblos for 1993 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Jemez Pueblo												
Jemez River at Pueblo Intakes	<0.010[a]	0.31	0.0217	0.1600	0.0840	<0.001	<0.003	<0.004	<0.004	<0.0040	0.42	<0.0002
Vallecitos Cr.	<0.000	<0.00	0.0137	0.0001	0.0001	<0.000	<0.000	<0.000	<0.000	<0.0000	<0.00	<0.0002
Nambé Pueblo												
Nambé Reservoir Inlet SW	0.010	2.00	<0.0020	<0.0100	0.0490	<0.001	<0.003	<0.004	0.008	0.0280	3.00	<0.0002
Nambé Reservoir Outlet SW	<0.010	0.32	<0.0020	<0.0100	0.0140	<0.001	<0.003	<0.004	<0.004	0.0050	0.41	<0.0002
Taos Pueblo												
Rio Lucero	<0.001	<0.03	<0.0020	<0.0100	0.0230	<0.001	<0.002	<0.010	<0.004	0.0011	<0.01	<0.0001
Rio Del Pueblo	<0.001	0.11	<0.0020	<0.0100	0.0370	<0.001	<0.002	<0.010	<0.004	0.0015	<0.01	<0.0001
Taos Pueblo Landfill	<0.010	<0.10	0.0027	<0.4000	0.0420	<0.001	<0.003	0.008	<0.004	<0.0040	17.00	<0.0002
EPA Primary Drinking Water Standard	0.05		0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard											0.3	
EPA Action Level										1.3		
Livestock Wildlife Watering Limit		5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Jemez Pueblo											
Jemez River at Pueblo Intakes	0.038	0.019	<0.01	<0.001	<0.001	<0.002	<0.000	0.0002	<0.001	<0.00	0.0000
Vallecitos Cr.	0.000	0.000	<0.00	<0.001	<0.001	<0.002	<0.000	0.0005	<0.001	0.00	0.0000
Nambé Pueblo											
Nambé Reservoir Inlet SW	0.150	0.210	0.05	0.007	0.002	<0.002	<0.030	0.0280	<0.001	0.01	0.0720
Nambé Reservoir Outlet SW	0.037	<0.008	0.03	0.001	<0.001	<0.002	<0.030	0.0230	<0.001	<0.00	0.0290
Taos Pueblo											
Rio Lucero	<0.001	<0.005	<0.01	<0.010	<0.001	<0.002	<0.005	0.0740	<0.005	<0.01	0.0057
Rio Del Pueblo	<0.001	<0.005	<0.01	<0.010	<0.001	<0.002	<0.005	0.1190	<0.005	<0.01	0.0082
Taos Pueblo Landfill	0.170	<0.008	<0.01	<0.002	<0.002	<0.002	<0.030	0.0860	<0.002	0.01	0.0250
EPA Primary Drinking Water Standard			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard	0.05										5.0
EPA Action Level				0.015							
EPA Health Advisory								25-90		0.08-0.11	
Livestock Wildlife Watering Limit				0.1						0.1	25.0

[a]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Table IV-20. Total Recoverable Trace Metals in Groundwaters Near Taos and Nambé Pueblos for 1993 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Taos Pueblo												
Bison Pasture Spring	<0.001[a]	0.030	<0.0020	<0.010	0.019	<0.0010	<0.002	<0.010	<0.004	0.0015	0.14	<0.0001
Nambé Pueblo												
Nambé Community Center Well	0.012	<0.009	0.0027	0.026	0.140	<0.0003	<0.006	<0.001	<0.007	0.0800	0.01	<0.0002
EPA Primary Drinking Water Standard	0.05		0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard											0.3	
EPA Action Level										1.3		
Livestock Wildlife Watering Limit		5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01
NMWQCC Groundwater Limit	0.05		0.1		1.0		0.01		0.05			0.002

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Taos Pueblo											
Bison Pasture Spring	<0.001	<0.005	<0.010	<0.010	<0.001	<0.002	<0.005	0.075	<0.005	<0.01	0.0083
Nambé Pueblo											
Nambé Community Center Well	<0.002	<0.006	<0.009	0.002	<0.001	<0.002	<0.020	0.390	<0.002	0.00	<0.0200
EPA Primary Drinking Water Standard			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard	0.05										5.0
EPA Action Level				0.015							
EPA Health Advisory								25-90		0.08-0.11	
Livestock Wildlife Watering Limit				0.1						0.1	25.0
NMWQCC Groundwater Limit				0.05		0.05					

[a]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Table IV-21. Total Recoverable Trace Metals in Soil Samples near Taos Pueblo for 1993 (μg/g)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Taos Pueblo												
Bison Pasture												
Station 5	<1.0[a]	20,000.0	4.2	3.5	190.0	0.89	<0.40	10.0	16.0	31.0	20,000.0	<0.01
Station 6B	<1.0	16,000.0	1.9	<1.0	130.0	0.80	<0.40	6.3	28.0	37.0	9,900.0	<0.01
Station 7	<1.0	13,000.0	2.1	<1.0	100.0	0.53	0.78	9.0	28.0	28.0	16,000.0	<0.01

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Taos Pueblo											
Bison Pasture											
Station 5	450.0	<4.00	12.0	24.0	<0.2	1.4	<4.0	46.0	0.2	32.0	160.0
Station 6B	110.0	<4.00	13.0	24.0	<0.3	4.2	<4.0	44.0	<0.3	34.0	140.0
Station 7	180.0	1.40	15.0	21.0	<0.3	1.7	<4.0	35.0	<0.3	40.0	140.0

[a]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.

Table IV-22. Radioactivity in Soil Samples near Taos Pueblo for 1993

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
Taos Pueblo										
Bison Pasture										
Station 5	0.3[a] (0.3)	0.4 (0.2)	0.3 (0.1)	N/A[b]	0.009 (0.003)	0.009 (0.002)	0.006 (0.003)	12 (3)	7 (1)	5 (1)
Station 6A	0.0 (0.3)	0.2 (0.2)	0.2 (0.1)	N/A	0.040 (0.003)	0.010 (0.002)	0.006 (0.002)	7 (2)	11 (1)	3 (1)
Station 6B	0.1 (0.3)	0.5 (0.2)	0.2 (0.1)	N/A	0.000 (0.003)	0.010 (0.002)	0.005 (0.002)	10 (2)	12 (1)	4 (1)
Station 6C	0.2 (0.3)	N/A	6.7 (3.6)	N/A	0.002 (0.003)	0.009 (0.003)	0.000 (0.005)	N/A	N/A	-150 (20)
Station 7	0.4 (0.3)	0.2 (0.2)	0.9 (0.2)	N/A	0.002 (0.003)	0.026 (0.003)	0.009 (0.002)	11 (2)	10 (1)	5 (1)

[a]Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.

[b]N/A means analysis not performed, lost in analysis, or not completed.

Table IV-23. Total Recoverable Trace Metals[a] in Sediments from Nambé Reservoir for 1993 (µg/g)

Location	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg
Nambé Pueblo												
Nambé Inlet	<1.0[b]	5,100.0	1.1	<2.0	35.0	0.37	<1.00	7.9	4.2	8.8	9900.0	<0.10
Nambé Upper	<1.0	25,000.0	3.4	6.0	180.0	1.60	<0.25	22.0	10.0	35.0	27000.0	<0.10
Nambé Lower	<0.3	31,000.0	6.2	11.0	260.0	1.90	<1.00	20.0	11.0	30.0	26000.0	<0.10
Nambé Outlet	<1.0	6,900.0	2.5	3.2	72.0	0.51	<1.00	10.0	3.2	7.1	10000.0	<0.10

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Nambé Pueblo											
Nambé Inlet	150.0	<1.5	5.3	<4.0	<0.12	0.6	3.5	8.6	<0.12	17.0	45.0
Nambé Upper	440.0	<1.0	15.0	21.0	<0.12	1.9	6.0	48.0	0.23	45.0	83.0
Nambé Lower	610.0	<1.0	16.0	20.0	<0.12	1.1	8.2	100.0	0.36	43.0	80.0
Nambé Outlet	210.0	<1.0	8.7	<4.0	<0.30	0.8	<7.0	47.0	<0.12	14.0	26.0

[a]EPA Analytical Procedure SW-846, Method 3050.
[b]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.

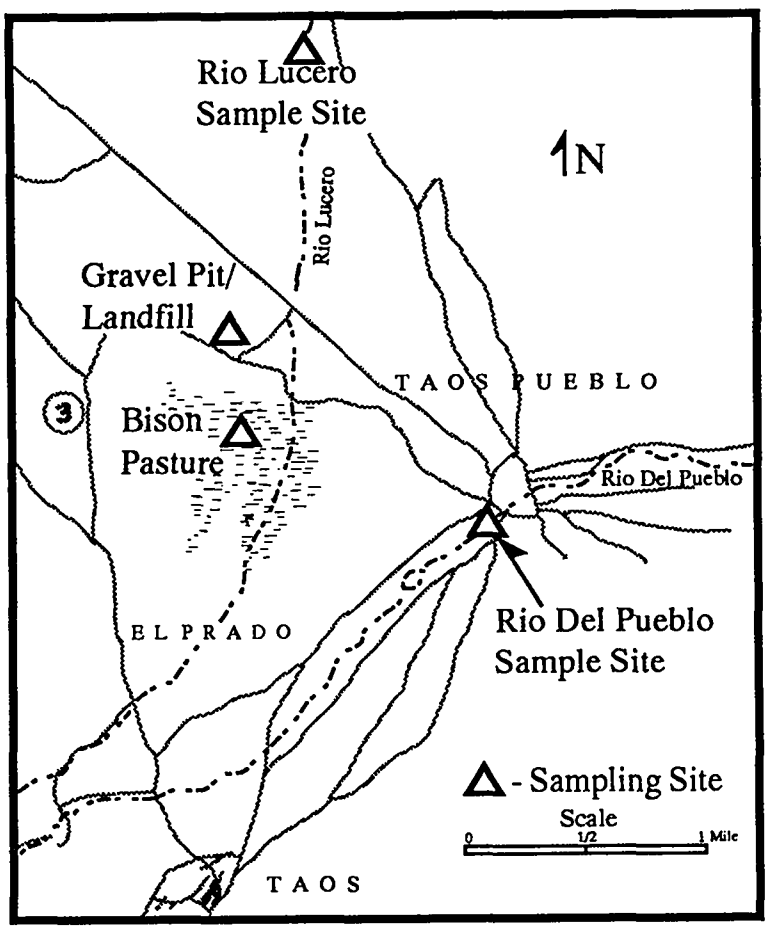


Figure IV-9. Location of sampling sites at Taos Pueblo.

(LLW that also contains nonradioactive hazardous waste components) management at DOE facilities. This order applies only to wastes disposed of after the order became effective. The order requires a performance assessment (PA) of the disposal site to demonstrate compliance with specific performance objectives including

- protecting public health and safety;
- ensuring that external exposure to the waste and concentrations of radioactive material that may be released into surface water, groundwater, or soil or that may be transmitted through contact with plants or animals result in an effective dose equivalent (EDE) that does not exceed 25 mrem/yr to any member of the public;
- ensuring that the committed EDEs received by individuals who inadvertently intrude into the waste disposal facility after the period of active institutional control (100 yrs) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure; and
- protecting groundwater resources, consistent with federal, state, and local requirements.

Performance Assessment for TA-54, Area G. TA-54, Area G is the Laboratory's only active site for the disposal of solid radioactive wastes. The PA for TA-54, Area G was initiated in 1989.

The following sections of the PA document for TA-54, Area G were completed in 1993: Introduction, Performance Objectives, Geography, and Demographics. The following sections were drafted but had not received complete review by the Laboratory by the end of 1993: Geology and Seismology, Hydrogeology, Climate and Meteorology, Ecology and Biotic Conditions, Unusual Events, Waste Generation, Characteristics and Disposal, Environmental Radiation Monitoring and Background, and Pathways and Scenarios. These sections and the calculations for the PA are expected to be complete in early 1994. Screening calculations have been performed and provided to EM-7 for the development of performance-based waste acceptance criteria. Preliminary calculations indicate that the primary radionuclide of concern at TA-54, Area G over the next 10,000 years is ^{241}Am.

Performance Assessment for the Mixed Waste Disposal Facility. The principal goal of the Mixed Waste Disposal Facility (MWDF) is to dispose of solid mixed waste in compliance with the regulatory and operational requirements of RCRA and DOE. A PA for the MWDF, proposed to be located at TA-67, was initiated in late 1992.

Several sections of the PA document were completed in 1993; however, the radionuclide of concern could not be determined because of the lack of a clear inventory of ER activities. Because the MWDF is a new facility, a significant amount of data needs to be collected to validate the modeling effort and to justify the assumptions made. Some of this information will become available during the preoperational surveys that are required at least one year before beginning construction; the rest of the data will become available as a "maintenance" item for the PA. Environmental surveillance of the area will be established from the data obtained during the preoperational surveys.

8. Preoperational Studies. (Philip Fresquez, ESH-20)

Preoperational studies are required under DOE Order 5400.1 for areas where a new facility or process may significantly impact the environment (DOE 1988a). This order requires that chemical, physical, and biological characteristics be assessed before the site is disturbed.

Two studies associated with the proposed Dual Axis Radiographic Hydrotest Facility (DARHT) at TA-15 were conducted in 1993 by the EARE section of EM-8. These studies included: (1) a baseline soil surface uranium and beryllium survey over the proposed DARHT facility, and (2) a soil surface and sediment chemical (heavy metals, semivolatile organic compounds (SVOCs), HE residues, and total uranium) survey over the Pulsed High Energy Radiation Machine Emitting X-Rays (PHERMEX) Facility firing site. DARHT is proposed to replace PHERMEX in the near future. Therefore, these two studies were conducted to determine potential pre- and post-disturbance impacts to the environment from these firing site activities.

DARHT Study. On August 18, 1993, EM-8 collected five soil surface composite samples for chemical analysis of uranium and beryllium on and around the proposed site of the DARHT facility at TA-15 (Fresquez 1994a). Average baseline concentrations of uranium and beryllium detected at the site are presented in Table IV-24.

Total uranium is just above the regional statistical (natural and worldwide fallout) reference level, whereas, beryllium is within soil standards measured around the Los Alamos area.

Table IV-24. Average Baseline Concentrations of Uranium and Beryllium at the DARHT Site

	Total U (μg/g)	Total Be (μg/g)
Mean (±2SD)	4.3 (±4.4)	0.91 (±1.82)
RSRL[a]	3.4[b]	2.88[c]

[a]Regional Statistical Reference Level.
[b]Data from Purtymun 1987a.
[c]Data from Ferenbaugh 1990.

PHERMEX Study. On April 7, 1993, EM-8 collected over 20 soil and sediment samples over the PHERMEX firing site at TA-15 (Fresquez 1994b). Soil samples were collected at the 0- to 3-in. depth along the length (0, 20, 40, 80, 160, and 200 ft) of each of four transects radiating outward from the center of the detonation area towards the northeast, east, southeast, and south southeast. Also sediment samples were collected from two drainage channels located down gradient of the detonation area. Soil and sediment samples were analyzed for Toxic Chemical Leaching Procedure (TCLP) metals (silver, arsenic, barium, cadmium, chromium, mercury, lead, and selenium), total heavy metals (beryllium, gallium, mercury, lead, and thorium), total uranium, HE residues, and SVOCs. The following are the major findings of this study:

- Most TCLP metals in soil and sediment samples were detected below proposed EPA action levels; two samples, however, contained TCLP-Pb above 5 μg/g (ppm).
- Many soil samples contained levels of beryllium (ranged from 0.2 to 218 μg/g), and total lead (ranged from 2.9 to 230 μg/g) above regional statistical soil background levels (i.e., beryllium = 2.88 μg/g and lead = 28.4 μg/g).
- No TCLP or total heavy metals were detected above EPA or background concentrations in any of the drainage channels.
- Over 21 SVOCs were detected over the PHERMEX firing site. Also, some SVOCs were detected at μg/kg (ppb) levels in the drainage channels.
- No traces of HE materials were detected in any of the soil or sediment samples.
- Total uranium in soil samples collected over the firing site ranges in concentrations from 0.8 to 13,398 μg/g. The average concentration over the entire site was 1,210 μg/g.
- Total uranium in sediments samples collected from the drainage channels ranged in concentration from 11.5 to 105 μg/g.
- With the exception of uranium, no other contaminants were detected above background concentrations beyond 200 ft of the detonation site. Total uranium concentrations 200 ft away from the detonation area averaged 27 μg/g.
- A regression of the uranium data with distance from the firing site shows that above background concentrations of uranium (e.g., 3.4 μg/g) would not be expected past 422 ft. (Fresquez 1995a).

9. Biological Resource Evaluations. (Terralene Foxx, Kathryn Bennett, James Biggs, David Keller, Tim Haarmann, Saul Cross, and Daniel Dunham, ESH-20)

a. Biological Surveys/Monitoring. In 1990, the Biological Resources Evaluation Team (BRET) began monitoring selected biota and sensitive habitats to provide long-term data in accordance with the Endangered

Species Act, Floodplain and Wetland Executive Orders, NEPA, and DOE Order 5400.1 (DOE 1988a). Monitoring studies on birds, reptiles and amphibians, small mammals, and invertebrates continued through 1993.

Aquatic Invertebrates. For the past four years, BRET conducted field studies of stream macroinvertebrate communities associated with outfalls of sanitary and industrial waste in Sandia Canyon. During the 1993 study, two extra stations were added for a total of five sampling stations. Results of the Sandia Canyon study were similar to those obtained in previous years. Data obtained from the stations indicated that the number and diversity of macroinvertebrate communities in Sandia Canyon are a function of water quality and physical characteristics of the stream. Diversity of macroinvertebrates generally increased with increased distance from a outfall area.

In addition to the study in Sandia Canyon, BRET collected aquatic macroinvertebrates from three sampling stations in Los Alamos and Guaje canyons. These stations will provide baseline data on aquatic macroinvertebrates. Data comparisons were made between Los Alamos Canyon (on-site canyon) and Guaje Canyon (off-site canyon). Initial data analyses show that aquatic communities are more diverse and richer in Guaje Canyon. The data also suggest that within each canyon, diversity and richness decrease with distance downstream. Fluctuations in stream flow appeared to be a major reason for decreases in diversity and richness. Periodic drought was seen at several sampling stations. This study will continue into 1994. Table IV-25 lists the macroinvertebrates that have been collected and identified in these studies. Aquatic insects collected from Los Alamos county and adjacent watersheds are presented in Table D-11.

Terrestrial Invertebrates. BRET conducted studies of terrestrial insects in both Los Alamos and Guaje canyons during 1993. Pit traps for terrestrial insects yielded large numbers of insects orders, genera, and species. More than 15,000 individual arthropods were trapped and identified. The results of the analysis indicated that at a 95% confidence interval, there is no significance difference in the arthropods in Los Alamos Canyon and those in Guaje Canyon for equivalent time periods and equivalent number of trapping days. Table IV-26 is a list of the insect families that have been collected on LANL property as of October 1993. Noninsect aquatic invertebrates collected from Los Alamos County and adjacent watersheds are presented in Table D-12.

Reptiles and Amphibians. During 1993, populations of reptiles and amphibians were monitored in Pajarito Canyon. Many-lined skink was the most abundant reptile captured, and the chorus frog the most abundant amphibian. Table IV-27 lists species captured during 1993.

Birds. During the 1993 field season, eight bird surveys were conducted. Surveys covered areas of Los Alamos, Guaje, Cañada del Buey, and Pajarito canyons, and 73 species of resident birds were encountered. Table IV-28 lists the species identified in these surveys.

In addition to these surveys, a systematic survey was conducted on LANL lands for the northern goshawk, a candidate under the federal Endangered Species Act. The survey was conducted within all areas of potential habitat (ponderosa pine overstory). No nesting goshawk were found on LANL lands; however, portions of LANL lands were determined to be in a goshawk post-fledging management area. These areas will continue to be monitored and managed for northern goshawks.

Medium Size and Large Mammals. In 1993, BRET conducted scent station surveys for medium and large size predator species of mammals. The primary purpose of collecting this data was to obtain sufficient information to evaluate use of the canyon systems by predator species and to possibly identify annual and seasonal trend use. Two transects were established in each canyon system, approximately 1.6 km (0.99 mi) apart. Each transect had a total of 10 scent stations that were placed 0.32 km (0.2 mi) apart. A scent station consisted of a circular plot of moist sifted topsoil with a centrally placed attractor. Due to extremely low visitation rates, access problems, and adverse weather conditions, Guaje Canyon sites were only monitored for two months. Bobcat and raccoon were the most common species recorded at the scent stations. Figure IV-10 gives the relative frequencies of each carnivore species recorded at the scent stations in Los Alamos Canyon.

Small Mammals. In 1993, BRET conducted field surveys in Guaje and Los Alamos canyons for small mammals. BRET used live-capture and release studies to obtain data to estimate population size and density of rodents. Two sites were trapped in each canyon, one in the mixed conifer and the second in ponderosa pine. A 12 × 12 grid was laid out at each site and centered within the canyon bottom. Program CAPTURE was used to estimate population size and density. The deer mouse was the only species captured in all trapping locations. Shrews and voles were only captured in the mixed conifer habitat types. Only two species, the deer mouse and

Table IV-25. Aquatic Macroinvertebrates Found (and Confirmed) in Los Alamos County

Non-Insect Macroinvertebrates

Phylum	Class, etc.
Annelida	Oligochaeta
Annelida	Oligochaeta B
Annelida	Oligochaeta seedworm
Arthropoda	Arachnoidea, Hydracarina
Crustacea	Amphipoda, Hyalella azteca
Crustacea	Cladocera
Crustacea	Copepoda
Crustacea	Ostracoda, Candoniidae, Candona
Crustacea	Ostracoda, Cyprididae, Cypris
Mollusca	Gastropoda
Mollusca	Gastropoda, Gyralus parvus
Mollusca	Gastropoda, Lymnaea
Mollusca	Gastropoda, Physa
Mollusca	Pelecypoda, Pisidium casertanum
Nematoda	
Nematomorpha	Gordius
Nematomorpha	
Platyhelminthes	Turbellaria

Insect Macroinvertebrates

Order	Family	Genus (species)
Collembola	Isotomidae	
Plecoptera	Chloroperlidae	
	Nemouridae	Amphinemura
	Nemouridae	Malenka
	Nemouridae	Podmosta delicatula
	Nemouridae	Zapada frigida
	Perlidae	Hesperoperla pacifica
	Perlodidae	Isoperla
	Perlodidae	Kogotus (modestus)
	Pteronarcyidae	Pteronarcella (badia)
	Pteronarcyidae	Pteronarcys
Ephemeroptera	Baetidae Baetis	
	Baetidae	Callibaetis
	Ephemerellidae	Drunella (coloradensis)
	Ephemerellidae	Drunella (doddsi)
	Ephemerellidae	Ephemerella (inermis)
	Ephemerellidae	Ephemerella (infrequens)
	Heptageniidae	Cinygmula
	Heptageniidae	Epeorus
	Leptophlebidae	Paraleptophlebia
	Siphlonuridae	Ameletus
	Siphlonuridae	Siphlonurus
	Tricorythidae	Tricorythodes (minutus)

Table IV-25. (Cont.)

Order	Family	Genus (species)
Hemiptera	Corixidae	Trichocorixa
	Gerridae	Gerris
	Gerridae	Metrobates
	Naucoridae	Ambrysus (mormon)
	Notonectidae	
	Veliidae	Microvelia
Odonata	Aeshnidae	Aeshna
	Aeshnidae	Boyeria
	Coenagriidae	Enallagma
	Lestidae	Archilestes
	Libellulidae	Leucorrhina
	Libellulidae	Sympetrum
Trichoptera	Brachycentridae	Micrasema
	Brachycentridae pupae	Micrasema
	Glossosomatidae	Agapetus
	Glossosomatidae	Glossosoma
	Helicopsychidae	Helicopsyche
	Hydropsychidae	Arctopsyche (grandis)
	Hydropsychidae	Cheumatopsyche
	Hydropsychidae	Hydropsyche
	Hydroptilidae	Hydroptila
	Lepidostomatidae	Lepidostoma large
	Lepidostomatidae	Lepidostoma small
	Leptoceridae	Oecetis
	Limnephilidae	Amphicosmoecus (cana)
	Limnephilidae	Hesperophylax
	Limnephilidae	Limnephilus
Trichoptera	Limnephilidae	Oligophlebodes
	Odontoceridae	Namamyia
	Philopotamidae	Dolophilodes
	Rhyacophilidae	Rhyacophila (brunnea)
	Rhyacophilidae	Rhyacophila (brunnea) pupae
Lepidoptera	Noctuidae	
	Pyralidae	
	Pyralidae	Paralygraotes
Coleoptera	Dryopidae	Helichus
	Dryopidae adults	Helichus
	Dytiscidae adults	Deronectes
	Dytsicidae adults	Hydroporus
	Dytiscidae adults	Laccophilus
	Elmidae	Heterlimnius (corpulentus)
	Elmidae adults	Heterlimnius (corpulentus)
	Elmidae	Narpus
	Elmidae adults	Narpus
	Elmidae	Zaitzevia
	Elmidae adults	Zaitzevia
	Gyrinidae adults	Gyrinus
	Haliplidae adults	Haliplus
	Helodidae	Prionocyphon
	Hydrophilidae	Ametor

Table IV-25. (Cont.)

Order	Family	Genus (species)	
Coleoptera (Cont.)		Hydrophilidae adult	Ametor
	Hydrophilidae adult	Helophorus	
	Hydrophilidae	Hydrochus	
	Psephenidae		
Diptera	Ceratopogonidae		
	Ceratopogonidae	Bezzia	
	Chironomidae	bagworms	
	Chironomidae	blackheads	
	Chironomidae	browns	
	Chironomidae	casemakers	
	Chironomidae	regulars	
	Chironomidae	smallheads	
	Chironomidae	tentacles	
	Chironomidae pupae		
	Culicidae		
	Culicidae	Chaoborus	
	Dixidae	Dixa	
	Dixidae Dixa A		
	Empididae	Chelifera	
	Empididae	Oreogeton	
	Muscidae	Limnophora	
	Psychodidae	Maruina	
	Psychodidae	Pericoma	
	Psychodidae	pupae	
	Ptychopteridae	Bittacomorpha	
	Ptychopteridae	Ptychoptera	
	Simuliidae		
	Simuliidae pupae		
	Stratiomyidae		
	Stratiomyidae	Odontomyia	
	Tipulidae	Antocha	
	Tipulidae	Dicranota	
	Tipulidae	Tipula	
	Tipulidae	Tipula B	

Table IV-26. Terrestrial Insects Found on LANL Property as of October 1993

Order	Family	Common Name
Thysanura (Bristletails)	Lepismatidae	Silverfish
Collembola (Springtails)	Sminthuridae	Globular springtail
	Entomobryidae	Elongate-bodied springtail
Odonata (Dragon and damselflies)	Aeshnidae	Darner
	Libellulidae	Common skimmer
	Coenagrionidae	Narrow-winged damselfly
	Gomphidae	Clubtail
Orthoptera (Grasshoppers and crickets)	Acrididae	Short-horned grasshopper
	Gryllacrididae	Camel cricket
	Gryllidae	True cricket
Plecoptera (Stoneflies)	Perlidae	Common stonefly
Dermaptera (Earwigs)	Forficulidae	Common earwig
Thysanoptera (Thrips)	Thripidae	Common thrip
Hemiptera (True bugs)	Belostomatidae	Giant water bug
	Miridae	Plant bug
	Reduviidae	Assassin bug
	Phymatidae	Ambush bug
	Lygaeidae	Seed bug
	Cydnidae	Burrower bug
	Scutelleridae	Shield-backed bug
	Pentatomidae	Stink bug
	Anthocoridae	Minute pirate bug
Homoptera (Cicadas and kin)	Cicadidae	Cicada
Neuroptera (Net-veined insects)	Myrmeleontidae	Antlion
	Raphidiidae	Snakefly
Coleoptera (Beetles)	Cicindelidae	Tiger beetle
	Carabidae	Ground beetle
	Silphidae	Carrion beetle
	Lampyridae	Firefly
	Cantharidae	Soldier beetle
	Lycidae	Net-winged beetle
	Buprestidae	Metallic wood-boring beetle
	Staphylinidae	Rove beetle
	Erotylidae	Pleasing fungus beetle
	Nitidulidae	Sap beetle
	Coccinellidae	Ladybird beetle
	Tenebrionidae	Darkling beetle
	Meloidae	Blister beetle
	Cerambycidae	Long-horned beetle
	Lucanidae	Stag beetle
	Scarabaeidae	Scarab beetle
	Chrysomelidae	Leaf beetle
	Curulionidae	Weevil
	Dermestidae	Dermestid beetle
Lepidoptera (Butterflies, moths)	Papilionidae	Swallowtail
	Lycaenidae	Copper
	Hesperiidae	Skipper
	Pieridae	White, sulphur, and orange
	Nymphalidae	Brush-footed butterfly
	Satyridae	Satyr, nymph, and artic

Table IV-26. (Cont.)

Order	Family	Common Name
Lepidoptera (Butterflies, moths) (Cont.)	Noctuidae	Noctuid moth
	Sphingidae	Sphinx moth
	Saturniidae	Giant silkworm moth
	Pterophoridae	Plume moth
Diptera (Flies)	Tabanidae	Horse and deer flies
	Therevidae	Stiletto fly
	Asilidae	Robber fly
	Bombyliidae	Bee fly
	Syrphidae	Hover fly
	Tachinidae	Tachinid fly
Hymenoptera (Bees, ants, wasps)	Ichneumonidae	Ichneumonid wasp
	Cynipidae	Gall wasp
	Mutillidae	Velvet ant
	Scoliidae	Scoliid wasp
	Formicidae	Ant
	Pompilidae	Spider wasp
	Eumenidae	Euminid wasp
	Vespidae	Vespid wasp
	Sphecidae	Sphecid wasp
	Halictidae	Metallic wasp
	Megachilidae	Leafcutting bee
	Apidae	Honey and bumble bees

Table IV-27. Species of Amphibian and Reptiles Captured in Pajarito Canyon during 1993

Common Name	Scientific Name	Number Caught	Relative Abundance (%)
Many-lined skink	*Eumeces multivirgatus*	50	36.76
Plateau whiptail	*Cnemidophorus velox*	23	16.91
Chorus frog	*Pseudacris triseriata*	22	16.18
Eastern fence lizard	*Sceloporus undulatus*	13	9.56
Western terrestrial garter snake	*Thamnophis elegans*	10	7.35
Woodhouse toad	*Bufo woodhousei*	9	6.62
Tiger salamander	*Ambystomia tigrinum*	5	3.68
Great Plains skink	*Eumeces obsoletus*	1	0.74
Canyon tree frog	*Hyla arenicolor*	1	0.74
Short-horned lizard	*Phrynosoma douglassii*	1	0.74
Couch's spadefoot toad	*Scaphiopus couchii*	1	0.74
TOTAL		136	100.00

Table IV-28. Species Identified in Bird Surveys during 1993

Common Name	Scientific Name
Acorn Woodpecker	*Melanerpes formicivorus*
American Kestrel	*Falco sparverius*
American Robin	*Turdus migratorius*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Barn Swallow	*Hirundo rustica*
Bell's Vireo	*Vireo bellii*
Black-chinned Hummingbird	*Archilochus alexandri*
Brown-headed Cowbird	*Molothrus ater*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Blue Grosbeak	*Guiraca caerulea*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Bushtit	*Psaltriparus minimus*
Cassin's Kingbird	*Tyrannus vociferans*
Canyon Towhee	*Pipilo fuscus*
Canyon Wren	*Catherpes mexicanus*
Chipping Sparrow	*Spizella passerina*
Clark's Nutcracker	*Nucifraga columbiana*
Common Grackle	*Quiscalus quiscula*
Cooper's Hawk	*Accipiter cooperii*
Common Raven	*Corvus corax*
Dark-eyed Junco	*Junco hyemalis*
Downy Woodpecker	*Picoides pubescens*
Dusky Flycatcher	*Empidonax oberholseri*
Great-horned Owl	*Bubo virginianus*
Gray Flycatcher	*Empidonax wrightii*
Grace's Warbler	*Dendroica graciae*
Hairy Woodpecker	*Picoides villosus*
Hermit Thrush	*Catharus guttatus*
House Finch	*Carpodacus mexicanus*
House Sparrow	*Passer domesticus*
House Wren	*Troglodytes aedon*
Lesser Goldfinch	*Carduelis psaltria*
Lewis' Woodpecker	*Melanerpes lewis*
Mallard	*Anas platyrhynchos*
MacGillivray's Warbler	*Oporornis tolmiei*
Mountain Chickadee	*Parus gambeli*
Mourning Dove	*Zenaida macroura*
Northern Flicker	*Colaptes auratus*
Northern Goshawk	*Accipiter gentilis*
Piñon Jay	*Gymnorhinus cyanocephalus*
Pine Siskin	*Carduelis pinus*
Plain Titmouse	*Parus inornatus*
Pygmy Nuthatch	*Sitta pygmaea*
Red-breasted Nuthatch	*Sitta canadensis*
Ruby-crowned Kinglet	*Regulus calendula*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Red-tailed Hawk	*Buteo jamaicensis*
Rufous Hummingbird	*Selasphorus rufus*
Red-winged Blackbird	*Agelaius phoeniceus*

Table IV-28. (Cont.)

Common Name	Scientific Name
Say's Phoebe	*Sayornis saya*
Savannah Sparrow	*Passerculus sandwichensis*
Scrub Jay	*Aphelocoma coerulescens*
Solitary Vireo	*Vireo solitarius*
Sharp-shinned Hawk	*Accipiter striatus*
Steller's Jay	*Cyanocitta stelleri*
Summer Tanager	*Piranga ruber*
Townsend's Solitaire	*Myadestes townsendi*
Turkey Vulture	*Cathartes aura*
Vesper Sparrow	*Pooecetes gramineus*
Violet-green Swallow	*Tachycineta thalassina*
Virginia's Warbler	*Vermivora virginiae*
Warbling Vireo	*Vireo gilvus*
White-breasted Nuthatch	*Sitta carolinensis*
Western Bluebird	*Sialia mexicana*
Western Kingbird	*Tyrannus verticalis*
Western Meadowlark	*Sturnella neglecta*
Western Tanager	*Piranga ludoviciana*
Williamson's Sapsucker	*Sphyrapicus thyroideus*
Wilson's Warbler	*Wilsonia pusilla*
White-throated Swift	*Aeronautes saxatalis*
Western Wood-Pewee	*Contopus sordidulus*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*

harvest mouse, were captured in the ponderosa pine habitat type. The mixed conifer habitat type had a much higher species diversity and a much greater number of captures compared to the ponderosa habitat types indicating higher population estimates and densities in those locations. Table IV-29 lists the small mammals species captured in this study.

Before beginning the small mammal field study in Los Alamos and Guaje canyons, BRET was requested by the Centers for Disease Control (CDC) to collect blood samples from rodents captured. These samples were used to obtain information on hantavirus seroprevalence, a disease that had an outbreak in northern New Mexico in 1993. BRET incorporated the collection of blood samples into the project design before entering the field. To ensure the health and safety of the field crew, a strict protocol was instituted, which included wearing respirators, gowns, gloves and booties; the field crew wore this personnel protective equipment while handling rodents. Blood samples were sent to the CDC for analysis. Servoprevalence was determined to be about 5%.

Bats. In 1993, BRET directed bat surveys in Los Alamos and Guaje canyons. The purpose of the study was to (1) identify species of bats inhabiting Laboratory lands and (2) determine if the spotted bat (*Euderma maculatum*), listed as endangered by the NM Department of Game and Fish, was using Laboratory lands for foraging or roosting. *Euderma* has been found in the adjacent Jemez Mountains. Mist nets were set up in a variety of habitat types within each canyon. Researchers monitored the nets from dusk to 2:00 am or from midnight to dawn. Data recorded included species, sex, age, reproductive status, forearm length, height, direction of flight, and time of capture. A total of 143 bats were captured; species captured during the study and number of captures are recorded in Table IV-30. At Los Alamos Canyon, 45 bats from 11 species were captured; at Guaje Canyon 98 bats from 9 species were caught. Seven species were common to both canyons.

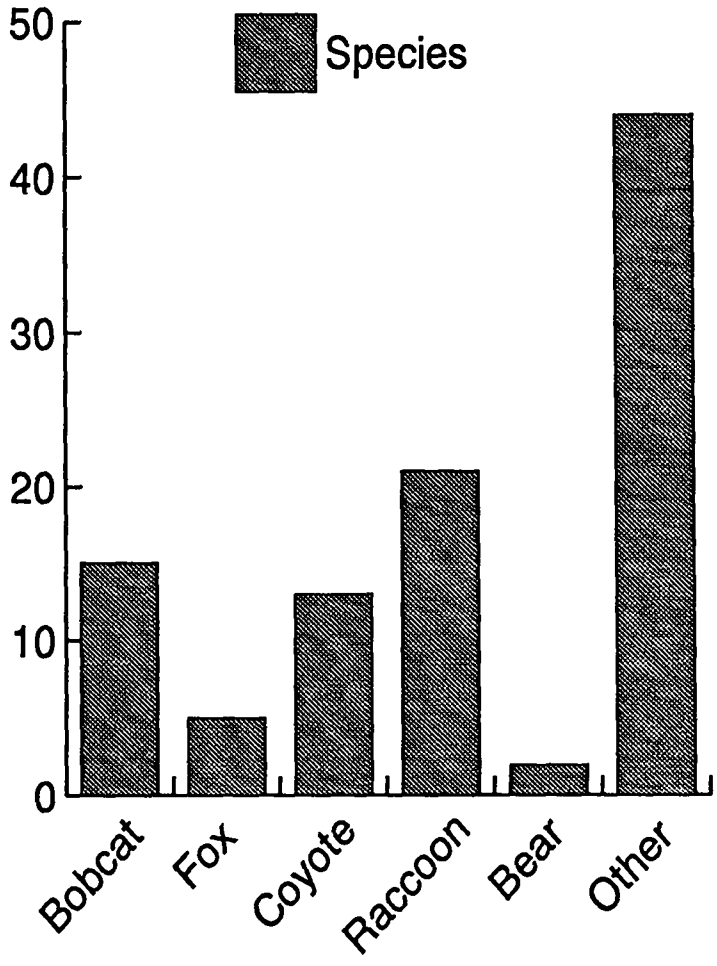


Figure IV-10. Relative frequencies for species recorded at scent stations in Los Alamos Canyon.

10. Biological Risk Assessment. (Roger Ferenbaugh, EES-15)

A formal ecological risk assessment program was initiated at the Laboratory in 1993 in response to requirements for ecological risk assessment and natural resource damage assessment in connection with implementation of the ER program.

Ecological risk assessment activities during 1993 consisted of assembling an Ecological Risk Assessment Team and educating ER program Operable Unit Leaders as to what ecological risk assessment is, why it is needed, and what to expect from it. By the end of the year, the nucleus of the team was in place, and preparations were underway to initiate ecological risk assessment activities. Information on ecological risk assessment and natural resource damage assessment is summarized in Appendix L of the ER Program Installation Work Plan (IWP 1993). A contract with Colorado State University was initiated for development of an Ecological Risk Assessment Model for use in the initial ecological risk assessment screening activities.

11. Stakeholder Involvement Activities at Los Alamos National Laboratory (Patricia Trujillo-Oviedo, SIO)

The Laboratory is currently expanding its efforts to involve the public in its decision-making processes. The Laboratory is committed to improving the processes for involving the public. Listed below are examples of how the Laboratory has interacted with the public and its plans for future interactions.

Table IV-29. Small Mammal Species Captured during 1993 in Los Alamos and Guaje Canyons by Habitat Types

Species	Ponderosa Pine Los Alamos	Ponderosa Pine Guaje	Mixed Conifer Los Alamos	Mixed Conifer Guaje
Least chipmunk			X	
Colorado chipmunk			X	
Long-tailed vole			X	X
Weasel			X	
Mexican woodrat				X
Brush mouse			X	X
Deer mouse	X	X	X	X
Harvest mouse	X			
Water shrew				X
Vagrant shrew				X
Shrew (unconfirmed species)			X	

Table IV-30. Number of Individuals per each Species Captured at Los Alamos Canyon and Guaje Canyon during Mist Net Surveys in 1993

Species	Los Alamos Canyon	Guaje Canyon
Antrozous pallidus	2	0
Eptesicus fuscus	1	9
Lasionycteris noctivagans	5	28
Lasiurus cinereus	1	8
Myotis californicus	6	3
Myotis evotis	7	7
Myotis leibii	8	9
Myotis thysanodes	2	24
Myotis volans	8	8
Myotis yumanensis	4	0
Pipistrellus hesperus	4	0
Tadarida brasiliensis	0	2
TOTALS		
Individuals	45	98
Species	11	9

- Laboratory representatives met individually with representatives from 27 public interest groups in northern New Mexico in early 1991 to discuss the interest groups' concerns. As an outgrowth of these contracts, the Laboratory hosted a series of dialogues to bring the groups together for further discussion.
- The Laboratory has recently cosponsored with various regional environmental interest groups events such as roundtable discussions, public fora, and conferences to address topics such as nuclear nonproliferation and the future of the Laboratory in the twenty-first century.
- Representatives of the Laboratory participated in the Working Group to Address Community Health Concerns. The group was formed in June 1991 by the Laboratory in response to concerns about a possible excess rate of brain tumors in the western area of Los Alamos. The Working Group was a collaboration between the Los Alamos community and the Los Alamos National Laboratory. The group held 34 meetings over a period of 30 months, providing a public forum on Laboratory operations and advocating the initiation of studies by appropriate organizations or persons to address these concerns. The group decided to disband in early 1994 because it felt it had concluded its mission.
- The ER program began public involvement activities with the development of the Community Relations Program Plan, published in 1990, and held public meetings and workshops in 1991 to discuss the five-year plan for environmental restoration and waste management and the draft 1991 Installation Work Plan.
- The ER program has held six sets of public information meetings since 1992. These meetings were held each time as a series in different locations (Los Alamos, Santa Fe, Espanola, and Taos).
- In addition to regularly scheduled information meetings, briefings have been given by ER program representatives to special interest groups such as local neighborhood associations, Los Alamos County Council, Eight Northern Pueblos Indian Council, the Pueblo of San Ildefonso, Los Alamos Board of Realtors, and Bandelier National Monument representatives to update the groups on current activities.
- The Laboratory sponsored special public briefings and tours of waste management facilities and facilities selected in the non-nuclear consolidation of the DOE Weapons Complex.
- In June 1993, the Laboratory relocated its Community Reading Room to the center of downtown Los Alamos to a more visible and accessible location. The Reading Room is a repository for documents of interest to the public about the Laboratory's activities.
- The Laboratory established a Native American Environmental Council to which 15 Pueblos from throughout New Mexico have been asked to nominate representatives. The council is intended to provide the Laboratory with Native American perspectives on a wide variety of environmental issues.
- The Laboratory established the Native American Coordinating Committee to coordinate Tribal relations and facilitate access to Laboratory officials by the Tribes. The committee has been the focal point of an environment, safety, and health outreach effort, which has resulted in approximately 35 visits with officials from nearby Pueblos and about 20 working-level visits for purposes of sampling and collaboration on environmental monitoring.
- In late 1993, the Laboratory established the Stakeholder Involvement Office (SIO) in the Office of the Laboratory Director. The primary responsibility of the SIO is to address public involvement issues, coordinate them across the Laboratory, and to serve as a primary contact at the Laboratory for stakeholders.
- SIO is also supporting DOE's Albuquerque Operations Office and the Los Alamos Area Office in the establishment of a citizens' advisory board to address Laboratory issues, following the recommendations of the Federal Facilities Environmental Restoration Dialogue Committee.
- A position paper for public access to information, in accordance with recommendations of the Federal Facilities Environmental Restoration Dialogue Committee, was signed by the national laboratory directors in October 1993. Policies for the implementation of this paper are being developed by SIO.

12. Waste Minimization and Pollution Prevention. (Micheline Devaurs, EM/P^{3}O)

The Laboratory's Waste Minimization and Pollution Prevention Program is funded by DOE in order to provide policy, guidance, oversight, and support to Laboratory organizations. These support funds have been used to build a

set of waste minimization tools and programs that can be used by generators to minimize their waste. Major accomplishments in 1993 include:

- Continued development of software tools for conducting Pollution Prevention Opportunity Assessments (PPOAs).
- Completed PPOAs on selected facilities: plutonium processing at TA-55, uranium processing at CMR, electroplating at Sigma, tritium processing, LAMPF, and Johnson Controls, Inc. construction services.
- Characterized mixed waste stream processes that need to be eliminated to comply with LANL's Federal Facilities Compliance Agreement. This information will be put into PPOAs.
- Recycled or reused almost 800 tons of materials that would have been sent to local landfills—from lead batteries and waste oil to office furniture and books.
- Distributed memos quarterly identifying excess chemicals available for exchange. An estimated 65% to 70% of chemicals available for exchange were successfully exchanged instead of disposed.
- Initiated external hazardous chemical recycling.
- Produced a waste minimization video and handbook for training and awareness. Additionally, waste minimization articles appeared monthly in the LANL Newsbulletin to highlight waste minimization efforts and successes around the Laboratory.
- Initiated a Waste Minimization Awards program to annually recognize employees whose suggestions reduce waste and save money for the Laboratory.
- Developed a waste management cost estimation model.
- Planned and facilitated quarterly meetings for Waste Management Coordinators.
- Chaired the DOE/HQ-sponsored Contractor Coordination Group and coordinated two waste minimization/pollution prevention tools workshops.
- Conducted a pollution prevention review of standard operating procedures.

The Laboratory is committed to the Waste Minimization and Pollution Prevention Awareness Program; the Laboratory Director's Policy emphasizes reduction or elimination of waste whenever and wherever possible. The program uses Process Waste Assessments to identify generation problems and potential solutions, Site Specific Plans to identify waste minimization implementation requirements for each site, an employee awareness plan that includes training and incentives for new ideas, and a data management plan to track waste generation and minimization.

13. Environmental, Safety, and Health Training. (Meg Cox, ESH-13)

The Laboratory maintains an extensive training program of Environment, Safety, and Health (ES&H) courses that meet compliance requirements under OSHA and EPA regulations, as well as DOE orders including LANL's Radiological Control Manual. These courses are designed, developed, delivered, and/or coordinated by the ES&H Training Group (HS-8). In 1993, training was available in the following categories: radiation training, including Radiological Worker and Radiological Control Technician; safety training, including courses on cranes, electrical safety, forklifts, lockout/tagout, and OSHA standards; health training, including courses on a variety of chemical hazards, first aid/CPR, and respirators; and environment training, including courses in waste management, spill coordination, and hazardous waste operations.

All new employees, contractors, affiliates, long-term visitors, students, and current employees working at sites governed by DOE Order 5480.20 are required to take General Employee Training, which consists of introductory information covering Laboratory ES&H topics, including OSHA Rights and Responsibilities, Industrial Hygiene, General Employee Radiological Training, and Occupational Medicine.

All internally developed Laboratory-wide training is done in conjunction with subject matter experts who validate technical content. All training materials are reviewed by Training and Development staff for essential instructional elements.

V. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

A major component of the Laboratory's Environmental Surveillance Program includes monitoring for potential exposures to the public from Laboratory-related radiation sources and assessing the risk associated with that exposure. Air effluents are routinely sampled at 90 release points on Laboratory property. Air sampling is conducted on Laboratory property, along the Laboratory perimeter, and in more distant areas that serve as regional background stations. Atmospheric concentrations of tritium, uranium, plutonium, americium, radioiodine, and gross alpha and beta are measured. The largest airborne release was 32,110 Ci of short-lived (8 s to 20 min half-lives) air activation products from the Los Alamos Meson Physics Facility (LAMPF). In 1993, total radioactive air emissions decreased by approximately 50%, which was mainly due to holding radionuclides in the LAMPF buildings to allow them to decay before releasing them to the atmosphere. Water effluent from the liquid waste treatment plant is sampled to determine the release of radionuclides. Total releases continued to decline in 1993. No radioactive contribution in foodstuffs posed a threat to the health or safety of the public. The maximum effective dose equivalent (EDE) to a member of the public from 1993 Laboratory operations was 3.1 mrem. The average doses to individuals in Los Alamos and White Rock because of 1993 Laboratory activities were 0.15 and 0.03 mrem, respectively. These doses are estimated to add lifetime risks of less than one chance in one million to an individual's risk of cancer mortality.

A. Introduction

Many of the activities that take place at the Los Alamos National Laboratory (LANL or the Laboratory) involve handling radioactive materials and operating radiation-producing equipment. A major component of the Laboratory's Environmental Surveillance Program includes monitoring for potential exposures to the public and environment from Laboratory-related radiation sources.

Radiation from radioactive materials and radiation-producing equipment is called ionizing radiation. Common types of ionizing radiation include alpha, beta, and gamma. Each type of ionizing radiation has a unique ability to penetrate or pass through materials and thereby be absorbed in living tissues potentially causing damage from the ionization process. Alpha radiation penetrates poorly; a piece of paper or outer dead skin layer can stop it. Beta radiation has low to moderate penetrating ability and is stopped by a few sheets of paper. X-rays and gamma radiation have much greater penetrating ability and are stopped by lead or concrete.

Radiation is released by both naturally occurring materials and by artificially produced or enhanced sources. Background radiation is made up of natural and man-made sources. Examples of natural background radiation sources include naturally occurring gases such as radon and naturally occurring elements such as uranium in regional rocks and soils. Ionizing radiation is also produced by medical diagnosis and treatment equipment such as x-rays, nuclear medicine procedures, and linear accelerators for such use as cancer treatment. Medical diagnostics and treatment account for the largest radiation dose to the American public from artificially produced sources of radiation. Tobacco products, smoke detectors, and television sets also have ionizing radiation associated with them.

Other sources of ionizing radiation include occupational exposure, residual fallout from past worldwide atmospheric weapons testing, the nuclear fuel cycle, and research and scientific activities at facilities such as the Laboratory.

B. Radiological Emissions

1. Measurement of External Penetrating Radiation

a. Introduction. Natural external penetrating radiation originates from terrestrial and cosmic sources. The terrestrial component results primarily from the decay of naturally occurring ^{40}K and radionuclides in the decay chains of thorium and uranium. Natural terrestrial radiation is highly variable with time, season, and location. During any year, external radiation levels can vary from 15% to 25% at any location because of changes in soil moisture and snow cover (NCRP 1975b). There is also spatial variation because of different topographies, soils, and rock types in different localities (ESG 1978).

Natural ionizing radiation from cosmic sources increases with elevation because of reduced shielding by the atmosphere. 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 (unshielded) 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 between 45 and 90 mrem/yr from cosmic sources. This component can vary ±10% because of solar modulations (NCRP 1987a).

Fluctuations in natural background ionizing radiation 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.

b. Monitoring Network and Results. Levels of external penetrating radiation (including x- and gamma-rays and charged-particle contributions from cosmic, terrestrial, and man-made sources) are measured with thermoluminescent dosimeters (TLDs) and High Purity Germanium (HPGe) detectors. The environmental monitoring of external penetrating radiation monitoring is made up of three independent networks. These networks are used to measure natural and man-made radiation levels (1) on site (the Laboratory) and off site (perimeter, and regional), (2) at the Laboratory boundary north of LAMPF, and (3) at on-site low-level radioactive waste management areas. These three networks are known respectively as TLDNET, LAMPFNET, and WASTENET.

Results from the environmental monitoring networks are presented below. In summary, the TLD measurements indicate no detectable radiological impact to humans or the environment from LANL operations due to external penetrating radiation.

Laboratory and Regional Areas (TLDNET). The environmental network consists of 53 stations divided into 3 groups. The off-site regional group consists of 7 locations, ranging 28 to 117 km (17 to 73 mi) from the Laboratory boundary. The regional stations are located at Fenton Hill and in the neighboring communities of Española, Pojoaque, and Santa Fe. The Pueblos of San Ildefonso, Jemez, and Taos are also part of this regional network. The off-site perimeter group consists of 23 stations within 4 km (2.5 mi) of the Laboratory boundary; the on-site group includes 23 locations on Laboratory grounds (Figure V-1). Table V-1 contains the TLD measurements obtained at off-site regional, off-site perimeter, and on-site monitoring stations. The current minimum detection limit (MDL) of the TLD system is 3 mrem. TLD network sampling methodology is explained in section VIII.B.1. TLD station No. 6 in Los Alamos was discontinued in the fourth quarter of 1993. Station No. 52 at Taos Pueblo was discontinued in the fourth quarter of 1993. Some of the TLD stations are lacking a complete year of quarterly data. Vandalism, animal predation, technical error, new TLD placement after January, removal requests by the public, all can result in loss of data for a given quarter.

Annual averages for the groups were generally the same in 1993 as in 1992 (Figure V-2) and close to the averages observed in 1991. The averages are consistent with the variability in natural background observed at these stations. Off-site stations, both regional and perimeter, showed no statistically significant increase in radiation levels attributable to Laboratory operations (Table V-1). For three or more quarters the annual dose averages at off-site regional stations ranged from 82 to 157 mrem. Annual measurements at off-site perimeter stations ranged from 79 to 174 mrem. Some comparisons provide a useful perspective for evaluating these measurements. For instance,

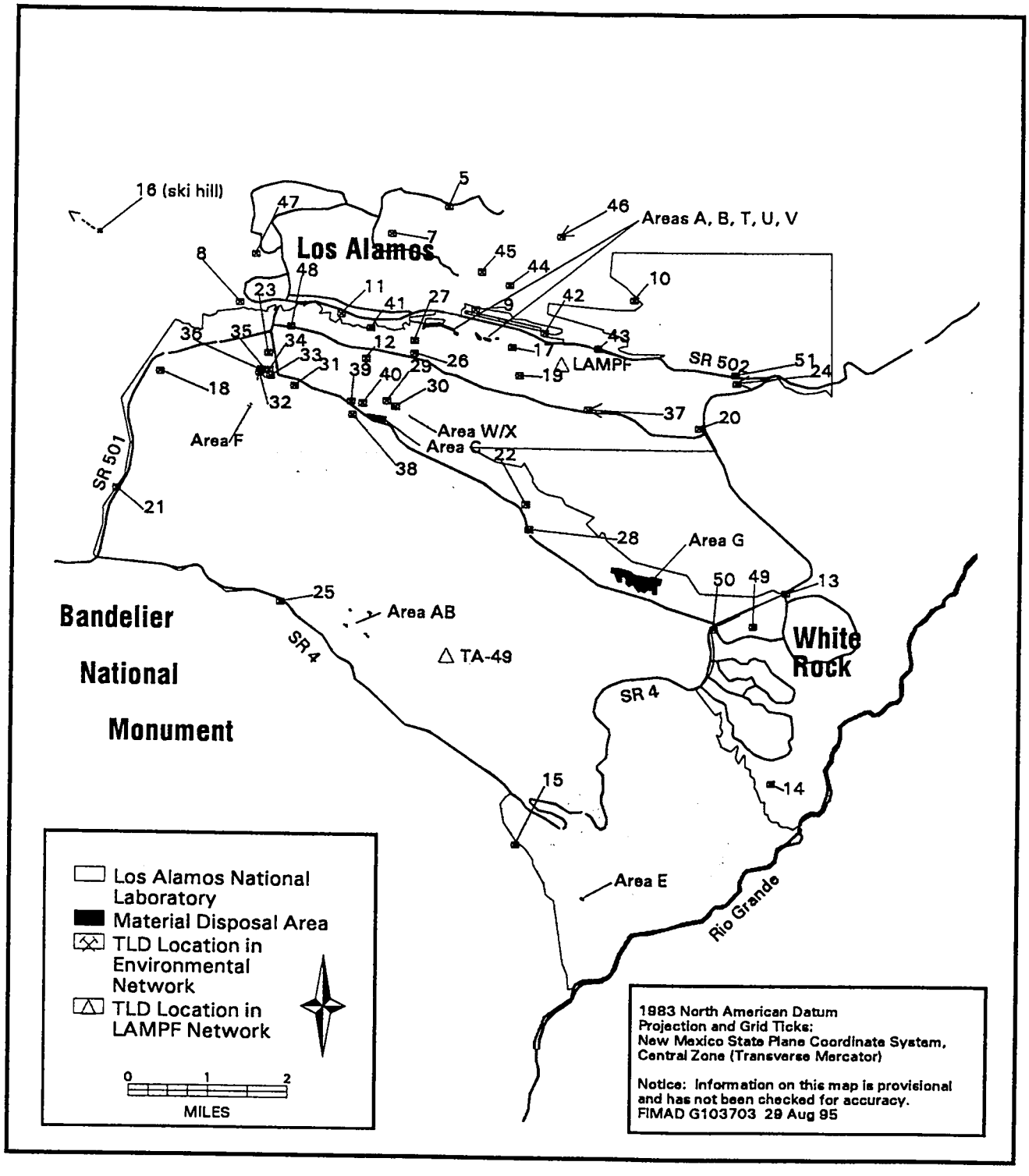


Figure V-1. Off-site perimeter and on-site Laboratory TLD Locations.
(Does not show off-site regional stations.)

Table V-1. TLD Measurements 1993

Station ID #	Location	Network Type	Total Annual Dose (mrem)	Uncertainty[a]
1	Española	Regional	105	12
2	Pojoaque	Regional	82[b]	10
3	Santa Fe	Regional	109	12
4	Fenton Hill	Regional	157	12
52	West Taos Pueblo	Regional	27[d]	6
53	San Ildefonso Pueblo	Regional	50[c]	10
54	Jemez Pueblo	Regional	66[c]	8
5	Barranca School, Los Alamos	Perimeter	112	12
6	Arkansas Avenue, Los Alamos	Perimeter	Discontinued 4th Quarter of 1992	
7	Cumbres School, Los Alamos	Perimeter	124	9
8	48th Street, Los Alamos	Perimeter	126	9
9	Los Alamos Airport	Perimeter	79[b]	7
10	Bayo Canyon, Los Alamos	Perimeter	148	12
11	Shell Station, Los Alamos	Perimeter	174	9
12	Royal Crest Trailer Court, Los Alamos	Perimeter	117	12
13	White Rock	Perimeter	113	11
14	Pajarito Acres, White Rock	Perimeter	126	12
15	Bandelier National Monument Lookout Station	Perimeter	138	9
16	Pajarito Ski Area	Perimeter	120	12
20	Well PM-1 (SR4 and Truck Rt.)	Perimeter	154	12
41	McDonald's Restaurant, Los Alamos	Perimeter	121	9
42	Los Alamos Airport-South	Perimeter	116	12
43	East Gate Business Park, Los Alamos	Perimeter	104	12
44	Big Rock Loop, Los Alamos	Perimeter	147	12
45	Cheyenne Street, Los Alamos	Perimeter	139	12
46	Los Pueblos Street, Los Alamos	Perimeter	82[b]	11
47	Urban Park, Los Alamos	Perimeter	82[b]	10
48	Los Alamos County Landfill	Perimeter	116	12
49	Piñon School, White Rock	Perimeter	103	12
50	White Rock Church of the Nazarene	Perimeter	81	12
51	Bayo Canyon Well, Los Alamos	Perimeter	112	13
17	TA-21 (DP West)	On-Site	139	9
18	TA-6 (Two Mile Mesa)	On-Site	82[b]	11
19	TA-53 (LAMPF)	On-Site	142	12
21	TA-16 (S-Site)	On-Site	129	11
22	Booster P-2	On-Site	117	12
23	TA-3 East Gate of SM 43	On-Site	109	12
24	State Highway 4	On-Site	147	12
25	TA-49 (Frijoles Mesa)	On-Site	113	9
26	TA-2 (Omega Stack)	On-Site	121	11
27	TA-2 (Omega Canyon)	On-Site	201	12
28	TA-18 (Pajarito Site)	On-Site	128	12
29	TA-35 (Ten Site A)	On-Site	91[b]	11
30	TA-35 (Ten Site B)	On-Site	119	12
31	TA-59 (Occupational Health Lab)	On-Site	119	9
32	TA-3-16 (Van de Graaff)	On-Site	123	12
33	TA-3-316 (Ion Beam Bldg.)	On-Site	130	12
34	TA-3-440 (CAS)	On-Site	110	12

Table V-1. (Cont.)

Station ID #	Location	Network Type	Total Annual Dose (mrem)	Uncertainty[a]
35	TA-3-420 (CMR Bldg. West Fence)	On-Site	109	12
36	TA-3-102 (Shop)	On-Site	116	12
37	TA-72 (Pistol Range)	On-Site	135	12
38	TA-55 (Plutonium Facility South)	On-Site	143	12
39	TA-55 (Plutonium Facility West)	On-Site	107[b]	10
40	TA-55 (Plutonium Facility North)	On-Site	150	12

[a]Uncertainty is the propagated error of the quarterly measurements.
[b]Annual Dose is the sum of three quarters.
[c]Annual dose is the sum of two quarters.
[d]Only 4th quarter data available.

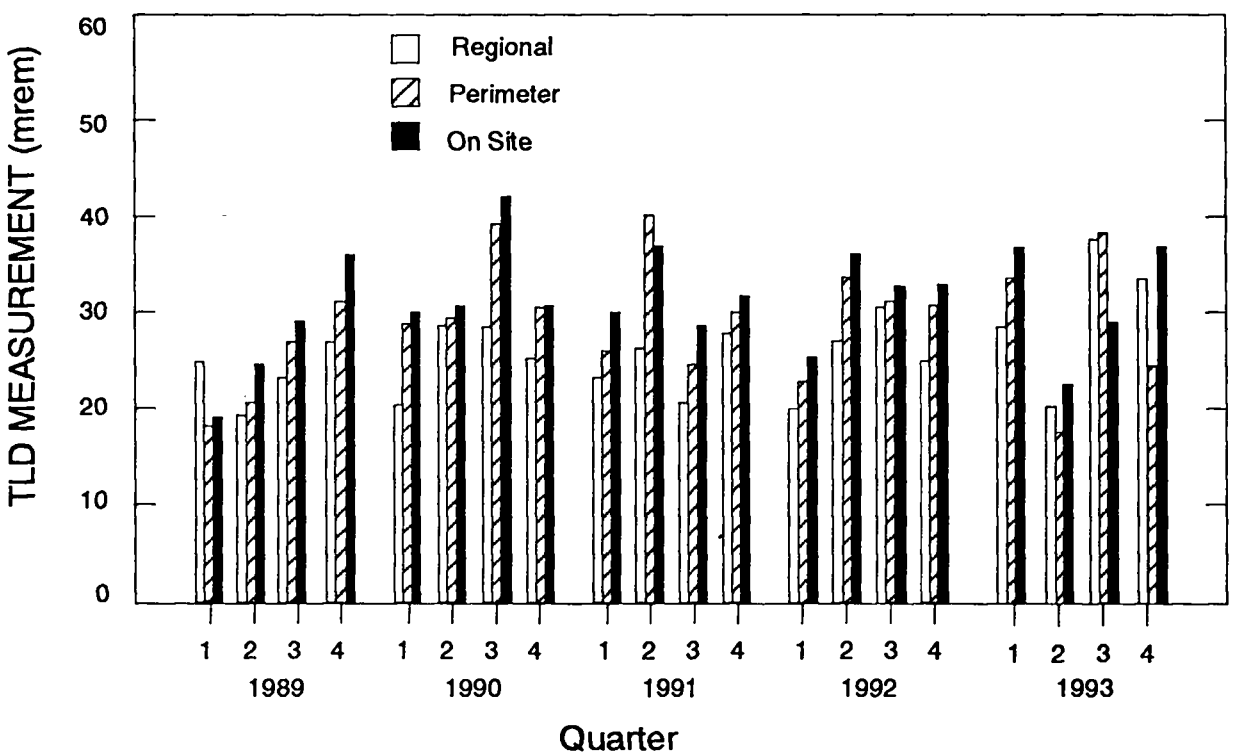


Figure V-2. TLD measurements (including contributions from cosmic, terrestrial, and Laboratory radiation sources).

the average person in the United States receives about 53 mrem/yr of radiation from medical diagnostic procedures (NCRP 1987a).

Technical Area (TA) 53 Network (LAMPFNET). This network monitors external penetrating radiation from airborne gases, particles, and vapors resulting from LAMPF operations at TA-53. Air emissions from the LAMPF linear accelerator constitute the largest Laboratory source of off-site external penetrating radiation. Because of prevailing southerly winds, the TA-53 TLD network is located at the Laboratory boundary 800 m (0.5 mi) north of LAMPF. The network consists of 24 TLD stations. Twelve monitoring TLD sites are directly across from LAMPF, and 12 background TLD sites are located about 9 km (5.5 mi) from TA-53, near the southern boundary of the Laboratory (Figure V-1). Both monitoring and background TLD stations are placed at about the same elevation. In addition to the TLDs, there is a HPGe detector network north of LAMPF. This part of the network consists of three HPGe detector systems installed in the north, north-northeast, and northeast sectors (Figure V-3). At each site, a gamma-ray energy spectrum is collected hourly and analyzed for various

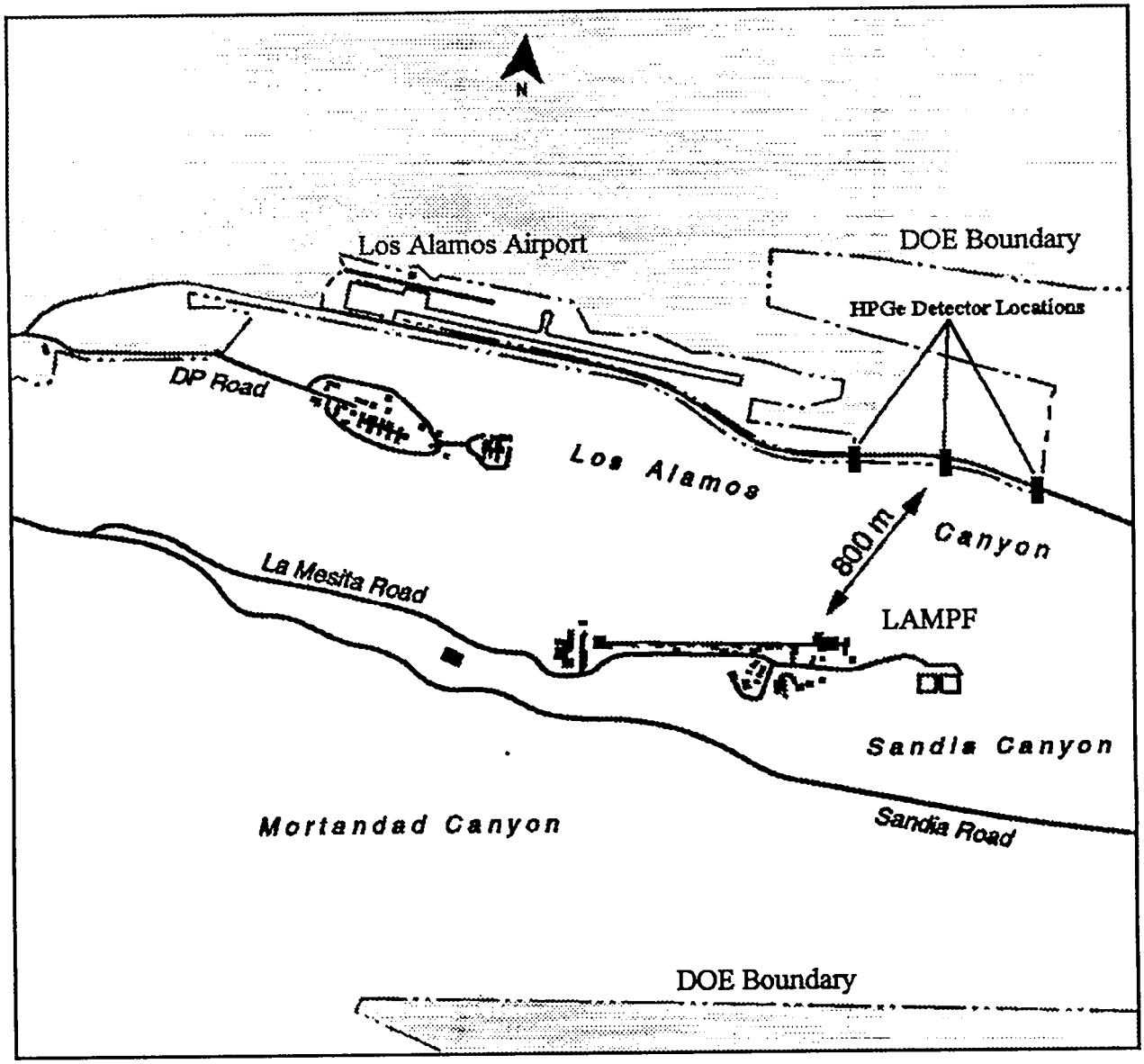


Figure V-3. High Purity Germanium Detector Monitoring network at LAMPF, TA-53.

radionuclides and the resulting exposure rate. In addition to the rapid analysis of data, these systems have an increased sensitivity with a level of detection equal to 0.04 μR/hr. Along with the HPGe systems, a high pressure ion chamber is present as a backup system at the center (north-northeast) station. Figure V-4 presents an example of the hourly dose rate measured during the last month of 1993 operating cycle of the LAMPF facility. Figure V-5 presents summary data on the contribution of external penetrating radiation to the maximum individual dose and the maximum Laboratory boundary dose.

Low-Level Radioactive Waste Management Areas Network (WASTENET). This network of 92 locations monitors radiation levels at 1 active and 10 inactive low-level radioactive waste management areas. These waste management areas are controlled-access areas that are not accessible to the general public. Active and inactive waste areas are monitored for external penetrating radiation with arrays of TLDs (Table V-2). Annual averages at all waste management sites ranged from 103 to 154 mrem. These waste management annual averages compare well with the annual averages for the perimeter locations (Tables V-1 and V-3). The upper dose extremes were measured at TA-54, Area G (the active low-level radioactive waste area) and at TA-21, Area U (an inactive waste area). Values for TA-21, Area U were slightly higher than in 1991 and 1992. The maximum recorded value for TA-54, Area G is a location near the aboveground storage area for mixed wastes.

2. Airborne Radioactivity Monitoring.

a. Introduction. Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made during the Laboratory's air sampling program. Worldwide background 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). Levels of background radioactivity in the atmosphere, which are useful in interpreting air sampling data, are summarized in Table V-3. Note that the measurements taken in Santa Fe by the Environmental Protection Agency (EPA) are similar to or lower than those taken by the Laboratory as regional background values and are significantly lower than DOE Derived Air Concentration (DAC) guides for uncontrolled areas.

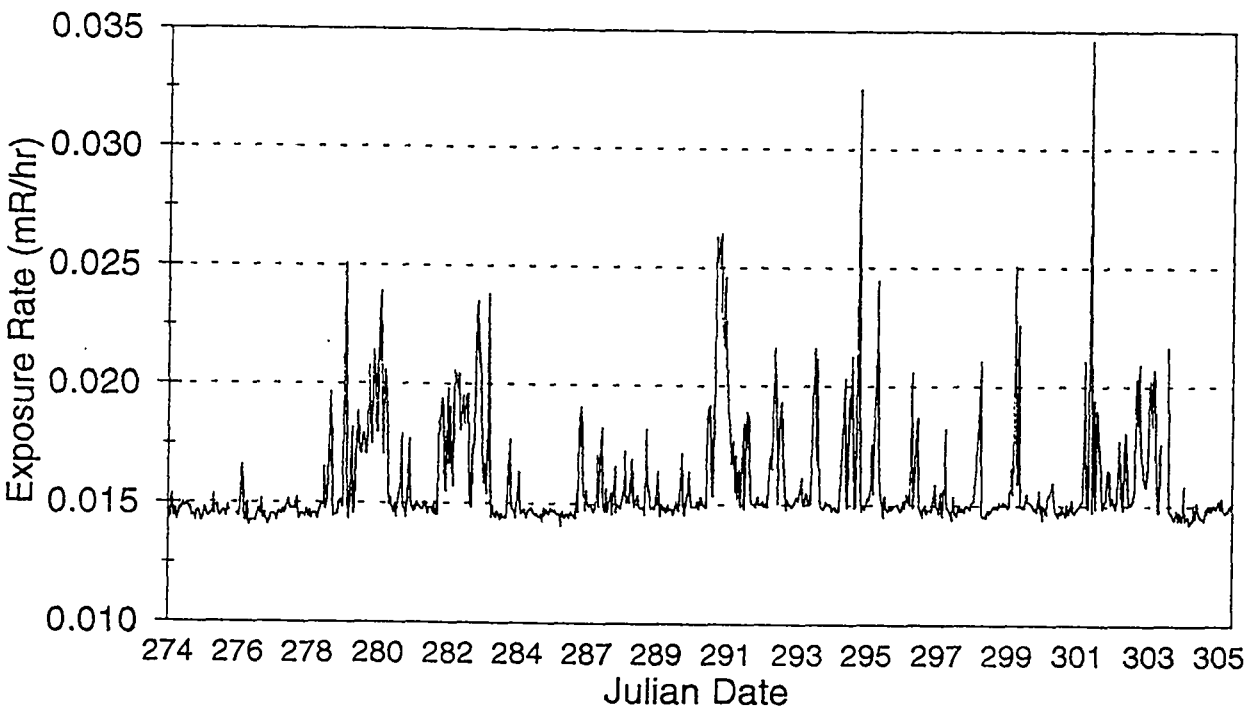


Figure V-4. Typical LAMPF hourly exposure rate at East Gate.

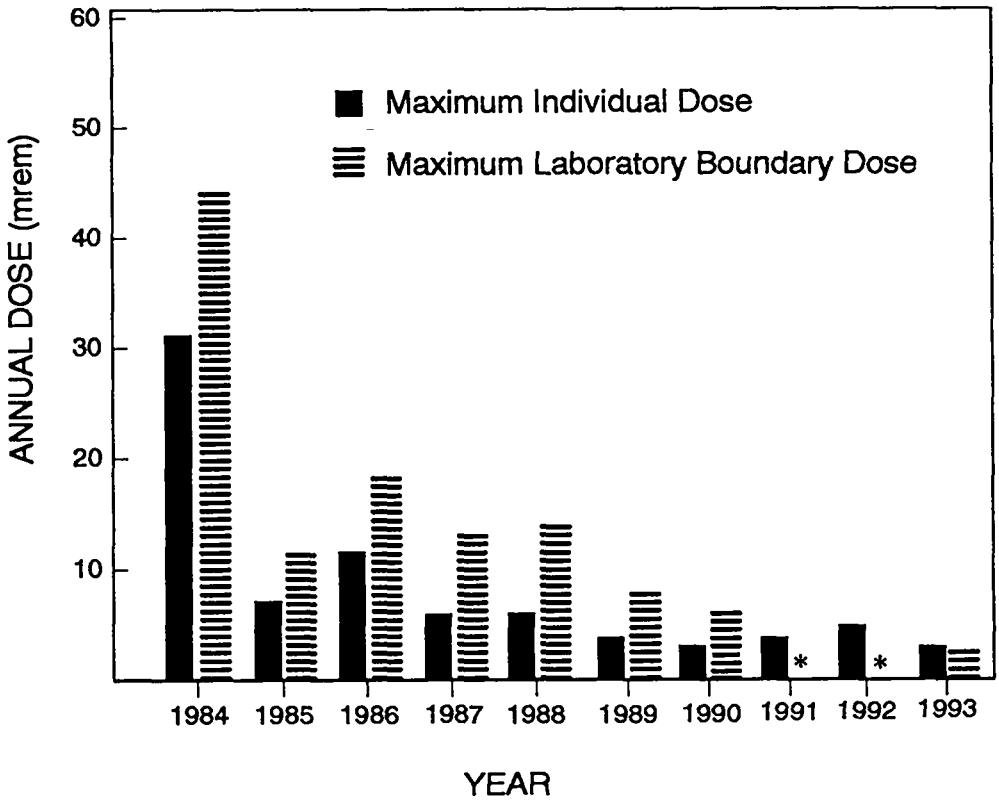


Figure V-5. Summary of estimated maximum individual and maximum Laboratory boundary doses from external penetrating radiation generated by Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources). Maximum individual dose calculated with DOE-approved methods that take building shielding and occupancy into account.

*No above-background Laboratory boundary doses, as measured by TLDs, were recorded during 1991 or 1992.

The radiological air sampling network at the Laboratory is designed to measure environmental levels of airborne radionuclides that may be released from Laboratory operations. Plutonium, americium, and uranium are released in microcurie amounts as a result of Laboratory operations. Tritium is released in curie amounts. Radioiodine and noble gases are released from facilities performing fission product chemistry and medical isotope preparation and research reactors. The Laboratory also releases radionuclides that emit beta and gamma radiation from LAMPF at TA-53 and from the Omega West Reactor at TA-2.

Particulate matter in the atmosphere is primarily caused by the resuspension of soil, which is dependent on current meteorological conditions. Windy, dry days can increase the soil resuspension, whereas 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 (Table V-3) are less than 1% of the DAC guide for uncontrolled areas. The DAC guide represents a concentration that would result in an annual dose of 100 mrem.

The quantities of airborne radioactivity released depend on the type of research activities and can vary markedly from year to year (Figures V-6 through V-8). During 1993, the most significant releases were from LAMPF. The amount released for the entire year was 32,110 Ci (118,770 GBq) of air activation products (gases, particles, and vapors) from all Laboratory operations (Tables V-4 and V-5). This emission was about 50% less than that in 1992 (Table V-6). Airborne phosphorus emissions decreased from 9 Ci (333 GBq) released in 1992 to 6 Ci (222 GBq)

Table V-2. Doses Measured by TLDs at On-Site Waste Disposal Areas during 1993

Waste Disposal Area	Number of TLD Locations	Annual Doses (mrem) Mean	Minimum	Maximum	Uncertainty[a] (Stdev ± 2)
TA-21, Area A	5	113	110	121	12
TA-21, Area B	14	115	102	126	12
TA-50, Area C	10	124	113	137	12
TA-33, Area E	4	127	114	142	12
TA-6, Area F	4	102	88	113	12
TA-54, Area G	27	148	73	277	11
TA-21, Area T	7	131	109	224	12
TA-21, Area U	4	154	148	159	12
TA-21, Area V	4	116	113	123	12
TA-35, Area W	3	115	72	164	11
TA-49, Area AB	10	104	82	115	12

[a]Uncertainty is the propogated error of the quarterly measurements.

Table V-3. Average Background Concentrations of Radioactivity in the Regional Atmosphere

Radioactive Constituent[a]	Units	Santa Fe[b] 1988–1992	New Mexico[c] 1993	DOE DAC Guide for Uncontrolled Area[d]
Gross beta	10^{-15} µCi/mL	12.0 (8.0)[e]	9.9 (7.9)	9,000
^{3}H	10^{-12} µCi/mL	—	0.5 (2.3)	100,000
U (natural)	pg/m^3	54.6 (38.9)	69.9 (47.15)	100,000
^{234}U	10^{-18} µCi/mL	20.7 (5.3)	22.4 (27.0)	90,000
^{235}U	10^{-18} µCi/mL	0.8 (0.7)	0.7 (2.2)	100,000
^{238}U	10^{-18} µCi/mL	18.2 (13.0)	23.3 (29.9)	100,000
^{238}Pu	10^{-18} µCi/mL	0.2 (0.3)	1.6 (4.2)	30,000
$^{239,240}Pu$	10^{-18} µCi/mL	0.2 (0.3)	2.9 (8.8)	20,000
^{241}Am	10^{-18} µCi/mL	—	1.6 (2.1)	20,000

[a]See Appendix D, Table D-11 for detection limits.

[b]EPA (1989–1993), Reports 53 through 72. Data are from the EPA Santa Fe, New Mexico, sampling location and were taken from January 1988 through December 1992. Data for 1993 were not available at time of publication.

[c]Data are annual averages from the regional stations (Española, Pojoaque, Santa Fe) and were taken by the Laboratory during CY93.

[d]See Appendix A. These values are presented for comparison.

[e]Uncertainties (± 2σ) are in parentheses.

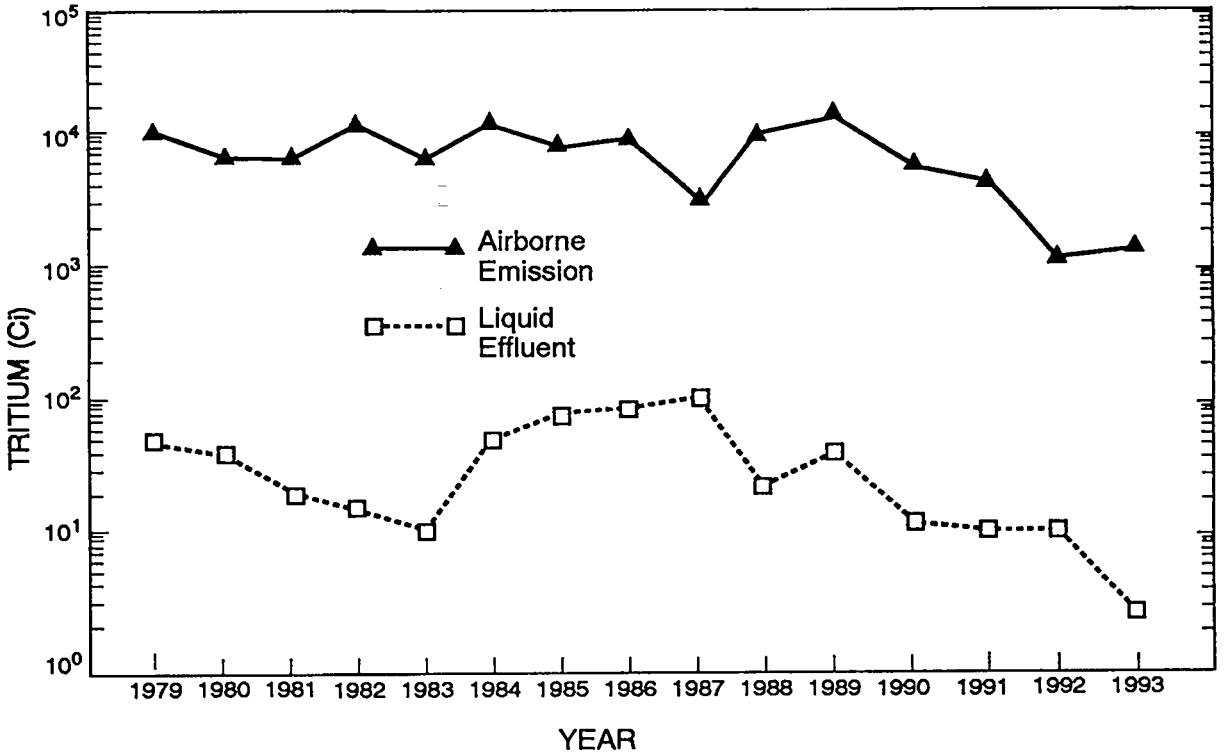


Figure V-6. Summary of tritium releases (airborne emissions and liquid effluents).

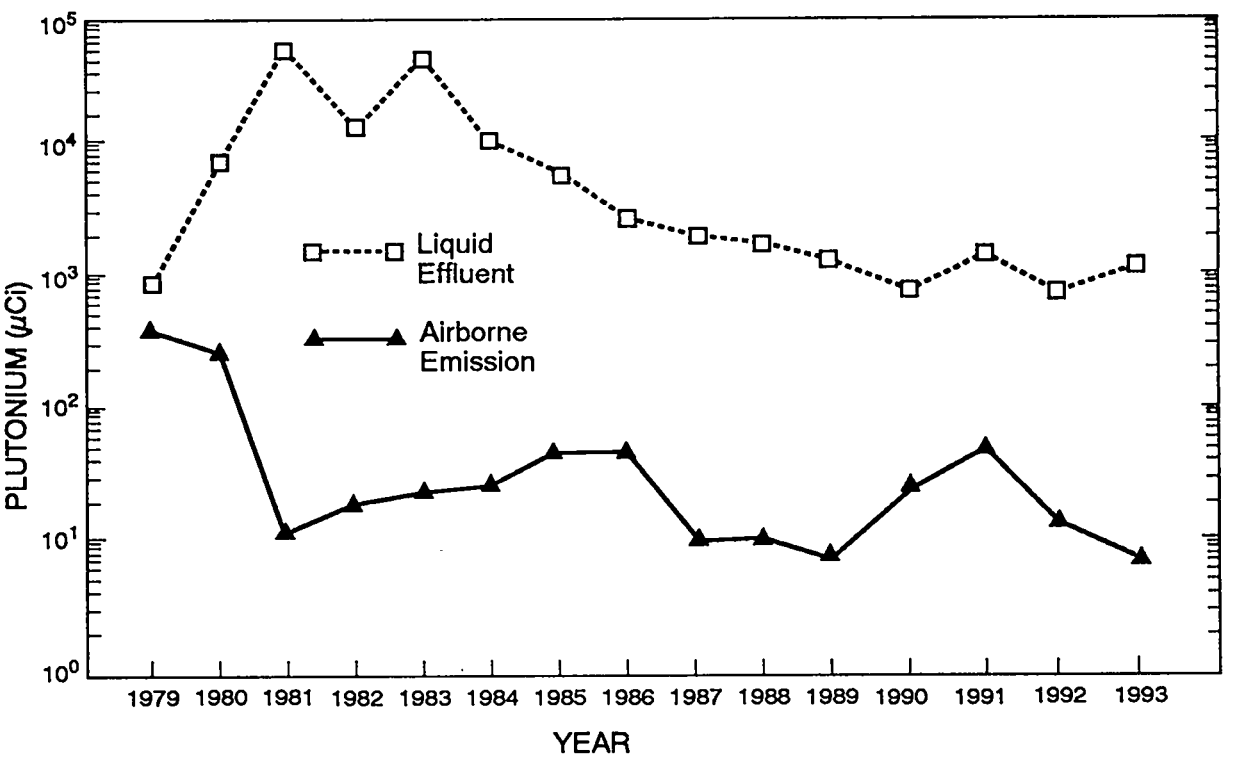


Figure V-7. Summary of plutonium releases (airborne emissions and liquid effluents).

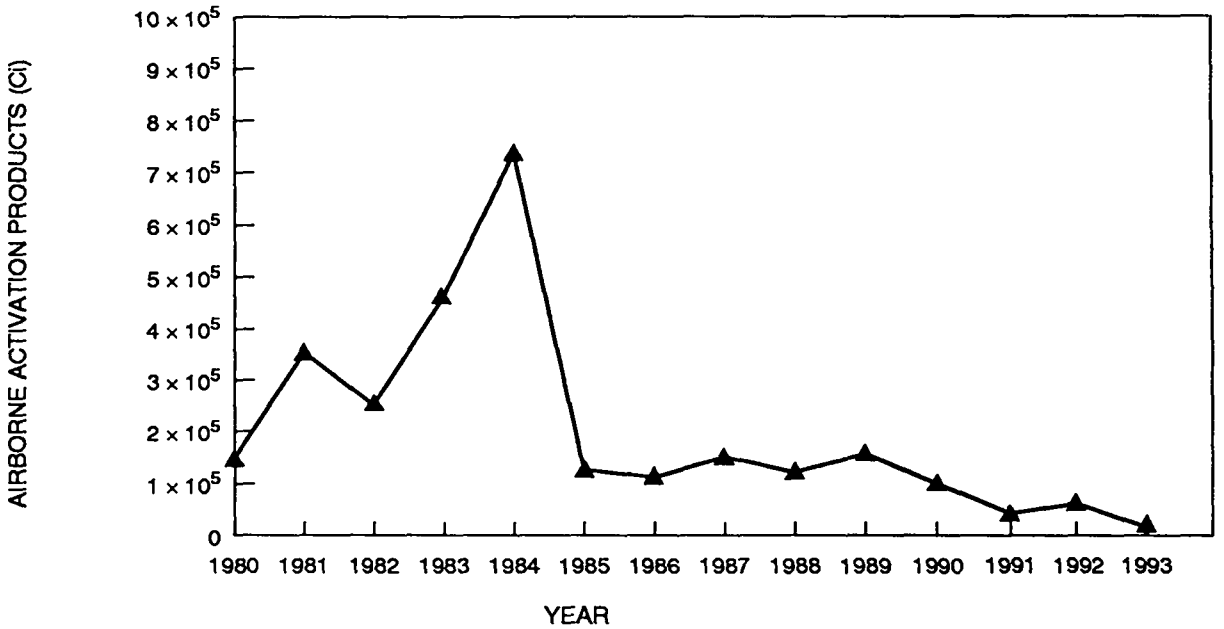


Figure V-8. Emissions of airborne gaseous mixed activation products (principally ^{10}C, ^{11}C, ^{12}N, ^{16}N, ^{14}O, ^{15}O, and ^{41}Ar) from LAMPF.

released in 1993. Airborne plutonium emissions decreased from 12 Ci (444 GBq) released in 1992 to 6 Ci (222 GBq) released in 1993 (Table V-6). Release of mixed fission products decreased from 2,750 μCi (101 MBq) to 1,360 (50 MBq) in 1993. Most of the radioactivity was from these radioisotopes, whose radioactivity declines very rapidly, before they reached the Los Alamos townsite.

Another source of airborne radioactivity at the Laboratory is diffuse emissions, or emissions that do not come from a discrete location such as a stack or vent. In 1993, the following emissions were estimated from diffuse sources.

Tritium (as water vapor):	15 Ci
Plutonium:	13.3 μCi
Uranium:	33,900 μCi
Mixed fission products:	0.0026 μCi
Gaseous mixed activation products:	1,400 Ci
Particulate/vapor activation products:	0.0031 μCi

In 1993, 99% of these emissions were gaseous mixed activation products that diffused from several buildings throughout the Laboratory, including TA-53. These activation products were purposely held in the building to allow them to decay before they were released into the atmosphere. A list of selected nuclides and their half-lives is given in Table D-14.

Radioactive air emissions at the Laboratory are monitored according to DOE/EH-0173T "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991) and 40 CFR (Code of Federal Regulations) Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (EPA 1989b). Based on off-site environmental monitoring results and on doses calculated from measured stack emissions, the off-site doses are less than the 10 mrem/yr standard given in 40 CFR 61.92. On July 17, 1990, LANL notified the Department of Energy (DOE) that the Laboratory met the 10 mrem/yr standard but did not meet the monitoring requirements (40 CFR 61.93) with its existing sampling program.

Table V-4. Airborne Radioactive Emissions from Laboratory Operations in 1993 (in Ci)

Radionuclide	TA-2	TA-3	TA-15[a]	TA-16	TA-21	TA-33	TA-35
^{3}H[b]		7.63×10^{1}		7.73×10^{-1}	4.26×10^{2}	3.50×10^{2}	MDA[c]
^{10}C							
^{11}C							
^{13}N							
^{16}N							
^{14}O							
^{15}O							
^{32}P							
^{41}Ar	NR[d]						
MFP[e]		6.05×10^{-6}			1.00×10^{-8}		
^{234}U			3.75×10^{-3}				
^{235}U		1.51×10^{-4}	1.92×10^{-4}		5.17×10^{-5}		
^{238}U		6.73×10^{-5}	9.93×10^{-4}				
Pu[f]		1.74×10^{-6}			8.10×10^{-7}		2.70×10^{-7}
P/VAP[g]							

Radionuclide	TA-41	TA-43	TA-48	TA-50	TA-53	TA-54	TA-55	Totals
^{3}H[b]	4.83×10^{2}				4.86×10^{1}		6.46×10^{1}	1.45×10^{3}
^{10}C					1.57×10^{3}			1.57×10^{3}
^{11}C					8.35×10^{3}			8.35×10^{3}
^{13}N					4.14×10^{3}			4.14×10^{3}
^{16}N					1.26×10^{3}			1.26×10^{3}
^{14}O					4.96×10^{2}			4.96×10^{2}
^{15}O					1.61×10^{4}			1.61×10^{4}
^{32}P		6.12×10^{-6}						6.12×10^{-6}
^{41}Ar					$1.81 \times 10^{+2}$			1.81×10^{2}
MFP[e]			1.35×10^{-3}	3.75×10^{-6}				1.36×10^{-3}
^{234}U								3.75×10^{-3}
^{235}U			1.42×10^{-6}					3.96×10^{-4}
^{238}U								1.06×10^{-3}
Pu[f]	1.00×10^{-8}		3.16×10^{-6}	2.80×10^{-7}		<MDA[c]	1.70×10^{-7}	6.44×10^{-6}
P/VAP[g]			7.59×10^{-2}		1.02×10^{1}			1.03×10^{1}

[a]For dose calculation purposes, emissions from both TA-15 and TA-36 are conservatively considered to be released from TA-15.

[b]1993 ^{3}H releases from TA-16, TA-21, and TA-53 were 88%, 57%, and 100% tritium oxide respectively. All remaining ^{3}H releases were of elemental ^{3}H.

[c]MDA = minimum detectable amount.

[d]NR = No release. The reactor remained shut down, and no ^{41}Ar release was reported for TA-2.

[e]MFP = mixed fission products.

[f]Plutonium includes ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{241}Am.

[g]P/VAP = particulate/vapor activation products. These include 6 radionuclides at TA-53 dominated by ^{82}Br, ^{7}Be, ^{48}V, and ^{77}Br, and 13 radionuclides at TA-48 dominated by ^{72}As, ^{75}Se, and ^{77}Br. Individual radionuclide totals for 1993 emissions are shown in Table V-5.

Table V-5. *Detailed Listing of Activation Products from Laboratory Operations in 1993 (in Ci)*

Mixed Activation Products	Radionuclide	Location	
		TA-53	TA-48
Particulate/Vapor (P/VAP)	^{72}As		2.08×10^{-2}
	^{73}As		3.20×10^{-3}
	^{74}As		3.00×10^{-3}
	^{194}Au		3.40×10^{-6}
	^{7}Be	2.26×10^{0}	3.55×10^{-5}
	^{77}Br	1.19×10^{0}	2.53×10^{-2}
	^{82}Br	1.16×10^{0}	
	^{58}Co		1.60×10^{-6}
	^{60}Co	4.70×10^{-5}	
	^{51}Cr	2.86×10^{-4}	
	^{68}Ga		2.00×10^{-4}
	^{146}Gd	8.70×10^{-4}	
	^{68}Ge		1.62×10^{-3}
	^{195}Hg	1.27×10^{-1}	
	^{197}Hg	1.04×10^{-2}	
	^{197m}Hg	3.65×10^{-3}	
	^{203}Hg	7.17×10^{-1}	
	^{131}I	2.29×10^{-4}	
	^{172}Lu	5.15×10^{-4}	
	^{173}Lu	1.87×10^{-4}	
	^{52}Mn	9.32×10^{-1}	
	^{54}Mn		6.33×10^{-6}
	^{22}Na	1.62×10^{-5}	
	^{24}Na	6.95×10^{-1}	
	^{185}Os	6.53×10^{-5}	
	^{183}Re		1.27×10^{-4}
	^{44}Sc	7.96×10^{-1}	
	^{44m}Sc	1.20×10^{-3}	
	^{46}Sc	7.56×10^{-2}	
	^{47}Sc	5.35×10^{-1}	
	^{75}Se	2.34×10^{-1}	2.15×10^{-2}
	^{182}Ta	8.74×10^{-4}	
	^{48}V	1.47×10^{0}	7.47×10^{-5}
Gaseous/Mixed (G/MAP)	^{41}Ar	1.81×10^{2}	
	^{10}C	1.57×10^{3}	
	^{11}C	8.35×10^{3}	
	^{13}N	4.14×10^{3}	
	^{16}N	1.26×10^{3}	
	^{14}O	4.96×10^{2}	
	^{15}O	1.61×10^{4}	

Table V-6. Comparison of 1992 and 1993 Releases of Radionuclides from Laboratory Operations

Airborne Emissions

Radionuclide	Units	Activity Released 1992	Activity Released 1993	Ratio 1993:1992
Tritium	Ci	1,298	1,410	1.1
^{32}P	μCi	9	6	0.7
Uranium	μCi	242[b]	267[b]	1.1
Plutonium	μCi	12	6	0.5
Gaseous mixed activation products	Ci	71,950	32,100	0.4
Mixed fission products	μCi	2,750	1,360	0.5
Particulate/vapor activation products	Ci	0.73	10.3	14.1
Total	Ci	73,248.73	33,523	

Liquid Effluents

Radionuclide	Activity Released (mCi) 1992	Activity Released (mCi) 1993	Ratio 1993:1992
Tritium	10,630.00	2,660.00	0.25
$^{82,85,89,90}Sr$	17.00	7.64	0.45
^{137}Cs	7.80[c]	8.17	1.04
^{234}U	0.05	0.12	2.40
$^{238,239,240}Pu$	0.70	1.08	1.54
^{241}Am	8.90[c]	11.20	1.26

[a]Detailed data are presented in Tables V-4 and V-5 for airborne emissions.
[b]Does not include dynamic testing.
[c]Corrected values from those listed in Environmental Surveillance at Los Alamos during 1992.

LANL's monitoring deficiencies are being addressed in a Federal Facilities Compliance Agreement (FFCA) with EPA Region 6. The FFCA will include schedules that the Laboratory will follow to come into compliance with the Clean Air Act. A revised action plan was submitted by DOE Los Alamos Area Office (LAAO) to EPA in March 1993. Until the FFCA is completed, the Laboratory will continue to address the issues raised in the 1991 NON.

b. Monitoring Network. The sampling network for ambient airborne radioactivity consists of 50 continuously operating air sampling stations (13 new stations, 1 station discontinued in 1993). 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. There are currently 14 perimeter stations located within 4 km (2.5 mi.) of the Laboratory boundary. Thirty-four one on-site stations are within the Laboratory boundary (Figure V-9, Table D-15). There are two co-located or replicate samplers at station #27 at TA-54 and at station #26 at TA-49.

In addition to the various networks or groups mentioned, stations can also be classified as being inside or outside a controlled area. A controlled area is where radioactive materials or elevated radiation fields may be present and are clearly posted as such (DOE 1988d). The active waste site TA-54, Area G is an example of a controlled area.

History of Changes in Monitoring Stations. In addition to station #27, which is part of the routine air sampling network, four stations are located at the active radioactive waste disposal site at TA-54, Area G. In May 1993, five additional stations were established at TA-54, Area G to monitor potential emissions from the waste remediation project known as the Transuranic Waste Inspectable Storage Project (TWISP).

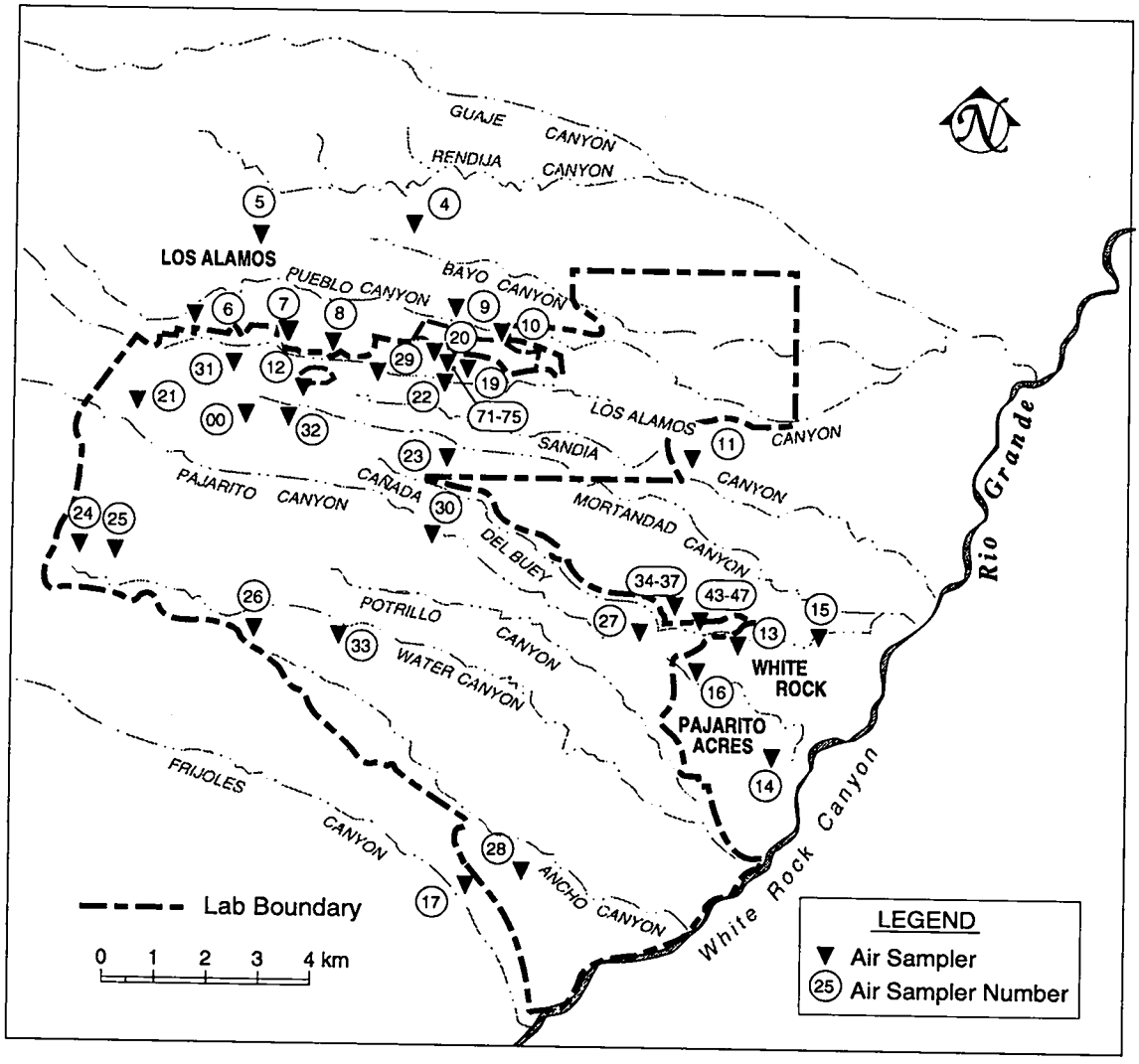


Figure V-9. Approximate locations for off-site perimeter and on-site Laboratory stations for sampling airborne radionuclides. (Does not show Regional Station;. see Table D-14 for specific locations.)

In October 1992, five new stations were established at TA-21 to monitor potential emissions resulting from the demolition and removal of a decommissioned nuclear facility, as part of the DOE's Environmental Restoration program.

During 1993, the Laboratory installed stations at the northern New Mexico pueblos of Jemez, San Ildefonso, and Taos at the request of the respective tribal governments.

In August 1992, five stations for sampling ^{131}I in air were added to the air monitoring network; an additional station was added in January 1993. These are co-located with existing stations.

c. Analytical Results

Gross Alpha and Beta Radioactivity. Gross alpha and beta analyses help in evaluating general radiological air quality. Alpha or beta activity for any single radionuclide cannot be present in greater quantity than the total gross concentration found on a filter. If gross activity in a sample is consistent with past observations and background, special analyses for specific radionuclides are not required. If the sample analytical results appear to be elevated, then analyses for specific radionuclides are required to confirm or deny a problem such as an unplanned release. Gross beta activity in air exhibits considerable environmental variability, as shown in Figure V-10 which plots the results from one regional and one perimeter station.

The fourth quarter samples of plutonium, uranium, and americium were analyzed for gross alpha and gross beta. There were no temporal deviations noted in this analysis. More detailed analyses were not completed due to loss of samples during laboratory analysis. In response to the loss of these samples, LANL has undertaken a new sample tracking process to reduce occurrences.

The National Council on Radiation Protection and Measurements (NCRP) estimates average concentrations of long-lived gross alpha and other naturally occurring radionuclides (NCRP 1987a). There were more than 1,000 air samples collected and analyzed for gross alpha activity in 1993; these results are presented in Table V-7. No unusual or above-background average alpha results were measured in 1993.

The NCRP estimated average concentration levels of long-lived gross beta activity in air to be 20.0×10^{-15} μCi/mL. This activity is primarily due to the presence of ^{210}Pb and ^{210}Bi (decay products of radon), and other naturally occurring radionuclides (NCRP, 1987a). There were more than 1,000 air samples collected and analyzed for gross beta-activity in 1993; these results are presented in Table V-8. No unusual or above-background average beta results were measured in 1993.

Tritium. Tritium is released by the Laboratory in Ci (Gbq) amounts. In addition, tritium is present in the environment as the result of nuclear weapons tests and is also produced naturally by the cosmogonic process (Kathern 1984). Sampling results are presented in Table V-9. About 10% of the off-site samples were above the upper limit background (ULB) or the regional samplers' mean plus two standard deviations value of 2.8×10^{-12} μCi/mL. The maximum off-site concentration ($54.9 \pm [11.3] \times 10^{-12}$ μCi/mL) was recorded during October at station #9 at the Los Alamos Airport. The annual total dose at station #9 was 0.027 mrem, which is 0.27% of the EPA's public dose limit (PDL) of 10 mrem per year. All annual mean concentrations were less than 0.1% of the DOE's derived air concentration (DAC) guide for uncontrolled areas or $100,000 \times 10^{-12}$ μCi/mL.

Elevated concentrations were observed at the TA-54, Area G waste site near shafts where tritium-contaminated waste is disposed. However, the maximum concentration observed ($1804 [\pm 73] \times 10^{-12}$ μCi/mL) is less than 0.1% of the DOE DAC for controlled areas or $20,000,000 \times 10^{-12}$ μCi/mL.

Plutonium. Plutonium is released by the Laboratory in μCi (kBq) 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). Samples for the fourth quarter of 1993 were not analyzed, and results are not available. Sampling results for ^{238}Pu are presented in Table V-10. About 6% of the off-site samples were above the ULB of 5.9×10^{-18} μCi/mL. The maximum off-site result ($7.0 \pm [9.1] \times 10^{-18}$ μCi/mL) was recorded during the third quarter at Station #13 (Piñon School). The maximum on-site value ($28.1 \pm [18.9] \times 10^{-18}$ μCi/mL) was recorded during the second quarter at station #46, Area G, TWISP site. All concentrations were less than 0.1% of the DOE's DAC guide for controlled areas or $200,000 \times 10^{-18}$ μCi/mL. Sampling results for ^{239}Pu are presented in Table V-11.

No off-site results above the ULB of 11.7×10^{-18} μCi/mL were recorded. The maximum on-site result ($99.0 + [15.4] \times 10^{-18}$ μCi/mL) occurred during the second quarter at Station #31 (TA-3). All on-site concentrations were

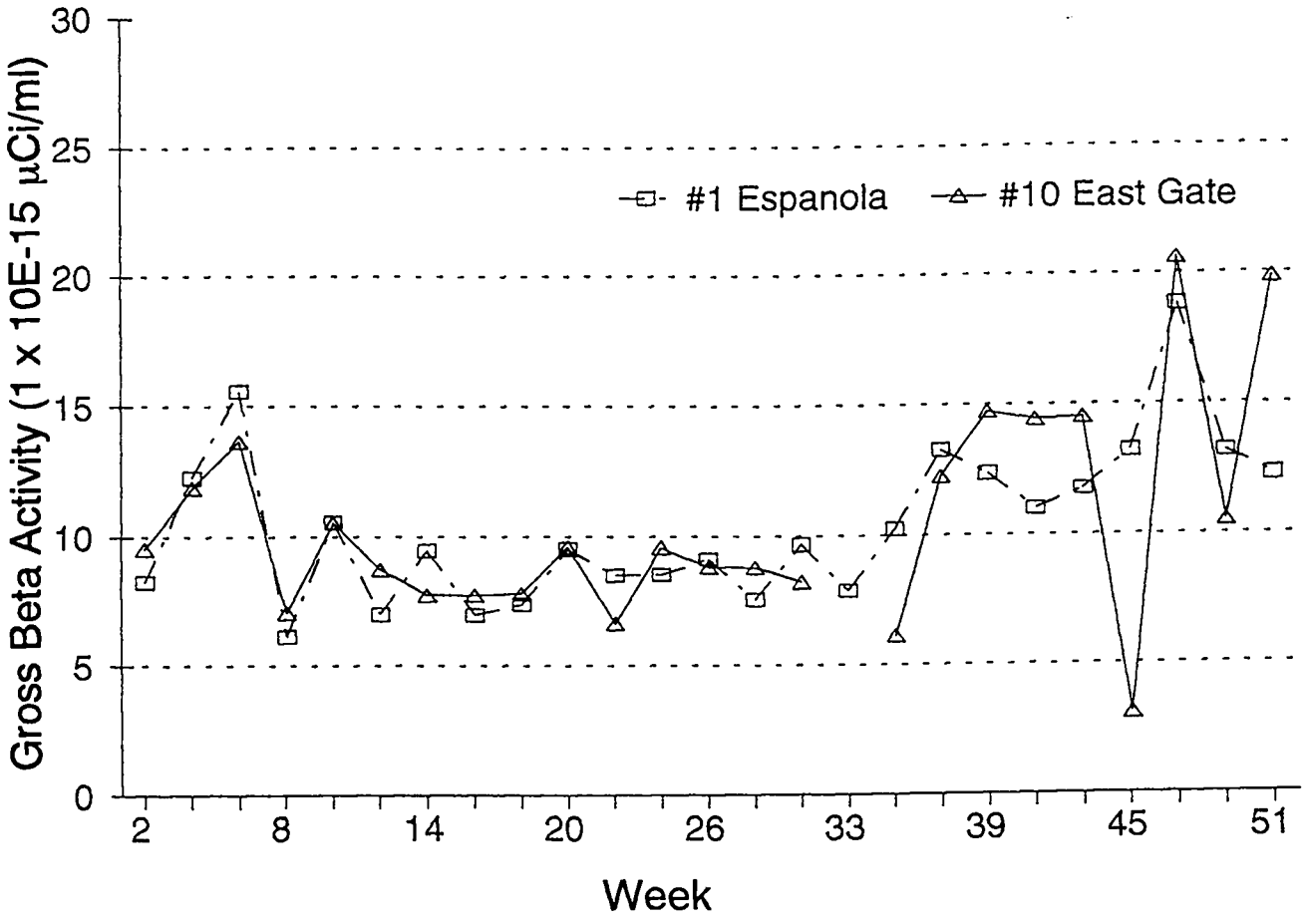


Figure V-10. 1993 Gross beta activity.

less than 0.1% of the DOE's DAC guide for controlled areas or 200,000 × 10^{-18} µCi/mL. Tables V-10 and V-11 present monitoring data on plutonium concentrations.

Americium. Since americium often occurs along with plutonium, a subset of plutonium samples are also submitted for this analysis; results are presented in Table V-12. No above-background results in uncontrolled areas were recorded for 1993. Annual mean concentrations of ^{241}Am were all less than 0.1% of the DOE's DAC guides for controlled and uncontrolled areas.

Uranium. Because uranium is a naturally occurring radionuclide in soil, it is found in airborne soil particles that have been resuspended by wind or mechanical forces (for example, vehicles or construction activity). As a result, uranium concentrations in air are heavily dependent on the immediate environment of the air sampling station. Stations with relatively high annual averages or maximums are in higher dust loading areas compared to Los Alamos, such as Santa Fe, Pojoaque, and Española (EID 1990). Heavier accumulations of dust on filters result in increased amounts of natural uranium in the samples, accounting for the higher uranium concentrations at regional stations.

Isotopic uranium analysis of the air samples was initiated in 1992, which allows for a more accurate dose assessment from potential exposures to uranium and helps to identify whether the source is natural or man-made. Activity concentrations for three isotopes are presented in Tables V-13 through V-15. Due to analytical laboratory error, samples for the second and fourth quarter were not analyzed, and results are not available. The measured mean concentrations of ^{238}U and ^{234}U from off-site regional stations are approximately equal, as would be expected for naturally occurring uranium. Total uranium concentrations, in terms of mass can be calculated using the conversion factors provided in Table V-16 for comparison with uranium data from previous environmental surveillance

Table V-7. Airborne Long-Lived Gross Alpha Concentrations for 1993

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (fCi/m^3 [1×10^{-15} $\mu Ci/mL$]) Maximum[c]	Minimum[c]	Mean[c]	2s
Off Site Regional Stations (28–44 km)							
1. Española	59100	25	0	4.8	0.5	1.8	2.4
2. Pojoaque	56200	24	2	6.1	-0.0	1.6	3.0
3. Santa Fe	58100	25	1	7.0	0.3	1.8	3.3
Group Summary		74	3	7.0	-0.0	1.7	2.9
Off Site Perimeter Stations (0–4 km)							
4. Barranca School	55200	23	1	7.3	0.1	1.8	3.5
5. Urban Park	55700	24	2	6.4	0.0	1.8	3.3
6. 48th Street	58800	25	0	5.8	0.5	1.8	2.6
7. Shell Station	61900	25	0	6.1	0.6	1.9	3.0
8. McDonald's	59000	25	0	7.6	0.5	2.0	3.3
9. Los Alamos Airport	57400	25	1	9.1	0.2	2.0	4.0
10. East Gate	56400	24	1	8.5	0.4	1.9	3.8
11. Well PM-1	62200	24	0	5.1	0.7	2.0	2.2
12. Royal Crest Trailer Park	59200	25	1	7.3	0.4	1.9	3.6
13. White Rock, Piñon School	53100	24	4	9.1	0.1	2.1	4.5
14. Pajarito Acres	22700	10	0	3.0	0.5	1.5	1.6
15. White Rock Fire Station	59300	25	2	8.4	0.1	1.8	3.9
16. White Rock Nazarene Church	59200	25	4	8.5	-0.0	1.9	4.4
17. Bandelier	54800	23	0	9.6	0.9	2.4	4.4
Group Summary		327	16	9.6	-0.0	1.9	3.5
On-Site Stations							
19. TA-21, DP Site	58400	25	2	9.3	0.1	2.1	4.3
20. TA-21, Area B	58900	25	4	8.8	0.1	1.8	4.2
21. TA-6	61300	25	1	9.5	0.3	1.9	4.0
22. TA-53, LAMPF	58400	25	0	8.7	0.6	2.0	3.7
23. TA-52, Beta Site	60600	24	2	9.1	-0.0	1.7	3.8
25. TA-16-450	55900	25	1	10.1	0.1	1.9	4.4
26. TA-49	47700	22	0	7.1	0.0	1.8	3.4
27. TA-54	57600	22	0	4.5	0.6	1.4	1.7
28. TA-33	58300	25	0	7.6	0.6	2.1	3.5
29. TA-2, Omega Site	55600	25	3	6.1	0.1	1.8	3.2
30. Booster P-2	59200	24	3	5.8	0.0	1.7	3.1
31. TA-3	39800	17	1	14.2	0.2	2.8	6.9
32. TA-48	50700	21	3	5.3	0.1	1.5	2.7
33. Area AB	58500	19	0	6.1	0.6	2.0	3.6
Group Summary		324	20	14.2	-0.0	1.9	3.8

Table V-7. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (fCi/m^3 [1×10^{-15} µCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	2s
Area G Fence Line							
34. Area G-1	55800	20	5	4.4	0.0	1.4	2.3
35. Area G-2	59000	20	0	2.2	0.6	1.2	0.8
36. Area G-3	58700	21	1	4.5	0.3	1.4	1.8
37. Area G-4	59400	22	3	11.6	0.3	1.8	5.0
Group Summary		83	9	11.6	0.0	1.5	2.9
Area G TRU Waste Inspectable Storage Program							
43. Area G(S of Dome)	28700	13	1	5.2	0.0	2.0	3.4
44. Area G(S Perimeter)	37800	15	1	6.1	0.3	2.0	3.7
45. Area G(SE Perimeter)	38700	16	1	6.7	0.4	2.2	3.9
46. Area G(E Perimeter)	37100	15	1	4.9	0.0	1.6	2.8
47. Area G(N Perimeter)	46500	16	2	5.8	0.0	1.6	3.5
Group Summary		75	6	6.7	0.0	1.2	3.4
TA-21 Decommissioning and Demolition Project							
71. TA-21.01	58600	24	0	12.7	0.4	2.6	5.7
72. TA-21.02	56000	23	0	9.1	0.4	2.2	4.1
73. TA-21.03	56000	23	2	9.1	0.3	1.9	4.0
74. TA-21.04	57100	22	1	7.8	0.4	1.9	3.6
75. TA-21.05	58800	23	1	7.8	0.3	2.1	3.5
Group Summary		115	4	12.7	0.3	1.4	4.2
Pueblo Stations							
41. San Ildefonso Pueblo	56800	24	3	4.2	-0.0	1.4	2.5
42. Taos Pueblo	27600	8	1	2.2	0.3	1.0	1.3
48. Jemez Pueblo	17700	4	1	1.0	0.0	0.5	0.9
Group Summary		36	5	4.2	-0.0	1.0	2.3
Firing Sites							
76. TA-15-41	5000	1	0	8.1	8.1	8.1	2.4
77. IJ Site	4200	1	0	5.4	5.4	5.4	3.9
78. TA-15-vacant	5000	2	0	9.1	2.1	5.6	9.9
Group Summary		4	0	9.1	2.1	6.2	6.3

Minimum Detection Limit = 0.4×10^{-15} µCi/mL.
DOE Controlled area DAC = $2{,}000 \times 10^{-15}$ µCi/mL.
DOE Uncontrolled area DAC = 20×10^{-15} µCi/mL.

Table V-8. Airborne Long-Lived Gross Beta Concentrations for 1993

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (fCi/m^3 [1×10^{-15} $\mu Ci/mL$]) Maximum[c]	Minimum[c]	Mean[c]	2s
Off Site Regional Stations							
1. Española	59100	25	0	18.8	6.1	10.4	6.0
2. Pojoaque	56200	24	1	18.4	0.0	9.6	8.1
3. Santa Fe	58100	25	0	24.3	1.5	9.8	9.6
Group Summary		74	1	24.3	0.0	9.9	7.9
Off-Site Perimeter Stations							
4. Barranca School	55200	23	0	16.2	0.9	9.1	6.8
5. Urban Park	55700	24	0	14.9	1.1	9.1	7.1
6. 48th Street	58800	25	0	14.5	3.7	9.4	5.0
7. Los Alamos Shell	61900	25	0	16.6	5.1	10.2	5.7
8. McDonald's	59000	25	0	14.9	4.8	9.9	5.7
9. Los Alamos Airport	57400	25	0	19.7	4.2	10.5	8.0
10. East Gate	56400	24	0	20.6	3.1	10.5	8.3
11. Well PM-1	62200	24	0	16.0	3.4	10.5	6.1
12. Royal Crest Trailer Park	59200	25	0	17.0	2.2	10.0	8.4
13. White Rock, Piñon School	53100	24	0	20.3	2.3	9.7	10.2
14. Pajarito Acres	22700	10	0	19.6	3.2	9.7	9.3
15. White Rock Fire Station	59300	25	1	20.3	0.1	8.8	9.9
16. White Rock Nazarene Church	59200	25	0	18.9	2.8	9.5	8.2
17. Bandelier	54800	23	1	23.2	0.2	11.3	10.5
Group Summary		327	2	23.2	0.1	9.9	7.9
On-Site Stations							
19. TA-21 DP Site	58400	25	0	19.7	1.2	9.7	9.4
20. TA-21 Area B	58900	25	0	19.7	1.4	9.5	10.2
21. TA-6	61300	25	0	12.3	4.6	8.9	4.4
22. TA-53 LAMPF	58400	25	0	17.4	3.4	10.1	7.3
23. TA-52 Beta	60600	24	1	46.9	0.4	10.3	18.4
25. TA-16-450	55900	25	0	39.3	4.8	9.9	13.7
26. TA-49	47700	22	0	17.4	0.0	10.2	7.4
27. TA-54 Area G	57600	22	0	19.2	7.0	11.5	7.3
28. TA-33 HP Site	58300	25	0	23.2	1.4	11.1	9.9
29. TA-2 Omega	55600	25	0	22.6	3.0	9.4	8.5
30. Booster P-2	59200	24	1	19.0	0.1	9.4	9.2
31. TA-3	39800	17	0	17.0	0.6	9.9	8.1
32. TA-48	50700	21	0	15.1	3.2	8.6	7.9
33. Area AB	58500	19	0	25.1	5.7	11.3	9.2
Group Summary		324	2	46.9	0.0	10.0	9.9

Table V-8. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (fCi/m^3 [1×10^{-15} $\mu Ci/mL$]) Maximum[c]	Minimum[c]	Mean[c]	2s
Area G Fence Line							
34. Area G-1	55800	20	0	35.5	0.7	9.7	15.7
35. Area G-2	59000	20	0	15.1	4.3	9.5	6.1
36. Area G-3	58700	21	0	19.2	3.7	10.3	7.3
37. Area G-4	59400	22	0	18.8	2.2	9.0	7.8
Group Summary		83	0	35.5	0.7	9.6	9.8
Area G TRU Waste Inspectable Storage Program							
43. Area G(S of Dome)	28700	13	0	18.3	4.0	11.6	8.1
44. Area G(S Perimeter)	37800	15	0	18.2	2.5	10.5	8.6
45. Area G(SE Perimeter)	38700	16	0	19.3	4.4	11.2	8.7
46. Area G(E Perimeter)	37100	15	1	15.9	0.1	9.6	7.9
47. Area G(N Perimeter)	46500	16	1	21.3	0.1	9.3	10.9
Group Summary		75	2	21.3	0.1	6.5	8.9
TA-21 Decommissioning and Demolition Project							
71. TA-21.01	58600	24	0	17.5	4.2	10.1	6.9
72. TA-21.02	56000	23	0	18.9	6.6	10.6	6.6
73. TA-21.03	56000	23	0	19.2	2.6	9.6	7.8
74. TA-21.04	57100	22	0	18.2	3.9	9.1	7.6
75. TA-21.05	58800	23	0	17.3	5.7	10.1	6.0
Group Summary		115	0	19.2	2.6	6.1	7.0
Pueblo Stations							
41. San Ildefonso Pueblo	56800	24	1	16.0	0.1	9.7	9.3
42. Taos Pueblo	27600	8	0	12.7	3.0	6.5	7.0
48. Jemez Pueblo	17700	4	1	8.6	-0.1	5.6	7.8
Group Summary		36	2	16.0	-0.1	6.5	9.1
Firing Sites							
76. TA-15-41	5000	1	0	18.2	18.2	18.2	3.8
77. IJ Site	4200	1	0	15.3	15.3	15.3	5.2
78. TA-15-vacant	5000	2	0	21.2	14.1	17.6	10.0
Group Summary		4	0	21.2	14.1	17.2	6.3

Minimum Detection Limit = 0.4×10^{-15} $\mu Ci/mL$.
DOE Controlled area DAC = $200{,}0000 \times 10^{-15}$ $\mu Ci/mL$.
DOE Uncontrolled area DAC = $9{,}000 \times 10^{-15}$ $\mu Ci/mL$.

Table V-9. Airborne Tritium as Tritiated Water Concentrations for 1993

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (pCi/m^3 [10^{-12} $\mu Ci/mL$]) Maximum	Minimum	Mean	2s
Off-Site Regional Stations (28–44 km)							
1. Española	104	25	22	4.6	-0.5	0.6	2.1
2. Pojoaque	95	23	22	8.2	-0.3	0.7	3.4
3. Santa Fe	103	25	25	1.3	-0.2	0.4	0.8
Group Summary		73	69	8.2	-0.5	0.5	2.3
Off-Site Perimeter Stations (0-4 km)							
4. Barranca School	97	23	21	8.8	0.0	1.2	3.8
5. Urban Park	95	23	21	14.8	-0.2	1.4	6.0
6. 48th Street	98	24	20	3.8	-0.0	1.1	1.9
7. Shell Station	109	25	19	3.2	0.3	1.4	1.7
8. McDonald's	100	24	16	6.0	0.3	2.2	3.0
9. Los Alamos Airport	83	20	13	54.9	-0.5	4.6	24.1
10. East Gate	100	24	16	20.5	0.2	2.7	8.1
11. Well PM–1	110	24	20	11.9	-0.7	2.0	6.4
12. Royal Crest Trailer Park	104	25	16	6.9	-1.0	1.9	3.3
13. White Rock, Piñon School	94	24	22	2.8	-0.5	0.9	1.5
14. Pajarito Acres	40	10	7	5.2	0.1	1.5	3.4
15. White Rock Fire Station	105	25	24	2.7	-0.5	0.8	1.2
16. White Rock Nazarene	100	24	21	12.8	-0.3	1.4	5.1
17. Bandelier	97	24	22	4.1	-0.9	0.7	2.1
Group Summary		319	258	54.9	-1.0	1.7	7.4
On-Site Stations							
19. TA-21, DP Site	99	24	2	24.9	-0.4	7.3	12.7
20. TA-21, Area B	96	23	15	22.6	0.0	2.8	9.9
21. TA-6	104	24	21	28.9	-0.8	3.3	15.5
22. TA-53, LAMPF	103	25	11	6.5	0.2	2.4	2.7
23. TA-52, Beta Site	103	24	13	10.4	0.6	2.6	4.5
25. TA-16-450	88	22	19	2.8	0.1	0.9	1.4
26. TA-49	84	21	19	18.1	-0.2	1.5	7.8
27. TA-54	102	25	2	44.8	1.0	13.7	22.8
28. TA-33	103	25	13	21.4	0.2	3.0	8.2
29. TA-2, Omega Site	90	22	11	7.9	0.0	2.5	4.1
30. Booster P-2	93	21	18	2.7	0.0	0.9	1.5
31. TA-3	64	16	8	30.6	0.0	5.3	15.7
32. TA-48	90	21	17	5.7	-0.4	1.4	2.9
33. Area AB	99	18	14	8.7	0.0	1.2	4.1
Group Summary		311	183	44.8	-0.8	3.6	12.3

Table V-9. (Cont.)

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (pCi/m^3 [10^{-12} $\mu Ci/mL$]) Maximum	Minimum	Mean	2s
Area G Fence Line							
34. Area G-1	99	24	5	38.8	0.3	12.8	26.6
35. Area G-2	104	24	1	1804.3	0.5	318.2	855.0
36. Area G-3	99	24	19	11.2	0.0	1.7	4.3
37. Area G-4	96	23	11	10.2	-0.5	3.0	5.1
Group Summary		95	36	1804.3	-0.5	84.8	503.6
Area G TRU Waste Inspectable Storage Program							
43. Area G(S of Dome)	54	14	3	21.4	0.9	9.7	12.8
44. Area G(S Perimeter)	67	16	3	13.7	0.6	6.9	8.9
45. Area G(SE Perimeter)	63	16	2	12.5	1.0	6.3	7.3
46. Area G(E Perimeter)	65	16	4	40.7	1.1	8.0	18.4
47. Area G(N Perimeter)	76	16	0	27.6	2.5	13.1	16.6
Group Summary		78	12	40.7	0.6	8.8	14.1
TA-21 Decontamination and Decommissioning Project							
71. TA-21.01	99	24	15	10.4	0.2	2.4	5.3
72. TA-21.02	98	24	12	34.6	0.4	4.0	14.0
73. TA-21.03	99	24	5	13.2	1.4	4.6	6.8
74. TA-21.04	97	23	7	12.1	0.7	3.4	6.0
75. TA-21.05	104	24	4	15.8	0.5	4.8	7.7
Group Summary		119	43	34.6	0.2	3.9	8.6
Pueblo Stations							
41. San Ildefonso Pueblo	100	24	23	2.8	-0.4	0.4	1.3
42. Taos Pueblo	45	8	8	0.6	0.1	0.3	0.4
48. Jemez Pueblo	12	2	2	0.1	-0.3	-0.1	0.6
Group Summary		34	33	2.8	-0.4	0.3	1.1
Firing Sites							
76. TA-15-41	9	2	2	1.3	0.8	1.1	0.7
77. IJ Site	8	1	1	1.1	1.1	1.1	0.6
78. TA-15-vacant	9	2	2	1.2	0.9	1.0	0.5
Group Summary		5	5	1.3	0.8	1.1	0.4

Minimum Detection Limit = 2 x 10E-12 $\mu Ci/mL$
DOE Controlled area DAC = 20,000,000 x 10E-12 $\mu Ci/mL$
DOE Uncontrolled area DAC = 100,000 x 10E-12 $\mu Ci/mL$

Table V-10. Airborne Plutonium-238 Concentrations for 1993

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} $\mu Ci/mL$]) Maximum	Minimum	Mean	2s
Off-Site Regional Stations (28–44 km)							
1. Española	44500	3	3	1.1	-1.4	-0.09	2.5
2. Pojoaque	41500	3	2	6.1	1.1	3.06	5.4
3. Santa Fe	42900	3	3	3.1	0.7	1.97	2.4
Group Summary		9	8	6.1	-1.4	1.6	4.2
Off-Site Perimeter Stations (0-4 km)							
4. Barranca School	40300	3	3	0.2	-0.9	-0.2	1.1
5. Urban Park	42200	3	3	0.7	-0.1	0.4	0.9
6. 48th Street	44000	3	3	0.0	-0.1	-0.1	0.2
7. Shell Station	47100	3	3	1.1	-1.0	-0.0	2.1
8. McDonald's	44200	3	3	-0.1	-0.8	-0.5	0.6
9. Los Alamos Airport	42600	3	3	3.3	0.4	1.4	3.2
10. East Gate	41600	3	3	0.3	-0.8	-0.3	1.0
11. Well PM–1	45100	3	3	1.8	0.0	0.6	2.1
12. Royal Crest Trailer Park	42500	3	3	1.3	-0.9	0.2	2.2
13. White Rock, Piñon School	38300	3	2	7.0	0.6	3.4	6.5
14. Pajarito Acres	22700	2	2	0.4	0.0	0.2	0.6
15. White Rock Fire Station	44400	3	3	1.8	0.9	1.4	0.9
16. White Rock Nazarene	44400	3	3	0.0	-1.0	-0.3	1.2
17. Bandelier	39900	3	3	2.1	0.0	1.2	2.2
Group Summary		41	40	7.0	-1.0	0.5	2.8
On-Site Stations							
19. TA-21, DP Site	43500	3	3	0.3	-0.1	0.1	0.4
20. TA-21, Area B	44000	3	3	3.2	1.4	2.2	1.8
21. TA-6	46400	3	3	0.8	-0.9	0.2	1.9
22. TA-53, LAMPF	43300	3	3	1.9	-1.5	0.0	3.4
23. TA-52, Beta Site	46100	3	3	1.0	-0.4	0.5	1.7
25. TA-16-450	43700	3	3	1.0	-1.2	0.2	2.4
26. TA-49	38500	3	3	1.2	-0.1	0.4	1.4
27. TA-54	42900	3	2	5.2	0.6	2.3	5.1
28. TA-33	43400	3	3	1.5	-0.3	0.9	2.1
29. TA-2, Omega Site	41200	3	3	2.4	0.3	1.0	2.3
30. Booster P-2	44300	3	3	3.5	0.8	1.9	2.8
31. TA-3	22600	2	1	8.9	2.4	5.7	9.1
32. TA-48	35700	3	3	1.6	0.3	0.9	1.3
33. Area AB	39400	3	3	3.5	0.0	1.5	3.6
Group Summary		41	39	8.9	-1.5	1.2	3.6

Table V-10. (Cont.)

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} $\mu Ci/mL$]) Maximum	Minimum	Mean	2s
Area G Fence Line							
34. Area G-1	41000	3	2	10.3	0.0	3.8	11.3
35. Area G-2	44200	3	3	1.4	-0.9	0.1	2.3
36. Area G-3	43600	3	2	5.8	1.8	3.2	4.5
37. Area G-4	44200	3	3	0.9	-0.6	0.3	1.5
Group Summary		12	10	10.3	-0.9	1.9	6.3
Area G TRU Waste Inspectable Storage Program							
43. Area G (S of Dome)	16100	2	1	4.1	3.2	3.7	1.2
44. Area G (S Perimeter)	23000	2	2	0.0	-0.1	-0.1	0.2
45. Area G (SE Perimeter)	23900	2	2	2.5	0.6	1.6	2.7
46. Area G (E Perimeter)	22300	2	0	28.1	5.9	17.0	31.4
47. Area G (N Perimeter)	31700	2	1	4.1	2.3	3.2	2.6
Group Summary		10	6	28.1	-0.1	5.1	16.6
TA-21 Decontamination and Decommissioning Project							
71. TA-21.01	43800	3	3	0.4	-0.1	0.1	0.6
72. TA-21.02	43800	3	3	3.7	0.4	1.8	3.4
73. TA-21.03	43800	3	3	3.6	1.6	2.7	2.0
74. TA-21.04	42000	3	3	3.7	0.0	2.1	3.8
75. TA-21.05	43700	3	3	1.6	0.0	0.8	1.6
Group Summary		15	15	3.7	-0.1	1.5	2.9
Pueblo Stations							
41. San Ildefonso Pueblo	42000	3	2	5.6	-0.4	2.0	6.3
42. Taos Pueblo	24400	2	2	0.6	0.0	0.3	0.9
48. Jemez Pueblo	8500	1	0	5.4	5.4	5.4	28.9
Group Summary		6	4	5.6	-0.4	2.0	5.5

Minimum Detection Limit = 4 x 10E-18 $\mu Ci/mL$
DOE Controlled area DAC = 2,000,000 x 10E-18 $\mu Ci/mL$
DOE Uncontrolled area DAC = 30,000 x 10E-18 $\mu Ci/mL$

Table V-11. Airborne Plutonium-239,240 Concentrations for 1993

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} $\mu Ci/mL$]) Maximum	Minimum	Mean	2s
Off-Site Regional Stations (28–44 km)							
1. Española	44500	3	2	8.2	-0.5	2.8	9.4
2. Pojoaque	41500	3	2	12.5	0.8	4.8	13.3
3. Santa Fe	42900	3	3	2.0	0.3	1.1	1.7
Group Summary		9	7	12.5	-0.5	2.9	8.8
Off-Site Perimeter Stations (0-4 km)							
4. Barranca School	40300	3	3	0.6	0.0	0.3	0.6
5. Urban Park	42200	3	3	1.9	0.6	1.2	1.3
6. 48th Street	44000	3	3	0.9	0.4	0.7	0.6
7. Shell Station	47100	3	3	1.8	0.3	0.8	1.7
8. McDonald's	44200	3	3	0.4	-0.4	0.0	0.8
9. Los Alamos Airport	42600	3	2	4.6	0.0	2.2	4.6
10. East Gate	41600	3	3	2.5	0.4	1.3	2.2
11. Well PM–1	45100	3	3	0.6	0.0	0.3	0.6
12. Royal Crest Trailer Park	42500	3	3	1.8	0.0	0.9	1.8
13. White Rock, Piñon School	38300	3	3	2.3	-1.2	1.0	3.9
14. Pajarito Acres	22700	2	2	1.8	0.2	1.0	2.3
15. White Rock Fire Station	44400	3	3	2.3	1.1	1.6	1.4
16. White Rock Nazarene	44400	3	3	1.9	1.0	1.3	1.0
17. Bandelier	39900	3	3	0.6	0.3	0.5	0.3
Group Summary		41	40	4.6	-1.2	0.9	2.0
On-Site Stations							
19. TA-21, DP Site	43500	3	3	1.9	0.3	1.2	1.6
20. TA-21, Area B	44000	3	3	1.9	-0.7	1.0	3.0
21. TA-6	46400	3	3	2.4	1.4	2.0	1.0
22. TA-53, LAMPF	43300	3	3	2.0	0.9	1.4	1.1
23. TA-52, Beta Site	46100	3	3	2.1	0.3	1.0	1.9
25. TA-16-450	43700	3	3	1.5	-0.3	0.3	2.0
26. TA-49	38500	3	2	3.4	1.6	2.2	2.0
27. TA-54	42900	3	1	25.1	0.9	14.5	24.8
28. TA-33	43400	3	3	1.4	0.3	0.9	1.1
29. TA-2, Omega Site	41200	3	2	15.9	0.0	5.4	18.2
30. Booster P-2	44300	3	1	5.4	1.3	3.2	4.1
31. TA-3	22600	2	1	99.0	0.6	49.8	139.0
32. TA-48	35700	3	3	1.9	1.2	1.5	0.7
33. Area AB	39400	3	3	3.0	0.1	1.5	2.8
Group Summary		41	34	99.0	-0.7	5.1	31.7

Table V-11. (Cont.)

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} µCi/mL]) Maximum	Minimum	Mean	2s
Area G Fence Line							
34. Area G-1	41000	3	1	6.7	2.7	5.0	4.2
35. Area G-2	44200	3	2	5.4	0.9	2.4	5.3
36. Area G-3	43600	3	3	2.0	-1.8	0.4	3.8
37. Area G-4	44200	3	3	2.2	1.3	1.8	0.9
Group Summary		12	9	6.7	-1.8	2.4	4.8
Area G TRU Waste Inspectable Storage Program							
43. Area G(S of Dome)	16100	2	0	3.8	3.0	3.4	1.1
44. Area G(S Perimeter)	23000	2	1	10.2	1.8	6.0	11.9
45. Area G(SE Perimeter)	23900	2	1	9.0	1.6	5.3	10.5
46. Area G(E Perimeter)	22300	2	2	2.9	1.9	2.4	1.4
47. Area G(N Perimeter)	31700	2	1	5.3	1.9	3.6	4.9
Group Summary		10	5	10.2	1.6	4.1	6.2
TA-21 Decontamination and Decommissioning Project							
71. TA-21.01	43800	3	2	5.4	0.3	2.0	5.9
72. TA-21.02	43800	3	2	6.3	1.4	3.2	5.4
73. TA-21.03	43800	3	0	11.3	3.1	6.5	8.6
74. TA-21.04	42000	3	1	11.8	0.0	5.8	11.8
75. TA-21.05	43700	3	1	7.8	0.0	4.9	8.6
Group Summary		15	6	11.8	0.0	4.5	7.9
Pueblo Stations							
41. San Ildefonso Pueblo	42000	3	3	1.5	0.6	1.1	1.0
42. Taos Pueblo	24400	2	2	0.3	-0.9	-0.3	1.6
48. Jemez Pueblo	8500	1	1	-0.2	-0.2	-0.2	28.9
Group Summary		6	6	1.5	-0.9	0.4	1.8

Minimum Detection Limit = 3 x 10E-18 µCi/mL
DOE Controlled area DAC = 2,000,000 x 10E-18 µCi/mL
DOE Uncontrolled area DAC = 20,000 x 10E-18 µCi/mL

Table V-12. Airborne Americium Concentrations for 1993

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} µCi/mL]) Maximum	Minimum	Mean	2s
Off-Site Regional Stations (28–44 km)							
3. Santa Fe	42900	3	2	2.7	0.7	1.6	2.1
Group Summary		3	2	2.7	0.7	1.6	2.1
Off-Site Perimeter Stations (0-4 km)							
9. Los Alamos Airport	42600	3	1	2.8	0.4	1.8	2.5
10. East Gate	41600	3	2	2.7	1.5	2.0	1.2
12. Royal Crest Trailer Park	42500	3	1	8.9	0.4	3.9	8.9
13. White Rock, Piñon School	38300	3	2	3.3	-0.3	1.6	3.6
15. White Rock Fire Station	44400	3	1	2.5	1.6	2.1	0.9
16. White Rock Nazarene	44400	3	2	2.1	1.6	1.8	0.5
Group Summary		18	9	8.9	-0.3	2.2	9.2
On-Site Stations							
19. TA-21, DP Site	43500	3	1	9.0	1.3	4.8	7.7
20. TA-21, Area B	44000	3	1	3.5	1.1	2.4	2.5
21. TA-6	46400	3	2	2.4	1.0	1.5	1.5
22. TA-53, LAMPF	43300	3	2	8.1	1.5	3.7	7.6
26. TA-49	38500	3	2	2.2	0.8	1.5	1.4
27. TA-54	42900	3	1	15.8	1.8	8.4	14.2
30. Booster P-2	44300	3	1	2.7	0.6	1.8	2.2
31. TA-3	22600	3	1	56.6	-0.1	18.8	65.5
Group Summary		24	11	56.6	-0.1	5.4	42.8
Area G Fence Line							
34. Area G-1	41000	3	1	9.8	0.6	4.2	9.8
35. Area G-2	44200	3	1	6.1	1.2	3.3	5.0
36. Area G-3	43600	3	3	1.4	0.4	1.0	1.0
37. Area G-4	44200	3	1	4.2	0.6	2.3	3.6
Group Summary		12	6	9.8	0.4	2.7	12.5

Minimum Detection Limit = 2 x 10E-18 µCi/mL
DOE Controlled area DAC = 2,000,000 x 10E-18 µCi/mL
DOE Uncontrolled area DAC = 20,000 x 10E-18 µCi/mL

Table V-13. Airborne Uranium-234 Concentrations for 1993

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} $\mu Ci/mL$]) Maximum	Minimum	Mean	2s
Off-Site Regional Stations (28–44 km)							
1. Española	29800	2	0	43.4	9.1	26.2	48.5
2. Pojoaque	26900	2	0	18.7	15.3	17.0	4.7
3. Santa Fe	28300	2	0	34.6	13.5	24.0	29.8
Group Summary		6	0	43.4	9.1	22.4	27.0
Off-Site Perimeter Stations (0-4 km)							
4. Barranca School	27100	2	0	19.5	12.1	15.8	10.6
5. Urban Park	27300	2	0	14.2	8.3	11.3	8.4
6. 48th Street	29200	2	0	11.7	8.8	10.2	4.0
7. Shell Station	32500	2	0	11.9	7.5	9.7	6.2
8. McDonald's	29300	2	0	15.9	11.2	13.6	6.7
9. Los Alamos Airport	28800	2	1	6.1	1.8	4.0	6.2
10. East Gate	26700	2	0	14.4	8.1	11.3	8.9
11. Well PM–1	31400	2	0	10.5	9.4	9.9	1.6
12. Royal Crest Trailer Park	27500	2	0	53.7	12.0	32.9	59.0
13. White Rock, Piñon School	24100	2	0	9.5	7.3	8.4	3.1
14. Pajarito Acres	9900	1	0	9.7	9.7	9.7	32.3
15. White Rock Fire Station	29600	2	0	7.4	7.2	7.3	0.3
16. White Rock Nazarene	29300	2	0	4.1	3.2	3.7	1.2
17. Bandelier	29400	2	0	12.1	8.4	10.3	5.3
Group Summary		27	1	53.7	1.8	11.3	18.6
On-Site Stations							
19. TA-21, DP Site	29300	2	0	7.2	6.9	7.0	0.4
20. TA-21, Area B	29300	2	0	12.9	5.4	9.1	10.7
21. TA-6	31400	2	0	11.9	5.6	8.7	8.9
22. TA-53, LAMPF	28500	2	0	9.9	8.0	8.9	2.7
23. TA-52, Beta Site	31300	2	0	13.9	12.9	13.4	1.4
25. TA-16-450	29100	2	0	12.6	10.3	11.4	3.3
26. TA-49	23700	2	0	14.4	10.2	12.3	6.0
27. TA-54	28000	2	0	30.6	12.6	21.6	25.5
28. TA-33	27800	2	0	16.7	3.2	9.9	19.1
29. TA-2, Omega Site	26200	2	0	16.0	6.2	11.1	13.9
30. Booster P-2	33100	2	0	11.0	9.8	10.4	1.7
31. TA-3	15600	1	0	8.5	8.5	8.5	20.5
32. TA-48	28200	2	0	13.1	12.0	12.6	1.5
33. Area AB	24600	2	0	19.3	16.5	17.9	3.9
Group Summary		27	0	30.6	3.2	11.7	10.8

Table V-13. (Cont.)

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} µCi/mL]) Maximum	Minimum	Mean	2s
Area G Fence Line							
34. Area G-1	29100	2	0	11.1	5.9	8.5	7.3
35. Area G-2	28300	2	0	34.3	9.0	21.7	35.8
36. Area G-3	28300	2	0	54.0	14.0	34.0	56.5
37. Area G-4	30100	2	0	16.5	8.9	12.7	10.7
Group Summary		8	0	54.0	5.9	19.2	33.2
Area G TRU Waste Inspectable Storage Program							
43. Area G(S of Dome)	9300	1	1	36.0	36.0	36.0	34.5
44. Area G(S Perimeter)	15900	1	1	9.5	9.5	9.5	20.1
45. Area G(SE Perimeter)	15900	1	1	3.3	3.3	3.3	20.1
46. Area G(E Perimeter)	15900	1	1	13.7	13.7	13.7	20.1
47. Area G(N Perimeter)	15900	1	1	9.7	9.7	9.7	20.1
Group Summary		5	5	36.0	3.3	14.4	25.2
TA-21 Decontamination and Decommissioning Project							
71. TA-21.01	28900	2	0	19.2	10.0	14.6	13.1
72. TA-21.02	29000	2	0	26.5	21.6	24.1	6.9
73. TA-21.03	29000	2	0	59.0	19.9	39.5	55.2
74. TA-21.04	27700	2	0	8.1	6.5	7.3	2.2
75. TA-21.05	29100	2	0	18.1	8.4	13.2	13.8
Group Summary		10	0	59.0	6.5	19.7	30.7
Pueblo Stations							
41. San Ildefonso Pueblo	27500	2	0	35.2	21.6	28.4	19.2
42. Taos Pueblo	8900	1	1	39.4	39.4	39.4	35.9
48. Jemez Pueblo	8500	1	1	12.4	12.4	12.4	28.9
Group Summary		4	2	39.4	12.4	27.2	24.9

Minimum Detection Limit = 4 x 10E-18 µCi/mL
DOE Controlled area DAC = 20,000,000 x 10E-18 µCi/mL
DOE Uncontrolled area DAC = 90,000 x 10E-18 µCi/mL

Table V-14. Airborne Uranium-235 Concentrations for 1993

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} $\mu Ci/mL$]) Maximum	Minimum	Mean	2s
Off-Site Regional Stations (28–44 km)							
1. Española	29800	2	2	1.5	-0.2	0.6	2.4
2. Pojoaque	26900	2	2	1.7	-0.2	0.7	2.8
3. Santa Fe	28300	2	1	2.0	-0.3	0.9	3.3
Group Summary	6	5	2.0	-0.3	0.7	2.2	
Off-Site Perimeter Stations (0-4 km)							
4. Barranca School	27100	2	2	0.9	0.3	0.6	0.9
5. Urban Park	27300	2	2	1.9	-1.5	0.2	4.9
6. 48th Street	29200	2	2	0.4	-2.5	-1.0	4.2
7. Shell Station	32500	2	1	2.4	1.0	1.7	1.9
8. McDonald's	29300	2	2	1.8	0.0	0.9	2.5
9. Los Alamos Airport	28800	2	2	1.7	0.0	0.9	2.4
10. East Gate	26700	2	1	4.4	1.1	2.7	4.8
11. Well PM–1	31400	2	1	3.0	1.1	2.0	2.6
12. Royal Crest Trailer Park	27500	2	1	19.4	0.0	9.7	27.4
13. White Rock, Piñon School	24100	2	2	0.9	0.9	0.9	0.0
14. Pajarito Acres	9900	1	1	-1.6	-1.6	-1.6	28.2
15. White Rock Fire Station	29600	2	2	0.3	0.1	0.2	0.2
16. White Rock Nazarene	29300	2	2	-0.7	-0.9	-0.8	0.2
17. Bandelier	29400	2	2	0.1	-0.5	-0.2	0.9
Group Summary		27	23	19.4	-2.5	1.3	7.8
On-Site Stations							
19. TA-21, DP Site	29300	2	2	0.7	0.3	0.5	0.7
20. TA-21, Area B	29300	2	1	2.2	1.6	1.9	0.9
21. TA-6	31400	2	2	0.1	0.0	0.1	0.2
22. TA-53, LAMPF	28500	2	2	0.8	-1.1	-0.2	2.6
23. TA-52, Beta Site	31300	2	1	3.3	1.0	2.2	3.1
25. TA-16-450	29100	2	2	0.5	-0.1	0.2	0.9
26. TA-49	23700	2	2	-0.5	-1.0	-0.8	0.8
27. TA-54	28000	2	2	1.9	-1.8	0.1	5.2
28. TA-33	27800	2	2	0.7	-2.3	-0.8	4.2
29. TA-2, Omega Site	26200	2	2	-0.4	-2.5	-1.5	2.9
30. Booster P-2	33100	2	2	0.7	0.4	0.5	0.4
31. TA-3	15600	1	1	1.5	1.5	1.5	20.5
32. TA-48	28200	2	1	2.6	1.2	1.9	2.0
33. Area AB	24600	2	2	0.9	-1.7	-0.4	3.6
Group Summary		27	24	3.3	-2.5	0.3	2.9

Table V-14. (Cont.)

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} µCi/mL]) Maximum	Minimum	Mean	2s
Area G Fence Line							
34. Area G-1	29100	2	2	1.3	-0.6	0.3	2.8
35. Area G-2	28300	2	1	2.6	1.3	2.0	1.8
36. Area G-3	28300	2	1	3.4	1.3	2.4	2.9
37. Area G-4	30100	2	2	1.3	0.7	1.0	0.8
Group Summary		8	6	3.4	-0.6	1.4	2.4
Area G TRU Waste Inspectable Storage Program							
43. Area G(S of Dome)	9300	1	1	1.3	1.3	1.3	30.2
44. Area G(S Perimeter)	15900	1	0	2.4	2.4	2.4	17.6
45. Area G(SE Perimeter)	15900	1	1	0.5	0.5	0.5	17.6
46. Area G(E Perimeter)	15900	1	1	0.6	0.6	0.6	17.6
47. Area G(N Perimeter)	15900	1	1	0.9	0.9	0.9	17.6
Group Summary							
TA-21 Decontamination and Decommissioning Project							
71. TA-21.01	28900	2	1	2.8	1.2	2.0	2.2
72. TA-21.02	29000	2	2	0.5	-0.3	0.1	1.1
73. TA-21.03	29000	2	0	4.0	2.5	3.2	2.2
74. TA-21.04	27700	2	2	0.3	-1.8	-0.8	2.9
75. TA-21.05	29100	2	1	4.0	1.5	2.8	3.6
Group Summary		10	6	4.0	-1.8	1.5	3.8
Pueblo Stations							
41. San Ildefonso Pueblo	27500	2	0	3.7	2.6	3.2	1.5
42. Taos Pueblo	8900	1	1	-1.8	-1.8	-1.8	31.4
48. Jemez Pueblo	8500	1	0	4.2	4.2	4.2	28.9
Group Summary		4	1	4.2	-1.8	2.2	5.5

Minimum Detection Limit = 2 x 10E-18 µCi/mL
DOE Controlled area DAC = 20,000,000 x 10E-18 µCi/mL
DOE Uncontrolled area DAC = 100,000 x 10E-18 µCi/mL

Table V-15. Airborne Uranium-238 Concentrations for 1993

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} $\mu Ci/mL$]) Maximum	Minimum	Mean	2s
Off-Site Regional Stations (28–44 km)							
1. Española	29800	2	0	52.3	11.7	32.0	57.4
2. Pojoaque	26900	2	0	19.7	14.6	17.1	7.2
3. Santa Fe	28300	2	0	24.5	16.3	20.4	11.7
Group Summary		6	0	52.3	11.7	23.2	29.9
Off-Site Perimeter Stations (0-4 km)							
4. Barranca School	27100	2	0	17.1	6.5	11.8	15.1
5. Urban Park	27300	2	0	7.8	6.7	7.2	1.6
6. 48th Street	29200	2	0	9.4	8.1	8.7	1.9
7. Shell Station	32500	2	0	13.0	12.1	12.6	1.2
8. McDonald's	29300	2	0	18.0	6.4	12.2	16.4
9. Los Alamos Airport	28800	2	0	12.7	5.2	8.9	10.6
10. East Gate	26700	2	0	16.1	9.6	12.8	9.1
11. Well PM–1	31400	2	0	10.1	9.1	9.6	1.4
12. Royal Crest Trailer Park	27500	2	0	19.4	11.1	15.3	11.7
13. White Rock, Piñon School	24100	2	0	7.0	4.8	5.9	3.0
14. Pajarito Acres	9900	1	0	15.7	15.7	15.7	24.2
15. White Rock Fire Station	29600	2	0	12.6	4.4	8.5	11.7
16. White Rock Nazarene	29300	2	0	3.8	3.4	3.6	0.6
17. Bandelier	29400	2	1	10.2	2.0	6.1	11.5
Group Summary		27	1	19.4	2.0	9.7	9.4
On-Site Stations							
19. TA-21, DP Site	29300	2	0	6.7	4.3	5.5	3.3
20. TA-21, Area B	29300	2	0	14.4	12.4	13.4	2.7
21. TA-6	31400	2	0	15.4	11.4	13.4	5.7
22. TA-53, LAMPF	28500	2	0	12.6	7.3	10.0	7.5
23. TA-52, Beta Site	31300	2	0	30.6	8.0	19.3	32.0
25. TA-16-450	29100	2	0	10.0	4.5	7.2	7.8
26. TA-49	23700	2	0	16.7	7.4	12.0	13.1
27. TA-54	28000	2	0	43.4	9.6	26.5	47.9
28. TA-33	27800	2	0	6.8	5.6	6.2	1.8
29. TA-2, Omega Site	26200	2	0	25.5	6.7	16.1	26.6
30. Booster P-2	33100	2	0	9.1	6.3	7.7	4.0
31. TA-3	15600	1	0	4.2	4.2	4.2	20.5
32. TA-48	28200	2	0	20.1	20.1	20.1	0.0
33. Area AB	24600	2	0	37.0	12.7	24.8	34.4
Group Summary		27	0	43.4	4.2	13.7	20.2

Table V-15. (Cont.)

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} µCi/mL]) Maximum	Minimum	Mean	2s
Area G Fence Line							
34. Area G-1	29100	2	1	12.4	1.5	7.0	15.4
35. Area G-2	28300	2	0	17.9	10.6	14.3	10.3
36. Area G-3	28300	2	0	28.7	14.8	21.7	19.7
37. Area G-4	30100	2	0	12.3	10.7	11.5	2.2
Group Summary		8	1	28.7	1.5	13.6	15.4
Area G TRU Waste Inspectable Storage Program							
43. Area G(S of Dome)	9300	1	0	42.7	42.7	42.7	25.9
44. Area G(S Perimeter)	15900	1	0	10.2	10.2	10.2	15.1
45. Area G(SE Perimeter)	15900	1	0	9.3	9.3	9.3	15.1
46. Area G(E Perimeter)	15900	1	0	11.7	11.7	11.7	15.1
47. Area G(N Perimeter)	15900	1	0	13.4	13.4	13.4	15.1
Group Summary		5	0	42.7	9.3	17.4	28.4
TA-21 Decontamination and Decommissioning Project							
71. TA-21.01	28900	2	0	17.0	7.2	12.1	13.9
72. TA-21.02	29000	2	0	11.5	10.3	10.9	1.8
73. TA-21.03	29000	2	0	12.3	8.7	10.5	5.1
74. TA-21.04	27700	2	0	5.6	5.0	5.3	0.8
75. TA-21.05	29100	2	1	19.0	2.8	10.9	22.9
Group Summary		10	1	19.0	2.8	9.9	10.4
Pueblo Stations							
41. San Ildefonso Pueblo	27500	2	0	38.2	20.2	29.2	25.4
42. Taos Pueblo	8900	1	0	51.1	51.1	51.1	26.9
48. Jemez Pueblo	8500	1	0	15.7	15.7	15.7	28.9
Group Summary		4	0	51.1	15.7	31.3	32.8

Minimum Detection Limit = 3 x 10E-18 µCi/mL
DOE Controlled area DAC = 20,000,000 x 10E-18 µCi/mL
DOE Uncontrolled area DAC = 100,000 x 10E-18 µCi/mL

Table V-16. Airborne Uranium Concentration Conversion Factors for 1993

Multiply # of	by	to obtain # of
μCi/mL ^{234}U	1.60×10^{14}	pg/m^3 ^{234}U
μCi/mL ^{235}U	4.63×10^{17}	pg/m^3 ^{235}U
μCi/mL ^{238}U	2.98×10^{18}	pg/m^3 ^{238}U

reports (EPG 1994). All measured means were less than 0.1% of the DOE's DAC guides for uranium in air for controlled and uncontrolled areas.

In addition to μCi (kBq) releases of enriched uranium from some Laboratory facilities, depleted uranium (consisting of primarily ^{238}U) is dispersed by experiments that use conventional high explosives. About 298.2 kg (657.5 lb) of depleted uranium was used in such experiments in 1993 (Table V-17). This mass contained about 0.0139 Ci (5.14 Gbq) of radioactivity. 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 an high explosive test (Dahl 1977). Dispersion calculations indicate that resulting maximum airborne concentrations ([40 to 100] $\times 10^{-18}$ μCi/mL) would be greater than concentrations attributable to the natural abundance of uranium that is resuspended in dust particles ([10 to 20] $\times 10^{-18}$ μCi/mL). Since the predicted values were not recorded at any on-site stations or off-site stations, the actual amount released is likely to be smaller than the values given in Table V-17. Additional sampling at the active firing sites will be conducted in the future to confirm this conclusion.

Iodine. With the shutdown of the Omega West research reactor in December 1992, the potential for ^{131}I emissions from LANL was reduced. Data from all six ^{131}I sampling stations are presented in Table V-18. All concentrations were below the minimum detection limit (10×10^{-12} μCi/mL) and well below the DOE DAC guide. Note that there were no results recorded above the MDL, thus the relatively large uncertainty associated with each concentration. There was no statistical difference between ^{131}I in air concentrations measured in 1992 and 1993.

d. Air Monitoring at TA-54, Area G

In addition to the routine air monitoring performed for the environmental surveillance program, four air samplers are operated within the controlled area at TA-54, Area G, the Laboratory's active waste management area. Area AB was added to the on-site group in 1993. In May 1993, five new stations were established to monitor potential emissions resulting from the uncovering and repackaging of 16,500 barrels of transuranic (TRU) waste at the TWISP site. This recovery effort will last through fiscal year 2002; these stations will be discontinued upon the completion of the project.

Table V-17. Estimated Concentrations of Radioactive Elements Released by Dynamic Experiments

Element	1993 Total Usage	Fraction Released[a] (%)	Annual Average Concentration (4 km)[b]	Annual Average Concentration (8 km)[b]	Applicable Standard[c]
^{234}U	3.8×10^{-2} Ci	10	5×10^{-17}	2×10^{-17}	9×10^{-14} μCi/mL
^{235}U	1.9×10^{-3} Ci	10	2×10^{-18}	8×10^{-19}	1×10^{-13} μCi/mL
^{236}U	5.4×10^{-6} Ci	10	7×10^{-21}	2×10^{-21}	1×10^{-13} μCi/mL
^{238}U	9.9×10^{-2} Ci	10	1×10^{-16}	4×10^{-17}	1×10^{-13} μCi/mL

[a]Dahl (1977)
[b]Distance downwind.
[c]DOE (1981)

Table V-18. Airborne Radioiodine Concentrations for 1993

Station Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Concentrations (aCi/m^3 [10^{-18} µCi/mL]) Maximum	Minimum	Mean	2s
Off-Site Perimeter Stations (0-4 km)							
8. McDonald's	240	46	46	6.9	-2.5	0.2	3.6
16. White Rock Nazarene	240	46	46	6.9	-3.7	0.8	4.3
On-Site Stations							
20. TA-21, Area B	240	46	46	5.7	-2.5	0.8	4.2
21. TA-6	200	38	38	5.2	-3.4	0.9	4.1
31. TA-3	140	26	26	9.6	-2.0	0.3	4.6
32. TA-48	200	39	39	6.2	-2.6	0.6	4.3

Minimum Detection Limit = 10 x 10E-12 µCi/mL
DOE Uncontrolled area DAC = 400 x 10E-12 µCi/mL

These samplers measure air concentrations of tritium, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am. The samplers are located near active waste handling and disposal operations, and the measured air concentrations reflect these operations. The air sampling results for 1993 are given in Tables V-7 through V-15. Most air concentrations are slightly above background but are less than 0.1% of the DOE's radioactivity DAC guides for controlled areas. Although the DACs for uncontrolled areas do not apply to TA-54, Area G, the annual average air concentrations measured during 1993 also are less than 0.3% of these more restrictive DAC guides.

Tritium air concentrations at Station #35, G-2, were observed to be higher than readings from other samplers in the area; these sampling results are shown in Figure V-11. Analysis of the results showed the data to be lognormally distributed. For lognormal data distributions, the median or geometric mean of the distribution are more appropriate estimates of the true value (Gilbert 1987). The 1993 median air concentration at G-2 for 1993 was 107×10^{-12} µCi/mL. The dose to a worker in the vicinity of Station G-2 would have been 0.003 mrem. All other air samplers at TA-54, Area G measured tritium concentrations within the range of those observed elsewhere. The G-2 air sampler is located south of shafts used to dispose of higher-activity waste containing tritium and reflects the air concentration close to the shafts.

e. TA-21 Decommissioning and Decontamination Project. Five stations were established in October 1992 to monitor potential emissions from facilities at TA-21 undergoing decommissioning. Stack emissions are also monitored during the project. The buildings TA-21-3 and TA-21-4 will be razed at the end of the decommissioning work. These structures were used mainly for nuclear chemistry involving uranium enriched in ^{235}U and may have residual radionuclides. By combining air sampling results with site specific meteorology and a dispersion model, estimates of airborne emissions can be made. Preliminary results are shown in Table V-19.

3. Surface Water Monitoring.

a. Introduction. Surface waters from off-site (regional and perimeter) and on-site (Laboratory and DOE lands) stations are monitored to routinely survey the environmental effects of Laboratory operations. As described in Section II.C, there are no perennial surface water flows that extend completely across the Laboratory in any of the canyons. Spring-fed flow originating on the flanks of the Jemez Mountains in Los Alamos Canyon maintains a flow into the Los Alamos Reservoir on US Forest Service lands west of the Laboratory. Discharge from the reservoir supports flow onto the western portion of the Laboratory for much of the year; during spring snowmelt, this flow is often sufficient to extend across the entire Laboratory for several weeks. Two canyons have perennial or

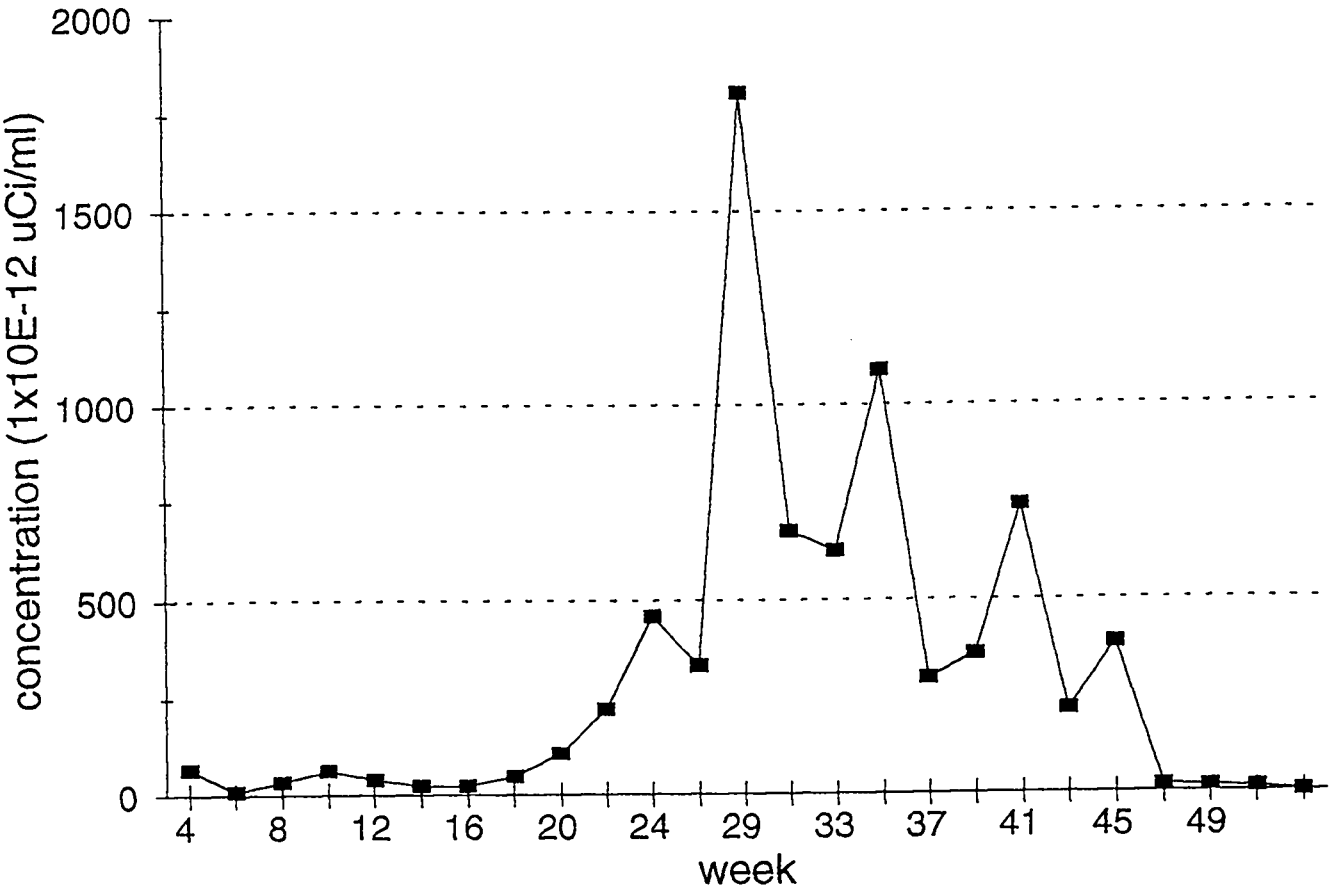


Figure V-11. Tritium in Air at G-2.

Table V-19. 1993 Emissions from TA-21

Radionuclide	Stack Releases (μCi)	Non-Stack Releases (μCi)
^{235}U	51.8	<100
^{239}Pu	0.814	<100

intermittent spring-fed flows over short distances east of the Laboratory in White Rock Canyon: Pajarito Canyon (on Los Alamos County land) and Ancho Canyon (on DOE land). 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.

Most canyons receive discharges from some of the approximately 140 NPDES-permitted industrial and sanitary effluent outfalls, which support flows for varying distances in some of the canyons. The largest effluent-supported flow is in Sandia Canyon from the TA-3 Sanitary Sewage Plant. In 1993, treated radioactive liquid waste effluents containing residual radioactivity were released only from the central Radioactive Liquid Waste Treatment Plant at TA-50 into the Mortandad Canyon drainage (Table V-6). In the past, Pueblo and Los Alamos canyons also received effluents containing radioactivity.

Concentrations of radionuclides in environmental water samples, whether from within the DOE site boundaries or from off site, are compared with the ingested water Derived Concentration Guide (DCGs) for members of the public.

b. Monitoring Network. The locations of surface water monitoring stations are shown in Figures V-12 and V-13 and are listed in Table D-16.

Off-Site Regional Stations. Regional surface water samples were collected within 75 km (47 mi) of the Laboratory from six stations on the Rio Grande, the Rio Chama, and the Jemez River. The six water sampling stations are located at current or former US Geological Survey (USGS) gaging stations. These waters provide baseline data for radiochemical and chemical analyses in areas beyond the Laboratory boundary. Stations on the Rio Grande were at Embudo, Otowi, Cochiti, and Bernalillo (a former gaging station).

The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 37,037 km^2 (14,300 mi^2) in southern Colorado and northern New Mexico. Discharge for the periods of record (1895 to 1905 and 1909 to 1993) has ranged from a minimum of 1.7 m^3/s (60 ft^3/s) in 1902 to 683 m^3/s (24,400 ft^3/s) in 1920. The discharge for water year 1993 (October 1992 through September 1993) ranged from 12 m^3/s (424 ft^3/s) in October to 22 m^3/s (776 ft^3/s)in April (USGS 1994).

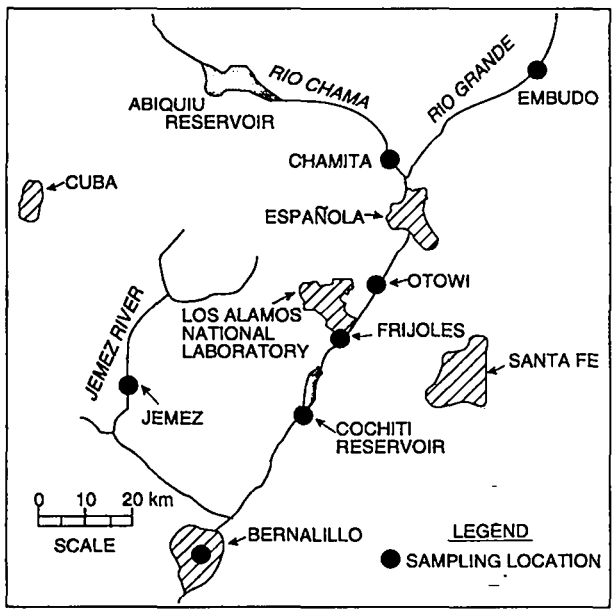


Figure V-12. Off-site regional surface water sampling locations. (Map denotes general locations only; see Table D-15 for specific coordinates.)

The Rio Chama is a tributary of the Rio Grande upstream from Los Alamos. At Chamita, on the Rio Chama, the drainage area above the station is 8,140 km^2 (3,143 mi^2) in northern New Mexico, together with a small area in southern Colorado. Since 1971, some flow has been supplied by transmountain diversion water from the San Juan drainage. Flow at the Chamita gage is governed by release from several reservoirs. Discharge at Chamita during water year 1993 ranged from 2 m^3/s (75 ft^3/s) in October to 96 m^3/s (3,390 ft^3/s) in June.

The station at Jemez on the Jemez River drains an area of the Jemez Mountains west of Los Alamos. The Fenton Hill Hot Dry Rock Geothermal Facility (TA-57) is located within this drainage. The drainage area is small, about 1,220 km^2 (471 mi^2). During water year 1993, discharge (as measured at the gage 3.5 mi north of Jemez) ranged from 0.4 m^3/s (13 ft^3/s) in September to 27 m^3/s (945 ft^3/s) in April. The river is a tributary of the Rio Grande downstream from Los Alamos.

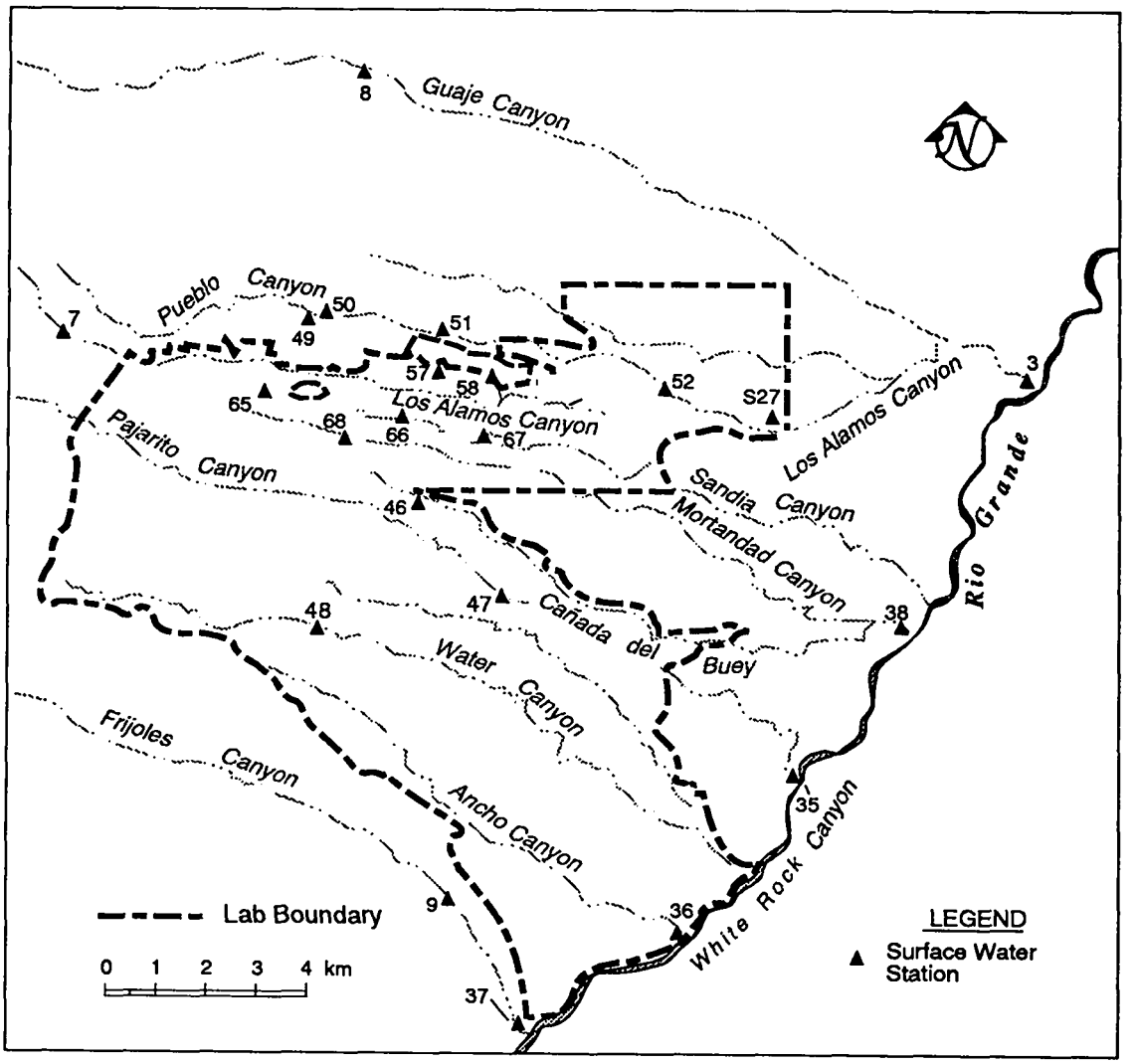


Figure V-13. Surface water sampling locations for off-site perimeter and on-site Laboratory sites. (Map denotes general locations only. See Table D-16 for specific locations).

Surface waters from the Rio Grande, the Rio Chama, and the Jemez River are used for irrigation of crops in the valleys, both upstream and downstream from Los Alamos. These rivers also run through recreational areas on state and federal lands.

Off-Site Perimeter Stations.

Radioactive Effluent Areas. Effluent-associated radionuclides occur off site in Pueblo and Los Alamos canyons. The residual contaminants are from past discharges and are predominantly associated with sediments in the canyons. Some resuspension and redissolution occurs when surface flows move across these sediments, resulting in measurable concentrations in the surface waters.

Acid Canyon, a small tributary of Pueblo Canyon, is a former on-site release area for industrial effluents. Acid Canyon and the upper portion of Pueblo Canyon are on what is now Los Alamos County land. Acid-Pueblo Canyon received untreated and treated industrial effluent containing residual radionuclides from 1944 to 1964 (ESG 1981). Most of the residual radioactivity from these historical releases is now associated with the sediments in Pueblo

Canyon with an estimated total inventory of about 600 mCi of plutonium (ESG 1981). About two-thirds (400 mCi) of this total are in the DOE-owned portion of lower Pueblo Canyon. Pueblo Canyon presently receives treated sanitary effluent from the Los Alamos County Bayo sewage treatment plant in the middle reach of Pueblo Canyon. Increased discharge of sanitary effluent from the county treatment plant, starting in 1990, resulted in nearly continual flow during most days of all months except June and July in the lower reach of Pueblo Canyon and across the DOE land into the off-site lower reach of Los Alamos Canyon on San Ildefonso Pueblo land. (See Section V.B.5.e for a discussion of the transport of radionuclides on sediments in surface runoff.)

This effluent flow from Pueblo Canyon into Los Alamos Canyon generally extends to somewhere between Totavi (just east of the DOE-Pueblo of San Ildefonso boundary) and the confluence of Guaje and Los Alamos canyons. During the peak irrigating season (mid-June through early August), the reduction in treatment plant discharge because of effluent diversion for golf course irrigation and higher evapotranspiration eliminates flow from Pueblo Canyon into Los Alamos Canyon.

The off-site surface water sampling stations are at Acid Weir (where Acid Canyon joins the main channel of Pueblo Canyon), Pueblo 1, and Pueblo 2. Flow is irregular at these locations and depends mainly on snowmelt and thunderstorm runoff and on return flow from the shallow alluvium. In the past, discharges from the Los Alamos County Pueblo Canyon sanitary sewage plant upstream from the confluence with Acid Canyon maintained more regular flow; however, discharges to the stream from this plant were permanently discontinued in 1991. In lower Los Alamos Canyon, off-site surface water samples are collected at its confluence with the Rio Grande.

Other Areas. Off-site perimeter stations within about 4 km (2.5 mi) of the Laboratory boundary include surface water stations at Los Alamos Reservoir, Guaje Canyon, and Frijoles Canyon. Los Alamos Reservoir, in upper Los Alamos Canyon on the flanks of the mountains west of Los Alamos, has a capacity of 51,000 m^3 (41 ac ft) and a drainage area of 16.6 km^2 (6.4 mi^2) above the intake. The reservoir is used for recreation and limited storage of water for irrigation of landscaping in the townsite.

The station in Guaje Canyon is below Guaje Reservoir, which is located in upper Guaje Canyon and has a capacity of 871 m^3 (0.7 ac ft) and a drainage area above the intake of about 14.5 km^2 (5.6 mi^2). Flow into the reservoir is maintained by perennial springs. The stream and reservoir are used for recreation and for storing water used for landscape irrigation in the townsite.

Surface water flow in Frijoles Canyon is sampled at Bandelier National Monument Headquarters. Flow in the canyon is from spring discharge in the upper reach of the canyon. The drainage area above the monument headquarters is about 44 km^2 (17 mi^2) (Purtymun 1980a). Surface flow in Frijoles Canyon is also sampled at the confluence with the Rio Grande.

There are two other off-site perimeter stations in White Rock Canyon along the Rio Grande just east of the Laboratory. These include the perennial reach of the stream in Pajarito Canyon (fed from Group I springs [see Section VII for additional information]), and the continual flow of treated sanitary effluent (from the community of White Rock) in Mortandad Canyon at its confluence with the Rio Grande.

On-Site Stations.

Radioactive Effluent Areas. On-site effluent release areas are canyons that receive, or have received, effluents containing radioactivity, including Pueblo, DP, Los Alamos, and Mortandad canyons (see Figure II-4 for location of on-site canyons).

As noted above in the section describing off-site radioactive effluent areas, the portion of lower Pueblo Canyon that is on DOE land contains sediments contaminated with residuals from past discharges into Acid Canyon. Surface flow is presently maintained across the DOE land in Pueblo Canyon by discharge of effluent from the Los Alamos County Bayo sanitary sewage treatment plant located just west of the county-DOE boundary. Some of this effluent flow infiltrates the tuff and maintains a shallow body of perched alluvial water. (See Section VII for further information.) Pueblo Canyon discharges into Los Alamos Canyon at State Road 502 near the eastern Laboratory boundary. Surface water is sampled at Pueblo 3 and at State Road 502 (Figure V-13).

DP Canyon, a small tributary of Los Alamos Canyon, received treated radioactive liquid waste effluents between 1952 and 1984. Some residuals remain, primarily associated with sediments that are subject to resuspension and redissolution in surface flow. DP Canyon presently receives some sanitary effluent from the treatment plant at TA-21. Sampling stations consist of two surface water stations in DP Canyon, DPS-1 and DPS-4.

In the upper reach of Los Alamos Canyon (above Station LAO-1), there were releases of treated and untreated radioactive effluents during the earliest years of operations at TA-1 (late 1940s) and some release of water from the research reactor at TA-2. The Los Alamos Canyon drainage also received discharge containing some radioactivity in previous years from the sanitary sewage lagoon system at LAMPF (TA-53). (In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon.) There is normally some surface flow in the westernmost portion of Los Alamos Canyon within Laboratory boundaries that is maintained by discharge from the Los Alamos Reservoir. This flow generally infiltrates the shallow alluvium in the canyon and is depleted before it reaches the eastern margin of the Laboratory at State Road 4. Water quality in this portion of Los Alamos Canyon is monitored through samples taken of the alluvial water. (See Section VII for further information.) Snowmelt will often saturate the alluvium sufficiently to result in some surface flow beyond State Road 4 for varying periods in the spring. In the fall of 1991, the USGS, under contract to the Laboratory, resumed continuous operation of a stream flow gaging station a short distance upstream from State Road 4.

Mortandad Canyon has a small drainage area that heads at TA-3. Industrial liquid wastes containing radionuclides are collected and processed at the industrial waste treatment plant at TA-50, which began operating in 1963. After treatment the effluents are released into Mortandad Canyon. Most of the residual contamination is now associated with the sediments in the canyon. The inventory of transuranic contaminants (about 400 mCi) is entirely contained on site (Stoker 1991). Hydrologic studies in the canyon were initiated by the USGS in 1960. Since that time, there has been no continuous surface water flow from the upper and middle reaches of the canyon down to or beyond the Laboratory's boundary; the small drainage area in the upper part of the canyon results in limited runoff and a thick section of unsaturated alluvium in the lower canyon allows rapid infiltration and storage of runoff when it does occur. One surface water station, Gaging Station 1 (GS-1) is located in Mortandad Canyon a short distance downstream from the effluent release point. Most water quality observations in Mortandad Canyon are made on the alluvial water. (See Section VII for further information.) 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. It is approximately another 1.5 km (1 mi) downstream to the Laboratory boundary with the Pueblo of San Ildefonso.

Other Areas. 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-3 sanitary treatment plant. These effluents support a continuous flow in a short reach of the upper 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 Laboratory boundaries or reach the Rio Grande. Three surface water sampling stations, SCS-1, SCS-2, and SCS-3, are located in the reach of the canyon that contains flow maintained by the effluents.

Surface water samples are collected in three other on-site canyons: Cañada del Buey, Pajarito, and Water (at Beta Hole). The flows at these locations are primarily maintained by effluents but do include some natural flows. Spring-supported perennial flows in Water and Ancho canyons are sampled at the DOE boundary where these streams join the Rio Grande.

c. Radiochemical Analytical Results. The results of radiochemical analyses of surface water samples for 1993 are listed in Table V-20. All results are below the DOE DCGs that limit potential exposure to the public from ingestion of water to levels below the DOE public PDL (see Appendix A). The majority of the results are near or below the detection limits of the analytical methods used. 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.

A few of the measurements at or above detection limits were from locations that do not typically show detectable activity. This year, the $^{239,240}Pu$ analyses for the Jemez River and the Rio Grande at Bernalillo were slightly above detection limits. The Jemez River analysis did not have ratios expected for worldwide fallout ($^{239,240}Pu$ about 20 times ^{238}Pu) and neither location reached detection limits in 1992 samples. Similarly, the measurements taken last year that were slightly above detection limits were not detected this year. The tritium level in this year's sample from Cañada del Buey is slightly elevated above detection limit levels. Cesium measurements

Table V-20. Radiochemical Analysis of Surface Water for 1993

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA (µg/L)	Total Uranium ICPMS (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)
OFF-SITE STATIONS											
REGIONAL STATIONS											
Rio Chama at Chamita	0.3 (0.3)[a]	0.8 (0.8)	4.7 (1.5)	N/A[b]	<1.0 (0.0)	0.004 (0.030)	0.008 (0.020)	0.000 (0.030)	0 (1)	3 (1)	-10 (100)
Rio Grande at Embudo	0.2 (0.3)	0.5 (0.8)	1.5 (1.2)	N/A	1.0 (0.5)	-0.004 (0.030)	0.013 (0.020)	0.023 (0.030)	1 (1)	5 (1)	40 (100)
Rio Grande at Otowi	0.4 (0.3)	0.8 (0.9)	2.1 (1.2)	N/A	1.3 (0.5)	0.000 (0.030)	0.000 (0.020)	-0.004 (0.030)	1 (1)	4 (1)	-40 (100)
Rio Grande at Frijoles	0.4 (0.3)	N/A	<1.1 (0.0)	3.9 (0.4)	3.0 (0.4)	0.003 (0.020)	-0.002 (0.030)	N/A	3 (1)	5 (1)	-100 (100)
Rio Grande at Cochiti	0.2 (0.3)	1.4 (1.1)	3.3 (1.2)	N/A	1.3 (0.5)	0.000 (0.030)	0.012 (0.020)	0.000 (0.030)	1 (1)	4 (1)	-190 (100)
Rio Grande at Bernalillo	0.4 (0.3)	0.0 (1.0)	1.4 (1.1)	N/A	1.4 (0.5)	0.004 (0.030)	0.075 (0.020)	0.036 (0.030)	1 (1)	4 (1)	-10 (100)
Jemez River	0.3 (0.3)	-0.1 (1.0)	2.8 (1.1)	N/A	<1.0 (0.0)	0.018 (0.030)	0.092 (0.024)	0.032 (0.030)	2 (1)	6 (1)	-170 (100)
PERIMETER STATIONS											
Radioactive Effluent Release Areas											
Acid-Pueblo Canyons											
Acid Weir	0.4 (0.3)	8.3 (0.8)	1.8 (1.2)	N/A	<1.0 (0.00)	0.000 (0.030)	0.121 (0.023)	0.000 (0.000)	0 (1)	19 (2)	-60 (90)
Pueblo 1	0.4 (0.3)	2.4 (0.8)	1.6 (1.1)	N/A	<1.0 (0.0)	-0.008 (0.030)	0.009 (0.020)	0.000 (0.000)	-1 (1)	8 (1)	-80 (90)
Pueblo 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon											
Los Alamos Canyon Reservoir	0.4 (0.3)	N/A	-0.0 (1.3)	N/A	<1.0 (0.0)	0.000 (0.030)	0.017 (0.020)	N/A	0 (0)	2 (0)	-60 (100)
Los Alamos at Rio Grande	1.1[c] (0.4)	0.6 (0.9)	0.8[c] (1.7)	N/A	<2.0[c] (0.0)	0.002[c] (0.042)	0.020[c] (0.028)	0.045 (0.030)	2[c] (2)	16[c] (3)	55[c] (141)
Other Areas											
Guaje Canyon	0.7 (0.3)	N/A	0.4 (1.2)	N/A	<1.0 (0.0)	0.013 (0.030)	0.017 (0.020)	N/A	1 (1)	2 (0)	60 (100)
Mortandad at Rio Grande	-0.1 (0.3)	N/A	N/A	0.4 (0.0)	1.0 (0.3)	0.008 (0.020)	0.021 (0.030)	N/A	-0 (1)	12 (1)	-100 (100)
Pajarito at Rio Grande	0.2 (0.3)	N/A	<0.4 (0.0)	0.4 (0.1)	1.0 (0.2)	0.020 (0.020)	0.045 (0.030)	N/A	1 (0)	2 (0)	900 (100)
Frijoles at Monument HQ	0.4 (0.3)	N/A	3.3 (1.2)	N/A	<1.0 (0.0)	-0.008 (0.030)	0.000 (0.020)	N/A	1 (1)	2 (0)	-140 (100)
Frijoles at Rio Grande	0.2 (0.3)	N/A	<1.7 (0.0)	0.0 (0.0)	<1.0 (0.0)	-0.002 (0.020)	0.005 (0.030)	N/A	0 (0)	2 (0)	0 (100)
ON-SITE STATIONS											
Radioactive Effluent Release Areas											
Acid Pueblo Canyons											
Pueblo 3	0.2 (0.3)	2.2 (0.7)	2.3 (1.3)	N/A	<1.0 (0.0)	-0.019 (0.030)	0.006 (0.020)	0.000 (0.000)	1 (1)	15 (2)	100 (100)
Pueblo at State Route	0.5 (0.3)	N/A	3.3 (1.2)	N/A	N/A	0.010 (0.030)	0.015 (0.020)	N/A	1 (2)	30 (3)	10 (100)
Mortandad Canyon											
Mortandad at GS-1	13.1 (1.1)	33.7 (2.2)	N/A	1.4 (0.1)	N/A	0.748 (0.058)	0.493 (0.046)	1.133 (0.089)	4 (2)	110 (10)	600 (100)

Table V-20. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA (µg/L)	Total Uranium ICPMS (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)
DP-Los Alamos Canyons											
DPS-1	0.2 (0.3)	0.0 (0.0)	3.0 (1.3)	N/A	<1.0 (0.0)	0.036 (0.030)	0.118 (0.024)	N/A	-3 (2)	210 (20)	150 (100)
DPS-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas											
Cañada Del Buey	0.7 (0.3)	N/A	1.1 (1.3)	N/A	<1.0 (0.0)	0.000 (0.030)	0.044 (0.020)	N/A	1 (1)	6 (1)	180 (100)
Pajarito Canyon	0.6[c] (0.4)	0.0 (0.7)	1.0[c] (1.5)	N/A	<2.0[c] (0.0)	0.005[c] (0.042)	0.006[c] (0.028)	0.009 (0.030)	1[c] (1)	8[c] (1)	-15[c] (141)
Water Canyon at Beta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	0.1 (0.3)	N/A	<1.3 (0.0)	0.4 (0.0)	<1.0 (0.0)	0.004 (0.020)	0.003 (0.030)	N/A	1 (0)	3 (0)	100 (100)
Sandia Canyon											
SCS-1	0.3 (0.3)	0.1 (0.7)	0.6 (1.1)	N/A	<1.0 (0.0)	0.004 (0.030)	0.012 (0.020)	0.010 (0.030)	-1 (1)	14 (1)	-130 (90)
SCS-2	0.6 (0.3)	1.0 (0.9)	1.0 (1.2)	N/A	<1.0 (0.0)	0.004 (0.030)	0.004 (0.020)	0.041 (0.030)	-3 (2)	11 (1)	-60 (90)
SCS-3	0.3 (0.3)	0.8 (0.8)	3.0 (1.2)	N/A	<1.0 (0.0)	-0.013 (0.030)	0.005 (0.020)	0.000 (0.000)	0 (2)	11 (1)	-50 (90)
Limits of Detection	0.4	3	2	0.1	1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose	2000	1000	3000	800	800	40	60	30			
DOE Drinking Water System DCG			120			1.6	1.2	1.2			
EPA Primary Drinking Water Standard	20	8		20	20				15		
EPA Screening Level										50	

[a]Counting uncertainties (±1 standard deviation) are shown in parentheses.

[b]N/A means analysis not performed, lost in analysis, or not completed.

[c]Mean of multiple samples.

in past years have raised some questions about the potential presence of ^{137}Cs contamination in areas where it would not be expected. These questions were raised because the detection limit of the analytical method was relatively high in comparison with the relevant guidelines or standards and also higher than typical environmental levels. A new method was implemented during 1992 by the Environmental Chemistry Group (See Section VIII.C.1.b). This method has a much lower detection limit, about 2 pCi/L. Some 1992 samples were analyzed by the older method; the 1993 sample results typically are 10 times lower than the 1992 results, reflecting the lower detection limits of the new method. Those from locations where only worldwide fallout levels of ^{137}Cs would be expected had results very near the detection limits of the new method, much lower than measured by the older method, and much lower than reported in previous years' reports. All of the ^{137}Cs results from 1993 are less than 5% of the DOE guide.

Multiple measurements of radioactivity in samples of runoff in Pueblo and Los Alamos canyons, as well as several additional locations, are presented and discussed in Section V.B.5.

One additional type of measurement was made on some water samples in 1993 to enhance understanding of transport mechanisms. These analyses were made for plutonium on the suspended solids filtered from the water samples. This was done in order to estimate the fraction of activity associated with the liquid and suspended solid fractions. Because many results included measurements below detection limits, the calculated percentages for individual samples had very large uncertainties. However, the results fell into two basic groups, confirming expectations on the transport of materials in the different watercourses. Samples from the Rio Grande (grab samples taken at the surface) and from natural flowing streams (Guaje Canyon, Los Alamos Canyon west of the Laboratory, Frijoles Stream, and Ancho and Chaquehui streams at the Rio Grande) contained about 5% to 15% of the total plutonium associated with filterable solids. Samples taken from watercourses within the Laboratory (Pueblo, Sandia, and Pajarito canyons and Cañada del Buey) contained about 50% to 80% of the total plutonium associated with the filterable solids. Even when the activity contained in the suspended solids is taken into account, the total radioactivity measured in each sample was less than 35% of the DOE guide for plutonium in ingested water.

In recent years, treated effluents containing low levels of radioactivity have been released from the central liquid waste treatment plant (TA-50), from a smaller plant serving laboratories at TA-21, and from a sanitary sewage lagoon system serving LAMPF at TA-53 (Table V-6 and Figures V-6 and V-7). In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon. There were no releases from the TA-21 plant or the TA-53 total retention lagoons in 1992 or 1993. Total activity released in 1993 (about 2.7 Ci) was significantly less than that released in 1992 (about 10.7 Ci) (Table V-6). The decrease resulted because of improved treatment of the radioactive liquid waste. Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon, where surface flow has not passed beyond the Laboratory's boundary since the plant began operation in 1963.

d. Long-Term Trends. Long-term trends of the concentrations of dissolved radionuclide (the portion of the sample that passes through a 0.45 μm filter) in surface water in Pueblo Canyon (a former release area) are depicted in Figure V-14. These measurements were made on samples collected at Station Pueblo 3, which is a short distance upstream of the confluence of Pueblo and Los Alamos canyons. This is taken to be representative of the surface water flow that moves off site into the lower reach of Los Alamos Canyon on the Pueblo of San Ildefonso. In general, there has been a decrease in the combined levels of ^{238}Pu and $^{239,240}Pu$ (in solution) over three and a half decades. With continual improvements in detection limits, it is still possible for some residuals to be detected. In the 1993 sample, the plutonium activity was 0.06 pCi/L, below the typical analytical detection limit. Except for an unexplained peak in 1982, tritium concentrations have fluctuated from near the detection limit of the analytical methods to several times the levels typically observed in regional surface waters. Transport of radioactivity occurs primarily as sediments are suspended and moved by the surface water flow. This aspect of off-site transport from Pueblo Canyon into Los Alamos Canyon is described in Section V.B.5.

4. Drinking Water.

This program includes sampling from various points in the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems to ensure compliance with the federal Safe Drinking Water Act (SDWA).

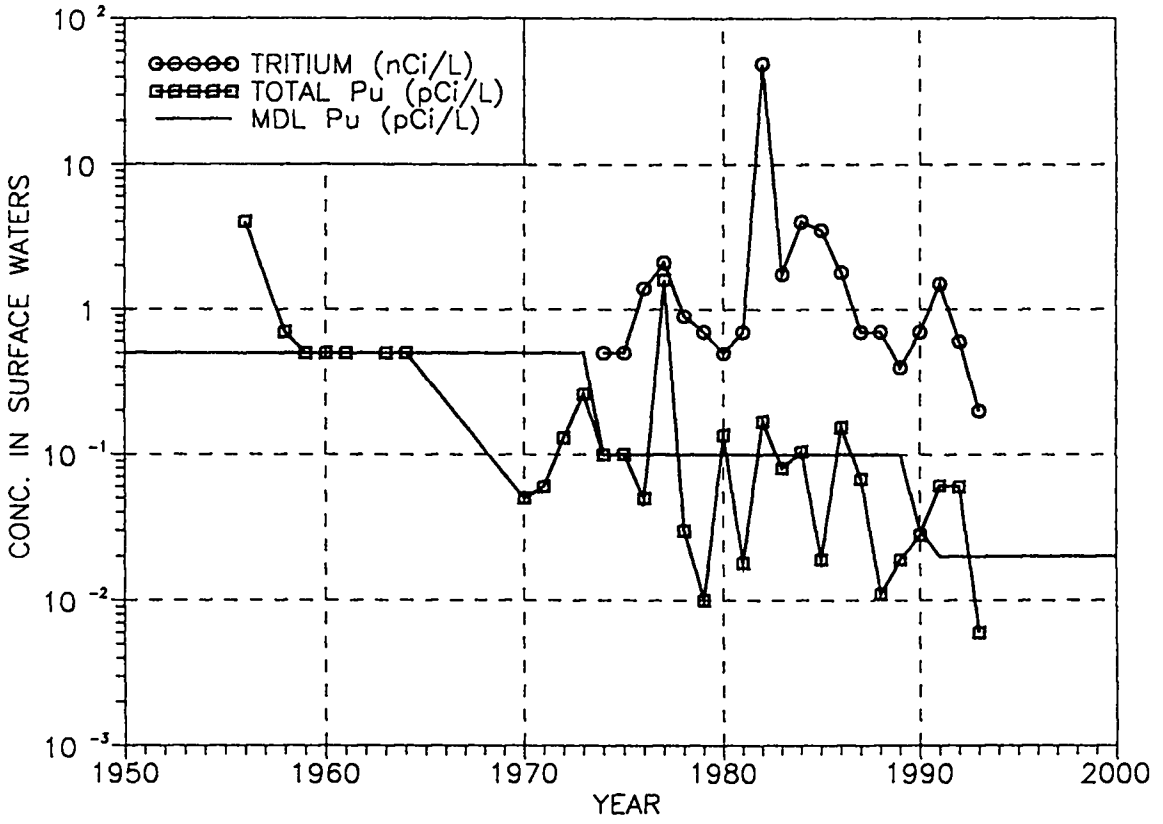


Figure V-14. Tritium and plutonium concentrations at the Pueblo-3 sampling station.

When gross activity measurements are below the screening limits, the Laboratory does not need to perform further isotopic analyses or perform dose calculations. The concentrations of gross alpha activity were less than the screening level of 5 pCi/L. For gross beta, the activity measurements were less than the screening limit of 50 pCi/L. These results are summarized in Table V-21.

Radon is a naturally occurring radionuclide produced during the decay of geological sources of uranium. In 1993, radon sampling was performed at points of entry of water from the three well fields 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 V-22, the radon concentrations in the sampled wells ranged from 68 to 508 pCi/L. If the MCL is finalized at the proposed 300 pCi/L level, waters from some well fields may need radon treatment by extended storage to allow radioactive decay or adsorption removal. Radon has a half-life of about 12 days; residence time in storage tanks will reduce radon concentrations before the water reaches consumers.

5. Sediment Monitoring

a. Introduction. Sediments from off-site (regional and perimeter) and on-site (Laboratory and DOE land) locations are monitored to provide routine surveillance of environmental effects of Laboratory operations. One major mechanism of transport of contaminants is the hydrologic cycle, principally in surface water. Sheet erosion of the movement of suspended sediment or the bed load in surface runoff in canyons are responsible for the transport of many substances. Many contaminants attach to sediment particles by adsorption or ion exchange. Thus contaminants from airborne deposition, effluent discharges, or unplanned releases often become associated with soils or sediments. Accordingly, soils are monitored at representative locations across the Laboratory, and sediments are sampled in all canyons, whether perennial or intermittent, that cross Laboratory lands.

Table V-21. Radioactivity in the Water Distribution System (pCi/L)

Location Standard for Calibration	Gross Alpha		Gross Beta	
Pajarito Booster #2				
^{241}Am	0.1	(0.2)[a]		
Natural U	0.2	(0.3)		
^{137}Cs			1.2	(0.8)
$^{90}Sr, ^{90}Y$			1.2	(0.8)
Los Alamos Booster #4				
^{241}Am	0.7	(0.3)		
Natural U	0.9	(0.4)		
^{137}Cs			3.1	(0.9)
$^{90}Sr, ^{90}Y$			3.2	(0.9)
Guaje Booster #2				
^{241}Am	0.7	(0.3)		
Natural U	0.8	(0.4)		
^{137}Cs			2.9	(0.9)
$^{90}Sr, ^{90}Y$			2.9	(0.9)
White Rock Fire Station				
^{241}Am	0.9	(0.5)		
Natural U	1.2	(0.7)		
^{137}Cs			3.9	(1.0)
$^{90}Sr, ^{90}Y$			4.0	(1.0)
Screening Level	5.0		50.0	
Maximum Contaminant Level (MCL)	15.0		[b]	

[a]Uncertainties are in parentheses.
[b]There is no MCL for gross beta.

Table V-22. Radon in Drinking Water (pCi/L)

Sample Location	Value[a]	
Pajarito Booster #2	68	(94)
Los Alamos Booster #4	508	(104)
Guaje Booster #2	449	(103)
White Rock Fire Station	298	(99)
Proposed EPA MCL	300	

[a]Uncertainties are in parentheses.

There are no standards directly applicable to radioactive contamination of sediments; rather, the levels of contaminants in soils or sediments must be interpreted by means of pathway analyses that determine the consequences in terms of dose to humans if the contaminated particles are either ingested or inhaled. As an indication of environmental contamination levels attributable to Laboratory operations, the results of the annual sampling are compared to levels attributable to worldwide fallout or natural background. Results of analyses of radionuclides in sediment samples from off-site regional stations routinely collected from 1974 through 1986 were used to establish statistical limits for worldwide fallout levels of tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$ and natural background levels of total uranium in northern New Mexico soils and sediments (Purtymun 1987a). The average concentration level in these samples plus twice the standard deviation of the mean was adopted as an indicator of an approximate upper limit for worldwide fallout or natural background concentrations.

Screening Action Levels (SALs) are used by the Laboratory's Environmental Restoration (ER) program to identify the presence of contaminants of concern at potential release sites. Both background concentration (i.e., mean plus twice the standard deviation as reported in Purtymun, 1987a) and SAL values for sediments are listed in tables summarizing analytical results for the environmental surveillance program. These values are intended for comparison to observed data and are provided as a convenience to the reader. Individual, media-specific, SAL values are derived from chemical-specific toxicity values and default exposure parameters using the most recently available data from EPA's Integrated Risk Information System database and Health Effects Assessment Summary Tables, along with EPA guidance (EPA 1989) and EPA's proposed computational methodology (EPA 1990b). SALs for a variety of media are available for the Laboratory (IWP 1993); some of the most recent updates are listed in the radioactive analyses tables.

b. Monitoring Network. The sediment sampling locations are shown in Figure V-15 (off-site regional), Figure V-16 (off-site perimeter and on site), and Figure V-17 (solid waste management areas) and are listed in Table D-17. The sediment stations are organized in the same groupings as the surface water sampling locations discussed in the Surface Water Monitoring section, which provides the basic rationale for the groupings and related historic information.

Off-Site Regional Stations. The regional stations for sediments are located in the three major drainages in northern New Mexico surrounding the Laboratory: the Rio Chama, the Rio Grande and the Jemez River. Special samples of lake sediments are also collected from three locations each in Abiquiu Reservoir and Lake Heron on the Rio Chama upstream from Los Alamos and in three locations in Cochiti Reservoir on the Rio Grande downstream of Los Alamos. The three lakes are the nearest upstream and downstream lakes relative to the Laboratory. One kg samples of these sediments (100 times the mass usually employed) are used to obtain lower detection limits for ^{238}Pu and $^{239,240}Pu$ analysis. Large samples increase the sensitivity of the analyses and are necessary so that plutonium concentrations due to worldwide fallout from atmospheric tests can be effectively evaluated.

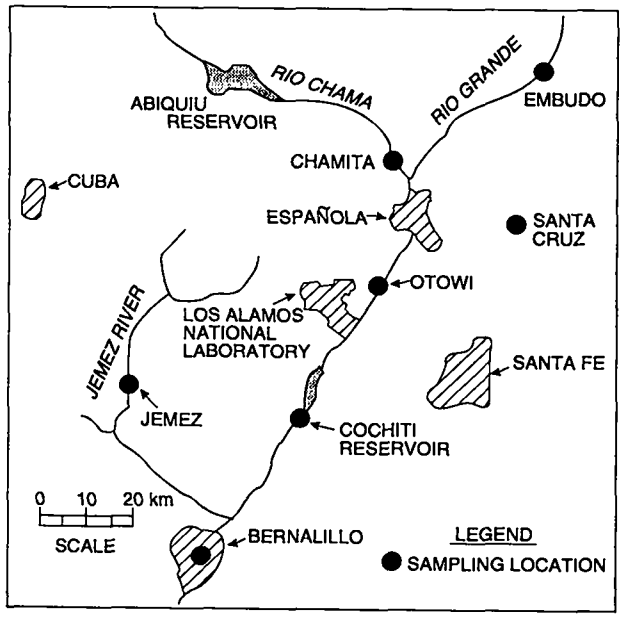


Figure V-15. Off-site regional sampling locations for sediments and soil. (Additional sediment samples are taken from the Rio Grande between Otowi and Cochiti, see Table D-16 and Figure V-16.)

Off-Site Perimeter Stations. Sediment sampling stations for the radioactive effluent release areas are located to monitor the off-site drainages affected by transport of residuals from past releases, as discussed in the previous section. The off-site areas in Acid and Pueblo canyons contain an estimated 150 mCi of plutonium from effluent releases

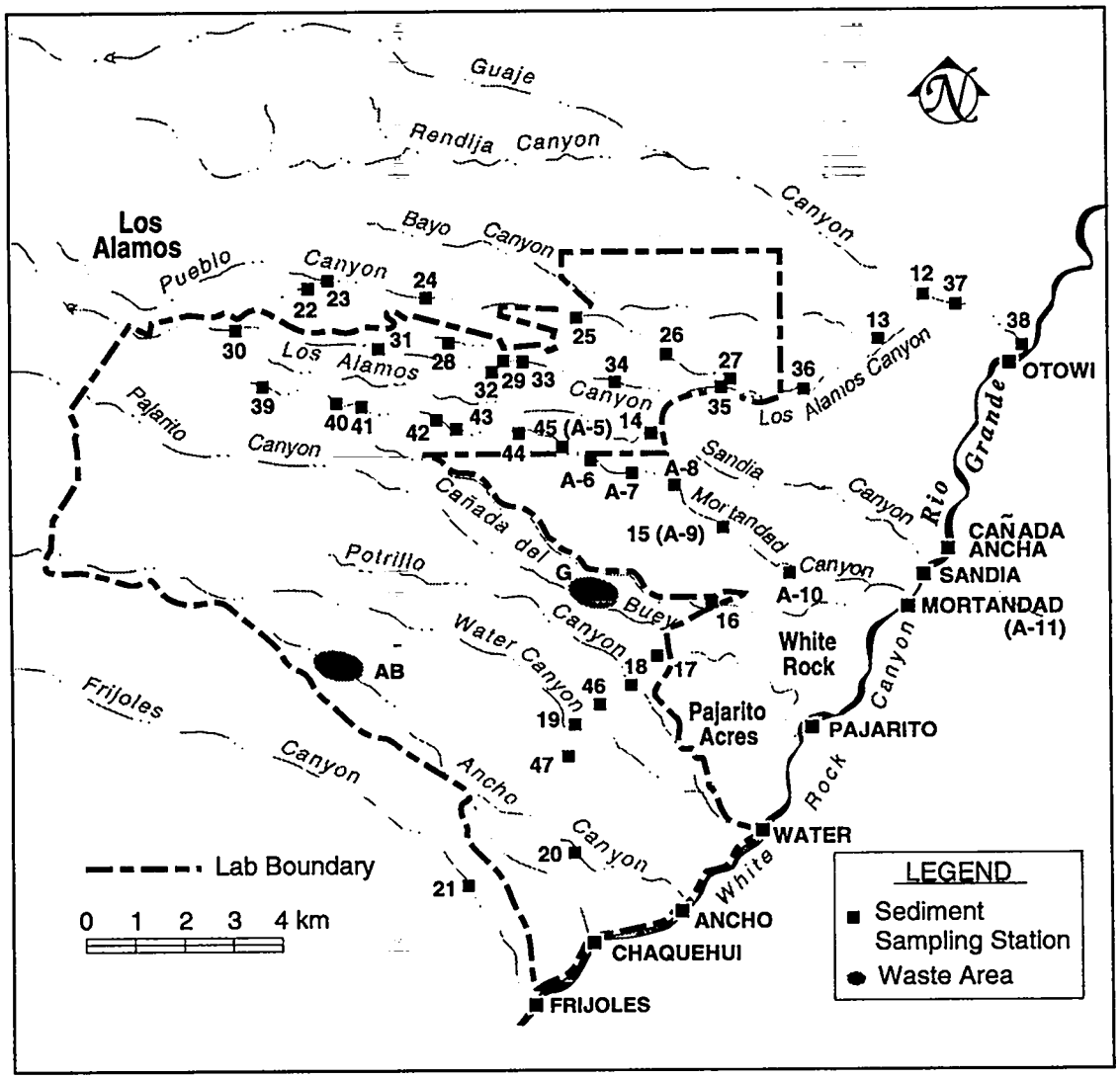
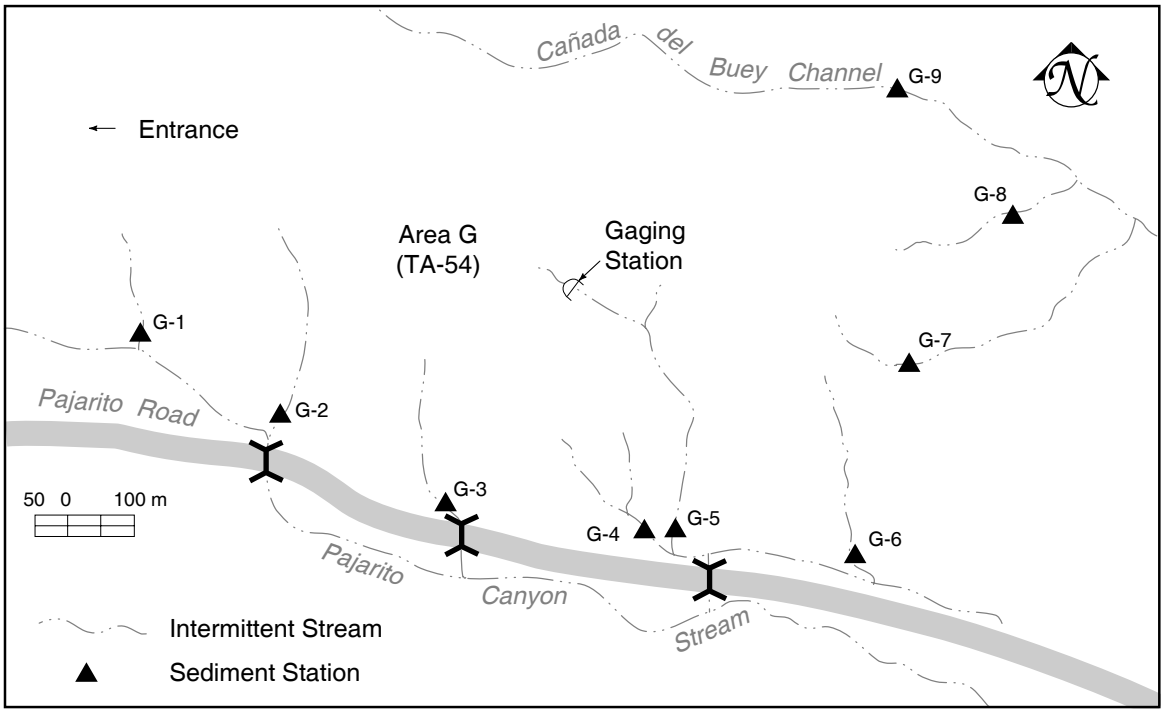


Figure V-16. Sediment sampling locations for off-site perimeter and on-site Laboratory stations. Solid waste management areas with multiple sampling locations are shown in Figure V-17. (Map denotes general locations only. See Table D-16 for specific coordinates).



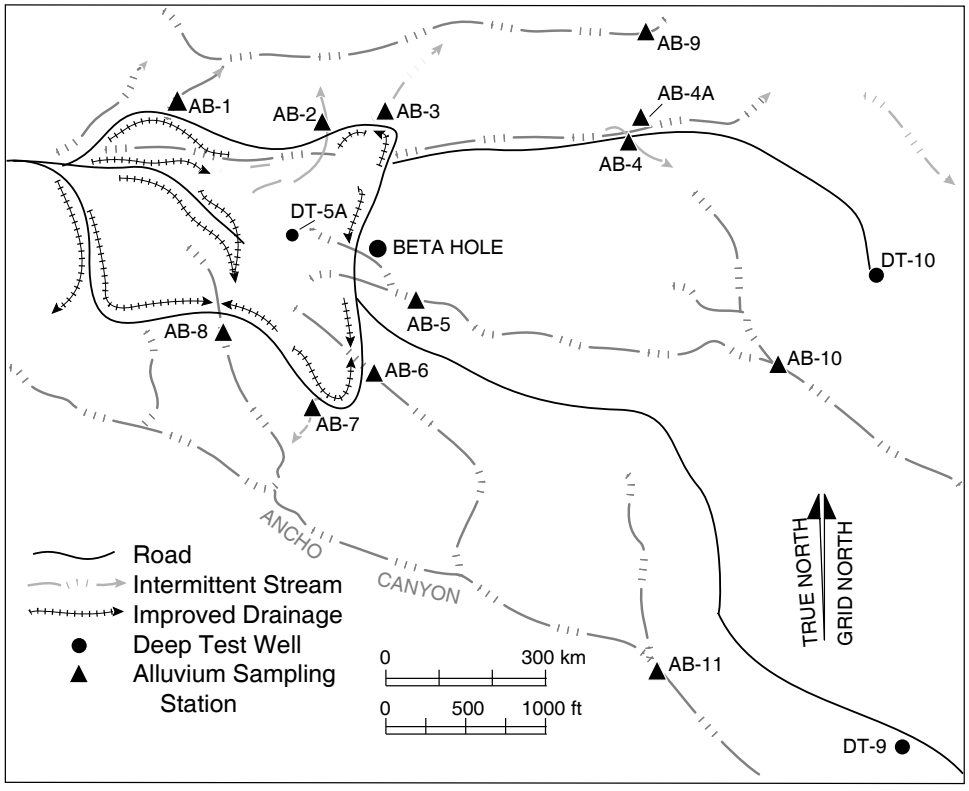


Figure V-17. Off-site perimeter and on-site sediment sampling locations on and near solid waste management areas.
a. Upper map shows the locations of alluvium sampling stations at TA-54, Area G.
b. Bottom map shows the location of sediment stations at TA-49, Area AB.

into Acid Canyon from 1944 through 1964 (ESG 1981). The three sampling stations include one in Acid Canyon at Acid Weir just above the confluence with Pueblo Canyon and two downstream in Pueblo Canyon at Pueblo 1 and Pueblo 2.

The off-site portion of Los Alamos Canyon contains an estimated 30 mCi of plutonium. Table D-17 lists the three stations that are sampled routinely. Transport of contaminated sediments off site is discussed in Section V.B.5.e (Transport of Radionuclides in Sediments from Surface Runoff). Canyons around the Laboratory, including those without perennial flow, have also been sampled.

Sediment samples have been collected in the off-site portion of Mortandad Canyon on Pueblo of San Ildefonso land so that conditions down gradient from the on-site residual contamination can be documented, as discussed in the Surface Water Monitoring section. Also, sediment samples have been taken from the Rio Grande at confluences with major canyons that cross the Laboratory and adjacent public or Pueblo of San Ildefonso lands.

On-Site Stations. The on-site sediment stations are grouped into radioactive effluent release areas, solid waste management areas, and other canyons areas. The radioactive effluent release areas are the same as those used for the surface water stations. Transport of contaminated sediments off site from Pueblo Canyon, transport of contaminated sediments within the on-site portion of Mortandad Canyon, and the sediment traps used for sampling are discussed below. No off-site transport of contaminated sediments from Mortandad Canyon has been measured. Sediments from natural drainages around two radioactive solid waste management areas are sampled to monitor transport of radioactivity from surface contamination. Nine sampling stations were established in 1982 outside the perimeter fence at TA-54, Area G (Figure V-17a), to monitor possible transport of radionuclides by sheet erosion from the active waste storage and disposal area. Some radionuclides are transported from the surface at TA-54, Area G in suspended or bed load sediments into channels that drain the area. This contamination is not related to the buried wastes in the pits and shafts; it is residual contamination on the land surface that occurred during earlier handling of the wastes.

From 1959 to 1961, hydronuclear experiments were conducted in underground shafts that ranged in depth from 15 to 36 m (49 to 118 ft) beneath the surface of the mesa at TA-49 (Purtymun 1987b, ESG 1988). The experiments involved a combination of conventional (chemical) high explosives usually in a nuclear weapons configuration. The quantity of fissile material was kept far below the amount required for a nuclear explosion (Purtymun 1987b). The residuals of the experiments were confined in the shafts and left in place. The site is designated Solid Waste Management Area AB. A surface contamination incident occurred in 1960 during excavation of a shaft, and some erosional transport of radioactivity occurred (Purtymun 1987b, ESG 1988). Eleven sediment stations were established in 1972 to monitor surface sediments in natural drainage from the experimental area. Another station (AB-4A) was added in 1981 as the drainage changed (Figure V-17b). These sediment monitoring stations are sampled annually.

The other canyon areas group contains eight sediment sampling stations, which are located where the canyons intersect State Road 4. All Laboratory facilities in or adjacent to those canyons are located upgradient of this highway.

c. Radiochemical Analytical Results. The results of radiochemical analyses of sediment samples collected during 1993 from off-site (regional and perimeter) and on-site locations, including solid waste management areas are listed in Table V-23.

Many sediment samples from the known radioactive effluent release areas, both off site and on site, including Acid-Pueblo, DP-Los Alamos, and Mortandad canyons, exceeded worldwide fallout levels, as expected. The levels observed are consistent with previous data. None of the sediment samples showed any concentration level that exceeded its respective SAL value.

Samples taken on Pueblo of San Ildefonso land in Mortandad Canyon are discussed in detail in Section IV.C.5. As seen in Table V-23, only the sample from location A-6 showed levels of ^{137}Cs slightly above the statistical regional reference level for fallout. An additional 11 special sediment samples were taken on Pueblo of San Ildelfonso lands in Mortandad Canyon, as discussed in Section IV.C.5.

The majority of the sediment samples collected outside known radioactive effluent release areas were within the statistically derived reference levels that reflect activity attributable to worldwide fallout (Purtymun 1987a). These statistical limits are based on regional samples collected between 1974 and 1986 and are given as the level expected to be exceeded by about 1 in 40 samples taken from the same population.

Table V-23. Radioactivity in Sediments

Location	^{3}H (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
OFF-SITE STATIONS										
REGIONAL STATIONS										
Chamita	-0.1 (0.3)[a]	0.0 (0.2)	0.1 (0.0)	1.9 (0.1)	0.003 (0.030)	0.006 (0.020)	0.002 (0.030)	2 (1)	2 (0)	-1 (0)
Embudo	0.1 (0.3)	0.0 (0.2)	0.1 (0.0)	1.2 (0.1)	0.005 (0.030)	0.006 (0.020)	0.001 (0.030)	3 (1)	3 (0)	0 (0)
Rio Grande at Otowi	N/A[b]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Frijoles	0.2 (0.3)	N/A	0.1 (0.0)	14.0 (3.5)	0.011 (0.030)	0.007 (0.020)	N/A	6 (1)	4 (0)	3 (0)
Rio Grande at Cochiti	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Bernalillo	0.0 (0.3)	0.4 (0.3)	0.1 (0.0)	1.5 (0.1)	0.001 (0.030)	0.005 (0.020)	0.002 (0.030)	3 (1)	2 (0)	-0 (0)
Jemez River	0.1 (0.3)	0.1 (0.2)	0.2 (0.0)	2.1 (0.1)	0.008 (0.030)	0.005 (0.020)	0.003 (0.030)	6 (1)	4 (1)	2 (0)
Rio Grande in White Rock Canyon										
Rio Grande at Sandia	-0.1 (0.3)	N/A	0.1 (0.0)	2.5 (0.3)	0.007 (0.030)	0.003 (0.020)	N/A	7 (2)	4 (1)	3 (0)
Rio Grande at Mortandad	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Pajarito	0.2 (0.3)	N/A	0.1 (0.0)	3.3 (0.4)	0.001 (0.030)	0.003 (0.020)	N/A	5 (1)	4 (0)	3 (0)
Rio Grande at Water	0.1 (0.3)	N/A	0.1 (0.0)	3.5 (0.4)	0.005 (0.030)	0.009 (0.020)	N/A	5 (1)	4 (0)	3 (0)
Rio Grande at Ancho	-0.1 (0.3)	N/A	0.1 (0.0)	2.0 (0.2)	0.013 (0.030)	0.003 (0.020)	N/A	3 (1)	2 (0)	2 (0)
Rio Grande at Chaquehui	0.3 (0.3)	N/A	0.0 (0.0)	1.4 (0.2)	0.010 (0.030)	0.011 (0.020)	N/A	5 (1)	3 (0)	3 (0)
PERIMETER STATIONS										
Acid-Pueblo Canyon										
Acid Weir	0.6 (0.3)	0.2 (0.2)	0.1 (0.0)	1.6 (0.1)	0.004 (0.030)	0.017 (0.020)	0.002 (0.002)	2 (0)	1 (0)	1 (0)
Pueblo 1	0.9 (0.5)	1.3 (0.2)	0.1 (0.0)	3.3 (0.2)	0.027 (0.030)	0.936 (0.032)	0.022 (0.030)	3 (1)	2 (0)	2 (0)
Pueblo 2	1.1 (0.3)	0.4 (0.2)	0.3 (0.0)	1.7 (0.1)	0.061 (0.030)	9.710 (0.317)	0.501 (0.030)	8 (2)	2 (0)	0 (0)
DP-Los Alamos Canyon										
Los Alamos at Totavi	0.8[c] (0.8)	0.3[c] (0.3)	0.2[c] (0.1)	1.9[c] (0.2)	0.011[c] (0.030)	0.140[c] (0.022)	0.018[c] (0.030)	2[c] (1)	2[c] (0)	4[c] (1)
Los Alamos at LA-2	0.4 (0.3)	0.1[c] (0.3)	0.3[c] (0.1)	1.6[c] (0.1)	0.014[c] (0.030)	0.244[c] (0.030)	0.026[c] (0.031)	2[c] (1)	2[c] (0)	3[c] (1)
Los Alamos at Otowi	0.2[c] (0.4)	0.1[c] (0.3)	0.1[c] (0.1)	1.2[c] (0.1)	0.003[c] (0.043)	0.134[c] (0.032)	0.009[c] (0.043)	2[c] (1)	1[c] (0)	-0[c] (1)
Other Areas										
Guaje at SR 4	0.2 (0.3)	0.3 (0.2)	-0.0 (0.0)	2.3 (0.1)	0.004 (0.030)	0.002 (0.020)	0.001 (0.030)	2 (0)	1 (0)	1 (0)
Bayo at SR 4	0.3 (0.3)	0.2 (0.8)	0.0 (0.0)	2.6 (0.2)	0.004 (0.030)	0.004 (0.020)	0.003 (0.030)	1 (0)	1 (0)	1 (0)
Sandia at Rio Grande	0.4[c] (0.4)	N/A	0.2[c] (0.0)	1.1[c] (0.2)	0.007[c] (0.042)	0.005[c] (0.028)	N/A	2[c] (1)	2[c] (0)	3[c] (0)
Cañada Ancha at Rio Grande	0.1 (0.3)	N/A	0.1 (0.0)	0.9 (0.2)	0.006 (0.030)	0.001 (0.020)	N/A	3 (1)	2 (0)	2 (0)
Pajarito at Rio Grande	0.1 (0.3)	N/A	<0.0[d] (0.0)	0.8 (0.1)	0.001 (0.030)	0.002 (0.020)	N/A	1 (0)	1 (0)	2 (0)
Water at Rio Grande	0.4 (0.3)	N/A	0.2 (0.0)	1.9 (0.3)	0.007 (0.030)	0.008 (0.020)	N/A	6 (1)	6 (1)	3 (0)

Table V-23. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
Other Areas (Cont.)										
Ancho at Rio Grande	0.3 (0.3)	N/A	0.1 (0.0)	2.7 (0.3)	0.002 (0.030)	0.003 (0.020)	N/A	2 (0)	2 (0)	2 (0)
Chaquehui at Rio Grande	0.3 (0.3)	N/A	0.2 (0.0)	2.5 (0.3)	0.005 (0.030)	0.013 (0.020)	N/A	3 (1)	2 (0)	3 (0)
Frijoles at National Monument Headquarters	0.0 (0.3)	0.1 (0.2)	0.1 (0.0)	3.0 (0.2)	0.000 (0.030)	0.007 (0.020)	0.004 (0.030)	3 (1)	2 (0)	2 (0)
Frijoles at Rio Grande	0.1 (0.3)	N/A	0.1 (0.0)	1.9 (0.2)	0.007 (0.030)	0.004 (0.020)	N/A	2 (0)	2 (0)	3 (0)
Mortandad Canyon on San Ildefonso Lands										
Mortandad A-6	2.1 (1.0)	0.1 (0.2)	0.8 (0.2)	1.4 (0.1)	0.001 (0.003)	0.006 (0.002)	0.004 (0.003)	3 (1)	4 (0)	4 (1)
Mortandad Transect at Boundary near A-6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad A-7	2.1 (1.0)	0.3 (0.2)	0.4 (0.1)	2.3 (0.2)	0.002 (0.003)	0.010 (0.002)	0.007 (0.003)	5 (1)	4 (0)	7 (1)
Mortandad A-8	1.2 (0.8)	0.2 (0.2)	0.2 (0.1)	3.0 (0.2)	0.001 (0.003)	0.004 (0.002)	0.001 (0.003)	4 (1)	3 (0)	7 (1)
Mortandad at SR4 (A-9)	0.3[c] (0.6)	0.3[c] (0.4)	0.1[c] (0.1)	2.5[c] (0.2)	0.002[c] (0.030)	0.003[c] (0.020)	0.003[c] (0.030)	3[c] (1)	2[c] (0)	3[c] (1)
Mortandad A-10	1.5 (0.8)	0.1 (0.2)	0.2 (0.1)	2.0 (0.1)	0.001 (0.003)	0.002 (0.002)	0.001 (0.003)	3 (1)	3 (0)	6 (1)
Mortandad at Rio Grande (A-11)	0.1 (0.3)	N/A	<0.0[d] (0.0)	1.3 (0.3)	0.002 (0.030)	0.001 (0.020)	N/A	2 (1)	1 (0)	2 (0)
ON-SITE STATIONS										
Radioactive Effluent Release Areas										
Acid-Pueblo Canyon										
Hamilton Bend Spring	N/A	0.6 (0.3)	0.0 (0.0)	3.2 (0.2)	0.003 (0.030)	0.426 (0.020)	0.017 (0.030)	3 (1)	2 (0)	2 (0)
Pueblo 3	0.6 (0.3)	0.6 (0.3)	0.0 (0.0)	2.7 (0.1)	0.003 (0.030)	0.015 (0.020)	0.007 (0.030)	3 (1)	3 (0)	2 (0)
Pueblo at SR 4	-0.1 (0.3)	0.1 (0.6)	0.1 (0.0)	3.2 (0.2)	0.002 (0.030)	0.167 (0.020)	0.006 (0.030)	2 (1)	2 (0)	2 (0)
DP-Los Alamos Canyon										
DPS-1	0.3 (0.3)	0.1 (0.1)	0.1 (0.0)	1.1 (0.1)	0.008 (0.030)	0.016 (0.020)	0.011 (0.030)	2 (0)	2 (0)	0 (0)
DPS-4	0.6 (0.3)	0.2 (0.2)	0.0 (0.0)	1.9 (0.4)	0.003 (0.030)	0.000 (0.020)	0.001 (0.030)	1 (0)	1 (0)	0 (0)
Los Alamos at Bridge	0.2 (0.3)	0.0 (0.2)	0.0 (0.0)	1.5 (0.2)	0.000 (0.030)	0.002 (0.020)	0.038 (0.030)	2 (1)	2 (0)	0 (0)
Los Alamos at LAO-1	0.8 (0.3)	0.0 (0.2)	0.2 (0.0)	1.9 (0.1)	0.008 (0.030)	0.170 (0.020)	0.046 (0.030)	2 (0)	0 (0)	1 (0)
Los Alamos at GS-1	N/A	0.3 (0.2)	1.0 (0.2)	1.3 (0.1)	0.015 (0.030)	0.104 (0.020)	0.083 (0.030)	1 (0)	3 (0)	1 (0)
Los Alamos at LAO-3	0.4 (0.3)	0.0 (0.2)	2.2 (0.3)	1.3 (0.1)	0.041 (0.030)	0.257 (0.020)	0.158 (0.030)	2 (1)	3 (0)	2 (0)
Los Alamos at LAO-4.5	0.7 (0.3)	0.6 (0.2)	2.0 (0.3)	1.8 (0.1)	0.023 (0.030)	0.168 (0.020)	0.119 (0.030)	2 (1)	4 (0)	2 (0)
Los Alamos at SR 4	0.9 (0.3)	0.5[c] (0.4)	1.5[c] (0.4)	1.8[c] (0.2)	0.025[c] (0.030)	0.199[c] (0.025)	0.187[c] (0.040)	3[c] (1)	3[c] (1)	5[c] (1)

Table V-23. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
Mortandad Canyon										
Mortandad near CMR	1.4 (0.4)	1.3 (0.8)	0.0 (0.0)	1.5 (0.1)	0.005 (0.030)	0.005 (0.020)	0.000 (0.000)	1 (0)	2 (0)	0 (0)
Mortandad west of GS-1	0.0 (0.3)	0.0 (2.0)	-0.0 (0.0)	3.4 (0.2)	0.005 (0.030)	0.006 (0.020)	0.003 (0.030)	3 (1)	3 (0)	1 (0)
Mortandad at GS-1	8.6 (0.9)	0.5 (0.3)	N/A	1.1 (0.1)	1.387 (0.046)	3.412 (0.108)	3.900 (0.200)	10 (2)	12 (1)	8 (1)
Mortandad at MCO-5	5.4 (0.7)	1.3 (0.3)	21.2 (3.2)	1.1 (0.1)	1.840 (0.080)	5.480 (0.220)	5.000 (0.300)	15 (3)	23 (2)	14 (1)
Mortandad at MCO-7	3.6 (0.6)	0.3 (0.2)	21.2 (3.2)	0.6 (0.1)	0.650 (0.040)	2.120 (0.130)	1.900 (0.100)	5 (1)	7 (1)	4 (0)
Mortandad at MCO-9	0.6 (0.3)	1.0 (0.2)	0.5 (0.1)	2.5 (0.2)	0.019 (0.030)	0.020 (0.020)	0.007 (0.030)	4 (1)	5 (1)	2 (0)
Mortandad at MCO-13 (A-5)	0.6 (0.3)	0.2 (0.4)	0.5 (0.1)	1.7 (0.1)	0.009 (0.030)	0.023 (0.020)	0.007 (0.030)	4 (1)	5 (1)	1 (0)
Other Areas										
Sandia at SR 4	0.5[c] (0.4)	0.2[c] (0.3)	0.0[c] (0.1)	1.1[c] (0.1)	0.003[c] (0.030)	0.003[c] (0.020)	0.001[c] (0.030)	2 (0)	1 (0)	1[c] (1)
Cañada del Buey at SR 4	0.2 (0.3)	0.4 (0.2)	0.0 (0.0)	1.1 (0.1)	0.005 (0.030)	0.004 (0.020)	0.005 (0.030)	2 (1)	2 (0)	0 (0)
Pajarito at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potrillo at SR 4	0.2 (0.3)	0.1 (0.2)	0.2 (0.0)	2.6 (0.2)	0.001 (0.030)	0.007 (0.020)	0.003 (0.030)	4 (1)	4 (1)	1 (0)
Fence at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water at SR 4	0.2 (0.3)	0.2 (0.2)	0.0 (0.0)	1.4 (0.1)	0.004 (0.030)	0.003 (0.020)	0.002 (0.030)	2 (0)	2 (0)	-28 (4)
Indio at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at SR 4	0.6 (0.4)	-0.1 (0.5)	0.0 (0.0)	1.4 (0.1)	0.002 (0.030)	0.004 (0.020)	0.007 (0.030)	2 (1)	2 (0)	0 (0)
TA-54, Area G										
G-1	1.1 (0.5)	N/A	0.1 (0.0)	3.7 (0.6)	0.021 (0.030)	0.005 (0.020)	N/A	5 (1)	4 (0)	2 (0)
G-2	N/A	N/A	0.1 (0.1)	0.8 (0.2)	0.002 (0.030)	0.001 (0.020)	N/A	2 (0)	1 (0)	0 (0)
G-3	2.3 (0.5)	N/A	0.3 (0.1)	2.7 (0.7)	0.008 (0.030)	0.011 (0.020)	N/A	5 (1)	5 (1)	3 (0)
G-4	3.7 (0.6)	N/A	0.1 (0.0)	3.8 (0.8)	0.011 (0.030)	0.101 (0.020)	N/A	7 (1)	5 (1)	4 (0)
G-5	5.5 (1.6)	N/A	0.1 (0.0)	1.9 (0.4)	0.011 (0.030)	0.039 (0.020)	N/A	4 (1)	2 (0)	2 (0)
G-6	5.2 (0.9)	N/A	0.1 (0.0)	1.5 (0.2)	0.010 (0.030)	0.031 (0.020)	N/A	5 (1)	3 (0)	3 (0)
G-7	1.5 (0.4)	N/A	0.2 (0.0)	1.8 (0.4)	0.011 (0.030)	0.131 (0.020)	N/A	4 (1)	3 (0)	3 (0)
G-8	3.7 (0.6)	N/A	0.1 (0.0)	1.3 (0.3)	0.131 (0.030)	0.058 (0.020)	N/A	3 (1)	4 (0)	1 (0)
G-9	3.5 (0.9)	N/A	0.3 (0.1)	3.1 (0.7)	0.023 (0.030)	0.134 (0.020)	N/A	5 (1)	2 (0)	-0 (0)
TA-49, Area AB										
AB-1	0.4[c] (0.4)	N/A	0.3 (0.1)	4.2 (0.4)	0.000 (0.020)	0.005 (0.030)	N/A	5 (1)	4 (1)	2 (0)
AB-2	-0.2[c] (0.4)	N/A	0.1 (0.0)	2.8 (0.3)	0.000 (0.020)	0.009 (0.030)	N/A	3 (1)	3 (0)	2 (0)
AB-3	-0.2[c] (0.4)	N/A	0.3 (0.1)	2.4 (0.7)	0.000 (0.020)	0.121 (0.030)	N/A	5 (1)	5 (1)	2 (0)
AB-4	0.2[c] (0.4)	N/A	0.3 (0.1)	3.3 (0.3)	0.020 (0.020)	0.021 (0.005)	N/A	4 (1)	5 (1)	2 (0)

Table V-23. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
Other Areas (Cont.)										
TA-49, Area AB (Cont.)										
AB-4A	0.3[c] (0.4)	N/A	0.2 (0.0)	2.5 (0.3)	0.000 (0.020)	0.022 (0.030)	N/A	5 (1)	5 (1)	2 (0)
AB-5	0.2[c] (0.4)	N/A	0.1 (0.0)	2.3 (0.5)	0.000 (0.020)	0.014 (0.030)	N/A	5 (1)	4 (0)	2 (0)
AB-6	-0.2[c] (0.4)	N/A	0.1 (0.0)	1.8 (0.2)	0.000 (0.020)	0.004 (0.030)	N/A	5 (1)	4 (1)	2 (0)
AB-7	0.1[c] (0.4)	N/A	N/A	2.4 (0.2)	0.000 (0.020)	0.007 (0.030)	N/A	5 (1)	4 (0)	2 (0)
AB-8	0.1[c] (0.4)	N/A	0.5 (0.1)	2.2 (0.2)	0.000 (0.020)	0.018 (0.030)	N/A	3 (1)	4 (0)	2 (0)
AB-9	-0.3[c] (0.5)	N/A	0.1 (0.0)	1.0 (0.1)	0.000 (0.020)	0.002 (0.030)	N/A	2 (1)	2 (0)	1 (0)
AB-10	-0.1[c] (0.4)	N/A	0.2 (0.0)	3.0 (0.5)	0.000 (0.020)	0.011 (0.003)	N/A	5 (1)	4 (0)	2 (0)
AB-11	0.3[c] (0.4)	N/A	0.7 (0.1)	2.3 (0.4)	0.000 (0.020)	0.014 (0.004)	N/A	3 (1)	4 (0)	2 (0)
Background[e]		0.87	0.44	4.4	0.006	0.023				7.9
S.A.L.[f]	20.0	5.9	4.0	95.0	20.0	18.0	17.0			

[a]Counting uncertainties (±1 standard deviation) are shown in parentheses.
[b]N/A means analysis not performed, lost in analysis, or not completed.
[c]Mean of multiple samples.
[d]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[e]Average plus 2 standard deviations of measurements in regional samples 1974–1986 (Purtymun 1987a).
[f]Screening Action Level, ER 1994.

In the samples from the regional stations, only the sample from the Rio Grande at Frijoles had a total uranium concentration above the background reference value. This value was more than three times larger than the regional background reference level. In addition, the samples from the Rio Grande at Frijoles, Sandia, Ancho, and Chaquehui, and the Jemez River had ^{238}Pu values that exceeded the background reference level. However, these variations are consistent with data from previous years.

In the off-site perimeter stations, the sample from the Pueblo 1 station had a ^{90}Sr value that exceeded the background reference limit, while Mortandad Canyon Station A-6 had a ^{137}Cs value above the background reference level. In addition, a number of sediment samples from Acid-Pueblo Canyon, DP-Los Alamos Canyon, and stations from other canyon areas had ^{238}Pu and $^{239,240}Pu$ values above the background reference levels for these isotopes.

The on-site stations in Acid-Pueblo Canyon, Hamilton Bend Spring, and Pueblo Canyon at State Route 502 showed $^{239,240}Pu$ values above the background reference level. In DP-Los Alamos Canyon, a number of stations exceeded background reference levels for ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$. In Mortandad Canyon, a number of stations exceeded background reference levels for ^{90}Sr, ^{137}Cs, ^{238}Pu and $^{239,240}Pu$. At TA-54, Area G, a number of stations exceeded background reference levels for ^{238}Pu and $^{239,240}Pu$. At TA-49, Area AB, Stations AB-7 and AB-11 exceeded the ^{137}Cs background reference level, while at station AB-4 the ^{238}Pu level was exceeded. At Station AB-3, the $^{239,240}Pu$ background reference level was exceeded.

In summary, all of the 1993 sediment samples appeared to be consistent with previous years results. Furthermore, no SALs were exceeded.

d. Long-Term Trends. The concentrations of radioactivity in sediments from the Acid, Pueblo, and Los Alamos canyons that are or may be transported off site were studied extensively about 12 years ago as part of the Formerly Utilized Sites Remedial Action Program and are fully documented (ESG 1981). Data gathered from selected locations as part of a routine monitoring program indicate that the concentrations of radionuclides in drainage sediment have been relatively constant at each location since 1980. The total plutonium concentrations (^{238}Pu and $^{239,240}Pu$) observed since 1980 in sediments at four indicator locations are shown in Figure V-18. The first location is Acid Weir, the location in Acid Canyon near its confluence with Pueblo Canyon where the highest concentrations are typically observed. This location is on Los Alamos County property and effectively integrates the mobile sediments from all of Acid Canyon. The second location is Pueblo Canyon at State Road 502, just upstream of the confluence with Los Alamos Canyon. This location is on DOE land and reflects levels just prior to off-site transport of sediments. The third location is Los Alamos Canyon at Totavi, located on the Pueblo of San Ildefonso, which represents the first off-site point. The fourth location is Los Alamos Canyon at Otowi, also located on the Pueblo of San Ildefonso, which reflects sediment concentrations at the point where they enter the Rio Grande.

e. Transport of Radionuclides in Sediments from Surface Runoff. The major transport pathway of radionuclides from canyons that have received radioactive effluents (Acid-Pueblo, DP-Los Alamos, and Mortandad canyons) is by surface runoff. Residual radionuclides in the effluents may become adsorbed or attached to sediment particles in the stream channels. Concentrations of radioactivity in the alluvium are generally highest near the effluent outfall and decrease downhill in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and surface stormwater runoff.

Pueblo-Los Alamos Canyons. Residual radioactivity from past effluent releases into DP Canyon, upper Los Alamos Canyon, and Acid Canyon is present on sediments in those canyons and in Pueblo Canyon downstream from Acid Canyon. Over the years some of that radioactivity has been transported off site into lower Los Alamos Canyon largely by snowmelt and thunderstorm runoff.

Starting in 1990, increased effluent flow from the Los Alamos County Bayo sanitary sewage treatment plant resulted in flow during most of the year through the lower part of Pueblo Canyon and into Los Alamos Canyon. This flow transported some of the contaminated sediments out of Pueblo Canyon and into the lower reach of Los Alamos Canyon. This effluent-induced flow from Pueblo Canyon entered Los Alamos Canyon on most days in 1993 (except between mid-June and early August) and typically extended to a location between Totavi (just east of the DOE-Pueblo of San Ildefonso boundary) and the confluence of Guaje and Los Alamos canyons.

Periodic grab samples of effluent and runoff collected from Pueblo Canyon above the confluence with Los Alamos Canyon, near State Road 502, were analyzed for radioactivity in solution and in suspended sediments. Radioactivity

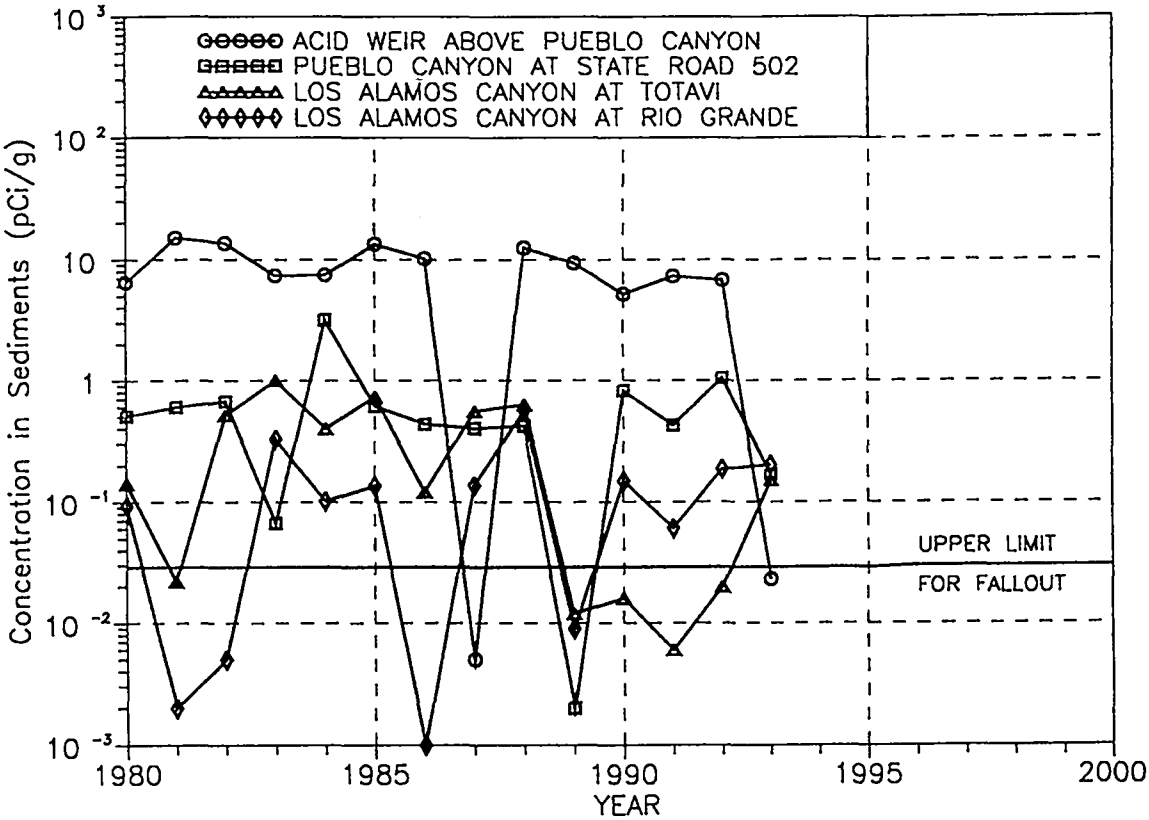


Figure V-18. Total plutonium concentrations in sediments.

in solution refers to the filtrate that passes through a 0.45-μm-pore-size filter; while radioactivity on suspended sediments refers to the residue retained by the filter. The samples collected from runoff contained above background amounts of Cs, Sr, and plutonium in solution, which was expected in light of the residuals from historical releases into Pueblo Canyon. The levels of plutonium detected are shown in Table V-24, and the levels for other radioactive constituents are shown in Table V-25. These tables also show results of grab samples of snowmelt runoff from other canyons.

Concentrations of plutonium in the suspended sediments from Pueblo and Los Alamos canyons were above background though the levels were comparable to those seen in previous years. The increased transport of contaminated sediments from Pueblo Canyon is not having any significant effect on the concentrations of plutonium in sediments from lower Los Alamos Canyon (ESG 1981). Current measurements from throughout the region are given in Table V-20; measurements from locations in lower Los Alamos Canyon are shown in Figure V-18. Runoff from summer thunderstorms and long periods of snowmelt periodically move accumulated sediments from lower Los Alamos Canyon into the Rio Grande (ESG 1981, Lane 1985).

The effluent-induced flow will slightly increase the rate at which contaminated sediments from historical discharges in Acid and Pueblo canyons are moved through Los Alamos Canyon to the Rio Grande. Theoretical estimates and field measurements (ESG 1981, Graf 1993) demonstrate that the incremental contributions to radioactivity on sediments in Cochiti Reservoir resulting from Laboratory operations are small (approximately 10%) relative to the contributions from worldwide fallout. The incremental doses accumulated through food pathways (see Section V.C.3.f) are well below DOE's applicable PDLs. See Section V.B.7.c for additional details.

Radionuclides in Water and Sediment from Snowmelt Runoff. During the spring snowmelt season, grab samples of runoff were collected from several other canyons. The analytical results are shown in Tables V-24 and V-25. These results are for unfiltered samples and represent total concentrations, both dissolved and suspended solids.

Table V-24. Plutonium in Surface Waters in 1993

Location and Date	Concentration in Solution		Concentration in Suspended Sediment[a]		Suspended Sediment	Total in Solution and Suspended Sediment (pCi/L)		
	^{239}Pu (pCi/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/g)	^{238}Pu (pCi/g)	(g/L)	^{239}Pu	^{238}Pu	% dissolved
OFF-SITE PERIMETER STATIONS								
Pueblo Canyon at Landfill near Complex								
03/25	0.009	0.013	N/A[a]	N/A	N/A	N/A	N/A	N/A
04/07	0.004	0.013	N/A	N/A	N/A	N/A	N/A	N/A
04/19	0.009	-0.004	0.014	-0.003	0.1373	0.02	0.00	39.6
05/04	0.254	-0.023	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon at Rio Grande								
01/30	0.013	0.031	0.001	0.000	0.0187	0.01	0.03	97.1
03/03	0.011	0.000	N/A	N/A	N/A	N/A	N/A	N/A
03/23	0.009	0.009	0.315	0.007	0.2173	0.32	0.01	5.3
04/06	0.044	-0.012	N/A	N/A	N/A	N/A	N/A	N/A
04/19	0.027	-0.009	0.222	0.012	0.1305	0.24	0.01	10.3
05/04	0.394	0.010	N/A	N/A	N/A	N/A	N/A	N/A
Guaje Canyon								
06/02	0.039	0.005	0.000	0.000	0.0238	0.03	0.00	100.0
Pajarito Canyon at SR 502								
03/25	0.004	-0.004	N/A	N/A	N/A	N/A	N/A	N/A
04/07	0.000	0.009	N/A	N/A	N/A	N/A	N/A	N/A
04/19	0.019	0.009	0.002	0.000	0.0403	0.02	0.00	90.8
05/04	0.005	0.022	N/A	N/A	N/A	N/A	N/A	N/A
Water Canyon at SR 502								
03/25	-0.004	-0.008	N/A	N/A	N/A	N/A	N/A	N/A
04/07	0.000	0.023	N/A	N/A	N/A	N/A	N/A	N/A
04/19	-0.009	0.019	0.001	0.002	0.0358	0.001	0.021	87.6
05/04	0.005	0.018	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon at Totavi								
04/06	0.000	-0.012	N/A	N/A	N/A	N/A	N/A	N/A
04/19	0.027	0.000	0.053	0.004	0.0305	0.08	0.00	31.9
05/04	0.045	0.004	N/A	N/A	N/A	N/A	N/A	N/A
ON-SITE STATIONS								
Pueblo at State Route 502								
01/30	0.005	-0.005	0.001	0.000	0.0180	0.00	0.00	79.9
04/19	0.015	0.010	0.045	0.001	0.0758	0.06	0.01	35.1
Pueblo Canyon at Gaging Station								
03/03	0.000	-0.010	N/A	N/A	N/A	N/A	N/A	N/A
03/23	0.008	0.028	0.149	0.000	0.0723	0.15	0.02	19.5
05/04	0.026	0.000	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon at Gaging Station 1								
03/23	0.040	0.004	N/A	N/A	N/A	N/A	N/A	N/A
03/25	0.029	0.017	N/A	N/A	N/A	N/A	N/A	N/A
04/06	0.036	0.012	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon at State Route 4								
04/19	0.038	0.011	0.041	0.003	0.0310	0.07	0.01	52.5
05/04	0.035	0.005	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon at Western Boundary								
03/25	0.005	0.000	N/A	N/A	N/A	N/A	N/A	N/A

Table V-24. (Cont.)

Location and Date	Concentration in Solution		Concentration in Suspended Sediment[a]		Suspended Sediment	Total in Solution and Suspended Sediment (pCi/L)		
	^{239}Pu (pCi/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/g)	^{238}Pu (pCi/g)	(g/L)	^{239}Pu	^{238}Pu	% dissolved
Pajarito Canyon								
03/25	0.015	0.000	N/A	N/A	N/A	N/A	N/A	N/A
04/07	0.000	0.019	N/A	N/A	N/A	N/A	N/A	N/A
04/19	-0.004	-0.018	0.000	0.000	0.0020	0.00	0.00	0.0
05/04	0.000	-0.008	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Canyon at State Route 4								
03/25	0.000	0.004	N/A	N/A	N/A	N/A	N/A	N/A
04/07	0.014	-0.004	N/A	N/A	N/A	N/A	N/A	N/A
04/19	0.005	0.009	0.019	0.018	0.1465	0.02	0.02	27.8

[a]Concentration in suspended sediment was converted to pCi/L using the amount of suspended sediment in sample in g/L.
[b]N/A means analysis not performed, lost in analysis, or not completed.

Radionuclides in Water and Sediment from Mortandad Canyon. Residual radionuclides are released in effluent from the treatment plant at TA-50 into Mortandad Canyon (Table V-6). The liquid infiltrates and recharges a shallow body of groundwater in the alluvium. This shallow aquifer is of limited extent and lies completely within Laboratory boundaries. Most of the radionuclides in the effluent are adsorbed or bound to the sediments in the channel.

The sediments and radionuclides in the stream channel alluvium may be transported when additional effluent releases or storm water runoff enters the channel. The canyon's small drainage area and the capacity of the thick unsaturated alluvium to store runoff have prevented transport to the Laboratory boundaries. To further ensure containment of sediment transport by major runoff events within Laboratory boundaries, a series of canyon sediment traps was installed in the early 1970s. These traps are located in Mortandad Canyon approximately 2.3 km (1.4 mi) upstream of the eastern facility boundary. The traps are excavated below the prevailing grade of the stream channel so that runoff water flows in and is retained temporarily, letting the heavier sediments settle out. When one trap is filled up to the level of the stream channel, the water flows on to the next trap. Runoff from several large thunderstorms in late July and early August 1991 filled all three sediment traps to capacity. Results from special sediment sampling conducted after these storms were reported in the 1991 surveillance report (EPG 1993). The three sediment traps were excavated during 1992 so that their original sediment retention volumes could be restored.

Since no significant thunderstorm runoff events occurred in Mortandad Canyon during 1993, only routine samples were collected. Furthermore, very little sediment in-filling of the sediment traps occurred during 1993.

Radionuclides in Wastewater. In recent years, treated effluents containing low levels of radioactivity have been released from the central liquid waste treatment plant (TA-50), from a smaller plant serving laboratories at TA-21, and from a sanitary sewage lagoon system serving LAMPF at TA-53 (Table V-6 and Figures V-6 and V-7). In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon. In 1993, there were no releases from the TA-21 plant or the TA-53 total retention lagoons.

f. Special Reservoir Sediment Studies. Results of the analyses of the large samples specially collected in 1993 from Abiquiu and Cochiti reservoirs are presented in Tables V-26 and V-27. The results are similar to those from past years.

Levels of strontium, cesium, and plutonium in the sample from the upper station in Cochiti Reservoir exceeded the statistically established regional fallout reference levels (Purtymun 1987a). The strontium and cesium levels in the samples from the upper, middle, and lower stations exceeded the statistically established regional fallout

Table V-25. Radiochemical Analysis of Spring Runoff Surface Water in 1993

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (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)
PERIMETER STATIONS (OFF SITE)										
Pueblo Canyon at Landfill near Complex	0.6[a] (0.6)[b]	N/A[c]	1.1[a] (2.2)	N/A	-0.000[a] (0.060)	0.069[a] (0.057)	N/A	3[a] (2)	7[a] (2)	70[a] (200)
Los Alamos Canyon at Rio Grande	0.7[a] (0.7)	N/A	0.7[a] (2.1)	N/A	0.005[a] (0.073)	0.083[a] (0.066)	N/A	2[a] (2)	14[a] (3)	33[a] (168)
Guaje Canyon	0.4 (0.3)	N/A	N/A	N/A	<0.005[d] (0.011)	0.039[a] (0.016)	N/A	1 (1)	4 (1)	300 (100)
Pajarito Canyon at SR 502	0.5[a] (0.6)	N/A	1.3[a] (2.6)	N/A	0.009[a] (0.060)	0.007[a] (0.040)	N/A	1[a] (1)	6[a] (2)	40[a] (200)
Water Canyon at SR 502	0.4[a] (0.6)	N/A	1.6[a] (2.5)	N/A	0.013[a] (0.060)	-0.002[a] (0.040)	N/A	2[a] (2)	7[a] (2)	188[a] (200)
Los Alamos Canyon at Totavi	0.8[a] (0.6)	N/A	0.9[a] (2.0)	N/A	-0.003[a] (0.052)	0.024[a] (0.035)	N/A	1[a] (1)	11[a] (2)	120[a] (173)
ON-SITE STATIONS										
Pueblo Canyon at SR	0.2[a] (0.7)	N/A	3.3 (1.2)	N/A	0.003[a] (0.073)	0.006[a] (0.049)	N/A	1 (2)	30 (3)	10 (100)
Pueblo Canyon at Gaging Station	0.5[a] (0.4)	N/A	1.5 (1.1)	N/A	0.006[a] (0.052)	0.011[a] (0.035)	N/A	1 (1)	17 (2)	180 (100)
Los Alamos Canyon at Gaging Station 1	1.1[a] (1.3)	N/A	2.9[a] (2.2)	N/A	0.011[a] (0.052)	0.035[a] (0.035)	N/A	1[a] (1)	11[a] (2)	40[a] (173)
Los Alamos Canyon at SR 4	0.9[a] (0.4)	N/A	0.4[a] (1.7)	N/A	0.008[a] (0.042)	0.037[a] (0.028)	N/A	1[a] (1)	8[a] (1)	25[a] (141)
Los Alamos Canyon at Western Boundary	0.5 (0.3)	N/A	2.0 (1.2)	N/A	0.000 (0.030)	0.005 (0.020)	N/A	1 (1)	3 (1)	50 (100)
Pajarito Canyon	0.6[a] (0.6)	N/A	0.9[a] (2.3)	N/A	-0.002[a] (0.060)	0.003[a] (0.040)	N/A	1[a] (2)	9[a] (2)	43[a] (200)
Ancho Canyon at SR 4	0.6[a] (0.5)	N/A	1.8[a] (2.1)	N/A	0.003[a] (0.052)	0.006[a] (0.035)	N/A	2[a] (2)	10[a] (2)	0[a] (173)
Limits of Detection	0.4	3	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose	2,000	1,000	3,000	800	40	60	30			
DOE Drinking Water System DCG			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard	20	8		20				15		
EPA Screening Level									50	
NMWQCC Groundwater Limit				5,000						

[a]Mean of multiple samples.

[b]Counting uncertainties (±1 standard deviation) are shown in parentheses.

[c]N/A means analysis not performed, lost in analysis, or not completed.

[d]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Table V-26. Radiochemical Analyses of Sediments in Reservoirs for 1993

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
RESERVOIRS ON THE RIO CHAMA AND RIO GRANDE										
Abiquiu Lake										
Abiquiu Upper	-0.2 (0.3)[a]	0.5 (0.4)	0.4 (0.1)	N/A[b]	0.000 (0.000)	0.008 (0.001)	0.002 (0.003)	6 (1)	5 (1)	3 (1)
Abiquiu Middle	0.0 (0.3)	0.4 (0.2)	0.4 (0.1)	N/A	0.000 (0.000)	0.005 (0.000)	0.004 (0.003)	4 (1)	3 (0)	0 (1)
Abiquiu Lower	0.1 (0.3)	0.5 (0.2)	0.2 (0.1)	N/A	0.000 (0.000)	0.002 (0.000)	0.002 (0.003)	13 (3)	3 (0)	3 (1)
Cochiti Lake										
Cochiti Upper	-0.1 (0.3)	1.4 (0.2)	4.1 (1.4)	N/A	0.012 (0.001)	0.085 (0.004)	0.014 (0.003)	28 (6)	7 (1)	N/A
Cochiti Middle	-0.2 (0.3)	1.3 (0.3)	3.4 (1.3)	N/A	0.000 (0.000)	0.004 (0.000)	0.004 (0.003)	8 (2)	3 (0)	N/A
Cochiti Lower	0.4 (0.3)	1.3 (0.2)	3.0 (1.2)	N/A	0.000 (0.000)	0.002 (0.000)	0.003 (0.003)	4 (1)	2 (0)	N/A
Background Statistical Limit[c]		0.87	0.44	4.4	0.006	0.023			7.9	
S.A.L.[d]	20.0	5.9	4.0	95.0	20.0	18.0	17.0			

[a]Counting uncertainties (±1 standard deviation) are shown in parentheses.

[b]N/A means analysis not performed, lost in analysis, or not completed.

[c]Average plus 2 standard deviations of measurements in regional samples 1974–1986 (Purtymun 1987a).

[d]Screening Action Level, ER 1994.

Table V-27. Plutonium Analyses of Sediments in Reservoirs on the Rio Chama and Rio Grande[a]

		^{238}Pu (fCi/g)		^{239,240}Pu (fCi/g)		Ratio (^{239,240}Pu/^{238}Pu)
Abiquiu Reservoir (Rio Chama)						
1984	$\bar{x}$ (*s*)	0.7	(0.4)[b]	12.7	(6.3)	18
1985	$\bar{x}$ (*s*)	0.7	(0.5)	8.8	(0.9)	12
1986	$\bar{x}$ (*s*)	0.3	(0.1)	7.5	(1.7)	25
1987	$\bar{x}$ (*s*)	0.2	(0.1)	3.8	(3.1)	19
1988	$\bar{x}$ (*s*)	0.3	(0.20)	7.5	(2.6)	25
1989	$\bar{x}$ (*s*)	0.2	(0.60)	3.7	(0.4)	18
1990	$\bar{x}$ (*s*)	0.14	(0.10)	2.6	(1.6)	19
1991	$\bar{x}$ (*s*)	0.33	(0.10)	7.2	(2.6)	22
1992	$\bar{x}$ (*s*)	0.08	(0.03)	0.8	(0.9)	10
1993	Upper	0.3	(0.1)	8.3	(0.6)	28
	Middle	0.1	(0.1)	4.7	(0.4)	47
	Lower	0.1	(0.1)	2.4	(0.3)	24
	$\bar{x}$ (*s*)	0.2	(0.1)	5.1	(0.4)	26
Cochiti Reservoir (Rio Chama)						
1984	$\bar{x}$ (*s*)	0.7	(1.1)	19.7	(14.0)	28
1985	$\bar{x}$ (*s*)	1.6	(0.6)	24.1	(7.3)	15
1986	$\bar{x}$ (*s*)	1.2	(0.5)	21.2	(6.1)	18
1987	$\bar{x}$ (*s*)	0.8	(0.7)	17.5	(13.8)	22
1988	$\bar{x}$ (*s*)	1.7	(2.3)	21.1	(2.9)	7
1989	$\bar{x}$ (*s*)	2.5	(2.3)	49.3	(7.3)	20
1990	$\bar{x}$ (*s*)	1.1	(0.5)	20.9	(10.7)	19
1991	$\bar{x}$ (*s*)	0.2	(0.1)	4.1	(3.4)	21
1992	$\bar{x}$ (*s*)	1.9	(3.1)	13.4	(21.0)	7
1993	Upper	12.0	(1.0)	85.0	(4.0)	7
	Middle	0.3	(0.1)	4.0	(0.4)	13
	Lower	0.1	(0.1)	2.4	(0.3)	24
	$\bar{x}$ (*s*)	4.1	(1.0)	30.5	(4.0)	15
Background						
(1974–1986)[c]		6.0		23.0		

[a]Samples were collected June 22, 1993, at Abiquiu Reservoir and July 8, 1993, at Cochiti Reservoir.
[b]Counting uncertainties (±1 standard deviation) are in parentheses.
[c]Purtymun (1987a).

reference levels. The ^{239,240}Pu level of 0.085 ± 0.004 pCi/g was somewhat above the reference level of 0.023 pCi/g, while the ^{238}Pu value of 0.012 ± 0.001 pCi/g was slightly above the reference level of 0.006 pCi/g. The average ^{137}Cs concentration of 3.5 ± 1.3 pCi/g was about eight times above the reference level of 0.44 pCi/g. The average ^{90}Sr concentration of 1.33 ± 0.23 pCi/g was about 1.5 times above the reference level of 0.87 pCi/g. The measurements of the other constituents were lower than regional statistical reference levels.

The results of these analyses are best interpreted in conjunction with information from a special study, "Plutonium Deposition and Distribution from Worldwide Fallout in Northern New Mexico and Southern Colorado," which provides a broader regional context for analyses of reservoir sediments (Purtymun 1990a). This study ana-

lyzed the radiochemical constituents of large (1 kg) samples of soils and sediments collected between 1979 and 1987 from locations in northern New Mexico and southern Colorado. The conclusions of greatest significance to interpreting the current samples from Abiquiu and Cochiti reservoirs are (1) the average total plutonium concentrations in Cochiti Reservoir are almost identical to the concentrations found in the Rio Grande Reservoir in Colorado; (2) reservoirs on the Rio Chama exhibit slightly lower concentrations than those found in the Rio Grande Reservoir; and (3) the isotopic ratios of $^{239,240}Pu$ to ^{238}Pu are essentially the same, with nearly complete overlap of the statistical uncertainties, for all of the soil and sediment samples analyzed. These findings are consistent with the interpretation that the source of plutonium at all locations studied is predominantly from worldwide fallout.

The data from the 1993 plutonium analyses are shown in a long-term context in Table V-27. The measurements in the samples from Cochiti Reservoir have some of the lowest long-term means for radionuclide concentration and the lowest isotope ratios. The samples from Abiquiu Reservoir had the lowest concentration ranges and isotopic ratios seen. The 1993 concentration averages have proportionately large standard deviations because of the great range of values in each data group. Thus, the average isotopic ratios also have large uncertainties. However, the isotopic ratios from Cochiti Reservoir are even lower than those typical for worldwide fallout, and therefore show no significant contribution of residual effluents from Laboratory operations in the Acid Canyon arm of Pueblo Canyon. Sediments from Acid-Pueblo Canyon exhibit a ratio of $^{239,240}Pu$ to ^{238}Pu that is much larger than values typical of worldwide fallout. This is consistent with the long-term observation that the contributions of radionuclides from Los Alamos Canyon are a relatively small proportion of the total carried in the Rio Grande.

The contribution of total plutonium carried by runoff from Los Alamos Canyon into the Rio Grande is estimated to be about 10% of the contribution from worldwide fallout (ESG 1981, Graf 1993). The range of plutonium levels in sediments in the Rio Grande in the vicinity of Los Alamos indicates a variable mixing of the generally higher concentrations and isotopic ratios observed on soils and sediments farther north in the Rio Grande drainage and the generally lower concentrations and lower isotopic ratios found in the Rio Chama system reservoirs and soils of northern New Mexico. Thus, the significant variability with time and the uncertainty in measurements of at least 5% to 10% in even the 1 kg samples (the uncertainty can be as high as 50% in samples collected for routine monitoring) combine to make it generally impossible to distinguish the contribution of sediments from Los Alamos Canyon to the Rio Grande by measuring concentrations. Similarly, there is no distinguishable increase in the $^{239,240}Pu$ to ^{238}Pu isotopic ratio, which would be expected if the higher concentration, higher ratio sediments from Los Alamos Canyon were making a large contribution.

g. Special Rio Grande Sediment Study. A geomorphologic study completed in 1991, "Geomorphology of Plutonium in the Northern Rio Grande System," (Graf 1993) uses a historical perspective to evaluate the contributions of plutonium from Los Alamos to the Rio Grande. This study uses historical aerial photography and hydrologic data to study the movement and deposition of sediments over time. Among the study's conclusions regarding a regional plutonium budget for the 1948 to 1985 period accounting for both worldwide fallout and input from Los Alamos Canyon for the northern Rio Grande, three are particularly relevant to interpreting the surveillance data:

- Fallout accounts for more than 90% of the plutonium in the system; slightly less than 10% is from activity at the Laboratory.
- About half of the total plutonium (from fallout and the Laboratory) is estimated to be stored along the river, and the remainder has been carried to Elephant Butte Reservoir.
- Most of the contributions from the Laboratory are found along the river between Otowi and Peña Blanca (just downstream from Cochiti Dam); since 1973 the downstream transport of the contributions from the Laboratory has terminated in Cochiti Reservoir.

The study identified locations where sediments had been deposited during specific periods. A special sediment sample deposited between 1941 and 1968 was collected from a floodplain near Buckman (just south of Cañada Ancha on Figure V-16). This sample was subjected to a very sensitive analysis (detection limits as little as 0.0001 pCi/gm) of plutonium isotopes by the Isotope Geochemistry Group at the Laboratory, which found that the plutonium levels in sediment at the Buckman site contained a ratio of ^{239}Pu and ^{240}Pu consistent with approximately an equal weight amount of plutonium on sediments from worldwide fallout and sediments originating from

the Acid-Pueblo-Los Alamos canyon system. The total level of ^{239}Pu to ^{240}Pu in the sample (0.017 pCi/g) was near the statistically derived fallout level (0.023 pCi/g). The precise analysis found that the deposit contained a substantial contribution from historical flows out of Los Alamos Canyon. Such techniques may be useful for research into other sediment transport processes.

6. Soil Monitoring

a. Introduction. A soil sampling and analysis program provides the most direct means of determining the concentration, inventory, and distribution of radionuclides (and heavy metals) around nuclear facilities (DOE 1991). Soil provides an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous effluents or indirectly from resuspension of on-site contamination, or through liquid effluents released to a stream that is subsequently used for irrigation. Hence, soil sampling and analysis is performed with the purpose of evaluating the long-term accumulation trends and to estimate environmental radionuclide and heavy metal inventories. In addition to radionuclides (and heavy metals) that are specific to a particular operation or facility, naturally occurring and/or fallout radionuclides and heavy metals can be expected in background soil samples.

b. Monitoring Network. Soil samples are collected annually from on-site, perimeter, and regional (background) locations. On-site and perimeter stations are located mostly downwind from the major potential contaminant sources in an effort to intercept any contamination related to Laboratory operations. These areas are compared to soils collected from regional (background) locations where radionuclides and radioactivity are due to natural and/or to worldwide fallout events.

Off-Site Regional (Background) Stations. The regional stations for soils are located in the three major drainages in northern New Mexico surrounding the Laboratory: Rio Chama, Embudo, and Otowi; Cochiti and Bernalillo; and Jemez. One additional soil station is located near Santa Cruz Lake, across the Rio Grande valley to the northeast of the Laboratory (Figure V-15). All are over 15 km (6 mi) from the Laboratory (DOE 1991) and are beyond the range of potential influence from normal Laboratory operations.

Off-Site Perimeter Stations. A total of six soil sampling stations are located within 4 km (2.5 mi) of the Laboratory (Figure V-19 and Table D-18). Four of these stations are located to reflect the soil conditions of the inhabited areas to the north and east 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 data.

On-Site Stations. The on-site soil sampling stations (Figure V-19 and Table D-18) are located near Laboratory facilities that are the principal sources of airborne emissions or that could be potential contaminant sources.

c. Radiochemical Analytical Results. Tables V-28 and V-29 show data from 1992 and 1993, respectively. The data table from 1992 was inadvertently omitted in last year's environmental surveillance report (EPG 1994); therefore, the data and the text are presented in this report for overall completeness.

1992 Soil Radiological Monitoring Data. Three perimeter soil samples and eight on-site samples contained ^{238}Pu or $^{239,240}Pu$ levels that ranged from slightly above to up to three times the statistical worldwide fallout reference level. While the levels were generally within the ranges of values seen previously, the number of samples is higher than seen in either 1990 or 1991 for no apparent reason. These samples with seemingly high levels are presumed to reflect normal variability as there were no known atmospheric releases; alternatively, they may reflect the deposition of plutonium from historical airborne releases in the earlier years of the Laboratory's operation. Two regional samples (collected at Cochiti and near Santa Cruz) contained elevated levels of ^{238}Pu, and one (from Otowi) showed an elevated level of $^{239,240}Pu$ up to twice the regional statistical reference level. Since the samples from Cochiti and Santa Cruz contained ratios of ^{238}Pu and $^{239,240}Pu$ that do not reflect worldwide fallout levels and because their $^{239,240}Pu$ levels were below the statistical reference level, it is likely that the ^{238}Pu measurements were analytical anomalies rather than real values. The levels in the sample from Otowi were almost identical to those seen in 1991 and were in the proportion expected for worldwide fallout.

Uranium levels in the perimeter and on-site locations contain higher concentrations of natural uranium than other regional stations in northern New Mexico because the soils are derived from the Pajarito Plateau's volcanic rocks whose natural uranium contents are higher than average. The uranium levels are in the same range as those previously measured.

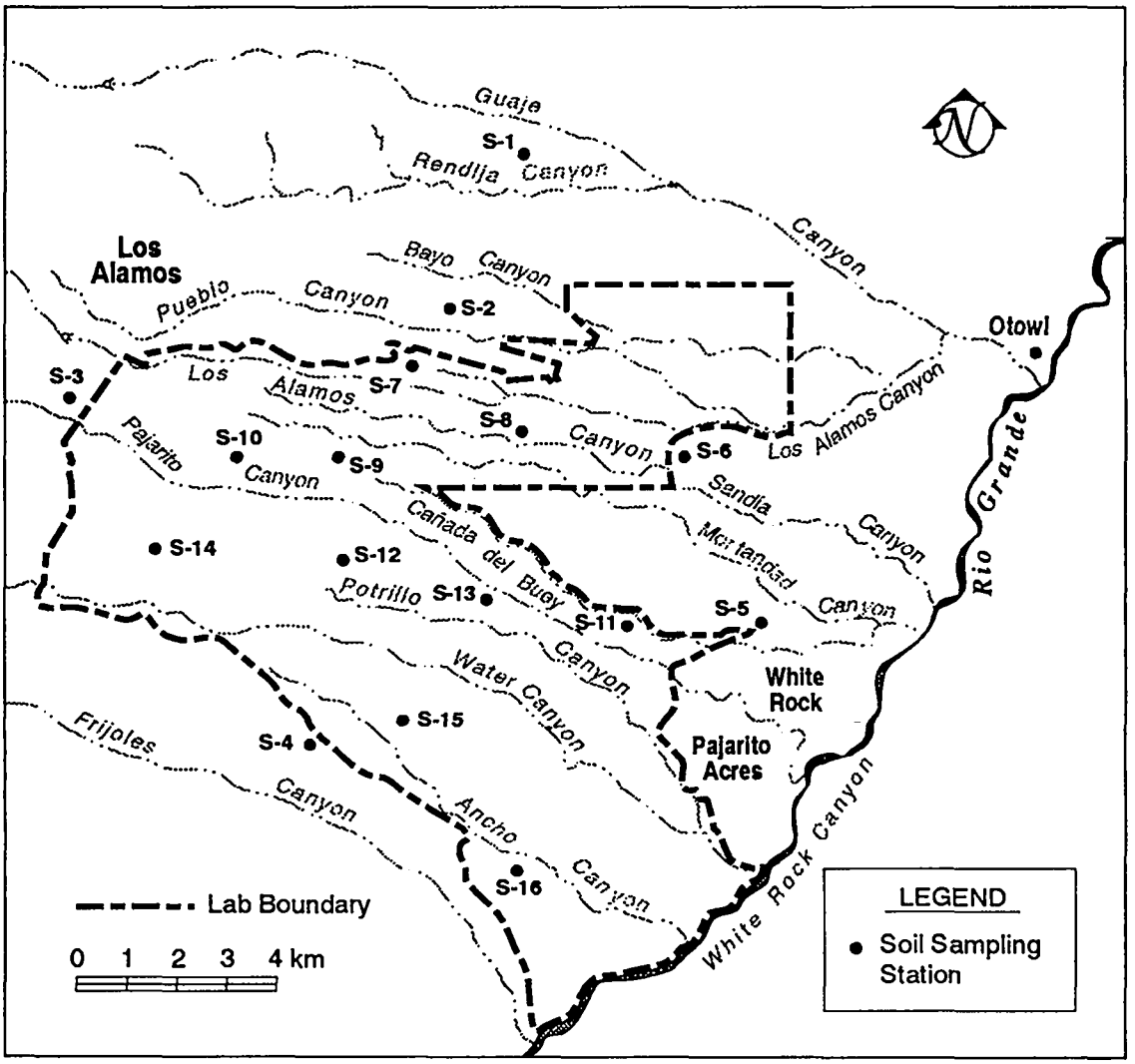


Figure V-19. Off-site perimeter and on-site Laboratory soil sampling locations. (Map denotes generalized locations only. Refer to Table D-12 for specific coordinates.)

1993 Soil Radiological Monitoring Data. The average concentrations of tritium, ^{137}Cs, $^{239,240}Pu$ and total uranium in soils collected from on-site and perimeter stations were not significantly ($p < 0.05$) different than radionuclide concentrations in soil samples collected from regional (background) locations. The average level of ^{238}Pu in on-site soils, on the other hand, was significantly higher than background concentrations. Although, the average level of ^{238}Pu in soils collected from on-site stations was significantly higher than background, only one ^{238}Pu value out of nine samples was a detectable value (i.e., where the analytical value was greater than two sigma) (please see the discussion on individual ^{238}Pu detectable values below). In any case, the average level of ^{238}Pu in soils collected from on-site stations (0.021 pCi/g) was far below the Laboratory's SAL of 27 pCi/g.

Two indices that summarize the amount of radionuclides in soils collected from background stations have been adopted as statistical reference levels of approximate upper limit background. They are (1) the current year's regional statistical reference level (CYRSRL), and (2) the long-term regional statistical reference level (LTRSRL). The CYRSRL is the current year's average background concentration plus twice the standard deviation of the mean. Similarly, the LTRSRL is the average background concentration plus twice the standard deviation of the mean from

Table V-28. Radiochemical Analyses of Soils Collected in 1992

Location	^{3}H (pCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
OFF-SITE STATIONS										
REGIONAL (BACKGROUND) STATIONS										
Rio Chama	0.4 (0.6)[a]	0.0 (0.6)	-0.2 (0.2)	2.1 (0.4)	0.002 (0.002)	0.005 (0.002)	0.048 (0.122)	8 (4)	5 (2)	-2 (2)
Embudo	0.0 (0.6)	0.3 (0.4)	0.1 (0.2)	1.9 (0.4)	0.002 (0.002)	0.021 (0.004)	0.033 (0.900)	7 (4)	5 (2)	-2 (2)
Otowi	0.1 (0.6)	0.0 (0.4)	0.1 (0.2)	3.3 (0.6)	0.002 (0.002)	0.055 (0.010)	0.160 (0.122)	7 (2)	4 (0)	1 (2)
Santa Cruz	0.3 (0.6)	0.1 (0.4)	-0.1 (0.2)	3.0 (0.6)	0.009 (0.004)	0.008 (0.002)	0.336 (0.160)	16 (8)	4 (0)	0 (2)
Cochiti	-0.1 (0.6)	0.2 (0.4)	0.1 (0.2)	2.5 (0.6)	0.015 (0.004)	0.004 (0.002)	0.174 (0.116)	10 (4)	4 (0)	-2 (2)
Bernalillo	0.2 (0.6)	0.2 (0.4)	0.1 (0.2)	2.9 (0.6)	0.001 (0.002)	0.002 (0.002)	0.100 (0.106)	5 (2)	3 (0)	-2 (2)
Jemez	0.2 (0.6)	0.3 (0.6)	0.2 (0.2)	2.1 (0.4)	-0.001 (0.002)	0.007 (0.002)	-0.024 (0.032)	7 (4)	3 (0)	-2 (2)
PERIMETER STATIONS										
L.A. Sportsman Club	0.5 (0.6)	0.3 (0.4)	0.0 (0.2)	2.3 (0.4)	0.011 (0.004)	0.012 (0.004)	0.179 (0.116)	8 (4)	4 (2)	2 (2)
North Mesa	0.3 (0.6)	0.3 (0.4)	-0.1 (0.2)	3.9 (0.8)	0.011 (0.004)	0.016 (0.004)	0.041 (0.108)	15 (6)	5 (2)	2 (2)
TA-8/GT Site	0.5 (0.6)	0.4 (0.4)	-0.1 (0.2)	2.1 (0.4)	0.003 (0.002)	0.022 (0.004)	0.125 (0.116)	7 (2)	4 (2)	1 (2)
TA-49	0.2 (0.6)	0.2 (0.6)	0.1 (0.2)	3.5 (0.8)	0.004 (0.002)	0.008 (0.002)	0.247 (0.142)	13 (6)	5 (2)	1 (2)
White Rock (East)	0.1 (0.6)	0.2 (0.6)	0.1 (0.2)	3.5 (0.8)	0.002 (0.002)	0.014 (0.004)	0.087 (0.134)	10 (4)	69 (14)	2 (2)
Tsankawi	0.2 (0.6)	0.4 (0.4)	-0.2 (0.2)	5.5 (1.0)	0.011 (0.004)	0.011 (0.004)	0.082 (0.120)	9 (4)	4 (0)	5 (2)
ON-SITE STATIONS										
TA-21 (DP Site)	0.4 (0.6)	0.1 (0.4)	0.2 (0.2)	3.5 (0.8)	0.020 (0.004)	0.013 (0.004)	-0.002 (0.050)	11 (4)	4 (2)	0 (2)
East of TA-53	0.4 (0.6)	0.2 (0.4)	-0.0 (0.2)	5.9 (1.2)	0.001 (0.006)	0.061 (0.008)	0.062 (0.092)	10 (4)	7 (2)	2 (2)
TA-50	0.5 (0.6)	0.1 (0.4)	-0.0 (0.2)	3.7 (0.8)	0.019 (0.004)	0.023 (0.004)	0.054 (0.118)	14 (6)	4 (2)	2 (2)
Two-Mile Mesa	1.1 (0.6)	0.3 (0.4)	0.2 (0.2)	3.5 (0.8)	0.018 (0.004)	0.017 (0.004)	0.065 (0.114)	9 (4)	4 (0)	0 (2)
East of TA-54	0.2 (0.6)	0.2 (0.4)	0.6 (0.4)	2.9 (0.6)	0.011 (0.004)	0.034 (0.006)	0.131 (0.112)	8 (4)	4 (2)	1 (2)
R-Site Road East	0.6 (0.6)	0.2 (0.4)	0.4 (0.4)	3.6 (0.8)	0.004 (0.002)	0.009 (0.004)	0.083 (0.118)	6 (2)	3 (0)	1 (2)
Potrillo Drive	0.2 (0.6)	0.2 (0.4)	0.6 (0.4)	3.4 (0.6)	0.061 (0.008)	0.046 (0.006)	0.041 (0.106)	11 (4)	4 (2)	1 (2)
S-Site (TA-16)	0.5 (0.6)	0.3 (0.4)	0.1 (0.2)	3.5 (0.8)	0.008 (0.004)	0.005 (0.002)	0.002 (0.106)	8 (4)	3 (0)	1 (2)
Near Test Well DT-9	4.0 (1.2)	0.0 (0.4)	0.3 (0.2)	3.6 (0.8)	0.002 (0.002)	0.032 (0.006)	0.055 (0.106)	8 (4)	5 (2)	3 (2)
Near TA-33	0.9 (0.6)	0.2 (0.4)	0.1 (0.2)	3.5 (0.8)	0.009 (0.004)	0.011 (0.004)	0.028 (0.106)	7 (4)	4 (2)	2 (2)

[a] (+2 counting uncertainty).

Table V-29. Radiochemical Analyses of Soils Collected in 1993

Location	^{3}H (pCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
OFF-SITE REGIONAL (BACKGROUND) STATIONS										
Rio Chama	0.2 (0.6)[a]	N/A[b]	0.7 (0.2)	1.4 (0.4)	0.003 (0.060)	0.027 (0.040)	N/A	3 (2)	4 (1)	3 (0)
Embudo	–0.2 (0.6)	N/A	0.6 (0.2)	0.8 (0.2)	0.004 (0.060)	0.018 (0.040)	N/A	4 (2)	4 (0)	3 (0)
Otowi	0.0 (0.6)	N/A	0.1 (0.0)	1.8 (0.4)	0.000 (0.060)	0.024 (0.040)	N/A	2 (2)	3 (0)	3 (0)
Santa Cruz	–0.1 (0.6)	N/A	0.1 (0.0)	2.1 (1.2)	0.002 (0.060)	0.004 (0.040)	N/A	7 (4)	3 (0)	3 (0)
Cochiti	0.2 (0.6)	N/A	0.1 (0.2)	1.2 (0.4)	0.001 (0.060)	0.010 (0.040)	N/A	4 (2)	4 (0)	3 (0)
Bernalillo	0.0 (0.6)	N/A	0.1 (0.0)	2.9 (0.6)	0.005 (0.060)	0.003 (0.040)	N/A	10 (8)	3 (0)	2 (0)
Jemez	–1.6 (1.8)	N/A	0.1 (0.0)	1.3 (0.4)	0.002 (0.060)	0.006 (0.040)	N/A	3 (2)	3 (0)	2 (0)
Mean (±2 SD)	-0.2 (1.3)		0.3 (0.5)	1.6 (1.4)	0.002 (0.003)	0.013 (0.019)		5 (6)	3 (1)	3 (1)
CYRSRL[c]	1.1		0.8	3.0	0.005	0.033		11	4	4
LTRSRL[d]	7.2		1.1	3.4	0.005	0.025				
SAL[e]	15.0[f]		4.0	185.1	27.000	18.000				
OFF-SITE PERIMETER STATIONS										
L.A. Sportsman Club	0.4 (0.6)	N/A	0.2 (0.2)	1.8 (1.0)	0.004 (0.060)	0.006 (0.040)	N/A	4 (2)	4 (0)	4 (0)
North Mesa	0.3 (0.6)	N/A	0.1 (0.0)	2.0 (0.4)	0.000 (0.060)	0.015 (0.040)	N/A	3 (2)	3 (0)	3 (0)
TA-8/GT Site	–0.2 (0.6)	N/A	2.1 (0.6)	1.7 (0.4)	0.008 (0.060)	0.068 (0.040)	N/A	6 (2)	8 (1)	4 (2)
TA-49	0.0 (0.6)	N/A	1.0 (0.4)	1.5 (0.8)	0.001 (0.060)	0.033 (0.040)	N/A	3 (2)	5 (1)	4 (0)
White Rock (East)	–0.1 (0.6)	N/A	0.0 (0.0)	2.0 (0.4)	0.006 (0.060)	0.002 (0.040)	N/A	4 (2)	4 (0)	4 (0)
Tsankawi	–0.1 (0.6)	N/A	0.1 (0.2)	3.2 (0.6)	0.003 (0.060)	0.025 (0.040)	N/A	3 (2)	4 (0)	4 (0)
Mean (±2 SD)	0.1 (0.5)		0.6 (1.7)	2.0 (1.2)	0.004 (0.006)	0.025 (0.050)		4 (2)	5 (4)	4 (1)
ON-SITE STATIONS										
TA-21 (DP Site)	0.5 (0.6)	N/A	0.1 (0.0)	1.7 (0.6)	0.025 (0.060)	0.030 (0.040)	N/A	3 (2)	3 (0)	3 (0)
East of TA-53	0.4 (0.6)	N/A	0.2 (0.0)	1.9 (1.0)	0.004 (0.060)	0.030 (0.040)	N/A	4 (2)	4 (0)	N/A
TA-50	0.1 (0.6)	N/A	0.2 (0.0)	2.2 (0.8)	0.005 (0.060)	0.062 (0.040)	N/A	4 (2)	4 (1)	3 (0)
Two-Mile Mesa	0.7 (0.6)	N/A	0.7 (0.2)	2.5 (0.8)	0.007 (0.060)	0.024 (0.040)	N/A	4 (2)	4 (1)	3 (0)

Table V-29. (Cont.)

Location	^{3}H (pCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{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)
ON-SITE STATIONS (Cont.)										
East of TA-54	9.5 (1.8)	N/A	2.0 (0.6)	1.8 (0.8)	0.088 (0.060)	2.248 (0.140)	N/A	5 (2)	6 (1)	5 (2)
R-Site Road East	1.2 (0.6)	N/A	0.4 (0.2)	3.6 (0.8)	0.042 (0.060)	0.015 (0.040)	N/A	8 (4)	8 (1)	4 (0)
Potrillo Drive	-0.2 (0.6)	N/A	0.2 (0.0)	2.3 (0.4)	0.003 (0.060)	0.009 (0.040)	N/A	4 (2)	4 (0)	4 (0)
S-Site (TA-16)	0.4 (0.6)	N/A	3.1 (1.0)	1.5 (0.4)	0.017 (0.060)	0.022 (0.040)	N/A	3 (2)	4 (0)	3 (0)
Near Test Well DT-9	0.2 (0.6)	N/A	1.0 (0.4)	2.6 (1.2)	0.007 (0.060)	0.031 (0.040)	N/A	4 (2)5 (1)4 (0)		
Near TA-33	1.1 (0.6)	N/A	0.1 (0.0)	1.3 (0.2)	0.007 (0.060)	0.001 (0.040)	N/A	5 (1)6 (2)4 (0)		
Mean (±2 SD)	1.4 (5.8)		0.8 (2.0)	2.1 (1.3)	0.021 (0.053)	0.247 (1.406)		4 (3)	5 (3)	4 (1)

[a] (±2 counting uncertainty).

[b] N/A means analysis not performed, lost in analysis, or not completed.

[c] CYRSRL(Current Year's Regional Statistical Reference Level; this is the upper limit background [mean ±2 std dev]).

[d] LTRSRL (Long-Term Regional Statistical Reference Level; this is the upper-limit background concentration [mean ±2 std dev] based on Purtymun 1987a).

[e] SAL (Los Alamos National Laboratory Screening Action Level).

[f] 15.0 µCi/g (≈ 15,000,000.00 pCi/g soil).

data collected over a 13-yr period; data from 1974 through 1986 from regional background stations were used to establish long-term regional statistical limits for worldwide fallout levels of tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$ and total uranium (Purtymun 1987a).

A comparison of individual radionuclide detectable values in soils collected from on-site and perimeter stations versus the CYRSRL and the LTRSRL show

Tritium. Three out of four detectable tritium samples collected from on-site stations exceeded the CYRSRL, and only one of these, a soil sample collected from TA-54, exceeded the LTRSRL. No tritium samples exceeded the Laboratory's SAL of 15,000,000 pCi/g of soil.

Cesium-137. Two out of three detectable ^{137}Cs values in soil samples collected from perimeter areas exceeded the CYRSRL and only one of these, a soil sample from TA-8, exceeded the LTRSRL. Of the 10 detectable ^{137}Cs values observed from on-site soil samples, only three exceeded the CYRSRL, and two of these (TA-54 and TA-16) exceeded the LTRSRL. The highest ^{137}Cs value (3.1 pCi/g) was found in a soil sample collected from TA-16 (S-site). All of these values, however, were still below the Laboratory's SAL of 4 pCi/g.

Total Uranium. All perimeter soil samples contained detectable uranium levels; only one, White Rock, exceeded the CYRSRL. Similarly, only 1 of the 10 detectable uranium values observed in soil samples collected from on-site stations exceeded the CYRSRL and LTRSRL. This sample contained 3.6 μg/g of uranium and was collected at TA-15 (R-site). All uranium values were far below the Laboratory's SAL of 185 μg/g.

Plutonium-238. Although the average level of ^{238}Pu in soils collected from on-site areas was significantly higher than ^{238}Pu in soils collected from background locations, only one detectable ^{238}Pu value was observed. It was from an on-site station at TA-54 (east of Area G) and was higher than the CYRSRL and the LTRSRL. As stated previously, the value was far below the Laboratory's SAL.

Plutonium-239,240. One detectable $^{239,240}Pu$ value was observed from the perimeter stations, and two detectable $^{239,240}Pu$ values were observed in soils collected from on-site areas (TA-50 and TA-54). These samples contained $^{239,240}Pu$ above the CYRSRL and the LTRSRL. The soil collected at TA-54, in fact, exceeded the LTRSRL by almost 90 times. This value may be an outlier since there were no known atmospheric releases of plutonium and a check of past $^{239,240}Pu$ values collected at the TA-54 station reveal no large quantities of $^{239,240}Pu$. The value detected near TA-54 (2.2 pCi/g) was far below the Laboratory's SAL for $^{239,240}Pu$ of 18 pCi/g, however.

Soils were also analyzed for heavy metals. These data will ultimately be used to establish a data base of results comparable to those reported by other agencies such as the USGS; these data are meaningful from a Laboratory operation/effects standpoint as well geochemical processes. The results of the 1992 and 1993 soil sampling program can be found in Tables VI-16 and VI-17, respectively. An error in aluminum and iron levels were detected in the 1992 data set (EPG 1994); therefore, these data are presented again with the correct values plus the text for overall completeness.

7. Foodstuffs Monitoring

a. Introduction. As part of the Environmental Protection Program at LANL, samples of foodstuffs are collected annually from the Laboratory and surrounding communities to determine the impact of Laboratory operations on the human food chain, as per DOE Orders 5400.1 and 5400.5. The two main objectives of the Foodstuffs Monitoring Program are to (1) determine and compare radioactive constituents (and heavy metals) between on-site LANL and off-site perimeter with regional areas; and (2) calculate a total EDE to area residents (Los Alamos townsite and White Rock/Pajarito Acres) who may consume such foodstuffs. Radiation doses to individuals from the ingestion of foodstuffs are presented in Section V.C.3.f.

b. Monitoring Network.

Produce, soil, bees, and honey. Fruits, vegetables, grains, bees, and honey are collected each year from on-site (Laboratory), off-site perimeter (Los Alamos townsite and White Rock/Pajarito Acres), and off-site regional (background) locations (Figures V-20 and V-21, and Table D-19). Samples of (garden) soils and foodstuffs were also collected during 1993 from the pueblos of Cochiti, Jemez, Taos, and San Ildefonso, which are located in the general vicinity of LANL (Fresquez 1995b). Regional or background samples are collected from gardens upstream from the confluence of the Rio Grande and intermittent streams that cross Laboratory lands. The regional sampling

locations are also sufficiently distant (e.g., >16 km [10 mi]) from the Laboratory) as to be unaffected by airborne emissions.

Heavy and trace metals in produce and honey are sampled every three years; the results of the next sampling session will be presented in the environmental surveillance reports for CY94 and CY95, respectively.

Fish. Fish are collected annually upstream and downstream of the Laboratory (Figure V-20). 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 Abiquiu, Heron, and/or El Vado 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. During 1993, fish from lakes at the pueblos of Jemez, Nambé, and San Ildefonso were also sampled, analyzed, and compared to fish collected from Abiquiu, Heron, and El Vado reservoirs (Fresquez 1995c).

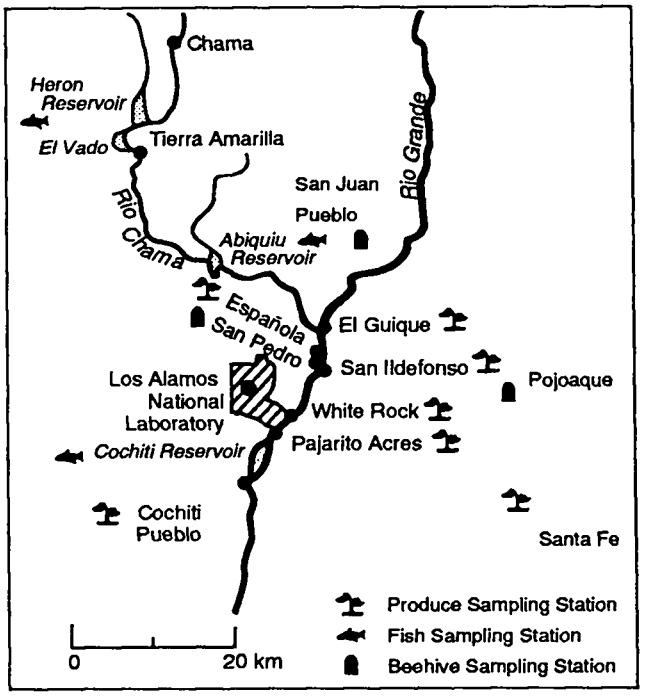


Figure V-20. Produce, fish, and beehive off-site (regional and perimeter) sampling locations. (Map denotes general locations only.)

Fish are separated into two categories for analysis: 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*).

Heavy and trace metals in fish are sampled every three years; the results of the next sampling session will be presented in the environmental surveillance report for CY94.

Game animals. Three adult female cow elk (*Cervus elaphus*) were harvested in October-December of 1991 and January-February of 1992 from TA-18 (Pajarito Canyon), TA-49 (Water Canyon), and TA-5 (Mortandad Canyon) (Figure V-22) (Fresquez 1994b). Similarly, three adult cow elk were collected by the NM Department of Game and Fish from the Lindreth, Tres Piedras, and Chama areas.

c. Radiochemical Analytical Results.

Produce. Concentrations of radionuclides in produce collected from on-site Laboratory and off-site perimeter and regional locations during the 1993 growing season are presented in Table V-30. No significant differences were found in any of the mean concentrations of most radionuclides in produce collected from on-site Laboratory or off-site perimeter areas as compared to off-site regional (background) areas. The concentrations of most radionuclides in produce collected from on-site and off-site locations were within values reported for these areas in past years (Fresquez 1994d).

Soil and Produce from the Pueblos of Cochiti, Jemez, Taos, and San Ildefonso. With the exception of total uranium, the concentration of all other radionuclides in soil samples collected from gardens located on pueblo lands were within regional statistical reference levels (Table V-31) (Fresquez 1995b). Results of analyses of the concentration of radionuclides in soil surface samples from various locations around northern New Mexico from 1974 through 1985 were used to establish statistical limits attributable to natural and/or worldwide fallout of tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, and total uranium (Purtymun 1987a). The average concentration level in these samples plus twice the standard deviation of the mean was adopted as an indicator of an approximate upper limit for natural

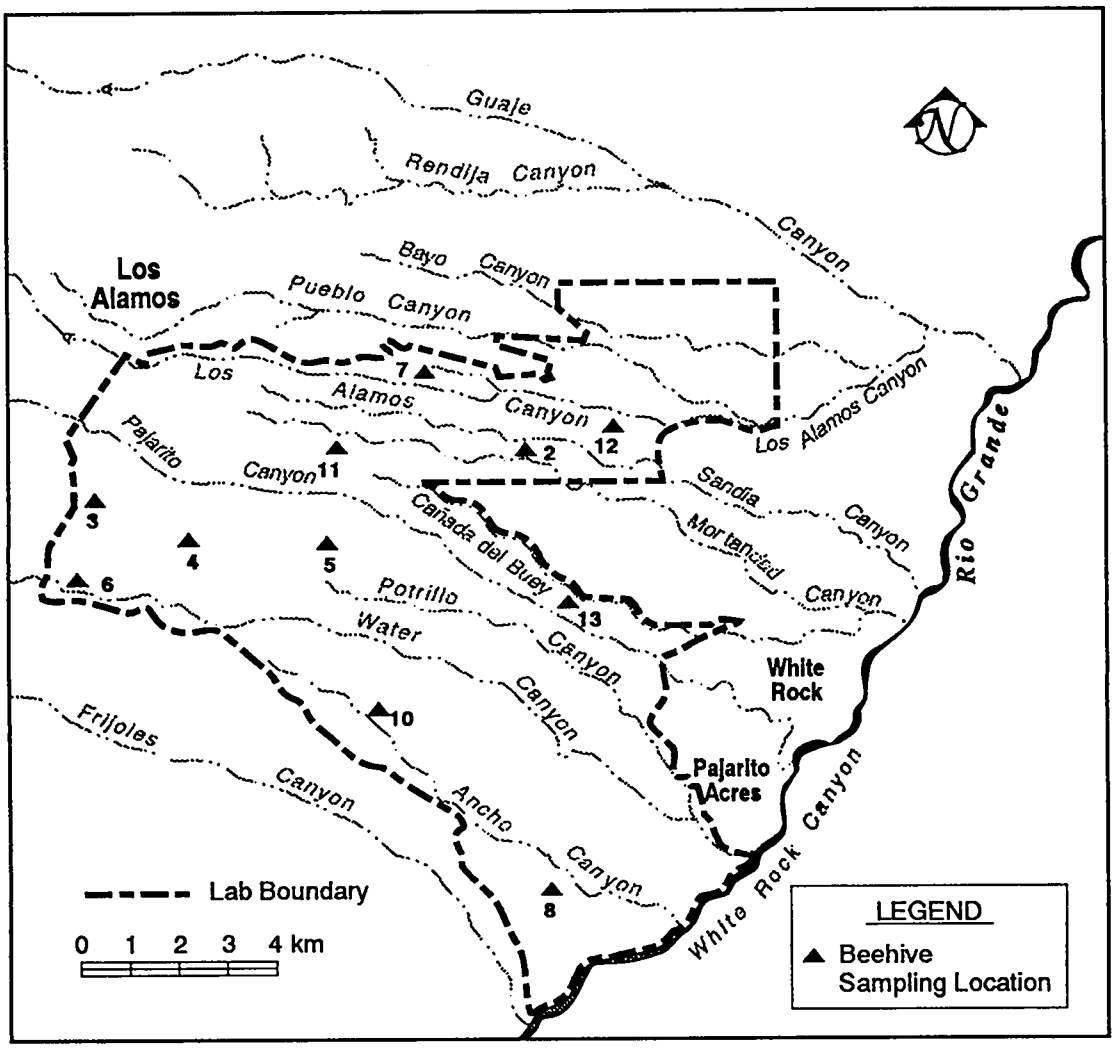


Figure V-21. Locations of beehives in on-site Laboratory areas. Regional stations are shown on Figure V-20. (Map denotes general locations. Specific locations are presented in Table D-19.)

or worldwide fallout background concentrations. No significant differences were found in any of the average concentrations of radionuclides in produce collected from gardens at the pueblos of Cochiti, Jemez, Taos or San Ildefonso as compared to produce collected from the Española/Santa Fe areas (Table V-30). Most radionuclide concentrations in produce collected from gardens on pueblo lands were within regional statistical reference levels for similar foodstuffs collected over a 16-yr period from gardens located in other parts of northern New Mexico (Fresquez 1994d).

Bees and Honey. Bee and honey data collected during the 1993 season are presented in Tables V-32 and V-33.

In general, concentrations of most radionuclides measured in bees collected from most TAs were higher than ULB concentrations (mean ±2SD). In almost every case, concentrations of radionuclides were higher than background in bees collected from TA-53 and TA-54. Samples collected from off-site perimeter areas also contained bees with radionuclide concentrations above ULB; bees from Los Alamos townsite had tritium, ^{90}Sr, and ^{137}Cs above ULB, whereas, bees from White Rock/Pajarito Acres had tritium, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{137}Cs and total uranium above ULB concentrations.

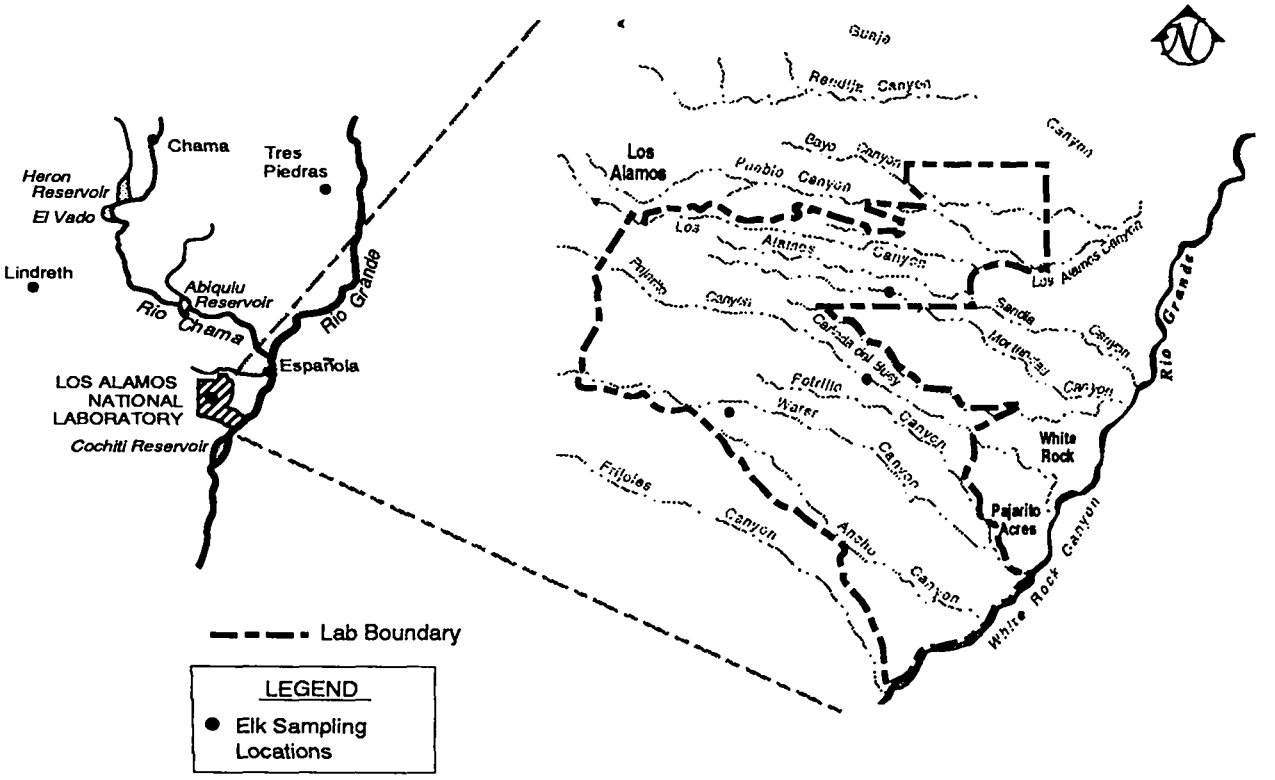


Figure V-22. Locations of elk collected from LANL lands (on-site) and regional areas (off-site).

Levels of tritium in bees collected from Laboratory areas ranged in concentration from 0.60 (±0.60) pCi/mL at TA-8 and TA-9 to 245.70 (±11.40) pCi/mL at TA-53 (Table V-32). The highest tritium contents in bees collected from the Laboratory were from TA-53 and TA-54. Off-site perimeter areas (Los Alamos townsite and White Rock/Pajarito Acres) contained bees with concentrations of tritium of 0.60 pCi/mL to 34.60 pCi/mL, respectively. The average concentration of tritium in bees collected from off-site areas was 0.60 (±0.40) pCi/mL.

In contrast to the bee data, most radionuclides detected in honey samples collected from LANL lands and perimeter areas were within ULB concentrations. In other words, most radionuclides picked up by bees were not readily transferred to the honey. Levels of tritium in honey collected from Laboratory beehives ranged from -0.40 (±0.60) pCi/mL at TA-9 to 238.00 (±11.00) pCi/mL at TA-54. Again, TA-53 and TA-54 contained the highest concentration of tritium in honey samples. Honey produced by the hives on Laboratory lands is not available for public consumption. As with the bees, the White Rock/Pajarito Acres hive contained higher concentrations of tritium in honey than background. Regional background levels of tritium in honey averaged 0.07 (±0.81) pCi/mL.

Fish.

Cochiti, Abiquiu, Heron, and El Vado Reservoirs. Concentration of radionuclides in game and nongame fish collected upstream and downstream of the Laboratory are presented in Table V-34.

The concentrations of most radionuclides (^{137}Cs, total uranium, ^{238}Pu, and ^{239}Pu) were not significantly different in game fish collected from Cochiti Reservoir as compared to game fish collected from reservoirs located upstream of the Laboratory. Concentrations of ^{90}Sr in game fish collected from Cochiti Reservoir, however, were significantly higher than background. Although the levels of ^{90}Sr in fish from Cochiti Reservoir (9.2×10^{-2} pCi/dry g) were statistically higher than background levels, they were still within the statistically derived reference level (i.e., $<17.0 \times 10^{-2}$ pCi/dry g) that reflects activity attributable to worldwide fallout (Fresquez 1994a). These statistical limits are based on upstream (background) samples collected over a 12-year-period between 1981 and 1993.

Table V-30. Radionuclides in Produce Collected from Off-Site and On-Site Areas during the 1993 Growing Season[a]

	^{3}H (pCi/mL)	^{90}Sr (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)
OFF-SITE STATIONS						
Regional						
Española/Santa Fe						
N	10	10	10	10	10	10
Minimum	−0.1[b] (0.6)[c]	0.0 (5.6)	0.5 (0.3)	−144.0 (640.0)	−64.0 (960.0)	−132.2 (123.0)
Maximum	0.6 (0.6)	48.0 (32.0)	15.3 (3.1)	40.8 (408.0)	117.0 (180.0)	14.3 (96.0)
Mean	0.3 (0.5)[d]	21.2 (32.2)	7.0 (11.6)	−3.5 (103.4)	14.0 (91.2)	−20.8 (84.6)
San Ildefonso						
N	5.0	5.0	5.0	5.0	5.0	5.0
Minimum	−0.2 (0.6)	0.0 (8.2)	1.9 (0.4)	0.0 (520.0)	9.9 (594.0)	−6.2 (11.2)
Maximum	0.3 (0.6)	225.5 (82.0)	6.3 (1.3)	20.5 (164.0)	213.2 (246.0)	16.6 (14.4)
Mean	−0.0 (0.4)	87.9(167.2)	3.5 (3.6)	8.2 (22.4)	53.6 (178.6)	1.1 (17.8)
Cochiti						
N	5.0	5.0	5.0	5.0	5.0	5.0
Minimum	−0.1 (0.6)	5.6 (5.6)	1.7 (0.3)	0.0 (584.0)	0.0(1158.0)	−9.7 (14.4)
Maximum	0.1 (0.6)	73.0 (58.4)	9.9 (1.9)	49.2 (656.0)	16.4 (984.0)	−2.7 (6.0)
Mean	−0.0 (0.6)	39.0 (60.0)	5.2 (7.0)	16.8 (38.8)	8.4 (15.8)	−5.4 (5.2)
Taos						
N	5.0	5.0	5.0	5.0	5.0	5.0
Minimum	−0.2 (0.6)	0.0 (5.4)	0.8 (0.2)	0.0 (108.0)	7.4 (222.0)	−9.9 (12.8)
Maximum	0.0 (0.6)	69.0 (34.0)	6.7 (1.3)	11.1 (148.0)	51.0 (612.0)	0.5 (14.8)
Mean	−0.1 (0.1)	20.0 (60.0)	2.4 (4.8)	6.1 (11.2)	23.8 (37.4)	−4.6 (8.6)
Jemez						
N	6.0	6.0	6.0	6.0	6.0	6.0
Minimum	0.0 (0.6)	6.6 (4.4)	0.3 (0.1)	4.4 (88.0)	4.4 (132.0)	−62.6 (89.8)
Maximum	0.5 (0.6)	99.2 (24.8)	12.4 (4.6)	24.8 (496.0)	74.4 (744.0)	6.4 (22.6)
Mean	0.3 (0.4)	42.1 (80.8)	3.4 (9.4)	15.0 (16.0)	24.4 (52.4)	−29.5 (58.6)
Perimeter						
Los Alamos						
N	5.0	5.0	4.0	5.0	5.0	5.0
Minimum	0.0 (0.6)	6.9 (4.6)	0.6 (0.1)	10.8 (108.0)	−140.8 (768.0)	−66.2 (111.4)
Maximum	0.5 (0.6)	53.0 (53.0)	28.1 (5.6)	76.8 (512.0)	155.4(1554.0)	7.6 (29.6)
Mean	0.3 (3.7)	34.7 (47.4)	7.9 (26.9)	30.3 (54.1)	9.8 (210.4)	−20.4 (57.1)
White Rock/Pajarito Acres						
N	5.0	5.0	5.0	5.0	5.0	5.0
Minimum	0.2 (0.6)	14.5 (29.0)	−0.8 (0.2)	0.0 (600.0)	11.5 (660.0)	−54.4 (86.4)
Maximum	0.6 (0.6)	53.6 (26.8)	6.0 (1.2)	14.5 (580.0)	45.0 (900.0)	53.3 (114.8)
Mean	0.4 (3.6)	37.7 (31.3)	2.9 (6.1)	7.9 (14.6)	28.4 (23.8)	−25.7 (89.3)
ON-SITE STATIONS						
N	9.0	9.0	9.0	9.0	9.0	9.0
Minimum	0.0 (0.6)	0.0 (12.2)	0.3 (0.1)	0.0 (492.0)	5.0 (150.0)	−9.6 (10.0)
Maximum	8.9 (1.8)	44.4 (66.6)	10.4 (4.1)	36.3 (484.0)	67.8 (678.0)	1.4 (9.4)
Mean	1.8 (5.7)	23.5 (30.8)	3.6 (6.6)	16.9 (28.8)	29.1 (47.4)	−1.8 (6.6)

[a]There are no concentration guides for produce; however, all mean radionuclide contents in produce from LANL and perimeter areas were not significantly different from regional background using a Student's t-test at the 0.05 probability level (Gilbert 1987).

[b]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

[c](±2 counting uncertainty)

[d](±2 standard deviation)

Table V-31. Radionuclides in Soils Collected from Cochiti, Jemez, Taos, and San Ildefonso Pueblo Gardens during the 1993 Growing Season

	^{3}H (pCi/mL)	^{90}Sr (pCi/dry g)	Total U (ug/dry g)	^{238}Pu (pCi/dry g)	$^{239,240}Pu$ (pCi/dry g)	^{137}Cs (pCi/dry g)
Cochiti						
	-0.10	0.30	4.22	0.003	0.005	0.16
	(0.30)[a]	(0.20)	(0.45)	(0.030)	(0.020)	(0.06)
Jemez						
	0.10	0.40	3.76	0.001	0.006	0.28
	(0.30)	(0.20)	(0.45)	(0.030)	(0.020)	(0.06)
Taos						
	0.10	0.30	3.65	0.002	0.005	0.23
	(0.30)	(0.20)	(0.45)	(0.030)	(0.020)	(0.07)
San Ildefonso						
	0.50	0.40	3.60	0.002	0.003	<0.08
	(0.30)	(0.20)	(0.40)	(0.030)	(0.020)	(0.00)
RSRL[b]						
	7.20	0.88	3.40	0.005	0.025	1.09

[a] (±2 counting uncertainty)

[b] RSRL (Regional Statistical Reference Level)

Table V-32. Radionuclides in Bees Collected from Off-Site and On-Site Areas during 1993

Location	^{3}H (pCi/mL)[a]	^{90}Sr (pCi/g ash)	^{238}Pu (pCi/g ash)	^{239}Pu (pCi/g ash)	^{137}Cs (pCi/g ash)	U (µg/g ash)
OFF-SITE STATIONS						
Regional						
San Pedro	0.6	0.1	-0.001[b]	-0.001	-0.012	0.37
	(0.6)[c]	(0.4)	(0.060)	(0.040)	(0.029)	(0.14)
Pojoaque	0.8	0.1	0.001	0.002	-0.011	0.35
	(0.6)	(0.6)	(0.006)	(0.040)	(0.041)	(0.14)
San Juan	0.4	0.1	0.014	0.015	-0.018	0.33
	(0.6)	(0.4)	(0.060)	(0.040)	(0.041)	(0.14)
$\bar{X}$[d]	0.6	0.1	0.005	0.005	-0.014	0.35
	(0.4)	(0.0)	(0.016)	(0.017)	(0.008)	(0.04)
Perimeter						
Los Alamos	0.6	0.3	-0.002	-0.002	3.050	0.35
	(0.6)	(0.4)	(0.060)	(0.040)	(0.924)	(0.14)
White Rock/Pajarito Acres/TA-36	34.6	1.0	0.036	0.071	0.020	0.60
	(3.6)	(0.4)	(0.060)	(0.040)	(0.037)	(0.16)
ON-SITE STATIONS						
TA-5	6.5	2.3	0.013	0.037	-0.021	0.97
	(1.6)	(0.4)	(0.060)	(0.040)	(0.030)	(0.32)
TA-8	0.6	0.3	0.001	0.008	-0.003	0.38
	(0.6)	(0.2)	(0.060)	(0.040)	(0.026)	(0.12)
TA-9	0.6	0.5	0.002	0.001	-0.013	0.64
	(0.6)	(0.2)	(0.060)	(0.040)	(0.029)	(0.18)
TA-15	6.9	0.6	0.004	0.030	0.001	1.26
	(1.6)	(0.2)	(0.060)	(0.040)	(0.026)	(0.38)
TA-16	1.1	0.4	0.008	0.008	-0.018	0.91
	(0.6)	(0.2)	(0.060)	(0.040)	(0.024)	(0.30)
TA-21	4.9	3.2	0.012	0.030	-0.027	0.35
	(1.4)	(0.4)	(0.060)	(0.040)	(0.023)	(0.08)
TA-33	9.9	2.1	0.007	0.013	-0.020	0.26
	(2.0)	(0.4)	(0.060)	(0.040)	(0.037)	(0.06)
TA-49	0.8	0.5	0.011	0.004	-0.027	2.04
	(0.6)	(0.2)	(0.060)	(0.040)	(0.029)	(0.66)
TA-50	15.6	0.8	0.003	0.011	-0.028	0.59
	(2.4)	(0.4)	(0.060)	(0.040)	(0.027)	(0.22)
TA-53	245.7	0.4	0.004	0.011	-0.062	0.28
	(11.4)	(0.2)	(0.060)	(0.040)	(0.064)	(0.08)
TA-54	54.4	1.8	0.009	0.034	0.125	0.54
	(4.6)	(0.2)	(0.060)	(0.040)	(0.053)	(0.10)

[a]pCi/mL of bee moisture.

[b]See Section VIII.C.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

[c]Counting uncertainties (±2 standard deviations) are in parentheses.

[d] $\bar{X}$ = average.

Table V-33. Radionuclides in Honey Collected from Off-Site and On-Site Areas during 1993

Location	^{3}H (pCi/mL)[a]	^{90}Sr (pCi/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/L)	^{137}Cs (pCi/L)	Uranium (μg/L)
OFF-SITE STATIONS						
Regional						
San Pedro	0.00	0.19	0.054	-0.054[b]	-5.83	4.20
	(0.60)[c]	(5.59)	(0.115)	(0.074)	(26.80)	(0.80)
Pojoaque	0.50	4.09	0.000	0.048	1.07	9.30
	(0.60)	(7.81)	(0.112)	(0.089)	(28.60)	(1.80)
San Juan	-0.30	2.05	0.076	0.006	-6.23	2.40
	(0.60)	(2.23)	(0.112)	(0.074)	(26.40)	(0.80)
$\bar{X}$[d]	0.07	2.11	0.043	0.000	-3.66	5.30
	(0.81)	(3.90)	(0.078)	(0.103)	(8.20)	(7.16)
CYRSRL[e]	0.88	6.01	0.121	0.103	4.54	12.46
LTRSRL[f]	21.22	6.01	0.121	0.103	327.35	6.46
Perimeter						
Los Alamos	0.30	0.93	0.008	0.007	19.1	—[g]
	(0.60)	(1.12)	(0.112)	(0.074)	(60.6)	
White Rock/Pajarito Acres/TA-36	37.30	0.93	0.006	-0.007	-0.70	5.90
	(3.80)	(2.23)	(0.112)	(0.074)	(30.6)	(1.20)
ON-SITE STATIONS						
TA-5	0.60	0.56	-0.026	-0.009	-12.28	0.90
	(0.60)	(8.23)	(0.112)	(0.074)	(28.00)	(0.40)
TA-8	—[g]	13.76	-0.011	-0.013	-1.94	1.90
	—[g]	(8.18)	(0.112)	(0.074)	(33.20)	(0.60)
TA-9	-0.40	0.00	0.011	-0.013	-19.20	0.60
	(0.60)	(2.98)	(0.112)	(0.074)	(11.56)	(0.14)
TA-15	0.60	3.91	0.041	0.024	-10.10	0.90
	(0.60)	(6.32)	(0.112)	(0.074)	(29.20)	(0.18)
TA-16	0.10	1.30	0.035	0.004	-4.07	1.40
	(0.60)	(1.12)	(0.112)	(0.074)	(26.60)	(0.60)
TA-21	120.00	5.02	0.004	0.004	5.44	0.70
	(2.20)	(1.49)	(0.112)	(0.074)	(39.20)	(0.40)
TA-33	-0.20	-0.19	-0.011	-0.006	-0.20	0.80
	(0.60)	(2.60)	(0.112)	(0.074)	(26.40)	(0.40)
TA-49	0.50	1.30	0.009	-0.020	-9.81	0.40
	(0.60)	(2.98)	(0.112)	(0.074)	(29.00)	(0.14)
TA-50	2.10	2.98	-0.004	-0.004	-15.80	4.40
	(0.80)	(2.98)	(0.112)	(0.074)	(23.40)	(1.80)
TA-53	117.90	2.05	0.065	0.004	-10.20	0.20
	(7.20)	(6.32)	(0.112)	(0.074)	(52.40)	(0.06)
TA-54	238.00	1.12	-0.002	0.017	-12.50	0.40
	(11.00)	(2.33)	(0.112)	(0.074)	(31.80)	(0.14)

[a]pCi/mL of honey moisture.

[b]See Section VIII.C.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

[c]Counting uncertainties (± 2 standard deviations) are in parentheses.

[d]$\bar{X}$ = average.

[e]Current Year Regional Statistical Level.

[f]Long Term Regional Statistical Level.

[g]Analysis not performed or lost in analysis.

Table V-34. Radionuclide Concentrations in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory During 1993

	^{90}Sr (10^{-2} pCi/dry g)	^{137}Cs (10^{-2} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
GAME FISH (Surface Feeders: Trout, Salmon, Crappie, Bass, and Walleye)					
Upstream (Abiquiu, Heron, and El Vado)					
N[a]	9.0	8.0	9.0	9.0	9.0
Minimum	0.7 (1.4)[b]	−1.8[c] (2.1)	0.3 (0.2)	0.0 (42.0)	0.0 (40.0)
Maximum	9.1 (2.6)	2.0 (2.8)	9.8 (2.8)	0.0 (90.0)	22.0 (44.0)
Mean	3.2 (5.5)[d]	0.4 (2.4)	3.3 (5.8)	0.0 (0.0)	5.1 (16.6)
Downstream (Cochiti)					
N	8.0	8.0	8.0	8.0	8.0
Minimum	3.4 (3.4)	−5.2 (3.3)	0.3 (3.8)	0.0 (96.0)	0.0 (64.0)
Maximum	17.1 (4.8)	1.7 (4.3)	20.7 (5.6)	40.0(120.0)	20.0 (80.0)
Mean	9.2 (9.2)	−0.6 (4.8)	5.5 (13.0)	5.0 (28.2)	4.6 (17.2)
NONGAME FISH (Bottom Feeders: Catfish, Sucker, and Carp)					
Upstream (Abiquiu, Heron, and El Vado)					
N	12.0	11.0	12.0	12.0	12.0
Minimum	2.1 (1.4)	−0.2 (2.0)	1.6 (0.3)	0.0 (42.0)	0.0 (28.0)
Maximum	9.8 (2.8)	1.8 (2.5)	9.5 (2.4)	27.0 (54.0)	9.0 (36.0)
Mean	4.7 (5.3)	0.8 (1.3)	4.3 (4.4)	7.6 (18.2)	2.9 (8.6)
Downstream (Cochiti)					
N	10.0	9.0	10.0	10.0	10.0
Minimum	2.1 (1.4)	−1.3 (2.7)	4.3 (0.8)	−9.0 (54.0)	0.0 (28.0)
Maximum	8.0 (1.6)	2.3 (2.7)	24.3 (13.2)	28.0 (84.0)	12.0 (48.0)
Mean	3.5 (3.6)	0.5 (2.5)	12.0 (10.4)	4.2 (21.0)	5.3 (9.6)

[a]N = number of composite samples.
[b](± 2 counting uncertainty).
[c]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[d](± 2 standard deviation).

Also, ^{90}Sr levels in fish from Cochiti Reservoir compare well with ^{90}Sr concentrations in crappie, trout, and salmon from comparable (background) reservoirs and lakes in Colorado (Wicker 1972, Nelson 1969).

Concentrations of ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239}Pu in nongame fish collected downstream of the Laboratory were not significantly different from nongame fish collected from background locations. Total uranium was the only element that was significantly higher in nongame fish from Cochiti Reservoir as compared to fish collected upstream of the Laboratory. Although both game and nongame fish from Cochiti Reservoir had higher concentrations of uranium than fish collected upstream of the Laboratory, the isotopic ratio of ^{235}U (1.25×10^{13} atoms/g ash) to ^{238}U (1.74×10^{15} atoms/g ash) in Cochiti Reservoir bottom-feeding fish were consistent with naturally occurring uranium (e.g., 0.0072) (Efurd 1994). In other words, there was no evidence of depleted uranium in these fish samples. Depleted uranium, a by-product of uranium enrichment processes, has been used in dynamic weapons testing at Laboratory firing sites since the mid-1940s (Becker 1992). The uranium detected in fish samples from Cochiti Reservoir (as well as from Abiquiu, Heron, and El Vado reservoirs) was probably from common uranium-bearing minerals found in the earth's crust (Wicker 1982). For example, uranium concentrations from northern New Mexico and in Bandelier tuff around the Los Alamos area range from 1.3 to 3.9 μg/g (Purtymun 1987a) and from 4.0 to 11.4 μg/g (Crowe 1978), respectively.

In addition to these sources, uranium may be entering Cochiti Reservoir via the Santa Fe River as it passes near the La Bajada Uranium Mine site, an abandoned 25-acre site approximately 1.8 km (6 mi) upstream of Cochiti Reservoir. The US Forest Service stated in an Environmental Assessment report that uranium, lead, and other materials were periodically entering the Santa Fe River and could move into Cochiti Reservoir during a major storm event.

As expected, the bottom feeders from both downstream and upstream reservoirs contained higher average uranium contents (8.1 ng/dry g) than the surface feeders (4.4 ng/dry g). The higher concentration of uranium in bottom feeders as compared to surface feeders may be attributed to the ingestion of sediments on the bottom of the lake (Gallegos 1971). Sediments represent the accumulation or sink compartment for most radionuclides (Wicker 1982).

No upward trends in radionuclide contents in game or nongame fish were observed from 1981 to 1993 in any of the radionuclide data from Cochiti Reservoir (Fresquez 1994a). In fact, the concentrations of ^{90}Sr and total uranium in nongame fish significantly decreased during this time. For example, total uranium in nongame fish collected from Cochiti Reservoir significantly decreased from 66 ng/dry g in 1981 to 12.0 ng/dry g in 1993.

Lakes at the Pueblos of Jemez, Nambé, and San Ildefonso. The concentrations of radionuclides in game and nongame fish collected from lakes at the pueblos of Jemez, Nambé, and San Ildefonso are presented in Table V-35 (Fresquez 1995c).

Most radionuclides (^{90}Sr, total uranium, ^{238}Pu, and ^{239}Pu) in (stocked) rainbow trout collected from lakes at Jemez and Nambé pueblos were not significantly different from game fish collected from Abiquiu, Heron, and El Vado reservoirs. Although ^{137}Cs levels in trout from lakes at the pueblos of Jemez and Nambé were significantly higher than background, both values were within the ULB concentration (e.g., $<28 \times 10^{-2}$ pCi/dry g) recorded over an 11-year-period (Fresquez 1994a). Only one game fish composite sample was collected from the lake at the Pueblo of San Ildefonso, and no statistical comparisons could be made between fish collected from the Pueblo of San Ildefonso and background. However, with the exception of total uranium, there were no detectable radiological values (i.e., where the concentration is higher than two times the standard deviation) in the game fish sample collected from the lake at the Pueblo of San Ildefonso. Also, no significant differences in ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239}Pu levels in nongame fish collected from lakes at the Pueblo of San Ildefonso were found as compared to background. The higher uranium concentrations detected in game and nongame fish samples from the Pueblo of San Ildefonso were probably a result of the higher natural uranium contents of the soils in the area as compared to the geology of the area upstream of the Pueblo of San Ildefonso.

Game Animals. The concentrations of total uranium, ^{137}Cs, ^{90}Sr, ^{238}Pu, and ^{239}Pu detected in various tissue samples collected from on-site and off-site cow elk can be found in Table V-36.

No significant differences in the concentration of radionuclides were detected in any of the elk tissue samples collected from on-site and off-site locations. The concentrations of radionuclides, in general, were low and within values (pCi/g ash) reported in a previous study (Meadows 1982). Also, comparisons between the average concentrations of radionuclides from elk collected from on-site and off-site locations varied from tissue to tissue: total uranium ranged in concentration from 1.3 ng/dry g in muscle to 78 ng/dry g in hair; ^{137}Cs ranged from 0.05 pCi/dry g in heart to 0.60 pCi/dry g in kidneys; ^{90}Sr ranged from 0.0 pCi/dry g in muscle to 1.6 pCi/dry g in jawbone; ^{238}Pu ranged from 0.000002 pCi/dry g in muscle to 0.000018 pCi/dry g in leg bone; and ^{239}Pu ranged from 0.000009 pCi/dry g in muscle to 0.00043 pCi/dry g in hair. Cesium-137, a chemical analog of potassium, and ^{90}Sr, a chemical analog of calcium, deposit primarily in muscle and bone tissue, respectively (Wicker 1982).

Strontium-90 levels in leg bone of elk collected from LANL areas in 1980 were significantly higher than ^{90}Sr concentrations in leg bone of elk collected from off-site areas (Meadows 1982). The differences in ^{90}Sr levels in leg bones in elk collected from LANL areas as compared with off-site elk was mainly attributed to differences in fallout patterns. Although no significant differences in ^{90}Sr levels were observed in tissue samples between elk collected from on-site and off-site locations in the current study, the jawbone and leg bone of elk contained significantly higher concentrations of ^{90}Sr than the other organ and muscle tissues. The levels of ^{90}Sr in elk bone, the critical deposition site, pose no threat to human consumers of elk meat; the transfer ratio of ^{90}Sr from elk bone to elk meat was estimated at <0.01 (Meadows 1982). Strontium-90 was not detected in muscle tissue in this study.

Table V-35. Radionuclide Concentrations in Game and Nongame Fish Collected from Jemez, Nambé, and San Ildefonso Tribal Lakes as compared to Abiquiu, Heron, and El Vado

	^{90}Sr (10^{-2} pCi/dry g)	^{137}Cs (10^{-2} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
GAME FISH (Surface Feeders)					
Jemez (Trout)					
N[a]	4.0	4.0	3	4.0	4.0
Minimum	0.6 (1.2)[b]	2.4 (2.3)	3.1 (6.4)	0.0 (36.0)	0.0 (24.0)
Maximum	1.5 (3.0)	4.7 (3.6)	8.4 (9.2)	16.0 (90.0)	30.0 (60.0)
Mean	1.0 (0.8)[c]	3.2 (2.2)	5.7 (5.2)	6.5 (15.8)	14.0 (25.0)
Nambé (Trout)					
N	4.0	4.0	4.0	4.0	4.0
Minimum	0.4 (0.8)	2.4 (1.4)	1.3 (0.2)	0.0 (24.0)	0.0 (16.0)
Maximum	1.6 (1.6)	14.3 (9.8)	4.5 (1.6)	8.0 (48.0)	8.0 (32.0)
Mean	0.9 (1.0)	7.5 (11.0)	2.9 (2.4)	2.0 (8.0)	4.7 (7.2)
San Ildefonso (Bass, Trout)					
N	1.0	1.0	1.0	1.0	1.0
Minimum	3.6 (2.4)	1.5 (2.6)	11.8 (5.2)	12.0 (72.0)	12.0 (48.0)
Maximum	3.6 (2.4)	1.5 (2.6)	11.8 (5.2)	12.0 (72.0)	12.0 (48.0)
Mean	3.6 (0.0)	1.5 (0.0)	11.8 (0.0)	12.0 (0.0)	12.0 (0.0)
Abiquiu, Heron, and El Vado					
N[a]	9.0	8.0	9.0	9.0	9.0
Minimum	0.7 (1.4)[b]	-1.8[d] (2.1)	0.3 (0.2)	0.0 (42.0)	0.0 (40.0)
Maximum	9.1 (2.6)	2.0 (2.8)	9.8 (2.8)	0.0 (90.0)	22.0 (44.0)
Mean	3.2 (5.5)[c]	0.4 (2.4)	3.3 (5.8)	0.0 (0.0)	5.1 (16.6)
NONGAME FISH (Bottom Feeders)					
San Ildefonso (Catfish, White Sucker, Carp, and Carp Sucker)					
N	3.0	3.0	3.0	3.0	3.0
Minimum	1.2 (1.2)	0.5 (2.3)	10.0 (0.2)	0.0 (36.0)	0.0 (24.0)
Maximum	8.4 (2.8)	0.8 (2.3)	16.5 (5.0)	6.0 (84.0)	14.0 (56.0)
Mean	4.7 (7.2)	0.6 (0.3)	14.0 (6.8)	2.0 (7.0)	4.7 (16.2)
Abiquiu, Heron, and El Vado					
N	12.0	11.0	12.0	12.0	12.0
Minimum	2.1 (1.4)	-0.2 (2.0)	1.6 (0.3)	0.0 (42.0)	0.0 (28.0)
Maximum	9.8 (2.8)	1.8 (2.5)	9.5 (2.4)	27.0 (54.0)	9.0 (36.0)
Mean	4.7 (5.3)	0.8 (1.3)	4.3 (4.4)	7.6 (18.2)	2.9 (8.6)

[a]N = number of composite samples.
[b](± 2 counting uncertainty).
[c](± 2 standard deviation).
[d]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

Table V-36. Radionuclide Concentrations in Various Tissues of Elk Collected from On-Site (LANL) and Off-Site (Background) Areas

	Total U (ng/dry g)		^{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)	
	On-site	Off-site	On-site	Off-site	On-site	Off-site	On-site	Off-site	On-site	Off-site
Brain	3.2[a]	2.2	59.6	593.5	8.3	14.0	3.0	7.0	1.3	9.3
	3.8[b]	4.5	77.6	457.4	8.0	7.0	5.2	7.0	2.3	16.2
Hair	135.1	20.2	107.3	283.9	13.0	8.7	11.0	4.3	57.7	27.7
	111.7	11.1	119.4	324.1	11.5	1.2	10.1	3.2	80.2	38.4
Heart	0.7	10.9	41.1	58.3	2.0	2.3	5.0	0.0	2.3	14.7
	1.7	19.0	40.4	4.8	3.5	2.1	6.2	0.0	2.1	25.4
Jawbone	63.5	5.6	491.8	34.5	1,945.3	1,361.3	0.0	20.0	19.7	0.0
	98.3	6.9	873.1	26.5	414.4	990.7	0.0	34.6	34.1	0.0
Kidneys	85.8	22.2	685.5	498.0	5.7	6.0	13.7	3.0	8.0	0.0
	134.4	1.7	629.4	229.1	6.0	0.0	7.8	4.2	6.1	0.0
Leg Bone	14.6	1.9	118.7	73.5	1,215.7	1,833.7	18.3	18.3	18.3	21.3
	10.4	1.8	119.7	118.9	424.2	1,037.1	31.8	31.8	31.8	37.0
Liver	4.6	5.2	174.9	222.7	4.0	3.0	1.3	1.7	3.3	3.3
	6.2	8.7	158.4	186.4	4.0	2.6	2.3	2.9	3.1	3.1
Muscle	1.8	0.8	134.0	209.4	0.0	0.0	0.4	0.0	1.8	0.0
	4.5	1.3	94.1	208.4	0.0	0.0	0.9	0.0	1.8	0.0

[a]All means between on-site and off-site samples were not significantly different at the 0.05 level using a Student's t-test.
[b]Standard deviation.

8. Unplanned Releases.

a. Airborne Radionuclide Releases. An estimated 7 μg of depleted uranium was inadvertently released during an open burn at TA-16 on June 23. The estimated dose to nearby employees was 2.6×10^{-7} mrem, and the dose to LANL's maximum exposed individual (MEI) location was 3.6×10^{-11} mrem.

During the period of August 30 to September 3, a total of 35.47 Ci of tritium was released from Building 86 at TA-33 (the normal release rate is ~1 Ci per day). The estimated dose to nearby employees was 1.0 mrem. The calculated dose to LANL's MEI location was 1.3×10^{-4} mrem.

b. Radioactive Liquid Releases. On December 23, 1992, the Laboratory decided to operate a boiler continuously at the Omega West Reactor, TA-2, to heat secondary sump water directly, and thus, to transfer heat to the primary coolant via reverse convective heat transfer in the cooling tower. A number of tests were performed with the boiler operating to determine the temperature change rates under a variety of conditions, including operation without the main pump. It was during these tests, which took place during the first few weeks of January 1993, that the reactor operators noted that the amount of system make-up water required for the system remained essentially constant (approximately 75 gal./day). The system is typically topped off twice a week. It was expected that the rate

of water loss due to ordinary operations would drop while the reactor was run under lower pressure conditions. When the rate of water loss did not drop, the question arose as to whether the system was experiencing water loss through an unknown mechanism.

A systematic procedure was developed to determine whether that was the case, along with a test that isolated the flow of primary water in a circular loop that included all primary piping not associated with either the secondary or primary piping beyond the primary pump. These procedures indicated positively that the water loss problem had been isolated to the remaining primary components. As required by DOE Order 5000.3A, DOE was notified on January 30, 1993, that a leak of tritiated water had been positively identified. The EPA and the New Mexico Environment Department (NMED) were also notified. Surface water samples were collected on January 30 and 31, 1993. Preliminary screening by the Health & Safety Division (HS) indicated that the tritium concentration of water in the primary cooling loop water was 18 to 20 million pCi/L and the concentration in the groundwater near Building 1 was 0.10 to 0.12 million pCi/L. Data collected at the Laboratory boundary indicated that the higher levels of tritiated water remained within DOE property. According to Section 207 of the NM Water Supply Regulations, the average annual tritium concentration assumed to produce a total body dose of 4 mrem/yr is 20,000 pCi/L. During the week of February 1, 1993, experimental plans for leak isolation were developed and written, and the plan approval process was initiated. By February 12, 1993, the fuel elements were moved to the deep pool. On February 16, 1993, the reactor and surge tank levels were pumped down by removing 8,000 gal. of water to TA-50 for temporary storage. This isolated the inlet line, delay line, and the reactor tank for leak testing. On February 17, 1993, the delay line was found to show fluid loss while the other two segments were leak-free. The outlet and inlet lines were pumped to the TA-50 storage tanks. Release of tritiated water to the environment ceased. The EPA and NMED were notified that the leak had ceased.

On January 20, 1993, a water leak from a ruptured back flow preventer at TA-2, Omega 44, caused the flow of potable water to three waste tanks. Less than 1,000 gal. of water overflowed from the three waste tanks onto the soil surrounding the tanks. Results of swipe samples of the floor in Omega 44 indicated minimum detectable activity (MDA) or below for both alpha and beta. No water from the discharge reached a watercourse. The discharge was stopped by turning off the valve associated with the back flow preventer.

On September 20, 1993, snow on the roof of Room 12, at TA-33, Building 86, melted and entered the room through a leak in the roof. The melted snow ran down the interior wall and discharged into a floor drain and into the facility's septic system. Approximately 1 gal. of water contaminated with tritium entered the floor drain. A sample of water was taken inside the building and had a tritium concentration of 2 mCi/mL. There are no limits in DOE orders regarding the amount of tritium allowed in liquid effluents. However, the section on radionuclide releases in DOE Order 5000.3A states that if the concentration exceeds 10 mCi/mL, the release would be considered an emergency category reportable event. The process to decontaminate and decommission the facility to began in 1993. The facility will be cleaned up under the Laboratory's decontamination and decommissioning program.

C. Radiological Doses

1. Introduction.

Radiological doses are calculated in order to measure the health impacts of any releases of radioactivity to the environment. Radiation dose refers to the quantity of radiation energy absorbed per unit mass, multiplied by adjustment factors for type of radiation. EDE is the principal measurement used in radiation protection. This term means the hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure that may be limited to a few organs. The EDE 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.

Standards exist which limit the maximum effective dose to the public. The DOE's PDL is 100 mrem/yr EDE received from all pathways, and the dose received by air is restricted by the EPA's effective dose standard of 10 mrem/yr ([40 CFR Part 61] Appendix A). These values are in addition to those from normal background, consumer

products, and medical sources. The standards apply to locations of maximum probable exposure to an individual in an off-site, uncontrolled area.

2. Methods for Dose Calculations.

a. Introduction. Annual radiation doses are evaluated for three principal exposure pathways: external exposure (which includes exposure from immersion in air containing photon-emitting radionuclides and direct and scattered penetrating radiation), inhalation, and ingestion. Estimates are made of the following exposures:

- Maximum individual organ doses and EDE to an individual at or outside the Laboratory boundary where the highest dose rate occurs and a person actually is present.
- Average organ doses and EDEs to nearby residents.
- Collective EDE for the population living within an 80 km (50 mi) radius of the Laboratory.

Two evaluations of potential airborne releases are conducted: one to satisfy 40 CFR Part 61 requirements and one for all pathways. Results of environmental measurements are used as much as possible in assessing doses to individual members of the public. Calculations based on these measurements follow procedures recommended by federal agencies to determine radiation doses (DOE 1991, NRC 1977). If the impact of Laboratory operations is not detected by environmental measurements, individual and population doses attributable to Laboratory activities are estimated through computer modeling of releases.

Dose conversion factors used for inhalation and ingestion calculations are given in Table D-20. These factors are taken from the DOE (1988b) and are based on factors in Publication 30 of the International Commission on Radiological Protection (ICRP 1978).

Dose conversion factors for inhalation assume a 1-μm diameter median aerodynamic activity, as well as the lung solubility category that will maximize the EDE (for comparison with DOE's 100 mrem/yr PDL) if more than one category is given. Similarly, the ingestion dose conversion factors are chosen to maximize the EDE if more than one gastrointestinal tract uptake is given (for comparison with DOE's 100 mrem/yr PDL for all pathways).

These dose conversion factors give the 50 year dose commitment for internal exposure. The 50 year dose commitment is the total dose received by an organ during the 50 year period following the intake of a radionuclide that is attributable to that intake.

External doses are calculated using the dose-rate conversion factors published by DOE (1988c) (Table D-21). These factors give the photon dose rate in millirems per year per unit radionuclide air concentration in microcuries per cubic meter. If these factors are not available in DOE 1988c, they are calculated with the computer program DOSFACTOR II (Kocher 1981).

Annual EDEs are estimated with the CAP-88 collection of computer codes published by the EPA if releases from Laboratory operations are so small that they are less than analytical detection limits. CAP-88 uses dose conversion factors generated by the computer program RADRISK. The 50 year dose commitment conversion factors from RADRISK were compared with the ICRP/DOE dose conversion factors and found to agree to within 5%. This agreement was judged more than adequate to justify RADRISK dose factors when CAP-88 is being used.

b. External Radiation. Environmental TLD, high-pressure ion chamber (HPIC), and high purity germanium detector (HPGe) measurements are used to estimate external penetrating radiation doses. The TLD measurements include background radiation and any external penetrating radiation contributed from Laboratory operations. The TLD measurements are corrected for background to determine the Laboratory's contribution. Background radiation estimates at each site are based on historical data, consideration of possible nonbackground contributions, and, if possible, values measured at locations of similar geology and topography. The estimated background value is subtracted from the total measured TLD value to yield the net annual dose. The annual TLD dose is assumed to represent the dose from Laboratory activities that would be received by an individual who spent 100% of his or her time during an entire year at the monitoring location.

The HPGe system collects an hourly gamma energy spectrum. Energy peaks in the spectrum are identified as belonging to radionuclides emitted by the Lab as well as those which occur naturally. The net counts in each energy peak are converted to an hourly dose rate.

The HPIC system measures total external penetrating radiation doses continuously. Daily background is determined during at least 12 hours of plume-free (LAMPF) occurrences.

The individual dose is estimated from these measurements by taking into account occupancy and shielding. At off-site locations where residences are present, an occupancy factor of 1.0 is used. Two types of shielding are considered: (1) shielding by buildings and (2) self-shielding. Each shielding type is estimated to reduce the external radiation dose by 30%. (Note: these reductions are not used for demonstrating compliance to the EPA standard, see Section C.4.b below.)

Neutron doses from the critical assemblies at TA-18 were based on field measurements. Neutron fields were monitored principally with neutron-detecting TLDs placed at the boundary of TA-18. The TLDs were housed in 23 cm (9 in.) cadmium-hooded, polyethylene spheres. At on-site locations at which above background doses were measured, but at which public access is controlled, dose estimates are based on a more realistic estimate of exposure time. During 1993, operations at TA-18 were minimal due to facility upgrades.

c. Inhalation Dose. Annual average air concentrations of tritium, ^{238}Pu, $^{239,240}Pu$, uranium (^{234}U, ^{235}U, ^{238}U), and ^{241}Am, determined by the Laboratory's air monitoring network, are corrected for background by subtracting the average concentrations measured at regional stations. The net concentration is reduced by 10% to account for indoor occupancy (Kocher 1980). These net concentrations are then multiplied by a standard breathing rate of 8,400 m^3/yr (ICRP 1975) to determine total adjusted intake via inhalation, in microcuries per year, for each radionuclide. Each intake is multiplied by appropriate dose conversion factors to convert radionuclide intake into 50 year dose commitments. Following ICRP methods, doses are calculated for all organs that contribute more than 10% of the total EDE for each radionuclide. The dose calculated for inhalation of tritium is increased by 50% to account for absorption through the skin.

This procedure for dose calculation conservatively assumes that a hypothetical individual is exposed to the measured air concentration continuously throughout the entire year (8,760 h). This assumption is made for the boundary dose, dose to the maximum exposed individual, and dose to the population living within 80 km of the site.

Organ doses and EDEs are determined at all sampling sites for each radionuclide. A final calculation sums all radionuclides to estimate the total inhalation organ doses and EDEs.

d. Ingestion Dose. Results from foodstuffs sampling are used to calculate organ doses and EDEs from ingestion for individual members of the public. The procedure is similar to that used in the previous section. Corrections for background are made by subtracting the average concentrations plus two standard deviations from sampling stations not affected by Laboratory operations. The radionuclide concentration in a particular foodstuff is multiplied by the annual consumption rate (NRC 1977) to obtain total adjusted intake of that radionuclide. Multiplication of the adjusted intake by the radionuclide's ingestion dose conversion factor for a particular organ gives the estimated dose to the organ. Similarly, EDE is calculated using the EDE conversion factor (Table D-20).

Doses are evaluated for ingestion of tritium, ^{90}Sr, ^{137}Cs, uranium, ^{238}Pu, and $^{239,240}Pu$ in fruits and vegetables; tritium, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{137}Cs, and uranium in honey; and ^{90}Sr, ^{137}Cs, uranium, ^{238}Pu, and ^{239}Pu in fish.

3. Estimation of Radiation Doses.

a. Doses from Natural Background. EDEs from natural background and from medical and dental uses of radiation are estimated to provide a comparison with doses resulting from Laboratory operations. Doses from global fallout are only a small fraction of total background doses (<0.3%) (NCRP 1987a) and are not considered further here. Exposure to natural background radiation results principally in whole-body doses and in localized doses to the lung and other organs. These doses are divided into those resulting from exposure to radon and its decay products that mainly affect the lung and those from non-radon sources that mainly affect the whole body.

Estimates of background radiation are based on a comprehensive report by the National Council on Radiation Protection and Measurements (NCRP 1987b). The 1987 NCRP report uses 20% shielding by structures for high-energy cosmic radiation and 30% self-shielding by the body for terrestrial radiation. The 30% protection factor is also applied to LANL sources of gamma radiation, which is less energetic than cosmic radiation.

Whole-body external dose is incurred from exposure to cosmic rays and to external terrestrial radiation from naturally occurring radioactivity in the earth's surface and from global fallout. EDEs from internal radiation are due to radionuclides deposited in the body through inhalation or ingestion.

Non-radon EDEs from background radiation vary each year depending on factors such as snow cover and the solar cycle (NCRP 1975b). Estimates of background radiation in 1993 from non-radon sources are based on measured external radiation background levels of 123 mrem (1.23 mSv) in Los Alamos and 106 mrem (1.06 mSv) in White Rock caused by irradiation from charged particles, x-rays, and gamma rays. These uncorrected measured doses were adjusted for shielding by reducing the cosmic ray component (60 mrem [0.60 mSv] at Los Alamos and 53 mrem [0.53 mSv] at White Rock) by 20% to allow for shielding by structures and by reducing the terrestrial component (63 mrem [0.63 mSv] at Los Alamos and 53 mrem [0.53 mSv] at White Rock) by 30% to allow for self-shielding by the body (NCRP 1987a). To these estimates, based on measurements, were added 10 mrem (0.1 mSv) at Los Alamos and 8 mrem (0.08 mSv) at White Rock from neutron cosmic radiation (20% shielding assumed) and 40 mrem (0.4 mSv) from self radiation (NCRP 1987a). The estimated whole body dose from background, non-radon radiation was 142 mrem (1.42 mSv) at Los Alamos and 127 mrem (1.27 mSv) at White Rock.

In addition to these non-radon doses, a second component of background radiation is dose to the lung from inhalation of ^{222}Rn and its decay products. The ^{222}Rn is produced by decay of radium (^{226}Ra), a member of the uranium series. The uranium series products are naturally present in soil and building construction materials. The EDE from exposure to background ^{222}Rn and its decay products is taken to be equal to the national average, 200 mrem/yr (2 mSv/yr) (NCRP 1987a). This background estimate may be revised if a nationwide study of ^{222}Rn background levels and its decay products in homes is undertaken, as has been recommended by the NCRP (1984, 1987a).

In 1993, the EDE to residents was 342 mrem (3.42 mSv) at Los Alamos and 327 mrem (3.27 mSv) at White Rock (Table V-37), or 142 mrem (1.42 mSv) from non-radon sources and 200 mrem (2 mSv) from radon at Los Alamos and 127 mrem (1.27 mSv) from non-radon sources and 200 mrem (2 mSv) from radon at White Rock.

Medical and dental radiation in the United States accounts for an additional average EDE, per person, of 53 mrem/yr (0.53 mSv/yr) (NCRP 1987a). This estimate includes doses from both x-rays and radiopharmaceuticals.

b. Doses to Individuals from External Penetrating Radiation from Airborne Emissions. The major source of external penetrating radiation from LANL operations has been airborne emissions from LAMPF. Nuclear reactions with air in the beam target areas at LAMPF (TA-53) cause the formation of air activation products, principally ^{11}C, ^{13}N, ^{14}O, and ^{15}O. These isotopes are all positron emitters and have 20.4 min, 10 min, 71 s, and 122 s half-lives, respectively. These isotopes are sources of gamma photon radiation because of the formation of two 0.511 Mev photons through positron-electron annihilation. The ^{14}O also emits a 2.4 Mev gamma photon.

Table V-37. Summary of Annual Effective Dose Equivalents Attributable to 1993 Laboratory Operations

	Maximum Dose to an Individual[a,b]	Average Dose to Nearby Residents[b]		Collective Dose to Population within 80 km of the Laboratory[b]
		Los Alamos	White Rock	
Dose	3.1 mrem	0.15 mrem	0.03 mrem	3 person-rem
Location	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
Background	342 mrem	342 mrem	327 mrem	72,000 person-rem
DOE Public Dose Limit	100 mrem	—	—	—
Percentage of Public Dose Limit	3.1%	0.15%	0.03%	—
Percentage of Background	0.91%	0.044%	0.009%	0.004%

[a]Maximum individual dose is the dose to any individual at or outside the Laboratory where the highest dose rate occurs. Calculations take into account occupancy (the fraction of time a person is actually at that location), self-shielding, and shielding by buildings.

[b]Doses are reported at the 95% confidence level.

The maximum off-site dose was determined using the new East Gate HPGe monitoring system for 1993. The maximum off-site EDE from external penetrating radiation was measured to be 3.1 mrem during 1993. This is 31% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr), and 3.1% of the DOE's PDL of 100 mrem/yr (1 mSv/yr).

c. Doses to Individuals from Direct Penetrating Radiation. No direct penetrating radiation from Laboratory operations was detected by TLD monitoring in off-site areas. On-site TLD measurements of external penetrating radiation reflected Laboratory operations and did not represent any significant exposure to the public. During most of 1993, operations at TA-18 were halted for facility upgrades. Because of minimal operations, the potential gamma and neutron dose to the public at the DOE controlled rad was estimated to be less than in 1992. In 1992, 10 to 20 mrem/yr (0.10 to 0.20 mSv/yr) above background was reported for this site.

d. Doses to Individuals from Inhalation of Airborne Emissions. The maximum individual EDEs attributable to inhalation of airborne emissions (Table V-38) are below the EPA air pathway standard of 10 mrem/yr (0.1 mSv/yr).

Exposure to airborne tritium (as tritiated water vapor), ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{234}U, ^{235}U, ^{238}U, and ^{131}I was determined by measurement. Correction for background was made by assuming that natural radioactivity and worldwide fallout were represented by data from the three regional sampling stations at Española, Pojoaque, and Santa Fe. The highest EDE measured off-site for ^{238}Pu, $^{239,240}Pu$, ^{241}Am, uranium, ^{234}U, ^{235}U, and ^{238}U, at the Royal Crest station was 0.02 mrem (0.0002 mSv), or 0.02% of the DOE's PDL of 100 mrem/yr (1 mSv/yr), and 0.2% of the EPA's 10 mrem/yr (0.1 mSv/yr) standard for dose from the air pathway. Emissions of air activation products from LAMPF resulted in negligible inhalation exposures. The total EDE to a member of the public from all TA-54, Area G operations during 1993 was estimated using the atmospheric transport model, CAP-88, to be 0.0001 mrem/yr, or less than 1% of the EPA radiation limit of 10 mrem/yr for the air pathway.

Exposure from all other atmospheric releases of radioactivity (Table V-4 and V-5) was also evaluated by theoretical calculations of airborne dispersion. All potential inhalation doses from these releases were less than 0.5% of the DOE's PDL of 100 mrem/yr (1 mSv/yr).

e. Doses to Individuals from Treated Effluents. At this time, discharged treated effluents do not flow beyond the Laboratory boundary but are retained in the alluvium of the receiving canyons. These treated effluents are monitored at point of discharge; their behavior in the alluvium of the canyons below outfalls has been studied and is monitored annually (Hakonson 1976a, 1976b; Purtymun 1971, 1974a).

Table V-38. Estimated Maximum Individual 50-Year Dose Commitments from 1993 Airborne Radioactivity[a]

Isotope	Location[b]	Estimated Dose (mrem/yr)	Percentage of Public Dose Limit
^{3}H	Los Alamos Airport	0.003	<0.1
^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar	Residence North of LAMPF	3.1	.31
^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239,240}Pu$, ^{241}Am	Royal Crest (Station 12)	0.02	<0.1

[a]Estimated maximum individual dose is the dose from Laboratory operations (excluding dose contributions from cosmic, terrestrial, medical diagnostics, and other non-Laboratory sources) to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where a person actually resides. It takes into account shielding and occupancy factors.

[b]See Figure V-9 for station locations.

Small quantities of radioactive contaminants transported during periods of heavy runoff have been measured in canyon sediments beyond the Laboratory boundary in Los Alamos Canyon (Figure II-4). Increased discharge from the Bayo Canyon sanitary sewage treatment plant has resulted in additional flow in Los Alamos Canyon, typically to a location between wells LA-6 and LA-2. Calculations made with radiological data from Acid-Pueblo and Los Alamos canyons (ESG 1981) indicate a minor potential exposure pathway from these canyon sediments. Obtaining 50% annual consumption of meat from a steer that drinks water from and/or grazes in lower Los Alamos Canyon could potentially result in a maximum committed EDE of 0.8 mrem (0.008 mSv).

f. Doses to Individuals from Ingestion of Foodstuffs. Data from samples of produce, fish, honey, and game animals are used to estimated the committed effective dose equivalents (CEDE) from the ingestion of foodstuffs. The CEDE is the committed dose equivalents to individual tissues resulting from an intake multiplied by the appropriate weighting factors and then summed over all tissues (ICRP 1984). This value thus represents the EDE to the whole body for radionuclides taken into the body. Assuming one individual consumed the total quantity listed for each food grouping, the maximum total CEDE in 1993 from all foodstuffs analyzed is <0.6% of DOE's 100 mrem/yr (1mSv/yr) public dose limit (DOE 1990a) indicating that Laboratory operations do not result in significant radiation doses to the general public from consuming foodstuffs in the local area.

Produce. Produce (fruits, vegetables, and grains) are collected from on site, perimeter (Los Alamos and White Rock/Pajarito Acres), and regional (Española and Santa Fe) locations. Samples area also collected from several Native American lands (the pueblos of San Ildelfonso, Cochiti, and Jemez) located in the general vicinity of the Laboratory. These samples are analyzed by the Environmental Chemistry Group (CST-9) for concentrations of tritium, uranium, ^{90}S, ^{238}Pu, $^{239,240}Pu$, ^{137}Cs. The total CEDE is based on the concentration plus two standard deviations for each radionuclide found in samples and a typical consumption rate for produce of 160 kg/yr (352 lb/yr) (Table V-39).

The maximum total CEDE from consuming produce from White Rock and Los Alamos is 0.166 mrem (<0.2% of the DOE PDL). There is no significant difference (at the 95% level of confidence) between the CEDE from produce grown in White Rock or Los Alamos and produce grown on site. In addition, ingestion of produce collected on site is not a significant exposure pathway because of the small amount of edible material, low radionuclide concentrations, and limited access to these foodstuffs.

Samples from the pueblos are collected in an area more than 10 km (6.2 mi.) beyond Laboratory boundaries. The main radionuclide that contributed to the off-site CEDE is ^{90}Sr, which resulted from fallout during atmospheric testing worldwide. Ingestion of produce collected from Cochiti Pueblo in 1993 provides a maximum total of CEDE

Table V-39. Total Committed Effective Dose Equivalent from the Ingestion of Produce Collected from Off-Site and On-Site Areas during the 1993 Growing Season

	Dose (EDE) (mrem/yr)	Percent of DOE PDL
Off-Site Stations		
Regional		
Cochiti Pueblo	0.068	<0.07%
Taos Pueblo	0.065	<0.07%
Jemez Pueblo	0.17	<0.2%
Pueblo of San Ildefonso	0.31	<0.4%
Perimeter		
White Rock	0.042	<0.04%
Los Alamos	0.17	<0.2%
On-Site Stations	0.063	<0.07%

of 0.068 mrem(<0.07% of the DOE PDL); produce ingested from Taos Pueblo provides a maximum total CEDE of 0.065 mrem(<0.07% of the DOE PDL); produce ingested from Jemez Pueblo provides a maximum total of CEDE of 0.173 mrem (<0.2% of the DOE PDL); and produce consumed from the Pueblo of San Ildelfonso provides a maximum total CEDE of 0.314 mrem (<0.2% of the DOE PDL).

Honey. Honey samples were collected from off-site regional stations (San Pedro, Pojoaque, and San Juan), off-site perimeter stations in Los Alamos and White Rock, and from 11 on-site locations in 1993. These samples were analyzed for tritium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{137}Cs, and uranium (Table V-40). The total CEDE is based on the concentration of each radionuclide plus two standard deviations and a typical annual consumption rate of 5 kg (11 lbs). Tritium values are adjusted to reflect the 18% water content of honey (Winston 1991). The regional backgrounds concentrations are subtracted from the off-site perimeter and on-site stations to provide an assessment of the impact of Laboratory operations on this foodstuff. The maximum total CEDE from ingestion of honey in Los Alamos and White Rock during 1993 is 0.011 mrem/yr (less than 0.02% of the DOE PDL). Honey that is collected from on-site Laboratory locations is not available for public consumption.

Table V-40. Total Committed Effective Dose Equivalent from the Ingestion of Honey Collected from Los Alamos and White Rock during 1993

	Dose (EDE) (mrem/yr)	Percent of DOE PDL
Off-Site Perimeter Stations		
Los Alamos	0.011	<0.02%
White Rock	0.003	<0.004%

NOTE: Honey collected from on-site locations is not available for public consumption and is not included in this table.

Fish. Fish samples were collected in 1993 from bottom and higher level feeders at locations upstream (Abiquiu, Heron, and/or El Vado reservoirs) and downstream (Cochiti Reservoir) of the Laboratory and at various lakes on tribal lands (Pueblos of San Ildelfonso, Nambé, and Jemez). These samples were analyzed for ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{137}Cs, and uranium (Table V-41). The CEDE is based on the concentration of each radionuclide plus two standard deviations and typical consumption rate of 21 kg (46 lbs). The concentrations from the upstream locations were subtracted from downstream stations and location on the pueblos to identify any differences in concentrations from regional backgrounds.

All samples collected are more than 10 km (6.2 mi) beyond Laboratory boundaries. The maximum total CEDE from bottom feeders is 0.026 mrem/yr (<0.03% of the DOE PDL) with uranium being the major contributor to the EDE. The maximum total CEDE from higher level feeders (bass and trout is 0.085 mrem/yr (<0.09% of the DOE PDL). Laboratory operations, therefore, do not result in significant radiation doses to the general public from consuming fish in the local area.

Game Animals. Three adult female (cow) elk were collected in 1991 and 1992 from on-site areas at TA-18, TA-49, and TA-5, and three adult cow elk were collected by the NM Department of Game and Fish during this same period from the Lindreth, Tres Piedras, and Chama areas. Of the tissue samples collected, it was decided that area residents could potentially ingest heart, liver , muscle, kidneys, and brain tissues. These samples were analyzed for ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{137}Cs, and uranium (Table V-42). The CEDE is based on the concentration of each radionuclide plus two standard deviations. Assuming the total consumption of one elk with a projected total weight of 233 kg (514 lbs), the consumption rate per year for these tissue groups becomes 1.4 kg (3.2 lbs) of heart, 2.6 kg (5.6 lbs) of liver, 102.5 kg (226 lbs) of muscle, 1.3 kg (3.0 lbs) of kidneys, and 0.3 kg (0.8 lbs) of elk brain. The

Table V-41. Total Committed Effective Dose Equivalent from the Ingestion of Fish Collected during 1993

	Dose (EDE) (mrem/yr)	Percent of DOE PDL
Bottom Feeders		
Cochiti Reservoir	0.016	<0.02%
Pueblo of San Ildefonso	0.026	<0.03%
Higher Level Feeders		
Cochiti Reservoir	0.085	<0.09%
Pueblo of San Ildefonso	0.073	<0.08%
Jemez Pueblo	0.017	<0.02%
Nambé Pueblo	0.043	<0.05%

Table V-42. Total Committed Effective Dose Equivalent from the Ingestion of Adult Cow Elk Collected during 1991 and 1992

	Dose (EDE) (mrem/yr)	Percent of DOE PDL
Tissue Type		
Heart	0.0015	<0.002%
Liver	0.0004	<0.0005%
Muscle	0.046	<0.05%
Kidney	0.033	<0.04%
Brain	0.000	<0.00%
Total	0.081	<0.09%

concentrations from the three elk collected off site were subtracted from the elk collected on the Laboratory to identify any differences in concentrations from the regional backgrounds.

The annual total CEDE from the consumption of the above tissue groups for cow elk collected on Laboratory property is 0.081 mrem (approximately 0./08% of the DOE PDL) with the CEDE for heart 0.0015 mrem/yr, for liver 0.0004 mrem/yr, for muscle 0.46 mrem/yr, and for kidneys being 0.033 mrem/yr. The amount of radionuclide concentrations in brain tissue did not differ from samples collected on site and those collected off site; therefore, consumption of brain tissue did not result in any additional dose to public members.

4. Total Maximum Individual Dose to a Member of the Public from 1993 Laboratory Operations.

a. Maximum Individual Dose. The maximum individual EDE to a member of the public from 1993 Laboratory operations is estimated to be 3.1 mrem/yr (0.061 mSv/yr). This is the total EDE from all pathways. This dose is 3.1% of the DOE's PDL of 100 mrem/yr (1 mSv/yr) EDE from all pathways (Table V-37) and 0.8% of the total annual dose contribution (Figure V-23).

The maximum individual dose occurred at East Gate (the Laboratory boundary northeast of LAMPF) and was primarily due to external penetrating radiation from air activation products released by the LAMPF accelerator. The 1993 dose estimate is based on environmental measurements for doses from external radiation from airborne radioactivity. See Section V. B. for discussion of environmental dose measurements.

The computer model CAP-88, which is discussed in more detail in the following section, was used to make the dose estimate for external radiation from airborne radioactivity. Doses from other exposure pathways were

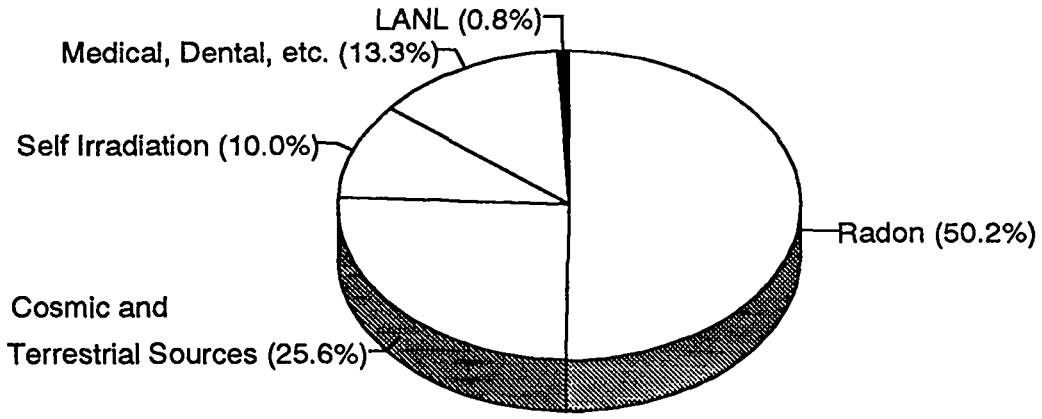


Figure V-23. Total contributions to 1993 dose at the Laboratory's maximum exposed individual location.

Note: The annual contribution from medical and dental sources (53 mrem) was not included in the total dose (342).

estimated using environmental monitoring results (see Sections V.C.3.d and V.C.3.f). Doses from liquid releases and direct radiation from LANL facilities did not impact this location. The maximum EDE for external radiation from airborne emissions was estimated by CAP-88 using all measured releases from LANL facilities (Tables V-4 and V-17) and 1993 meteorological data. The dose estimate took into account shielding by buildings (30% reduction for submersion dose, 10% for inhalation dose) and occupancy (100% for residences, 25% for businesses) (Kocher 1980). The contribution to the maximum individual off-site dose via each pathway is presented in Figure V-24.

The average EDE to residents in Los Alamos townsite that is attributable to Laboratory operations in 1992 was 0.12 mrem (0.0012 mSv). The corresponding dose to White Rock residents was 0.11 mrem (0.0011 mSv). The doses are approximately 0.12% and 0.11% of DOE's PDL of 100 mrem/yr (1.0 mSv/yr).

b. Estimate of Maximum Individual Dose from Airborne Emissions for Compliance with 40 CFR Part 61, Subpart H. As required by the EPA, compliance with regulation 40 CFR 61, Subpart H must be demonstrated with the CAP-88 version of the computer codes PREPAR2, AIRDOS2, DARTAB2, and RADRISK (EPA 1990a). These codes use measured radionuclide release rates and meteorological information to calculate transport and airborne concentrations of radionuclides released to the atmosphere. The programs estimate radiation exposures from inhalation of radioactive materials; external exposure to the radionuclides present in the atmosphere and deposited on the ground; and ingestion of radionuclides in produce, meat, and dairy products.

Calculations for Laboratory airborne releases use the radionuclide emissions given in Tables V-4 and V-6. Wind speed, wind direction, and stability class are continually measured at meteorology towers located at TA-54, TA-49, TA-6, and East Gate. Emissions were modeled with the wind information most representative of the release point.

The maximum individual EDE from airborne emissions, as determined by CAP-88, was 5.7 mrem (005.7 mSv). As expected, more than 98% of the maximum individual dose resulted from external exposure to air activation products from LAMPF. The 5.7 mrem (0.057 mSv) maximum dose, which would occur in the area just northeast of LAMPF, is 57% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr) EDE.

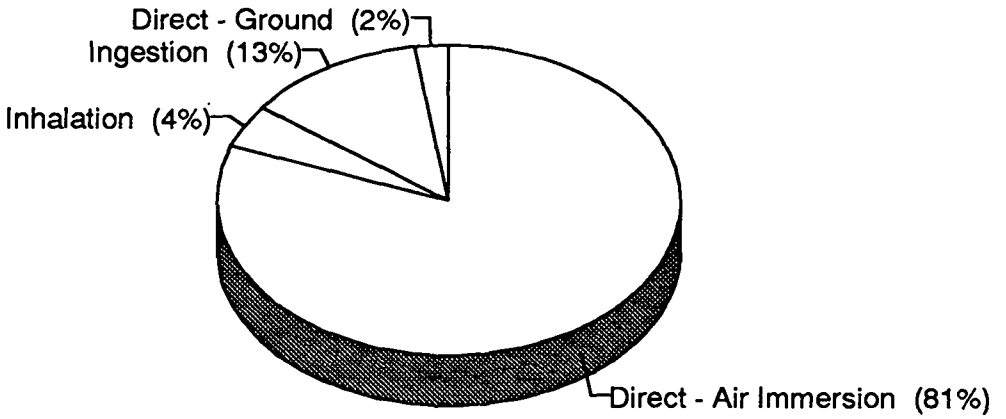


Figure V-24. LANL contributions to 1993 dose at LANL's MEI location by pathway

5. Collective Dose Equivalents.

The collective EDE from 1993 Laboratory operations was evaluated for the area within 80 km (50 mi) of the Laboratory. Over 99% of this dose is expected to have resulted from airborne radioactive emissions from Laboratory programs. As a result, the collective dose was estimated by modeling 1993 radioactive air emissions, their transport off site, and the resulting radiation exposures that could occur.

The 1993 collective EDE (in person-rem) was calculated with the CAP-88 collection of computer codes PREPAR2, AIRDOS2, and DARTAB2. These codes were also used to calculate the maximum EDE to a member of the public as required by the EPA regulations 40 CFR Part 61 (EPA 1989c).

The collective dose calculation used the EPA's CAP-88-generated agricultural profile of the area within an 80 km (50 mi) radius. 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 1993 population collective EDE attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory was calculated to be 3.0 person-rem (0.03 person-Sv). This dose is <0.1% of the 72,000 person-rem (720 person-Sv) exposure from natural background radiation and <0.1% of the 12,000 person-rem (120 person-Sv) exposure from medical radiation (Table V-43).

The collective dose from Laboratory operations was calculated from measured radionuclide emission rates (Table V-5), atmospheric modeling using measured meteorological data for 1993, and population data based on the Bureau of Census count (Table II-3). The collective dose from natural background radiation was calculated using the background radiation levels given above. For the population living within the 80 km (50 mi) radius of the Laboratory, the dose from medical and dental radiation was calculated using a mean annual dose of 53 mrem (0.53 mSv) per capita. The population distribution in Table II-3 was used in both these calculations to obtain the total collective dose.

Also shown in Table V-43 is the collective EDE in Los Alamos County from Laboratory operations, natural background radiation, and medical and dental radiation. Approximately 70% of the total collective dose from Laboratory operations is to Los Alamos County residents. This dose is <0.1% of the collective EDE from background and 0.2% of the collective dose from medical and dental radiation, respectively.

Table V-43. Estimated Collective Effective Dose Equivalents during 1993 (person-rem [person-Sv])

Exposure Mechanism	Los Alamos County (18,366 persons)	80 km Region (219,000 persons)[a]
Total caused by Laboratory releases	2.0 (0.020)	3 (0.03)
Natural background		
Non-radon[b]	2,500 (25)	27,000 (270)
Radon	3,600 (36)	45,000 (450)
Totals caused by natural sources of radiation	6,100 (61)	72,000 (720)
Diagnostic medical exposures (~53 mrem/yr/person)[c]	1,000 (10)	12,000 (120)

[a]Includes doses reported for Los Alamos County.
[b]Calculations are based on TLD measurements. They include a 20% reduction in cosmic radiation from shielding by structures and a 30% reduction in terrestrial radiation from self-shielding by the body (NCRP 1987a).
[c]NCRP (1987a).

D. Risk to an Individual from Laboratory Releases

1. Estimating Risk.

Risk estimates of possible health effects from radiation doses to the public resulting from Laboratory operations have been made to provide a perspective in interpreting these radiation doses. These calculations, however, may overestimate actual risk for low-linear energy transfer (LET) radiation. The NCRP (1975a) has warned that "risk estimates for radiogenic cancers at low doses and low dose rates derived on the basis of linear (proportional) extrapolation from the rising portions of the dose incidence curve at high doses and high dose rates . . . cannot be expected to provide realistic estimates of the actual risks from low-level, low-LET radiation, and have such a high probability of overestimating the actual risk as to be of only marginal value, if any, for purposes of realistic risk-benefit evaluation."

Low-LET radiation, which includes beta particles and gamma rays, is the principal type of environmental radiation resulting from Laboratory operations. Estimated doses from high-LET radiation, such as neutron or alpha particle radiation, are less than 3% of estimated low-LET radiation doses. Consequently, risk estimates in this report may overestimate the true risks.

Risk estimates used here are based on two recent reports by the National Research Council's Committee on the Biological Effects of Ionizing Radiation (BEIR IV 1988, BEIR V 1990). These reports incorporate the results of the most current research and update risk estimates in previous surveillance reports that were based on the work of the ICRP. The procedures used in this report for the risk estimates are described in more detail below.

2. Risks from Whole-Body Radiation.

Radiation exposures considered in this report are of two types: (1) whole-body exposures, and (2) individual organ exposures. The primary doses from non-radon natural background radiation and from Laboratory operations are whole-body exposures. With the exception of natural background radon exposures, discussed below, radiation doses and associated risks from those radionuclides that affect only selected body organs are a small fraction of the dose and are negligible. Risks from whole-body radiation were estimated using the factors of the BEIR V report.

Risk factors are taken from the BEIR estimate (BEIR V 1990) of the risk from a single, instantaneous, high-dose rate exposure of 10 rem. The BEIR V report states that this estimate should be reduced for an exposure distributed over time that would occur at a substantially lower dose rate. The committee discussed dose rate effectiveness factors (DREFs) ranging from 2 to 10 that should be applied to the nonleukemia part of the risk estimate.

For the risk estimates presented in this report, a DREF of 2 is used for the nonleukemia risk. Following the BEIR V report, no dose rate reduction was made for the leukemia risk. The risk is then averaged over male and female populations. The total risk estimate is 440 nonleukemia and leukemia cancer fatalities per 10^9 person-mrem.

3. Risks from Exposure to Radon.

Exposures to radon and radon decay products are important parts of natural background radiation. These exposures differ from the whole-body radiation discussed above in that they principally involve only the localized exposure of the lung and not other organs in any significant way. Consequently, the risks from radon exposure were calculated separately.

Exposure rates to radon (principally ^{222}Rn) and radon decay products are usually measured with a special unit, the working level (WL); 1 WL corresponds to a liter of air containing short-lived radon decay products whose total potential alpha energy is 1.3×10^5 MeV. An atmosphere having a 100 pCi/L concentration of ^{222}Rn at equilibrium with its decay products corresponds to 1 WL. Cumulative exposure is measured in working level months (WLMs). A WLM is equal to exposure to 1 WL for 170 hours.

The estimated national average radon EDE that was given by the NCRP is 200 mrem/yr. The NCRP derived this dose from an estimated national average radon exposure of 0.2 WLM/yr. Because the risk factors are derived in terms of WLM, for the purposes of risk calculation it is more convenient to use the radon exposure of 0.2 WLM/yr than to use the radon dose of 200 mrem/yr. However, the 0.2 WLM/yr and the 200 mrem/yr EDE correspond to the same radiation exposure.

Risks from radon were estimated using a risk factor of 350×10^{-6}/WLM. This risk factor was taken from the BEIR IV report (BEIR IV 1988).

4. Risk from Natural Background Radiation and Medical and Dental Radiation.

During 1993, persons living in Los Alamos and White Rock received an average EDE of 140 mrem (1.40 mSv) and 127 mrem (1.27 mSv), respectively, of nonradon radiation (principally to the whole body) from natural sources (including cosmic, terrestrial, and self-irradiation sources, with allowances for shielding and cosmic neutron exposure). Thus, the added risk of nonleukemia cancer mortality attributable to natural whole-body radiation in 1993 was 1 chance in 16,000 in Los Alamos and 1 chance in 18,000 in White Rock.

Natural background radiation also includes exposure to the lung from ^{222}Rn and its decay products (see above) in addition to exposure to whole-body radiation. This exposure to the lung also carries a chance of cancer mortality from natural radiation sources that were not included in the estimate for whole-body radiation. For the background EDE of 200 mrem/yr (2 mSv/yr), the added risk because of exposure to natural ^{222}Rn and its decay products is 1 chance in 14,000.

The total risk of cancer mortality from natural background radiation is 1 chance in 8,000 for Los Alamos and White Rock residents (Table V-44). The additional risk of cancer mortality from exposure to medical and dental radiation is 1 chance in 43,000.

5. Risk from Laboratory Operations.

The risks calculated above 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 1993 Laboratory activities were 0.15 and 0.03 mrem (0.0015 and 0.0003 mSv), respectively. These doses are estimated to add lifetime risks of nonleukemia cancer mortality of 1 in 1,000,000 (Table V-44). These risks are <0.1% of the risk attributed to exposure to natural background radiation or to medical and dental radiation.

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). The incremental risk in Los Alamos attributable to Laboratory operations is equivalent to the additional exposure from cosmic rays a person would get from flying in a commercial jet aircraft for 25 minutes at an altitude of 9,100 m (30,000 ft) (NCRP 1987b). The exposure from Laboratory operations to Los Alamos County residents is well within variations in exposure of these people to natural cosmic and terrestrial sources and global

fallout. For example, the amount of snow cover and variability of the solar sunspot cycle can explain a 10 mrem (0.1 mSv) difference from year to year (NCRP 1975b).

Table V-44. Added Individual Lifetime Cancer Mortality Risks Attributable to 1993 Radiation Exposure

Exposure Source	EDE Used in Risk Estimate (mrem)	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.15	less than 1 in 1,000,000
White Rock area	0.03	less than 1 in 1,000,000
Natural Radiation		
Cosmic, terrestrial, self-irradiation, and radon exposure[a]		
Los Alamos	342	1 in 8,000[b]
White Rock	327	1 in 8,000
Medical X Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in 43,000

[a]An EDE of 200 mrem was used to estimate the risk from inhaling ^{222}Rn and its transformation products.

[b]The risks from natural radiation from non-radon sources were estimated to be 1 chance in 16,000 in Los Alamos and 1 chance in 18,000 for White Rock. The risk of lung cancer from radon exposure was estimated to be 1 chance in 14,000 for both locations. Risk estimates are derived from the NRC BEIR IV and BEIR V reports and the NCRP Report 93 (BEIR IV 1988, BEIR V 1990, NCRP 1987a).

VI. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

Los Alamos National Laboratory (LANL or the Laboratory) quantifies and assesses nonradioactive pollutant releases to the environment by calculating and monitoring nonradioactive emissions and effluents, evaluating unplanned releases, and conducting environmental sampling. Air emissions were determined for steam, power, and asphalt plants and from the detonation and burning of explosives, the removal of asbestos, and beryllium processing operations. All nonradioactive air emissions remained within federal limits during 1993.

Surface water is monitored to determine the Laboratory's impact on the environment; no observable effects are caused by Laboratory operations.

Soils are monitored for trace metals; values for 1993 reflect the natural background levels.

Sediments are also monitored to determine the Laboratory's impact on the environment and to account for geochemical processes. Concentrations of trace metals in sediments did not indicate significant contributions above natural concentrations; no organics were found above the limits of quantification.

A. Nonradioactive Emissions and Effluent Monitoring

1. Air Quality.

a. Introduction. In addition to the radiological monitoring network, the Laboratory operates a network of nonradiological ambient air monitors. Because the Los Alamos area lies in a remote area far from large metropolitan areas and major sources of air pollution, extensive monitoring has not been conducted. The Laboratory operates monitors to routinely measure primary (or "criteria") pollutants, beryllium, acid precipitation, and visibility.

b. Monitoring Network. The nonradiological monitoring network consists of a variety of monitoring stations: an on-site criteria pollutant monitor, 8 beryllium monitors, 1 perimeter acid rain monitor, and 1 perimeter visibility monitoring station.

c. Primary Pollutants. The New Mexico Environment Department (NMED) operates the Laboratory-owned criteria pollutant monitoring station at TA-49, adjacent to Bandelier National Monument. This station, which began operation in the second quarter of 1990, continuously monitors air concentrations of nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Filters to trap small particulate matter with a diameter of less than 10 μ (PM_{10}) are collected every six days and weighed. The NMED analyzes all results and provides the results to the Laboratory. The data collected during 1993 are shown in Table VI-1. Measured ozone concentrations did not exceed the federal primary or secondary standard. However, the maximum hourly concentration exceeded the New Mexico ambient standard.

The ozone levels in many areas of the state exceeded state standards; although the causes are unknown, the ozone levels may result from transport from urban areas or may be generated by local sources. Because the NM Air Quality Act does not specifically require compliance with state standards, there are no enforcement actions associated with these levels. Instead, the state uses these standards as guidelines for setting allowable emission limits for regulated sources based on modeling results. At present, LANL is not affected by these emission limits.

Table VI-1. Nonradiological Ambient Air Monitoring Results for 1993

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards		Measured Concentration
				Primary	Secondary	
Sulfur dioxide[a]	Annual arithmetic mean	ppm	0.02	0.03		0.002
	24 hours	ppm	0.10	0.14		
	3 hours	ppm			0.5	
	1 hour	ppm				0.006
Particulate Matter$_{10}$[a]	Annual arithmetic mean	µg/m^3		50	50	8
	24 hours	µg/m^3		150	150	30
Ozone[a]	1 hour	ppm	0.06	0.12	0.12	0.077
Nitrogen dioxide[a]	Annual arithmetic mean	ppm	0.05	0.053	0.053	0.003
	24 hours	ppm	0.10			
	1 hour	ppm				0.027
Beryllium[b]	Calendar quarter	ng/m^3				0.08
	30 day	ng/m^3	10			

[a]Measurements made at TA-49, near the boundary with Bandelier National Monument.
[b]Maximum on-site and perimeter concentration.

1990 Air Pollutant Emissions Inventory. During 1991, because of the Clean Air Act Amendments (CAAA) of 1990, the Laboratory undertook an intensive effort to create a comprehensive, Laboratory-wide air pollutant emissions inventory based on 1990 chemical usages and operations. The goal of this effort was to update and expand the original emissions inventory prepared in 1987. The original inventory was performed to evaluate emissions under the NMED-regulated toxic air pollutants and determine whether source registration under Air Quality Control Regulation (AQCR) 752 was required. The 1990 inventory expanded upon the 1987 work to include criteria pollutants, as well as hazardous air pollutants (HAPs) not currently regulated under AQCR 702 but listed in the federal CAAA. Results from the 1987 and 1990 inventories indicate that 79% of the Laboratory's stationary source emissions are from criteria pollutants. The primary source of these criteria pollutants is the combustion in the power plant, steam plants, asphalt plant, and local space heaters.

In 1993, the Laboratory implemented a site-wide evaluation of chemical emissions from all routine and experimental operations. The impetus for an updated, inclusive emissions inventory is the emissions reporting requirements specified in the 1990 CAAA, which requires the Laboratory to report all air emissions of criteria pollutants, as well as all HAPs. The Laboratory began efforts to identify methods of tracking chemical use and air emissions associated with that use from the many diverse operations conducted at the Laboratory. In April 1993, the Laboratory implemented the Automated Chemical Inventory System (ACIS) designed to account for all chemicals brought into the facility, track the movement of chemicals within the Laboratory, and account for all chemical usage by Laboratory operations. Additionally, the Laboratory's Environmental Protection Group (EM-8) began work on developing a computerized air emissions program designed to characterize the types of operations performed at the Laboratory and estimate emissions from these operations using established emission factors, chemical inputs, and waste stream data. The Laboratory plans to use the ACIS database in conjunction with the emissions inventory program to determine air emissions annually. Updated air emission information will be required by the NMED to assure compliance with the 1990 CAAA.

d. Beryllium. The Laboratory conducted beryllium monitoring at eight monitoring stations in 1993. The stations included 1 regional station (28–44 km [17–27 mi]), 4 perimeter stations (0–4 km [0–2mi]), and 3 on-site stations. Biweekly samples are taken, composited quarterly, and analyzed. The fourth quarter composite samples were inadvertently destroyed before completion of the analysis and, therefore, not included in the results presented in Table VI-2. For 1993, all concentrations were well below the New Mexico air standards.

e. Acid Precipitation. EM-8 operates a wet deposition station that is part of the National Atmospheric Deposition Program network. The station is located at the Bandelier National Monument perimeter station. The 1993 annual and quarterly deposition rates are presented in Table VI-3. The mean field pH is reported as a logarithmic mean.

Table VI-2. Airborne Beryllium Concentrations for 1993

Station Location[a]	Total Air Volume (m^3)	No. of Samples	Concentrations (ng/m^3)			
			Maximum	Minimum	Mean	2s
OFF-SITE STATIONS, UNCONTROLLED AREAS						
Regional (28–44 km)						
Pojoaque	11,200	3	0.10	0.03	0.05	0.09
Perimeter (0–4 km)						
Barranca School	42,600	3	0.08	0.01	0.04	0.07
Los Alamos, 48th Street	46,100	3	0.04	0.00	0.02	0.03
Pajarito Acres	22,700	2	0.04	0.04	0.04	0.0
Bandelier	42,100	3	0.06	0.00	0.08	0.05
Group Summary		11	0.08	0.00	0.03	0.04
ON-SITE STATIONS, CONTROLLED AREAS						
TA-52 Beta Site	48,200	3	0.04	0.01	0.03	0.0
TA-16 S-Site	46,400	3	0.04	0.01	0.02	0.03
TA-3	24,700	2	0.01	0.01	0.01	0.01
Group Summary		8	0.04	0.01	0.02	0.03

[a]See Figure V-9 for map of off-site perimeter and on-site stations.
[b]Uncertainties ($\pm 2\sigma$) are in parentheses.

Deposition rates for the various ionic species vary widely and are somewhat dependent on precipitation. The highest deposition rates usually coincide with high precipitation. The lowest rates normally occur in the winter, probably reflecting the decrease in wind-blown dust. The ions in the rainwater are from both nearby and distant anthropogenic and natural sources. High nitrate and sulfate deposition may be caused by man-made sources, such as motor vehicles, copper smelters, and power plants.

The natural pH of rainfall, without man-made contributions, is unknown. Because of the contribution from entrained alkaline soil particles in the southwest, natural pH may be higher than 5.6, the pH of rainwater in equilibrium with atmospheric carbon dioxide. Some studies indicate that there may be an inverse relationship between elevation and pH.

f. Visibility. Since October 1988, LANL has operated a visibility monitoring station, an optical missometer, on site (TA-49, TA-33) adjacent to Bandelier National Monument. Measurements are performed using protocols established for the National Park Service, Forest Service, the Environmental Protection Agency (EPA), and other government agencies under the auspices of the Interagency Monitoring of Protected Visual Environments Network. Visibility is determined by measuring the opacity of the air and expressed as a deciview (dv) or visual range. Data

Table VI-3. Annual and Quarterly Wet Deposition Statistics for 1993

1993	Quarter				
	First	Second	Third	Fourth	Annual
Field pH (Log.)					
Mean	4.8	5.0	4.8	5.0	4.9
Minimum	4.5	4.7	4.6	4.6	4.5
Maximum	5.2	5.3	5.0	5.3	5.3
Precipitation (cm)	18.0	5.9	20.6	7.6	52.1
Deposition (microequivalents per square meter)					
Ca	299	1,198	1,846	549	3,892
Mg	41	181	271	66	559
K	18	64	79	20	181
Na	174	217	535	161	1,087
NH_4	942	665	1,885	499	3,991
NO_3	855	1,065	3,113	823	5,856
Cl	169	141	508	113	931
SO_4	1,645	1,437	3,060	1,020	7,162
PO_4	NR	NR	NR	NR	NR
H	1,550	591	2,300	856	5,297

NR = Not reported.

collected to date indicate that the visibility near the monitoring site is generally very good, with the visual range exceeding 11.9 dv (117 km [73 mi]) most of the time (Table Vi-4). On the clearest days, visibility exceeds 9.0 dv (161 km [100 mi]).

Factors that affect visibility at Bandelier National Monument and other locations include the amount of man-made pollution in the air, the amount of natural particles and light-scattering or light-absorbing gases in the air, and meteorological factors like relative humidity and precipitation.

g. Lead Pouring Operations. Lead pouring operations were discontinued at the Laboratory in April 1991.

h. Steam Plants and Power Plant. Fuel consumption and emission estimates for the three steam plants at the Laboratory and at the TA-3 power plant are reported in Table VI-5. The plants are sources of PM_{10}, nitrogen oxides, sulfur oxides, carbon monoxide, and hydrocarbons. The nitrogen oxides emissions from the TA-3 power plant were estimated based on measurements of boiler exhaust gas. The increase in nitrogen oxides emissions at the TA-3 power plant from 15.3 ton/yr in 1992 to 166.4 ton/yr in 1993 reflects greater accuracy in the exhaust gas measurements. EPA emission factors were used in making the other emission estimates (EPA 1993). The emissions from these plants are low, posing no threat of violating ambient air quality standards. The Western Area steam plant, used as a standby plant, was not operated during 1993.

Table VI-4. Average Visibility Measured at Bandelier National Monument in 1993

Quarters	dv	km	mi
Winter	9.5	148	92
Spring	9.0	161	100
Summer	9.8	142	88
Fall	11.8	117	73

Table VI-5. Emissions and Fuel Consumption during 1993 from the Steam Plants and TA-3 Power Plant

Pollutant	TA-3[a]	TA-16[b]	TA-21[b]	Western Area[b]	Total
Emissions (ton/yr)					
Particulate matter	2.84	2.14	0.53	0.0	5.51
Oxides of nitrogen	166.40	21.91	5.39	0.0	193.70
Carbon monoxide	22.70	5.48	1.35	0.0	29.53
Hydrocarbons	0.97	0.91	0.22	0.0	2.10
Sulfur oxides	0.34	0.09	0.02	0.0	0.45
Fuel Consumption (10^9 Btu/yr)	1,184.00	326.00	80.00	0.0	1,590.00

[a]Power plant.
[b]Steam plant.

i. Asphalt Plant. In addition to the steam plants and the power plant at TA-3, Johnson Controls Inc. (JCI) operates an asphalt plant at TA-3. As part of its contract with the Laboratory, JCI provides annual records summarizing operations at the plant. The records presented in Table VI-6 show 1993 production figures and estimates of emissions. Although asphalt production has decreased steadily since 1986 because most of the asphalt used at the Laboratory has been purchased from an outside vendor, production in 1993 was slightly higher than in 1992. Although it is not required to, the plant meets the New Source Performance Standards stack emission limits for asphalt plants.

Table VI-6. Asphalt Plant Emissions in 1993

Production (ton/yr)	Emissions					
	Particulate Matter Emissions (lb/yr)	Sulfur Oxide Emissions (lb/yr)	Nitrogen Oxide (lb/yr)	Carbon Monoxide (lb/yr)	Volatile Organic Carbons (lb/yr)	Formaldehyde (lb/yr)
4,840	339	481	174	184	136	0.7

j. 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, including the type of explosive and weight fired at each mound to track emissions from this activity. Table VI-7 summarizes the explosives detonation conducted at the Laboratory during 1993. The Laboratory also burns scrap and waste explosives when burning proves to be the safest disposal option. In 1993, the Laboratory burned 310,260 g (10,684 lb) of scrap and waste explosive. In addition, 2.9 g (0.006 lb) of scrap high explosives were detonated.

k. Asbestos. During 1993, JCI removed approximately 654 m (2,146 lin ft) of friable pipe insulation as part of individual small jobs covered by the annual notification to the NMED. Large jobs resulted in the removal of 4,450 L (157 cu ft) of friable and nonfriable material potentially contaminated with radionuclides. A total of 13,088 L (462 cu ft) of material potentially contaminated with radionuclides, both friable and nonfriable, was removed in 1993. A total of 653 m^2 (7,024 sq ft) of unregulated material such as vinyl asbestos tile, transit board, siding, and pipe was also removed through small job activities. This material resulted in approximately 79,433 L (2,804 cu ft) of disposal.

Table VI-7. Estimated Concentrations of Toxic Elements Released by Dynamic Experiments

Element	1993 Total Usage (kg)	Fraction Released (%)	Annual Average Concentration ($\mu g/m^3$) (1,500 m)[a]	Annual Average Concentration ($\mu g/m^3$) (3,800 m)[b]	Applicable Standard ($\mu g/m^3$)
beryllium	4.0	2	3.5×10^{-6}	1.2×10^{-6}	0.01[c]
Lead	19.9	100[d]	8.4×10^{-4}	2.8×10^{-4}	1.5[e]
Heavy metals[f]	1,407.1	100[d]	5.8×10^{-2}	2.0×10^{-2}	10[c]

[a]Distance downwind to nearest public access point.
[b]Distance downwind to nearest off-site receptor.
[c]Standard for 30 day average, NM ACQR 201.
[d]No data are available; estimate was done assuming worst-case percentage was released into the air.
[e]Standard for 3 month average (40 CFR 50.12).
[f]Although lead (Pb) is a heavy metal, it is listed separately because there is an air standard applicable to lead.

2. Water and Effluent Monitoring

a. Surface Water Monitoring. Surface waters are sampled and analyzed to monitor dispersion of chemicals from Laboratory operations. Chemical concentrations in water from areas where there has been no direct release of treated effluents show no observable effects from Laboratory operations. The chemical quality of surface waters from areas with no effluent release varied with seasonal fluctuations. The quality of water off site and downstream from the release areas reflects some impact from Laboratory operations, but these waters are not a source of municipal or industrial water supply. Water in lower Los Alamos Canyon is used by livestock.

Monitoring Network. Section V.B.3 presents information on the monitoring network used in this program.

Nonradioactive Analyses. The results of major chemical constituents in surface water samples for 1993 are listed in Table VI-8. The results are consistent with those observed in previous years, with some expected variability. None of the measurements exceed standards for water supplies for livestock and wildlife.

The results of metal analyses on surface water samples for 1993 are listed in Table VI-9. The levels are generally consistent with previous observations. The measurement for aluminum slightly exceed the limits for livestock and wildlife watering (Appendix A) at Rio Grande at Embudo, located more than 10 mi upstream of the Laboratory. The measurements for cadmium, chromium, and copper significantly exceed the limits for livestock and wildlife watering at the Pueblo 1 perimeter station: cadmium was 20 times larger than the limit, chromium 5 times the limit, and copper 10 times the limit. Sampling or analytical errors are suspected as a cause of the elevated levels, for two key reasons: first, results from the 1992 and 1994 (preliminary) samples show levels of these metals several orders of magnitude lower than the 1993 results; second, there are no obvious sources of metals upstream of this location.

Analyses for organics in surface water were performed during May and June of 1993 at all perimeter and on-site stations, except for three on-site stations, which were dry at the time of sampling (Water Canyon at Beta Hole, Pueblo 2, and DPS-4). The parameters analyzed included the volatile and semivolatile organics. Of the 17 stations tested, 1 perimeter and 4 on-site stations had traces of organic compounds detected. Possible traces of acetone were found in a sample from Guaje Canyon (23 µg/mL compared with the quantification limit of 20 µg/mL). Guaje Canyon is a perimeter station located upstream from the Laboratory. Stations located in Sandia Canyon (SCS-1, 2, and 3) each showed trace levels of organics. Chloroform was detected in SCS-1 (14 µg/mL versus quantification limit of 5 µg/mL), and possible traces of acetone were detected in SCS-2 and SCS-3 (30 and 31 µg/mL versus quantification limit of 20 µg/L). Chloroform may be residual from the chlorination of sanitary effluents discharged into upper Sandia Canyon. There are no obvious sources of acetone in the drainage system, but it is a common analytical laboratory trace contaminant. The sample from Pajarito Creek at the Rio Grande contained Bis-2-ethylhexylphthalate at 630 µg/mL (compared to the quantification limit of 13). The source is unknown.

Table VI-8. Chemical Quality of Surface Waters for 1993 (mg/L)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
OFF-SITE STATIONS																	
REGIONAL STATIONS																	
Rio Chama at Chamita	15	33	8.0	2	13	3	0.1	<1[c]	69	0.1	59	0.12	N/A[d]	210	115	8.1	235
Rio Grande at Embudo	20	24	5.3	4	11	3	0.2	<1	59	0.2	21	0.19	N/A	176	82	7.8	143
Rio Grande at Otowi	19	30	6.6	4	13	3	0.2	<1	64	0.1	34	0.08	N/A	180	105	8.2	184
Rio Grande at Frijoles	19	45	9.0	2	19	7	0.4	<5	109	<0.0	51	<0.04	<0.01	224	50	8.2	322
Rio Grande at Cochiti	19	25	5.2	2	11	3	0.2	<1	62	0.1	34	0.06	N/A	174	85	8.0	180
Rio Grande at Bernalillo	19	25	5.1	2	11	4	0.2	<1	68	0.1	35	0.05	N/A	164	88	8.2	193
Jemez River	30	20	2.6	3	16	19	0.3	<1	63	0.1	8	<0.04	N/A	192	55	8.3	174
PERIMETER STATIONS																	
Radioactive Effluent Release Areas																	
Acid-Pueblo Canyons																	
Acid Weir	25	13	1.9	N/A	62	71	0.3	<5	55	0.9	13	1.00	N/A	244	30	7.0	394
Pueblo 1	30	13	2.0	N/A	63	37	0.2	<5	<5	1.2	13	<0.04	N/A	308	36	1.7	8550
Pueblo 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon																	
Los Alamos Canyon Reservoir	36	6	2.2	2	5	5	<0.1	<1	26	0.0	6	0.61	N/A	134	15	8.1	87
Los Alamos at Rio Grande	46[e]	26[e]	4.8[e]	5[e]	32[e]	31[e]	0.4[e]	9[e]	78[e]	0.8[e]	14[e]	2.19[e]	N/A	218[e]	83[e]	8.2[e]	295[e]
Other Areas																	
Guaje Canyon	52	7	2.4	2	5	2	0.1	<1	30	0.0	7	0.06	N/A	118	10	7.8	84
Mortandad at Rio Grande	92	28	7.7	15	76	49	0.9	<5	112	6.4	27	0.51	0.02	350	100	7.5	484
Pajarito at Rio Grande	65	22	4.9	3	13	6	0.4	<5	83	<0.0	7	<0.04	<0.01	140	74	8.3	200
Frijoles at Park Headquarters	62	8	2.7	2	8	5	0.1	<1	35	0.0	5	<0.04	N/A	162	22	7.8	113
Frijoles at Rio Grande	49	10	3.3	2	9	4	0.2	<5	53	<0.0	4	<0.04	<0.01	126	38	8.2	124
ON-SITE STATIONS																	
Radioactive Effluent Release Areas																	
Acid-Pueblo Canyons																	
Pueblo 3	91	15	2.6	N/A	40	34	0.4	<5	141	5.3	23	4.53	N/A	404	55	7.3	538
Pueblo at SR 4	86	16	4.0	12	62	38	0.6	<5	104	1.1	26	8.38	N/A	376	64	8.7	497
Mortandad Canyon																	
GS-1	49	38	3.5	5	60	9	0.6	<5	138	0.6	9	18.00	<0.01	302	110	8.2	442

Table VI-8. (Cont.)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
Radioactive Effluent Release Areas (Cont.)																	
DP-Los Alamos Canyons																	
DPS-1	26	36	2.5	7	87	111	0.7	<5	138	0.1	12	<0.04	N/A	356	104	7.8	671
DPS-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas																	
Cañada del Buey	35	12	3.8	N/A	18	18	0.5	<5	53	0.7	4	0.10	N/A	182	22	6.5	123
Pajarito Canyon	32[e]	28[e]	7.1[e]	5[e]	28[e]	58[e]	0.1[e]	<5[e]	68[e]	0.0[e]	13[e]	0.04[e]	N/A	228[e]	106[e]	7.9[e]	339[e]
Water Canyon at Beta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	73	16	4.0	2	10	4	0.4	<5	63	<0.0	4	<0.04	<0.01	128	56	8.4	143
Sandia Canyon																	
SCS-1	96	15	4.2	N/A	58	54	0.4	<5	109	2.3	24	2.80	N/A	376	55	7.7	489
SCS-2	87	21	4.3	N/A	110	66	0.9	<5	146	2.5	98	0.72	N/A	544	70	8.4	757
SCS-3	89	22	4.6	N/A	110	70	0.9	<5	139	0.3	100	1.36	N/A	558	72	8.6	784
EPA Primary Drinking Water Standard							4					10	0.2				
EPA Secondary Drinking Water Standard											250			500		6.8-8.5	
EPA Health Advisory					20												

[a]Total dissolved solids.

[b]Standard Units.

[c]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

[d]N/A means analysis not performed, lost in analysis, or not completed.

[e]Mean of multiple samples.

Table VI-9. Total Recoverable Trace Metals in Surface Waters for 1993 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
OFF-SITE STATIONS												
REGIONAL STATIONS												
Rio Chama at Chamita	<0.010[a]	2.10	N/A[b]	0.0200	0.0730	<0.001	<0.003	<0.004	<0.004	<0.004	1.50	<0.0002
Rio Grande at Embudo	<0.010	5.20	0.0028	0.0310	0.0890	<0.001	<0.003	<0.004	<0.004	<0.004	5.50	<0.0002
Rio Grande at Otowi	<0.010	4.80	0.0027	0.0200	0.1100	<0.001	<0.003	<0.004	<0.004	0.007	4.90	<0.0002
Rio Grande at Frijoles	<0.010	1.20	0.0030	0.0400	0.0830	<0.001	<0.003	<0.004	<0.004	<0.004	1.10	<0.0002
Rio Grande at Cochiti	<0.010	1.40	<0.0020	0.0180	0.0540	<0.001	<0.003	<0.004	<0.004	<0.004	1.20	<0.0002
Rio Grande at Bernalillo	<0.010	1.60	<0.0020	0.0220	0.0700	<0.001	<0.003	<0.004	0.020	0.022	1.80	<0.0002
Jemez River	<0.010	2.10	0.0215	0.1300	0.0600	<0.001	<0.003	<0.004	<0.004	<0.004	2.10	<0.0002
PERIMETER STATIONS												
Radioactive Effluent Release Areas												
Acid Weir	0.056	1.00	0.0030	0.0740	0.0370	0.004	<0.007	<0.008	0.047	0.015	0.62	<0.0002
Pueblo 1	0.370	1.10	<0.0020	4.2000	5.2000	1.200	1.000	0.850	5.000	5.300	0.79	<0.0002
Pueblo 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon												
Los Alamos Canyon Reservoir	<0.010	1.40	<0.0020	<0.0100	0.0280	<0.001	<0.003	<0.004	<0.004	<0.004	0.60	<0.0002
Los Alamos at Rio Grande	<0.010[c]	2.30[c]	0.0052[c]	0.0650[c]	0.0760[c]	0.001[c]	<0.003[c]	<0.004[c]	0.004[c]	0.007[c]	1.80[c]	<0.0002[c]
Other Areas												
Guaje Canyon	<0.010	1.20	<0.0020	<0.0100	0.0240	<0.001	<0.003	<0.004	<0.004	<0.004	0.69	<0.0002
Mortandad at Rio Grande	<0.010	3.30	0.0030	0.4000	0.0600	<0.001	<0.003	<0.004	0.004	0.019	2.20	<0.0002
Pajarito at Rio Grande	<0.010	<0.20	<0.0020	0.0250	0.0380	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
Frijoles at Monument HQ	<0.010	1.80	<0.0020	<0.0100	0.0250	<0.001	<0.003	<0.004	<0.004	<0.004	0.96	<0.0002
Frijoles at Rio Grande	<0.010	<0.20	<0.0020	0.0160	0.0160	<0.001	<0.003	<0.004	<0.004	<0.004	0.12	<0.0002
ON-SITE STATIONS												
Radioactive Effluent Release Areas												
Acid-Pueblo Canyons												
Pueblo 3	0.028	0.87	0.0040	0.0700	0.0300	<0.001	<0.003	0.005	0.024	<0.004	0.64	<0.0002
Pueblo at State Route	0.690	<0.10	0.0122	0.2700	0.0170	<0.001	<0.003	<0.004	0.006	0.017	0.20	<0.0002
Mortandad Canyon												
Mortandad at GS-1	<0.010	0.94	0.0030	0.0300	0.0360	0.002	<0.003	0.004	0.005	0.015	0.72	<0.0002
DP-Los Alamos Canyons												
DPS-1	<0.010	0.15	<0.0020	<0.0100	0.1000	<0.001	<0.003	<0.004	<0.004	<0.004	0.20	<0.0002
DPS-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas												
Cañada Del Buey	0.020	11.00	0.0032	0.0500	0.1200	<0.001	<0.003	0.006	0.014	0.032	7.40	<0.0002
Pajarito Canyon	<0.010[c]	2.10[c]	<0.0020[c]	0.0255[c]	0.1235[c]	<0.001[c]	<0.003[c]	0.066[c]	0.004[c]	0.004[c]	1.16[c]	<0.0002[c]
Water Canyon at Beta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	<0.010	0.25	<0.0020	0.0400	0.0320	<0.001	<0.003	<0.004	<0.004	<0.004	0.19	<0.0002
Sandia Canyon												
SCS-1	<0.010	0.15	<0.0020	0.0600	0.0260	<0.001	<0.003	<0.004	<0.004	<0.004	0.23	<0.0002
SCS-2	<0.010	0.58	0.0051	0.0640	0.0330	<0.001	<0.003	<0.004	0.012	0.006	0.58	<0.0002
SCS-3	<0.010	0.89	0.0053	0.0670	0.0390	<0.001	<0.003	<0.004	0.011	0.006	0.74	N/A

*Data on additional trace metals from surface waters are presented on page VI-10.

Table VI-9. (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
EPA Primary Drinking Water Standard	0.05		0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard											0.3	
EPA Action Level										1.3		
Livestock Wildlife Watering Limit		5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01

*Data on additional trace metals from surface waters are presented on page VI-11.

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
OFF-SITE STATIONS											
REGIONAL STATIONS											
Rio Chama at Chamita	0.0390	0.008	<0.010	<0.0020	<0.001	0.0027	<0.03	0.270	<0.001	0.01	<0.0100
Rio Grande at Embudo	0.3600	<0.008	<0.010	0.0070	<0.001	0.0029	<0.03	0.180	<0.001	0.02	0.0360
Rio Grande at Otowi	0.2600	<0.008	<0.010	0.0170	<0.001	0.0033	<0.03	0.230	<0.001	0.02	0.0350
Rio Grande at Frijoles	0.0620	<0.008	<0.010	0.0040	<0.001	<0.0020	<0.03	0.340	<0.001	<0.00	0.1100
Rio Grande at Cochiti	0.0440	<0.008	<0.010	<0.0020	<0.001	0.0030	<0.03	0.190	<0.001	0.01	0.0240
Rio Grande at Bernalillo	0.0740	2.400	0.300	0.0030	<0.001	0.0030	<0.03	0.190	<0.001	<0.00	0.0660
Jemez River	0.0950	<0.008	<0.010	0.0080	<0.001	0.0030	<0.03	0.083	<0.001	0.01	0.0160
PERIMETER STATIONS											
Radioactive Effluent Release Areas											
Acid-Pueblo Canyons											
Acid Weir	0.0040	0.020	0.084	0.0018	<0.001	<0.0020	<0.03	0.073	<0.001	<0.00	0.2400
Pueblo 1	5.4000	1.000	5.500	0.0021	<0.001	<0.0020	0.92	5.300	<0.001	1.00	1.3000
Pueblo 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Los Alamos Canyon											
Los Alamos Canyon Reservoir	0.0110	<0.008	<0.010	<0.0020	<0.001	<0.0020	<0.03	0.056	<0.001	<0.00	0.0210
Los Alamos at Rio Grande	0.0665[c]	0.018[c]	<0.010[c]	0.0065[c]	<0.002[c]	<0.0020[c]	<0.03[c]	0.165[c]	<0.010[c]	0.01[c]	0.0365[c]
Other Areas											
Guaje Canyon	0.0170	<0.008	<0.010	<0.0020	<0.001	<0.0020	<0.03	0.042	<0.001	<0.00	<0.0100
Mortandad at Rio Grande	0.0830	0.014	<0.010	0.0030	<0.001	<0.0020	<0.03	0.100	<0.001	0.01	0.0340
Pajarito at Rio Grande	0.0020	<0.008	<0.020	<0.0010	<0.001	<0.0020	<0.03	0.120	<0.001	0.01	<0.0200
Frijoles at Monument HQ	0.0270	<0.008	0.023	0.0030	<0.001	<0.0020	<0.03	0.055	<0.001	0.01	0.0270
Frijoles at Rio Grande	0.0030	<0.008	<0.020	<0.0010	<0.001	<0.0020	<0.03	0.057	<0.001	<0.00	<0.0200
ON-SITE STATIONS											
Radioactive Effluent Release Areas											
Acid Pueblo Canyons											
Pueblo 3	0.0400	0.013	0.030	0.0038	<0.001	<0.0020	<0.03	0.088	<0.001	<0.00	0.4200
Pueblo at State Route	0.0650	<0.008	<0.010	N/A	N/A	<0.0020	<0.01	0.078	<0.001	0.03	0.0280

Table VI-9. (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Radioactive Effluent Release Areas (Cont.)											
Mortandad Canyon											
Mortandad at GS-1	0.0610	0.160	<0.020	0.0020	0.003	0.0020	<0.03	0.091	0.006	<0.00	<0.0200
DP-Los Alamos Canyons											
DPS-1	0.2000	<0.008	<0.010	0.0021	<0.001	<0.0020	<0.03	0.180	<0.001	<0.00	0.0170
DPS-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas											
Cañada Del Buey	0.4600	0.100	<0.020	0.0100	<0.001	<0.0020	<0.03	0.074	<0.001	0.01	0.0660
Pajarito Canyon	0.1300[c]	0.340[c]	<0.010[c]	0.0019[c]	<0.002[c]	<0.0020[c]	<0.03[c]	0.180[c]	<0.010[c]	0.04[c]	0.0270[c]
Water Canyon at Beta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	0.0100	<0.008	<0.010	0.0020	<0.001	<0.0020	<0.03	0.071	<0.001	0.01	<0.0200
Sandia Canyon											
SCS-1	0.0300	0.600	<0.010	0.0020	<0.001	<0.0020	<0.03	0.075	<0.001	0.01	0.1900
SCS-2	0.0130	0.460	<0.010	0.0020	<0.001	<0.0020	<0.03	0.110	<0.001	0.01	0.0620
SCS-3	0.0210	0.450	<0.010	0.0030	<0.001	<0.0020	<0.03	0.120	<0.001	0.01	0.0700
EPA Primary Drinking Water Standard			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard	0.05										5.0
EPA Action Level				0.015							
EPA Health Advisory							25-90			0.08-0.11	
Livestock Wildlife Watering Limit				0.1						0.1	25.0

[a]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[b]N/A means analysis not performed, lost in analysis, or not completed.
[c]Mean of multiple samples.

b. National Pollutant Discharge Elimination System. The DOE and the University of California have two National Pollutant Discharge Elimination System (NPDES) permits. One permit covers the effluent discharges for 10 sanitary wastewater treatment facilities and 130 industrial outfalls at the Laboratory. A summary of these outfalls is presented in Table D-2. The other permit covers one industrial outfall at the hot dry rock geothermal facility located 50 km (30 mi) west at Fenton Hill. Both permits are issued and enforced by the EPA Region 6 in Dallas, Texas. Under the Laboratory's permit for Los Alamos, samples are collected weekly for analysis, and results are reported each month to the EPA and the NMED. The NMED performs some compliance evaluation inspections and monitoring for the EPA through a Section 106 water quality grant. After having operated under an administrative continuance for several years, the EPA issued a final NPDES permit for the Laboratory in September 1993. Errors in the permit were discovered, and a new final permit with the errors corrected was drafted by the EPA in January 1994. This draft permit will go out for public comment and is expected to be issued sometime in 1994. A complete description of the NPDES permit renewal process is presented in Section III.B.6.a.

During 1993, effluent limits were not exceeded in any of the 147 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 19 times in the 2,120 samples collected from the industrial outfalls. As shown in Figure III-1, overall compliance for the sanitary and industrial discharges during 1993 was 100% and 99.1%, respectively. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1993.

In 1993, the Laboratory was under Administrative Order (AO) Docket No. VI-92-1306. The AO specified corrective activities and compliance schedules to bring the Laboratory into NPDES permit compliance. All projects under the AO were completed as scheduled except for the High Explosive (HE) Wastewater Treatment Project (outfall category O5A). The AO contained a schedule for completion of the Laboratory's Waste Stream Characterization Field Surveys. These were completed by September 30, 1993, except the survey of TA-55, which was delayed until October 8, 1993.

The interim date for the start of Title I design for the HE Wastewater Treatment Project was delayed from October 1993 to December 22, 1993, to allow for line item funding to be approved. A delay in the construction start date and the construction completion date was recognized by the Laboratory. These delays were addressed under the new AO Docket No. VI-94-1210 issued to the Laboratory on December 6, 1993. The new AO incorporated the revised HE Wastewater Treatment Project schedule and the remaining schedule for completion of the Waste Stream Characterization Project corrective activities.

On May 28, 1993, the EPA issued AO Docket No. VI-93-0178 to the Laboratory for effluent violations at the steam plant (outfall category O2A) and of treated cooling water (outfall category O3A) between October 1992 through March 1993. The AO stipulated that the Laboratory come into compliance with the permit limitations within 30 days of issuance of the AO. The Laboratory also submitted a detailed report on specific corrective actions taken by the Laboratory to ensure future compliance at the two outfall categories.

TA-50 Liquid Waste Treatment Plant. Treated effluents from the liquid waste treatment plant at TA-50 are also subject to NPDES permit limits. Table VI-10 presents information on the quality of effluent from the plant during 1992 and 1993. The total effluent volume increased slightly in 1993, with the majority of NPDES regulated constituents showing a decrease (see Section V.B.2 for information on radioactive constituents released from the plant). Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon where surface flow has not passed beyond the Laboratory's boundary since the plant began operation in 1963.

TA-50 Treatment Studies. Although the TA-50 Radioactive Liquid Waste Treatment Facility meets NPDES outfall criteria, personnel employed at TA-50 have embarked on efforts to improve effluent quality through alternate or combined treatment technologies. Current efforts are centered around membrane processes primarily because these processes have been successfully demonstrated in a number of industrial treatment plants to treat industrial wastes to high-quality effluent streams at high-productivity rates. Currently, ultrafiltration and reverse osmosis units are under evaluation to address their effectiveness in treating radioactive wastewater and providing better quality effluent.

Waste Stream Characterization Studies. EM-8 continued the waste stream identification and characterization program during 1993 in order to verify that each waste stream is correctly characterized and permitted under the proper outfall category. These studies consist of dye testing; interviews with user groups; and coordination with

Table VI-10. Quality of Nonradioactive Effluent Released from the TA-50 Radioactive Liquid Waste Treatment Plant in 1992 and 1993

Nonradioactive Constituents	Mean Concentration (mg/L)	
	1992	1993
Total Cd[a]	1.1×10^{-2}	2.29×10^{-3}
Ca	187	78
Cl	59	63
Total Cr[a]	3.2×10^{-2}	1.2×10^{-2}
Total Cu[a]	9.5×10^{-2}	0.13
Total Fe[a]	3	3
Total Hg[a]	1.8×10^{-3}	2.4×10^{-4}
Mg	0.2	0.9
Na	329	570
Total Pb[a]	3.5×10^{-2}	3.0×10^{-3}
Total Zn[a]	0.2	0.14
CN	0.1	0.2
COD[a]	18	26
NO_3-N	204	360
PO_4	0.2	0.4
TDS[b]	1,920	2,660
pH[a]	7.05–7.54	6.8–7.6
Total Effluent Volume (L)	1.99×10^7	2.17×10^7

[a]Regulated by NPDES permit.
[b]Total dissolved solids.

other Laboratory organizations to determine sources, concentrations, and volumes of pollutants that enter waste streams, receive treatment, and are discharged to the environment. Field surveys for waste stream identification and characterization have been completed for 100% of the Laboratory facilities.

c. Safe Drinking Water Act, Municipal and Industrial Water Supplies. This program includes sampling from various points in the Laboratory, the Los Alamos County, and Bandelier National Monument water distribution systems to ensure compliance with the Safe Drinking Water Act (SDWA) (40 CFR 141). 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 of New Mexico and are included in the NM Water Supply Regulations (NMEIB 1991). The NMED has been authorized by the EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

Compliance samples are analyzed for organic and inorganic constituents and for radioactivity at the State of New Mexico Scientific Laboratory Division (SLD) in Albuquerque. SLD reports the analytical results directly to the NMED. The JCI Environmental (JENV) Laboratory also collects samples from the Laboratory, Los Alamos County, and Bandelier National Monument distribution systems and tests the samples for microbiological contamination, as required under the SDWA. The JENV Laboratory is certified by NMED for microbiological testing of drinking water.

Chemical Analyses of Drinking Water. Trihalomethanes are organic byproducts of the use of chlorine to disinfect drinking water. Quarterly trihalomethane samples are collected at six locations throughout the distribution system (as shown in Table VI-11, all trihalomethane measurements were well below the MCL). The TA-33 sampling location showed the highest concentration due to its position at the end of a long distribution main.

Table VI-11. Total Trihalomethane Concentrations in the Water Distribution System (μg/L)

Sampling Location	1993 Quarters First	Second	Third	Fourth
Los Alamos Airport	1.90	N/A[a]	15.10	6.1
White Rock Fire Station	N[b]	0.2	2.67	N[b]
North Community Fire Station	N[b]	5.7	10.20	3.4
S-Site Fire Station	N[b]	2.5	6.05	0.7
Barranca School	N[b]	N/A[a]	1.55	0.8
TA-33, Bldg. 114	5.20	13.1	14.30	7.3

1993 Average	4.03 μg/L
MCL	100.00 μg/L
Laboratory Minimum Detectable Level (MDL)	4.00 μg/L

[a]N/A = insufficient sample for analysis due to laboratory error or no sample submitted.
[b]N = none detected above detection limit.

Samples analyzed for volatile organic compounds (VOCs) were drawn from each of the eight operating wells and combined into two composite samples by the analyst at SLD. All chemical results were in compliance with MCLs. These results are summarized in Table VI-12.

A new sampling program for lead and copper measured at residential taps was initiated in 1992 and continued throughout 1993 in accordance with the SDWA. The object of this program is to measure lead and copper in the tap water under circumstances that maximize the potential for the water to leach lead and copper from plumbing materials inside the home. The Laboratory cooperated with officials of Los Alamos County to identify and contact residents of single family homes with copper piping built between 1982 and 1987. The residents were given sample containers and instructions for collecting first draw samples. Residents returned the filled sample containers to the JENV Laboratory, where the samples were acidified and packaged for transport to the SLD for analysis.

Table VI-12. Volatile Organic Compounds in Drinking Water in 1993 (μg/L)

Sample Location	VOC Group I 63 Compounds
Well Head Composites	
Pajarito Mesa Wells 1, 2, 3, 5	N[a]
Guaje Wells G1a, G2, G5, Otowi Well 4	N[a]
MDL	1.0

[a]N = none detected above detection limit.

There is currently no MCL for lead or copper in the tap water. Instead an "action level" is set for each metal. If more than 10% of the samples from selected sites exceed the action level, water suppliers must take prescribed actions to monitor and control the corrosivity of the water supplied to the customers. If the 90th percentile values for lead and copper are less than the action levels, the system is in compliance without the need to implement corrosion control. As shown in Table VI-13, during 1993, none of the samples were above the EPA action levels for lead and copper.

In 1993, inorganic chemicals were sampled at four entry points to distribution and at nine well heads. Taps are flushed for several minutes so that samples represent water that is freshly drawn from the water main. As shown in Table VI-14, all locations and all parameters were below MCLs.

Table VI-13. Lead and Copper in Drinking Water at Residential Taps in 1993

Values	Lead	Copper
Less than or equal to detection limit	64 samples	21 samples
Detectable but less than action level	6 samples	49 samples
Greater than action level	0 samples	0 samples
Totals	70 samples	70 samples
MDL	5 µg/L	50 µg/L
90th percentile value	<5 µg/L	140 µg/L
EPA action level	15 µg/L	1,300 µg/L

Microbiological Analyses of the Water Distribution System. Each month during 1993, an average of 50 samples was collected from the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems to determine the free residual chlorine available for disinfection and the microbiological quality of the distribution systems. During 1993, of the 602 samples analyzed, 10 indicated the presence of coliforms, and 4 indicated the presence of fecal coliforms. Noncoliform bacteria were present in 49 of the microbiological samples. A summary of the monthly analytical data is found in Table VI-15. Noncoliform bacteria are not regulated, but their presence in repeated samples may serve as indicators of biofilm growth in water pipes.

3. Soils Monitoring.

Soils were analyzed for trace and heavy metals. These data will ultimately be used to establish a data base of results comparable to those reported by other agencies such as the United States Geological Survey; these data are meaningful from a Laboratory operation/effects standpoint as well as for geochemical process. The results of the 1992 and 1993 soil sampling program are found in Tables VI-16 and VI-17, respectively. An error in aluminum and iron were detected in the 1992 data (EPG 1994); therefore, these data are presented with the correct values.

Section V.B.6 presents information on the monitoring network used in this program.

1992 Soil Heavy Metal Monitoring Data. None of the results indicate any significant accumulation of metals above what can be attributed to natural concentrations (Table VI-16).

1993 Soil Heavy Metal Monitoring Data. Most all of the heavy metal values in soils collected from on-site and perimeter stations appear to be within the normal range based on the background current year's regional statistical reference level (CYRSRL) (Table VI-17). However, some metals, particularly beryllium in some on-site samples and cadmium in some perimeter samples, exceed their respective CYRSRL. Although beryllium and cadmium levels in soil samples collected from on-site and perimeter stations exceeded the CYRSRL, these values were still within the range of concentrations for heavy metals found in the Los Alamos area (Ferenbaugh 1990) and continental United States (Shacklette 1984). Also, most all heavy metals, with the exception of the beryllium and arsenic, were well below the Laboratory's screening action level (SAL). The SAL's for beryllium and arsenic are lower than background concentrations for the regional area.

Table VI-14. Inorganic Constituents in the Water Distribution System in 1993 (mg/L)

Sampling Location	As	Ba	Be	Cd	Cr	F	Hg	Ni	NO_3 (as N)	NO_2 (as N)	Se	Sb	Tl
Entry Points to Distribution													
Los Alamos Booster #4	<0.005	0.1	<0.0005	<0.001	<0.005	0.31	<0.0005	<0.005	0.37	N/A[a]	<0.005	<0.005	<0.001
Guaje Booster #2	0.015	<0.1	<0.0005	<0.001	0.006	0.57	<0.0005	<0.005	0.50	N/A	<0.005	<0.005	<0.001
Pajarito Booster #2	<0.005	<0.1	<0.0005	<0.001	<0.005	0.25	<0.0005	<0.005	0.33	N/A	<0.005	<0.005	<0.001
White Rock Fire Station	0.005	0.1	<0.0010	<0.001	<0.005	1.00[b]	<0.0005	<0.005	0.56	N/A	<0.005	<0.005	<0.001
Pajarito Well Field PM-1	0.001	<0.1	<0.0010	<0.001	0.003	0.20	<0.0005	<0.010	0.56	0.04	<0.005	<0.001	<0.001
Pajarito Well Field PM-2	<0.005	<0.1	<0.0010	<0.001	<0.005	0.17	<0.0005	<0.005	0.39	0.04	<0.005	N/A	N/A
Pajarito Well Field PM-3	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	0.52	0.04	[c]	[c]	[c]
Pajarito Well Field PM-4	0.001	0.1	<0.0010	<0.001	0.003	0.29	<0.0005	<0.010	[c]	[c]	<0.005	<0.001	<0.001
Pajarito Well Field PM-5	0.001	<0.1	<0.0010	<0.001	0.003	0.21	<0.0005	<0.010	0.37	0.04	<0.005	<0.001	<0.001
Otowi Well Field O-4	0.002	<0.1	<0.0010	<0.001	<0.005	0.26	<0.0005	<0.010	0.42	0.04	<0.005	<0.001	<0.001
Guaje Well Field G-1A	0.010	<0.1	<0.0010	<0.001	0.003	0.54	<0.0005	<0.010	0.50	0.04	<0.005	<0.001	<0.001
Guaje Well Field G-2	0.041	<0.1	<0.0010	<0.001	0.008	0.99	<0.0005	<0.010	0.48	0.04	<0.005	<0.001	<0.001
Guaje Well Field G-5	0.001	<0.1	<0.0010	<0.001	0.002	0.25	<0.0005	<0.010	0.69	0.04	<0.005	<0.001	<0.001
EPA MCLs	0.050[d]	2.0	0.0040	0.005	0.100	4.00	0.0020	0.100	10.00	1.00	0.050	0.006	0.002

[a]N/A means analysis not performed, lost in analysis, or not completed.

[b]The White Rock water supply is fluoridated by Los Alamos County.

[c]The well was out of service during sampling.

[d]There is no EPA MCL for As, only a New Mexico Water Supply Regulations standard

Table VI-15. Microbiological Sampling of the Water Distribution System in 1993

Month	No. of Samples Collected	No. of Positive Tests		
		Coliform[a]	Fecal Coliform	Noncoliform
January	49	0	0	2
February	45	0	0	1
March	48	0	0	6
April	48	0	0	2
May	47	0	0	11
June	54	1	1	8
July	50	0	0	1
August	70	8	2	11
September	52	1	1	1
October	45	0	0	1
November	48	0	0	1
December	46	0	0	4
Total 1993	602	10	4	49
MCL (5% of samples collected)		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.

4. Sediment Monitoring.

Beginning in 1992, sediments from known radioactive effluent release areas were analyzed for trace metals. These analyses are being made to establish a database of results comparable to those reported by other agencies such as the US Geological Survey. Hopefully these data will be meaningful for accounting for variations in natural geochemical processes. The monitoring network, including individual sample locations, is described in detail in Section V.B.5.b. All of the sediment sampling locations are shown in Figures V-15, V-16, and V-17 (Solid Waste Management Areas). The specific coordinates of these locations are listed in Table D-17.

Trace Metal Analysis. Trace metal results for the sediment samples collected in 1993 are presented in Table VI-18. None of the results show any indication of any significant accumulations of metals above what can be attributed to natural concentrations. Beginning in September 1992, all soil and sediment samples were prepared in the laboratory following EPA procedures specified in SW-846 Method 3050. Hence, individual station concentration values from 1992 to 1993 for specific metals may differ due to variability in nature or in laboratory sample preparation procedures. Some of the effects of these procedural differences are summarized below.

Reported detection limits for antimony, mercury, and molybdenum increased from 1992 to 1993 (i.e., from about 0.05 μg/g, 0.01 μg/g, and 0.30 μg/g, respectively, to about 0.20 μg/g, 0.10 μg/g, and 2.0 μg/g, respectively). These differences probably resulted from a decrease in the typical sediment sample size from 250 mg in 1992 to 125 mg in 1993; in addition, the sediment sample preparation procedures also changed. Furthermore, the reported 1992 iron values were two to three times higher than their respective counterparts in 1993, and the 1992 aluminum values were about 10 times larger than their 1993 counterparts. Note that the reported 1992 values for aluminum and iron in Table IV-22 of the Environmental Surveillance Report for 1992 should each be multiplied by a factor of 10; this omission resulted from a units conversion error. The concentration differences between aluminum and iron

Table VI-16. Total Recoverable Trace and Heavy Metals In Soils Collected in 1992[a,b]

Stations	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg
OFF-SITE STATIONS												
REGIONAL (BACKGROUND) STATIONS												
Rio Chama	<1.0[c]	4.94	2.07	19	103	0.55	<0.5	9.0	4.0	5.5	1.65	<0.01
Embudo	<1.0	5.09	1.50	23	102	0.70	<0.5	8.0	5.0	7.0	1.56	<0.01
Otowi	<1.0	6.19	0.69	11	91	0.67	<0.5	6.6	4.0	7.0	1.52	<0.01
Santa-Cruz	<1.0	5.16	4.70	16	184	1.00	<0.5	16.0	6.0	10.0	2.10	0.01
Cochiti	<1.0	4.91	2.28	15	161	0.70	<0.5	11.0	6.0	9.0	1.84	<0.01
Bernalillo	<1.0	3.93	7.50	20	233	0.70	<0.5	10.0	4.0	8.0	1.45	<0.01
Jemez	<1.0	4.58	2.37	22	180	0.80	<0.5	10.0	4.0	9.0	1.35	0.02
PERIMETER STATIONS												
Sportsman Club	<1.0	5.74	1.36	9	70	0.72	<0.5	6.0	5.0	5.0	1.36	<0.01
North Mesa	<1.0	5.42	3.23	13	133	1.00	<0.5	11.0	7.0	9.0	1.71	0.01
TA-8	3.0	5.81	2.34	7	83	0.50	<0.5	3.6	4.0	6.5	1.19	0.01
TA-49	<1.0	5.64	3.95	17	193	1.20	<0.5	12.0	8.0	8.0	1.81	0.02
White-Rock	<1.0	6.03	2.48	21	170	1.30	<0.5	11.0	6.0	8.0	1.98	<0.01
Tsankawi	<1.0	6.00	1.01	22	62	1.10	<0.5	3.1	2.4	3.5	1.35	<0.01
ON-SITE STATIONS												
TA-21	N/A[d]	5.13	0.00	22	N/A	N/A	N/A	N/A	8.0	N/A	1.57	N/A
East of TA-53	<1.0	5.88	2.70	21	82	1.00	<0.5	9.0	2.8	7.0	1.49	0.02
TA-50	2.3	6.29	2.28	24	166	1.20	<0.5	12.0	7.0	7.0	1.93	0.03
2-Mile Mesa	<1.0	4.79	3.31	23	112	1.00	<0.5	10.0	4.0	3.4	1.30	0.01
East of TA-54	<1.0	6.07	1.34	26	88	0.90	<0.5	6.9	4.0	4.9	1.50	<0.01
R-Site-RD-E	<1.0	4.96	2.18	48	96	0.80	<0.5	9.0	6.0	3.1	1.45	<0.01
Potrillo-DR	<1.0	5.48	2.23	39	116	0.97	<0.5	11.0	7.0	5.8	1.68	<0.01
S-Site	<1.0	4.75	2.86	26	114	1.00	<0.5	11.0	4.0	2.9	1.31	<0.01
Near Well DT-9	<1.0	6.32	2.83	32	178	1.40	<0.5	13.0	6.0	7.0	1.87	0.02
Near TA-33	<1.0	5.78	2.00	30	97	1.40	<0.5	12.0	5.0	7.4	1.80	0.01

Table VI-16. (Cont.)

Stations	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
OFF-SITE STATIONS											
REGIONAL (BACKGROUND) STATIONS											
Rio Chama	171	<0.4	10	8	<0.20	0.45	14	44	<2.0	20.0	23
Embudo	257	<0.4	10	12	<0.20	0.39	15	29	<2.0	16.0	27
Otowi	254	0.7	9	10	0.20	2.10	13	44	4.0	16.0	33
Santa-Cruz	328	<0.4	14	11	0.26	0.68	21	103	<2.0	32.0	43
Cochiti	316	<0.4	12	17	0.30	0.43	17	94	1.3	26.0	37
Bernalillo	211	0.6	9	11	0.24	0.72	20	265	<2.0	26.0	30
Jemez	412	<0.4	8	21	0.15	0.42	26	41	2.0	21.0	50
PERIMETER STATIONS											
Sportsman Club	292	<0.5	7	33	2.00	<2.00	10	19	<2.0	11.0	32
North Mesa	522	<0.4	10	15	0.20	0.30	13	27	4.0	29.0	34
TA-8	44	50.4	5	21	<0.20	0.26	10	19	<2.0	9.4	36
TA-49	62	10.4	12	19	0.19	0.41	14	36	<2.0	28.0	35
White-Rock	392	<0.4	11	84	0.19	0.33	13	36	<2.0	21.0	47
Tsankawi	25	80.4	5	22	<0.20	0.20	8	15	<2.0	6.4	23
ON-SITE STATIONS											
TA-21	N/A	N/A	10	N/A	N/A	0.00	N/A	N/A	N/A	N/A	N/A
East of TA-53	183	<0.4	7	24	<0.20	0.31	13	19	<2.0	16.0	45
TA-50	376	<0.4	11	16	<0.20	0.40	16	33	<2.0	28.0	37
2-Mile Mesa	516	<0.4	7	17	<0.20	0.35	15	29	<2.0	34.0	22
East of TA-54	324	<0.4	7	18	<0.20	0.22	12	19	<2.0	13.0	41
R-Site-RD-E	278	<0.4	8	12	<0.20	0.31	13	26	<2.0	24.0	20
Potrillo-DR	370	<0.4	10	14	<0.20	0.26	14	23	<2.0	23.0	29
S-Site	482	<0.4	7	14	<0.20	0.27	15	30	<2.0	30.0	23
Near Well DT-9	348	<0.4	11	16	<0.20	0.38	16	32	<2.0	27.0	40
Near TA-33	28	70.6	10	19	<0.20	0.38	15	28	<2.0	20.0	41

[a] This table contains corrected Al and Fe values.
[b] All metals with the exception of Al (%) and Fe (%) are expressed in µg/g.
[c] The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.
[d] N/A means analysis not performed, lost in analysis, or not completed.

Tables VI-17. Total Recoverable Trace and Heavy Metals in Soils Collected in 1993[a,b]

Stations	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg
OFF-SITE REGIONAL (BACKGROUND) STATIONS												
Rio Chama	<1.0[c]	0.58	1.9	<1.0	100	0.32	<0.40	14.0	5.5	6.5	1.70	<0.01
Embudo	<1.0	0.78	1.1	1.9	75	0.37	<0.40	10.0	3.6	4.3	1.20	<0.01
Otowi	<1.0	0.44	1.0	2.1	66	0.41	<0.40	4.1	2.5	4.7	0.52	<0.01
Santa-Cruz	<1.0	1.70	3.0	8.0	200	0.74	<0.40	18.0	6.0	8.0	1.70	<0.01
Cochiti	<1.0	1.30	2.3	4.5	110	0.59	<0.40	14.0	5.8	7.5	1.70	<0.01
Bernalillo	<1.0	0.59	5.9	7.2	180	0.40	<0.40	6.6	3.5	8.7	0.77	<0.01
Jemez	4.2	0.78	2.5	9.0	120	0.55	<0.40	8.2	4.0	10.0	0.78	<0.01
Mean (±2SD)	1.5 (2.4)	0.88 (0.91)	2.5 (3.3)	4.8 (6.5)	122 (101)	0.48 (0.30)	<0.40 (0.0)	10.7 (9.7)	4.4 (2.7)	7.1 (4.2)	1.20 (1.02)	<0.10 (0.0)
CYRSRL[d]	3.9	1.79	5.8	11.3	223	0.78	<0.40	20.4	7.1	11.3	2.20	<0.10
SAL[e]	400.0		0.4		5600	0.16	80.00	400.0				24.00
OFF-SITE PERIMETER STATIONS												
Sportsman's Club	<1.0	0.65	1.7	1.6	74	0.67	<1.00	4.9	4.9	3.6	0.65	<0.01
North Mesa	<1.0	1.10	2.5	3.4	130	0.80	0.49	10.0	7.8	5.3	1.20	<0.01
TA-8	<1.0	0.87	2.3	<3.0	150	0.60	0.67	7.6	4.9	8.5	0.99	<0.01
TA-49	<1.0	0.75	2.2	<1.0	59	0.55	0.50	5.9	2.6	3.6	0.80	<0.01
White-Rock	<1.0	0.85	1.7	3.0	120	0.77	<0.40	11.0	5.5	6.6	0.94	<0.01
Tsankawi	<1.0	0.47	1.1	<1.0	47	0.74	<0.40	3.4	1.8	3.6	0.43	<0.01
Mean (±2SD)	<1.0 (0.0)	0.78 (0.43)	1.9 (1.0)	2.2 (2.2)	97 (84)	0.69 (0.20)	0.58 (0.46)	7.1 (5.9)	4.6 (4.3)	5.2 (4.0)	0.84 (0.54)	<0.10 (0.0)
ON-SITE STATIONS												
TA-21	<1.0	1.20	3.0	2.7	130	0.85	<0.40	9.7	7.2	4.8	1.20	<0.01
East of TA-53	<1.0	1.00	3.5	<1.0	120	0.79	<0.40	7.9	5.0	5.2	1.10	<0.01
TA-50	<1.0	1.60	2.6	2.2	150	0.93	<0.40	11.0	6.1	6.4	1.30	<0.01
2-Mile Mesa	3.5	0.72	2.3	2.1	140	0.54	<0.40	6.1	4.1	7.6	0.92	<0.01
East of TA-54	<1.0	0.51	1.4	2.3	54	0.48	<0.40	3.7	2.5	5.2	0.48	<0.01
R-Site-RD-E	<1.0	1.30	2.7	<1.0	170	0.96	<0.40	7.4	5.2	6.3	1.00	<0.01
Potrillo-DR	<1.0	1.20	2.7	3.6	120	0.94	<0.40	10.0	5.5	5.6	1.30	<0.01
S-Site	11.0	0.87	2.2	1.5	140	0.72	<0.40	6.4	4.6	5.5	0.86	<0.01
Near Well DT-9	<1.0	0.98	1.9	<1.0	130	0.78	<0.40	6.1	4.1	6.2	0.73	<0.01
Near TA-33	<1.0	2.60	4.5	5.0	350	1.80	<0.40	17.0	6.2	14.0	1.80	<0.01
Mean (±2SD)	2.0 (6.0)	1.20 (1.60)	2.7 (1.7)	2.2 (2.6)	150 (153)	0.88 (0.72)	<0.40 (0.0)	8.5 (7.4)	5.1 (2.6)	6.7 (5.4)	10.70 (0.73)	<0.10 (0.0)

Table VI-17. (Cont.)

Stations	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
OFF-SITE REGIONAL (BACKGROUND) STATIONS											
Rio Chama	240	<2.0	6.1	16	<0.12	<0.20	<8.0	44	<0.12	39.0	35
Embudo	200	<2.0	5.0	<6	<0.12	<0.20	<8.0	18	<0.12	24.0	25
Otowi	180	<2.0	<2.0	10	<0.20	<0.20	<8.0	20	<0.20	9.5	23
Santa-Cruz	280	<2.0	9.0	13	<0.12	0.40	<8.0	110	0.25	37.0	39
Cochiti	320	<2.0	8.3	<6	<0.12	<0.20	<8.0	49	0.12	38.0	38
Bernalillo	170	<2.0	6.1	12	<0.20	0.40	<8.0	240	0.20	14.0	26
Jemez	330	<2.0	6.1	19	<0.20	<0.20	<8.0	32	<0.20	14.0	37
Mean (±2SD)	246 (132)	<2.0 (0.0)	6.1 (4.6)	12 (10)	0.15 (0.10)	0.26 (0.20)	<8.0 (0.0)	73 (160)	0.17 (0.10)	25 (26)	32 (14)
CYRSRL	378	<2.0	10.7	22	0.25	0.46	<8.0	233	0.27	51	46
SAL			1600.0	500	32.00	400.00			6.40		
OFF-SITE PERIMETER STATIONS											
Sportsman Club	370	<2.0	5.0	15	<0.20	<0.20	<5.0	13	0.20	11.0	19
North Mesa	480	<2.0	7.2	21	<0.12	<0.20	<8.0	24	0.12	24.0	33
TA-8	730	<2.0	6.7	19	<0.20	0.40	<8.0	33	<0.20	15.0	51
TA-49	170	<2.0	4.0	12	<0.20	<0.20	<8.0	11	<0.20	11.0	22
White-Rock	420	<2.0	5.7	48	<0.20	<0.20	<8.0	17	0.20	16.0	43
Tsankawi	210	<2.0	<2.0	28	<0.20	<0.20	<8.0	11	0.20	6.0	27
Mean (±2SD)	397 (405)	<2.0 (0.0)	5.1 (3.8)	24 (26)	0.19 (0.07)	0.23 (0.16)	7.5 (2.5)	18 (18)	0.19 (0.07)	14 (12)	33 (25)
ON-SITE STATIONS											
TA-21	360	<2.0	8.0	15	<0.20	<0.20	<8.0	26	0.20	25.0	30
East of TA-53	180	<2.0	7.0	20	<0.20	<0.20	<8.0	24	0.30	19.0	42
TA-50	340	<2.0	8.7	18	<0.20	<0.20	<8.0	28	0.30	24.0	35
2-Mile Mesa	690	<2.0	5.7	21	<0.20	0.40	<8.0	30	<0.20	13.0	48
East of TA-54	170	<2.0	3.2	19	<0.20	0.30	<8.0	10	<0.20	7.8	31
R-Site-RD-E	320	<2.0	7.5	17	<0.20	<0.20	<8.0	25	0.20	18.0	26
Potrillo-DR	380	<2.0	8.2	20	<0.20	<0.20	<8.0	30	0.20	22.0	40
S-Site	570	<2.0	6.3	17	<0.20	0.50	<8.0	22	0.20	13.0	29
Near Well DT	220	<2.0	5.3	12	<0.20	0.30	<8.0	22	0.20	12.0	20
Near TA-33	230	<2.0	14.0	25	<0.20	<0.20	<8.0	51	0.30	25.0	54
Mean (±2SD)	346 (339)	<2.0 (0.0)	7.4 (5.7)	18 (7)	<0.20 (0.0)	0.27 (0.21)	<8.0 (0.0)	27 (21)	0.23 (0.1)	18 (12)	36 (21)

[a] All metals with the exception of Al (%) and Fe (%) are expressed in µg/g.

[b] Analysis by EPA Method 3051 for total recoverable metals.

[c] The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.

[d] CYRSRL (Current Year Regional Statistical Reference Level); the upper-limit background concentration = mean + 2SD.

[e] SAL (Los Alamos National Laboratory Screening Action Level).

Table VI-18. Total Recoverable Trace and Heavy Metals[a] from Sediments for 1993 (µg/g)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg[a]
OFF-SITE STATIONS												
REGIONAL STATIONS												
Rio Chama at Chamita	<1.0[b]	3,300.0	0.90	<3.0	40.00	0.22	<0.40	2.00	3.00	1.50	3,600.0	<0.1
Rio Grande at Embudo	<1.0	7,600.0	2.30	<3.0	160.00	0.54	<0.40	5.90	12.00	7.00	12,000.0	<0.1
Rio Grande at Otowi	N/A[c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Frijoles	<1.0	8,900.0	2.40	3.9	190.00	0.53	<0.40	5.20	11.00	5.80	11,000.0	<0.1
Rio Grande at Cochiti	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Bernalillo	<1.0	3,500.0	2.00	<3.0	130.00	0.24	<0.40	2.90	4.30	2.90	6,200.0	<0.1
Jemez River	<1.0	2,100.0	3.60	<3.0	18.00	0.24	<0.40	1.10	1.70	1.20	4,000.0	<0.1
Rio Grande in White Rock Canyon												
Rio Grande at Sandia	<1.0	8,300.0	2.00	3.3	190.00	0.51	<0.40	7.00	10.00	5.20	11,000.0	<0.1
Rio Grande at Mortandad	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Pajarito	<1.0	11,000.0	2.80	4.8	180.00	0.64	<0.40	7.20	11.00	6.90	12,000.0	<0.1
Rio Grande at Water	<1.0	8,400.0	2.70	3.4	190.00	0.53	<0.40	5.50	10.00	6.10	11,000.0	<0.1
Rio Grande at Ancho	<1.0	5,600.0	2.20	<3.0	110.00	0.39	<0.40	4.60	7.60	4.10	7,800.0	<0.1
Rio Grande at Chaquehui	<1.0	5,600.0	1.60	<3.0	190.00	0.42	<0.40	6.80	17.00	2.50	19,000.0	<0.1
PERIMETER STATIONS												
Radioactive Effluent Release Areas												
Acid-Pueblo Canyon												
Acid Weir	<1.0	2,200.0	1.50	<3.0	24.00	0.28	<0.40	2.20	5.40	4.10	8,600.0	<0.1
Pueblo 1	<1.0	1,600.0	0.90	<3.0	23.00	0.26	<0.40	2.20	3.80	1.70	4,700.0	<0.1
Pueblo 2	<1.0	2,700.0	<0.20	<3.0	20.00	0.31	<0.40	2.40	3.70	<0.70	15,000.0	<0.1
DP-Los Alamos Canyon												
Los Alamos at Totavi	7.5[d]	5,500.0[d]	1.15[d]	<3.0[d]	58.50[d]	0.43[d]	<0.40[c*]	3.35[d]	5.95[c*]	5.90[d]	7,700.0[d]	<0.1[c]
Los Alamos at LA-2	<1.0[d]	2,450.0[d]	0.66[d]	<3.0[d]	37.50[d]	0.27[d]	<0.40[d]	3.20[d]	4.10[d]	3.80[d]	6,750.0[d]	<0.1[c]
Los Alamos at Otowi	<1.0[d]	1,433.3[d]	0.66[d]	0.5[d]	30.67[d]	0.15[d]	<0.40[d]	2.70[d]	2.30[d]	1.80[d]	3,566.7[d]	<0.1[c]
Other Areas												
Guaje At SR 4	<1.0	1,900.0	0.40	<3.0	22.00	0.17	<0.40	2.30	4.40	3.20	5,200.0	<0.1
Bayo at SR 4	<1.0	1,900.0	<0.20	<3.0	22.00	0.16	<0.40	2.20	4.00	3.60	5,500.0	<0.1
Sandia at Rio Grande	<1.0[d]	3,600.0[d]	0.80[d]	<3.0[d]	47.00[d]	0.31[d]	<0.40[d]	4.90[d]	7.40[d]	4.40[d]	10,650.0[d]	<0.1[c]
Cañada Ancha at Rio Grande	<1.0	2,800.0	2.00	<3.0	40.00	0.29	<0.40	4.30	4.90	3.50	8,100.0	<0.1
Pajarito at Rio Grande	<1.0	2,000.0	2.30	<3.0	17.00	0.11	<0.40	2.90	4.00	2.30	6,400.0	<0.1
Water at Rio Grande	<1.0	21,000.0	2.20	5.0	170.00	1.30	<0.40	6.50	12.00	8.40	16,000.0	<0.1
Ancho at Rio Grande	<1.0	4,100.0	0.70	<3.0	33.00	0.31	<0.40	4.10	3.40	3.40	5,700.0	<0.1
Chaquehui at Rio Grande	<1.0	5,500.0	0.70	<3.0	60.00	0.44	<0.40	5.10	6.80	4.90	14,000.0	<0.1
Frijoles at Monument HQ	<1.0	2,800.0	<0.20	<3.0	18.00	0.32	<0.40	1.40	2.40	1.00	4,800.0	<0.1
Frijoles at Rio Grande	<1.0	2,000.0	<0.20	<3.0	17.00	0.22	<0.40	3.60	2.70	1.50	6,900.0	<0.1
Mortandad Canyon on Pueblo of San Ildefonso Lands												
Mortandad A-6	<1.0	2,100.0	0.83	<1.0	14.00	0.18	<0.40	0.60	1.60	1.90	2,700.0	<0.1[c]
Mortandad Transect at Boundary Near A-6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad A-7	<1.0	2,400.0	0.96	<1.0	19.00	0.28	<0.40	1.00	1.50	0.50	6,500.0	<0.1[c]
Mortandad A-8	<1.0	4,800.0	0.97	2.5	37.00	0.40	<0.40	2.20	2.70	1.50	6,600.0	<0.1[c]
Mortandad at SR 4 (A-9)	<1.0[d]	5,100.0[d]	1.13[d]	<3.0[d]	63.00[d]	0.49[d]	<0.40[d]	3.45[d]	4.40[d]	1.80[d]	7,600.0[d]	<0.1[c]
Mortandad A-10	<1.0	5,300.0	1.50	<1.0	85.00	0.49	<0.40	2.60	4.60	2.50	6,900.0	<0.1[c]
Mortandad at Rio Grande (A-11)	<1.0	2,800.0	0.90	<3.0	30.00	0.19	<0.40	3.90	4.40	4.00	5,900.0	<0.1

[a]Data on additional trace metals from sediments are presented beginning on page V-25.

Table VI-18. (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
ON-SITE STATIONS												
Radioactive Effluent Release Areas												
Acid Pueblo Canyon												
Hamilton Bend Spring	<1.0	1,900.0	0.50	<3.0	21.00	0.22	<0.40	2.00	5.00	<0.50	6,500.0	<0.1
Pueblo 3	<1.0	3,100.0	0.40	<3.0	43.00	0.39	<0.40	3.40	3.20	1.40	6,400.0	<0.1
Pueblo at SR 4	<1.0	5,200.0	0.70	<3.0	34.00	0.58	<0.40	2.30	3.50	2.30	5,300.0	<0.1
DP–Los Alamos Canyon												
DPS-1	<1.0	1,200.0	1.00	<3.0	12.00	0.11	<0.40	1.40	1.70	<0.50	2,600.0	<0.1
DPS-4	<1.0	4,700.0	0.70	<3.0	50.00	0.30	<0.40	3.00	5.20	<0.50	7,100.0	<0.1
Los Alamos at Bridge	<1.0	2,000.0	1.40	<3.0	23.00	0.13	<0.40	2.80	4.10	<0.50	4,600.0	<0.1
Los Alamos at LAO-1	<1.0	3,900.0	1.30	<3.0	67.00	0.35	<0.40	3.30	10.00	<0.50	7,100.0	0.2
Los Alamos at GS-1	<1.0	1,600.0	1.00	<3.0	13.00	0.15	<0.40	0.88	2.20	<0.50	2,800.0	<0.1
Los Alamos at LAO-3	<1.0	1,900.0	<0.20	<3.0	22.00	0.19	<0.40	1.10	3.90	<0.50	12,000.0	<0.1
Los Alamos at LAO-4.5	<1.0	2,200.0	0.40	<3.0	34.00	0.19	<0.40	2.50	3.70	<0.50	4,800.0	<0.1
Los Alamos at SR 4	6.5[d]	2,050.0[d]	0.71[d]	<3.0[d]	30.00[d]	0.29[d]	<0.40[d]	2.20[d]	3.45[d]	5.30[d]	4,950.0[d]	<0.1[c]
Mortandad Canyon												
Mortandad near CMR	<1.0	3,900.0	2.00	<3.0	40.00	0.22	<0.40	3.00	6.70	<0.50	7,300.0	<0.1
Mortandad W GS-1	<1.0	2,500.0	0.50	<3.0	27.00	0.13	<0.40	2.20	4.30	<0.50	5,900.0	<0.1
Mortandad at GS-1	<1.0	1,900.0	0.60	<3.0	20.00	0.18	<0.40	3.00	2.00	<0.50	4,900.0	<0.1
Mortandad at MCO-5	<1.0	2,100.0	0.80	<3.0	19.00	0.18	<0.40	1.70	2.10	<0.50	4,200.0	<0.1
Mortandad at MCO-7	<1.0	1,900.0	0.40	<3.0	12.00	0.17	<0.40	1.40	1.10	<0.50	2,700.0	<0.1
Mortandad at MCO-9	<1.0	5,100.0	1.00	<3.0	49.00	0.50	<0.40	1.90	3.40	<0.50	8,200.0	<0.1
Mortandad at MCO-13 (A-5)	<1.0	4,300.0	0.70	<3.0	34.00	0.38	<0.40	1.90	2.50	<0.50	5,400.0	<0.1
Other Areas												
Sandia at SR 4	5.1[d]	2,050.0[d]	0.93[d]	<3.0[d]	17.00[d]	0.26[d]	<0.40[d]	2.10[d]	4.80[d]	1.55[d]	3,750.0[d]	<0.1[c]
Cañada Del Buey at SR 4	<1.0	3,200.0	0.30	<3.0	31.00	0.28	<0.40	2.30	3.80	0.92	6,700.0	<0.1
Pajarito at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potrillo at SR 4	<1.0	4,400.0	1.30	<3.0	46.00	0.47	<0.40	2.80	4.90	1.70	9,800.0	<0.1
Fence at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water at SR 4	<1.0	2,100.0	<0.20	<3.0	17.00	0.26	<0.40	1.50	2.00	0.97	3,700.0	<0.1
Indio at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at SR 4	<1.0	4,400.0	0.70	<3.0	35.00	0.39	<0.40	2.30	3.60	2.40	6,000.0	<0.1
TA-54, Area G												
GS-1	<1.0	6,400.0	1.00	3.8	58.00	0.46	<0.40	3.00	5.20	1.60	7,300.0	<0.1
GS-2	<1.0	4,000.0	1.00	1.6	45.00	0.29	<0.40	3.00	4.30	<1.00	9,900.0	<0.1
GS-3	<1.0	11,000.0	1.70	4.1	110.00	0.74	<0.40	3.90	7.60	3.70	11,000.0	<0.1
GS-4	<1.0	5,100.0	1.00	2.9	46.00	0.63	<0.40	2.00	3.20	<1.00	7,700.0	<0.1
GS-5	<1.0	5,100.0	0.60	2.2	46.00	0.38	<0.40	6.50	3.50	1.40	5,300.0	<0.1
GS-6	<1.0	4,000.0	0.90	<1.0	42.00	0.38	<0.40	4.00	6.10	<1.00	11,000.0	<0.1
GS-7	<1.0	6,200.0	1.00	2.6	68.00	0.52	<0.40	3.50	4.40	1.20	7,100.0	<0.1
GS-8	<1.0	1,800.0	0.50	1.3	17.00	0.11	<0.40	1.70	2.80	<1.00	2,800.0	<0.1
GS-9	<1.0	21,000.0	3.00	5.4	83.00	1.40	<0.40	4.60	13.00	5.20	15,000.0	<0.1
TA-49, Area AB												
AB-1	<1.0	8,200.0	1.50	<1.0	51.00	0.51	<0.40	4.00	8.70	2.90	11,000.0	<0.1
AB-2	<1.0	15,000.0	4.40	2.0	170.00	0.88	<0.40	7.40	12.00	6.50	15,000.0	<0.1
AB-3	<1.0	22,000.0	3.00	4.0	210.00	1.10	<0.40	6.80	14.00	7.20	16,000.0	<0.1

*Data on additional trace metals from sediments are presented beginning on page V-26.

Table VI-18. (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
Other Areas (Cont.)												
TA-49, Area AB (Cont.)												
AB-4	<1.0	13,000.0	1.90	2.5	120.00	0.69	<0.40	4.00	9.00	4.10	9,800.0	<0.1
AB-4A	<1.0	21,000.0	2.00	4.0	190.00	0.98	<0.40	7.00	14.00	6.20	16,000.0	<0.1
AB-5	<1.0	21,000.0	3.90	3.0	180.00	1.00	0.45	9.00	14.00	4.80	15,000.0	<0.1
AB-6	<1.0	32,000.0	4.80	5.0	200.00	1.50	<0.40	5.90	15.00	6.40	17,000.0	<0.1
AB-7	<1.0	24,000.0	5.50	4.0	120.00	1.30	0.49	6.30	15.00	<0.60	18,000.0	<0.1
AB-8	<1.0	11,000.0	2.60	2.1	69.00	0.67	<0.40	3.20	7.70	3.60	11,000.0	<0.1
AB-9	<1.0	6,200.0	4.80	<1.0	53.00	0.35	<0.40	4.70	5.20	1.50	8,900.0	<0.1
AB-10	<1.0	16,000.0	2.60	3.6	120.00	0.74	<0.40	6.60	13.00	4.90	14,000.0	<0.1
AB-11	<1.0	15,000.0	2.80	<1.0	140.00	1.00	<0.40	8.00	13.00	6.40	15,000.0	<0.1

*Data on additional trace metals from sediments are presented beginning on page V-27.

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
REGIONAL STATIONS											
Rio Chama at Chamita	85.0	<2.0	<2.0	<5.0	<0.12	<0.20	<8.0	16.00	<0.12	7.20	11.0
Rio Grande at Embudo	370.0	<2.0	7.5	7.6	<0.12	<0.20	<8.0	43.00	<0.12	25.00	41.0
Rio Grande at Otowi	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Frijoles	250.0	<2.0	9.3	<5.0	<0.20	<0.20	<8.0	97.00	<0.20	22.00	33.0
Rio Grande at Cochiti	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Bernalillo	170.0	<2.0	3.6	<5.0	<0.12	<0.20	<8.0	47.00	<0.12	11.00	14.0
Jemez River	140.0	<2.0	<2.0	<5.0	<0.12	<0.20	<8.0	3.60	<0.12	3.90	20.0
Rio Grande in White Rock Canyon											
Rio Grande at Sandia	230.0	<2.0	9.5	<5.0	<0.20	<0.20	<8.0	76.00	<0.20	24.00	26.0
Rio Grande at Mortandad	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Pajarito	260.0	<2.0	9.8	<5.0	<0.20	0.30	<8.0	100.00	<0.20	24.00	35.0
Rio Grande at Water	250.0	<2.0	9.6	<5.0	<0.20	0.30	<8.0	85.00	<0.20	23.00	27.0
Rio Grande at Ancho	170.0	<2.0	5.9	<5.0	<0.20	<0.20	<8.0	49.00	<0.20	16.00	19.0
Rio Grande at Chaquehui	230.0	<2.0	8.0	<5.0	<0.20	<0.20	<8.0	37.00	<0.20	48.00	29.0
PERIMETER STATIONS											
Radioactive Effluent Release Areas											
Acid-Pueblo Canyons											
Acid Weir	260.0	<2.0	<2.0	32.0	<0.12	<0.20	<8.0	4.60	<0.12	8.10	62.0
Pueblo 1	290.0	<2.0	<2.0	26.0	<0.12	<0.20	<8.0	3.80	<0.12	4.80	34.0
Pueblo 2	320.0	<2.0	<2.0	8.1	<0.12	<0.20	<8.0	6.00	<0.12	11.00	72.0
DP-Los Alamos Canyons											
Los Alamos at Totavi	210.0[d]	<2.0[d]	2.3[d]	10.0[d]	<0.10[d]	0.60[d]	<8.0[d]	14.50[d]	<0.10[d]	14.50[d]	32.0[c]
Los Alamos at LA-2	210.0[d]	<2.0[d]	3.5[d]	6.0[d]	<0.10[d]	0.25[d]	<8.0[d]	6.75[d]	<0.10[d]	10.20[d]	29.5[c]
Los Alamos at Otowi	128.0[d]	<2.0[d]	2.9[d]	2.0[d]	<0.12[d]	<0.20[d]	<8.0[d]	7.93[d]	<0.12[d]	6.00[d]	12.1[c]
Other Areas											
Guaje At SR 4	88.0	<2.0	<2.0	<5.0	<0.12	<0.20	<8.0	5.70	<0.12	12.00	12.0
Bayo at SR 4	99.0	<2.0	3.9	<5.0	<0.12	<0.20	<8.0	5.40	<0.12	12.00	12.0
Sandia at Rio Grande	210.0[d]	<2.0[d]	10.9[d]	8.2[d]	<0.20[d]	<0.20[d]	<8.0[d]	17.50[d]	<0.20[d]	21.50[d]	25.0[c]
Cañada Ancha at Rio Grande	150.0	<2.0	7.7	<5.0	<0.20	<0.20	<8.0	16.00	<0.20	17.00	17.0
Pajarito at Rio Grande	98.0	<2.0	5.0	<5.0	<0.20	<0.20	<8.0	8.20	<0.20	9.50	21.0

Table VI-18. (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Other Areas (Cont.)											
Water at Rio Grande	390.0	<2.0	11.0	14.0	<0.20	<0.20	<8.0	29.00	<0.20	24.00	47.0
Ancho at Rio Grande	150.0	<2.0	<2.0	<5.0	<0.20	<0.20	<8.0	9.70	<0.20	8.40	21.0
Chaquehui at Rio Grande	350.0	<2.0	11.0	<5.0	<0.20	<0.20	<8.0	13.00	<0.20	20.00	45.0
Frijoles at Monument HQ	190.0	<2.0	<2.0	<5.0	<0.12	<0.20	<8.0	4.40	<0.12	4.60	23.0
Frijoles at Rio Grande	240.0	<2.0	<2.0	<5.0	<0.20	<0.20	<8.0	6.30	<0.20	6.90	31.0
Mortandad Canyon on Pueblo of San Ildefonso Lands											
Mortandad A-6	110.0	<1.0	<2.0	7.3	<0.10	<0.20	<4.0	1.70	<0.02	2.30	17.0
Mortandad Transect at Boundary Near A-6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad A-7	280.0	<1.0	<2.0	1.0	<0.10	<0.20	<4.0	2.70	<0.02	3.70	38.0
Mortandad A-8	280.0	1.8	3.4	6.0	<0.02	<0.20	<4.0	5.20	0.07	7.30	33.0
Mortandad at SR 4 (A-9)	345.0[d]	<2.0[d]	4.2[d]	8.0[d]	<0.12[d]	<0.20[d]	<8.0[d]	7.85[d]	0.09[d]	11.70[d]	30.0[c]
Mortandad A-10	260.0	<1.0	10.0	7.0	<0.02	<0.20	<4.0	12.00	0.10	11.00	26.0
Mortandad at Rio Grande (A-11)	120.0	<2.0	4.2	<5.0	<0.20	<0.20	<8.0	11.00	<0.20	12.00	22.0
ON-SITE STATIONS											
Radioactive Effluent Release Areas											
Acid-Pueblo Canyons											
Hamilton Bend Spring	160.0	<2.0	<2.0	11.0	<0.10	0.30	<8.0	4.60	<0.10	3.30	28.0
Pueblo 3	260.0	<2.0	3.0	8.4	<0.12	<0.20	<8.0	6.30	<0.12	8.30	23.0
Pueblo at State Route	200.0	<2.0	2.4	10.0	<0.12	<0.20	<8.0	10.00	<0.12	6.80	25.0
DP-Los Alamos Canyons											
DPS-1	90.0	<2.0	<2.0	7.6	<0.10	0.30	<8.0	2.70	<0.10	2.30	19.0
DPS-4	200.0	<2.0	<2.0	<5.0	<0.10	0.40	<8.0	13.00	<0.10	15.00	18.0
Los Alamos at Bridge	89.0	<2.0	<2.0	<5.0	<0.10	0.30	<8.0	7.60	<0.10	7.50	23.0
Los Alamos at LAO-1	200.0	<2.0	<2.0	21.0	<0.10	0.40	<8.0	9.50	<0.10	8.70	50.0
Los Alamos at GS-1	88.0	<2.0	<2.0	14.0	<0.10	<0.20	<8.0	3.10	<0.10	2.70	16.0
Los Alamos at LAO-3	290.0	<2.0	<2.0	13.0	<0.10	<0.20	<8.0	4.30	<0.10	8.80	59.0
Los Alamos at LAO-4.5	240.0	<2.0	<2.0	11.0	<0.10	<0.20	<8.0	5.90	<0.10	5.40	24.0
Los Alamos at SR 4	160.0[d]	<2.0[d]	<2.0[d]	8.8[d]	<0.10[d]	<0.20[d]	<8.0[d]	4.70[d]	0.10[d]	5.15[d]	32.5[c]
Mortandad Canyon											
Mortandad Near CMR	180.0	<2.0	<2.0	20.0	<0.10	0.40	<8.0	12.00	<0.10	10.00	100.0
Mortandad W GS-1	100.0	<2.0	<2.0	<5.0	<0.10	<0.20	<8.0	9.50	<0.10	12.00	14.0
Mortandad GS-1	180.0	<2.0	<2.0	<5.0	<0.10	<0.20	<8.0	4.10	<0.10	3.30	26.0
Mortandad at MCO-5	150.0	<2.0	<2.0	<5.0	<0.10	<0.20	<8.0	3.20	<0.10	3.50	25.0
Mortandad at MCO-7	100.0	<2.0	<2.0	5.3	<0.10	<0.20	<8.0	2.30	<0.10	2.10	14.0
Mortandad at MCO-9	330.0	<2.0	<2.0	11.0	<0.10	0.40	<8.0	7.40	0.10	7.50	45.0
Mortandad at MCO-13 (A-5)	220.0	<2.0	<2.0	<5.0	<0.10	<0.20	<8.0	5.30	<0.10	5.30	27.0
Other Areas											
Sandia at SR 4	155.0[d]	<2.0[d]	<2.0[d]	3.6[d]	<0.12[d]	<0.20[d]	<8.0[d]	2.95[d]	<0.12[d]	3.90[d]	26.0[c]
Cañada Del Buey at SR 4	220.0	<2.0	<2.0	6.2	<0.12	<0.20	<8.0	4.30	<0.12	9.40	23.0
Pajarito at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potrillo at SR 4	310.0	<2.0	3.6	12.0	<0.12	<0.20	<8.0	6.60	<0.12	13.00	41.0
Fence at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water at SR 4	120.0	<2.0	<2.0	7.5	<0.12	<0.20	<8.0	2.90	<0.12	3.20	20.0
Indio at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at SR 4	170.0	<2.0	<2.0	<5.0	<0.12	<0.20	<8.0	6.70	<0.12	7.10	24.0

Table VI-18. (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Other Areas (Cont.)											
TA-54, Area G											
G-1	230.0	1.8	4.7	7.1	<0.10	<0.20	<8.0	12.00	<0.10	10.00	33.0
G-2	260.0	<0.9	4.2	<4.0	<0.10	0.40	<8.0	10.00	<0.10	9.90	49.0
G-3	380.0	<0.9	5.5	22.0	<0.10	0.50	<8.0	18.00	<0.10	14.00	47.0
G-4	320.0	<0.9	3.0	5.1	<0.10	<0.20	<8.0	8.20	<0.10	6.60	46.0
G-5	210.0	<0.9	<2.0	6.9	<0.10	<0.20	<8.0	7.00	<0.10	7.10	28.0
G-6	290.0	<0.9	4.1	10.0	<0.10	<0.20	<8.0	5.80	<0.10	20.00	49.0
G-7	310.0	<0.9	3.8	9.1	<0.10	0.40	<8.0	9.40	<0.10	11.00	28.0
G-8	80.0	<0.9	<2.0	<4.0	<0.10	0.50	<8.0	4.30	<0.10	4.40	15.0
G-9	260.0	<0.9	10.0	8.8	<0.10	<0.20	<8.0	20.00	0.20	24.00	43.0
TA-49, Area AB											
AB-1	210.0	2.4	4.5	<9.0	<1.00	0.50	<6.0	12.00	<1.00	22.00	20.0
AB-2	460.0	<0.2	8.3	21.0	<1.00	0.50	<6.0	31.00	<1.00	31.00	30.0
AB-3	420.0	<0.2	9.2	15.0	<0.20	<0.20	<6.0	41.00	<1.00	31.00	63.0
AB-4	210.0	<0.2	6.6	<9.0	<0.20	0.40	<6.0	25.00	<1.00	19.00	20.0
AB-4A	400.0	1.7	9.0	13.0	<0.20	<0.20	<6.0	34.00	0.20	32.00	33.0
AB-5	540.0	<0.2	7.8	15.0	<0.20	<0.20	<6.0	27.00	<1.00	31.00	28.0
AB-6	340.0	<0.2	12.0	<9.0	<0.20	<0.20	<6.0	30.00	<1.00	30.00	40.0
AB-7	300.0	<0.2	10.0	19.0	<0.20	<0.20	<6.0	24.00	<1.00	30.00	40.0
AB-8	280.0	<0.2	5.5	13.0	<0.20	0.50	<6.0	13.00	<1.00	16.00	34.0
AB-9	310.0	<0.2	4.5	<9.0	<0.20	0.30	<6.0	7.90	<1.00	14.00	24.0
AB-10	360.0	<0.2	6.8	13.0	<0.20	<0.20	7.5	25.00	<1.00	28.00	28.0
AB-11	510.0	<0.2	9.8	17.0	<0.20	0.30	9.4	26.00	<1.00	28.00	28.0

[a] EPA Analytical Procedure SW-846, Method 3050.
[b] Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[c] N/A means analysis not performed, lost in analysis, or not completed.
[d] Mean of multiple samples.

values are probably due to changes in sample preparation procedures mentioned above. A more complete analyses of all trace metal concentration levels will be made once the 1994 sediment analyses have been completed.

Sediments from the perimeter locations in White Rock Canyon were first analyzed for specific trace metals in 1991. None of the results indicate significant accumulations of metals above what can be attributed to natural variability in trace metal concentrations or to variability due to differences in sample preparation methods. Except as mentioned above, the trace metal measurements reported for 1993 generally yielded results comparable to those obtained in 1992.

Organic Analysis. Beginning in 1993, sediments from known radioactive effluent release areas were also analyzed for VOC and semi-volatile organic compounds (SVOC), and polychlorinated biphenyls (PCB). Lists of individual compounds that were analyzed in the laboratory are given in Tables D-25 (VOC) and D-26 (SVOC). These VOC, SVOC, and PCB analyses are scheduled to be repeated every three years for sediment samples.

Sediment samples for VOC, SVOC, and PCB analyses were collected at all of the regional, perimeter, and on-site stations listed in Table D-17, except at stations located in TA-54 and the sediment stations located at Heron, Abiquiu, and Cochiti Reservoirs. These analytical results confirmed that there were no PCB or SVOC compounds detected in any of the sediment samples collected during 1993. However, three samples and a laboratory quality control methods blank showed trace levels of the VOC compound acetone, a common laboratory reagent. The three State Road stations were Bayo at State Road 4 (26 µg/kg of acetone), Pajarito at State Road 4 (30 µg/kg of acetone), and Potrillo at State Road 4 (26 µg/kg of acetone); the methods blank (29 µg/kg of acetone) also tested positive. It

was therefore concluded that the field samples became contaminated with acetone during the laboratory analyses. None of the other sediment samples showed any VOC contamination levels above the respective limits of quantification.

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

Section 313 of the Emergency Planning and Community Right-to-Know Act exempts facilities not meeting certain Standard Industrial Classification (SIC) code criteria from reporting requirements. All research operations at the Laboratory are exempt under provisions of the regulation; only pilot plants, production, or manufacturing operations at the Laboratory must report their releases. It is Laboratory policy to exercise the SIC and research exemptions, thereby limiting release reporting to regulated chemical use at the Plutonium Processing Facility (TA-55), which is the only operation at the Laboratory engaged in production activities and subject to Section 313. Nitric acid is the only regulated chemical that is used at the Plutonium Processing Facility in amounts greater than the Section 313 reporting thresholds.

A report describing the use of Section 313 chemicals must be submitted to the EPA in July for the preceding calendar year. The 1993 report covered the releases of nitric acid during 1992. About 6,073 kg (13,360 lb) of nitric acid were used for plutonium processing with releases to the air of approximately 86 kg (190 lb). The amount of nitric acid released to the atmosphere was calculated using EPA emission factors and approved engineering techniques. The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in the wastewater treatment operations. Only the air releases required reporting for 1992. Reports filed in previous years indicate that air emissions from the Laboratory run 100 to 1,000 times less than the top ten air emitting facilities in the state.

6. Toxic Substances Control Act.

The Toxic Substances Control Act (TSCA 15 U.S.C. 2601-2692) is administered by the EPA, which has authority to conduct premanufacture reviews of new chemicals before their introduction into the marketplace. TSCA requires the testing of chemicals that may present a significant risk to humans and the environment; requires record keeping and reporting requirements for new information regarding adverse health and environmental effects associated with chemicals; governs the manufacture, use, storage, handling, and disposal of PCB equipment; and sets standards for PCB spill cleanups. Because the Laboratory's activities are in the realm of research and development, the 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, paints, slurries, dredge spoils, soils, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to transformers and capacitors and to PCB concentrations above a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to items whose PCB concentrations are 50 ppm and above. At the Laboratory, equipment and materials with PCB levels greater than 500 ppm PCBs are transported off site for treatment and disposal, and those containing 50 to 499 ppm are incinerated off site or disposed of at TA-54, Area G. TA-54, Area G is approved by the EPA for disposal of PCB-contaminated materials.

Table VI-19 summarizes the types of PCB-contaminated waste that were disposed of during 1993. Most of the waste sent off site was associated with the retrofilling or replacement of PCB-containing transformers and capacitors. The Laboratory has been retrofilling, replacing, and dechlorinating PCB-containing transformers and capacitors in order to reduce environmental contamination and regulatory risks.

During 1993, four PCB transformers (three pad type and one pole mount) were removed and replaced with non-PCB units. Design and review work for the removal and replacement of 22 PCB transformers was completed in August 1993. Removal and replacement of these 22 PCB transformers will occur during calendar year (CY) 94. No new retrofilling operations were initiated in 1993. Retrofilling activities continued for 22 transformers. Only 2 of these 22 transformers have yet been reclassified to non-PCB status. Reclassification for non-PCB status for these two transformers is expected to occur in CY94. During 1993, 24 PCB and PCB-contaminated transformers were dechlorinated. Twenty-three of the 24 were reclassified to non-PCB status. Reclassification to non-PCB status of the one remaining transformer is expected to occur during CY94. Also during 1993, 111 PCB capacitors previously

Table VI-19. Disposal of PCBs in 1993

Off-Site Disposal in kg (lb)

Medium	50-499 ppm		>500 ppm	
Water	1,170	(2,575)	174	(382)
Oil	172	(378)	4,967	(10,928)
Debris	4	(8)	5,148	(11,326)
Equipment	—		86	(189)
Transformers	—		7,121	(15,666)
Capacitors	—		10,679	(23,494)
Total off-site disposal			29,521	(64,946)

On-Site Disposal at TA-54, Area G in kg (lb)

Medium	>50 ppm	
Water	—	
Oil	—	
Debris	10,346	(22,760)
Equipment	959	(2,110)
Transformers	—	
Capacitors	—	
Total off-site disposal	11,305	(24,870)
PCBs disposed of in 1993:	40,826	(89,816)

loaned to Cornell University to conduct mutual research with the Laboratory were recalled and disposed of by an EPA-approved facility.

Two PCB spill cleanups were initiated in 1993. A PCB transformer that was replaced at TA-16 had leaked in July 1987, and as part of the PCB transformer replacement corrective activity at the site, a cleanup to below 10 ppm of the immediate area around the original transformer pad was conducted, as required by 40 CFR 761.

In addition, cleanups of the north and south transformer pads at TA-3, SM 22 were initiated. These cleanups were conducted because of reported minor leaks in 1989 and 1990. However, after the cleanups were initiated and sampling conducted, it was apparent from the high sampling results that other leaks or spills must have occurred before 1989 (research of records showed maintenance was done on these units in 1961). Because these spills occurred before 1987, it was recommended that decontamination occur under the Laboratory's Environmental Restoration program, instead of the PCB Corrective Activities program.

Surveying of Laboratory technical areas and facilities continued during 1993. Six hundred twenty-seven samples were submitted for analysis for PCBs. These samples were gathered in the process of surveying 258 structures at 6 Laboratory TAs. One hundred ten PCB capacitors and 14 miscellaneous PCB and PCB-contaminated items were added to the Laboratory's in-service inventory as a result of the 1993 PCB survey. As of December 31, 1993, PCB equipment in service at the Laboratory included 24 PCB transformers, 24 PCB-contaminated transformers, 456 PCB capacitors, and 18 miscellaneous PCB and PCB-contaminated equipment. Surveying of Laboratory TAs and facilities will continue into CY94.

During 1993, the Laboratory continued to prepare a report to respond to the EPA Region 6's submitted requests for data and information regarding hydrogeology of the TA-54, Area G landfill and disposal of PCB waste. This report supports the Laboratory's request for authorization renewal to continue disposal activities of PCB waste at the TA-54, Area G landfill.

Also during 1993, the DOE and EPA had several communications regarding the storage of PCB waste contaminated with radioactive constituents. In a meeting in October 1993, it was agreed to initiate negotiations on a Federal Facilities Compliance Agreement (FFCA) to allow this storage. Waste that currently cannot be disposed of within the one-year storage limit required by PCB regulations will be covered by this FFCA. To support this effort, a draft

interim plan for the management and storage of Laboratory-generated radioactive PCB waste has been prepared and is currently undergoing review by DOE/Los Alamos Area Office and Laboratory staff involved in these discussions.

During August 2–12, 1993, EPA Region 6 conducted a 10-day environmental multimedia audit at the Laboratory. This audit included inspection of the Laboratory's PCB Management Program. Deficiencies that were noted included the following:

- combustible materials located within 5 m (16 ft) of 7 PCB transformers throughout the Laboratory;
- inaccuracies in the annual PCB document's inventories with respect to actual concentrations of PCBs in equipment, location of PCB equipment, and discrepancies on manifests;
- one 55 gal. drum, located at TA-35-7 and containing 2 gal. of an aqueous solution from a PCB spill cleanup had a date of February 1992, indicating that the one-year storage-for-disposal requirement had been exceeded;
- three PCB capacitors were found at TA-21-209 without regulatory-required PCB labels.

No enforcement action has been taken by EPA Region 6 against the Laboratory regarding these PCB-related deficiencies to date.

7. Federal Insecticide, Fungicide, and Rodenticide Act.

The Federal Insecticide, Fungicide, and Rodenticide Act regulates the manufacturing of pesticides with requirements on 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 recommended procedures for storage and disposal and requirements for certification of workers who apply pesticides. The Laboratory is also regulated by the NM Pest Control Act, administered by NM Department of Agriculture (NMDA), which regulates pesticide use, storage, and certification. The NMDA conducts an annual inspection of JCI's compliance with the act. The application, storage, disposal, and certification of these chemicals is conducted in compliance with these regulations. JCI applies pesticides under the direction of the Laboratory's Pest Control Administrator. A Laboratory Pest Management Plan, which includes programs for managing vegetation, insects, and small animals, was established in 1984 and is being revised by the Pest Control Oversight Committee, a committee established to review and recommend policy changes in the overall pest management program at the Laboratory.

An annual inspection conducted by the NMDA found no deficiencies in the Laboratory's pesticide application program and certified applications equipment. The herbicide and insecticide usage for 1993 is summarized in Table VI-20.

Table VI-20. Herbicide and Insecticide Usage during 1993

Type	Brand Name	Annual Usage
Insecticides		
	Inspector	369 oz
	Tempo	51 tablespoons
	Diazinon 4E	2.5 tablespoons
	Diazinon Granules	1 lb.
	Gencor	1.5 mL
	P.O.W.	12 oz
	Pro-Fogger	12 oz
Herbicides		
	Telar	169 g
	A-4-D	233 oz
	Velpar	40 gal.
	Roundup	128 oz

B. Unplanned Releases of Nonradiological Materials

1. Airborne Releases.

During 1993, one unplanned airborne nonradiological release occurred and was reported to the National Response Center and the NMED. On May 13, 1993, during a routine inspection of the storage facilities at TA-54, Area L, a leaking gas cylinder overpack containing a 142-L (5-cu-ft) gas cylinder of chlorine was discovered. The amount of chlorine was not known but was estimated to be less than 10 lbs. The overpack was opened after the excess gas was vented and treated, and the interior cylinder was determined to be in deteriorated condition. The cylinder was placed inside another overpack and put back into storage. Four days later, the second overpack was discovered to be leaking, and it was determined that due to the condition of the interior cylinder, any new overpack could possibly be breached by the leaking chlorine. It was concluded that the safest alternative was to detonate the overpack and cylinder to release the chlorine under controlled conditions. Air dispersion modelling was performed, which demonstrated that the planned release of chlorine by detonation would not result in significant gas concentrations at public access points, based on American Industrial Hygiene Association guidelines. On May 18, 1993, the overpack was detonated at the TA-36-MINIE firing site.

2. Liquid Releases.

During 1993, 28 releases of nonradioactive liquids occurred at the Laboratory and were reported to the EPA and the NMED. The NMED Surface Water Bureau has requested that all liquid releases be reported regardless of any potential impact on the environment. Each of these discharges were minor in nature and were contained on Laboratory property. No discharges were found to be of any threat to health or the environment. Sampling and cleanup were completed, as appropriate to confirm the presence or absence of pollutants and to prevent further migration.

The following is a summary of these 28 unplanned releases:

- three releases of potable water that originated from water line breaks and other sources in the Los Alamos water supply system;
- twelve releases of sanitary sewage (less than 11,355 L [3,000 gal.] each) from the Laboratory's wastewater treatment plant collection systems;
- four releases of ethylene glycol: TA-3, Bldg 40, 3.8 L (1 gal.) on January 26, 1993; TA-53, Bldg. 28, 227 L (60 gal.) on June 18, 1993; TA-3, Bldg. 34, 380 L (100 gal.) on June 22, 1993; and TA-53 parking lot, 7.6 L (2 gal.) on July 6, 1993;
- two discharges of liquid water treatment chemicals: TA-3, Bldg. 22 (power plant), 454 L (120 gal.) on June 17, 1993 and TA-46, Bldg. 87, 757 L (200 gal.) on September 9, 1993;
- oil spill at Pajarito Well #4, 76 L (20 gal.) on September 14, 1993;
- release of gas and water at TA-64, Bldg. 1: 19 L (5 gal.) of gas and 95 L (25 gal.) of water on January 21, 1993;
- one quart (about 1 L) of transmission fluid at TA-9 through permitted outfall EPA-05A-066 on February 18, 1993;
- four releases of treated effluent: TA-3, Bldg. 336, 322,000 L (85,000 gal.) on March 3, 1993; treated boiler water at TA-46, Bldg. 88, on October 31, 1993, SWSC effluent reuse line at TA-46, 7,690 L (2,000 gal.) on November 9, 1993; and TA-35 sandfilters, 1,150-3,075 L (300-800 gal.) on February 10, 1993.

EM-8 prepared a generalized Notice of Intent (NOI) for the discharge of potable water from the Los Alamos water supply system, including production wells, transmission lines, storage tanks, booster pump stations, and other related facilities. The generalized NOI provides the Laboratory with regulatory coverage for releases of potable water from the water supply system that are not considered hazardous to public health and are not covered by the NPDES permit. EM-8 also prepared a generalized NOI for the release of steam condensate from the Laboratory's steam distribution and condensate return systems.

VII. GROUNDWATER PROTECTION MANAGEMENT PROGRAM

Efforts to monitor and protect groundwater quality in the Los Alamos area began in 1949. The data indicate that Department of Energy (DOE) operations at Los Alamos National Laboratory (LANL or the Laboratory) have resulted in little measurable contamination of the main aquifer, the exception being trace levels of tritium contamination found at four locations in Los Alamos and Pueblo canyons and one location in Mortandad Canyon. The presence of tritium does not pose a risk to public health, as the highest level was about 2% of the federal drinking water limit for tritium. In addition, there has been no significant depletion of the main aquifer groundwater resource.

A. Introduction

Groundwater resource management and protection at the Laboratory are focused on the main aquifer underlying the region (see Section II.C of this report). The aquifer has been of paramount importance to Los Alamos since the period following the World War II Manhattan Engineer District days, when the Atomic Energy Commission (AEC) needed to develop a reliable water supply. The US Geological Survey (USGS) was extensively involved in overseeing and conducting various studies for development of groundwater supplies beginning in 1945 and 1946. Studies specifically aimed at protecting and monitoring groundwater quality were initiated as joint efforts between the AEC, the Los Alamos Scientific Laboratory, and the USGS in about 1949.

The long and comprehensive record of data through 1993 indicates that DOE operations at the Laboratory have not resulted in any measurable contamination of the main aquifer, except for low levels of tritium contamination found at four locations in Los Alamos and Pueblo Canyons, and one location in Mortandad Canyon (see Section VII.E.1). The tritium contamination was discovered in four test wells which penetrate only a short distance into the top of the main aquifer, and in a former water supply well in lower Los Alamos Canyon. Some of these wells draw water from formations a relatively short depth below shallow alluvium, known to have past tritium contamination. The casing of other wells was probably not cemented during construction, and leakage down the well bore is a possibility. The wells are all located downstream of present or former sites of discharge of treated radioactive liquid industrial waste into either Acid-Pueblo or Mortandad Canyons. The presence of tritium does not pose a risk to public health, as the highest level detected was about 2% of the federal drinking water limit for tritium. Confirmed evidence of tritium contamination has not been discovered in samples taken from any of the current public water supply wells.

The development and production of the water supply have not resulted in any significant depletion of the resource as there is no major widespread decline of the main aquifer piezometric surface. Drawdowns are localized in the vicinity of the production wells; nearly complete recoveries are observed when wells are shut down for routine maintenance.

The early groundwater management efforts evolved with the growth of the Laboratory's current Groundwater Protection Management Program that addresses environmental monitoring, resource management, aquifer protection, and geohydrologic investigations. Essentially all of the action elements required by DOE Order 5400.1 (DOE 1988a) as part of the Groundwater Protection Management Program have been functioning at the Laboratory for varying lengths of time before the order was issued. Formal documentation for the program, the "Groundwater Protection Management Program Plan," was issued in April 1990. Several hundred reports and articles document studies and data germane to groundwater and the environmental setting of Los Alamos (Bennett 1990).

Groundwater resource monitoring routinely documents conditions of the water supply wells and the hydrologic conditions of the main aquifer as part of the overall Groundwater Protection Management Program. This information is documented in a series of annual reports providing detailed records of pumping and water level measurements. The most recent report in this series is entitled "Water Supply at Los Alamos during 1991" (Purtymun 1994).

The groundwater quality monitoring described in this report reflects the current status of the program that was initiated by the USGS for the AEC in 1949. Groundwater quality monitoring addresses the main aquifer at Los Alamos; shallow alluvial groundwaters in canyons; the intermediate-depth perched groundwater systems in the basalt and the Puye conglomerate beneath parts of Pueblo, Los Alamos, and Sandia canyons; and special studies on the vadose zone. See Section II.C for a general description of the hydrogeology of the Los Alamos area, and the Glossary for definitions of terms.

Concentrations of radionuclides in environmental water samples from the main aquifer, the alluvial perched water in the canyons, and the intermediate-depth perched systems, whether collected within the Laboratory boundaries or off site, may be evaluated by comparison with derived concentration guides (DCGs) for ingested water calculated from DOE's public dose limits (see Section V.C.2). Concentrations of radioactivity in samples of water from the water supply wells completed in the Los Alamos main aquifer are also compared to NM Environment Department (NMED), NM Environmental Improvement Board (NMEIB), and Environmental Protection Agency (EPA) drinking water standards 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 NMEIB and EPA drinking water standards (maximum concentration levels [MCLs]), even though these standards are only directly applicable to the public water supply. The supply wells in the main aquifer are the source of the public water supply in Los Alamos. Although it is not a source of municipal or industrial water, the 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 Standards established by the NM Water Quality Control Commission (NMWQCC 1991).

B. Monitoring Network

There are three principal groups of groundwater sampling locations: main aquifer, alluvial perched groundwater in the canyons, and the localized intermediate-depth perched groundwater systems. The sampling locations for the main aquifer, the intermediate-depth perched groundwater systems, and for springs interpreted to be discharging from either the main aquifer (Purtymun 1980b) or perched intermediate systems are shown in Figure VII-1. The sampling locations for the canyon alluvial perched groundwater systems are shown in Figure VII-2.

Water for drinking and industrial use is also obtained from a well at the Laboratory's experimental geothermal site (Fenton Hill, TA-57) about 45 km (28 mi) west of Los Alamos on Forest Service land. The well is about 133 m (436 ft) deep and is completed in volcanics. Information about groundwater and other environmental monitoring at this remote technical area is presented in Section IV.C.4.

1. Main Aquifer.

Sampling locations for the main aquifer include test wells, supply wells, and springs. Eight deep test wells, completed into the main aquifer, are routinely sampled. The test wells are not part of the water supply system but were drilled to monitor water quality in the upper portion of the main aquifer. Two of the test wells are off site; the other six are within the Laboratory boundary. One off-site well, Test Well 2, drilled in 1949, is in the middle reach of Pueblo Canyon, downstream from the confluence with Acid Canyon, on Los Alamos County land. Depth to water in 1993 was 242 m (793 ft). The other off-site well, Test Well 4, drilled in 1950 on the mesa above Acid Canyon, is near the former outfall of the decommissioned TA-45 radioactive liquid waste treatment plant. Depth to water in 1993 was 358 m (1,175 ft).

Of the on-site wells, Test Well 1, drilled in 1950, is in the lower reach of Pueblo Canyon, near the boundary with the Pueblo of San Ildefonso. Depth to water in 1993 was 167 m (547 ft). Test Well 3, drilled in 1949, is in the

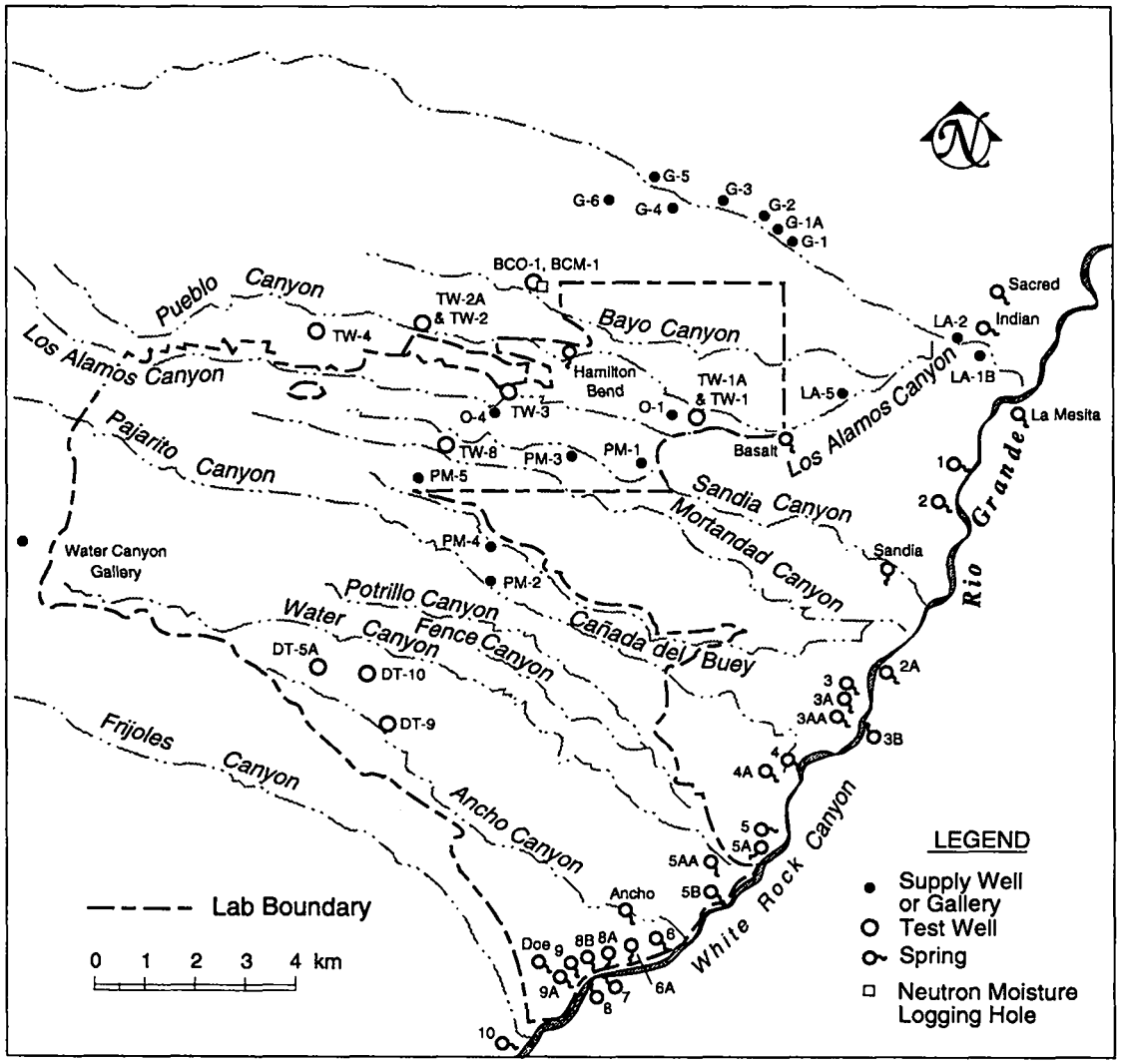


Figure VII-1. Springs and deep and intermediate wells used for groundwater sampling. (See Table D-17 for specific locations.)

middle reach of Los Alamos Canyon just upstream from the confluence with DP Canyon. Depth to water in 1993 was 237 m (776 ft).

Test Well 8, drilled in 1960, is in the middle reach of Mortandad Canyon, downstream from the TA-50 radioactive waste liquid waste treatment plant outfall. Depth to water in 1993 was 303 m (993 ft). Test wells DT-5A, DT-9, and DT-10 (all of which were drilled in 1960) are at the southern edge of the Laboratory at TA-49. The depths to water in 1993 were 361 m (1,183 ft) at DT-5A, 340 m (1,116 ft) at DT-9, and 335 m (1,097 ft) at DT-10. No perched water between the surface of the mesa and the top of the main aquifer was observed when these four wells were drilled.

Samples were collected from nine deep wells in three well fields that produce water for the Laboratory and community. The well fields include the Guaje Well Field, located off site in Guaje Canyon on US Forest Service lands northeast of the Laboratory, and the on-site Pajarito and Otowi fields.

The Guaje Well Field contains seven wells, three of which had significant production during 1993. Wells in this field range in depth from 463 m to 610 m (1,519 ft to 2,001 ft). Movement of water in the upper 430 m (1,410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

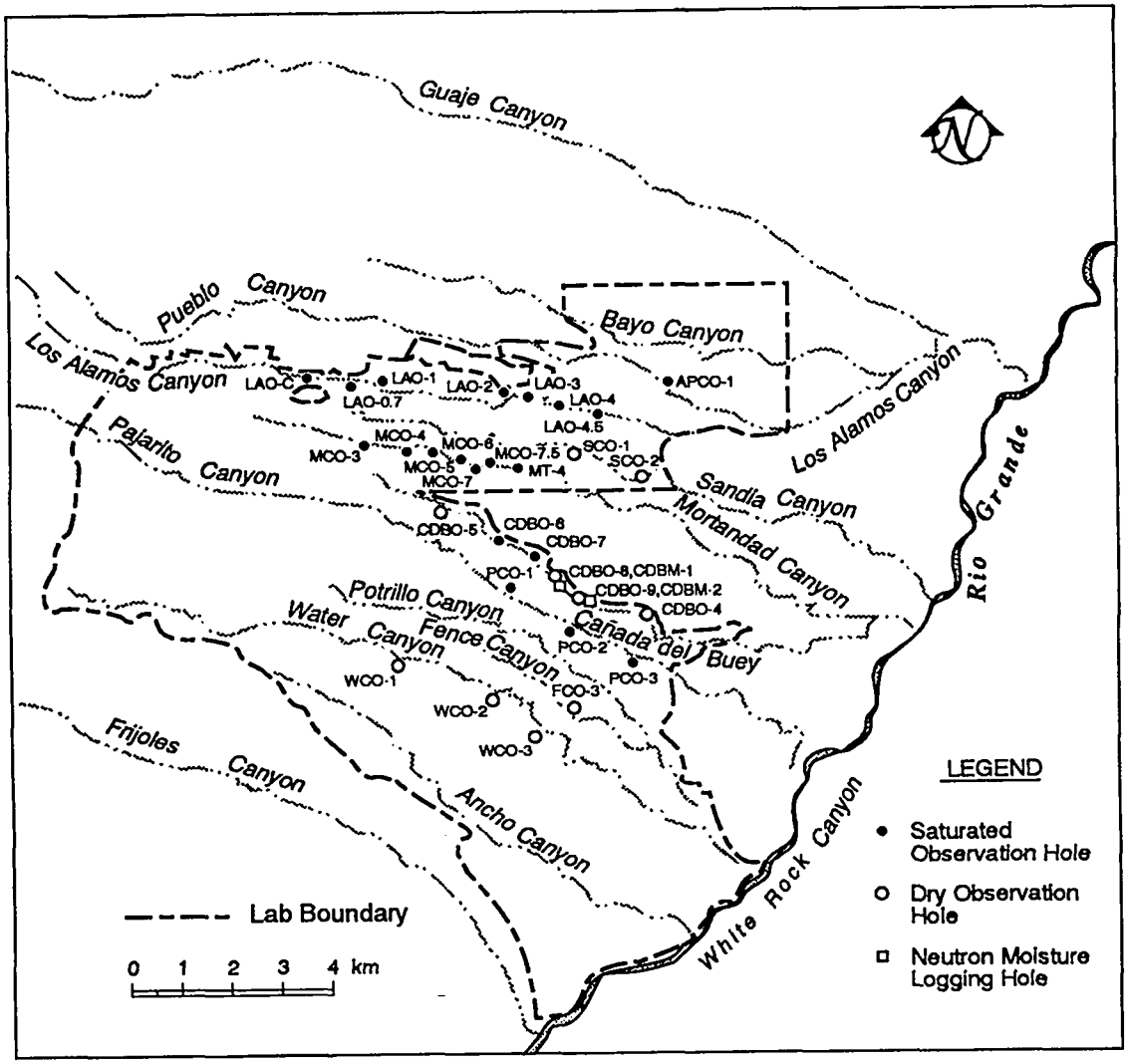


Figure VII-2. Alluvial observation wells and neutron moisture holes.

The Pajarito Well Field is located in Sandia and Pajarito canyons and on mesa tops between those canyons. The Pajarito Well Field comprises five wells ranging in depth from 701 m to 942 m (2,299 ft to 3,090 ft). Movement of water in the upper 535 m (1,755 ft) of the aquifer is eastward at 29 m/yr (95 ft/yr) (Purtymun 1984).

Two new water supply wells were completed in 1990. These are the first wells in a new field designated as the Otowi Well Field, and the wells were designated Otowi-1 and Otowi-4. Otowi-4 was connected to the distribution system and began production during 1993. Wells Otowi-1 and Otowi-4 are 795 m and 855 m in depth (2,609 ft and 2,805 ft).

Additional samples were taken from 13 other wells located in the Santa Fe Group of sedimentary deposits. These wells were sampled as part of the special sampling on the Pueblo of San Ildefonso. See Section IV.C.5 for information on the Memorandum of Understanding between DOE, the Bureau of Land Management (BLM), and the Pueblo of San Ildefonso.

Numerous springs near the Rio Grande were sampled because they are interpreted as being representative of natural discharge from the main aquifer (Purtymun 1980b). See Section II.C. for information on discharge into the Rio Grande. In White Rock Canyon four groups of springs discharge from the main aquifer. Three groups (I, II, and III) have similar, aquifer-related chemical quality. Chemical quality of springs in Group IV reflect local

conditions in the aquifer, which are probably related to waters discharging through faults in volcanics. Indian and Sacred springs are west of the river in lower Los Alamos Canyon. These two springs discharge from faults in the siltstones and sandstones of the Tesuque Formation.

2. Perched Groundwater in Canyon Alluvium.

The alluvial perched groundwaters in five canyons were sampled by means of shallow observation wells as part of the routine monitoring program. Pueblo and Los Alamos canyons are former radioactive effluent release areas, and Mortandad Canyon presently receives treated radioactive effluents. The fourth is Pajarito Canyon, immediately south of the existing solid waste management areas at TA-54 on Mesita del Buey. The fifth is Cañada del Buey, immediately north of the existing solid waste management areas at TA-54 on Mesita del Buey, and downstream of the Laboratory's new Sanitary Wastewater Systems Consolidation (SWSC) project. All of these alluvial perched groundwater sampling locations are on site. The extent of saturation in the alluvial groundwater systems varies seasonally, in response to variations in runoff from snowmelt, summer thunderstorms, and discharges from the Laboratory's National Pollutant Discharge Elimination System (NPDES)-permitted outfalls. In any given year, some of these alluvial observations wells may be dry, and no water samples can be obtained.

Acid Canyon, a small tributary of Pueblo Canyon, received untreated and treated industrial effluent from 1944 to 1964 that contained residual radionuclides (ESG 1981). 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. One sampling point, 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, almost abandoned Los Alamos County Pueblo sewage treatment plant. Further east, at the location of Well APCO-1, the alluvium is continuously saturated, mainly because of infiltration of effluent from the Los Alamos County Bayo sanitary sewage treatment plant. At APCO-1, the alluvium is about 3.4 m (11 ft) thick and depth to water is about 1.8 m (6 ft).

The on-site reach of Los Alamos Canyon presently carries flow from the Los Alamos Reservoir (west of the Laboratory), as well as NPDES-permitted effluents from TA-2, TA-53, and TA-21. In the past, Los Alamos Canyon received treated and untreated industrial effluents containing some radionuclides. An industrial liquid waste treatment plant at TA-21 discharged effluent containing radionuclides into DP Canyon, a tributary to Los Alamos Canyon, from 1952 to 1986. Infiltration of NPDES-permitted effluents and natural runoff from the stream channel maintains a shallow body of water in the alluvium of Los Alamos Canyon, within the Laboratory boundary west of State Road 4. Water levels are highest in late spring because of snowmelt runoff and in late summer because of thundershowers. Water levels decline during the winter and early summer when runoff is at a minimum. Sampling stations consist of seven observation wells completed into the alluvium in Los Alamos Canyon. The wells range in depth from about 6 m to about 9 m (20 ft to 30 ft). Depth to water is typically in the range of 1.5 m to 3 m (5 ft to 10 ft).

Alluvial perched groundwater also occurs in the lower portion of Los Alamos Canyon on Pueblo of San Ildefonso lands. This alluvium is not continuous with the alluvium within the Laboratory. During 1993, this groundwater was sampled at five locations on Pueblo of San Ildefonso lands, utilizing wells installed by the Bureau of Indian Affairs. See Section IV.C.5 for information on the results obtained at Pueblo of San Ildefonso.

Mortandad Canyon has a small drainage area that heads at TA-3. The drainage area presently receives inflow from natural precipitation and a number of NPDES-permitted effluents including those from the existing radioactive liquid waste treatment plant at TA-50. These effluents infiltrate the stream channel and maintain a saturated zone in the alluvium extending about 3.5 km (2.2 mi) downstream from the TA-50 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. 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 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 1974c, 1983). The top of the main aquifer is about 290 m (950 ft) below the perched alluvial groundwater. Monitoring wells that are sampled as part of the routine monitoring program consist of six observation wells in the shallow perched alluvial groundwater. These wells range in depth from about 3.7 m to about 21 m (12 to 69 ft) with depths to water ranging from about 0.9 m to about 14 m (3 to 46 ft). In any given year, some of these wells may be dry, and no water samples can be obtained. Additional wells that have been installed in the lower reach of the canyon are dry.

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 if 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).

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), while the underlying weathered tuff ranges in thickness from 3.7 to 12 m (12 to 40 ft). In 1992, saturation was found within only a 0.8-km- (0.5-mi-) long segment, starting at about the location of well CDBO-6 and including well CDBO-7 (EPG 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 new 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 level holes was installed during the early summer of 1992 within the upper and middle reaches of the drainage (EPG 1994). Construction of the SWSC project was completed in late 1992. Possible changes in the quality and extent of groundwater in the alluvium will be monitored with five new shallow observation wells (CDBO-5 through CDBO-9) and an older well (CDBO-4) installed in 1985, all of which are located adjacent to the Cañada del Buey active stream channel. As a complement to the shallow groundwater monitoring network, two neutron moisture logging access tubes (CDBM-1 and -2) were installed to gage the rate of downward movement of the effluent should the canyon bottom become saturated. Additionally, a continuously recording USGS stream gaging station was installed where Cañada del Buey crosses the eastern (downstream) Laboratory boundary at State Road 4.

The Cañada del Buey monitoring network was installed to demonstrate that effluent discharges from SWSC meet the requirements of the NMWQCC regulations. The monitoring also satisfies requirements of DOE Order 5400.1 for preoperational studies.

3. Intermediate-Depth Perched Groundwater.

Perched groundwater of limited extent occurs in the conglomerates and basalts beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia canyons. Samples are obtained from two test wells and one spring. Test Well 2A is located in the off-site middle reach of Pueblo Canyon. Test Well 2A (drilled in 1949 to a depth of 40.5 m [133 ft]) penetrates the alluvium and Bandelier Tuff and is completed in the Puye Conglomerate. Pump tests indicated that the perched groundwater in the conglomerate is of limited extent. Depth to water was about 33 m (108 ft) in 1993.

Test Well 1A is located in the on-site lower reach of Pueblo Canyon. Test Well 1A (drilled in 1950 to a depth of 69 m [226 ft]) penetrates the alluvium, Puye Conglomerate, and basalt and is completed in basalts. Depth to water was about 59 m (194 ft) in 1993. Perched water in the basaltic rocks is also sampled from Basalt Spring, which is off site in lower Los Alamos Canyon on the Pueblo of San Ildefonso. Measurements of water levels and chemical quality over a period of time indicate that the perched groundwater is hydrologically connected to the stream in Pueblo Canyon. Perched water in similar stratigraphy was observed during the drilling of water supply wells Otowi-4 in Los Alamos Canyon (depth about 61 to 76 m [200 to 250 ft]), Otowi-1 in Pueblo Canyon (depth about 69 to 76 m [225 to 250 ft]), and PM-1 in Sandia Canyon (depth about 137 m [450 ft]).

Some recharge to the perched groundwater in the basalt occurs near Hamilton Bend Spring. The time for water from the recharge area near Hamilton Bend Spring to reach Test Well 1A is estimated to be one to two months, with

another two to three months required for the water to reach Basalt Spring. Recharge may also occur in Los Alamos Canyon (Abrahams 1966).

Some perched water occurs in volcanics on the flanks of the Jemez Mountains off site, west of the Laboratory. This water discharges at several springs (Armstead and American) and yields a significant flow from the gallery in Water Canyon. The gallery contributed to the Los Alamos water supply for 41 years, producing 23 to 96 million gal./yr. Since 1988 it has only been used for makeup water for the steam plant at TA-16, producing about 6.40 million gal. in 1993.

4. Vadose Zone.

The occurrence and movement of water in unsaturated conditions has been studied in numerous locations within the Laboratory starting with special USGS studies in the 1950s (Purtymun 1990c). Knowledge of vadose zone processes is relevant to understanding the potential for downward movement of water that could constitute recharge to the main aquifer and provide a mechanism for downward migration of contaminants.

In general, the vadose zone studies show that there is consistently low-moisture content (less than 10% by volume) at depths greater than a few meters in the tuff beneath mesa tops. Only the upper zone is affected by seasonal changes in moisture and evapotranspiration. This implies that very little, if any, recharge from the mesas is able to reach the main aquifer, which is about 305 m (1,000 ft) deep.

The canyons with alluvial aquifers are presumed to have a greater potential for downward water movement because there is a constant supply of water for potential recharge. Since the mid-1980s several alluvial aquifer investigations have been performed under various Resource Conservation and Recovery Act compliance requirements. As part of these investigations, the Laboratory installed monitoring facilities in canyons, which further define the occurrence of alluvial water and help to understand the potential for movement of water or contaminants.

In 1985, observation wells were installed in canyons adjacent to the operating solid waste management and disposal areas at TA-54. These wells included the three in Pajarito Canyon (south of TA-54) that were already described in Section VII.B.2 and four in the Cañada del Buey drainage (north of TA-54). Three of the wells in Cañada del Buey were located in a side drainage, west and north of TA-54, Area L, and penetrated to 2.4 to 3.7 m (8 to 12 ft) of dry alluvium. The fourth well in the main channel north of the eastern end of TA-54, Area G, penetrated 2.7 m (9 ft) of dry alluvium. These four wells have remained dry on subsequent observation, indicating the absence of any saturation in this reach of Cañada del Buey (Devaurs 1985).

In 1989, boreholes or monitoring wells were installed in four canyons to determine whether saturated conditions occurred in the alluvium. Two holes in Sandia Canyon, SCO-1 (near Supply Well PM-2), drilled to 24 m (79 ft), and SCO-2 (near Supply Well PM-1), drilled to 9 m (29 ft), penetrated the alluvium without encountering any saturated zone. These were completed as observation holes and have remained dry. One hole in Potrillo Canyon, PCTH-1 (about 0.3 km [1/2 mi] west of State Road 4) was drilled to 23 m (75 ft). It penetrated only dry weathered and unweathered tuff, and this hole was later plugged. One hole in Fence Canyon, FCO-1 (within 0.2 km [0.1 mi] of State Road 4) was drilled to 9 m (30 ft) and completed as an observation well. It penetrated only dry weathered and unweathered tuff, indicating no past saturation. Three holes in Water Canyon, WCO-1 (about 3.2 km [2 mi] west of State Road 4) drilled to 11 m (37 ft), WCO-2 (about 1.6 km [1 mi] west of State Road 4) drilled to 12 m (38 ft), and WCO-3 (within about 0.3 km [0.2 mi] of State Road 4) drilled to 4 m (14 ft) all penetrated the alluvium without revealing saturated conditions. They were all completed as observation wells for future monitoring of potential saturation (Purtymun 1990b).

In 1987, nine observation wells were installed in Cañon de Valle adjacent to inactive Waste Disposal Area P in TA-16. These wells, drilled on the toe of the landfill above the channel alluvium; revealed no saturation and showed no evidence of leachate or seepage from the landfill.

In 1992, five new holes were drilled in Cañada del Buey to document the conditions in and beneath the alluvium (see Section VII.B.2). Two of them, completed as a monitoring wells, were added to the routine monitoring locations in conformance with a Groundwater Discharge Plan submitted to the NMED for discharge from the new sanitary waste treatment plant at TA-46.

C. Analytical Results

1. Radiochemical Constituents.

The results of radiochemical analyses of groundwater samples for 1993 are listed in Table VII-1. Discussion of the results will address the main aquifer, the canyon alluvial groundwaters, and finally the intermediate perched groundwater system.

For samples from wells or springs in the main aquifer, almost all results for tritium, ^{90}Sr, uranium, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and gross beta were below the DOE DCGs or the EPA or NM standards applicable to a drinking water system. The exception was White Rock Canyon Spring 3B, which is discussed below. Most of the results were near or below the detection limits of the analytical methods used.

Some samples from wells and springs contained levels of plutonium or americium slightly (generally less than a factor of two) above analytical method detection limits. Because of inconsistencies between the types of analyses, (i.e., apparent ^{238}Pu without any corresponding $^{239,240}Pu$ or vice versa), the large counting uncertainties in the measurements at the low levels near average detection limits (often 50% or more of the value), and, in the case of springs, the fact that such samples often must be collected in contact with surface rocks or channel sediments, none of the findings are interpreted to represent any indication of contamination in the main aquifer.

The uranium values were determined using either the induction coupled plasma emission spectroscopy (ICPES) or kinetic phosphorimetric analysis (KPA) methods. The ICPES method ordinarily gives high values for prepared standards; the alternative KPA method gives low values. The uranium values for the White Rock Canyon springs were determined by both methods. In most cases, the two values are in reasonable agreement. For example, the Spring 2 KPA value is 8.1 ± 50.8 μg/L, and the ICPES value is 14.0 ± 6.0 μg/L; the KPA value is only one standard deviation (6 μg/L) below the ICPES value. The exception is Spring 3B: the KPA value is 25.2 ± 2.5 μg/L, and the ICPES value is 39.0 ± 5.0 μg/L; the KPA value is about three standard deviations (3 × 5 μg/L) below the ICPES value. The water from Spring 3B exceeds the drinking water limit of 20 μg/L. The gross alpha analysis for Spring 3B is also above the limit that would be applicable to a drinking water distribution system. Springs 1, 2, and 10, and La Mesita Spring have high uranium concentrations; springs in this area have always contained a relatively high concentration of natural uranium (Purtymun 1980b).

All ^{137}Cs measurements of samples from the main aquifer wells and springs for 1993 are less than 5% of the DCG applicable to DOE Drinking Water Systems. Cesium measurements in past years have raised some questions about the potential presence of ^{137}Cs contamination in some areas, because the previously used analytical method had a detection limit that was relatively high in comparison with the relevant guidelines or standards, and typical environmental levels. A new method was implemented during 1992 by the Environmental Chemistry Group (EM-9) (EPG 1994), which has a much lower detection limit (about 2 pCi/L).

Tritium measurements of samples from main aquifer wells and springs were near or below the detection limit for the EPA-specified liquid scintillation analytical method. These results are consistent with additional special tritium measurements made as part of a special study utilizing very low-detection-limit measurements of tritium to estimate the age of water in the main aquifer (see Section VII.E.1.b and c). In the case of the six water supply wells in the Guaje Field, the four wells in the Pajarito Field, and the Otowi-4 well in the Otowi Field, sampling conducted from 1991 through 1993 revealed no measurable tritium, even with the special method. An apparent detection of a small amount of tritium in Well PM-3 was later discovered to have resulted from sample contamination in the laboratory (see Section VII.E.1). Low-detection-limit measurements on the main aquifer springs also confirm that their tritium levels are far below the detection limit of the normal liquid scintillation analysis (EPG 1994).

White Rock Canyon Spring 3A showed a tritium value of 0.8 ± 0.3 nCi/L (800 ± 300 pCi/L), slightly above the detection limit of liquid scintillation analysis. However, preliminary low-detection-limit measurements of a sample collected for this spring in September 1994 give a much lower tritium value of 2.7 ± 0.3 pCi/L.

None of the radiochemical analysis for alluvial groundwaters show concentrations that are above the DOE DCGs for Public Dose for Ingestion of Environmental Water. Levels of tritium, ^{137}Cs, uranium, ^{238}Pu, $^{239,240}Pu$, and ^{90}Sr, and gross alpha, beta, and gamma are, for the most part, 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. Compared to observations from Los Alamos

Table VII-1. Radiochemical Analysis of Groundwater for 1993

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA[a] (µg/L)	Total Uranium ICPES[b] (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)
MAIN AQUIFER ON SITE											
Test Wells											
Test Well 1	0.5 (0.3)[c]	0.0 (0.8)	2.5 (1.3)	N/A[d]	2.4 (0.8)	0.004 (0.030)	0.044 (0.020)	-0.004 (0.030)	-0 (1)	4 (1)	-60 (90)
Test Well 3	0.2 (0.3)	0.2 (0.8)	1.7 (1.2)	N/A	<2.0[e] (0.0)	-0.025 (0.030)	0.005 (0.020)	0.039 (0.030)	1 (1)	3 (0)	-110 (100)
Test Well 8	0.4 (0.3)	N/A	-0.4 (0.5)	N/A	N/A	-0.006 (0.030)	-0.007 (0.020)	N/A	0 (0)	2 (0)	20 (60)
Test Well DT-5A	0.4 (0.3)	0.4 (0.8)	2.3 (1.4)	N/A	<2.0 (0.0)	0.014 (0.030)	0.230 (0.080)	0.032 (0.030)	0 (0)	2 (0)	70 (100)
Test Well DT-9	0.3 (0.3)	0.3 (0.8)	2.1 (1.2)	N/A	<2.0 (0.0)	-0.014 (0.030)	0.005 (0.020)	0.008 (0.030)	2 (1)	4 (1)	-20 (100)
Test Well DT-10	0.3 (0.3)	0.2 (0.8)	1.0 (1.2)	N/A	<2.0 (0.0)	-0.004 (0.030)	0.009 (0.020)	0.000 (0.030)	0 (0)	2 (0)	30 (100)
Water Supply Wells											
O-4	0.3 (0.3)	N/A	N/A	N/A	<1.0 (0.0)	-0.006 (0.030)	0.006 (0.020)	N/A	3 (1)	5 (1)	110 (100)
PM-1	0.3 (0.3)	N/A	N/A	N/A	2.0 (0.1)	-0.018 (0.030)	0.005 (0.020)	N/A	2 (1)	5 (1)	130 (100)
PM-2	0.5 (0.3)	0.8 (0.9)	1.4 (1.2)	N/A	<1.0 (0.0)	0.004 (0.030)	0.127 (0.024)	0.021 (0.030)	1 (1)	2 (0)	60 (90)
PM-3	0.4 (0.3)	-0.6 (1.0)	2.0 (1.3)	N/A	<2.0 (0.0)	-0.008 (0.030)	0.099 (0.023)	0.031 (0.030)	-1 (1)	4 (1)	40 (90)
PM-4	0.6 (0.3)	0.7 (0.8)	-0.5 (0.5)	N/A	<1.0 (0.0)	-0.012 (0.020)	0.015 (0.030)	0.009 (0.030)	N/A	N/A	190 (100)
PM-5	0.4 (0.3)	-0.5 (0.9)	0.2 (0.5)	N/A	<1.0 (0.0)	-0.008 (0.020)	0.030 (0.030)	0.039 (0.030)	N/A	N/A	210 (100)
MAIN AQUIFER OFF SITE											
Test Wells											
Test Well 2	0.5 (0.3)	0.0 (1.0)	2.3 (1.1)	N/A	<1.0 (0.0)	0.009 (0.030)	0.055 (0.020)	0.033 (0.030)	-1 (1)	3 (1)	-10 (90)
Test Well 4	0.2 (0.3)	0.2 (0.7)	N/A	N/A	<1.0 (0.0)	0.005 (0.030)	0.063 (0.020)	0.025 (0.030)	0 (1)	3 (1)	40 (90)
Water Supply Wells											
G-1A	0.3 (0.3)	N/A	N/A	N/A	<1.0 (0.0)	0.005 (0.030)	0.042 (0.020)	N/A	1 (1)	3 (1)	80 (90)
G-2	0.5 (0.3)	N/A	N/A	N/A	<1.0 (0.0)	0.007 (0.030)	0.047 (0.020)	N/A	2 (1)	4 (1)	70 (90)
G-5	0.4 (0.3)	N/A	N/A	N/A	<1.0 (0.0)	0.005 (0.030)	0.048 (0.020)	N/A	1 (1)	3 (1)	80 (90)
MAIN AQUIFER SPRINGS											
White Rock Canyon Springs											
Group I											
Sandia Spring	0.2 (0.3)	N/A	N/A	0.7 (0.1)	1.0 (0.1)	-0.004 (0.020)	-0.003 (0.030)	N/A	1 (0)	4 (1)	100 (100)
Spring 3	0.1 (0.3)	N/A	<1.7 (0.0)	0.7 (0.1)	2.0 (0.2)	0.024 (0.020)	0.021 (0.030)	N/A	2 (0)	4 (0)	0 (100)
Spring 3A	0.8 (0.3)	N/A	<1.1 (0.0)	0.5 (0.1)	1.5 (0.4)	0.013 (0.020)	0.040 (0.030)	N/A	2 (1)	3 (0)	-100 (100)
Spring 3AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 4	0.0 (0.3)	N/A	N/A	0.2 (0.1)	1.0 (0.4)	0.004 (0.020)	-0.005 (0.030)	N/A	1 (0)	3 (0)	-200 (100)

Table VII-1. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA[a] (µg/L)	Total Uranium ICPES[b] (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)
MAIN AQUIFER SPRINGS (Cont.)											
Group I (Cont.)											
Spring 4A	0.1 (0.3)	N/A	<0.9 (0.0)	1.0 (0.1)	1.0 (0.4)	0.024 (0.020)	-0.004 (0.030)	N/A	2 (0)	2 (0)	0 (100)
Spring 5	0.0 (0.3)	N/A	N/A	0.8 (0.1)	1.0 (0.2)	0.030 (0.020)	0.050 (0.030)	N/A	1 (0)	3 (0)	0 (100)
Spring 5AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Spring	0.0 (0.3)	N/A	<0.6 (0.0)	0.1 (0.0)	<1.0 (0.0)	0.010 (0.020)	-0.004 (0.030)	N/A	1 (0)	2 (0)	600 (100)
Group II											
Spring 5A	0.1 (0.3)	N/A	<1.2 (0.0)	1.2 (0.1)	1.5 (0.2)	0.001 (0.020)	0.017 (0.030)	N/A	1 (0)	4 (1)	400 (100)
Spring 5B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 6	0.1 (0.3)	N/A	<0.6 (0.0)	0.3 (0.0)	<1.0 (0.0)	0.007 (0.020)	-0.002 (0.030)	N/A	1 (0)	2 (0)	100 (100)
Spring 6A	0.0 (0.3)	N/A	<1.1 (0.0)	0.2 (0.0)	<1.0 (0.0)	0.016 (0.020)	-0.006 (0.030)	N/A	1 (0)	2 (0)	300 (100)
Spring 7	-0.2 (0.3)	N/A	<1.0 (0.0)	0.6 (0.1)	2.0 (0.3)	0.030 (0.020)	-0.008 (0.030)	N/A	2 (1)	2 (0)	700 (100)
Spring 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 8A	-0.1 (0.3)	N/A	<1.1 (0.0)	0.0 (0.0)	<1.0 (0.0)	0.009 (0.020)	0.010 (0.030)	N/A	1 (0)	3 (0)	-100 (100)
Spring 8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 9	0.1 (0.3)	N/A	N/A	0.3 (0.0)	<1.0 (0.0)	0.013 (0.020)	0.011 (0.030)	N/A	1 (0)	3 (0)	0 (100)
Spring 9A	0.0 (0.3)	N/A	<0.5 (0.0)	0.6 (0.1)	<1.0 (0.0)	0.021 (0.020)	0.002 (0.030)	N/A	1 (0)	4 (0)	0 (100)
Doe Spring	0.2 (0.3)	N/A	<2.2 (0.0)	0.1 (0.0)	<1.0 (0.0)	-0.007 (0.020)	-0.001 (0.030)	N/A	0 (0)	2 (0)	1000(200)
Spring 10	0.2 (0.3)	N/A	<0.5 (0.0)	3.6 (0.4)	6.0 (2.0)	0.000 (0.020)	0.004 (0.030)	N/A	8 (2)	12 (1)	100 (100)
Group III											
Spring 1	0.5 (0.3)	N/A	N/A	3.9 (0.4)	7.0 (1.0)	-0.008 (0.020)	0.011 (0.030)	N/A	5 (1)	6 (1)	-100 (100)
Spring 2	0.1 (0.3)	N/A	N/A	8.1 (0.8)	14.0 (6.0)	0.067 (0.022)	0.005 (0.030)	N/A	10 (2)	9 (1)	0 (100)
Group IV											
La Mesita Spring	0.3 (0.3)	-0.5 (1.0)	2.1 (1.2)	N/A	12.5 (2.4)	-0.005 (0.030)	0.010 (0.020)	0.000 (0.000)	0 (1)	7 (1)	80 (100)
Spring 2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 3B	0.5 (0.3)	N/A	<0.8 (0.0)	25.2 (2.5)	39.0 (5.0)	-0.001 (0.020)	0.011 (0.030)	N/A	24 (6)	15 (2)	-200 (100)
Other Springs											
Sacred Spring	0.5 (0.3)	0.3 (0.7)	1.3 (1.1)	N/A	2.0 (0.1)	0.004 (0.030)	0.004 (0.020)	0.024 (0.030)	-2 (1)	5 (1)	70 (90)
Indian Spring	-0.2 (0.3)	-0.4 (0.7)	2.8 (1.2)	N/A	2.0 (0.1)	0.023 (0.030)	0.000 (0.020)	0.014 (0.030)	-2 (1)	3 (1)	150 (100)

Table VII-1. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA[a] (µg/L)	Total Uranium ICPES[b] (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)
CANYON ALLUVIUM GROUNDWATERS											
DP-Los Alamos Canyons											
LAO-C	0.2 (0.3)	N/A	2.9 (1.3)	N/A	<1.0 (0.0)	-0.010 (0.030)	0.032 (0.020)	N/A	2 (1)	6 (1)	0 (100)
LAO-0.7	0.6 (0.3)	N/A	2.9 (1.3)	N/A	8.0 (1.0)	0.013 (0.030)	0.242 (0.045)	N/A	60 (10)	22 (2)	210 (100)
LAO-1	1.3 (0.3)	N/A	2.9 (1.3)	N/A	<1.0 (0.0)	0.016 (0.030)	0.080 (0.021)	N/A	0 (1)	26 (3)	100 (100)
LAO-2	0.4 (0.3)	367.7 (23.4)	N/A	50.4 (2.7)	N/A	0.356 (0.041)	1.584 (0.095)	0.019 (0.001)	N/A	N/A	N/A
LAO-3	1.1 (0.3)	N/A	3.0 (1.3)	N/A	4.8 (0.4)	0.005 (0.030)	0.015 (0.020)	N/A	1 (1)	92 (9)	300 (100)
LAO-4	0.9 (0.3)	N/A	0.1 (1.3)	N/A	<1.0 (0.0)	0.000 (0.030)	0.088 (0.023)	N/A	1 (1)	16 (2)	10 (100)
LAO-4.5	0.8 (0.3)	N/A	2.3 (1.2)	N/A	1.0 (0.2)	0.019 (0.030)	0.039 (0.021)	N/A	-1 (1)	10 (1)	100 (100)
Mortandad Canyon											
MCO-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MCO-4	36.9 (1.9)	88.4 (5.7)	11.4 (2.0)	5.2 (0.5)	N/A	2.350 (0.141)	7.630 (0.332)	43.000 (3.000)	140 (30)	270 (30)	200 (100)
MCO-5	28.5 (1.6)	46.5 (3.1)	1.5 (0.4)	2.7 (0.3)	N/A	0.174 (0.034)	0.256 (0.043)	1.307 (0.101)	13 (3)	130 (10)	300 (100)
MCO-6	27.5 (1.6)	39.8 (2.6)	0.8 (0.6)	4.0 (0.4)	N/A	0.078 (0.025)	0.172 (0.034)	0.792 (0.067)	11 (3)	140 (10)	300 (100)
MCO-7	28.3 (1.6)	1.8 (6.0)	0.4 (0.5)	4.1 (0.4)	N/A	0.048 (0.020)	0.066 (0.030)	0.576 (0.060)	12 (3)	44 (5)	400 (100)
MCO-7.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pajarito Canyon											
PCO-1	0.7 (0.3)	N/A	2.8 (1.3)	N/A	<1.0 (0.0)	-0.016 (0.030)	0.004 (0.020)	N/A	3 (1)	6 (1)	70 (90)
PCO-2	0.7 (0.3)	N/A	3.2 (1.3)	N/A	2.0 (0.1)	0.022 (0.030)	0.036 (0.020)	N/A	12 (3)	11 (1)	110 (100)
PCO-3	0.5 (0.3)	N/A	2.6 (1.3)	N/A	18.0 (5.0)	0.059 (0.030)	0.018 (0.020)	N/A	9 (3)	11 (1)	50 (90)
Acid/Pueblo Canyons											
APCO-1	0.4 (0.3)	N/A	N/A	1.0 (0.1)	N/A	0.003 (0.021)	0.281 (0.034)	N/A	4 (1)	16 (2)	140 (90)
Cañada del Buey											
CDBO-6	0.5 (0.3)	N/A	-0.5 (0.3)	5.8 (0.7)	N/A	0.010 (0.030)	-0.003 (0.020)	N/A	24 (5)	29 (3)	60 (60)
CDBO-7	0.3 (0.3)	N/A	-0.4 (0.2)	2.6 (0.6)	N/A	-0.007 (0.030)	0.013 (0.020)	N/A	17 (4)	20 (2)	100 (60)
PERCHED GROUNDWATER IN PUEBLO/LOS ALAMOS CANYON											
Test Well 1A	0.2 (0.3)	-0.1 (0.8)	1.7 (1.3)	N/A	<1.0 (0.0)	-0.009 (0.030)	0.009 (0.020)	0.012 (0.030)	0 (1)	9 (1)	10 (90)
Test Well 2A	3.1 (0.5)	0.7 (0.7)	-0.7 (1.3)	N/A	<1.0 (0.0)	-0.004 (0.030)	0.018 (0.020)	0.024 (0.030)	-0 (1)	3 (1)	100 (100)
Basalt Spring	0.2 (0.3)	0.4 (0.9)	3.0 (1.3)	N/A	2.1 (0.4)	0.013 (0.030)	0.063 (0.022)	0.000 (0.000)	-1 (1)	5 (1)	30 (90)

Table VII-1. (Cont.)

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium KPA[a] (µg/L)	Total Uranium ICPES[b] (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)
PERCHED GROUNDWATER IN VOLCANICS											
Water Canyon Gallery	0.1[f] (0.4)	-0.4[f] (1.3)	0.7[f] (1.6)	N/A	*<2.0[f] (0.0)	0.006[f] (0.030)	0.017[f] (0.022)	0.000[f] (0.030)	-1[f] (1)	5[f] (1)	30[f] (141)
Limits of Detection	0.4	3	2	0.1	1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose	2,000	1,000	3,000	800	800	40	60	30			
DOE Drinking Water System DCG			120			1.6	1.2	1.2			
EPA Primary Drinking Water Standard	20	8		20	20				15		
EPA Screening Level										50	
NMWQCC Groundwater Limit				5,000	5,000						

[a]KPA = kinetic phosphorimetric analysis.

[b]ICPES - inductively-coupled plasma emission soectroscopy.

[c]Counting uncertainties (±1 standard deviation) are shown in parentheses.

[d]N/A means analysis not performed, lost in analysis, or not completed.

[e]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

[f]Mean of multiple samples.

Canyon for recent years, the sample from Well LAO-2 showed unusually high levels of ^{90}Sr, uranium, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am. This well is located at the mouth of DP Canyon, which received treated radioactive effluent discharges from TA-21, from 1952 to 1986. Concentrations in this range have not been observed in surface and groundwaters in Los Alamos and DP Canyons since the late 1970s. It appears (see discussion under Nonradioactive Analyses, below) that this sample had a high suspended sediment content; radionuclides tend to be associated with the sediment particles, rather than being dissolved in water. Preliminary 1994 sample results for Well LAO-2 show much lower values than typical of recent years.

The alluvial groundwater samples from Mortandad Canyon showed levels of radionuclides at levels within the ranges observed previously. The levels tend to be highest at Well MCO-4 and are lower further down the canyon.

Pueblo Canyon Well APCO-1 had a $^{239,240}Pu$ level of 0.28 pCi/L, slightly above the detection limit. Pajarito Canyon Well PCO-3 had a uranium concentration of 18 µg/L; values in recent years have been near the detection limit. It appears that this latter sample also had a high suspended sediment content, which might account for high radionuclide concentrations.

The radioactivity measurements in samples from Test Wells 1A and 2A, and Basalt Spring in the intermediate-depth perched zones in Pueblo Canyon indicate a connection with surface and alluvial waters 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. Test Well 2A, the one furthest upstream and closest to the historical discharge area in Acid Canyon, showed the highest levels. The tritium measurement obtained by conventional methods was 3.1 nCi/L; this was confirmed by the low-detection-limit measurement, which was about 2.3 nCi/L (see Section VII.E.1.c). Test Well 1A and Basalt Spring also showed possible traces of ^{137}Cs (slightly above the detection limit). Test Well 1A showed about 148 pCi/L of tritium by the low-detection-limit method (see Section VII.E.1.c).

The sample from the Water Canyon gallery was consistent with previous results, showing no evidence of contamination from Laboratory operations.

2. Nonradioactive Constituents.

The results of general chemical parameter analyses of groundwater samples for 1993 are listed in Table VII-2. 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.

The results of metal analyses of groundwater samples for 1993 are listed in Table VII-3. Several wells and springs show high values for trace metals, greatly exceeding values previously reported (EPG 1994). We believe that the high trace metal values are due to several factors: (1) the samples drawn from some springs and wells are likely to contain a high amount of suspended sediment; (2) the samples were not filtered before analysis; (3) the technique by which samples were prepared for analysis is for total recoverable metals, which partially digests the suspended sediment; (4) these elements are commonly either adsorbed onto suspended sediments; or (5) are constituents of the suspended sediment particles themselves. The elements affected were for the most part determined by the ICPES metals analyses: aluminum, arsenic, barium, beryllium, cadmium, chromium, iron, manganese, nickel, vanadium, and zinc, as well as calcium, magnesium, and potassium. Lead, antimony, and thallium analyses were by the induction coupled plasma mass spectroscopy (ICPMS) method. The reported TDS values confirm that suspended sediment is the probable source of the high metal concentrations. TDS was determined by evaporation of filtered samples. For samples having high trace metals values, the TDS values are much lower than the sum of all of the analytes listed for the sample.

Values for all parameters measured in the water supply wells were within drinking water limits, with the following exceptions. Several values for Well G-2 were of concern. The pH was 8.7, which was above the EPA secondary standard range (6.8 to 8.5). The arsenic level in Well G-2 was about 80% of the standard and was similar to previous measurements, and the lead level exceeded the EPA action level. Regarding the lead level in Well G-2, it is important to note that the EPA regulates lead in drinking water systems through a process of sampling at community water taps (see Section VI.2.C), and that blending of waters in the distribution system results in overall system compliance. The cadmium level in Well G-2 is at the EPA limit; and the vanadium value of 0.26 mg/L is above the EPA health advisory range of 0.08 to 0.11 mg/L. This well was also sampled for compliance with the Safe Drinking

Table VII-2. Chemical Quality of Groundwater for 1993 (mg/L)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
MAIN AQUIFER ON SITE																	
Test Wells																	
Test Well 1	54	45	9.3	3	15	29	0.4	<1[c]	107	0.1	21	5.88	N/A[d]	248	150	8.1	366
Test Well 3	81	17	5.2	2	12	3	0.4	<1	71	0.0	4	0.64	N/A	158	64	8.2	117
Test Well 8	63	12	4.4	1	10	3	0.1	<5	63	0.0	4	0.17	<0.01	90	48	8.0	138
Test Well DT-5A	63	8	2.3	1	10	2	0.3	<1	58	0.0	3	0.44	N/A	104	29	8.0	43
Test Well DT-9	72	10	2.9	1	11	2	0.3	<1	50	0.0	3	0.32	N/A	112	37	8.2	48
Test Well DT-10	62	11	3.5	1	11	2	0.3	1	57	<0.0	3	0.24	N/A	104	42	8.2	68
Water Supply Wells																	
O-4	124	17	6.0	3	16	7	0.3	<5	108	0.0	6	0.37	N/A	178	61	7.8	219
PM-1	87	30	7.1	4	22	6	0.3	<5	110	0.0	6	0.50	N/A	204	104	8.1	228
PM-2	89	9	2.8	2	10	2	0.2	<1	48	0.0	3	<0.04	N/A	136	34	8.2	48
PM-3	<100	22	7.3	3	17	7	0.3	2	115	0.1	6	<0.04	N/A	218	85	8.3	204
PM-4	97	11	3.7	2	13	3	0.3	<5	58	0.0	4	0.38	N/A	146	42	8.3	138
PM-5	98	12	4.5	2	14	4	0.3	<5	73	0.0	4	0.10	N/A	320	48	7.6	149
MAIN AQUIFER OFF SITE																	
Test Wells																	
Test Well 2	46	11	3.1	1	14	3	0.6	<1	60	0.1	4	0.22	N/A	96	40	8.3	75
Test Well 4	5	11	3.7	3	12	39	0.3	3	75	0.2	25	<0.04	N/A	86	43	8.6	83
Water Supply Wells																	
G-1A	80	8	0.5	2	26	4	0.6	<5	80	0.0	5	0.45	N/A	144	5	8.4	143
G-2	84	10	0.6	2	30	3	0.8	<5	87	0.0	5	0.48	N/A	222	27	8.7	166
G-5	71	15	3.1	2	10	6	0.3	<5	75	0.0	4	0.63	N/A	140	50	8.4	125
MAIN AQUIFER SPRINGS																	
White Rock Canyon Springs																	
Group I																	
Sandia Spring	39	49	4.3	3	15	5	0.5	<5	156	<0.0	5	<0.04	<0.01	210	140	8.3	288
Spring 3	40	24	1.9	3	15	5	0.4	<5	73	<0.0	6	<0.04	<0.01	192	67	8.3	186
Spring 3A	53	22	2.2	3	14	4	0.4	<5	79	0.0	7	<0.04	<0.01	166	63	8.3	173
Spring 3AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table VII-2. (Cont.)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[b]	Hardness as $CaCO_3$	pH[c]	Conductivity (µS/cm)
MAIN AQUIFER SPRINGS (Cont.)																	
Group I (Cont.)																	
Spring 4	63	24	4.6	2	12	7	0.5	<5	82	<0.0	10	0.09	<0.01	218	78	7.6	200
Spring 4A	74	20	4.6	2	11	6	0.4	<5	74	0.0	6	<0.04	<0.01	86	68	8.3	175
Spring 5	49	19	5.3	3	11	5	0.4	<5	79	<0.0	6	<0.04	<0.01	182	69	8.0	182
Spring 5AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Spring	73	14	3.4	2	10	4	0.4	<5	61	<0.0	4	<0.04	<0.01	138	50	8.1	134
Group II																	
Spring 5A	56	25	3.3	3	17	6	0.4	<5	110	<0.0	8	<0.04	<0.01	192	76	8.0	220
Spring 5B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 6	73	13	3.9	2	10	4	0.3	<5	90	<0.0	4	<0.04	<0.01	104	48	8.2	138
Spring 6A	76	13	3.3	2	9	3	0.3	<5	50	<0.0	4	<0.04	<0.01	148	46	8.1	119
Spring 7	77	18	3.9	3	18	4	0.4	<5	85	<0.0	8	<0.04	<0.01	206	60	7.9	196
Spring 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 8A	83	12	3.5	2	12	3	0.4	<5	65	<0.0	4	<0.04	<0.01	156	44	8.3	131
Spring 8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 9	66	20	4.5	2	12	4	0.5	<5	77	0.1	4	<0.04	<0.01	172	68	7.9	159
Spring 9A	72	12	3.4	1	10	4	0.5	<5	58	<0.0	4	<0.04	<0.01	128	44	7.8	129
Doe Spring	60	12	3.4	<1	10	4	0.5	<5	58	<0.0	4	<0.04	<0.01	180	46	8.1	122
Spring 10	68	87	18.0	8	13	4	0.5	<5	86	0.4	6	1.10	<0.01	122	290	8.1	178
Group III																	
Spring 1	35	28	4.7	5	33	6	0.5	<5	110	0.0	9	<0.04	<0.01	128	88	7.8	237
Spring 2	37	51	11.0	5	58	5	1.2	<5	175	2.3	8	<0.04	<0.01	224	170	7.8	362
Group IV																	
La Mesita Spring	34	36	2.0	N/A	26	7	0.2	<5	116	0.1	14	2.91	N/A	218	90	8.2	285
Spring 2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 3B	82	86	13.0	9	130	6	0.7	<5	501	0.1	25	<0.04	<0.01	640	270	6.8	958
Other Springs																	
Sacred Spring	33	24	0.7	3	21	3	0.5	<1	82	0.1	15	0.28	N/A	188	63	7.7	182
Indian Spring	52	35	2.8	2	25	32	0.4	<1	92	0.0	8	0.88	N/A	256	99	8.3	295

Table VII-2. (Cont.)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[b]	Hardness as $CaCO_3$	pH[c]	Conductivity (µS/cm)
CANYON ALLUVIUM GROUNDWATERS																	
DP-Los Alamos Canyons																	
LAO-C	40	12	3.3	5	28	39	0.2	<5	48	0.3	7	0.34	N/A	184	32	7.4	184
LAO-0.7	39	18	6.1	9	36	53	0.3	<5	40	0.9	8	<0.04	N/A	202	32	7.0	238
LAO-1	40	10	2.2	2	36	42	0.4	<5	57	0.1	8	0.10	N/A	184	25	7.4	214
LAO-2	48	320	77.0	30	34	52	0.9	<5	99	29.0	11	0.11	0.04	206	1,100	6.9	366
LAO-3	49	17	4.4	9	36	44	0.9	<5	58	0.4	9	0.15	N/A	186	38	7.7	251
LAO-4	42	15	3.9	5	27	38	0.6	<5	58	0.1	8	<0.04	N/A	174	46	6.9	219
LAO-4.5	42	13	4.4	6	32	44	0.8	<5	59	0.3	9	<0.04	N/A	178	43	6.8	250
Mortandad Canyon																	
MCO-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MCO-4	40	58	5.5	27	150	19	1.2	<5	214	0.2	19	66.00	0.03	724	170	7.4	1,031
MCO-5	35	37	5.2	28	100	17	1.2	<5	149	0.3	14	47.00	0.02	574	110	7.2	778
MCO-6	35	48	6.9	36	130	19	1.2	<5	163	0.6	13	54.00	0.02	602	150	7.2	840
MCO-7	43	61	20.0	26	120	25	1.0	<5	150	0.8	17	60.00	0.02	644	240	7.1	878
MCO-7.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pajarito Canyon																	
PCO-1	38	18	5.7	N/A	27	30	0.2	<5	74	0.1	11	0.29	N/A	166	52	7.1	234
PCO-2	33	26	8.3	N/A	25	43	0.2	<5	72	0.7	8	<0.04	N/A	200	85	7.0	314
PCO-3	47	210	48.0	N/A	160	452	0.2	<5	322	0.4	43	<0.04	N/A	1,420	682	6.7	1,813
Acid/Pueblo Canyons																	
APCO-1	52	25	5.5	12	66	35	0.4	<5	110	2.6	27	<0.04	<0.01	266	85	7.1	392
Cañada del Buey																	
CDBO-6	55	42	21.0	22	30	12	0.2	<5	67	0.4	8	0.04	<0.01	192	190	7.1	199
CDBO-7	62	28	9.3	10	29	11	0.1	<5	98	0.1	8	<0.04	<0.01	210	110	7.1	236
PERCHED GROUNDWATER IN PUEBLO/LOS ALAMOS CANYON																	
Test Well 1A	61	27	7.9	6	54	43	0.6	<1	133	0.1	22	5.78	N/A	318	100	7.5	469
Test Well 2A	68	35	6.8	3	22	38	0.2	<1	73	2.5	25	3.62	N/A	260	115	8.6	334
Basalt Spring	56	32	8.3	N/A	33	26	0.4	<5	97	1.7	21	2.27	N/A	302	111	7.4	384

Table VII-2. (Cont.)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[b]	Hardness as $CaCO_3$	pH[c]	Conductivity (µS/cm)
PERCHED GROUNDWATER IN VOLCANICS																	
Water Canyon Gallery	45[e]	11[e]	3.8[e]	3[e]	12[e]	12[e]	0.2[e]	<5[e]	47[e]	0.2[e]	6[e]	0.15[e]	N/A	137[e]	39[e]	7.7[e]	129[e]
EPA Primary Drinking Water Standard							4					10	0.2				
EPA Secondary Drinking Water Standard											250			500		6.8-8.5	
EPA Health Advisory					20												
NMWQCC Groundwater Limit						250	1.6					10					

[a]Total dissolved solids.
[b]Standard units.
[c]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[d]N/A means analysis not performed, lost in analysis, or not completed.
[e]Mean of multiple samples.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1993 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg *
MAIN AQUIFER ON SITE												
Test Wells												
Test Well 1	<0.01[a]	0.130	0.0036	0.0590	0.0740	<0.001	<0.003	<0.004	<0.004	0.013	0.76	<0.0002
Test Well 3	<0.01	0.051	<0.0020	0.0330	0.0380	<0.001	<0.003	<0.004	0.007	0.010	2.40	<0.0002
Test Well 8	<0.01	<0.100	<0.0020	<0.0100	0.0110	<0.001	0.004	<0.004	<0.004	0.005	0.10	<0.0002
Test Well DT-5A	<0.01	0.035	0.0046	0.0130	0.0250	<0.001	<0.003	<0.004	<0.004	0.370	0.84	<0.0002
Test Well DT-9	<0.01	0.100	0.0033	0.0110	0.0220	<0.001	<0.003	<0.004	<0.004	0.350	4.70	<0.0002
Test Well DT-10	<0.01	<0.100	<0.0020	0.0160	0.0030	<0.001	<0.003	<0.004	<0.004	<0.004	0.89	<0.0002
Water Supply Wells												
O-4	<0.01	<0.100	<0.0020	0.0300	0.0390	<0.001	<0.003	<0.004	0.005	0.015	<0.10	<0.0002
PM-1	<0.01	<0.100	<0.0020	0.0460	0.0880	<0.001	<0.003	<0.004	0.004	0.014	<0.10	<0.0002
PM-2	<0.01	<0.100	<0.0020	0.0110	0.0250	<0.001	<0.003	<0.004	<0.004	0.016	<0.10	<0.0002
PM-3	<0.01	<0.100	<0.0020	0.0420	0.0480	<0.001	<0.003	<0.004	<0.004	0.023	0.04	<0.0002
PM-4	<0.01	<0.100	0.0023	<0.4000	0.0270	<0.001	<0.003	<0.004	0.006	<0.004	<0.10	<0.0002
PM-5	<0.01	<0.100	<0.0020	0.5000	0.0300	<0.001	<0.003	<0.004	0.006	<0.004	<0.10	<0.0002
MAIN AQUIFER OFF SITE												
Test Wells												
Test Well 2	<0.01	0.110	<0.0020	0.0280	0.0320	0.001	<0.003	<0.004	<0.004	0.033	2.90	<0.0002
Test Well 4	<0.01	<0.100	<0.0020	0.0420	0.0510	<0.001	<0.003	<0.004	<0.004	0.023	0.48	<0.0002
Water Supply Wells												
G-1A	<0.01	<0.100	0.0140	0.0300	0.0330	<0.001	<0.003	<0.004	0.008	0.014	<0.10	<0.0002
G-2	<0.01	<0.100	0.0372	0.0330	0.0740	<0.001	0.005	0.130	0.015	0.028	0.15	<0.0002
G-5	<0.01	<0.100	0.0020	0.0200	0.0110	<0.001	<0.003	<0.004	<0.004	0.014	0.12	N/A[b]
MAIN AQUIFER SPRINGS												
White Rock Canyon Springs												
Group I												
Sandia Spring	<0.01	0.870	<0.0020	0.0190	0.1900	<0.001	<0.003	<0.004	<0.004	<0.004	0.84	<0.0002
Spring 3	<0.01	0.090	0.0020	0.0200	0.0370	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
Spring 3A	<0.01	1.000	0.0030	0.0200	0.0570	<0.001	<0.003	<0.004	0.004	<0.004	0.82	<0.0002
Spring 3AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 4	<0.01	<0.200	<0.0020	0.0190	0.0380	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
Spring 4A	<0.01	<0.200	<0.0020	0.0220	0.0390	<0.001	<0.003	<0.004	0.007	<0.004	<0.10	<0.0002
Spring 5	<0.01	1.600	<0.0020	0.0180	0.0410	<0.001	<0.003	<0.004	0.008	<0.004	1.40	<0.0002
Spring 5AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Spring	<0.01	<0.200	<0.0020	0.0170	0.0320	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002

*Data on additional trace metals in groundwaters are presented on page VII-20.

Table VII-3. (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg *
Group II												
Spring 5A	<0.01	0.590	0.0020	0.0300	0.0380	<0.001	<0.003	<0.004	0.005	<0.004	0.36	<0.0002
Spring 5B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 6	<0.01	<0.100	<0.0020	<0.0100	0.0250	<0.001	<0.003	<0.004	0.005	<0.004	<0.10	<0.0002
Spring 6A	<0.01	0.930	<0.0020	<0.0100	0.0430	<0.001	<0.003	<0.004	<0.004	<0.004	0.63	<0.0002
Spring 7	<0.01	<0.200	<0.0020	0.0210	0.0350	<0.001	<0.003	<0.004	<0.004	<0.004	<0.10	<0.0002
Spring 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 8A	<0.01	<0.200	<0.0020	<0.0100	0.0290	<0.001	<0.003	<0.004	<0.004	<0.004	0.15	<0.0002
Spring 8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 9	<0.01	1.700	<0.0020	0.0120	0.0740	<0.001	<0.003	<0.004	<0.004	<0.004	1.10	<0.0002
Spring 9A	<0.01	0.360	<0.0020	<0.0100	0.0170	<0.001	<0.003	<0.004	<0.004	<0.004	0.65	<0.0002
Doe Spring	<0.01	<0.200	<0.0020	0.0120	0.0130	<0.001	<0.003	<0.004	<0.004	<0.004	0.11	<0.0002
Spring 10	<0.01	32.000	0.0090	0.0260	0.7100	0.002	<0.003	0.016	0.031	0.035	29.00	<0.0002
Group III												
Spring 1	<0.01	9.200	0.0120	0.0500	0.1700	<0.001	<0.003	<0.004	0.025	0.006	7.80	<0.0002
Spring 2	<0.01	21.000	0.0330	0.0900	0.3400	0.002	<0.003	0.010	0.022	0.031	16.00	<0.0002
Group IV												
La Mesita Spring	<0.01	2.000	<0.0020	0.0400	0.1700	<0.001	<0.003	<0.004	0.005	<0.004	3.30	<0.0002
Spring 2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 3B	<0.01	1.300	0.0160	0.1400	0.1400	<0.001	<0.003	<0.004	<0.004	<0.004	1.90	<0.0002
Other Springs												
Sacred Spring	<0.01	1.000	0.0043	0.0380	0.1300	<0.001	<0.003	<0.004	<0.004	<0.001	1.00	<0.0002
Indian Spring	<0.01	<0.100	0.0041	0.0340	0.1000	<0.001	<0.003	<0.004	0.004	<0.004	<0.10	<0.0002
CANYON ALLUVIUM GROUNDWATERS												
DP-Los Alamos Canyons												
LAO-C	<0.01	8.100	0.0035	<0.0100	0.1200	0.001	<0.003	<0.004	2.000	<0.004	9.40	<0.0002
LAO-0.7	<0.01	88.000	0.0310	<0.0100	0.9300	0.008	<0.003	0.023	0.029	0.020	45.00	<0.0002
LAO-1	<0.01	2.800	0.0030	<0.0100	0.0390	<0.001	<0.003	<0.004	0.004	<0.004	1.70	<0.0002
LAO-2	<0.01	240.000	0.0830	0.0670	2.4000	0.022	0.022	0.071	0.400	0.870	190.00	0.0140
LAO-3	<0.01	18.000	0.0040	<0.0100	0.1600	0.003	<0.003	<0.004	0.010	0.016	12.00	<0.0002
LAO-4	<0.01	5.000	0.0040	<0.0100	0.0740	0.001	<0.003	0.004	<0.004	0.014	3.60	<0.0002
LAO-4.5	<0.01	6.900	<0.0020	<0.0100	0.0870	0.001	<0.003	<0.004	0.004	0.015	4.90	<0.0002
Mortandad Canyon												
MCO-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MCO-4	<0.01	9.600	0.0020	0.1000	0.2200	0.002	<0.003	<0.004	0.020	0.035	6.80	0.0005

*Data on additional trace metals in groundwaters are presented on page VII-21.

Table VII-3. (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg *
Mortandad Canyon (Cont.)												
MCO-5	<0.01	7.300	0.0020	0.0700	0.2100	<0.001	<0.003	<0.004	0.013	0.031	5.70	<0.0002
MCO-6	<0.01	12.000	<0.0020	0.0800	0.2900	0.002	<0.003	0.006	0.011	0.026	8.10	<0.0002
MCO-7	<0.01	44.000	0.0070	0.0800	0.7400	0.003	<0.003	0.008	0.027	0.070	31.00	<0.0002
MCO-7.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pajarito Canyon												
PCO-1	<0.01	11.000	0.0034	0.0300	0.2100	<0.001	<0.003	<0.004	0.081	<0.004	9.40	<0.0002
PCO-2	<0.01	20.000	0.0074	0.0240	0.3500	0.003	<0.003	0.007	0.390	0.013	21.00	<0.0002
PCO-3	<0.01	100.000	0.0683	0.0230	2.8000	0.019	0.007	0.049	0.740	0.130	110.00	<0.0002
Acid-Pueblo Canyons												
APCO-1	<0.01	8.500	0.0050	0.2100	0.2400	<0.001	<0.003	0.017	0.006	0.011	5.20	<0.0002
Cañada del Buey												
CDBO-6	<0.01	160.000	0.0240	0.0500	1.5000	0.020	0.005	0.028	0.100	0.071	130.00	<0.0002
CDBO-7	<0.01	52.000	0.0100	0.0500	0.6800	0.005	<0.003	0.008	0.020	0.015	29.00	<0.0002
PERCHED GROUNDWATER IN PUEBLO/LOS ALAMOS CANYONS												
Test Well 1A	<0.01	<0.100	0.0056	0.1600	0.0820	<0.001	<0.003	<0.004	<0.004	<0.004	0.65	<0.0002
Test Well 2A	<0.01	<0.100	<0.0020	0.0920	0.0360	<0.001	<0.003	<0.004	<0.004	0.020	1.00	<0.0002
Basalt Spring	<0.01	2.300	0.0060	0.1100	0.0800	<0.001	<0.003	<0.004	<0.004	0.000	1.50	<0.0002
PERCHED GROUNDWATER IN VOLCANICS												
Water Canyon Gallery	<0.01[c]	0.900[c]	<0.0020[c]	0.0235[c]	0.2345[c]	<0.001[c]	<0.003[c]	<0.004[c]	<0.004[c]	0.008[c]	0.56	<0.0002[c]
EPA Primary Drinking Water Standard	0.05		0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard											0.3	
EPA Action Level										1.3		
Livestock and Wildlife Watering Limit		5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01
NMWQCC Groundwater Limit	0.05		0.1		1.0		0.01		0.05			0.002

*Data on additional trace metals in groundwaters are presented on page VII-22.

Table VII-3. (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
MAIN AQUIFER ON SITE											
Test Wells											
Test Well 1	0.0260	<0.008	<0.020	1.0370	0.0164	<0.002	<0.03	0.2700	<0.0010	<0.01	0.890
Test Well 3	0.0380	<0.008	0.035	0.0090	0.0020	<0.002	<0.03	0.0800	<0.0100	<0.01	0.290
Test Well 8	0.0030	<0.008	<0.010	0.0190	<0.0020	<0.002	<0.03	0.0540	<0.0020	0.01	1.000
Test Well DT-5A	0.0280	<0.008	<0.020	9.0000	0.2800	<0.002	<0.03	0.0430	<0.0100	<0.01	2.300
Test Well DT-9	0.1100	<0.008	<0.020	0.0530	<0.0020	<0.002	<0.03	0.0540	<0.0100	<0.01	1.400
Test Well DT-10	0.0170	<0.008	<0.020	0.0750	0.0020	<0.002	<0.03	0.0500	<0.0100	<0.01	2.100
Water Supply Wells											
O-4	<0.0020	<0.008	<0.010	0.0070	0.0010	<0.002	<0.03	0.0940	<0.0010	0.02	0.040
PM-1	<0.0020	<0.008	0.010	0.0010	0.0040	<0.002	<0.03	0.1700	<0.0010	0.01	0.034
PM-2	<0.0020	<0.008	<0.020	<0.0010	<0.0010	<0.002	<0.03	0.0420	<0.0010	<0.01	<0.010
PM-3	<0.0020	<0.008	<0.020	<0.0060	<0.0020	<0.002	<0.03	0.1200	<0.0100	0.02	<0.010
PM-4	<0.0020	0.011	<0.010	0.0097[c]	0.0010	<0.002	<0.03	0.0520	0.0190	0.01	0.020
PM-5	<0.0020	<0.008	<0.010	0.0091[c]	<0.0010	<0.002	<0.03	0.0600	0.0140	0.01	<0.020
MAIN AQUIFER OFF SITE											
Test Wells											
Test Well 2	0.1400	<0.008	0.022	0.0304	<0.0010	<0.002	<0.03	0.0560	<0.0010	<0.01	0.880
Test Well 4	0.2300	<0.008	<0.020	0.0596	0.0010	<0.002	<0.03	0.0640	<0.0010	<0.01	2.200
Water Supply Wells											
G-1A	<0.0020	<0.008	<0.010	0.0080	<0.0010	<0.002	<0.03	0.0640	<0.0010	0.04	0.023
G-2	0.0100	<0.008	0.020	0.0390	0.0010	<0.002	<0.03	0.0750	<0.0010	0.26	0.053
G-5	<0.0020	<0.008	<0.010	0.0060	<0.0010	<0.002	<0.03	0.0730	<0.0010	0.02	0.021
MAIN AQUIFER SPRINGS											
White Rock Canyon Springs											
Group I											
Sandia Spring	0.3800	<0.008	<0.020	<0.0010	<0.0010	<0.002	<0.03	0.3800	<0.0010	<0.00	<0.020
Spring 3	0.0030	<0.008	<0.010	<0.0010	<0.0010	<0.002	<0.03	0.2400	<0.0010	0.02	<0.020
Spring 3A	0.0280	<0.008	<0.020	<0.0010	<0.0010	<0.002	<0.03	0.2200	<0.0010	0.01	<0.020
Spring 3AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 4	<0.0020	<0.008	<0.020	0.0020	<0.0010	<0.002	<0.03	0.1300	<0.0010	0.01	<0.020
Spring 4A	0.0030	<0.008	<0.020	<0.0010	<0.0010	<0.002	<0.03	0.0940	<0.0010	<0.00	<0.020
Spring 5	0.0370	<0.008	<0.020	0.0015	<0.0010	<0.002	<0.03	0.0920	<0.0010	0.01	<0.020
Spring 5AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Spring	0.0300	<0.008	<0.020	<0.0010	<0.0010	<0.002	<0.03	0.0650	<0.0010	<0.00	<0.020

Table VII-3. (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Group II											
Spring 5A	0.0180	<0.008	<0.010	<0.0010	<0.0010	<0.002	<0.03	0.2000	<0.0010	0.02	<0.020
Spring 5B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 6	<0.0020	<0.008	<0.010	<0.0010	<0.0020	<0.002	<0.03	0.0600	<0.0010	0.01	<0.020
Spring 6A	0.0260	<0.008	<0.010	0.0020	<0.0010	<0.002	<0.03	0.0580	<0.0010	<0.00	<0.020
Spring 7	0.0030	<0.008	<0.020	<0.0010	<0.0010	<0.002	<0.03	0.1000	<0.0010	0.01	<0.020
Spring 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 8A	0.0050	<0.008	<0.010	<0.0010	<0.0010	<0.002	<0.030	0.0540	0.0010	0.01	<0.020
Spring 8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 9	0.0590	<0.008	<0.020	0.0020	<0.0010	<0.002	<0.030	0.0770	<0.0010	0.01	<0.020
Spring 9A	0.0350	<0.008	<0.010	0.0020	0.0010	<0.002	<0.030	0.0530	0.0010	<0.00	0.054
Doe Spring	0.0070	<0.008	<0.020	<0.0010	<0.0010	<0.002	<0.030	0.0540	<0.0010	0.01	<0.020
Spring 10	0.8800	<0.008	0.031	0.0320	<0.0010	<0.002	<0.030	0.3100	<0.0010	0.07	0.130
Group III											
Spring 1	0.2700	<0.008	<0.020	0.0055	0.0070	<0.002	<0.030	0.3200	0.0160	0.05	0.023
Spring 2	0.9000	<0.008	0.020	0.0220	<0.0010	<0.002	<0.030	0.5600	<0.0010	0.16	0.056
Group IV											
La Mesita Spring	0.0580	<0.010	0.010	0.0010	<0.0010	<0.002	<0.030	0.9200	<0.0010	0.01	0.030
Spring 2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 3B	0.0410	<0.008	<0.020	0.0020	<0.0010	0.002	<0.030	0.5000	<0.0010	0.03	<0.020
Other Springs											
Sacred Spring	0.0350	<0.008	<0.010	<0.0060	<0.0010	0.003	<0.030	0.5100	<0.0010	0.01	0.030
Indian Spring	<0.0020	0.009	<0.010	<0.0060	<0.0010	0.004	<0.030	0.4200	<0.0010	0.01	0.400
CANYON ALLUVIUM GROUNDWATERS											
DP-Los Alamos Canyons											
LAO-C	0.9200	<0.008	<0.010	0.0190	<0.0010	<0.002	<0.030	0.0900	<0.0010	0.01	0.067
LAO-0.7	9.4000	<0.008	0.038	0.0900	<0.0010	0.003	<0.030	0.2000	0.0027	0.05	0.230
LAO-1	0.0390	0.150	<0.010	0.0034	<0.0010	<0.002	<0.030	0.0780	<0.0010	<0.00	0.032
LAO-2	3.6000	0.710	0.170	0.4070	<0.0010	0.010	<0.030	0.9300	0.0030	0.35	1.600
LAO-3	0.4600	0.340	0.015	0.0255	<0.0010	<0.002	<0.030	0.1200	<0.0010	0.02	0.070
LAO-4	0.1000	0.024	<0.010	0.0066	<0.0010	<0.002	<0.030	0.1000	<0.0010	<0.00	0.035
LAO-4.5	0.2000	<0.008	<0.010	0.0141	<0.0010	<0.002	<0.030	0.0970	<0.0010	0.01	0.047
Mortandad Canyon											
MCO-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MCO-4	0.3200	0.210	<0.010	0.0250	<0.0020	<0.002	<0.030	0.2000	<0.0020	0.07	0.060
MCO-5	0.1700	0.140	<0.010	0.0340	<0.0020	<0.002	<0.030	0.1800	<0.0020	0.01	0.130

Table VII-3. (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Mortandad Canyon (Cont.)											
MCO-6	0.6700	0.190	<0.010	0.0380	<0.0020	<0.002	<0.030	0.2300	<0.0020	0.02	0.089
MCO-7	0.6500	0.031	0.030	0.0410	<0.0020	<0.002	<0.030	0.3900	<0.0020	0.05	0.170
MCO-7.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pajarito Canyon											
PCO-1	0.5700	0.011	<0.010	0.0090	0.0010	<0.002	<0.030	0.1500	<0.0010	0.01	0.030
PCO-2	0.8000	<0.008	<0.010	0.0310	<0.0010	<0.002	<0.030	0.2100	<0.0010	0.03	0.080
PCO-3	13.0000	0.020	0.066	0.2070	<0.0010	0.006	<0.030	1.5000	0.0020	0.14	0.640
Acid/Pueblo Canyons											
APCO-1	6.6000	<0.020	<0.020	0.0070	0.0020	<0.002	<0.030	0.1500	<0.0010	0.02	0.061
Cañada del Buey											
CDBO-6	2.4000	<0.008	0.080	0.2420	<0.0020	0.003	<0.030	0.3300	0.0020	0.15	0.720
CDBO-7	0.9200	<0.008	0.020	0.0540	<0.0020	<0.002	<0.030	0.2000	<0.0020	0.04	0.160
PERCHED GROUNDWATER IN PUEBLO/LOS ALAMOS CANYONS											
Test Well 1A	0.0860	0.008	<0.020	<0.0010	<0.0010	<0.002	<0.030	0.1600	<0.0010	<0.01	0.490
Test Well 2A	0.1100	<0.008	0.041	0.0046	<0.0010	<0.002	<0.030	0.2000	<0.0010	<0.01	0.800
Basalt Spring	0.0780	0.010	<0.010	0.0052	<0.0010	<0.002	<0.030	0.1900	<0.0010	0.01	0.030
PERCHED GROUNDWATER IN VOLCANICS											
Water Canyon Gallery	0.0125[c]	<0.008[c]	<0.020[c]	0.0017[c]	<0.0020[c]	<0.002[c]	<0.030[c]	0.0805[c]	0.0012[c]	0.01	<0.400[c]
EPA Primary Drinking Water Standard			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard	0.05										5.0
EPA Action Level				0.015							
EPA Health Advisory								25-90		0.08-0.11	
Livestock and Wildlife Watering Limit				0.1						0.1	25.0
NMWQCC Groundwater Limit				0.05		0.05					

[a]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[b]N/A means analysis not performed, lost in analysis, or not completed.
[c]Mean of multiple values.

Water Act (SDWA) (see Section III.B.7) and cadmium concentrations were below the detection limit of 0.001 mg/L. Vanadium was not analyzed in the SDWA samples. Supply Wells PM-4 and PM-5 had thallium levels significantly above the EPA limit of 0.002 mg/L; again, SDWA sample concentrations for those wells were below the detection limit of 0.001 mg/L.

The test wells in the main aquifer showed levels of several constituents that exceed standards for drinking water distribution systems, although the test wells are not part of the water supply system (see Section VII.E.1). These high levels are believed to be associated with the more than 40-year-old steel casings and pump columns in the test wells. Iron was high in all of the main aquifer test wells except Test Well 3; manganese, in Test Wells 2, 4, and DT-10; antimony in Test Wells 1 and DT-5A; and zinc, in Test Wells 4, DT-5A, and DT-10. Lead levels exceeded the EPA action level in all of the main aquifer test wells except Test Well 3 (see Section VII.E.1). Several of the test wells have occasionally had elevated lead levels in previous years.

Samples from a few springs (La Mesita Spring; Sacred Spring; and Springs 1, 2, 3B, 9, and 10) in White Rock Canyon showed aluminum levels that are higher than expected, and that exceed NM Livestock and Wildlife Watering Standards. These levels are believed to be due to several factors, including sample turbidity, as discussed above. Hem (1989) reports that for unfiltered samples, aluminum concentrations should only be a few mg/L. Samples from a few springs (La Mesita Spring; Sacred Spring; Sandia Spring and Springs 1, 2, 3A, 3B, 5, 5A, 6A, 9, 9A, 10) in White Rock Canyon showed levels of iron and, in some cases, manganese that would exceed secondary standards for drinking water systems. However, these elements are also associated with suspended sediment particles. According to Hem (1989) iron and manganese concentrations in aerated water, in the pH range 6.5 to 8.5, should be less than a few mg/L. Spring 1 had antimony and thallium levels higher than primary drinking water standards, and Spring 2 had a vanadium concentration above the EPA health advisory range. Spring 2 also exceeded the NM Livestock and Wildlife Watering Standards for arsenic, and Springs 2 and 10 exceeded the drinking water action level for lead. Selenium levels were below the standard this year, discounting suspect levels from 1991 samples that were measured by a method with a much higher detection limit.

Alluvial canyon groundwaters in the areas receiving effluents showed the effects of those effluents, in that levels of some parameters were elevated. The effects were seen in the samples from Pueblo, Los Alamos, and Mortandad canyons. The trace metal data for the alluvial canyon groundwaters were particularly influenced by what are believed to be the effects of suspended sediment in unfiltered samples. The affected samples include the groundwater samples from Pajarito Canyon and Cañada del Buey, and those from the Pueblo of San Ildefonso (see Section IV.C.5).

In particular, wells LAO-2 and PCO-3 had unusual results for almost all trace metals, as well as calcium, magnesium, and potassium. These two samples were noted earlier to have had high readings for several radioactive constituents. Well CDBO-6 also had unusual results for almost all trace metals, and Well CDBO-7 had several high values. Twelve of the wells exceeded the EPA action level for lead. To resolve these issues, the Laboratory is reassessing methods used for field collection and laboratory analysis of surveillance water samples and is also considering whether to redevelop the alluvial observation wells, a process designed to lessen the amount of suspended sediments entering the well bore.

Except for manganese and iron, none of the intermediate perched groundwaters or the Water Canyon Gallery showed any concentrations of inorganic constituents that are of concern.

Analyses for organic constituents were performed on most of the water supply wells, alluvial observation wells, and for the first time on the White Rock Canyon Springs in 1993. The analyses addressed the volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), and PCBs (see Tables D-25 and D-26 for detailed listings of parameters). Test Wells 1, 2, 3, and DT-5A and Water Supply Wells PM-2, 3, 4, and 5 were not sampled for organics. CH-2 is a borehole located at TA-49. The samples where organics were detected are listed in Table VII-4. Most of the organics detected were a result of either laboratory contamination or were substances also detected in blank samples from the field, and therefore are suspected to result from other sample contamination. Acetone, Bis-2-Ethylhexylphthalate, Di-N-Octylphthalate, Methylene chloride, and 2-Butanone are common laboratory contaminants.

The only definite organic detections were in Test Well DT-9 (2,4-Dinitrophenol, Pentochlorophenol, and Acetone); Borehole CH-2 (Toluene); Water Supply Well PM-1 and Alluvial Observation Well LAO-1 (Bis-2-

Table VII-4. Groundwater Samples with Organic Compounds Detected

Well	Compound	Amount (µg/L)	Comments
Test Wells			
DT-9	2,4-Dinitrophenol	130. ± 10	
	Pentochlorophenol	110. ± 10	
	Acetone	46. ± 20	
DT-10	Chlorodibromomethane	5.4 ± 5	contamination in field blank
CH-2	2,6-Dinitrotoluene	35. ± 10[a]	
	N-Nitrosodiphenylamine	23. ± 10[a]	
	Pyrene	32. ± 10[a]	
	Bis-2-Ethylhexylphthalate	2,200. ± 10[a]	
	Di-N-Octylphthalate	11. ± 10[a]	
	Benzoic Acid	12. ± 10[a]	
	Methylene chloride	41. ± 5	lab contamination
	2-Butanone	32. ± 20	lab contamination
	Toluene	10. ± 5	
Water Supply Wells			
O-4	Chlorodibromomethane	5.8 ± 5[b]	
	Chlorodibromomethane	12. ± 5[b]	
	Bromoform	7.6 ± 5[b]	
	Chloroform	5.6 ± 5[b]	
	Bromodichloromethane	9.2 ± 5[b]	
	Acetone	40. ± 20	trip blank contaminated
PM-1	Bis-2-Ethylhexylphthalate	2,000. ± 11	
White Rock Canyon Springs			
La Mesita Spring	1,2-Dichloroethane	6.2 ± 5	
Spring 4A	Acetone	24. ± 20	possible lab contamination
Alluvial Observation Wells			
LAO-1	Bis-2-Ethylhexylphthalate	18. ± 11	
PCO-1	Carbon disulfide	510. ± 5	possible lab contamination
PCO-2	Carbon disulfide	50. ± 5	possible lab contamination

[a]The laboratory quality control for these analyses did not meet EPA criteria.
[b]May be due to chlorination during testing of the well or laboratory contamination; no semivolatiles were detected in these samples, which makes the analyses suspect.

Ethylhexylphthalate); and La Mesita Spring (1,2-Dichloroethane). Bis-2-Ethylhexylphthalate is a common contaminant found in samples that have come in contact with plastic laboratory and sampling equipment. The organics detected in Water Supply Well Otowi-4 were all only slightly above detection limits and could result from either chlorination of the well during testing (the well was disinfected during September and October of 1992) or from laboratory contamination. A composite sample from Water Supply wells O-4, G-1A, G-2, and G-5 analyzed for SDWA VOCs in April 1993 detected none of these compounds (see Section III.B.7).

D. Long-Term Trends

1. Main Aquifer.

The long-term trends of the water quality in the main aquifer are simple to summarize for all locations. Except for tritium contamination discovered in a low-detection-limit analysis 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

tritium by extremely low detection limit analytical methods (see Section VII.E.1) 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 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 (see Section VII.E.1).

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. The westernmost well, Test Well 4, shows less than 3 m (10 ft) of change. In the central part of the plateau, water levels in Test Wells 2, 3, and 8 have declined about 7.6 to 10.7 m (25 to 35 ft) in slightly more than 45 years, or less than about 0.25 m/yr. Test Well 3 is located about 1.6 km (1 mi) from the nearest supply wells (PM-5 and PM-3); Test Well 2 is about 3.0 km (2 mi); and Test Well 8 is less than 1 km (0.5 mi) from the nearest supply wells. Near the southern boundary of the Laboratory, water levels in Test Wells DT-5A, DT-9, and DT-10 have declined about 3 to 4 m (10 to 13 ft) in 33 years. The initial years of this decline occurred before any of the Pajarito field wells were drilled and must be attributed to a general regional trend unaffected by pumping. Thus, the decline observed in the test wells to the north and in the pumping wells is probably partly attributable to a general trend in the regional aquifer.

One test well, Test Well 1, shows an apparent increase in water level. The anomalous behavior of this well is not understood and is under investigation. Two prior surveillance reports provide a detailed discussion of some preliminary tests to evaluate this well (EPG 1993, EPG 1994).

The Pajarito Field wells have always been the best producers. As expected, they show the least decline in water levels; about 6 to 12 m (20 to 40 ft) since 1990. Nonpumping levels in Supply Well PM-5 have declined about 5 m (16 ft) in 11 years and in PM-3 have declined about 9.4 m (31 ft) in 27 years. PM-3 is the largest producer of all the wells, producing more than 200 million gal./yr in the last several years.

In the Guaje Well Field northeast of the Laboratory, the water levels have ranged from almost no decline to about 37 m (120 ft) of decline since 1950. The westernmost wells show the least decline overall and have recovered significantly in recent years with somewhat lower production. Wells G-4 and G-5 recovered significantly in 1993 when they were not pumped. The overall nonpumping levels have declined an average of about 19 m (62 ft) for the entire field over the past 40 years.

The Los Alamos Well Field was retired from service after 1991. The average water level in the field declined about 18.6 m (61 ft) from 37 m (121 ft) in 1951 to 55 m (182 ft) in 1964. After 1965 the production from the field decreased, and the average water level recovered about 21 m (68 ft) from 55 m (182 ft) in 1964 to 35 m (114 ft) in 1991. With the end of production from the field, there was a sharp recovery in water levels. The eastern most wells, which were artesian wells at completion, have regained most of their levels; LA-1B has again become an artesian well. All remaining facilities in the Los Alamos Well Field were turned over to the Pueblo of San Ildefonso in July 1992.

2. Alluvial Perched Groundwaters in Mortandad Canyon.

Long-term trends of radionuclide concentrations in shallow alluvial perched groundwater in Mortandad Canyon (the current radioactive effluent release area for the waste treatment plant at TA-50) are depicted in Figure VII-3. The samples are from Observation Well MCO-6 in the middle reach of the canyon. The combined total of ^{238}Pu and $^{239,240}Pu$ concentrations are relatively constant, fluctuating up and down in response to variations in the treatment plant effluent and storm runoff that cause some dilution in the shallow alluvial water. 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. Special Studies

1. Main Aquifer.

a. Lead in Test Wells. In May of 1993, representatives of the NMED/Agreement in Principle (AIP), Geology and Geochemistry Group (EES-1), and the Environmental Protection Group (EM-8) collected water samples

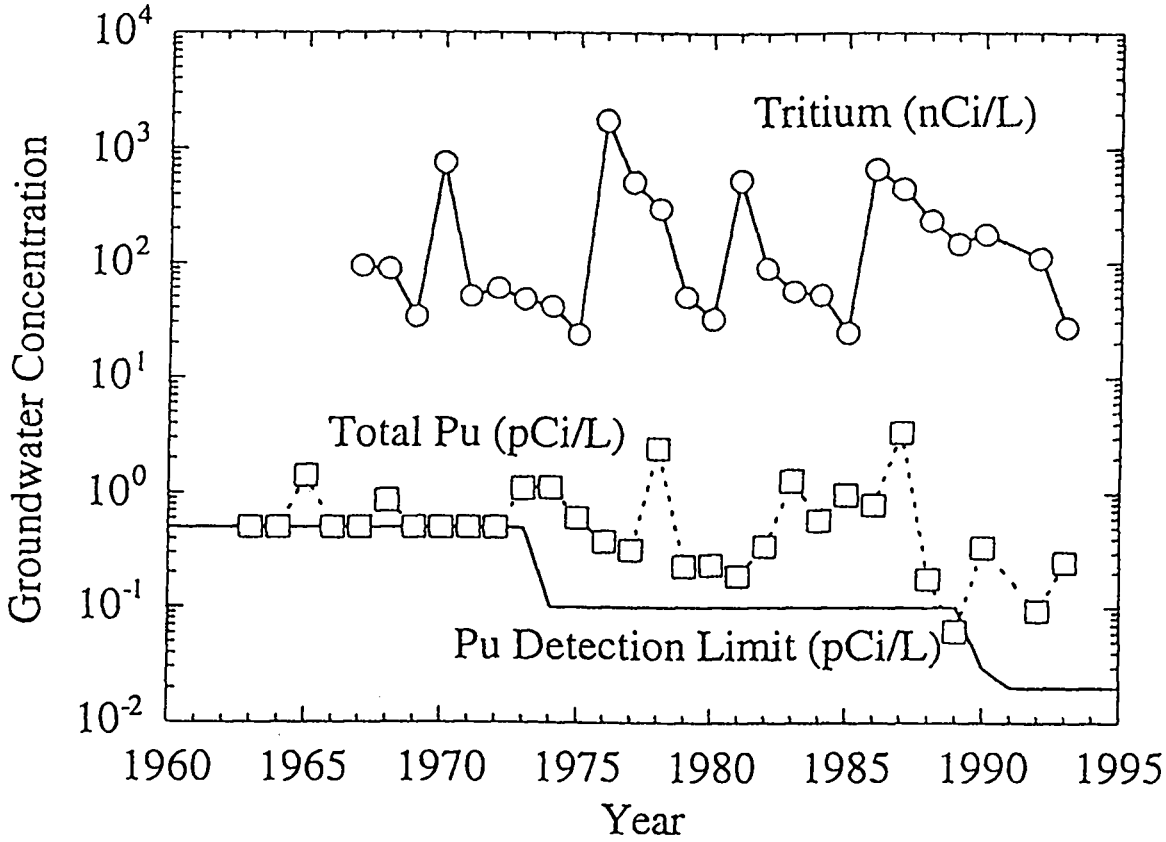


Figure VII-3. Tritium and plutonium concentrations in unfiltered water samples from Mortandad Canyon Alluvial Observation Well MCO-6.

from several of the Laboratory's test wells. In July, the AIP staff informally advised EM-8 that their sample from Test Well DT-5A (located at TA-49) showed a lead level of 5 mg/L. (The EPA drinking water action level for lead is 0.015 mg/L; the NMED drinking water standard is 0.05 mg/L). The EM-9 analysis of a duplicate sample showed a lead concentration of 9.0 mg/L. The results were a significant departure from previous lead measurements in Test Well DT-5A (Tables VII-5 and VII-6), and suggested a possible upward trend in lead concentrations. Lead levels higher than previous values were also measured for four other test wells: DT-9 and DT-10 (also at TA-49), TW-1 (in Pueblo Canyon above SR 4), and TW-4 (in upper Pueblo Canyon). The production wells that supply drinking water to the Los Alamos community generally have not shown excessive lead levels (Table VII-5).

The dissolved concentrations of lead in surface and groundwaters of near-neutral pH (pH ~7) are commonly extremely low, due in part to precipitation with manganese or adsorption on particle surfaces (Hem 1989). Samples evaluated by EM-9 and the NMED/AIP were unfiltered; possibly the lead was associated with suspended sediment particles. The EES-1 analysis of a filtered sample showed a far lower lead concentration of 0.037 mg/L. For Test Well DT-5A, the source of lead contamination was suspected to be the pump hardware (originally installed in Test Well 4 in the 60s, then moved to DT-5A in the 70s). For Test Well DT-5A and the other four test wells, modifications made to the wells in 1992 may have jarred the piping and caused lead particles to fall to the bottom of the well, to be later drawn into water samples.

The appearance of high lead levels in test wells at TA-49 is of concern because past underground tests at the site, involving high explosives and radioactive materials, raise the possibility of groundwater contamination (Purtymun 1987b). The tests were conducted in 1960 and 1961, at the direction of President Eisenhower, to evaluate safety aspects of certain nuclear weapons systems. Tests were carried out in large-diameter holes, up to 120 ft deep. Materials dispersed by detonation of the high explosives remain at the bottom of the experimental holes. These materials include 40 kg of plutonium, 93 kg of enriched uranium, 82 kg of depleted uranium, and 90,000 kg of lead,

Table VII-5. Summary of Lead Analyses in Main Aquifer Wells (mg/L)[a]

	1988		1991		1992		1993	
	Result	Date Sampled	Result	Date Sampled	Result	Date Sampled	Result	Date Sampled
Test Wells								
TW-1	<0.001	3/88	0.022	9/23/91	0.010	10/8/92	*1.037*[d]	5/19/93
TW-2	[b]		*0.053*	5/22/91	0.008	10/8/92	*0.030*	5/19/93
TW-3	<0.001	3/88	0.001	5/21/91	[b]		0.009	5/20/93
TW-4	[c]		[c]		[c]		*0.060*	5/19/93
TW-8	*0.060*	3/88	0.036	9/23/91	[b]		*0.019*	12/5/93
DT-5A	0.048	3/88	0.033[d]	9/23/91	*0.209*	11/18/92	*9.000*[d]	5/20/93
DT-9	0.017	3/88	0.026	9/23/91	*0.055*	2/25/93	*0.053*	5/20/93
DT-10	0.039	3/88	0.028	9/23/91	*0.050*	2/25/93	*0.075*	5/20/93
Supply Wells								
PM-1	0.007		0.002	5/9/91	<0.001	8/18/92	0.001	6/2/93
PM-2	0.002		<0.001	5/9/91	<0.001	8/18/92	<0.001	5/19/93
PM-3	0.006		0.002	5/9/91	<0.001	8/18/92	<0.006	5/19/93
PM-4	[b]		<0.001	5/9/91	[b]		0.010	8/18/93
PM-5	<0.001		0.003	5/9/91	<0.001	8/18/92	0.009	8/18/93
G-1	0.001		*0.049*	5/9/91	<0.001	8/18/92	[b]	
G-1A	<0.001		0.001	5/9/91	<0.001	8/18/92	0.008	6/2/93
G-2	0.002		<0.001	5/9/91	<0.001	8/18/92	*0.039*	6/2/93
G-4	<0.001		<0.001	5/9/91	<0.001	8/18/92	[b]	
G-5	<0.001		*0.095*	5/9/91	<0.001	8/18/92	0.006	6/2/93
G-6	<0.001		0.007	5/9/91	0.0011	8/18/92	[b]	
O-4	[b]		0.003	4/90[e]	[b]		0.010	5/20/93
							0.007	6/2/93

[a] Samples were unfiltered, analyses for Total Recoverable Lead. Values in italic type exceed (1) the EPA drinking water action level of 0.015 mg/L (effective in 1992, for water drawn from residential water supply systems), or (2) prior to 1992 the EPA maximum contaminant level (MCL) was 0.050 mg/L. The NMED drinking water standard for lead is 0.05 mg/L.
[b] Well not in service.
[c] Well had no pump.
[d] Additional samples collected at same time, but filtered through 0.45 micron filter showed 0.011 mg/L (TW-1, 5/19/93); 0.030 mg/L (DT-5A, 9/23/91); 0.037 mg/L (DT-5A, 5/20/93).
[e] Sampled during test pumping.

which was used as shielding (Purtymun 1987b, LANL 1992a). The area is considered to be a hazardous and radioactive material disposal area for purposes of compliance with DOE and EPA requirements. Environmental monitoring carried out since the time of the testing has indicated no contamination of the groundwater, which lies at a depth of 1,200 ft below TA-49.

Recent studies relating to groundwater age dating have a bearing on the source of lead in Test Well DT-5A, and the possibility that underlying groundwater has been contaminated by weapons-testing debris carried downwards by shallow recharge (see Sections VII.E.1.b and E.1.c). The ^{14}C age estimates and very low tritium content of this well water indicate that the observed lead is not transported by young, downward-percolating groundwater (Goff 1993).

Under the requirements of DOE Order 5003.B, EM-8 notified the DOE on July 20, 1993, that unusual levels of lead had been detected in five test wells; the NMED/AIP was notified on July 19, 1993. The EM-8 hydrology staff met with the NMED/AIP to plan follow-up sampling to determine the source of the lead. The plan included pump-

Table VII-6. Summary of Test Well DT-5A Lead Results

Date	Lead (mg/L)		Lab
	Unfiltered samples	Filtered samples	
3/88	0.048		EM-9
9/23/91		0.030	EES-1
9/23/91	0.033		EM-9
11/18/92	0.209		EM-9
5/20/93		0.037	EES-1
5/20/93	5.0		NMED/AIP
5/20/93	9.0		EM-9
8/2/93	2.675		EM-9
8/2/93		0.137	EM-9
8/9/93	0.410		EM-9
8/9/93		0.076 - 0.010	EM-9

ing TW-1 and DT-5A for a period of two weeks and collecting water samples for analysis. Materials from the wells (conduit and possibly leaded paint samples from well fittings) would be subjected to leaching and abrasion tests to determine the possibility of lead mobilization from these potential sources.

Pumping of DT-5A began in August 1993. Water samples were collected during the week of August 2, 1993, which showed lead concentrations in unfiltered samples of 2.7 mg/L, and in filtered samples of 0.14 mg/L (Table VII-6). During the week of August 9, 1993, lead concentrations in unfiltered samples were 0.41 mg/L; filtered samples were 0.08 to 0.01 mg/L. Due to difficulties with the pumping and filtration system, the Laboratory was unable to consistently produce discharge water from the test that had lead levels below the applicable regulatory limits. On October 1, 1993, the Laboratory filed a Notice of Intent covering the proposed discharge of filtered water from the well tests under the Laboratory's NPDES permit with NMED. The tests were not completed by the end of 1993.

b. Age of Water in Main Aquifer. In order to evaluate the risk and possible pathways of contamination for the main aquifer system at Los Alamos, EM-8's Hydrology Team initiated a study to help define the sources of recharge to the aquifer in 1991 (EPG 1993, EPG 1994). The cooperative study involves participation by researchers in other divisions at Los Alamos (Earth and Environmental Sciences and Isotope and Nuclear Chemistry Divisions) and another DOE contractor (RUST GeoTech at Grand Junction, CO.).

The study is attempting to apply a variety of radioactive and stable isotope geochronology techniques to help identify the sources and age of the main aquifer water. It is important to employ several techniques in order to overcome the limitations in measurement and interpretation inherent in these methods. Samples have been collected from the test wells and the water supply production wells that penetrate the main aquifer, from springs that issue along the Rio Grande, from wells and springs associated with the intermediate perched groundwater system, and from wells at the Pueblo of San Ildefonso. These Rio Grande springs have been interpreted to be discharging directly from the main aquifer (Purtymun 1980b). A number of ^{14}C and low-detection-limit tritium measurements are now available and permit some preliminary evaluation of recharge pathways and estimates of the age of water in the main aquifer. This section is primarily concerned with the age dating results; the specific low-detection-limit tritium measurements are discussed in the next section.

"Age of water" means the time elapsed since the water, as precipitation, entered the ground to form recharge and became isolated from the atmosphere. At the time of entry into the ground, the recharge water is assumed to have been in equilibrium with atmospheric concentrations of both tritium and ^{14}C. Radioactive ^{14}C and tritium are both produced in the atmosphere by interaction of cosmic rays with nitrogen (and, in the case of tritium, oxygen) atoms. Tritium also comes from decay of naturally occurring radioactive elements in rocks, fallout from atmospheric

nuclear weapons testing, and from operations at the Laboratory. Once water enters the ground as recharge, radioactive decay and/or mixing with older water would result in reduction of the concentration of either isotope in present day groundwater samples. Carbon-14, with a half-life of about 5,730 years, is useful for estimating ages ranging from a few thousand to several tens of thousands of years. Tritium, with a half-life of about 12.3 years, is useful for estimating ages in the range of decades.

Carbon-14 Age-Dating of Groundwater. The interpretation of ^{14}C age dates is complicated by the fact that other sources of carbon may have influenced the concentration of this isotope. The maximum possible ages (Table VII-7) result from a direct ^{14}C measurement, which gives an age based on the radioactive decay of ^{14}C. This value is often greater than the actual age, because the amount of ^{14}C in groundwater can be diluted by the dissolution of dead carbon (carbon with no remaining radiocarbon) from carbonate minerals in the rocks. Estimating this dilution effect requires measurement of other carbon isotopes and making assumptions about mixing. Calculating a minimum age based on the estimated dilution can lead to very young or meaningless ages if the geochemistry is not well characterized. It is also possible that ^{14}C from other sources such as laboratory effluents could raise the amount of ^{14}C in a sample and lead to an inferred age that is very "young" or even give a meaningless negative number. If the measured amount of ^{14}C present in the sample is greater than found in precipitation, then it is probably an indication of contamination.

The main aquifer groundwater ^{14}C ages are depicted in Figure VII-4. Preliminary interpretation of the results of ^{14}C analyses indicate that the minimum age of water in the main aquifer ranges from about a thousand years under

Table VII-7. Summary of Carbon-14 and Tritium-based Age Estimates (in Years) for Wells in the Los Alamos Main Aquifer

		Carbon-14 Age Estimates		Tritium		Tritium Age Estimates[a]	
Well	Carbon-14 (% modern)	Minimum[b]	Maximum[c]	(pCi/L)	(T.U.[d])	Piston Flow[e]	Well -Mixed[f]
PM-5	53.7	1,040	5,140	0.29	0.09	85	>10,000
				1.3	0.39	49	4,500
DT-5A	57.6	1,810	4,560	0.23	0.07	80	>10,000
				0.45	0.14	70	>10,000
O-4	25.0	3,890	11,500	1.0	0.32	50	5,000
PM-3	23.9	4,950	11,800	0.75	0.23	60	4,500
PM-1	18.5	5,620	14,000	1.7	0.51	44	3,500
				2.2	0.69	39	2,500
G-5	26.8	6,110	10,900	0.26	0.08	80	10,000
				1.4	0.43	47	4,000
LA-1A	13.9	6,250	16,300	64.	19.7	20	50
E. Artesian	3.8	18,200	27,000	1.0	0.31	55	5,000
LA-1B	<0.9	>27,000	>39,000	0.58	0.18	60	9,000
				0.065	0.02	100	10,000
W. Artesian	0.0	>35,000	>45,000	0.39	0.12	70	>10,000
				0.42	0.13	70	>10,000

[a] Blake 1995.
[b] Assumes dilution by dead carbon from dissolution of carbonates, estimated by $\Delta^{13}C$.
[c] Assumes radioactive decay only, no dissolution of carbonates.
[d] Tritium Units, one tritium atom in 10^{18} hydrogen atoms; 1 TU = 3.24 pCi/L.
[e] Piston Flow model assumes no mixing or dilution with other water.
[f] Well Mixed model assumes complete mixing in reservoir, inflow = outflow, no other inputs.

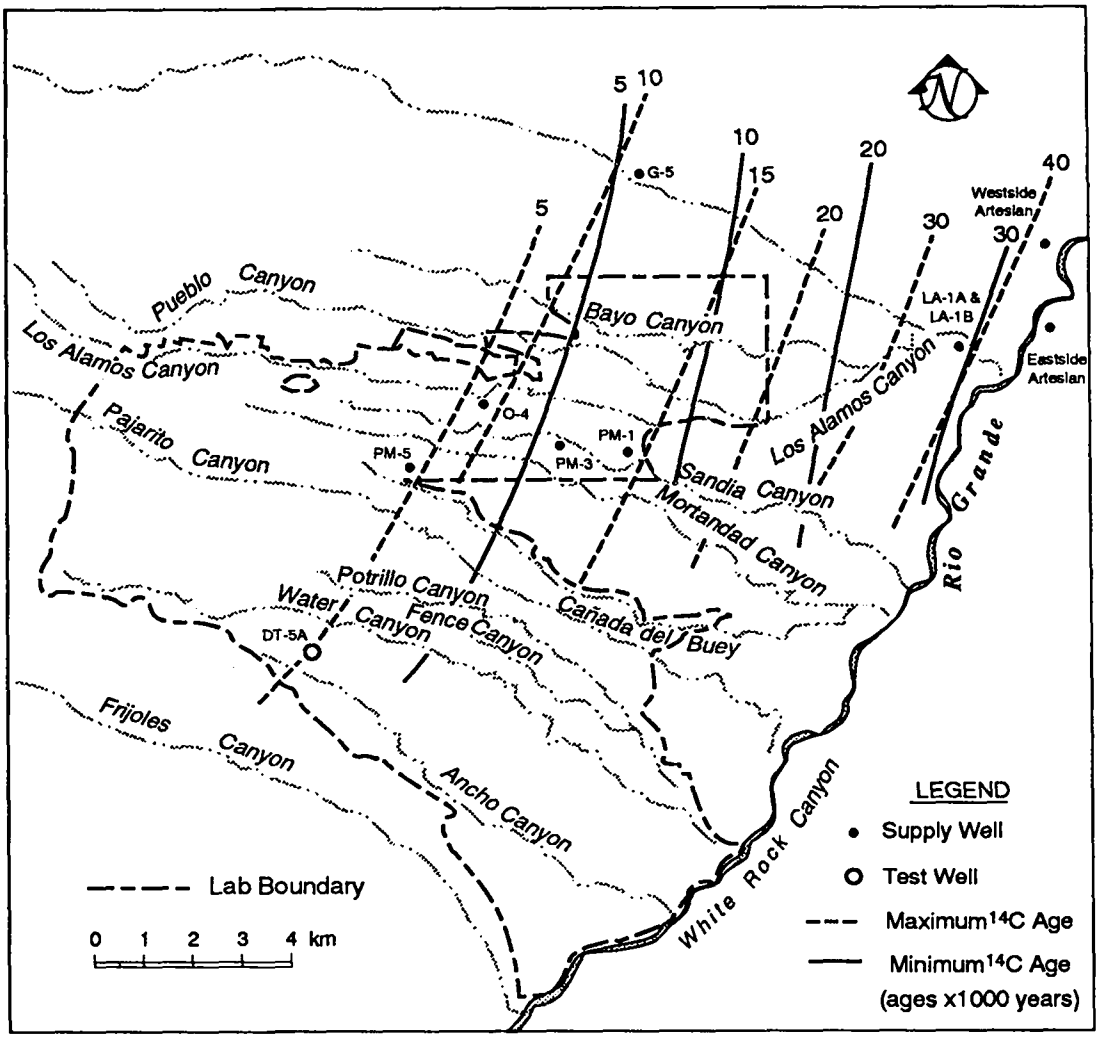


Figure VII-4. Minimum and maximum main aquifer ^{14}C groundwater ages (thousands of years).

the western portion of the Pajarito Plateau, and increases eastward to about 30,000 years near the Rio Grande (Table VII-7). These values are consistent with the general understanding of the Los Alamos main aquifer, based on physical and geologic conditions.

Purtymun (1984) determined flow rates for the main aquifer from pump tests on water supply wells. The rates range from about 76 m/yr (250 ft/yr) in the Puye Conglomerate near the Otowi-4 Well, to about 6 m/yr (20 ft/yr) in the Tesuque Formation below the Los Alamos Well Field. For the 8.8 km (5.5 mi) distance between wells PM-3 and LA-1B, these flow rates give a range of water travel times between the wells of 115 to 1,450 years. These travel times are far smaller than the 22,000 to 27,000 year difference in the ^{14}C ages for these wells. One possible explanation for this inconsistency is that Purtymun's (1984) estimates are based on aquifer tests, which mainly reflect the more permeable portions of the aquifer. On the other hand, the ^{14}C samples may be influenced by dilution within the entire aquifer. These wells have very large screen intervals, of 300 to 900 m (1,000 to 3,000 ft), and draw water from a large cross section of the aquifer.

Tritium Age-Dating of Groundwater. Before discussing tritium measurements in the Los Alamos area deep wells, it is helpful to give some background on tritium levels. Before atmospheric testing of nuclear weapons

began, tritium levels in precipitation were about 20 pCi/L. By the mid-1960s, tritium in atmospheric water in northern New Mexico reached a peak level of about 6,500 pCi/L, the annual average for 1963–1964. Since then, both radioactive decay and dilution by mixing through the global hydrologic cycle have reduced the concentrations of tritium in atmospheric water. Radioactive decay alone would have reduced the peak level of about 6,500 pCi/L to a present value of about 650 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 65 to 325 pCi/L (EPG 1993, EPG 1994). As a basis for comparison, the present EPA and NM drinking water standard is 20,000 pCi/L. Routine evaluation of compliance with the drinking water regulations is determined using the EPA-specified liquid scintillation counting method, with a detection limit of about 300 to 700 pCi/L. The low-detection-limit method of tritium measurements employed by this study were performed at the University of Miami and have a detection limit of about 1 pCi/L.

Of the more than 50 low-detection-limit tritium measurements, about 45 low-detection-limit tritium analyses show no measurable tritium. This indicates that the water in the main aquifer contains no significant component of "recent" recharge (that is, precipitation from the last several decades, and almost certainly not "post-bomb" precipitation). These results are consistent with the ^{14}C measurements and general understanding of the hydrogeologic setting of Los Alamos, that indicates little if any expected recharge through the hundreds of feet of nearly dry rock separating the land surface and the main aquifer. The ^{14}C results indicate that minimum ages of most deep groundwater samples in the Los Alamos area are greater than 1,000 years and should contain no measurable tritium because of its short half-life. However, a few samples do show measurable tritium.

The tritium concentration in groundwater can be altered by mixing with water already in the aquifer. To account for this possibility, two different age-determination schemes are employed (Table VII-7). The "piston flow" calculation assumes that the tritium value measured in the groundwater results only from radioactive decay of the original tritium in recharge water, which has moved undiluted through the aquifer; this gives a minimum age. The "well-mixed" model assumes that the recharge has completely mixed with water from the entire groundwater reservoir; this gives a maximum age.

Age determinations from tritium are most reliable for times less than 100 years. For ages above 1,000 years, there is substantial uncertainty (Blake 1995). Confidence in greater ages is increased if ^{14}C ages are also available. Groundwaters that contain between 16 and 65 pCi/L of tritium are most likely the result of recent recharge, and are best modeled with the piston flow method (Blake 1995). Waters with tritium concentrations below about 1.6 pCi/L are likely to be old and can be modeled as well-mixed reservoirs. The ages of these waters are greater than or equal to 3,000 years, but there may be large errors associated with small tritium concentrations (Blake 1995). With a tritium concentration below 0.5 pCi/L, modeled ages are greater than or equal to 10,000 years, but this is at the limit of tritium age determinations. Waters with tritium concentrations greater than or equal to 1,000 pCi/L and collected after 1990 cannot have their ages modeled, and can only be the result of contamination (Blake 1995).

The tritium groundwater ages (Table VII-7) are generally consistent with the ^{14}C ages, within the limits just described for this technique. Groundwater ages in the central part of the Pajarito Plateau are in the 5,000 year range. Closer to the Rio Grande, the ages are near or greater than 10,000 years. These ages indicate a residence time for groundwater in the main aquifer greater than 5,000 years and suggest that this water is isolated for the most part from recent surface recharge. The exceptions to this trend are discussed in the following section.

c. Tritium Detection in Test Wells. Measurements of tritium by extremely low-detection-limit analytical methods 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 concentrations measured range from less than 2% to less than 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. Low or trace concentrations of tritium were also detected at two wells and one spring associated with the intermediate-depth perched aquifer beneath Pueblo and Los Alamos canyons and at four household wells at the Pueblo of San Ildefonso.

The locations where low concentrations of tritium were clearly detected (Table VII-8) are: Test Wells 1 and 1A in lower Pueblo Canyon; Test Well 2A and Test Well 4 in upper Pueblo Canyon; Test Well 8 in Mortandad Canyon; Basalt Spring in lower Los Alamos Canyon; Wells LA-1A and LA-2 in the former Los Alamos Well Field; and the Otowi House, New Community, Martinez House, and Sanchez House wells at the Pueblo of San Ildefonso.

Table VII-8. Low Detection Limit Tritium Measurements in Groundwater

Location	Date	Tritium Units Tritium	± [a]	pCi/L Tritium	±
Main Aquifer Production Wells					
LA-1B	10/22/91	0.02	0.09	0.06	0.29
	5/12/93	0.18	0.09	0.58	0.29
LA-1A	5/12/93	19.7	0.7	64	2.3
LA-2	5/12/93	4.04	0.13	13	0.42
LA-5	5/12/93	0.25	0.1	0.81	0.32
PM-1	10/23/91	0.51	0.1	1.7	0.32
	8/18/92	0.69	0.09	2.2	0.29
PM-2	2/14/92	0.04	0.09	0.13	0.29
	8/18/92	0.15	0.09	0.49	0.29
	5/19/93	0.49	0.09	1.6	0.29
PM-3	8/18/92	0.23	0.09	.75	0.29
Original Analysis	5/19/93	6.67	0.22	22	0.71
Re analysis 1, 11/93	5/19/93	0.12	0.09	0.39	0.29
Re analysis 2, 11/93	5/19/93	-0.06	0.09	-0.19	0.29
PM-5	10/23/91	0.09	0.09	0.29	0.29
	8/18/92	0.39	0.12	1.3	0.39
O-4	Feb-Mar 93	<0.96	0.11	3.1	0.36
	Avg.	0.32	0.19	1.0	0.62
G-1	8/18/92	0.34	0.09	1.1	0.29
G-1A	8/18/92	0.28	0.11	0.91	0.36
G-2	8/18/92	0.28	0.09	0.91	0.29
G-4	8/18/92	0.19	0.10	0.62	0.32
G-5	8/18/92	0.43	0.09	1.4	0.29
	10/22/91	0.08	0.09	0.26	0.29
G-6	8/18/92	0.56	0.10	1.8	0.32
Main Aquifer Test Wells					
TW-1	10/8/92	109	4	353	13
	5/19/93	113	3.7	366	12
TW-2	10/8/92	0.22	0.09	0.71	0.29
	5/19/93	0.85	0.1	2.8	0.32
TW-3	5/20/93	0.89	0.09	2.9	0.29
TW-4	5/19/93	3.34	0.11	11	0.36
DT-5A	10/23/91	-0.07	0.09	-0.23	0.29
	5/20/93	0.07	0.09	0.23	0.29
TW-8	12/6/93	27.6	0.09	89	0.29
DT-9	5/20/93	0.14	0.09	0.45	0.29
DT-10	5/20/93	0.41	0.09	1.3	0.29
Intermediate Perched Zone, Pueblo Canyon (150-250 ft depth)					
TW-1A	10/8/92	41.3	1.4	134	4.5
	5/19/93	45.8	1.5	148	4.9
TW-2A	10/8/92	698	23	2262	75
	5/19/93	699	23	2265	75
Intermediate Perched Zone, Los Alamos Canyon					
Basalt Spring	6/11/91	37.9	1.3	123	4.2
	12/29/92	50.1	1.7	162	5.5

Table VII-8. (Cont.)

Location	Date	Tritium Units Tritium	± [a]	pCi/L Tritium	±
San Ildefonso Wells					
Eastside Artesian	2/5/92	-0.13	0.09	-0.42	0.29
	5/12/93	0.31	0.10	1.0	0.32
Westside Artesian	2/5/92	0.13	0.09	0.42	0.29
	5/18/93	0.12	0.09	0.39	0.29
Halladay House	2/5/92	-0.21	0.15	-0.68	0.49
	5/12/93	0.29	0.09	0.94	0.29
Otowi House	5/12/93	44.9	1.5	145	4.9
Pajarito Pump #1	2/5/92	-0.04	0.11	-0.13	0.36
Pajarito Pump #2	5/18/93	0.94	0.09	3.0	0.29
Don Juan	2/5/92	-0.05	0.09	-0.16	0.29
	5/12/93	0.16	0.09	0.52	0.29
New Comm. Well	5/12/93	8.00	0.26	26	0.84
Martinez House	5/18/93	1.81	0.10	5.9	0.32
Sanchez House	5/18/93	6.90	0.23	22	0.75

[a] The ± values represent one standard deviation of the uncertainty of measurement. The University of Miami detection limit is 1 pCi/L (0.3 TU); one TU = 3.24 pCi/L

Related information for Context

Pre-Bomb Atmospheric moisture	about 20 pCi/L (6 TU)
Peak Levels in atmospheric precipitation in Northern NM (mid-60s)	about 6500 pCi/L (2000 TU)
Those levels decayed to present (piston flow model)	about 650 pCi/L (200 TU)
Typical level in contemporary precipitation	
North American Continent	30-50 pCi/L (10-15 TU)
Los Alamos Vicinity	65-325 pCi/L (20-100 TU)
EPA Drinking Water Standard	20,000 pCi/L (6200 TU)
Proposed EPA MCL & DOE Guide for drinking water	60,000 pCi/L (18,500 TU)
Low-Level Analysis Detection Limit (U. of Miami through EES-1 contract)	1 pCi/L (0.3 TU)
Standard liquid scintillation analysis detection limit (EM-9, NMED)	300-700 pCi/L (100-200 TU)

An apparent detection of trace levels of tritium occurred in the PM-3 water supply well but was later discovered to have resulted from laboratory sample contamination. These results are discussed individually below.

In some of the six main aquifer samples, the results are understandable. The first is in Test Well 1, located in Pueblo Canyon near the confluence with Los Alamos Canyon, suspected for several years of having a well-bore leakage (or other) communication from the surface, as inferred from other types of data. The second and third are in old observation and water supply wells LA-1A and LA-2, located in Los Alamos Canyon near its confluence with the Rio Grande. These wells have screened intervals starting at depths not far below the canyon alluvium. The tritium observed at these locations could be attributed to infiltration of water containing both past Laboratory releases (from Acid-Pueblo Canyon and from DP-Site and other Los Alamos Canyon sources) and precipitation containing post-atmospheric test fallout. The fourth location is Test Well 8, in Mortandad Canyon, located about a mile downstream from the outfall of TA-50, the Laboratory's radioactive liquid waste treatment plant. The shallow alluvial perched water in Mortandad Canyon has contained high levels of tritium for about 30 years.

In two other locations, PM-3 and TW-4, the results are questionable and require further investigation. Resampling must incorporate meticulous quality assurance to determine whether the results are real or an artifact of sampling or analysis error.

In several of the cases of tritium detection, the source of tritium appears to be downward migration from canyon bottom alluvium. Many of the wells are located downstream of present or former sites of treated radioactive liquid industrial waste discharge into either Acid-Pueblo or Mortandad Canyons. There are at least four possible pathways for the known source of tritium to be moving toward the main aquifer.

- For older wells drilled by the cable tool method, which does not include an annular seal, there could be migration down the well bore outside the steel casing.
- There could be saturated flow carrying tritium downwards through fractures or faults.
- There could be movement in unsaturated flow through the vadose zone.
- Tritium could move downwards in the vapor phase through the unsaturated zone.

Well PM-3. Water Supply Well PM-3 was sampled in August 1992 with the analysis showing a concentration of 1.2 pCi/L of tritium, an essentially unmeasurable amount of tritium. A second sample was taken in May 1993; the analytical result was 22 pCi/L. The well, located in Sandia Canyon, had been in service without interruption since its completion in 1966 and is not near any known source of surface contamination. The well was completed with several grouted, telescoping casings. The casings reach a depth of 778 m (2,552 ft) below the surface and incorporate 485 m (1,591 ft) of inlet screens extending from 291 to 777 m (956 to 2,547 ft). The nonpumping water level in recent years has been at about 235 m (770 ft) below the surface. The pump operates at 1,300 to 1,400 gal./min and has produced about 15% of the total Los Alamos water supply in recent years. Because of the considerable thickness of the aquifer tapped by the well, it would require a major influx of contaminated water to result in the apparent tritium level. Three other water supply wells within 1.6 to 3.2 km (1 to 2 mi) (PM-1, PM-5, and O-4) have shown no measurable tritium. Thus, the May 1993 sample result from Supply Well PM-3 had no obvious explanation.

In November, the University of Miami reported reanalysis of previously unused portions of the May 1993 samples from Test Well 4 and Supply Well PM-3. The result for Test Well 4 was unchanged, at about 11 pCi/L. The new result for the PM-3 sample was no detectable tritium, as compared to the earlier reported value of about 22 pCi/L. The University of Miami noted that their quality control records enabled them to establish that the initial result for the PM-3 sample was attributable to contamination from the Test Well 2A sample, which had a level of about 2,260 pCi/L. The reanalysis of the PM-3 sample is consistent with the August 1992 sample that was reported with no measurable tritium. Resampling of PM-3 at four specific depths is planned for 1994.

Test Well 4. Test Well 4 is located on a mesa east of the former discharge points into Acid Canyon (untreated discharge from original TA-1 between 1944 and 1951 and treated effluents from the former liquid waste treatment plant at TA-45 from 1951 to 1964). Test Well 4 had been capped and was out of service for about 20 years until the fall of 1992 when it was refurbished and equipped with a new pump; those operations introduced

some water from the surface. The well is about 366 m (1,200 ft) deep and only penetrates into the main aquifer a short distance. Water fills less than the bottom 3 m (10 ft) of the well, so it can only be pumped at a very slow rate.

The sample taken in May 1993 showed a concentration of 10.8 pCi/L. Other data (for example temperature) suggests there is some doubt that the well was pumped long enough to completely purge any introduced water, which constitutes a possible source of tritium. This well is scheduled to be resampled in June or July 1994.

Test Wells 1 and 1A. The expected main aquifer tritium detection results include two samples from Test Well 1. Test Well 1 is located in Pueblo Canyon near its confluence with Los Alamos Canyon. One sample was taken in October 1992 with a result of 353 pCi/L; the second sample was taken in May 1993 with a result of 366 pCi/L. Other information and observations since 1991 indicated possible communication with an adjacent shallower test well, Test Well 1A. The sample from this well had a result of 134 pCi/L in October 1992; the second sample in May 1993 showed a concentration of 148 pCi/L of tritium. The Test Well 1A values indicate recent recharge from the surface, although they are not much outside the general atmospheric tritium levels of 65 to 325 pCi/L in the Los Alamos vicinity. The USGS drilled both wells in 1949 by cable tool to monitor water down gradient from the former TA-45 waste treatment plant. Test Well 1A was drilled to a depth of 69 m (225 ft), penetrating the intermediate-depth perched groundwater body in the basalts lying between the tuff and the main aquifer. Test Well 1 was drilled to a depth of 196 m (642 ft), penetrating the top of the main aquifer in the Puye Conglomerate.

Starting with measurements made by the USGS in the 1950s and 1960s, the intermediate perched groundwater has been known to be affected by effluents discharged into Pueblo Canyon. In Test Well 1, some chemical quality data and indications in 1991 of unexpectedly high water levels suggested a downward communication of water to the main aquifer from the intermediate perched groundwater sampled by Test Well 1A. Results of those initial investigations were reported in the 1991 Environmental Surveillance Report for Los Alamos National Laboratory (EPG 1993). The low-detection-limit tritium samples were collected to help understand the potential problem. The two consistent results indicate that communication between the intermediate and main aquifer does exist beneath Pueblo Canyon. One possible route of communication is a downward movement through the rock beneath the canyon. The other possibility is along the ungrouted, cable-tool installed casings.

Test Well 2A. A similar paired-well situation occurs upstream (further west) in Pueblo Canyon. These are Test Wells 2A and 2, reaching to the intermediate perched groundwater and the main aquifer respectively. The USGS also drilled these wells by cable tool in 1949, to monitor discharge water from the former TA-45 waste treatment plant. Test Well 2A was drilled to a depth of 41 m (133 ft). Test Well 2 was drilled to a depth of 241 m (789 ft) and deepened to 254 m (834 ft) in 1991. Samples from those wells in October 1992 and May 1993 showed the presence of tritium in Test Well 2A, as expected from previous routine environmental monitoring. The concentrations of tritium found in Test Well 2A were about 2,260 pCi/L, which is consistent with previously reported levels and measurements made in 1992 and 1993 (Table VII-1). These values far exceed the decayed value of 650 pCi/L (piston flow model), which could have resulted from the peak 1960s atmospheric tritium levels and indicate a definite tritium source from past industrial operations at the Laboratory. Measurements of water levels and chemical quality over a period of time have indicated that the perched groundwater is hydrologically connected to the stream in Pueblo Canyon. Samples from Test Well 2 showed no measurable tritium in either sample. This is taken as an indication that there is no measurable migration through the rock formations in the immediate vicinity and that the seal around Test Well 2 is adequate to prevent downward movement in the well bore (even though it was installed by cable tool).

Basalt Spring. Basalt Spring, which is off site in lower Los Alamos Canyon on Pueblo of San Ildefonso land, discharges water from the intermediate perched groundwater system. Basalt Spring is known to be recharged from the canyon bottom alluvium in Pueblo Canyon near Hamilton Bend Spring, and to be hydrologically connected with Test Well 1A (Abrahams 1966). The Basalt Spring low-detection-limit tritium analyses are similar to those for Test Well 1A: one sample was taken in June 1991, with a result of 123 pCi/L; the second sample was taken in December 1992, with a result of 162 pCi/L. These tritium values reflect the presence of recent recharge from the surface.

Test Well 8. Another main aquifer tritium result that is not surprising is from Test Well 8 in Mortandad Canyon, about a mile downstream of the outfall of the Laboratory's radioactive liquid waste treatment plant at TA-

50. Tritium is known to be migrating downward in the unsaturated zone beneath the alluvial perched groundwater in Mortandad Canyon, based on measurements from cores collected at depths of 30 to 60 m (100 to 200 ft), in another borehole a few hundred feet west of Test Well 8 (Stoker 1991).

Test Well 8 had been out of service since 1992 because of pump failure and was sampled in early December 1993 as part of the routine environmental monitoring program. The last previous sample was collected as part of the routine program in 1991 and did not show measurable tritium. The earlier tritium measurements from this well used a less sensitive technique that cannot detect tritium at concentrations less than about 700 pCi/L. The new result is not inconsistent with those previous results, and it is impossible to tell how long small amounts of tritium have been present in the well. Low-detection-limit tritium analysis of the December 1993 sample showed a tritium concentration of 89 pCi/L. This result clearly shows the presence of recent recharge and is high enough to indicate the source could be effluent from the radioactive liquid waste treatment plant.

The well was completed in December 1960, before construction of the TA-50 treatment plant, as part of the USGS hydrogeologic study of Mortandad Canyon (Baltz 1963). The well was drilled to the main aquifer by cable tool and completed with 8-in. steel casing to a depth of 325 m (1,065 ft) in the Puye Conglomerate, with the bottom 34 m (112 ft) slotted with a welding torch. Water level at that time was 295 m (968 ft); the water level in 1993 was about 303 m (994 ft). The well passes through the shallow alluvial perched groundwater in Mortandad Canyon, which contains residual contaminants discharged by the TA-50 treatment plant. Concentrations of tritium in the alluvial groundwater in the vicinity of Test Well 8 have been about 100,000 pCi/L in the last few years, ranging to as much as 1,000,000 pCi/L in the mid-1970s.

Los Alamos Well Field. A final main aquifer tritium result that is not surprising comes from two former supply and observation wells in Lower Los Alamos Canyon about 1.6 km (1 mi) upstream from the confluence with the Rio Grande. Observation Well LA-1A was constructed in 1946, as part of the USGS water supply investigations. This well is about 122 m (400 ft) deep, penetrating about 24 m (78 ft) of channel alluvium and then into the main aquifer formations; the well originally flowed under artesian pressure. Neither the completion method nor the depth of any perforations are documented, and the well casing is believed to not be grouted. The tritium content of the May 1993 sample was 64 pCi/L. This tritium value similar to the concentration found in recent rainfall levels in the Los Alamos area of about 65 to 325 pCi/L and indicates recent recharge from the surface. This analysis is suspect, as the sample may not be representative of the groundwater composition. The sample was collected using a bailer, and the well was not purged first. The chemical analyses of another sample collected a week later, after pumping the well, was significantly different from the first. However, the second sample was not analyzed for tritium by the low-detection-limit method.

The second result is from former Supply Well LA-2, completed to a depth of 269 m (882 ft) in 1946 penetrating about 18 m (60 ft) of alluvium and then into the Santa Fe Group. The tritium concentration of the May 1993 sample from LA-2 was 13 pCi/L. Screens or slotted casing start at 32 m (105 ft) depth. Because of the construction of these wells and their shallow screen depth, evidence of downward movement of surface water is not surprising. The nearby Supply Well, LA-1B, completed in 1960, is cased to 534 m (1,750 ft) with screens starting at 99 m (326 ft). Its construction included 20 m (64 ft) of surface casing set through the alluvium and cemented. This well showed no measurable tritium in samples collected in October 1991 and May 1993. This is consistent with the construction method that would be expected to seal out infiltration along the well bore and the greater depth of first screen further into the Santa Fe Group formations of the main aquifer.

Pueblo of San Ildefonso. At the mouth of Los Alamos Canyon are two private residences with shallow wells of undocumented construction. The Otowi House, north of Los Alamos Canyon, has a shallow well, probably drawing water from the alluvium and gravels of the Rio Grande and possibly some from the alluvium of Los Alamos Canyon (but not deep enough to reach the main aquifer). A sample taken in May 1993 from this well showed a tritium concentration of 145 pCi/L. This result is reasonable, because the alluvial water would reflect recent water from both precipitation and flow from the portions of Los Alamos Canyon within the Laboratory with known tritium. The second well, at the Halladay House located on the south side of Los Alamos Canyon, was sampled in February 1992 and May 1993, with both results showing no measurable concentrations of tritium. This is consistent with the chemical quality of the well, which is similar to other main aquifer waters, and its location is far enough away from the stream channel as to be unlikely to penetrate any saturated alluvium. The Otowi House

well sample's tritium result is consistent with preliminary 1994 analyses that show that water from this well has a nitrate concentration of 10.8 mg/L (nitrate as nitrogen), exceeding the EPA drinking water standard of 10 mg/L (nitrate as nitrogen). The source of the nitrate is probably leakage from a septic system; both the nitrate and tritium results are consistent with recent recharge from the surface. The 1994 nitrate result for the Halladay House well is only 1.1 mg/L (nitrate as nitrogen); although this may indicate minor nitrate contamination, it is consistent with little recent recharge.

Three other private wells, the New Community Well, the Martinez House Well, and Sanchez House Well also showed low concentrations of tritium. The values, respectively, are 26, 5.9, and 22 pCi/L. These wells are located along the Rio Grande, north of its confluence with Los Alamos Canyon. The depths and sources of water for these wells is unknown. These results indicate recent recharge but are all below background levels for precipitation in northern New Mexico (about 30 pCi/L). The tritium results are not surprising, because recent water analyses from these and other wells in the area also indicate high levels of nitrate in the water. Preliminary results from 1994 analyses from these wells shows that the Martinez House and Sanchez House wells have nitrate levels near or exceeding the EPA drinking water standard of 10 mg/L (nitrate as nitrogen).

Future Work. Additional work is required to resolve the questions raised by the unexpected tritium results. The most immediate need is to resample the wells in the main aquifer for tritium using the low-detection-limit analyses. This will have to be done with extensive quality assurance samples to verify that no possible cross-contamination of the samples occurs during the sampling, sample handling, transportation, and analytical steps. This is especially critical for these very low concentrations of tritium.

Immediate plans are to resample all the operable test wells and all the operable water supply wells in the Pajarito and Otowi fields. This will include Test Wells 1, 2, 3, 4, 8; and DT-5A; DT-9; and DT-10; and Water Supply Wells PM-1, PM-2, PM-4, PM-5, and O-4.

Additional ^{14}C analyses are presently underway, on samples collected at the same time as the May 1993 tritium samples discussed above. The results should add insight about the hydrogeologic system. This effort and other sensitive geochemical or geochronometric studies will be considered to help improve understanding of the hydrogeologic conditions.

Longer term actions being considered include the need to install new or replacement test wells to monitor the main aquifer, which are constructed to contemporary standards.

d. Water Production Records. Monthly water production records are provided to the NM State Engineer's Office under the water rights permit held by DOE for the Los Alamos water system. During 1993, total production from the wells and gallery for potable and nonpotable use was 5.51×10^6 m^3 (1.46 billion gal. or 4,470 ac ft). This production amounts to 81% of the total diversion right of 6.8×10^6 m^3 (5,541 ac ft) that is available to the DOE under its permit. Details of the performance of the water supply wells (pumpage, water levels, drawdown, and specific yield) and their operation are published in a series of separate reports, the most recent of which is "Water Supply at Los Alamos during 1991" (Purtymun 1994).

e. Water Level Measurements. In October 1992, the Laboratory began measuring and recording water level fluctuations in test wells completed into the main aquifer below Pajarito Plateau. These data are automatically recorded at hourly intervals using calibrated pressure transducers. Table VII-9 summarizes the locations, start and end dates, and final water level recorded during 1993.

f. Measurement of Barometric and Earth Tide Responses in Test Wells. Two test holes were cored along the eastern edge of TA-49 near Test Well DT-10 during the week of May 18, 1993; locations are shown in Figure VII-5. These test wells were completed into the upper units of the Tshirege Member of the Bandelier Tuff. The first test hole, TBM-1, was cored to 42 m (138 ft) below the surface and penetrated Units 3 through 6; these geologic units were previously described by (Weir 1962). Figure VII-6a depicts the geology, while Figure VII-6b shows the borehole completion. Test hole TBM-1 was constructed to measure barometric pressure fluctuations in the unsaturated Bandelier Tuff, including atmospheric pressure lags at varying depths as weather fronts pass over Pajarito Plateau. As seen in Figure VII-6b, three barometric pressure (BP) transducers were attached to each of the 1/2-in. diameter PVC pipes, and one BP transducer was open to the surface atmosphere. These BP transducers record fluctuations in barometric pressure at hourly intervals. A more detailed analysis of the barometric pressure data will be presented in a special report once a sufficiently long record has been collected.

Table VII-9. Wells Equipped with Recording Transducers

Well	Date Started	Date Ended	Water Depth[a]	Elevation[b]
Main Aquifer Locations:				
TW-1	06-19-93	12-31-93	545.76	5,822.42
TW-2	06-19-93	12-31-93	794.17	5,854.59
TW-3	06-19-93	06-27-93	778.22	5,819.39
TW-4	06-19-93	12-31-93	1,176.29	6,070.04
TW-8	06-19-93	11-02-93	993.31	5,884.72
DT-5A	01-01-93	12-31-93	1,183.35	5,961.28
DT-9	01-01-93	12-31-93	1,115.96	5,920.75
DT-10	01-01-93	12-31-93	1,096.92	5,923.00
LA-1B	07-27-93	12-31-93	flowing	5,630.83[c]
LA-1A	06-19-93	07-30-93	7.54	5,623.18
Intermediate Perched Zone Locations:				
TW-1A	10-27-93	12-31-93	193.91	6,177.31
TW-2A	06-19-93	12-31-93	106.01	6,545.23
SHB-3	06-19-93	08-26-93	664.46	6,944.23
Canyon Alluvial Locations:				
APCO-1	02-17-93	06-18-93	6.35	6,361.84
MCO-5	10-30-92	12-01-93	20.70	6,856.72
MCO-6B	10-30-92	12-31-93	37.36	6,813.60

[a]Depth to water (ft) measured below top of casing on end date.
[b]Water elevation (ft) relative to mean sea level (MSL) on end date.
[c]Overflow drain-pipe elevation is about 5616 ft above MSL; top-of-pipe elevation is about 5,622 ft above MSL. Water levels were recorded using a mechanical packer set below the overflow pipe.

Test hole TBM-2 was constructed within about 2.4 m (8 ft) of test hole TBM-1. However, TBM-2 was equipped with an Applied Geomechanics, Inc., Model 510 Geodetic Biaxial Tiltmeter. Borehole completion is shown in Figure VII-7. This borehole tiltmeter senses angular movement with respect to the vertical gravity vector using two extremely sensitive electrolytic tilt sensors that are monitored hourly. These sensors measure rotations in two orthogonal vertical planes; the vector sum of these rotations in both planes yields the direction and magnitude of rotation of the tiltmeter. Tilt resolution is less than 10 nanoradians. Hence, the effects of earth tides associated with the lunar and solar bodies on rock deflections can be measured directly. These measurement will assist in the interpretation of small water level fluctuations recorded in main aquifer test wells across Pajarito Plateau. A detailed analysis of these data will be released once sufficient tiltmeter data has been assembled.

g. Pump Test in Supply Well Otowi-4. A pump test was conducted in the Otowi-4 municipal water supply well from February 24 to March 18, 1993. The pumping rate during this test averaged 1,660 gpm. The total volume of water extracted during this test was 52.48 million gal. in 22.042 days. Drawdown histories were recorded in Otowi-4 and Test Well 3 (TW-3, located 126 m [413 ft] east of Otowi-4). Municipal water supply wells PM-3 (located 1,838 m [6,029 ft] southeast of Otowi-4), and PM-5 (located 2,047 m [6,714 ft] southwest of Otowi-4) remained off during this test and were also used as observation wells. No recordable drawdown data were observed at these two wells in response to pumpage at Otowi-4. In addition, no recordable drawdown was observed in Test Well TW-2, located to the northwest, or in Test Well TW-8, located to the southwest.

When the observed drawdown from Otowi-4 is plotted against time on semi-logrithmic paper, the Cooper-Jacob procedure says that the hydrologic parameters of transmissivity (T) and storage coefficient (S) are 11,064 sq ft/day, and 0.00534, respectively. These values favorably compare to T and S values previously reported for a much shorter step-drawdown test conducted in 1990 at Otowi-4 (Stoker 1992). While the test results reported here are more representative of actual conditions in the main aquifer than earlier T and S values, it should be noted that the

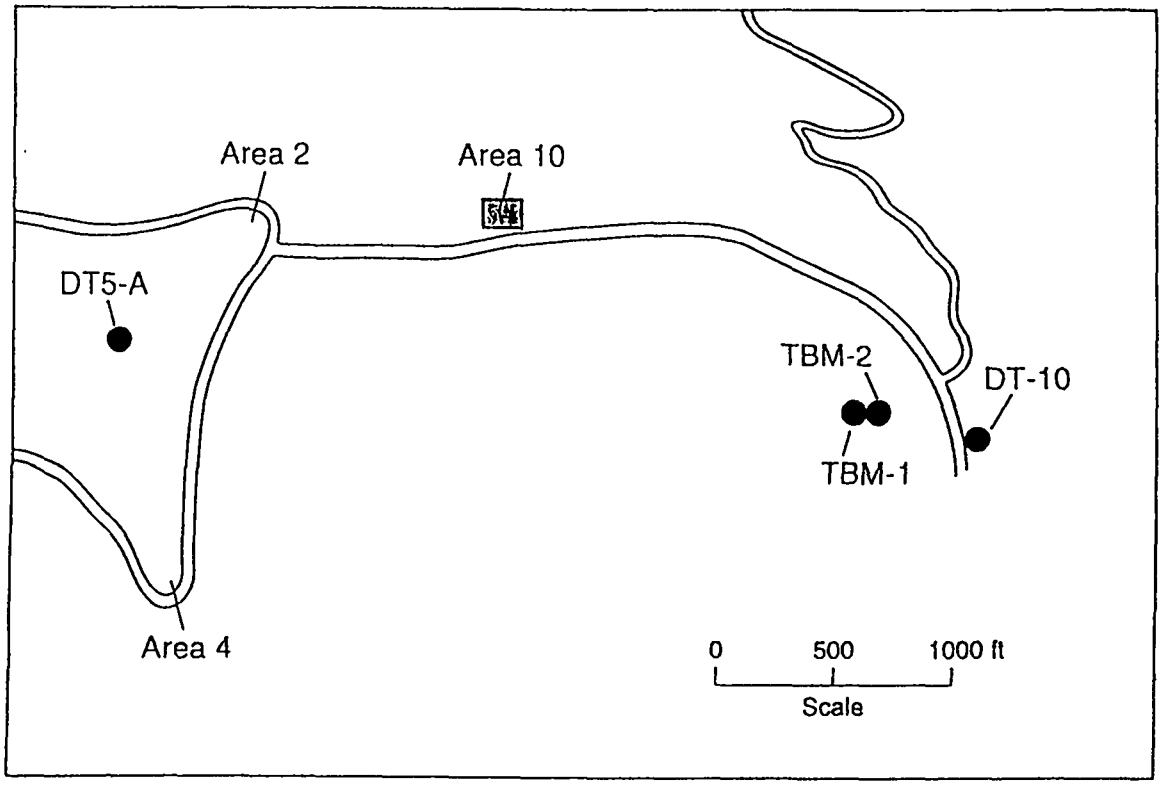


Figure VII-5. Locations of test holes TBM-1 and TBM-2 at TA-49.

drawdown values were still recorded in the production well, and these results are not as desirable as those from a fully penetrating observation well.

2. Omega West Reactor Leak.

a. Introduction. While testing the reactor cooling system under lower pressure conditions at the Omega West Reactor (OWR), TA-2, during early January 1993, the reactor operators discovered that the amount of make-up water required for the cooling system remained essentially constant (approximately 3 gal./h). The operators had expected that the normal water loss rate would drop while the reactor was run under lower pressure conditions. When the water loss rate did not drop, the question arose as to whether the system was leaking.

A systematic procedure was developed to determine whether the reactor cooling system was leaking. These tests showed that the water loss was occurring in the primary coolant system. As required by DOE Order 5000.3A, DOE was notified on January 30, 1993, that a leak of tritiated water had been positively identified. The EPA and the NMED were also notified. Preliminary screening by the Health & Safety Division (HS) indicated that tritium was the primary contaminant of concern, and other radionuclides were not released to the environment in significant levels. The reactor coolant water contains high tritium levels because the water absorbs neutrons during its passage through the reactor core. Data from water samples collected at the Laboratory boundary indicated that the higher levels of tritiated water remained within DOE property.

On February 16, 1993, the reactor cooling system was drained by removing 8,000 gal. of water and placing it at TA-50 for temporary storage. This isolated the cooling system inlet line, delay line, and the reactor tank and allowed for leak testing. On February 17, 1993, the delay line was found to show fluid loss while the other two segments were leak-free. With refilling of the cooling system, the estimated leak rate reached 0.3 gal./h on February 23, and returned to the original rate of 3 gal./h on March 2. Draining the cooling system resumed on March 12. The EPA and NMED were notified that the leak had ceased.

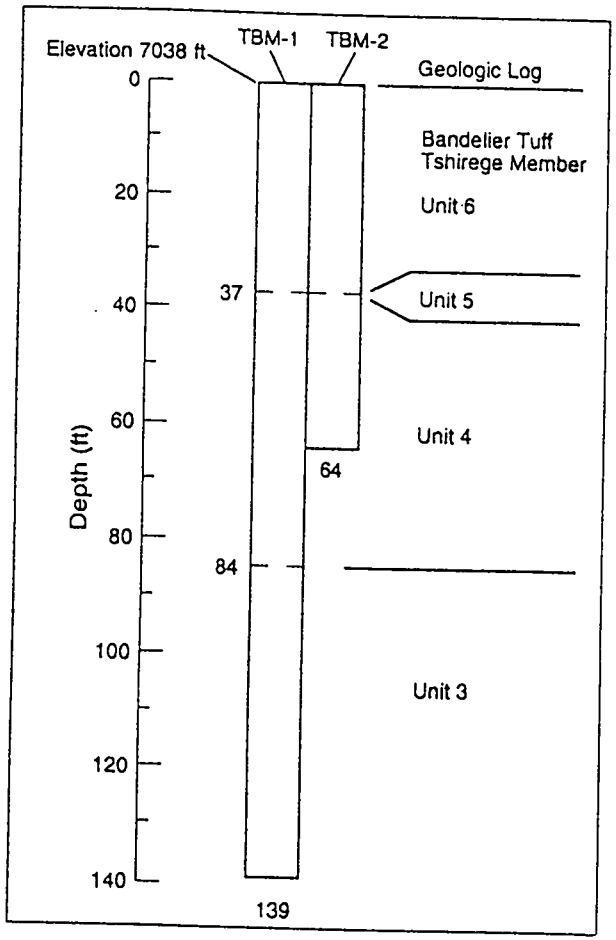


Figure VII-6a. Geologic logs of test holes TBM-1 and TBM-2 at TA-49.

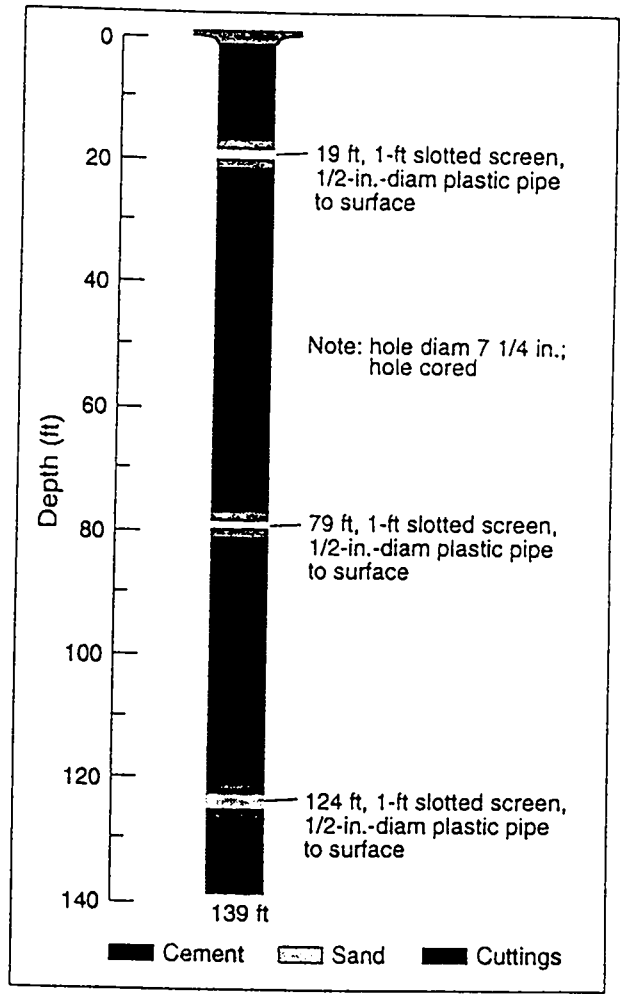


Figure VII-6b. Test hole TBM-1 constructed with three zones to measure barometric pressures in the tuff at depths of 19, 79, and 124 ft.

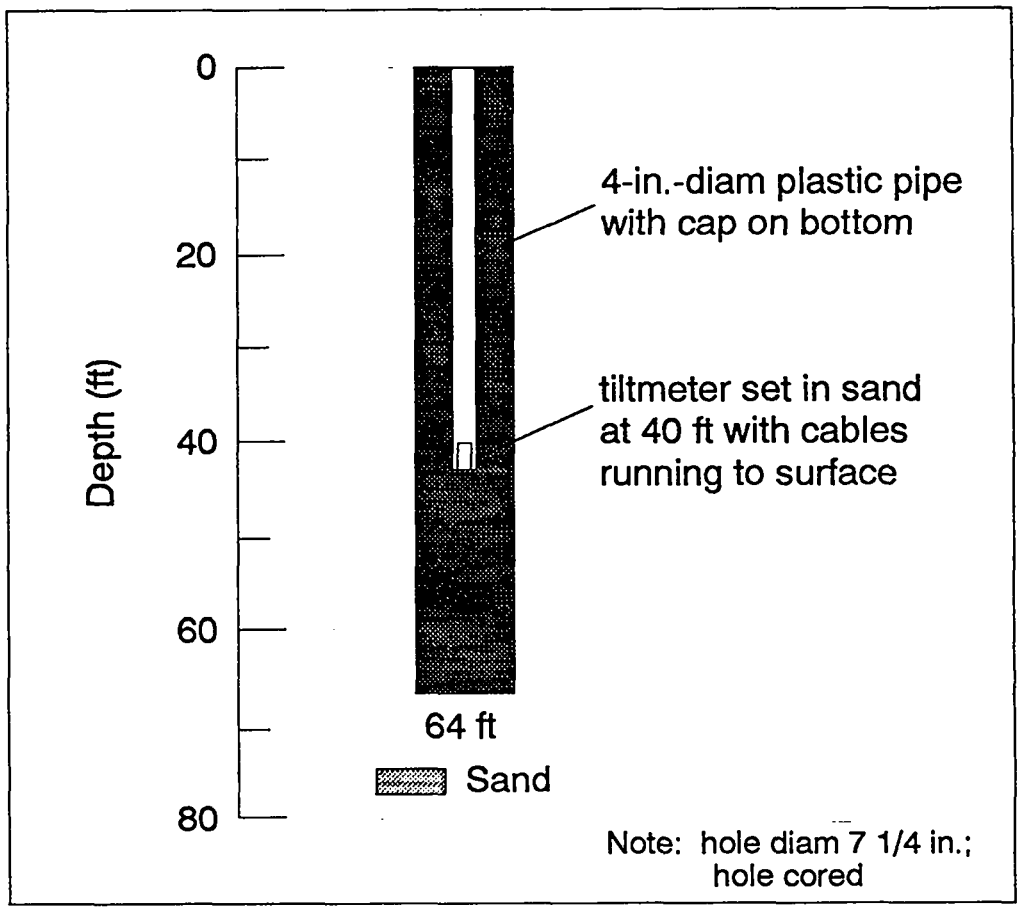


Figure VII-7. Test hole TBM-2 equipped with a biaxial tiltmeter to measure deformation of the tuff at 40 ft.

b. Historical Tritium Concentrations in Los Alamos Canyon. The following presentation of the history of tritium contamination in Los Alamos Canyon provides the context for interpreting the impact of the leak at the OWR. Elevated concentrations of tritium and other radionuclides have been detected in Los Alamos and DP canyons since the beginning of surveillance measurements in the mid-1960s. An industrial liquid waste treatment plant at TA-21 (Figure VII-8) discharged effluent containing radionuclides into DP Canyon from 1952 to 1986. After 1986, the treated effluent was diverted to the TA-50 radioactive liquid waste treatment plant. Since the Manhattan Project, sewage and cooling water effluent have been released into Los Alamos Canyon from TA-41 and TA-2.

In the late 1960s, tritium concentrations in DP Canyon surface water ranged from 170,000 to 4,860,000 pCi/L (Purtymun 1973). Alluvial groundwater tritium concentrations in Los Alamos Canyon monitoring Wells LAO-2, -3, and -4, located below the confluence with DP Canyon, ranged from below the detection limit (50,000 pCi/L) to 860,000 pCi/L (Purtymun 1973). For Well LAO-1, located just downstream of the OWR, alluvial groundwater tritium concentrations ranged from below the detection limit (50,000 pCi/L) to 80,000 pCi/L. Purtymun (1973) attributed the high tritium concentrations in lower Los Alamos Canyon Wells LAO-2, -3, and -4 to discharges from TA-21 and noted that concentrations decreased downstream in both canyons as a result of dilution by other effluents and storm runoff.

The levels of tritium in the Los Alamos Canyon alluvial groundwater wells since the late 1960s are shown in Figure VII-9. The instrumental tritium detection limit for these data is about 400 to 700 pCi/L. In the mid-1980s, it

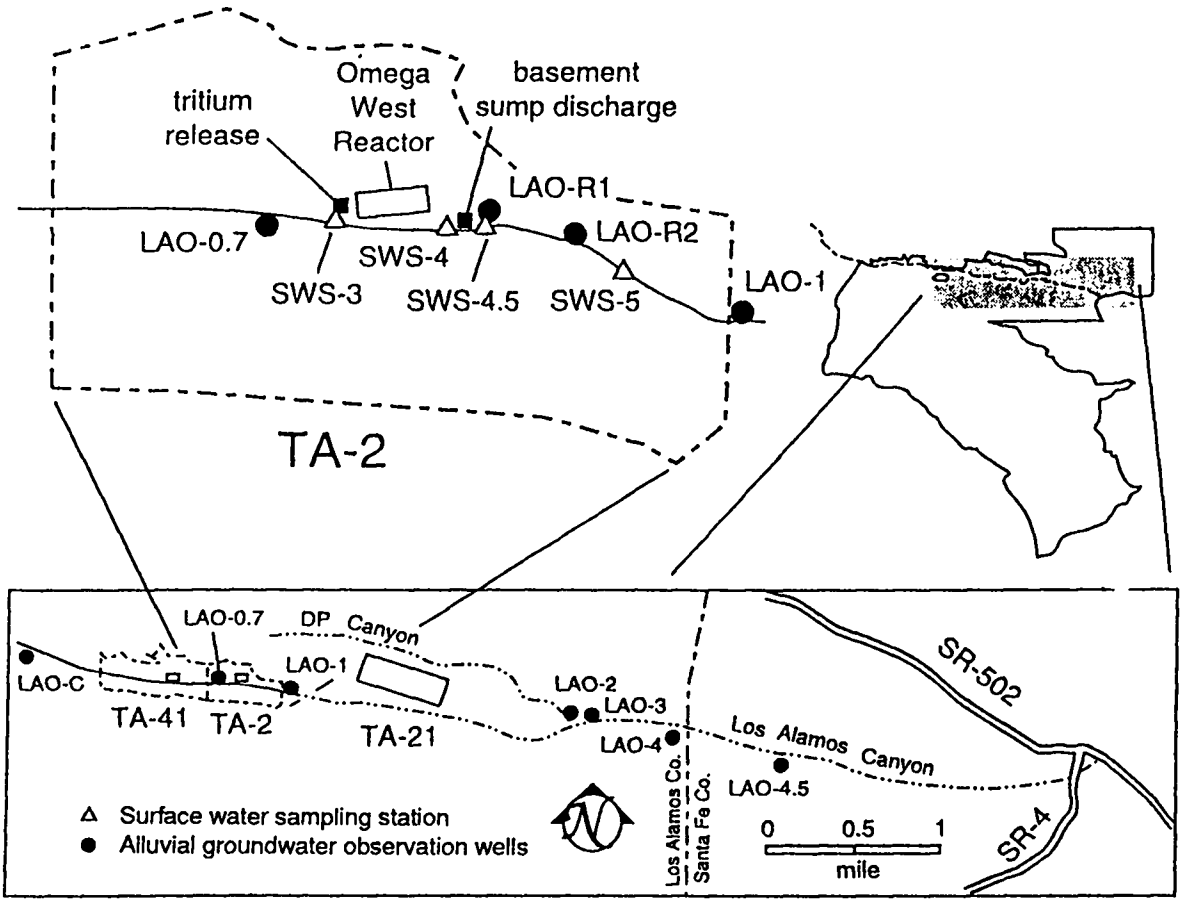


Figure VII-8. Map of lower Los Alamos Canyon (after Purtymun 1995) showing locations of Omega West Reactor, the tritium release point, the basement sump discharge into Los Alamos Canyon, alluvial groundwater observation wells, and surface water sampling stations.

was discovered that some of those laboratory analyses may have been contaminated by tritium released from operation of the nearby Van de Graaff generator. Thus, the effective detection limit for analyses up to this time might be only 2,000 pCi/L, and values as high as 5,000 pCi/L could be suspect.

The compilation of surveillance data (Figure VII-9) for the Los Alamos Canyon alluvial groundwater wells shows that tritium concentrations in the Los Alamos Canyon wells LAO-2, -3, -4, and -4.5 have decreased by about two orders of magnitude since the late 1960s. The tritium concentration for each of these wells has been about 1,000 to 2,000 pCi/L during the early 1990s. The EPA standard for tritium in drinking water is 20,000 pCi/L. This concentration decrease may correspond to a reduction in the quantity of contaminants released from the industrial liquid waste treatment plant at TA-21. Well LAO-C is a background well located upstream of TA-41 and TA-2. The tritium concentrations in this well have remained slightly above the current range for tritium detection, of about 400 to 700 pCi/L. The fluctuations in tritium concentrations seen, for example, at Wells LAO-C and -1, could be related to seasonal variations in surface water flow and infiltration to the alluvial groundwater.

The record of tritium concentration for Well LAO-1 suggests that tritium concentrations since 1970 have remained approximately constant at about 10,000 pCi/L. This is a factor of 10 higher than both the tritium concentrations at background Well LAO-C and the reduced concentrations observed in Wells LAO-2, -3, -4, and -4.5 in the early 1990s. The steady tritium concentrations at Well LAO-1 indicate the presence of a constant source

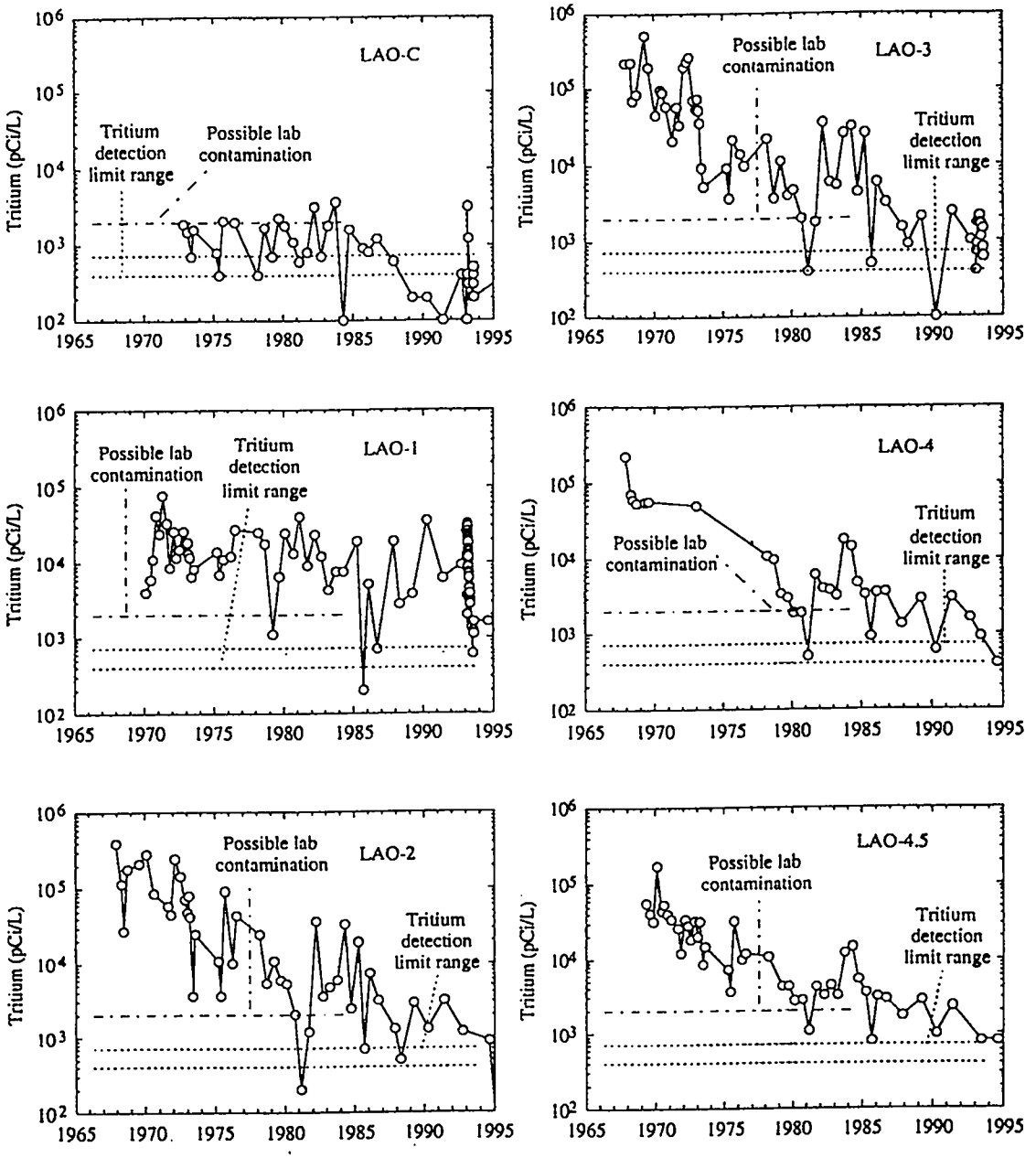


Figure VII-9. Historical tritium concentrations in lower Los Alamos Canyon, from alluvial groundwater observations wells. The tritium detection limit range is shown for reference. Some samples prior to 1985 may have been contaminated by operational releases from the Van de Graaf generator.

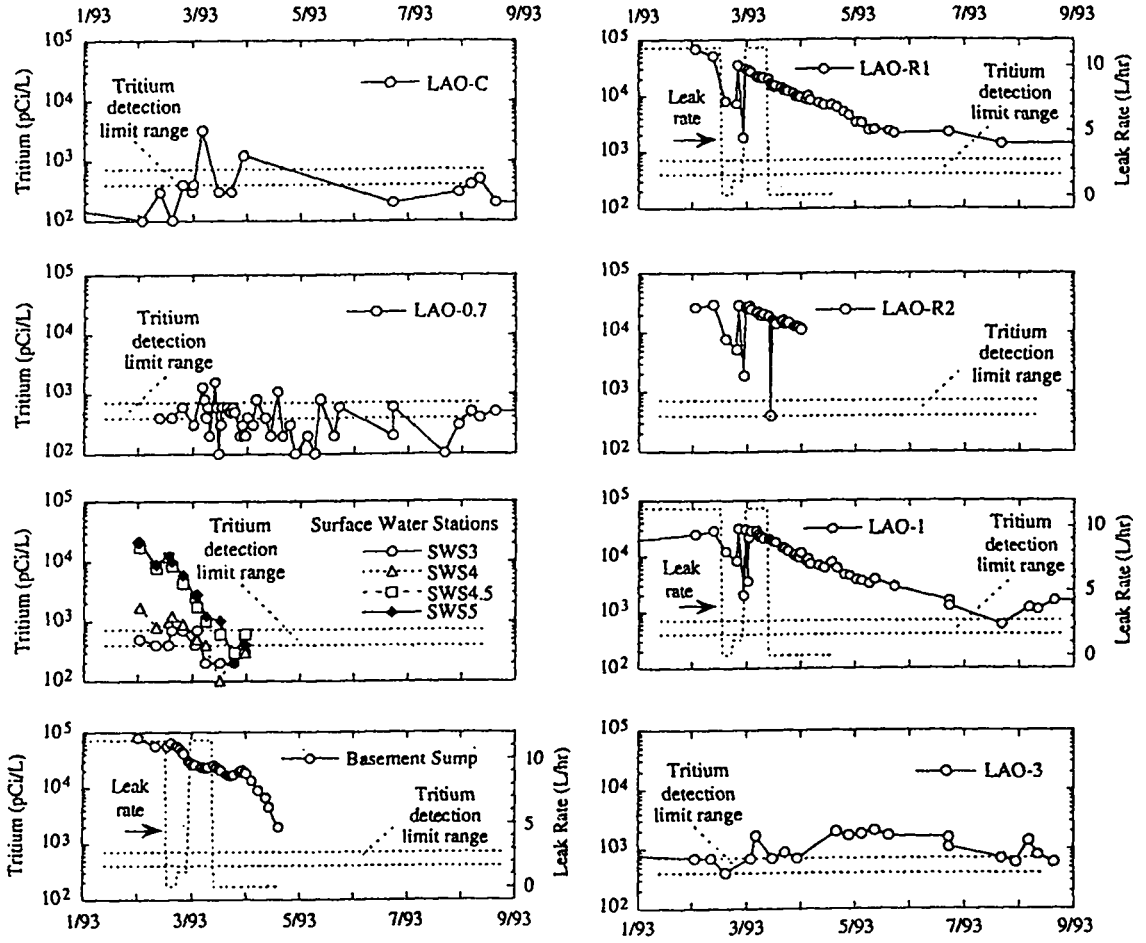


Figure VII-10. Tritium concentrations near the TA-2 Omega West Reactor from January through August 1993, from alluvial groundwater observation wells, surface water stations, and the basement sump discharge into Los Alamos Canyon from the Omega West Reactor building.

of tritium immediately upstream and are consistent with a constant leakage of cooling water from the OWR since it began operation in 1956.

c. Tritium Concentrations after Discovery of the Reactor Leak. EM-8 carried out a special surface and groundwater monitoring program in response to discovery of the OWR leak. Surface and groundwater samples were collected at several stations (Figure VII-8) between late January and early April 1993 and analyzed for tritium concentration (Figure VII-10).

The tritium leak was isolated in the cooling system delay line, located immediately west of the OWR building (Figure VII-8). During high stream flow, groundwater infiltrates into the basement of the reactor building. This groundwater is discharged through a sump outlet southeast of the reactor building into the surface drainage of Los Alamos Canyon. On January 30 and 31, 1993, the concentration of tritium in groundwater in the reactor building basement was between 100,000 and 120,000 pCi/L (OWR Recovery Team 1993). The trend of tritium concentrations in the basement (19,300 to 115,000 pCi/L) and sump (2,000 to 78,000 pCi/L) was similar during early 1993; only the sump concentrations are shown in Figure VII-10.

Low concentrations of tritium were found at Observation Wells LAO-C and LAO-0.7 (100 to 3,200 pCi/L), and surface water stations SWS 3 and 4 (100 to 1,700 pCi/L). These wells are both upstream of the reactor building, and the surface water stations are in a concrete-lined channel upstream of the basement sump discharge. The low tritium concentrations for these wells and surface water stations indicate that the OWR, and not TA-41, was the source of the tritium contamination. Observation wells LAO-R1, -R2, and -1, and surface water stations SWS 4.5 and 5 are located immediately east of the reactor building. These stations show tritium concentrations slightly below the levels seen in the reactor building basement groundwater and the sump discharge to surface water.

During the period of the reactor leak investigation, the concentrations of tritium for Well LAO-3 remained at about the 1000 to 2000 pCi/L level observed during the early 1990s. This indicates that the high tritium concentrations issuing from the OWR did not propagate down Los Alamos Canyon to this point, probably because of dilution by surface runoff and groundwater flow within the canyon.

Several of the plots in Figure VII-10 show the estimated leak rate from the reactor cooling system, which was at a maximum of 11.4 L/h (3 gal./h) during early 1993. This estimated leak rate is based on the volume of water required to maintain a certain level in the cooling system but may not include water lost while refilling the system. From February 17–22, 1993, the cooling system was drained, and the leak rate is believed to have been zero. Refilling of the system with clean water began on February 17, 1993, with the estimated leak rate reaching 1.2 L/h (0.3) gal./h on February 23, 1993, and again attaining the previous leak rate of 11.4 L/h (3 gal./h) on March 2, 1993.

During the time the cooling system was drained, the concentration of tritium declined sharply in water discharged from the reactor building basement sump, in Wells LAO-R1, -R2, and -1, and surface water stations SWS 4.5 and 5. The concentrations of tritium in the wells increased at the time of system refilling on February 23, 1993, (after the leak is believed to have resumed), and again after complete refilling on March 2, 1993. The drop in tritium levels in these wells might be related to draining of the cooling system and shut off of the coolant system leak, or could be a result of refilling the cooling system with clean water, which may have itself leaked and diluted groundwater tritium levels. Other factors which could have affected tritium concentrations in the groundwater are fluctuating surface runoff and infiltration related to variations in snowmelt.

Tritium concentrations in the wells and surface water stations just downstream from the reactor continued to fall after the leak was shut off on March 16, 1993: from 69,200 to 400 pCi/L for the wells, and from 21,700 to 200 pCi/L for the surface water stations. However, the levels of tritium downstream from the OWR did not decline as sharply following final shut off of the leak, as they did during the earlier cooling system draining that began February 17, 1993. This suggests that the leak discovered in the cooling system delay line may not have been the only source of tritium contamination and that the connection between the leak and groundwater tritium concentrations is not straightforward. Tritium concentrations in the basement sump water and in observation wells LAO-R1, -R2, and -1 have declined since shutdown of the reactor and final drainage of the cooling system. The tritium concentration in Well LAO-1 had declined to 1300 pCi/L on June 23, 1993, suggesting that the OWR is no longer leaking tritiated water into Los Alamos Canyon.

VIII. QUALITY ASSURANCE AND SAMPLING PROCEDURES

Quality assurance (QA) includes all of the planned and systematic actions and activities necessary to provide adequate confidence that a system or process will perform satisfactorily. Each monitoring and compliance activity sponsored by the Los Alamos National Laboratory's (LANL or the Laboratory) Environmental Protection Group (EM-8) has its own quality assurance program (QAP) with documented sampling procedures. The Environmental Chemistry Group (EM-9) also has a documented QAP for sample analysis and data verification.

A. Quality Assurance Program

Quality is the extent to which an item or activity meets or exceeds requirements. 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. In 1993, the Quality Policy & Performance Directorate oversaw QA functions at the Laboratory. The Laboratory Assessment Office manages an independent environmental appraisal and auditing program that verifies appropriate implementation of environmental requirements. The Laboratory's Quality Assurance Support Office performs QA and quality control (QC) audits and surveillance of Laboratory and subcontractor activities in accordance with the QAP for the Laboratory and for specific activities, as required.

Each monitoring activity sponsored by EM-8 has its own QAP. QAPs 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 U.S. Department of Energy (DOE) Orders 5400.1 (DOE 1988a) and 5700.6B (DOE 1989). Each QAP must address the following criteria:

- Organization
- Design control
- Procurement document control
- Plans, procedures, and drawings
- Document control
- Control of purchased items and services
- Identification and control of data, samples, and items
- Control of processes
- Inspection
- Test control
- Control of measuring and test equipment
- Handling, storage, and shipping
- Status of inspection, test, and operations
- Control of nonconforming items and activities
- Corrective action
- QA records
- Audits and surveillances

QAPs for each environmental monitoring program performed by EM-8 have been drafted and will be included in the Environmental Monitoring Plan (EMP) for CY93. The EMP is reviewed every year and revised every three years. The QAPs will be revised under DOE Order 5700.6C within two years. The Laboratory's Quality Assurance Support Office distributed the Quality Assurance Management Plan to Laboratory managers in January 1993.

B. Sampling Procedures

1. Thermoluminescent Dosimeters.

Thermoluminescent dosimeters (TLDs) used at the Laboratory are composed of lithium fluoride (LiF) in the form of 6.4-mm square by 0.9-mm thick chips. After exposure to external penetrating radiation, TLDs emit light when heated under laboratory conditions. The amount of light released is proportional to the amount of radiation absorbed by the TLD. The LiF TLDs used in the Laboratory's environmental monitoring program are insensitive to neutrons, so the contribution of cosmic neutrons to natural background radiation is not measured by them.

The chips are annealed to 400°C (752°F) for one hour and then cooled rapidly to room temperature. This is followed by annealing at 100°C (212°F) for one hour and again cooling rapidly to room temperature. For the annealing conditions to be repeatable, chips are put into rectangular borosilicate glass vials that each hold 48 LiF chips. These vials are slipped into a borosilicate glass rack so they can be simultaneously placed into annealing ovens maintained at 400°C and 100°C.

Each dosimeter contains four LiF chips, which are enclosed in a two-part threaded assembly made of an opaque yellow acetate plastic. A calibration set is prepared each time chips are annealed. The calibration set is read at the start of the dosimetry cycle. The number of dosimeters and exposure levels are determined for each calibration in order to be within the expected dose range. Each calibration set contains up to 150 dosimeters, which are irradiated at levels between 0 and 80 mR using a ^{137}Cs source calibrated by the National Institute of Standards and Technology (NIST).

A factor of 1 mrem (tissue) = 1.050 mR is used for evaluating the dosimeter data. This factor is the reciprocal of the product of the roentgen-to-rad conversion factor of 0.958 for ^{137}Cs in muscle and of 0.994, which corrects for attenuation of the primary radiation beam at the electronic equilibrium thickness. A rad-to-rem conversion factor of 1.0 for gamma rays is used, as recommended by the International Commission on Radiation Protection (ICRP 1970, Johns 1983). A method of weighted least-squares linear regression is used to determine the relationship between TLD reader response and dose (the weighting factor is the variance) (Bevington 1969).

The TLD chips used were all from the same production batch and were selected by the manufacturer so that the measured standard deviation in thermoluminescent sensitivity is 2.0% to 4.0% of the mean at a 10 R exposure. At the end of each field cycle, the dose at each location in the network is estimated from the regression line, along with the upper and lower confidence limits at the estimated value (Natrella 1963). At the end of the calendar year, individual field cycle doses are summed for each location. The uncertainty is calculated as the summation in quadrature of the individual uncertainties (Bevington 1969).

2. Air Sampling.

a. Radioactive Ambient Air Monitoring. Samples are collected biweekly at all of the 52 continuously operating stations. Airborne particulates are collected from the atmosphere using vacuum pumps with constant flow rates of 2 L/s (approximately 4 cu ft per minute [cfm]). The flow rates are multiplied by the total run time to determine the volume of air sampled. The particulates are collected on 60-mm-diameter polystyrene filters (Microsorban), which are mounted on charcoal cartridges. The charcoal cartridge is used to quantitatively determine the presence of gaseous gamma emitters should an unplanned release occur.

The particulate filters are analyzed biweekly for gross alpha, gross beta activity, and gamma spectrometry. Particulate filters are combined and analyzed quarterly for plutonium, americium, and uranium.

Part of the total airflow (200 cm^3/min) from the above system is passed through a cartridge containing 200 to 300 g of indicating silica gel. The silica gel absorbs atmospheric water vapor to be used for tritium analysis. Indi-

cating silica gel is used to determine if moisture was absorbed through the entire sample during the collection period. If the gel indicates breakthrough has occurred, the sample is discarded.

A rotameter, calibrated twice a year using a factory-calibrated flowmeter, is used to determine air flow. The total time of operation is multiplied by the average flow rate to determine the volume of air sampled. The silica gel collected biweekly is heated to drive off the moisture collected from the atmosphere. The moisture is then analyzed for tritium using liquid scintillation counting.

A specific ^{131}I sampling program with six sampling stations has been operating since August 1991. The system uses vacuum pumps with constant airflow regulators that sample at 1 cfm. Cartridges that contain activated treated charcoal are used to collect ^{131}I as gas. A 47-mm borosilicate microglass particulate filter is placed in front of the charcoal cartridge to collect any iodine in particulate form. Air volumes are determined by multiplying the constant flow rate of 1 cfm by the total time sampled. Samples are collected weekly. Filters and cartridges are qualitatively analyzed by gamma spectroscopy before they are sent to the analytical laboratory for quantitative analysis.

Measurements of tritium in rainwater are included in the monitoring results. This sampling program was initiated to support the Laboratory's Environmental Restoration program and is conducted by the Geology and Geochemistry Group. In the laboratory, the level of tritium in rainwater is measured through ultra-low-level beta counting in gas proportional counters. The tritium content of the rainwater sample is enriched through electrolysis, and then the water is reduced to hydrogen gas, which is injected into the counter and measured. The measurement is compared with background levels and standards before it is released to the investigator. Levels of tritium are given in tritium units (TU): one TU is 3.2 pCi/L of water.

b. Radioactive Air Emissions Monitoring. Samples are collected at weekly intervals from approximately 90 release points. Sample collection and analysis are performed by personnel from Health Physics Groups, HS-1 and HS-4, and Environmental Chemistry Group, EM-9.

The typical system for monitoring particulate radioactivity in stack emissions consists of one or more sampling probes that continuously extract a sample from the stack exhaust stream through the use of an air sampling pump that passes the sample through a filter that traps the particles. The pumps typically sample at a rate of 2 cfm. The activity of the filter, with its trapped particles, is then determined. The filters are counted for either gross alpha or gross beta activity or are counted by gamma spectroscopy, depending on the isotope(s) that are present at the facility. To determine the total activity released, the radioactivity on the sample filter is multiplied by the ratio of the volume of air released from the stack to the volume of air sampled by the pump. This total activity is expressed in μCi or Ci. The radioisotopes of plutonium are not listed separately because the gross alpha analysis count does not distinguish between the individual isotopes. Likewise, the gross beta counts analysis does not distinguish between the individual radioisotopes in the group called mixed-fission products.

Tritium is monitored in one of three ways. The first method measures total tritium , which includes the gaseous form and the water vapor form. In this method, one or more sampling probes continuously extract a sample from the effluent or exhaust stream. This sample is passed through metal tubes (or lines) to a remotely located instrument, which measures the concentration of tritium. This concentration, in conjunction with the effluent exhaust rate and the expected ratio of tritium gas to tritium water vapor, is used to determine the tritium activity (in Ci) released to the environment over a period of time. In the second method, which is used at facilities such as the Tritium Systems Test Assembly and the Weapons Engineering Tritium Facility, the effluent containing tritium is captured in a bubbler system. This system collects tritium gas and tritium water vapor separately so the quantity of each can be measured. A third method of measuring tritium is used at the Los Alamos Meson Physics Facility (LAMPF) where tritium water vapor is captured on silica gel. Each month, the gel is replaced, and the activity of the vapor is determined.

Particulate/vapor activation products are captured on paper filters in the case of particulates or on charcoal filters in the case of vapor, and total radioactivity is counted. Gaseous mixed activation products are counted in a flow-through air ionization chamber to determine total radioactivity. Isotopic ratios are measured using high-purity germanium (HPGe) detectors. Stack flow rates are measured by Johnson Controls Inc. (JCI) in accordance with Environmental Protection Agency (EPA) reference methods that use calibrated Pitot tubes. Table D-22 presents a list of procedures that have been prepared and implemented in monitoring radioactive air emissions.

c. Environmental Air Emissions Monitoring. In August 1992, LANL completed the installation of three HPGe detector systems along its north-eastern boundary with Los Alamos County. These systems were installed to detect air effluent released from LAMPF. Historically, LAMPF has contributed more than 98% of LANL's off-site dose from the air-effluent pathway; the primary dose contribution being from short-lived air activation products. The HPGe system collects an hourly gamma energy spectrum. The net count in energy spectrum for peaks associated with the air activation products is converted to an hourly dose rate.

As a backup to the HPGe system, a high-pressure ion chamber (HPIC) was also installed at the HPGe station located 800 meters north-northeast of the main LAMPF stack. The HPIC system continuously measures total external penetrating radiation dose. Daily background is determined during at least 12 hours of effluent-free occurrences. The Lab's goal with the installation and continuous operation of these systems is to demonstrate environmental compliance to EPA's national emission standards for radionuclides. The Lab currently confirms EPA compliance via computer modeling of LAMPF's air effluent releases.

d. Nonradioactive Air Emissions Monitoring. The nonradiological monitoring network consists of 1 criteria pollutant station, 1 visibility monitoring station, 1 acid precipitation monitoring station, and 17 samplers where beryllium is monitored.

The criteria pollutant monitoring station owned by the Laboratory is located south of TA-49, adjacent to Bandelier National Monument. This station, which began operation in the second quarter of 1990 and was funded by the National Park Service, continuously monitors air concentrations of nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Filters to trap small particulate matter (less than 10 μm in diameter) are collected every six days and weighed. Once each month, the NM Environment Department (NMED) audits the flow rate of the instrumentation.

Atmospheric visibility is also analyzed using a transmissometer. A 10-minute measurement is taken every hour, 24 h/day. The visibility is measured between TA-49 and TA-33, a distance of 4.58 km (2.84 mi). Air Resources of Fort Collins, Colorado, is responsible for data quality.

Acid deposition from precipitation is measured once per week. Water samples are examined in the field for visible contamination, pH, and electrical conductivity. Samples are sent to Colorado State University (CSU) to be further analyzed for inorganic content and pH. Blind samples are audited by CSU twice per year, and equipment checks are made once every three years.

Beryllium is monitored on the continuous ambient air monitors that are operated as part of the ambient radionuclide monitoring system. The samples are taken using a flow rate of 6 cfm. The flow rate is calibrated to a dry gas flow meter that in turn is calibrated to a NIST spirometer. The equipment operates continuously, and samples are collected monthly. A composite of the monthly samples is generated quarterly.

3. Water Sampling.

The Laboratory maintains three separate programs for monitoring water quality: the surface and groundwater monitoring program, and the National Pollutant Discharge Elimination System (NPDES) and the Safe Drinking Water Act (SDWA) compliance sampling programs. The first program involves sampling of water supply wells and special monitoring wells under the long-term environmental surveillance program. The samples are collected by EM-8 personnel and are analyzed by EM-9. Routine chemical analyses of water samples have been carried out for many constituents over a number of years. Although surface water and shallow groundwater are not sources of municipal or industrial water supplies, results of these analyses are compared with NMED and EPA drinking water standards (maximum concentration levels). The chemical quality of surface waters is compared to NM Livestock and Wildlife Watering Standards. The results of these programs are reported for nonradioactive constituents in Sections VI.A.2 and VII.C.2 of this report. Detailed descriptions of the procedures for sampling surface water and groundwater are presented in Section VIII.B.3.a.

Under the Laboratory's existing NPDES permit, samples are collected on a weekly basis and analyzed for the chemicals listed in the permit. Results are reported each month to EPA and NMED. See Section VIII.B.3.b for more information on the NPDES compliance sampling program.

Samples collected by the Laboratory to ensure compliance with SDWA standards are analyzed for organic, inorganic, and radioactive constituents at the NM Health Department's Scientific Laboratory Division (SLD) in

Albuquerque. SLD reports the analytical results directly to NMED. The JCI Environmental (JENV) Laboratory also collects samples from the Laboratory, county, and Bandelier National Monument water distribution systems and tests them for microbiological contamination, as required by SDWA. JENV Laboratory is certified by NMED for microbiological testing of drinking water. See Section VIII.B.3.c for more information on the sampling program.

a. Surface Water and Groundwater. Surface water and groundwater sampling stations are grouped by location (off-site regional, off-site perimeter, and on-site) and hydrologic similarity. Water samples are collected once a year. Samples from wells are collected after sufficient water has been pumped or bailed to ensure that the sample is representative of the aquifer. Spring samples (groundwater) are collected at the discharge point.

The water samples are collected in 4-L polyethylene bottles for radiochemical analyses. The 4-L bottles are acidified in the field with 5 mL of concentrated nitric acid and then are returned to the laboratory within a few hours of sample collection for filtration through a 0.45-μm membrane filter. The samples are routinely analyzed for tritium, ^{137}Cs, uranium, ^{238}Pu, and $^{239,240}Pu$, as well as for gross alpha, beta, and gamma activities. Selected samples are also analyzed for ^{241}Am, ^{90}Sr, and accelerator-induced activation products. Analytical methodology and its QAP are discussed in Section VIII.C. Detailed container and preservation requirements of EM-9 are documented in a handbook (Williams 1990).

Water samples for inorganic and organic chemical analyses are collected at the same time. Most samples collected for inorganic analyses are put into three 1-L polyethylene bottles to provide the proper range of preservatives for the analysis performed: one with no additives, one with sulfuric acid, and one with nitric acid. When necessary, additional containers with appropriate preservatives are collected for mercury, cyanide, and sulfide analyses. In addition, selected samples are also collected in glass containers for organic analyses. Details of container and preservation requirements and identification of EPA methodology for each analysis are contained in the EM-9 handbook (Williams 1990).

Samples of runoff are analyzed for radionuclides in solution and suspended sediments. The samples are filtered through a 0.45-μm filter. Solution is defined as the filtrate passing through the filter; suspended sediment is defined as the residue on the filter.

b. National Pollutant Discharge Elimination System. Personnel from EM-8 complete sample collection, preservation, and field analysis of the Laboratory's industrial outfall discharges that are regulated through NPDES permits. Industrial effluent samples are collected for specific parameters at the monitoring frequencies and locations specified in the NPDES permit. Monitoring is conducted according to EPA-approved methods documented in 40 CFR Part 136 and NPDES Permit Nos. NM0028355 and NM0028576. Chain-of-custody (COC) procedures for sample collection and analysis are conducted during sampling for NPDES industrial compliance.

EM-9 analyzes industrial discharges for pollutants listed in the NPDES permits. Samples are tested according to EPA-approved methods documented in 40 CFR Part 136, "Guidelines Establishing Test Procedures for Analysis of Pollutants" under the Clean Water Act; Final Rule and Technical Amendments (EPA 1991) or otherwise specified in the NPDES permits.

Treated effluent samples are collected from the sanitary treatment plants by JENV Laboratory in accordance with the monitoring conditions specified in NPDES Permit NM0028355. Representative samples are collected from the monitoring points designated for each outfall in the permit. Sample collection and preservation are conducted according to test procedures approved under 40 CFR 136. COC procedures are used by JENV Laboratory for sample collection and analysis. JENV Laboratory conducts the sanitary wastewater testing for pollutants listed in the NPDES permit. Testing procedures are conducted according to the seventeenth edition of "Standard Methods for the Examination of Water and Wastewater" (APHA 1989) and other conditions specified by the NPDES permit.

All instruments used for sanitary and industrial field and laboratory analyses are routinely serviced and calibrated; records are properly maintained. Measurements are made in accordance with the NPDES permit QA requirements, 40 CFR Section 122.41. QA procedures include the use of duplicate, replicate, and spike analyses; sample splits; outside reference samples; blanks; reagent blanks to check for sources of error; and method verification. Both JENV and the EM-9 laboratories participate in the National Discharge Monitoring Report Quality Assurance Program. EM-9 also participates in the EPA Water Pollution Study for blind spike analyses. The Laboratory's NPDES program is subject to annual compliance evaluation inspections by EPA and NMED.

c. Safe Drinking Water Act. The sampling program for drinking water quality is designed to meet or exceed regulatory requirements under the federal SDWA and the NM Environmental Improvement Act. Sampling locations, frequencies, preservation, handling, and analyses follow the requirements specified in federal and state regulations.

Samples are drawn at taps on the individual water supply well heads for VOCs at least once every year. Samples are collected in 40-mL glass septum vials. Travel blanks are submitted with the samples.

Well head samples are drawn monthly for microbiological quality, which includes total coliforms and noncoliforms analyses and heterotrophic plate counts. Autoclaved 100-mL polyethylene bottles are used to collect microbiological samples.

Samples for inorganic chemicals are collected annually from entry points to the distribution system and from the well heads. Samples are collected in 1-L polyethylene containers.

Samples for radiological contaminants are collected annually from entry points to the distribution system. Samples are collected in 4-L polyethylene containers.

Trihalomethane (THM) samples are collected quarterly from six sampling locations spread throughout the distribution system. The sample containers are 40-mL glass septum vials. Travel blanks are submitted with the samples.

Microbiological samples are also collected at approximately 80 locations throughout the distribution system. The sampling sites are rotated so that at least 40 samples from throughout the system are taken each month. Samples are analyzed for total coliforms, fecal coliforms, and noncoliform bacteria. Autoclaved 100-mL polyethylene bottles are used to collect microbiological samples.

Microbiological sampling and analyses are performed by personnel of the JENV Laboratory, certified by the State of New Mexico for microbiological compliance analysis. Certification requirements include proficiency samples, maintenance of an approved QA/QC program, and periodic audit by the NMED.

Chemical and radiochemical sampling is performed by LANL staff certified by NMED to perform drinking water compliance sampling. These samples are sent to SLD or other laboratories for analysis. The SLD QA/QC program is certified by the EPA.

4. Sediment Sampling.

Sediment samples are collected from dune buildup behind boulders in the main channels of perennially flowing streams. Samples from the beds of intermittently flowing streams are collected by scooping a line of uniform depth across the main channel. Reservoir sediments are collected from a boat, using an Eckman dredge. Bottom reservoir sediments are collected from an area 10 cm by 15 cm (4 in. by 6 in.) to a depth of 5 cm (2 in.).

Depending on the reason for taking a particular sediment sample, it may be analyzed for any of the following: gross alpha and gross beta activities, ^{90}Sr, uranium, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and possibly selected accelerator-induced activation products. Moisture distilled from soil and sediment samples may be analyzed for tritium.

5. Soil Sampling.

The soil sampling procedure involves taking five plugs, 75 mm (3.0 in.) in diameter and 50 mm (2.0 in.) deep, at the center and corners of a 10 m (33 ft) square area. The five plugs are combined and mixed to form a single composite sample for radiochemical analysis. Soils are split and dried at 100 °C (212°F) before analysis.

6. Foodstuffs Sampling.

Produce and soil samples are collected from local gardens in the summer and fall of each year (Salazar 1984). Each produce or soil sample is sealed in a labeled plastic bag. Samples are refrigerated until prepared for chemical analyses. Produce samples are washed, as if prepared for consumption, and quantitative wet, dry, and ash weights are determined. A complete sample bank is kept until all radiochemical analyses have been completed. All results are reported on an oven-dry-weight basis (dry g). Water is distilled from samples and submitted for tritium analysis and reported as pCi/mL moisture.

Bees and honey are collected by a professional (contract) bee keeper (Fresquez 1994c). Approximately 500 g of bees are collected. The frames of honey are enclosed in large plastic bags, marked for identification, and transported in an ice chest to the laboratory. At the laboratory, the honey is separated from the combs into 500-mL polyethylene bottles by a heat lamp. The bees and honey samples are submitted directly for radiochemical analyses. Heavy and trace metals in produce and honey are sampled every three years; the results of the next sampling session will be presented in the environmental surveillance report for CY94 and CY95, respectively.

At each reservoir, hook and line, trot line, or gill nets are used to capture fish (Salazar 1984). Fish samples are transported under ice to the laboratory for preparation. Fish are individually washed, as if for consumption, and dissected. Wet, dry, and ash weights are determined, and ash is submitted for analysis. Concentrations of uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs are determined. Also, the ratio of ^{235}U to ^{238}U in bottom-feeding fish is determined by thermal ionization mass spectrometry (Efurd 1993). All results are reported on an oven-dry-weight basis (dry g). Variations in the mean radionuclide content in fish collected upstream and downstream of the Laboratory are tested using a Student's t-test at the 0.05 probability level (Gilbert 1987). Heavy and trace metals in fish are sampled every three years; the results of the next sampling session will be presented in the environmental surveillance report for CY94.

Three adult female (cow) elk (*Cervus elaphus*) were harvested in January/February of 1992 from LANL areas TA-18 (Pajarito Canyon), TA-49 (Water Canyon), and TA-5 (Mortendad Canyon) (Fresquez 1994b). Similarly, three adult cow elk were collected by the New Mexico Department of Game and Fish during this same period of time from the Lindreth, Tres Piedras, and Chama areas. Tissue samples from each elk were collected: >200 g each of brain, hair, heart, jaw bone, kidneys, leg bone, liver, and muscle. Samples were submitted to EM-9 for the determination of tritium, uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs. All results are reported on an oven-dry-weight basis (dry g). Variations in the mean radionuclide content for each tissue component from elk collected from on-site and off-site areas were tested using a Student's t-test at the 0.05 probability level (Gilbert 1987).

7. Meteorological Monitoring.

QA of meteorological datasets is presently done for all of the towers by visual inspection of the chart records for any systemic errors (power outages, tower calibration, inspection, instrument repair or maintenance, etc.) and for any meteorological inconsistencies (e.g., trends of temperature versus relative humidity should generally be observed to have an opposite tendency unless there is a significant advection effect, etc.).

An internal Laboratory and an independent, external audit of the total meteorological system, including both tower and SODAR maintenance and inspection are performed once each year. These activities are scheduled about six months apart so that the entire system is inspected at least twice a year. During 1993, the internal tower audit was performed during the first quarter with the corresponding inspection dates for specific towers as follows:

TA-6: January 28, 1993

TA-49: January 25, 1993

TA-53: March 4, 1993

TA-54: White Rock: February 5, 1993

The external audit of the entire meteorological system was performed between May 4–25, 1993, by Met Associates (META 1993).

The internal audit was performed using a complete backup system for the sensors at each tower. The primary sensor system was brought into the laboratory for a thorough analysis while the back-up sensors operated routinely until replaced by the primary sensors after the audit process. In contrast, the external audit of the SODAR, meteorological towers, and data loggers was done at the individual tower sites. Needed adjustments were made immediately if they were simple; otherwise, the equipment was brought back into the laboratory for adjustment and/or replacement. The overall data completeness at TA-6 for 1993 was 98.1% (Table D-23).

C. Analytical Chemistry

1. Methodology.

a. Introduction. Most analytical chemistry services are provided by the Laboratory's EM-9 Group, which provides analytical services to the Laboratory's environmental, waste management, radiation protection, and industrial hygiene operations. EM-9 is responsible for QA for the health and environmental analytical work. EM-9 participates in the following interlaboratory QAPs:

- National Institute for Occupational Safety and Health, Proficiency Analytical Testing Program;
- Environmental Monitoring and Support Laboratory, Cincinnati (EMSL-CI) Drinking Water Program;
- EMSL-CI Water Pollution Study;
- EPA Environmental Monitoring Systems Laboratory-Las Vegas;
- Environmental Measurements Laboratory;
- NPDES; and
- DOE Beryllium Intercomparison Study.

The EM-9 Sample Management Section functions as an interface between the group and its customers. This section provides the sample collector with presampling information about sample containers, sample volumes, and sample preservation techniques. Collection of samples for chemical and radiochemical analyses follows a set procedure to ensure proper sample collection, documentation, submittal for chemical analysis, and posting of analytical results.

Before sample collection, the Sample Management Section discusses the schedule and procedures to be followed with the sample collector. The discussion includes

- number and type of samples;
- type of analyses and required limits of detection;
- proper sample containers;
- preparation of sample containers with preservative, if needed; and
- sample schedule to ensure minimum holding time so that analyses comply with EPA criteria.

After a sample is collected, it is delivered to the EM-9 Sample Management Section, where the pertinent information is entered into the EM-9 Laboratory Information Management System, and the request is given a form number. Each number, representing a single sample, is assigned to a particular station and is entered into the collector's log book. The processing of samples includes (1) validating all samples for sampling correctness and integrity, (2) scheduling and labeling all samples for analysis, (3) initiating internal COC procedures for all samples, and (4) arranging for the proper disposal of any unused portions of samples.

The request form number is entered in the collector's log book opposite sample numbers submitted, along with the date the sample was delivered to EM-9. EM-9 provides COC forms for the samples once they are received if COC did not begin in the field. The date, time, temperature (if the sample is water), and other pertinent information and remarks are entered opposite the sample number and station previously listed in the log book. The sample container is labeled with station name, sample number, date, and preservative, if added.

The analytical request form contains the following information related to ownership and the program submitted: (1) requester, i.e., sample collector; (2) program code; (3) sample owner, i.e., program manager; (4) date; and (5) total number of samples. The second part of the request form contains (1) sample number or numbers; (2) matrix, e.g., water; (3) types of analyses, i.e., specific radionuclide and/or chemical constituents; (4) technique, i.e., analytical method to be used for individual constituents; (5) analyst, i.e., chemist to perform analyses; (6) priority of sample or samples; and (7) remarks. One copy of the form goes to the collector for filing, one is kept by the Sample Management Section, and the other copies accompany the sample.

The analytical results are returned to the sample collector, who posts the data according to sample and station taken from the log book. These data sheets are included in the final report.

b. Radioactive Constituents. Environmental samples are routinely analyzed for the following radioactive constituents: gross alpha, beta, and gamma; isotopic plutonium; americium; uranium; cerium; tritium; and strontium. Detailed procedures are published in the EM-9 Analytical Methods Manual (Gautier 1986). Occasionally, other radionuclides from specific sources are determined: ^{7}Be, ^{22}Na, ^{40}K, ^{51}Cr, ^{60}Co, ^{65}Zn, ^{83}Rb, ^{106}Ru, ^{134}Cs, ^{140}Ba, ^{152}Eu, ^{154}Eu, and ^{226}Ra. All but ^{226}Ra are determined by gamma-ray spectrometry on large HPGe detectors. The requirements for detection of ^{137}Cs in drinking water were lowered to 10 pCi/L in 1992. In 1993, a detector was configured in a new chamber, shielded for lower background to meet this detection limit. This detector appeared capable of attaining the 10 pCi/L detection limit. These additional reconfigured detectors were used as needed for measurement of ^{137}Cs in many of the environmental samples analyzed for 1993. Depending on the concentration and matrix, ^{226}Ra is measured by emanation or by gamma-ray spectrometry of its ^{214}Bi decay product.

During 1992, the criteria for uranium analyses were changed to require lower detection limits and better estimates of the isotopic ratio. At that time, these requirements were achieved by development of a method of measurement by employing radiochemistry and alpha spectrometry (RAS). In 1993, a few samples needed to be analyzed by inductively-coupled plasma mass spectrometer (ICPMS) as was done in past years, but the great majority of isotopic uranium analyses were done by RAS. Kinetic phosphorimetric analysis (KPA) was used for samples where direct total uranium determination was required. This very sensitive method replaced the delayed neutron activation method, use of which was curtailed by shutdown of Omega West Reactor where the analysis had been done in past years.

c. Stable Constituents. A number of analytical methods are used for various stable isotopes. The choice of method is based on many criteria, including the operational state of the instruments, time limitations, expected concentrations in samples, quantity of sample available, sample media, and EPA regulations. Instrumental techniques available include atomic absorption, ion chromatography, color spectrophotometry (manual and automated), potentiometry, ICPMS, and inductively coupled plasma atomic emission spectrometry. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capabilities include flame, furnace, and cold vapor, as well as flame emission spectrophotometry. The methods used and references for determination of various chemical constituents are presented elsewhere (Gautier 1986).

d. Organic Constituents. Environmental soil and water samples are analyzed using EPA procedures outlined in EPA SW-846 (EPA 1989d) or modified procedures (Gautier 1986) that meet QA criteria outlined in Chapter 1 of SW-846, as shown in Table VIII-1. Methods used are supported by documented spike/recovery studies, method and field blanks, matrix spikes, surrogate spikes, and blind QC samples. VOCs are analyzed using Method 8260, SW-846. Tables D-24 and D-25 list VOCs on the target list for water and soil samples, respectively. Semivolatile organic compounds (SVOCs) are analyzed using Method 8270, SW-846. Table D-26 is the target list for SVOCs in water. Soil-gas (pore-gas) monitoring is performed by collecting organic vapors on carbonaceous adsorbent traps, thermal desorption of the traps, and analysis using gas chromatography/mass spectrometry (GC/MS). Soil-gas target compounds are listed in Table D-27, and the Toxicity Characteristics Leaching Procedure (TCLP) target compounds are listed in Table D-28.

Instruments available for organic analysis include GC/flame ionization detector, GC/electron capture detector (ECD), GC/MS, high performance liquid with ultraviolet (UV) and refractive index detectors, Fourier transform infrared spectrometer, and UV/visible spectrophotometer. Sample preparation methods include Soxhlet extraction, ultrasonic extraction, continuous liquid/liquid extraction, Kuderna Danish concentration, evaporative blowdown, and gel permeation chromatography cleanup of sample extracts.

Organic mixed waste analyses are performed for samples containing up to 300 nCi/g (solids/sludges) or 300 nCi/L (solutions) of alpha, beta, or gamma activity. Higher level samples are analyzed on a case-by-case basis. New methods are being developed for routine analysis of mixed waste greater than 300 nCi/g (or 300 nCi/L).

Table VIII-1. Method Summary (Organic Compounds)

Analyte	Matrix	Method	Technique[d]
VOCs	Air	—	GC/MS
	Soil	8260	PAT/GC/MS
	Water	8260	PAT/GC/MS
TCLP[a]	Soil	1311; 8080; 8150; 8260; 8270	GC/ECD
PCBs[b]	Water	8080	GC/ECD
	Soil	8080	GC/ECD
	Oil	IH 320[c]	GC/ECD
SVOCs	Soil and waste	8270	GC/MS

[a]Toxicity characteristics leaching procedure (TCLP)
[b]Polychlorinated biphenyl (PCBs)
[c]Industrial hygiene (IH).
[d]Gas chromatography (GC), purge and trap (PAT), electron capture detection (ECD), and mass spectrometry (MS).

2. Quality Evaluation Program.

a. Introduction. Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of several general types: calibration standards, reagent blanks, process blanks, matrix blanks, duplicates, spikes, and reference materials. Analysis of control samples fills two needs in analytical work: (1) it provides QC over analytical procedures so that problems that might occur can be identified and corrected, and (2) data obtained from analysis of control samples permit evaluation of the capabilities of a particular analytical technique to determine a given element or constituent under a certain set of circumstances.

Blind QC samples are numbered to resemble unknown samples in a set. The concentrations of the analytes of interest are not revealed until after the data have been formally reported. These samples are submitted to the laboratory at regular intervals and are analyzed in association with other samples; that is, they are not handled as a unique set of samples. Up to 10% of stable constituent, organic, and selected radioactive constituent analyses are run as QC samples using the materials described above. A detailed description of EM-9's QAP and a complete listing of results have been published annually since 1976 (Gautier 1993).

b. Radioactive Constituents. In addition to samples prepared internally, QC and QA samples for radioactive constituents are provided by outside agencies. The Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA, Las Vegas) provides water, milk, and air filter samples for analysis of gross alpha, gross beta, tritium, ^{40}K, ^{60}Co, uranium, ^{65}Zn, ^{90}Sr, ^{106}Ru, ^{131}I, ^{134}Cs, ^{137}Cs, ^{226}Ra, and $^{239,240}Pu$ as part of an ongoing laboratory performance evaluation program. NIST provides several soil and sediment standard reference materials (SRMs) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{238}Pu, ^{239}Pu, ^{241}Am, and several other nuclides. The DOE's Environmental Measurements Laboratory also provides QA samples.

Soil, rock, and ore samples obtained from the Canadian Geological Survey (CGS) are used for QA of uranium and thorium determinations in silicate matrices. EM-9's own in-house standards are prepared by adding known quantities of liquid SRMs for radioactivity, prepared by NIST to blank matrix materials.

c. Stable Constituents. QA for the stable constituent analysis program is maintained through analyses of certified or well-characterized environmental materials. NIST has a large set of silicate, water, and biological SRMs. EPA distributes standards for minerals and other trace constituents in water. Rock and soil reference materials have been obtained from the CGS and the United States Geological Survey. Details of this program have been published elsewhere (Gautier 1993). Stock solutions of inorganic analytes are prepared and spiked on blank matrices by EM-9's Quality Assurance Section.

The analytical QC program for a specific batch of samples is a combination of many factors. These include the calibration of the instrument and/or reagents, recovery for SRMs, method blanks, duplicate precision, spike sample recovery, and run time instrumental QC (continuing calibration standards and blanks).

d. Organic Constituents. Soil samples are analyzed for VOCs, SVOCs, pesticides, and herbicides for compliance work done under RCRA. Certified matrix-based reference materials are not available for these analyses, so stock solutions of the analytes are prepared and spiked directly on blank soil by the Quality Assurance Section. Because homogeneity of the sample cannot be ensured, the entire sample is analyzed. VOCs are analyzed by GC/MS and are spiked in the microgram-per-kilogram range.

The majority of water samples submitted during 1993 were environmental compliance samples analyzed for pesticides, herbicides, VOCs, SVOCs, and polychlorinated biphenyl (PCBs). Methods were developed and refined for in-house preparation of QC samples for VOCs and SVOCs in water.

Oil samples are received for the analysis of PCBs and organic solvents. QC samples for PCBs are prepared by diluting EPA standards or by preparing standards in hexane from the neat analyte. In the United States, the only PCBs that have been found in transformers have been PCBs 1242, 1254, and 1260. Samples submitted for analysis have contained only these PCBs, so only these have been used to spike QC samples. Vacuum pump oil was chosen for the oil base blank.

3. Data Handling of Radiochemical Samples.

Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the analytical technique. Consequently, individual measurements can result in values of positive or negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is determined 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

ci = 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.

4. Indicators of Analytical Accuracy and Precision.

Accuracy is the degree of difference between average test results and true results when the latter are known or assumed. Precision is the degree of mutual agreement among replicate measurements (frequently assessed by calculating the standard deviation of a set of data points). Accuracy and precision are evaluated from results of

analyses of reference materials. These results (r) are normalized to the known quality in the reference material to permit comparison among references of a similar matrix containing different concentrations of the analyte:

$$r = \frac{\text{Reported quantity}}{\text{Known quantity}}.$$

A mean value R for all normalized analyses of a given type is calculated as follows for a given matrix type (N is total number of analytical determinations):

$$R = \frac{\sum_i^{r_i}}{N},$$

Standard deviations of R are calculated assuming a normal distribution of the population of analytical determinations (N):

$$s = \sqrt{\frac{\sum_i (R - r_i)^2}{(N-1)}}.$$

These calculated values are presented as the EM-9 "Ratio ± Std Dev" in Tables D-29 to D-31. The mean value of R is a measure of the accuracy of a procedure. Values of R greater than unity indicate a positive bias in the analysis; values less than unity indicate a negative bias. The standard deviation is a measure of precision. Precision is a function of the concentration of analyte; that is, as the absolute concentration approaches the limit of detection, precision deteriorates. For instance, the precision for some determinations is quite good because many standards approach the limits of detection of a measurement. We address this issue by calculating a new QA parameter:

$$\left|\overline{X}_E - \overline{X}_C\right|,$$

where X_E is the experimentally determined mean concentration based on N measurements, and X_C is the certified or consensus mean concentration. The total standard deviation, S_T, of $X_E - X_C$ is given by

$$Sr = \sqrt{\left(U_E^2 / N\right) + S_C^2},$$

where U_E is the standard deviation of a single experimentally determined measurement, and S_c is the standard deviation of the certified or consensus mean elemental concentration.

5. Analytical Control Conditions.

Analyses are considered under control if the absolute value of the difference between our result (X_E) and the certified or consensus mean (X_C) is within the propagated standard deviation of the experimental uncertainty (U_E)

and of the certified mean (S_C). N is equal to the number of measurements on a sample, and in this case, is equal to 1. This concept, an adaptation of Dixon and Massey (Dixon 1969), is expressed in the following equation to include the experimental uncertainty:

$$z = \frac{\left|\overline{X}_E - \overline{X}_C\right|}{\sqrt{\left(U_E^2/N\right) + S_C^2}}$$

The test statistics used in this document are based on 5% and 0.2% levels of significance. The respective critical regions are defined for values of z between 2 and 3. Data having a calculated z value ≤2 are accepted as in control at the 5% level of significance. Data that have a calculated z value >2 and ≤3 are considered at the warning level, or the 0.2% level of significance. Data with a z value >3 are considered out of control. These test statistics are also incorporated in the QACHECK computer program.

The percentage of the tests for each parameter where $X_E - X_C$ fell within ≤2 S_T (under control), between $2S_T$ and $3S_T$ (warning level), or outside >$3S_T$ (out of control) is shown in Tables D-29 to D-31. A summary of the overall state of statistical control for analytical work done by EM-9 is provided in Table VIII-2.

With the exception of bulk materials, more than 90% of the organic analyses are within <2 propogated standard deviations of the certified/consensus mean values (under control). Inorganic data has a lower percentage of analyses within control limits, but the data is comparable to that obtained during 1992. Trace levels of radiochemical constituents in biological materials and soils still provide more analytical difficulty as illustrated by the lower level of overall analytical control. Other radiochemical measurements are unchanged since 1992. Areas with <90% of the analyses being under control were the focus of increased quality assurance/quality control efforts during 1993. Data on analytical detection limits are given in Table D-32.

Table VIII-3 summarizes recovery information on organic surrogate compounds required for use in the EPA-Contract Laboratory Program protocol. Table VIII-4 summarizes EM-9's overall record of meeting EPA SW-846-specified holding times for samples during 1993. The data include all samples for which holding times were missed and the customer elected to either resample or accept the data as usable. Table D-33 reports the incidence of false positive results for blank QC samples and false negative results for spiked QC samples at the 95% confidence level.

Table VIII-2. Overall Summary of EM-9 Quality Assurance Tests for 1993

Analysis	Number of Quality Control (QC) Tests	Under Control <2σ (%)	Warning 2Ý3σ (%)	Out of Control >3σ (%)
Stable Elements				
Biologicals	1	100	—	—
Bulk Materials	9	22	11	66
Filters	16	75	19	6
Soils	231	84	10	6
Water	4,703	94	3	3
Radiochemical Elements				
Biologicals	60	87	8	5
Filters	406	97	2	1
Soils	226	78	12	10
Water	1,208	96	3	1
Organic Compounds				
Bulk Materials	353	86	6	8
Charcoal Tube	924	97	—	3
Filters	56	92	4	4
Soils	1,608	97	1	2
Water	1,906	94	2	4

Table VIII-3. Summary of EM-9 Organic Surrogate Compounds as Required for Compliance with EPA SW-846 Criteria for 1993

Matrix Analysis	CAS[a] #	EPA SW-846 Range Low	EPA SW-846 Range High	Number of Surrogates In Range	Number of Surrogates Total	% In Range	% of Samples Run With Surrogate
Soil							
2-Fluorophenol	204	25	121	258	271.0	95.2	100.0
Phenol d6	205	24	113	265	271.0	97.8	100.0
Nitrobenzene d5	206	23	120	268	271.0	98.9	100.0
2-Fluorobiphenyl	207	30	115	268	271.0	98.9	100.0
2,4,6-Tribromophenol	208	19	122	258	271.0	95.2	100.0
p-Terphenyl d14	209	18	137	264	271.0	97.4	100.0
1,2-Dichloroethane d4	201	70	121	276	342.0	80.7	100.0
Toluene d8	202	81	117	337	342.0	98.5	100.0
4-Bromofluorobenzene	203	74	121	251	342.0	73.4	100.0
Water							
2-Fluorophenol	204	21	100	109	126.0	86.5	100.0
Phenol d6	205	10	94	115	126.0	91.3	100.0
Nitrobenzene d5	206	35	114	114	126.0	90.5	100.0
2-Fluorobiphenyl	207	43	116	109	126.0	86.5	100.0
2,4,6-Tribromophenol	208	10	123	119	126.0	94.4	100.0
p-Terphenyl d14	209	33	141	103	126.0	81.7	100.0
1,2-Dichloroethane d4	201	76	114	176	207.0	85.0	99.5
Toluene d8	202	88	110	207	207.0	100.0	99.5
4-Bromofluorobenzene	203	86	115	126	207.0	60.9	99.5

[a]Chemical abstract service.

Table VIII-4. EM-9 EPA SW-846 Holding Time Summary for 1993

Organic Analysis Type	Number Meeting EPA Criteria	Total Number Performed	% Within EPA Criteria
Extraction holding times			
Volatiles in soils	347	360	96.4
Volatiles in waters	132	154	85.7
Semivolatiles in soils	215	217	99.1
Semivolatiles in waters	132	138	95.7
PCBs in soils	352	362	97.2
PCBs in waters	68	84	81.0
Instrument analysis holding times			
Volatiles in soils	360	360	100.0
Volatiles in waters	154	154	100.0
Semivolatiles in soils	217	217	100.0
Semivolatiles in waters	138	138	100.0
PCBs in soils	298	362	82.3
PCBs in waters	77	84	91.7

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APPENDIX A

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 dose factors from Refs. A1 and A2. The dose factors adopted by DOE are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP).[A3]

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard (RPS) for the public.[A4] 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 information in Refs. A1 and A2 are based on recommendations of the ICRP and the National Council on Radiation Protection and Measurements.[A3,A4]

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 surveillance program are compared with DOE's derived air concentrations (DACs) and derived concentration guides (DCGs), respectively (Table A-2).[A5] 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 50th 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) 1989 standard of 10 mrem/yr (effective dose equivalent).[A6] To demonstrate compliance with these standards, doses from the air pathway are compared directly with the EPA dose limits. This dose limit of 10 mrem/yr replaced the previous EPA limits of 25 mrem/yr (whole body) and 75 mrem/yr (any organ).[A7]

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.

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 NM Water Supply Regulations (Table A-4).[A8] EPA's primary maximum contaminant level (MCL) is the maximum permissible level of a contaminant in drinking water that is delivered to the ultimate user of a public water system.[A9] EPA has set "action levels" in lieu of MCLs for lead and copper. If more than 10% of the samples from specified sites exceed

Table A-1. DOE Public Dose Limits (PDL) for External and Internal Exposures

Exposure of Any Member of the Public [a]

	EDE[b] at Point of Maximum Probable Exposure
All Pathways	100 mrem/yr[c]
	EDE at Point of Maximum Probable Exposure
Air Pathway Only [d]	10 mrem/yr
Drinking Water	4 mrem/yr

Occupational Exposure [a]

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] In keeping with DOE policy, exposures shall 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 Ref. A4. Limits for occupational exposure are taken from DOE Order 5480.11.

[b] 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.

[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. DOE's Derived Concentration Guides (DCGs) for Water and Derived Air Concentrations (DACs)[a]

Nuclide	DCGs for Water in Uncontrolled Areas (μCi/mL)	DCGs for Drinking Water Systems (μCi/mL)	DACs (μCi/mL) Uncontrolled Areas	DACs (μCi/mL) Controlled Areas
^{3}H	2×10^{-3}	8×10^{-5}	1×10^{-7}	2×10^{-5}
^{7}Be	1×10^{-3}	4×10^{-5}	4×10^{-8}	8×10^{-6}
^{89}Sr	2×10^{-5}	8×10^{-7}	3×10^{-10}	6×10^{-8}
^{90}Sr[b]	1×10^{-6}	4×10^{-8}	9×10^{-12}	2×10^{-9}
^{137}Cs	3×10^{-6}	1.2×10^{-7}	4×10^{-10}	7×10^{-8}
^{234}U	5×10^{-7}	2×10^{-8}	9×10^{-14}	2×10^{-11}
^{235}U	6×10^{-7}	2.4×10^{-8}	1×10^{-13}	2×10^{-11}
^{238}U	6×10^{-7}	2.4×10^{-8}	1×10^{-13}	2×10^{-11}
^{238}Pu	4×10^{-8}	1.6×10^{-9}	3×10^{-14}	3×10^{-12}
^{239}Pu[b]	3×10^{-8}	1.2×10^{-9}	2×10^{-14}	2×10^{-12}
^{240}Pu	3×10^{-8}	1.2×10^{-9}	2×10^{-14}	2×10^{-12}
^{241}Am	3×10^{-8}	1.2×10^{-9}	2×10^{-14}	2×10^{-12}
	(μg/L)	(μg/L)	(pg/m^3)	(pg/m^3)
Natural Uranium	800	30	1×10^{5}	3×10^{7}

[a]Guides for uncontrolled areas are based on DOE's PDL for the general public[A4]; 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]Guides for ^{239}Pu and ^{90}Sr are the most appropriate to use for gross alpha and gross beta, respectively.

the action level, the agency that manages the public water supply must initiate a corrosion control program. EPA's secondary drinking water standards, which are not included in the NM Water Supply Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water.[A9] 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[A9] and New Mexico Water Supply Regulations, Sections 206 and 207.[A8] These regulations provide that combined ^{226}Ra and ^{228}Ra may not exceed 5×10^{-9} μCi/mL. Gross alpha activity (including ^{226}Ra, but excluding radon and uranium) may not exceed 15×10^{-9} μCi/mL.

A screening level of 5×10^{-9} μCi/mL 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 (Table A-4) 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. In its Resource Conservation and Recovery Act (RCRA) regulations, EPA has established minimum concentrations of certain contaminants in water extracted from wastes that will cause the

waste to be designated as hazardous because of its toxicity.[A10] The toxicity characteristic leaching procedure (TCLP) must follow steps outlined by the EPA in 40 CFR 261, Appendix II. In this report, the TCLP minimum concentrations (Table A-5) are used for comparison with concentrations of selected constituents extracted from the Laboratory's active waste areas.

Table A-3. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	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	µg/m³	60		
	30 days	µg/m³	90		
	7 days	µg/m³	110		
	24 hours[a]	µg/m³	150		
PM_{10}[b]	Annual arithmetic mean	µg/m³		50	50
	24 hours	µg/m³		150	150
Carbon monoxide	8 hours[a]	ppm	8.7	9	
	1 hour[a]	ppm	13.1	35	
Ozone	1 hour[c]	ppm	0.06	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	µg/m³		1.5	1.5
Beryllium	30 days	µg/m³	0.01		
Asbestos	30 days	µg/m³	0.01		
Heavy metals (total combined)	30 days	µg/m³	10		
Nonmethane hydrocarbons	3 hours	ppm	0.19		

[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 above the limit is ≤1.

Table A-4. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Inorganic Chemicals, Organic Chemicals, and Radiochemicals[a]

Inorganic Chemical Contaminants

Primary Standards	MCL (mg/L)
Ag	0.05
As	0.05
Ba	2
Be	0.004
Cd	0.005
Cr	0.1
F	4.0
Hg	0.002
Ni	0.1
NO_3 (as N)	10.0
NO_2 (as N)	1.0
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
SO_4	250
Zn	5.0
TDS[c]	500
pH	6.5–8.5 standard unit

Radiochemical Contaminants

	MCL
Gross alpha[b]	15 pCi/mL
Gross beta & photon	4 mrem/yr
^{3}H	20,000 pCi/mL
^{90}Sr	8 pCi/mL
^{226}Ra & ^{228}Ra	5 pCi/mL
	Screening Limits
Gross alpha[b]	5×10^{-9} µCi/mL (5 pCi/L)
Gross beta	50×10^{-9} µCi/mL (50 pCi/L)

Table A-4. (Cont.)

Organic Chemical Contaminants	MCL (mg/L)
Insecticides:	
Endrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8a-octa hydro-1,4-endo, endo-5, 8-dimethano napthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2, 2-bis[p-methoxyphenyl] ethane)	0.1
Toxaphene (C_{10} H_{10} C_{l8} - technical chlorinated camphene, 67-69 percent chlorine)	0.005
Herbicides:	
2,4-D, (2,4-Dichlorophenoxyacetic acid)	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophenoxy-propionic acid)	0.01
Total trihalomethanes	0.10
Other Organic Contaminants:	
Benzene	0.005
Vinyl Chloride	0.002
Carbon tetrachloride	0.005
1,2-Dichloroethane	0.005
Trichloroethylene	0.005
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.20
para-Dichlorobenzene	0.075

Microbiological Contaminants	MCL
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]Refs. A8 and A9.

[b]See text for discussion of application of gross alpha MCL and gross alpha screening level of 5×10^{-9} μCi/mL.

[c]Total dissolved solids.

Table A-5. Levels of Contaminants Determined by the Toxicity Characteristic Leaching Procedure[a]

Contaminant	(mg/L)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0
m-Cresol	200.0
p-Cresol	200.0
Cresol	200.0
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor (and its epoxide)	0.008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TP (Silvex)	1.0
Vinyl chloride	0.2

[a]Ref. A[10].

Table A-6. Wildlife Watering Standards

Livestock Contaminant	Concentration (mg/L)
Dissolved Al	5.0
Dissolved As	0.02
Dissolved B	5.0
Dissolved Cd	0.05
Dissolved $Cr^{(+3, +6)}$	1.0
Dissolved Co	1.0
Dissolved Cu	0.5
Dissolved Pb	0.1
Total Hg	0.01
Dissolved Se	0.05
Dissolved V	0.1
Dissolved Zn	25.0
$^{226}Ra + ^{228}Ra$	30 pCi/L

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A3. 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).

A4. National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).

A5. US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 8, 1990).

A6. US Environmental Protection Agency, "40 CFR 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).

A7. US Environmental Protection Agency, "National Emission Standard for Radionuclide Emissions Other than Radon from Department of Energy Facilities," *Code of Federal Regulations,* Title 40, Part 61, Subpart H (December 15, 1989).

A8. New Mexico Environmental Improvement Board, "NM Water Supply Regulations," (as amended through April 12, 1991).

A9. 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).

A10. US Environmental Protection Agency, "Identification and Listing of Hazardous Waste, Table I. Maximum Concentration of Contaminants for the Toxicity Concentrations," *Code of Federal Regulations*, Title 40, Section 261.24 (1992).

A11. New Mexico Water Quality Control Commission, "Water Quality Standards for Interstate and Intrastate Streams in New Mexico," Section 3-101.K (as amended through November 12, 1991).

APPENDIX B

UNITS OF MEASUREMENT

Throughout this report the International System of Units (SI) or metric system of measurements has been used, with some exceptions. For units of radiation activity, exposure, and dose, US Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively.

Table B-1 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0×10^3, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the right of its present location. The number would then read 2,000. If the value given is 2.0×10^{-5}, the decimal point should be moved five numbers to the left of its present location. The result would 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.

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)	35.7	Cubic feet (ft^3)
Hectares (ha)	2.47	Acres
Grams (g)	0.035	Ounces (oz)
Kilograms (kg)	2.2	Pounds (lb)
Kilometers (km)	0.62	Miles (mi)
Liters (L)	0.26	Gallons (gal.)
Meters (m)	3.28	Feet (ft)
Micrograms per gram (µg/g)	1	Parts per million (ppm)
Milligrams per liter (mg/L)	1	Parts per million (ppm)
Square kilometers (km^2)	0.386	Square miles (mi^2)

Table B-3. Common Measurement Abbreviations and Measurement Symbols

aCi	attocurie
ac ft	acre feet
Bq	becquerel
Btu/yr	British thermal unit per year
cc/sec	cubic centimeters per second
cfm	cubic feet per minute
cfs	cubic feet per second
Ci	curie
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot
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

Table B-3. (Cont.)

µCi/L	microcurie per liter
µCi/mL	microcurie per milliliter
µg/g	microgram per gram
$\mu g/m^3$	microgram per cubic meter
mL	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter
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
S_T or σ	standard deviation
Sv	sievert
sq ft (ft^2)	square feet
TU	tritium unit
>	greater than
<	less than
±	plus or minus

APPENDIX C

DESCRIPTIONS 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 II-3. The main programs conducted at each of the areas are listed in this Appendix.

TA-0, Town Site: The Laboratory has about 180,000 sq ft of leased space for training, support, architectural engineering design, unclassified research and development, and the publicly accessible Community Reading Room and Bradbury Science Museum. DOE's Los Alamos Area Office is also located at the townsite.

TA-2, Omega Site: Omega West Reactor, an 8-MW nuclear research reactor, is located here. It served as a research tool by providing a source of neutrons for fundamental studies in nuclear physics and associated fields before it was shut down this year.

TA-3, Core Area: The Administration Building that contains the Director's office and administrative offices and laboratories for several divisions is 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, a Van de Graaff accelerator, the main cafeteria, and the Study Center. TA-3 contains about 50% of the Laboratory's employees and floor space.

TA-5, Beta Site: This site contains some physical support facilities such as an electrical substation, test wells, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, 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 home to 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 non-nuclear 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 new 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: The fundamental behavior of nuclear chain reactions with simple, low-power reactors called critical assemblies is studied here. Experiments are operated by remote control and observed by closed-circuit television. 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.

TA-21, DP Site: This site has two primary research areas: DP West and DP East. DP West is gradually being decontaminated and decommissioned. 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: Nuclear safeguards research and development, which are conducted here, are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research is done on reactor safety, laser fusion, optical sciences, pulse-power systems, and high-energy physics. Tritium fabrication, metallurgy, ceramic technology, and chemical plating are also done here.

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 non-nuclear 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.

TA-46, WA Site: Applied photochemistry, which includes development of technology for laser isotope separation and laser enhancement of chemical processes, is investigated here. The Sanitary Wastewater System Consolidation project has been installed at the east end of this site. Environmental management operations are also located here.

TA-48, Radiochemistry Site: Laboratory scientists and technicians at this site study nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made, and hot cells are used for remote handling of radioactive materials.

TA-49, Frijoles Mesa Site: This site is currently restricted to carefully selected functions because of its location near Bandelier National Monument and past use in high explosive and radioactive materials experiments. The Hazardous Devices Team Training Facility is located here.

TA-50, Waste Management Site: Personnel at this site have responsibility for treating and disposing of most industrial liquid and radioactive liquid waste received from Laboratory technical areas, for development of improved methods of solid waste treatment, and for containment of radioactivity removed by treatment.

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, Meson Physics Facility: The Los Alamos Meson Physics Facility, a linear particle accelerator, is used to conduct research in areas of basic physics, materials studies, and isotope production. The Los Alamos Neutron Scattering Center, the Ground Test Accelerator, and the Proton Storage Ring are also located at this TA.

TA-54, Waste Disposal Site: The primary function of this site is radioactive solid and hazardous chemical waste management and disposal.

TA-55, Plutonium Facility Site: Processing of plutonium and research on plutonium metallurgy are done at this site.

TA-57, Fenton Hill Site: About 45 km (28 mi) west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains, is the location of the Laboratory's Hot Dry Rock geothermal project.

TA-58: This site is reserved for multi-use 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 sanitary landfill.

TA-62: This site is reserved for multi-use experimental science, public and corporate interface, and environmental research and buffer uses.

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.

TA-65: This undeveloped TA was incorporated into TA-51 and no longer exists.

TA-66: This site is used for industrial partnership activities.

TA-67: This is a dynamic testing area that contains significant archaeological sites. It is designated for future mixed and low-level hazardous waste storage.

TA-68: This is a dynamic testing area that contains archaeological 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 archaeological sites and an endangered species breeding area. The site also contains Laboratory water wells and future wellfields.

APPENDIX D

Supplementary Environmental Information

Table D-1. Hazardous Waste Management Facilities at Los Alamos National Laboratory

Technical Area/Building	Facility Type	Inclusion in Part B Permit Application or Interim Status[a]
3-29[b]	Container (2 Units)	Interim S
3-102-118A	Container	Closed
14-35	OB/OD[c] (2 Units)	Interim T
15-184[b]	OB/OD	Interim T
16, Area P	Landfill	Closure in Progress
16	OB/OD (6 Units)	Interim T
16	Surface Impoundment	Closure in Progress
16-88[b]	Container	Interim S
16-1150	Incinerator	Interim T
21-61[b]	Container	Interim S
22-24	Container	Closed
35-85	Surface Impoundment	Closure in Progress
35-125	Surface Impoundment	Closure in Progress
36-8[b]	OB/OD	Interim T
39-6	OB/OD	Interim T
39-57	OB/OD	Interim T
40, SDS	OB/OD	Closure in Progress
40-2	Container	Closed
50-1-60A[b]	Container	Interim TS
50-1-60D[b]	Container	Interim S
50-1-BWTP	Aboveground Tank	Permitted TS
50-37-115[b]	Aboveground Tank (2 Units)	Interim S
50-37-115[b]	Container	Interim S
50-37-117	Container	Permitted S
50-37-117[b]	Container	Interim S
50-37-118[b]	Container	Interim S
50-37-CAI[b]	Incinerator	Interim T
50-37-CAI	Incinerator	Permitted T
50-69[b]	Container	Interim S
50-69[b]	Container	Interim S
50-114	Container	Permitted S
50-114[b]	Container	Interim S
50-137[d]	Container	Permitted S
50-138[d]	Container	Permitted S
50-139[d]	Container	Permitted S
50-140[d]	Container	Permitted S
53-166[b]	Surface Impoundment	Interim S
53-166[b]	Surface Impoundment	Interim S
53-166[b]	Surface Impoundment	Interim S
54, Area G Over Pit 33[b]	Container	Interim S
54, Area G	Landfill	Closure in Progress

Table D-1. (Cont.)

Technical Area/Building	Facility Type	Inclusion in Part B Permit Application or Interim Status[a]
54, Area G Pad 1[b]	Container	Interim S
54, Area G Pad 2[b]	Container	Interim S
54, Area G Pad 4[b]	Container	Interim S
54, Area G Over Pit 30[b]	Container	Interim S
54, Area G Shaft 145[b]	Container	Interim S
54, Area G Shaft 146[b]	Container	Interim S
54, Area G Shaft 148[b]	Container	Interim S
54, Area G Shaft 147[b]	Container	Interim S
54, Area G Shaft 149[b]	Container	Interim S
54, Area H	Landfill	Closure in Progress
54, Area L	Aboveground Tank (4 Tanks)	Permitted T
54, Area L Shaft 36[b]	Container	Interim S
54, Area L Shaft 37[b]	Container	Interim S
54, Area L Gas Cyl[b]	Container	Interim S
54, Area L Gas Cyl	Container	Permitted S
54-8[b]	Container	Interim S
54-31	Container	Permitted S
54-32	Container	Permitted S
54-33[b]	Container	Interim S
54-48[b]	Container	Interim S
54-49[b]	Container	Interim S
54-68	Container	Permitted S
54-69	Container	Permitted S
55, Near Bldg 4[b]	Container	Interim S
55-4[b]	Container (3 Units)	Interim S
55-4[b]	Tank (13 Tanks)	Interim TS
55-4[b]	Container	Interim S
55-4[b]	Container	Interim S
55-4[b]	Container	Interim TS
55-4[b]	Container	Interim S

[a]S = Storage; T = Treatment.
[b]Designates mixed waste units.
[c]OB/OD = open burning/open detonation.
[d]These units have not yet been constructed.

Table D-2. Types of Discharges and Parameters Monitored at the Laboratory under NPDES Permit NM0028355

EPA Identification No.	Type of Discharge	Number of Outfalls	Monitoring Required	Sampling Frequency
01A	Power plant	1	Total suspended solids, free available chlorine, pH, flow	Monthly
02A	Boiler blowdown	2	pH, total suspended solids, flow, total copper, total iron, total phosphorus, total sulfite (as SO_3), total chromium	Weekly except total chromium which is sampled once a month
03A	Treated cooling water	38	Total suspended solids, free available chlorine, total phosphorus, pH, flow	Weekly
04A*	Noncontact cooling water	52	pH, flow	Weekly
050*, 051	Radioactive waste treatment plant (TA-21 and TA-50)	2	Ammonia (as N), chemical oxygen demand, total suspended solids, total cadmium, total chromium, total copper, total iron, total lead, total mercury, total zinc, pH, flow	Weekly except ammonia which is sampled once a month
05A	High explosives wastewater	21	Chemical oxygen demand, pH, flow, total suspended solids	Weekly
06A	Photo waste water	13	Total cyanide, total silver, pH, flow	Weekly
128	Printed circuit board	1	pH, chemical oxygen demand, total suspended solids, total iron, total copper, total silver, flow	Weekly except silver which is sampled once a month
S*	Sanitary wastewater	10	Biochemical oxygen demand, flow, pH, total suspended solids, fecal coliform bacteria	Variable frequency, from three per month to once per three months

*NPDES outfalls 02S, 03S, 04S, 06S, 07S, 9S, 10S, 12S, 050, and 04A093 were deleted from the NPDES permit on July 9, 1993.

Table D-3. Limits Established by NPDES Permit NM0028355 for Sanitary Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01S TA-3 Treatment Plant	BOD[a]	30.0	45.0	mg/L
		225.2	N/A	lb/day
	TSS[b]	30.0	45.0	mg/L
		225.2	N/A	lb/day
	Fecal coliform bacteria	1,000.0	2,000.0	org/100 ml
	pH	6–9	6–9	standard unit
05S TA-21 Package Plant	BOD[a]	30.0	45.0	mg/L
		4.3	N/A	lb/day
	TSS[b]	30.0	45.0	mg/L
		4.3	N/A	lb/day
	pH	6–9	6–9	standard unit

[a]Biochemical oxygen demand.
[b]Total suspended solids.
NOTE: Sanitary Outfalls 02S, 03S, 04S, 06S, 07S, 09S, 10S, and 12S were eliminated from the Laboratory's NPDES permit on July 9, 1993.

Table D-4. NPDES Permit Monitoring of Effluent Quality at Sanitary Sewage Treatment Outfalls, 1993[a]

Discharge Location (Outfall)	Permit Parameters	Number of Deviations
TA-3 (01S)	BOD[b]	0
	TSS[c]	0
	Fecal coliform bacteria	0
	pH	0
*TA-9 (02S)	BOD	0
	TSS	0
	pH	0
*TA-16 (03S)	BOD	0
	TSS	0
	pH	0
*TA-18 (04S)	BOD	0
	TSS	0
	pH	0
*TA-21 (05S)	BOD	0
	TSS	0
	pH	0
*TA-41 (06S)	BOD	0
	TSS	0
	Fecal coliform bacteria	0
	pH	0
*TA-46 (07S)	BOD	0
	TSS	0
	pH	0
*TA-53 (09S)	BOD	0
	TSS	0
	pH	0
*TA-35 (10S)	BOD	0
	TSS	0
	pH	0
*TA-46 (12S)	BOD	0
	TSS	0
	pH	0

[a]Limits set by the NPDES permit are presented in Table D-3.

[b]Biochemical oxygen demand.

[c]Total suspended solids.

*Sanitary outfalls eliminated from the NPDES permit on July 9, 1993.

Table D-5. Limits Established by NPDES Permit NM0028355 for Industrial Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01A Power plant	TSS[a]	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	pH	6–9	6–9	standard unit
02A Boiler blowdown	TSS	30	100	mg/L
	Total Fe	10	40	mg/L
	Total Cu	1	1	mg/L
	Total P	20	40	mg/L
	SO_3	35	70	mg/L
	Total Cr	Report[b]	Report[b]	mg/L
	pH	6–9	6–9	standard unit
03A Treated cooling water	TSS	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	Total P	5.0	5.0	mg/L
	pH	6–9	6–9	standard unit
04A Noncontact cooling water[c]	pH	6–9	6–9	standard unit
050 Radioactive waste treatment plant[c] (TA-21)	COD[d]	18.8	37.5	lb/day
	TSS	3.8	12.5	lb/day
	Total Cd	0.01	0.06	lb/day
	Total Cr	0.02	0.08	lb/day
	Total Cu	0.13	0.13	lb/day
	Total Fe	0.13	0.13	lb/day
	Total Pb	0.01	0.03	lb/day
	Total Hg	0.007	0.02	lb/day
	Total Zn	0.13	0.37	lb/day
	pH	6–9	6–9	standard unit
	Ammonia (as N)	Report	Report	mg/L
051 Radioactive waste treatment plant (TA-50)	COD	94.0	156.0	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
	pH	6–9	6–9	standard unit
	Ammonia (as N)	Report	Report	mg/L
05A High explosive	COD	150.0	250.0	mg/L
	TSS	30.0	45.0	mg/L
	pH	6–9	6–9	standard unit

Table D-5 (Cont.)

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
06A Photo waste	CN	0.2	0.2	mg/L
	Ag	0.5	1.0	mg/L
	pH	6–9	6–9	standard unit
128 Printed circuit board	COD	1.9	3.8	lb/day
	TSS	1.25	2.5	lb/day
	Total Fe	0.05	0.1	lb/day
	Total Cu	0.05	0.1	lb/day
	Total Ag	Report	Report	mg/L
	pH	6–9	6–9	standard unit

[a]Total suspended solids.

[b]Effluents are reported to EPA but are not subject to limits.

[c]NPDES outfall 050 and 04A093 were eliminated from the Laboratory's NPDES permit on July 9, 1993.

[d]COD = chemical oxygen demand.

Table D-6. NPDES Permit Monitoring of Effluent Quality at Industrial Outfalls, 1993[a]

Discharge Category	Outfall No.	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls with Deviations
Power plant	01A	1	TSS[b]	0	—	0
			Free Cl	0	—	0
			pH	0	—	0
Boiler blowdown	02A	2	pH	1	9.2	1
			TSS	5	170–526	2
			Cu	0	—	0
			Fe	0	—	0
			P	0	—	0
			SO_3	0	—	0
			Cr	0	—	0
Treated cooling water	03A	38	TSS	3	210–335	2
			Free Cl	4	0.52–0.63	4
			P	1	6.3	1
			pH	0	—	0
Noncontact cooling water	04A[c]	52	pH	1	9.1	1
Radioactive waste treatment plant	051 and 050[c]	2	COD[d]	0	—	0
			TSS	0	—	0
			Cd	0	—	0
			Cr	0	—	0
			Cu	0	—	0
			Fe	0	—	0
			Pb	0	—	0
			Hg	0	—	0
			Zn	0	—	0
			pH	0	—	0
			Foam	1	—	1
High explosive	05A	21	COD	0	—	0
			TSS	0	—	0
			pH	0	—	0

Table D-6. (Cont.)

Discharge Category	Outfall No.	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls with Deviations
Photo waste	06A	13	CN	1	0.35	1
			Ag	0	—	0
			TSS	0	—	0
			pH	0	—	0
Printed circuit board	128	1	pH	1	9.8	1
			COD	0	—	0
			Ag	0	—	0
			Fe	0	—	0
			Cu	0	—	0
			TSS	0	—	0
			Solids	1	—	1
		130				

[a]Limits set by the NPDES permit are presented in Table D-5.

[b]Total suspended solids.

[c]Outfalls 050 and 04A093 were eliminated from the Laboratory's NPDES Permit on July 9, 1993.

[d]Chemical oxygen demand.

Table D-7. Federal Facilities Compliance Agreement and Administrative Order: Schedule for Upgrading the Laboratory's Wastewater Outfalls

Outfalls	Date	Status or Target Date
Outfall 05A (HE Wastewater Treatment)		
Complete conceptual design report	July 1992	Completed
Complete design criteria	June 1993	June 30, 1993
Begin line item project	January 1994	January 31, 1994
Complete Title I design	July 1994	July 31, 1994
Complete Title II design	July 1995	July 31, 1995
Advertisement of construction	August 1996	August 31, 1996
Award of construction contract	October 1996	October 31, 1996
Construction completion	September 1997	September 30, 1997
Achieve compliance with final permit limits	October 1997	October 31, 1997
Waste Stream Identification and Characterization		
Completion of waste stream final report	March 1994	March 31, 1994
Complete 25% corrective actions	September 1994	September 30, 1994
Complete 50% corrective actions	September 1995	September 30, 1995
Complete 100% corrective actions	September 1996	September 30, 1996
Achieve compliance with permit limitations	October 1996	October 31, 1996

Table D-8. TA-6 Tower Variables

Wind

U horizontal wind speed (m/s) at z = 11.5, 23, 46, and 92 m

- σ_u standard deviation of wind speed
- $\overline{U}$ 24-h mean wind speed
- U_{mx} maximum gust in in a 24-h period
- t_{mx} time of the maximum gust
- U_{mx1} maximum 1-min gust at z = 11.5 m in a 24-h period
- t_{mx1} time of the 1-min gust

θ horizontal vector wind direction (deg) at z = 11.5, 23, 46, and 92 m

- σ_θ standard deviation of wind direction
- θ_{mx} direction of the maximum gust
- θ_{mx1} direction of the maximum 1-min gust at z = 11.5m

w vertical wind speed (m/s) at z = 11.5, 23, 46, 92 m

u_*^2 friction velocity squared (m^2/s^2) at z = 11.5 m; toward the surface is positive
$u_*^2 = \overline{u'w'}$

Atmospheric State

Temperature

T air temperature (°C) at z = 1.2, 11.5, 23, 46, and 92 m

- T_{mx} maximum temperature at z = 1.2 m in a 24-h period
- t_{mx} time of the maximum temperature
- T_{mn} minimum temperature at z = 1.2 m in a 24-h period
- t_{mn} time of the minimum temperature

T' air temperature fluctuations measured by a thermocouple at z = 11.5 m

T_d dew point temperature (°C) at z = 1.2 m
T_d = f($VP(h,SVP(T,h))$), where VP and SVP are the vapor pressure and saturation vapor pressure and h is the relative humidity

- $\overline{T_d}$ 24-h mean value
- T_{dmx} maximum dew point temperature in a 24-h period
- T_{dmn} minimum dew point temperature in a 24-h period

T_s soil temperature (°C) at z = -10 cm

Table D-8. (Cont.)

Humidity

h relative humidity (%) at z = 1.2 m

$\overline{h}$ 24-h mean relative humidity
h_{mx} maximum relative humidity in a 24-h period
h_{mn} minimum relative humidity in a 24-h period

q' absolute humidity fluctuations (g water/m^3 of air) at z = 11.5 m

Atmospheric Pressure

p pressure (mb) at z = 1.2 m

p_{mx} maximum pressure in a 24-h period
p_{mn} minimum pressure in a 24-h period

Precipitation

r total precipitation in 15 min (in./100), water equivalent when snow; logged as -1 for a trace.

$\hat{r}$ total precipitation in a 24-h period

Surface Energy Exchange

Radiation Flux Densities

K↓ incoming solar radiation flux (W/m^2) at z = 1.5 m; toward the surface is positive

$$\hat{K}\downarrow = \int^{24} K\downarrow \, dt \quad (kW\ h/m^2)$$

K↑ reflected solar radiation at z = 1.5 m; away from the surface is positive

$$\hat{K}\uparrow = \int^{24} K\uparrow \, dt$$

L↓ incoming longwave radiation flux (W/m^2) at z = 1.5 m; toward the surface is positive

$$\hat{L}\downarrow = \int^{24} L\downarrow \, dt \quad (kW\ h/m^2)$$

L↑ outgoing longwave radiation flux at z = 1.5 m; away from the surface is positive

$$\hat{L}\uparrow = \int^{24} L\uparrow \, dt$$

Table D-8. (Cont.)

Q^* net all-wave radiation (W/m^2) at z = 1.5 m; toward the surface is positive
$Q^* = L\downarrow + L\uparrow + K\downarrow + K\uparrow$

$\hat{Q}^* = \int^{24} Q^* \, dt$ ($kW\ h/m^2$)

Heat Flux Densities

Q_g ground heat flux (W/m^2) at z = - 1 cm; away from the surface is positive; the heat storage term is neglected

$\hat{Q}_g = \int^{24} Q_g \, dt$ ($kW\ h/m^2$)

Q_h sensible heat flux (W/m2) at z = 11.5 m; away the surface is positive
$Q_h = 1.08 c_p \rho \overline{w'T'} + 0.1 Q_e$, where c_p is the specific heat of air at constant pressure (= 1 J/g • K at 10°C)

$\hat{Q}_h = \int^{24} Q_h \, dt$ ($kW\ h/m^2$)

Q_e latent heat flux (W/m^2) at z = 11.5 m; away from the surface is positive
$Q_e = L \, \overline{w'q'}$, where L is the specific heat of vaporization of water (= 2480 J/g)

$\hat{Q}_e = \int^{24} Q_e \, dt$ ($kW\ h/m^2$)

Table D-9. Meteorological Variables Measured by the Existing Tower Network

Tower Location (Elevation [a])	Level [b]	Wind [c]	Temperature	Humidity	Precipitation	Solar Radiation	Radiation Fluxes [d]	Sensible Heat Flux	Latent Heat Flux	Ground Heat Flux	Momentum Flux	Soil Temperature	Pressure
		Variable											
TA-6 (2,265)	92	x	x										
	46	x	x										
	23	x	x										
	12	x	x					x	x		x		
	1		x	x	x	x	x						x
	<0									x		x	
TA-49 (2,146)	92												
	46	x	x										
	23	x	x										
	12	x	x										
	1		x	x	x	x							
TA-53 (2,139)	92												
	46	x	x										
	23	x	x										
	12	x	x										
	1		x	x	x	x							
TA-41 (2,108)	92												
	46												
	23	x											
	12	x	x										
	1		x			x							
TA-54 (1,996)	92												
	46	x	x										
	23	x	x										
	12	x	x										
	1		x	x	x	x	x						x
	<0											x	

[a] In m above sea level.
[b] Levels are nominal heights above the ground in meters.
[c] Horizontal wind direction and speed; vertical wind speed for levels ≥ 4 m.
[d] Incoming and outgoing short-wave and long-wave radiation.

Table D-10. Radiochemical Detection Limits for Analyses of Typical Environmental Samples

Parameter	Approximate Sample Volume or Weight	Count Time	Detection Limit Concentration	
Air Sample				
Tritium	3 m^3	30 min	1×10^{-12}	µCi/mL
^{131}I	3.0×10^2 m^3	1×10^3 s	1×10^{-11}	µCi/mL
^{238}Pu	2.0×10^4 m^3	8×10^4 s	4×10^{-18}	µCi/mL
$^{239,240}Pu$	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
^{241}Am	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	µCi/mL
Gross alpha	6.5×10^3 m^3	100 min	4×10^{-16}	µCi/mL
Gross beta	6.5×10^3 m^3	100 min	4×10^{-16}	µCi/mL
^{234}U	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
^{235}U	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	µCi/mL
^{238}U	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
Water Sample				
Tritium	0.005 L	30 min	4×10^{-7}	µCi/mL
^{90}Sr	0.5 L	200 min	3×10^{-9}	µCi/mL
^{137}Cs	0.5 L	5×10^4 s	4×10^{-8}	µCi/mL
^{238}Pu	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
$^{239,240}Pu$	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
^{241}Am	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
Gross alpha	0.9 L	100 min	3×10^{-9}	µCi/mL
Gross beta	0.9 L	100 min	3×10^{-9}	µCi/mL
Soil Sample				
Tritium	1 kg	30 min	0.003	pCi/g
^{90}Sr	2 g	200 min	2	pCi/g
^{137}Cs	100 g	5×10^4 s	0.1	pCi/g
^{238}Pu	10 g	8×10^4 s	0.002	pCi/g
$^{239,240}Pu$	10 g	8×10^4 s	0.002	pCi/g
^{241}Am	10 g	8×10^4 s	0.002	pCi/g
Gross alpha	2 g	100 min	3	pCi/g
Gross beta	2 g	100 min	3	pCi/g
U (delayed neutron)	2 g	20 s	0.2	µg/g

Table D-11. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION[1]
Plecoptera (Stoneflies)	Capniidae	*Capnia*		F
	Capniidae			F
	Chloroperlidae	*Chloroperla*		F
	Chloroperlidae	*Paraperla*	*frontalis*	G,L
	Chloroperlidae	*Paraperla*		F
	Chloroperlidae	*Sweltsa*	*coloradensis*	F
	Chloroperlidae	*Sweltsa a*	*lamba*	F
	Chloroperlidae	*Sweltsa*		F,G
	Chloroperlidae	*Suwallia*		G,L
	Chloroperlidae			F,G,L,SG
	Leuctridae	*Paraleuctra*	*vershina*	F
	Nemouridae	*Amphinemura*		F
	Nemouridae	*Amphinemura*	*banksi*	F,G,L,P,SG
	Nemouridae	*Malenka*	*coloradensis*	F
	Nemouridae	*Malenka*		G,L
	Nemouridae	*Nemoura*		F
	Nemouridae	*Zapada*	*cinctipes*	F
	Perlidae	*Acroneuria*	*abnormis*	F
	Perlidae	*Hesperoperla*	*pacifica*	F,L,SG
	Perlodidae	*Cultus*		G
	Perlodidae	*Isoperla*	*fulva*	F
	Perlodidae	*Isoperla*	*quinquepunctata*	F
	Perlodidae	*Isoperla*		F,G,L,S
	Perlodidae	*Kogotus*	*modestus*	G,L
	Perlodidae	*Skwala*	*parallela*	G
	Pteronarcyidae	*Pteronarcella*	*badia*	F,G
	Pteronarcyidae	*Pteronarcella*		F
	Pteronarcyidae	*Pteronarcys*	*californica*	G
	Taeniopterygidae	*Taenionema*		F
Ephemeroptera (Mayflies)	Baetidae	*Baetis*	*bicaudata*	F
	Baetidae	*Baetis*	*insignificans*	F
	Baetidae	*Baetis*	*tricaudatus*	A,D,F,G,L, PS,S
	Baetidae	*Baetis*		A,C,F,G,H,L,P,PS, S,SG,128
	Baetidae	*Callibaetis*		G,L,P,PS,S,48
	Ephemerellidae	*Drunella*	*coloradensis*	G,L
	Ephemerellidae	*Drunella*	*doddsi*	F,G
	Ephemerellidae	*Drunella*	*grandis*	F,G
	Ephemerellidae	*Ephemerella*	*grandis grandis*	F
	Ephemerellidae	*Ephemerella*	*inermis*	F,G,L
	Ephemerellidae	*Ephemerella*	*infrequens*	F,G
	Ephemerellidae	*Ephemerella*		F
	Heptageniidae	*Cinygmula*		F,G,L
	Heptageniidae	*Epeorus*	*longimanus*	F,G

Table D-11. (Cont.)

ORDER	FAMILY	GENUS	SPECIES	LOCATION[1]
	Heptageniidae	*Epeorus*		F,G,L
	Heptageniidae	*Heptagenia*		G
	Heptageniidae	*Nixe*	*simplicoides*	L
	Heptageniidae	*Rhithrogena*		F
	Leptophlebiidae	*Paraleptophlebia*		F,G,L
	Siphlonuridae	*Ameletus*		F,G,L,S,SG
	Siphlonuridae	*Siphlonurus*	*occidentalis*	F,L
	Siphlonuridae	*Siphlonurus*		F
	Siphlonuridae			A
	Tricorythidae	*Tricorythodes*	*minutus*	S
	Tricorythidae	*Tricorythodes*		A,F
Odonata				
suborder Anisoptera (Dragonflies)	Aeshnidae	*Aeshna*		A,C,F,I,S
	Aeshnidae	*Anax*		H,P,S,48
	Aeshnidae	*Boyeria*		S
	Cordulegastridae	*Cordulegaster*		F,S
	Corduliidae	*Belonia*?		A,C,P
	Gomphidae			L,P
	Libellulidae	*Leuchorrhina*		I
	Libellulidae	*Libellula*		PS
	Libellulidae	*Pantala*		A,C
	Libellulidae	*Platyhemis*?		P
	Libellulidae	*Sympetrum*?		PS
	Libellulidae			A,F,PS
suborder Zygoptera (Damselflies)	Agriidae	*Argion*		A
	Agriidae	*Hetaerina*		A,PS
	Coenagrionidae	*Argia*		A,C,F,P,S,PS
	Coenagrionidae	*Enallagma*		I
	Coenagrionidae	*Hyponeura*		F
	Coenagrionidae	*Ishnura*	*perparua*	F
	Coenagrionidae	*Ishnura*		H,S
	Coenagrionidae	*Zoniagrion*		S
	Lestidae	*Archilestes*		PS,S
Hemiptera (True bugs)	Corixidae	*Corisella*		F
	Corixidae	*Sigara*		F
	Corixidae	*Trichocorixa*		A,P,S
	Gerridae	*Gerris*	*marginatus*	F
	Gerridae	*Gerris*	*notabilis*	F
	Gerridae	*Gerris*		A,D,F,G,H,I,L,S, PS
	Gerridae	*Metrobates*		PS
	Gerridae	*Trepobates*		H
	Naucoridae	*Ambrysus*	*mormon*	A,C,PS
	Notonectidae	*Notonecta*	*undulata*	F
	Notonectidae	*Notonecta*		C,S

Table D-11. (Cont.)

ORDER	FAMILY	GENUS	SPECIES	LOCATION[1]
	Veliidae	*Microvelia*		F,G
	Veliidae	*Rhagovelia*		S
	Veliidae			A,PS
Trichoptera (Caddisflies)	Brachycentridae	*Amiocentrus*		F
	Brachycentridae	*Brachycentrus*	*americanus*	F
	Brachycentridae	*Brachycentrus*		F
	Brachycentridae	*Micrasema*		F,G,L
	Calamoceratidae	*Phylloicus*		F
	Glossomatidae	*Agapetus*		G
	Glossosomatidae	*Anagapetus*		G
	Glosssosomatidae	*Glossosoma*		F,G,L
	Helicosychidae	*Helicopsyche*	*borealis*	G,L,PS
	Helicopsychidae	*Helicopsyche*		F
	Hydropsychidae	*Arctopsyche*	*grandis*	A,F,G,L,S,PS
	Hydropsychidae	*Cheumatopsyche*		G,PS
	Hydropsychidae	*Hydropsyche*	*occentalis*	PS
	Hydropsychidae	*Hydropsyche*	*oslari*	A,F
	Hydropsychidae	*Hydropsyche*		F
	Hydrospsychidae	*Hydropsyche*		F,G,PS,S,SG
	Hydroptilidae	*Alisotrichia*		PS
	Hydroptilidae	*Hydroptila*		A,P,PS,S
	Hydroptilidae	*Leucotrichia*		PS
	Hydroptilidae	*Ochrotrichia*		F,G,L
	Hydroptilidae	*Stactobiella*		A,PS
	Lepidostomatidae	*Lepidostoma*		F,G,L,S,SG
	Lepidostomatidae			G
	Leptoceridae	*Oecetis*		L,P,S
	Limnephilidae	*Dicosmoecus*		F
	Limnephilidae	*Hesperophylax*		G,L,P,S,SG
	Limnephilidae	*Limnephilus*		F,F,G,L,S
	Limnephilidae	*Oligophlebodes*		F,G,L,P,S
	Limnephilidae	*Psychoronia*		F,G
	Limnephilidae			G,L
	Philopotamidae	*Chimarra*		A,PS
	Philopotamidae	*Dolophilodes*	*aequalis*	F
	Philopotamidae	*Dolophilodes*	*sortosa*	F,G
	Philopotamidae	*Dolophilodes*		G,L
	Philopotamidae	*Wormaldia*		F,PS
	Polycentropidae	*Polycentropus*		F
	Rhyacophilidae	*Rhyacophila*	*acropedes*	F,G
	Rhyacophilidae	*Rhyacophila*	*brunnea* complex	F,G
	Rhyacophilidae	*Rhyacophila*	*hyalinata*	F,G
	Rhyacophilidae	*Rhyacophila*	*valuma*	F,G
	Rhyacophilidae	*Rhyacophila*		F
	Rhyacophilidae	*Rhyacophila*	Type A	A
Megaloptera (Nerve-wings)	Corydalidae	*Neohermes?*		G,L

Table D-11. (Cont.)

ORDER	FAMILY	GENUS	SPECIES	LOCATION[1]
Lepidoptera (Butterflies and moths)	Noctuidae			G,PS
	Pyralidae			S
	Pyralidae	*Paraponyx*		PS
	Pyralidae	*Parargyractis*	*kearfottalis*	F,PS
	Pyralidae	*Petrophyla*		PS
Coleoptera (Beetles)	Curculionidae	*Phytonomus*		G,L,S
	Curculionidae			D,F
	Dryopidae	*Helichus*	*suturalis**	F
	Dryopidae	*Helichus*	*striatus**	F
	Dryopidae (adults)	*Helichus*		F,L,P,PS
	Dryopidae (adults)			S
	Dytiscidae	*Agabus*	*cordatus**	F
	Dytiscidae	*Agabus*	*tristus**	F
	Dytiscidae	*Agabus*		A,C,D,L,P,S
	Dytiscidae	*Deronectes*	*striatellus**	F
	Dytiscidae	*Deronectes**		L
	Dytiscidae	*Dytiscus**		F
	Dytiscidae	*Hydroporus*	*vilis**	F
	Dytiscidae			L,S
	Dytiscidae (adults)			G,PS,S
	Dytiscidae (adults)		Type A	M
	Dytiscidae (adults)		Type B	M
	Dytiscidae (adults)	*Hydaticus*		G,L,PS,S
	Elmidae	*Cleptelmis addenda**		F
	Elmidae	*Cylloepus*		F
	Elmidae	*Dubiraphia**		G
	Elmidae	*Heterlimnius*	*corpulentis*	F,G,L,PS,SG
	Elmidae (adults)	*Heterlimnius*	*corpulentis*	G,L,PS,SG
	Elmidae	*Microcylloepus**		PS
	Elmidae	*Narpus **	*concolor*	F
	Elmidae	*Narpus*		F,G,L
	Elmidae (adults)	*Narpus*		G,L
	Elmidae	*Optioservus*	*castanipennis**	F
	Elmidae	*Optioservus*	*divergens**	F
	Elmidae	*Optioservus**		D,F,L,PS,S
	Elmidae	*Rhizelmis*		F
	Elmidae	*Zaitzevia*	*parvula*	D,F,L
	Elmidae	*Zaitzevia*		G,L
	Elmidae (adults)	*Zaitzevia*		C,G,L,S
	Elmidae			G,L,S
	Elmidae (adults)			C,S,PS
	Gyrinidae (adults)	*Gyrinus*		A,F,S,PS

Table D-11. (Cont.)

ORDER	FAMILY	GENUS	SPECIES	LOCATION[1]
	Haliplidae	*Haliplus*		IC
	Haliplidae	*Peltodytes*		G
	Haliplidae (adults)			S
	Helodidae			P
	Hydrophilidae	*Ametor*	*scabrosus**	F
	Hydrophilidae	*Ametor*		A,C
	Hydrophilidae (adults)	*Ametor*		G
	Hydrophilidae	*Berosus*	*styliferous*	F
	Hydrophilidae	*Crenitis**		F
	Hydrophilidae	*Cymbiodyta*	*dorsalis**	F
	Hydrophilidae (adults)	*Hydrochus*		G
	Hydrophilidae			G,L,P
	Hydrophilidae (adults)			G
	Psephenidae	*Psphenus?*		C,P,48
Diptera (Flies)	Blephariceridae			F
	Ceratopogonidae (Heleidae)	*Bezzia*		G,S
	Ceratopogonidae (Heleidae)			F,G,P,S,PS
	Chironomidae	*Ablabesmyia*		F
	Chironomidae	*Brillia*		F,L,S
	Chironomidae	*Cardiocladius*		F,G
	Chironomidae	*Crichotopus*		F
	Chironomidae	*Chironomus*		F
	Chironomidae	*Corynoneura*		PS
	Chironomidae	*Cricotopus*		A,F,G,PS
	Chironomidae	*Cryptochironomus*		F
	Chironomidae	*Eukiefferiella*		A,F,G,L
	Chironomidae	*Micropsectra*		A,F
	Chironomidae	*Microtendipes*		D,F
	Chironomidae	*Nanocladius*		F
	Chironomidae	*Pagastia*		L
	Chironomidae	*Polypedilum*		A,F
	Chironomidae	*Procladius*		F
	Chironomidae	*Pseudochironomus*		A
	Chironomidae	*Pseudosmittia*		G
	Chironomidae	*Rheotanytarsus*		A,F,PS
	Chironomidae	*Thienemannimyia*		A,S
	Chironomidae	*Thienimanniella*		A
	Chironomidae	*Zavrelia*		F
	Chironomidae	Type A		C,H,L,P,PS,S,SG, 128
	Chironomidae	Type B		G,L,P,S,PS
	Chironomidae	Type C		H,P,S,128
	Chironomidae	Type D		G,L,P,PS,S
	Chironomidae	Type E		L,PS
	Chironomidae	Type F		G,L,S

Table D-11. (Cont.)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Chironomidae	Type G		A,C,G,H,L,P,PS,S
	Chironomidae	Type H		S
	Chironomidae	Type I		SG
	Chironomidae (pupae)			C,I,S
	Chironomidae (pupae)	Type PB		S
	Culicidae	*Aedes*		F
	Culicidae	*Chaoborus*		I,48
	Culicidae	*Culex*		F,H,128
	Culicidae	*Culiseta*		D,H,M,48,128
	Culicidae (pupae)			H,M,G,L,128
	Culicidae			S
	Dixidae	*Dixa*	*californica*	F
	Dixidae	*Dixa*		F,G,L,PS
	Dixidae	*Dixa*	Type A	G,L,P,PS
	Empididae	*Chelifera*		F,G,L
	Empididae	*Oreogeton*		C,F,G,P,S
	Empididae			H
	Ephydridae	*Brachydeutera*		S
	Ephydridae (pupae)			S
	Muscidae	*Limnophora*	*aequifrons*	F
	Muscidae	*Limnophora*		A,D,L,S,SG
	Psychodidae	*Maruina*		G,L
	Psychodidae	*Pericoma*		F,G,L
	Psychodidae (pupae)			S
	Ptychopteridae	*Bittocomorpha*		A,G,L,S
	Ptychopteridae			F
	Simuliidae	*Prosimilium*		A,F,G,L,S
	Simuliidae	*Simulium*		F,L
	Simuliidae			D,F,G,L,S,SG
	Simuliidae (pupae)			S
	Stratiomyidae	*Eulalia*		F
	Stratiomyidae	*Odontomyia?*		PS,S
	Stratiomyidae			A,F
	Syrphidae	*Tubifera*	*bastardii*	F
	Tabanidae	*Chrysops*		H,M
	Tabanidae	*Tabanus*		128
	Tabanidae			F,G,L
	Tanyderidae	*Protanyderus*		F
	Tipulidae	*Antocha*	*monticola*	F,G
	Tipulidae	*Antocha*		G,L
	Tipulidae	*Dicranota*		F,G,L,PS,S,SG
	Tipulidae	*Hexatoma*		F
	Tipulidae	*Holorusia*	*grandis*	F
	Tipulidae	*Limonia*		F
	Tipulidae	*Pedicia*		F
	Tipulidae	*Tipula*		D,F,G,L,PS,S
	Tipulidae	*Tipula*	Type B	S

Table D-11. (Cont.)

[1]**Locations:**

A = Ancho Canyon
C = Chaquehui Canyon
D = DP Canyon
F = Rio Frijoles and Frijoles Canyon
G = Guaje Canyon
H = High Explosives wastewater stream
I = Ice House pond, off West Jemez Road
L = Los Alamos Canyon
O = Otowi fire station pond
M = Mortandad
P = Pajarito Wetlands
PS = Pajarito Springs
S = Sandia Canyon
SG = Starmer's Gulch
48 = TA-48 pond
128 = Outfall 128

Table D-12. Non-Insect Aquatic Invertebrates Collected in Los Alamos County and Adjacent Watersheds

PHYLUM or SUBPHYLUM	CLASS, ETC	COMMON NAME	LOCATION [1]
Annelida (Segmented worms)	Naididae	Coil worms	F,L,S
	Oligochacta, Lumbriculidae, *Eiseniella tetraedra*	Aquatic earthworms	F
	Oligochaeta, Lumbriculidae	Aquatic earthworms	A,F,G,L,PS, S,SG
	Oligochaeta B, Lumbriculidae	Aquatic earthworms	G
	Hirudinea	Leeches	A,F
Arthropoda, Arachnoidea (Spiders, ticks, and mites)	Hydracarina	Water mites	C,F,G,PS,SG
Aschelminthes (Round worms and hairworms)	Nematomorpha	Horsehair worms	C,F,G,L,P,S,SG
	Nematomorpha, *Gordius*	Horsehair worms	F
Crustacea (Crustaceans)	Amphipoda, *Hyalella azteca*	Scuds	A,C,PS
	Cladocera	Water fleas	O
	Copepoda	Copepods	S
	Ostracoda, Candoniidae	Seed shrimp	S
	Ostracoda, Cyprididae	Seed shrimp	C,S,SG
	Palaemonidae	Scuds	A,C
Mollusca (Mollusks)	Planorbidae, *Gyraulus parvus*	Snails	G,IC,S
	Lymnaeidae, *Lymnaea*	Snails	A,G,L,P,S
	Physidae, *Physella*	Snails	A
	Physidae, *Physa*	Snails	F,S
	Gastropoda	Snails	SG
	Pelecypoda, *Pisidium casertanum*	Clams	F,G,L
	Pelecypoda, *Pisidium compressa*	Clams	H
	Sphaeriidae	Clams	F
Nematoda (Round worms)		Free-living roundworm	F,S
Platyhelminthes (Flatworms)	Turbellaria	Planaria	A,C,F,G,PS, S,SG

[1]**Locations:**

A = Ancho Canyon
C = Chaquehui Canyon
D = DP Canyon
F = Rio Frijoles and Frijoles Canyon
G = Guaje Canyon
H = High Explosives wastewater stream
I = Ice House pond, off West Jemez Road
L = Los Alamos Canyon
O = Otowi fire station pond
M = Mortandad
P = Pajarito Wetlands
PS = Pajarito Springs
S = Sandia Canyon
SG = Starmer's Gulch
48 = TA-48 pond
128 = Outfall 128

Table D-13. Summary of Selected Radionuclides Half-Life Information

Nuclide	Half-Life
^{3}H	12.3 yr
^{7}Be	53.4 d
^{11}C	20.5 min
^{13}N	10.0 min
^{15}O	122.2 s
^{22}Na	2.6 yr
^{32}P	14.3 d
^{40}K	1,277,000,000 yr
^{41}Ar	1.83 h
^{54}Mn	312.7 d
^{56}Co	78.8 d
^{57}Co	270.9 d
^{58}Co	70.8 d
^{60}Co	5.3 yr
^{75}Se	119.8 d
^{85}Sr	64.8 d
^{89}Sr	50.6 d
^{90}Sr	28.6 yr
^{131}I	8 d
^{134}Cs	2.06 yr
^{137}Cs	30.2 yr
^{234}U	244,500 yr
^{235}U	703,800,000 yr
^{238}U	4,468,000,000 yr
^{238}Pu	87.7 yr
^{239}Pu	24,131 yr
^{240}Pu	6,569 yr
^{241}Pu	14.4 yr
^{241}Am	432 yr

NOTE: For the half-life of the principal airborne activation products, see discussion on page V-2.

Table D-14. Locations of Air Sampling Stations[a]

Station	New Mexico State Plane Coordinates Northing	Easting
Regional (28–44 km)		
1. Española	1819247.9	54436954
2. Pojoaque	1770753.2	564196.6
3. Santa Fe	1698592.5	297029.1
Perimeter (0–4 km)		
4. Barranca School	1783276.3	490540.6
5. Arkansas Avenue	1783435.0	472030.6
6. 48th Street	1776555.5	476714.3
7. Shell Station	1775843.3	483461.3
8. McDonald's	1774932.1	485435.7
9. Los Alamos Airport	1776244.0	492348.4
10. East Gate	1773917.6	498437.5
11. Well PM-1	1768256.6	507326.5
12. Royal Crest Trailer Park	1772809.5	485105.5
13. White Rock- Piñon School	1754709.8	511035.6
14. Pajarito Acres	1743891.3	512275.3
15. White Rock Fire Station	1756934.4	513175.6
16. White Rock Church of the Nazarene	1754506.1	508400.5
17. Bandelier National Monument	1739541.6	495304.8
18. North Rim	(non-active)	
On Site Stations, Controlled Areas		
19. TA-21 DP Site	1773715.6	494734.2
20. TA-21 Area B	1774828.5	491772.0
21. TA-6	1771795.4	471440.1
22. TA-53 (LAMPF)	1771895.6	495063.1
23. TA-52 Beta Site	1767650.1	492181.5
24. TA-16 S Site	1764329.7	468060.8
25. TA-16-450	1760923.5	469442.7
26. TA-49	1756028.7	479579.8
27. TA-54 Area G	1757907.9	503080.9
28. TA-33 HP Site	1740552.3	497858.9
29. TA-2 Omega Site	1770682.3	495062.9
30. Booster P-2	1762897.1	495802.5
31. TA-3	1773116.5	478357.4
32. TA-48	1774935.5	480119.8
00. TA-59 OHL	1770897.2	480387.6
Waste Site Stations, Controlled Areas		
33. Area AB	1755216.2	485590.5
34. Area G-1 NE Corner	1757855.5	504906.8
35. Area G-2 South Fence	1757153.7	501450.2
36. Area G-3 Gate	1758458.7	500850.0
37. Area G-4 H_2O Tank	1756065.1	505642.7

Table D-14. (Cont.)

Station		New Mexico State Plane Coordinates Northing	Easting
Area G TRU Waste Inspectable Storage Program			
43.	Area G/S of Dome	1757484.2	504240.4
44.	Area G/S Perimeter	1757408.6	504638.2
45.	Area G/SE Perimeter	1757359.2	504855.1
46.	Area G/E Perimeter	1757627.8	504893.9
47.	Area G/N Perimeter	1757947.9	505612.4
TA-21 Decontamination and Decommissioning Project			
71.	TA-21-01	1774879.3	491782.3
72.	TA-21-02	1774815.7	492045.3
73.	TA-21-03	1774682.8	492390.2
74.	TA-21-04	1774133.2	491841.1
75.	TA-21-05	1773984.0	492259.9
Pueblo Stations			
41.	San Ildefonso	1780214.9	538094.3
42.	Taos Pueblo	1971428.7	703170.0
48.	Jemez Pueblo	1503337.0	356323.6

[a]See Figure V-9 for station locations.

Table D-15. Locations of Surface Water Sampling Stations[a]

Station	Latitude or Northing Coordinate[b]	Longitude or Easting Coordinate[b]	Map Designation[a]
OFF-SITE STATIONS			
REGIONAL STATIONS			
Rio Chama at Chamita	30°05″	106°07″	Chamita
Rio Grande at Embudo	36°12″	105°58″	Embudo
Rio Grande at Otowi	1 773 000	532 300	Otowi
Rio Grande at Cochiti	35°37″	106°19″	Cochiti
Rio Grande at Bernalillo	35°17″	106°36″	Bernalillo
Jemez River	35°40″	106°44″	Jemez
PERIMETER STATIONS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyons			
Acid Weir	1 778 741	484 214[b1]	49
Pueblo 1	1 778 817	484 165[b1]	50
Pueblo 2	1 776 803	495 013[b1]	51
Los Alamos Canyon			
Los Alamos at Rio Grande	1 773 000	532 300[b2]	3
Other Areas			
Guaje Canyon	1 794 000	471 600[b2]	8
Los Alamos Reservoir	1 777 200	468 600[b2]	7
Mortandad at Rio Grande	1 756 595	523 638[b3]	38
Pajarito at Rio Grande	1 747 532	516 715[b3]	35
Frijoles at Park Headquarters	1 737 929	494,140[b3]	9
Frijoles at Rio Grande	1 729 494	499 198[b3]	37
ON-SITE STATIONS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyons			
Pueblo 3	1 774 826	506 429[b1]	52
Pueblo at SR 502	1 771 862	512 695[b1]	S27
DP—Los Alamos Canyons			
DPS-1	1 774 796	493 081[b1]	57
DPS-4	1 773 228	497 258[b1]	58
Mortandad Canyon			
GS-1	1 770 230	486 502[b1]	68
Other Areas			
Cañada del Buey	1 766 666	491 631[b1]	46
Pajarito Canyon	1 759 676	497 730	47
Water Canyon at Beta	1 757 513	485 058	48
Sandia Canyon			
SCS-1	1 773 872	480 978[b1]	65
SCS-2	1 771 081	492 581[b1]	66
SCS-3	1 770 207	495 655[b1]	67
Ancho at Rio Grande	1 735 497	509 307[b3]	36

[a]Off-site regional surface water sampling locations are shown in Figure V-12; off-site perimeter and on-site sampling locations are given in Figure V-I3.
[b]New Mexico State Plane Coordinates, NAD27.
[b1]Coordinate measured by professional land surveyor.
[b2]Coordinate measured by Global Positioning System (GPS) instrument, estimated accuracy ±2 to 5 m.
[b3]Coordinate scaled from map, estimated accuracy ±100 m.

Table D-16. Locations of Sediment Sampling Stations

Station	Latitude or Northing Coordinate	Longitude or Easting Coordinate	Map Designation[a]
OFF-SITE STATIONS			
REGIONAL STATIONS			
Chamita[b]	36°05″	106°07″	Chamita
Embudo[b]	36°12″	106°58″	Embudo
Rio Grande at Otowi[b]	35°52″	106°08″	Otowi
Rio Grande at Sandia[c]	1758925	525014	Sandia
Rio Grande at Pajarito[c]	1747532	516715	Pajarito
Rio Grande at Water[c]	1741139	514154	Water
Rio Grande at Ancho[c]	1735497	509307	Ancho
Rio Grande at Frijoles[c]	1729494	499198	Frijoles
Rio Grande at Cochiti[b]	35°37″	106°19″	Cochiti
Rio Grande at Bernalillo[b]	35°17″	106°36″	Bernalillo
Jemez River[b]	35°40″	106°44″	Jemez
PERIMETER STATIONS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyon			
Acid Weir[d]	1778741.5	484213.6	22
Pueblo 1[d]	1778817.4	484165.4	23
Pueblo 2[d]	1776802.8	495013.5	24
DP-Los Alamos Canyon			
Los Alamos at Totavi	1772357.9	519683.8	36
Los Alamos at LA-2[d]	1777157.0	526680.1	37
Los Alamos at Otowi	1774114.9	531709.9	38
Other Canyons			
Guaje at SR 502	1777366.5	525674,0	12
Bayo at SR 502	1774361.7	522361.8	13
Sandia at Rio Grande[c]	1758925	525014	Sandia
Cañada Ancha at Rio Grande	N/A[e]	N/A	Cañada Ancha
Pajarito at Rio Grande[c]	1747532	516715	Pajarito
Frijoles at National Monument Headquarters	1737929.3	494139.8	21
Frijoles at Rio Grande[c]	1729494	499198	Frijoles
Mortandad Canyon on San Ildefonso Pueblo Lands			
Mortandad A-6	N/A	N/A	A-6
Mortandad A-7	N/A	N/A	A-7
Mortandad A-8	N/A	N/A	A-8
Mortandad at SR 4 (A-9)[d]	1763782.7	509436.7	15
Mortandad A-10	N/A	N/A	A-10
Mortandad at Rio Grande (A-11)[b]	1756595	523638	Mortandad(A-11)

Table D-16. (Cont.)

Station	Latitude or Northing Coordinate	Longitude or Easting Coordinate	Map Designation[a]
ON-SITE STATIONS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyon			
Hamilton Bend Spring[d]	1775857.4	502232.8	25
Pueblo 3[d]	1774826.4	506425.0	26
Pueblo at SR 502[d]	1771862.0	512694.7	27
DP-Los Alamos Canyon			
DPS-1[d]	1774796.3	493080.9	28
DPS-4[d]	1773227.8	497258.4	29
Los Alamos at Bridge[d]	1775550.8	478015.5	30
Los Alamos at LAO-1[d]	1773884.4	489162.8	31
Los Alamos at GS-1[d]	1770827.3	507906.9	32
Los Alamos at LAO-3[d]	1773012.4	497803.4	33
Los Alamos at LAO-4.5[d]	1772073.7	503410.1	34
Los Alamos at SR 4[d]	1771473.8	511651.0	35
Mortandad Canyon			
Mortandad near CMR Building[d]	1772092.7	479491.8	39
Mortandad west of GS-1	N/A	N/A	40
Mortandad at GS-1[d]	1770229.5	486502.2	41
Mortandad at MCO-5[d]	1769482.7	492212.1	42
Mortandad at MCO-7[d]	1768419.6	494306.2	43
Mortandad at MCO-9[d]	1768309.1	497813.6	44
Mortandad at MCO-13 (A-5)[d]	1767168.7	501051.6	45
Other Canyons			
Sandia at SR 4[d]	1767568.8	507558.5	14
Cañada del Buey at SR 4[d]	1756281.4	511459.2	16
Pajarito at SR 4[d]	1754333.2	508284.8	17
Potrillo at SR 4[d]	1751097.4	505375.0	18
Fence at SR 4	1751220.5	505153.7	46
Water at SR 4[d]	1749965.7	500428.6	19
Indio at SR 4	1747798.3	501075.1	47
Ancho at SR 4	1741156.4	500015.5	20
Water at Rio Grande[c]	1741139	514154	Water
Ancho at Rio Grande[c]	1735497	509307	Ancho
Chaquehiu at Rio Grande[c]	1733012	502768	Chaquehui
Solid Radioactive Waste Management Areas			
Area G, TA-54[d]			
G-1	1757654.9	501645.5	G-1
G-2	1757160.7	502094.9	G-2
G-3	1756706.5	503162.6	G-3
G-4	1756643.1	503955.1	G-4
G-5	1756592.8	504153.1	G-5
G-6	1756494.6	504786.9	G-6

Table D-16. (Cont.)

Station	Latitude or Northing Coordinate	Longitude or Easting Coordinate	Map Designation[a]
Area G, TA-54[d] (Cont.)			
G-7	1757361.2	505155.7	G-7
G-8	1757539.2	506507.4	G-8
G-9	1758521.8	505236.2	G-9
Area AB, TA-49[d]			
AB-1	1775633.2	484290.4	AB-1
AB-2	1755169.0	485200.5	AB-2
AB-3	1755569.9	485238.6	AB-3
AB-4	1755640.2	486640.9	AB-4
AB-4A	1755773.2	486638.4	AB-4A
AB-5	1754799.9	485631.3	AB-5
AB-6	1754684.8	485643.4	AB-6
AB-7	1754417.4	485583.5	AB-7
AB-8	1754383.4	484698.5	AB-8
AB-9	1756396.7	488195.0	AB-9
AB-10	1754547.5	488279.6	AB-10
AB-11	1752019.9	488479.1	AB-11

[a]Sediment sampling locations in Figures V-15 and V-16.
[b]Latitude/Longitude data from US Geological Survey (USGS).
[c]Coordinate data from GPS, estimated accuracy ±2 to 5 m.
[d]Coordinate data from standard land survey.
[e]Not available.

Table D-17. Location and Description of Soil Sampling Stations

Station	Latitude or Northing Coordinate	Longitude or Easting Coordinate	Map Designation[a]	Description of Nearby LANL Contaminant Sources
Regional Soils[b]				
Rio Chama	36°05'	106°07'	Chamita	
Embudo	36°12'	105°58'	Embudo	
Otowi	35°52'	106°08'	Otowi	
Near Santa Cruz	35°59'	105°54'	Santa Cruz	
Cochiti	35°37'	106°19'	Cochiti	
Bernalillo	35°17'	106°36'	Bernalillo	
Jemez	35°40'	106°44'	Jemez	
Perimeter Soils[c]				
L.A. Sportsman Club	1788074.0	496249.0	S1	
North Mesa	1780010.3	490085.7	S2	
Near TA-8 (GT Site)	1771742.0	470821.0	S3	
Near TA-49	1752276.0	489350.8	S4	Inactive Waste Site
White Rock (east[c]	1758239.4	514872.4	S5	
Tsankawi	1768048.2	507740.9	S6	
On-Site Soils[c]				
TA-21 (DP Site)	1774927.1	491022.1	S7	Pu/Chem. Research
East of TA-53	1773526.6	486055.2	S8	LAMPF Accelerator
TA-50	1769486.5	486145.8	S9	Rad. Water Treatment
Two-Mile Mesa	1769432.4	476142.2	S10	Main Technical Area
East of TA-54	1757820.7	504918.6	S11	Rad. Disposal Site
R-Site Road East	1761861.2	485618.9	S12	PHERMEX Accelerator
Potrillo Drive	1751838.6	490581.7	S13	HE Detonation
S-Site (TA-16)	1759266.8	478624.5	S14	HE Res.; ^{3}H Facility
Near Test Well DT-9	1752276.0	489350.8	S15	Inactive Waste Site
Near TA-33	1740744.1	498243.9	S16	Ex ^{3}H Facility

[a]Soil sampling locations are given in Figures V-15 and V-19.
[b]Latitude/Longitude data from USGS.
[c]Coordinate data from standard land survey.

Table D-18. Locations of Groundwater Sampling Stations

Station[a]	Northing Coordinate	Easting Coordinate
MAIN AQUIFER ON SITE		
Test Wells		
Test Well 1	1772014.8[b]	509797.3
Test Well 3	1773076.0	497483.2
Test Well 8	1769444.5	492329.6
Test Well DT-5A	1754923.5	485098.3
Test Well DT-9	1752318.4	489300.0
Test Well DT-10	1755228.5	488780.9
Water Supply Wells		
Well PM-1	1768050.0	507490.1
Well PM-2	1760264.0	496542.0
Well PM-3	1769364.0	502386.8
Well PM-4	1764612.0	495472.4
Well PM-5	1767747.0	492839.0
Well O-4	1772933	497093
MAIN AQUIFER OFF SITE		
Test Wells		
Test Well 2	1777205.8	493986.9
Test Well 4	1777618	483783.9
Water Supply Wells		
Well G-1A	1784291.0	514996.6
Well G-2	1785061.0	513966.2
Well G-3	1786156.0	511432.1
Well G-5	1787845.0	506705.3
MAIN AQUIFER SPRINGS		
White Rock Canyon Springs		
Group I		
Sandia Spring[c]	1761428	522938
Spring 3[c]	1753500	521243
Spring 3A[c]	1753236	521276
Spring 3AA[c]	1750988	521047
Spring 4[c]	1747825	515784
Spring 4A[b]	1747800	515900
Spring 5[c]	1742479	515812
Spring 5AA[b]	1742500	510900
Ancho Spring[b]	1739900	505400
Group II		
Spring 5A[c]	1741943	515121
Spring 5B[b]	1738100	510800
Spring 6[c]	1735455	508638
Spring 6A[c]	1734210	506318
Spring 7[b]	1733500	504800
Spring 8[b]	1733400	504200
Spring 8A[c]	1733446	503574
Spring 8B[b]	1733500	503000
Spring 9[c]	1733255	503191

Table D-18. (Cont.)

Station	Northing Coordinate	Easting Coordinate
Group II (Cont.)		
Spring 9A[c]	1733085	502498
Doe Spring[c]	1733536	502081
Spring 10[c]	1728100	497779
Group III		
Spring 1[c]	1767795	527684
Spring 2[c]	1766286	527068
Group IV		
La Mesita Spring[b]	1770700	516300
Spring 2A[b]	1754800	522400
Spring 3B[c]	1749752	521110
Other Springs		
Sacred Spring[b]	1780300	529800
Indian Spring[b]	1777200	525700
ALLUVIAL CANYON AQUIFERS		
DP-Los Alamos Canyons		
LAO-C	1775187.8	481913.6
LAO-1	1773894.3	489150.7
LAO-2	1773033.8	497363.4
LAO-3	1773036.3	497766.3
LAO-4	1772667.4	500507.7
LAO-4.5	1772025.6	503414.8
Mortandad Canyon		
MCO-3	1770174.7	487118.3
MCO-4	1769725.8	490970.1
MCO-5	1769475.9	492221.9
MCO-6	1768950.7	493391.1
MCO-7	1768447.8	494273.6
MCO-7.5	1768378.4	495210.6
Pajarito Canyon		
PCO-1	1759928.6	497675.1
PCO-2	1757380.8	501456.2
PCO-3	1755427.3	505844.4
Acid-Pueblo Canyons		
APCO-1	1772957.9	508965.3
Cañada del Buey		
CDBO-6	1764698	495965
CDBO-7	1763239	497156
PERCHED SYSTEM IN CONGLOMERATES AND BASALT		
Test Well 1A	1772003.7	509812.7
Test Well 2A	1777226.0	493940.6
Basalt Spring[b]	1770700	516300
PERCHED AQUIFER IN VOLCANICS		
Water Canyon Gallery[b]	1762500	463900

Table D-18. (Cont.)

Station	Northing Coordinate	Easting Coordinate
SAN ILDEFONSO WELLS		
Well LA-1B	1776890.0	528003.5
Well LA-2	1777157.0	526680.1
Well LA-5	1772471.0	519582.1
Westside Artesian Well	N/A[d]	N/A
Halladay Welll	N/A	N/A
Pajarito Well (Pump 1)	N/A	N/A
Eastside Artesian Well	N/A	N/A
Don Juan Playhouse Well	N/A	N/A

[a]See Figure VII-1 for locations of springs and deep wells, Figure VII-2 for alluvial observation wells, and Figure IV-9 for Pueblo of San Ildefonso wells.
[b]Not available.
[c]Coordinates estimated from USGS quadrangle map.
[d]Coordinate data from GPS, estimated accuracy ±2 to 5 m.

Table D-19. Locations of Beehives[a]

Station	Northing[b]	Easting[b]
OFF-SITE STATIONS, UNCONTROLLED AREAS		
Regional (28–44 km)		
San Pedro	1809664.111	554217.954
Pojoaque	1783159.441	568681.063
San Juan	1839089.577	548510.294
Perimeter (0–4 km)		
P1. Northern Los Alamos County		
P2. TA-36 (White Rock/ Pajarito Acres)	1755631.839	506042.806
ON-SITE STATIONS, CONTROLLED AREAS		
2. TA-5	1768416.067	494776.600
3. TA-8	1768539.659	469339.373
4. TA-9	1765971.113	472725.585
5. TA-15	1763387.514	487418.827
6. TA-16	1758766.096	468362.902
7. TA-21	1774400.589	493945.945
8. TA-33	1740570.164	498738.650
10. TA-49	1751354.820	485772.089
11. TA-50	1770129.362	485363.401
12. TA-53	1770340.109	499720.283
13. TA-54	1757000.077	503475.736

[a]Approximate locations of off-site regional beehives are presented in Figure V-20; on-site beehives are presented in Figure V-21.
[b]New Mexico State Plane Coordinates.

Table D-20. Dose Conversion Factors for Calculating Internal Doses[a]

Inhalation

Radionuclide	EDE (rem/μCi Intake)
^{3}H	6.3×10^{-5}
^{234}U	1.3×10^{2}
^{235}U	1.2×10^{2}
^{238}U	1.2×10^{2}
^{238}Pu	4.6×10^{2}
$^{239,240}Pu$	5.1×10^{2}
^{241}Am	5.2×10^{2}

Ingestion

Radionuclide	EDE (rem/μCi Intake)
^{3}H	6.3×10^{-5}
^{7}Be	1.1×10^{-4}
^{90}Sr	1.3×10^{-1}
^{137}Cs	5.0×10^{-2}
^{234}U	2.6×10^{-1}
^{235}U	2.5×10^{-1}
^{238}U	2.3×10^{-1}
^{238}Pu	3.8
$^{239,240}Pu$	4.3
^{241}Am	4.5

[a]Dose conversion factors taken from DOE 1988b.

Table D-21. Dose Conversion Factors for Calculating External Doses

Radionuclide[a]	EDE ([mrem/yr]/[μCi/m^3])
^{10}C[b]	8,830
^{11}C	5,110
^{13}N	5,110
^{16}N	29,300
^{14}O[b]	18,900
^{15}O	5,120
^{41}A	6,630

[a]Dose conversion factors taken from DOE 1988c.

[b]Dose conversion factors for ^{10}C and ^{14}O were not given in DOE 1988c and were calculated with the computer program DOSFACTER II (Kocher 1981).

Table D-22. Table of Contents 1993 Procedures Notebook

INDEX NUMBER	PROCEDURE NUMBER	TITLE
1	HS-9-RAEM-QP-01, R1	Radioactive Air Emission Management Group Document Control Procedure
2	HS-9-RAEM-QP-02, R1	HS-9 Radioactive Air Emission Management Design Control Procedures
3	HS-9-RAEM-QP-03, R1	HS-9 Radioactive Air Emission Management Program Records Control Procedure
4	HS-9-RAEM-QP-04, R1	HS-9 Radioactive Air Emission Management Training and Certification Procedures
5	HS-9-RAEM-QP-05, R0	HS-9 Radioactive Air Emission Management for Test Control Procedure
6	HS-9-RAEM-QP-06, R1	HS-9 Radioactive Air Emission Management QA Procedures for Control and Reporting of Nonconformance
7	HS-9-RAEM-QP-07, R1	HS-9 Radioactive Air Emission Management Procurement Procedure
8	HS-9-RAEM-QP-08, R1	HS-9 Radioactive Air Emission Management Procedures for Corrective Action
9	HS-9-RAEM-QP-09, R1	HS-9 Radioactive Air Emission Management Operating Group Audits
10	HS-DO-RAEM-DP-10, R0	Representative Sampling and Monitoring of Airborne Radioactive Effluent at LANL
11	HS-9-RAEM-QP-11, R1	HS-9 Radioactive Air Emission Management for Logbook Use and Control
12	HS-9-RAEM-QP-12, R0	HS-9 Radioactive Air Emission Management Change Notification
13	HS-9-RAEM-QP-13, R0	Compiling Radioactive Air Emission Data
14	HS-9-RAEM-QP-14, R0	Validating Radioactive Air Emissions Data
15	HS-9-RAEM-STD-15, R0	Requirements for Radioactive Air Emissions Data
16	HS-DO-RAEM-DP-16, R0	Chain-of-Custody for Radioactive Samples
17	HS-9-RAEM-STD-15, R0	LAMPF Compliance with Laboratory Radioactive Air Emission Limit
18	HS-1/TA-53 STACK DP-001, R0	Detailed Procedure for Filter Media Exchange on Monitored Stacks at TA-53
19	HS-1/TA-53 STACK DP-002, R0	Detailed Procedure for the Tritium Sample Exchange on Monitored Stack at TA-53
20	HS-1/TA-53 STACK DP-003	Detailed Procedure for Calibrating the High-Purity Germanium System used on the Monitored Stacks at TA-53

Table D-22. (Cont.)

INDEX NUMBER	PROCEDURE NUMBER	TITLE
21	HS-1/TA-53 STACK DP-004	Detailed Procedures for Performance Testing of the Kanne Air Flow-Through Ion Chambers used on the Monitored Stacks at TA-53
22	HS-1/TA-53 STACK DP-005	Detailed Procedures for Determining the Isotopic Composition of the Gaseous Effluent on the Monitored Stacks at TA-53
23	HS-1/TA-53 STACK DP-006	Detailed Procedures for Data Reduction and Reporting of the Monitored Stacks at TA-53
24	HS-1/TA-53 STACK DP-007, R0	HS-9 Radioactive Air Emissions Management Daily surveys of Air Monitoring Equipment
25	HS-12-RAEM-DP-06,R1	Calibration Procedure for Magnehelic Gauges
26	MP-7-OP-9-1.01	Procedure for Calibration of LAMPF Stack Flow Rate and Pressure Monitoring Equipment
27	MP-7-OP-9-2.01	Procedure for Building, Testing, and Filling LAMPF Gamma Cans
28	MP-7-OP-9-3.01	Procedure in the Event the LAMPF Main Stack Run Permit Interlock Fails
29	MP-7-OP-9-4.01	Procedure for Verifying Proper Operation of the LAMPF Stack Monitoring System
30	MP-7-OP-9-5.01	Procedure for Leak Checking Sample Lines at LAMPF Stacks
31	**RESERVED**	(TA-53 Procedure MP-7-OP-9-6.00 Procedure for 511 Kev Gamma Counting at LAMPF Stack FE-3)
32	SCL-CP-0001	Calibration Procedure for Dwyer Magnehelic Pressure Gauge with Pitot Tube
33	HS-4-ICS-QP-02, R2	Instrumentation and Calibration Section Instrument Recall and Issue Procedure
34	HS-4-HPAL-DP-04, R2	Detailed Procedure for Gamma Spectroscopy of LAMPF Stack Filters and Water Samples
35	HS-4-HPAL-DP-14, R0	HS-4 Detailed Procedure for Operation of the Impulse Alpha Analyses System
36	HS-4-HPAL-DP-15, R1	Procedure for Liquid Scintillation Analysis
37	ER 210	EM-9 Procedure: Tritium in Environmental Matrices—Distillation Procedure
38	MOI 41-30-009	JCI Procedure: Exhaust Stack (RAEMP) Air Flow Measurements
39	PM1 40-25-002	JCI Procedure: Exhaust Stack (RAEMP) Air Monitor System Maintenance, Repair and Installation
40	HS-9-RAEM-QP-19, R0	Certifying Radioactive Air Emission Data for Reports Submitted to EPA

Table D-23. Percentage of Incomplete Data in Met Data Set – TA-6, 1993

Total parameters = 1,556,725
Total incomplete = 29,698
Percentage incomplete = 1.907723

Parameter	Number Incomplete	Percentage of Total Incomplete
dir4	1617	5.444811
dir3	709	2.387366
dir2	709	2.387366
dir1	737	2.481649
sddir4	1617	5.444811
sddir3	709	2.387366
sddir2	709	2.387366
sddir1	737	2.481649
spd4	507	1.707186
spd3	495	1.666779
spd2	496	1.670146
spd1	565	1.902485
sdspd4	507	1.707186
sdspd3	495	1.666779
sdspd2	496	1.670146
sdspd1	565	1.902485
w4	627	2.111253
w3	611	2.057378
w2	611	2.057378
w1	534	1.798101
sdw4	627	2.111253
sdw3	611	2.057378
sdw2	611	2.057378
sdw1	534	1.798101
temp4	489	1.646576
temp3	488	1.643208
temp2	488	1.643208
temp1	488	1.643208
t0	441	1.484948
tss	441	1.484948
td0	441	1.484948
rh	441	1.484948
insol	441	1.484948
refins	441	1.484948
netrad	492	1.656677
inlw15	441	1.484948
outlw15	442	1.488316
press	449	1.511886
precip	443	1.491683
qhflux	2416	8.135228
qeflux	1337	4.501987
qgflux	1483	4.993602
u2flux	733	2.46818

Table D-23. (Cont.)

Parameter	Number Incomplete	Percentage of Total Incomplete
avespd4	17	0.057243
maxgust4	6	0.020203
dirgust4	12	0.040407
timegst4	6	0.020203
avespd3	17	0.057243
maxgust3	6	0.020203
dirgust3	6	0.020203
timegst3	6	0.020203
avespd2	17	0.057243
maxgust2	6	0.020203
dirgust2	6	0.020203
timegst2	6	0.020203
avespd1	17	0.057243
maxgust1	7	0.023571
dirgust1	8	0.026938
timegst1	7	0.023571
maxtmp	6	0.020203
tmaxtmp	6	0.020203
mintmp	8	0.026938
tmintmp	8	0.026938
td1avg	0	0
td0max	8	0.026938
td0min	9	0.030305
td0avg	8	0.026938
maxrh	8	0.026938
minrh	6	0.020203
averh	8	0.026938
tinsol	36	0.12122
trefin	9	0.030305
tnetrad	16	0.053876
inlw24	8	0.026938
outlw24	8	0.026938
tqhflx	42	0.141424
tqeflx	25	0.084181
tqgflx	13	0.043774
maxpres	9	0.030305
minpres	11	0.03704
max1gs	7	0.023571
dir1gs	7	0.023571
tim1gs	6	0.020203
totprec	5	0.016836

Table D-24. Volatile Organic Compounds in Water Determined by PAT[a] Analyses

Compound	CAS[b] #	Representative Limit of Quantification[c] (µg/L)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,2-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-2	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
Vinyl acetate	108-05-4	10
2-Butanone	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
1-Chlorohexane	544-10-5	5
Ethylbenzene	100-41-4	5
m,p-Xylene (total)	108-38-3 + 106-42-3	5
o-Xylene	95-47-6	5
Styrene	100-42-5	5

Table D-24. (Cont.)

Compound	CAS[b] #	Representative Limit of Quantification[c] (µg/L)
1,1,2,2-Tetrachloroethane	79-34-5	5
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	95-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
1,2,4-Trichlorobenzene	120-82-1	N/A
Naphthalene	91-20-3	N/A
1,2,3-Trichlorobenzene	87-61-6	N/A
Hexachlorobutadiene	87-68-3	N/A
Dichlorodifluoromethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5
2-Chloroethylvinylether	110-75-8	50
Acrylonitrile	107-13-1	100
Acrolein	107-02-8	100

[a]Purge-and-trap gas chromatography/mass spectrometry.
[b]Chemical abstract service.
[c]Column: Supelco SPB-5 60 m × 0.25 mm × 1.0 µm. Limits of detection estimated by minimum signal required to yield identifiable mass spectral scan.

Table D-25. Volatile Organic Compounds in Solids Determined by SW-846 Method 8260

Compound	CAS[a] #	Limit of Quantification[b] (mg/kg)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,5-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-4	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
Vinyl acetate	108-05-4	10
2-Butanone (MEK)	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone (MIK)	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
1-Chlorohexane	544-10-5	5
Ethylbenzene	100-41-4	5
Mixed Xylene (total)	1330-20-7	5
Styrene	100-42-5	5
1,1,2,2-Tetrachloroethane	79-34-5	5

Table D-25. (Cont.)

Compound	CAS[a] #	Limit of Quantification[b] (mg/kg)
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	98-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
1,2,4-Trichlorobenzene	120-82-1	N/A
Naphthalene	91-20-3	N/A
1,2,3-Trichlorobenzene	87-61-6	N/A
Hexachlorobutadiene	87-68-3	N/A
Dichlorodifluonomethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5
2-Chloroethylvinylether	110-75-8	50
Acrylonitrile	107-13-1	100
Acrolein	107-02-8	100

[a]Chemical abstract service.

[b]Column: 60 m × 0.32 mm SPB-5 fused silica capillary, using a methanolic parti tion with purge and trap. Limits of quantification are calculated from the intercept of the external calibration curve using a flame-ionization detector.

Table D-26. Semivolatile Organics in Water

Compound	CAS[a] #	Limit of Quantification (µg/L)
N-Nitrosodimethylamine	62-75-9	10
Aniline	62-55-3	10
Phenol	108-95-2	10
bis(-2-Chloroethyl)ether	111-44-4	10
2-Chlorophenol	95-57-8	10
1,3-Dichlorobenzene	541-73-1	10
1,4-Dichlorobenzene	106-46-7	10
Benzyl alcohol	100-51-6	10
1,2-Dichlorobenzene	95-50-1	10
2-Methylphenol	95-48-7	10
bis(2-Chloroisopropyl)ether	39638-32-9	10
4-Methylphenol	106-44-5	10
N-Nitroso-di-*n*-propylamine	621-64-7	10
Hexachloroethane	67-72-1	10
Nitrobenzene	98-95-3	10
Isophorone	78-59-1	10
2-Nitrophenol	88-75-5	10
2,4-Dimethylphenol	105-67-9	10
Benzoid acid	65-85-0	10
bis(-2-Chloroethoxy)methane	111-91-1	10
2,4-Dichlorophenol	120-83-2	10
1,2,4-Trichlorobenzene	120-82-1	10
Naphthalene	91-20-3	10
4-Chloroaniline	106-47-8	10
Hexachlorobutadiene	87-68-3	10
4-Chloro-3-methylphenol	59-50-7	10
2-Methylnaphthalene	91-57-6	10
Hexachlorocyclopentadiene	77-47-4	10
2,4,6-Trichlorophenol	88-06-2	10
2,4,5-Trichlorophenol	95-95-4	10
2-Chloronaphthalene	91-58-7	10
2-Nitroaniline	88-74-4	10
Dimethyl phthalate	131-11-3	10
Acenaphthylene	208-96-8	10
3-Nitroaniline	99-09-2	10
Acenaphthene	83-32-9	10
2,4-Dinitrophenol	51-28-5	10
4-Nitrophenol	100-02-7	10
Dibenzofuran	132-64-9	10
2,4-Dinitrotoluene	121-14-2	10
2,6-Dinitrotoluene	606-20-2	10
Diethylphthalate	84-66-2	10
4-Chlorophenyl-phenylether	7005-72-3	10
Fluorene	86-73-7	10
4-Nitroaniline	100-01-6	10
4,6-Dinitro-2-methylphenol	534-52-1	10
N-Nitrosodiphenylamine	86-30-6	10

Table D-26. (Cont.)

Compound	CAS #	Limit of Quantification (µg/L)
Azobenzene	103-33-3	10
4-Bromophenyl-phenylether	101-55-3	10
Hexachlorobenzene	118-74-1	10
Pentachlorophenol	87-86-5	10
Phenanthrene	85-01-8	10
Anthracene	120-12-7	10
Di-*n*-butylphthalate	84-74-2	10
Fluoranthene	206-44-0	10
Benzidine	92-87-5	10
Pyrene	129-00-0	10
Butylbenzylphthalate	85-68-7	10
3,3'-Dichlorobenzidine	91-94-1	10
Benzo(*a*)anthracene	56-55-3	10
bis(2-Ethylhexyl)phthalate	117-81-7	10
Chrysene	218-01-9	10
Di-*n*-octyl phthalate	117-84-0	10
Benzo(*b*)fluoranthene	205-99-2	10
Benzo(*k*)fluoranthene	207-08-9	10
Benzo(*a*)pyrene	50-32-8	10
Indeno(1,2,3-*cd*)pyrene	193-39-5	10
Dibenzo(*a,h*)anthracene	53-70-3	10
Benzo(*g,h,i*)perylene	191-24-2	10

[a]Chemical abstract service.

Table D-27. Volatiles Determined in Air (Pore Gas) – Thermal Desorption

Compound	CAS[a] #	Limit of Quantification[b] (μg/L)
Dichlorodifluoromethane	75-71-8	1.0
Chloromethane	74-87-3	1.0
Vinyl chloride	75-01-4	1.0
Bromomethane	74-83-9	1.0
Chloroethane	75-00-3	1.0
Trichlorofluoromethane	75-69-4	1.0
1,1-Dichloroethene	75-35-4	1.0
Acetone	67-64-1	1.0
Trichlorotrifluoroethane	76-13-1	1.0
Carbon disulfide	75-15-0	1.0
Methylene chloride	75-09-2	1.0
t-1,2-Dichloroethene	156-60-5	1.0
1,1-Dichloroethane	75-34-3	1.0
2-Butanone	78-93-3	1.0
c-1,2-Dichloroethene	156-59-2	1.0
Bromochloromethane	74-97-5	1.0
Chloroform	67-66-3	1.0
1,1,1-Trichloroethane	71-55-6	1.0
1,1-Dichloropropene	563-58-6	1.0
Carbon tetrachloride	56-23-5	1.0
1,2-Dichloroethane	107-06-2	1.0
Benzene	71-43-2	1.0
1,2-Dichloropropane	78-87-5	1.0
c-1,3-Dichloropropene	1006-10-15	1.0
Trichloroethene	79-01-6	1.0
Dibromomethane	74-95-3	1.0
Bromodichloromethane	75-27-4	1.0
4-Methyl-2-pentanone	10-81-1	1.0
Toluene	108-88-3	1.0
t-1,3-Dichloropropene	1006-10-26	1.0
1,1,2-Trichloroethane	79-00-5	1.0
2-Hexanone	59-17-86	1.0
Tetrachloroethene	127-18-4	1.0
Chlorodibromomethane	124-48-1	1.0
Chlorobenzene	108-90-7	1.0
1,1,1,2-Tetrachloroethane	630-20-6	1.0
Ethylbenzene	100-41-4	1.0
o,m,p-Xylene (total)	133-02-7	1.0
Styrene	100-42-5	1.0
Bromoform	75-25-2	1.0
1,1,2,2-Tetrachloroethane	79-34-5	1.0
Bromobenzene	108-86-1	1.0
n-Propylbenzene	103-65-1	1.0
1,3,5-Trimethylbenzene	108-67-8	2.0
1,2,4-Trimethylbenzene	95-63-6	2.0
1,3-Dichlorobenzene	541-73-1	1.0
1,4-Dichlorobenzene	106-46-7	1.0
1,2-Dichlorobenzene	95-50-1	1.0

[a]Chemical abstract service.
[b]Assuming a 0.5 L sample volume.

Table D-28. Toxicity Characteristic Leaching Procedure Target Organic Contaminants

Contaminant	Regulatory Level (mg/L)
Compound	
Acrylonitrile	5.0
Benzene	0.07
Carbon disulfide	14.4
Carbon tetachloride	0.07
Chlorobenzene	1.4
Chloroform	0.07
1,2-Dichloroethane	0.04
1,1-Dichlorethylene	0.1
Isobutanol	25
Methylene chloride	8.6
Methyethyl ketone	7.2
1,1,1,2-Tetachloroethane	10.0
1,1,2,2-Tetachloroethane	1.3
Tetachloroethylene	0.1
Toluene	14.4
1,1,1-Trichloroethane	25
1,1,2-Trichloroethane	1.2
Trichloroethylene	0.07
Vinyl chloride	0.05
o-Cresol	10.0
m-Cresol	10.0
p-Cresol	10.0
Pentachlorophenol	3.6
Phenol	14.4
2,3,4,6-Tetachlorophenol	1.5
2,4,5-Trichlorophenol	5.8
2,4,6-Trichlorophenol	0.30
Bis(2-chloroethyl)ether	0.05
1,2-Dichlorobenzene	4.3
1,4-Dichlorobenzene	10.8
2,4-Dinitrotoluene	0.13
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.72
Hexachloroethane	4.3
Nitrobenzene	0.13
Pyridine	5.0
Heptachlor	0.001
Insecticides	
Endrin	0.003
Lindane(γ-BHC)	0.06
Methoxychlor	1.4
Toxaphene	0.07
Herbicides	
2,4-D	1.4
2,3,5-TP (Silvex)	0.14

Table D-29. Summary of EM-9 Quality Assurance Tests for 1993 (Stable Element Analyses)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Biological Materials					
B	1	100	—	—	0.86
Bulk Materials					
Ag	1	—	—	100	blank
As	1	—	100	—	blank
Ba	1	—	—	100	2.88
Cd	1	—	—	100	2.09
Cr	1	—	—	100	2.30
Flashpoint	1	100	—	—	1.07
Hg	1	100	—	—	0.76
Pb	1	—	—	100	0.22
Se	1	—	—	100	38.10
Filters					
Be	16	75	19	6	1.07 ± 0.18
Silicate Materials					
Al	7	71	29	—	0.77 ± 0.15
As	23	91	9	—	1.19 ± 0.30
B	2	100	—	—	0.90
Ba	17	76	12	12	0.72 ± 0.20
Be	21	81	14	5	0.93 ± 0.38
Cd	13	100	—	—	1.38 ± 0.54
Co	3	100	—	—	0.98 ± 0.07
Cr	19	95	5	—	0.92 ± 0.14
Cu	6	100	—	—	0.85 ± 0.13
Fe	7	100	—	—	0.87 ± 0.06
Ga	4	—	—	100	0.42 ± 0.05
H_2O (unbound water)	8	100	—	—	0.94 ± 0.07
Hg	31	77	13	10	0.84 ± 0.29
Mn	2	100	—	—	0.93
Mo	1	100	—	—	1.05
Ni	14	100	—	—	0.80 ± 0.13
Pb	27	70	26	4	0.76 ± 0.24
Sb	13	100	—	—	18.58
Se	4	50	—	50	20.59 ± 8.66
Sr	1	100	—	—	1.00
Th	4	25	50	25	0.73 ± 0.15
V	2	100	—	—	0.95
Zn	2	100	—	—	0.93
Water					
Ag	224	82	2	16	1.04 ± 0.84
Al	82	96	1	2	0.99 ± 0.09
As	306	97	1	2	1.02 ± 0.14
B	80	85	8	8	0.91 ± 0.12
Ba	243	91	3	6	1.05 ± 0.36

Table D-29. (Cont.)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Water (Cont.)					
Be	246	93	3	4	1.00 ± 0.19
Br	1	—	—	100	0.46
Ca	50	96	4	—	1.05 ± 0.11
Cd	248	94	2	4	0.99 ± 0.16
Cl	93	100	—	—	0.93 ± 0.04
CN	2	50	—	50	0.73
Co	84	96	4	—	0.94 ± 0.08
COD	3	100	—	—	0.93 ± 0.03
Conductivity	55	91	9	—	0.94 ± 0.05
Cr	257	95	2	3	0.99 ± 0.16
Cu	117	96	3	2	1.03 ± 0.12
F	58	98	2	—	1.01 ± 0.07
Fe	74	99	—	1	1.04 ± 0.14
Ga	5	100	—	—	1.07 ± 0.10
Hardness	25	92	8	—	1.01 ± 0.10
Hg	166	99	—	1	1.00 ± 0.10
K	43	95	—	5	0.99 ± 0.13
Li	62	97	2	2	0.98 ± 0.10
Mg	51	96	4	—	1.00 ± 0.09
Mn	98	95	4	1	1.03 ± 0.14
Mo	98	87	9	4	1.28 ± 1.95
Na	47	96	4	—	1.02 ± 0.11
NH_3-N (Ammonia Nitrogen)	4	75	25	—	0.89 ± 0.10
Ni	194	94	3	3	1.00 ± 0.15
NO_3-N (Nitrate Nitrogen)	71	100	—	—	1.02 ± 0.04
Oil and Grease	9	100	—	—	0.92 ± 0.07
P	2	100	—	—	1.00
Pb	283	92	4	4	1.04 ± 0.24
pH	60	100	—	—	1.01 ± 0.01
PO_4-P (Phosphate Phosphorus)	49	98	2	—	0.98 ± 0.22
Sb	140	81	9	10	0.94 ± 0.20
Se	304	98	1	1	1.00 ± 0.11
SiO_2	58	100	—	—	1.10 ± 0.22
Sn	54	89	6	6	3.36 ± 15.40
SO_4	68	100	—	—	0.91 ± 0.03
Sr	82	100	—	—	1.06 ± 0.07
Total Alkalinity	49	100	—	—	1.08 ± 0.06
TDS (total dissolved solids)	62	98	2	—	0.94 ± 0.08
Th	4	100	—	—	1.16 ± 0.04
Ti	5	100	—	—	1.16 ± 0.04
Total Kjeldahl Nitrogen	2	100	—	—	1.02

Table D-29. (Cont.)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Water (Cont.)					
Tl	167	92	5	2	1.06 ± 0.22
TSS (total suspended solids)	13	100	—	—	0.93 ± 0.04
V	98	95	3	2	1.02 ± 0.23
Zn	107	93	5	2	1.01 ± 0.19

Table D-30. Summary of EM-9 Quality Assurance Tests for 1993 (Radiochemical Analyses)

Matrix	Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Biologicals						
	^{137}Cs	14	79	21	—	0.82 ± 0.20
	^{238}Pu	13	100	—	—	0.97 ± 0.06
	^{239}Pu	13	69	15	15	0.99 ± 0.04
	^{90}Sr	11	91	—	9	0.99 ± 0.17
	U	7	100	—	—	1.02 ± 0.11
	^{235}U	1	100	—	—	blank
	^{238}U	1	100	—	—	1.31
Filters						
	Alpha	158	100	—	—	0.86 ± 0.10
	^{241}Am	16	75	19	6	0.88 ± 0.07
	Beta	155	98	2	—	0.93 ± 0.06
	^{238}Pu	19	100	—	—	1.03 ± 0.07
	^{239}Pu	19	84	16	—	1.06 ± 0.07
	^{234}U	13	85	8	8	1.02 ± 0.07
	^{235}U	13	100	—	—	1.10 ± 0.33
	^{235}U	13	92	—	8	1.07 ± 0.06
Silicate Materials						
	Alpha	8	100	—	—	1.19 ± 0.26
	^{241}Am	18	83	17	—	1.29 ± 1.13
	Beta	8	63	38	—	1.20 ± 0.27
	^{137}Cs	20	100	—	—	1.04 ± 0.23
	Gamma	32	100	—	—	0.87 ± 0.05
	^{3}H	21	48	24	29	1.00 ± 0.36
	^{238}Pu	31	87	6	6	0.97 ± 0.08
	^{239}Pu	30	70	10	20	1.07 ± 0.19
	^{90}Sr	11	64	18	18	0.93 ± 0.04
	U	26	65	15	19	0.96 ± 0.26
	^{234}U	7	71	29	—	0.96 ± 0.17
	^{235}U	7	57	29	14	0.66 ± 0.25
	^{238}U	7	86	—	14	1.03 ± 0.21
Water						
	Alpha	258	98	1	—	1.38 ± 0.19
	^{241}Am	10	100	—	—	0.44 ± 1.15
	Beta	256	98	1	1	1.08 ± 0.10
	^{137}Cs	68	82	15	3	1.24 ± 0.42
	Gamma	225	97	3	—	1.03 ± 0.10
	^{3}H	219	98	2	—	0.99 ± 0.11
	^{238}Pu	27	89	—	11	0.84 ± 0.36
	^{239}Pu	27	78	11	11	0.93 ± 0.36
	Ra	1	100	—	—	1.72
	^{226}Ra	1	100	—	—	1.02
	^{90}Sr	31	97	3	—	0.97 ± 0.05
	U	82	91	5	4	1.04 ± 0.14
	$^{235/238}U$	1	100	—	—	1.25
	^{238}U	2	100	—	—	1.09

Table D-31. Summary of EM-9 Quality Assurance Tests for 1993 (Organic Analyses)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Bulk Materials					
Mixed-Aroclor	89	73	11	16	0.81 ± 0.72
Aroclor 1242	88	91	5	5	0.99 ± 0.70
Aroclor 1254	88	91	1	8	0.70 ± 0.40
Aroclor 1260	88	90	6	5	0.58 ± 0.25
Charcoal Tubes					
Acetone	11	100	—	—	1.82 ± 0.30
Benzene	44	98	—	2	1.01 ± 0.23
Bromobenzene	44	98	—	2	0.91 ± 0.12
Bromochloromethane	11	45	—	55	blanks
Bromodichloromethane	11	100	—	—	blanks
Bromoform	11	100	—	—	blanks
Bromomethane	11	100	—	—	blanks
2-Butanone	11	73	—	27	0.30 ± 0.02
Carbon disulfide	11	100	—	—	1.10
Carbon tetrachloride	44	100	—	—	0.96 ± 0.14
Chlorobenzene	44	100	—	—	0.96 ± 0.09
Chlorodibromomethane	11	100	—	—	blanks
Chloroethane	11	100	—	—	blanks
Chloroform	44	91	2	7	0.82 ± 0.31
Chloromethane	11	100	—	—	blanks
Dibromomethane	11	55	—	45	0.32 ± 0.03
o-Dichlorobenzene (1,2)	11	100	—	—	blanks
m-Dichlorobenzene (1,3)	11	100	—	—	blanks
p-Dichlorobenzene (1,4)	11	100	—	—	blanks
Dichlorodifluoromethane	11	100	—	—	blanks
1,2-Dichloroethane	11	100	—	—	blanks
1,1-Dichloroethane	11	100	—	—	blanks
trans-1,2-Dichloroethene	11	100	—	—	blanks
1,1-Dichloroethene	11	100	—	—	blanks
cis-1,2-Dichloroethylene	11	100	—	—	blanks
1,2-Dichloropropane	11	100	—	—	blanks
trans-1,3-Dichloropropene	11	100	—	—	blanks
1,1-Dichloropropene	11	100	—	—	blanks
cis-1,3-Dichloropropene	11	100	—	—	blanks
Ethylbenzene	140	99	1	—	0.96 ± 0.22
2-Hexanone	11	100	—	—	0.80 ± 0.02
4-Methyl-2-pentanone	11	100	—	—	1.16 ± 0.24
Methylene chloride	11	73	9	18	2.03 ± 1.03
Propylbenzene	11	100	—	—	blanks
Styrene	11	73	—	27	1.03 ± 0.04
1,1,1,2-Tetrachloroethane	11	100	—	—	blanks
1,1,2,2-Tetrachloroethane	11	100	—	—	blanks
Tetrachloroethylene	44	98	—	2	0.99 ± 0.26
Toluene	44	100	—	—	1.03 ± 0.19

Table D-31. (Cont.)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Charcoal Tubes (Cont.)					
1,1,2-Trichloro-1,2,2-trifluoroethane	11	100	—	—	blanks
1,1,1-Trichloroethane	44	98	—	2	0.98 ± 0.26
1,1,2-Trichloroethane	11	91	—	9	0.64
Trichloroethene	44	100	—	—	0.97 ± 0.19
Trichlorofluoromethane	11	100	—	—	blanks
1,2,4-Trimethylbenzene	44	100	—	—	1.01 ± 0.13
1,3,5-Trimethylbenzene	11	100	—	—	blanks
Vinyl chloride	11	82	—	18	blanks
Mixed-Xylenes (*o* + *m* + *p*)	44	100	—	—	1.00 ± 0.10
Filters					
Mixed-Aroclor	14	86	7	7	0.96 ± 0.81
Aroclor 1242	14	93	—	7	0.68 ± 0.14
Aroclor 1254	14	100	—	—	3.47
Aroclor 1260	14	93	7	—	0.83 ± 0.45
Silicate Materials					
Acenaphthene	18	94	—[a]	6	0.51
Acenaphthylene	18	100	—	—	0.76 ± 0.07
Acetone	25	68	—	32	0.34 ± 0.09
Aniline	18	89	—	11	0.15
Anthracene	18	100	—	—	0.80 ± 0.09
Mixed-Aroclor	12	92	—	8	0.88 ± 0.29
Aroclor 1242	12	92	—	8	0.71 ± 0.20
Aroclor 1254	12	100	—	—	1.11 +/- 0.24
Aroclor 1260	12	100	—	—	blanks
Azobenzene	18	100	—	—	blanks
Benzene	25	100	—	—	1.23
m-Benzidine	18	100	—	—	blanks
Benzo[*a*]anthracene	18	100	—	—	blanks
Benzo[*a*]pyrene	18	100	—	—	blanks
Benzo[*b*]fluoranthene	18	100	—	—	0.77
Benzo[*g,h,i*]perylene	18	100	—	—	blanks
Benzo[*k*]fluoranthene	18	100	—	—	blanks
Benzoic acid	18	94	—	6	0.82
Benzyl alcohol	18	94	6	—	0.67 ± 0.07
Bis(2-chloroethoxy)methane	18	100	—	—	blanks
Bis(2-chloroethyl)ether	18	100	—	—	blanks
Bis(2-chloroisopropyl)ether	18	100	—	—	blanks
Bis(2-ethylhexyl)phthalate	18	100	—	—	blanks
Bromobenzene	25	100	—	—	0.91 ± 0.17
Bromochloromethane	25	100	—	—	1.21 ± 0.22
Bromodichloromethane	25	100	—	—	1.07 ± 0.17
Bromoform	25	100	—	—	1.09
Bromomethane	25	100	—	—	blanks
4-Bromophenylphenyl ether	18	100	—	—	0.72
2-Butanone	25	88	8	4	0.60 ± 0.14
Butyl benzyl phthalate	18	94	—	6	0.67

Table D-31. (Cont.)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Silicate Materials (Cont.)					
sec-Butylbenzene	25	100	—	—	1.07
n-Butylbenzene	25	100	—	—	blanks
tert-Butylbenzene	25	100	—	—	0.80 ± 0.09
Carbon disulfide	25	100	—	—	1.07 ± 0.09
Carbon tetrachloride	25	100	—	—	1.20 ± 0.18
4-Chloro-3-methylphenol	18	89	11	—	0.71 ± 0.12
4-Chloroaniline	18	67	—	33	0.31 ± 0.09
Chlorobenzene	25	100	—	—	0.97 ± 0.13
Chlorodibromomethane	25	100	—	—	blanks
Chloroethane	25	100	—	—	blanks
Chloroform	25	100	—	—	0.97 ± 0.13
Chloromethane	25	100	—	—	blanks
2-Chloronaphthalene	18	100	—	—	blanks
o-Chlorophenol	18	94	6	—	0.66
4-Chlorophenylphenyl ether	18	100	—	—	0.71
p-Chlorotoluene	25	100	—	—	0.80
o-Chlorotoluene	25	100	—	—	1.11 ± 0.08
Chrysene	18	100	—	—	0.75 ± 0.07
Di-*n*-butyl phthalate	18	83	6	11	0.81 ± 0.15
Di-*n*-octyl phthalate	18	100	—	—	blanks
Dibenzo[*a*,*h*]anthracene	18	100	—	—	blanks
Dibenzofuran	18	100	—	—	blanks
1,2-Dibromo-3-chloropropane	25	100	—	—	blanks
Dibromomethane	25	100	—	—	1.05
o-Dichlorobenzene (1,2)	43	93	2	5	0.71 ± 0.22
m-Dichlorobenzene (1,3)	43	86	7	7	0.53 ± 0.08
p-Dichlorobenzene (1,4)	43	95	5	—	0.70 ± 0.08
3,3'-Dichlorobenzidine	18	100	—	—	blanks
Dichlorodifluoromethane	25	100	—	—	blanks
1,2-Dichloroethane	25	100	—	—	blanks
1,1-Dichloroethane	25	100	—	—	1.28
trans-1,2-Dichloroethene	25	100	—	—	0.88 ± 0.10
1,1-Dichloroethene	25	100	—	—	blanks
cis-1,2-Dichloroethylene	25	100	—	—	0.90
2,4-Dichlorophenol	18	94	—	6	0.54
1,3-Dichloropropane	25	100	—	—	1.12
1,2-Dichloropropane	25	96	—	4	1.09
2,2-Dichloropropane	25	100	—	—	0.99 ± 0.14
1,1-Dichloropropene	25	100	—	—	blanks
trans-1,3-Dichloropropene	25	96	—	4	1.01
cis-1,3-Dichloropropene	25	96	—	4	25.00
Diethyl phthalate	18	94	—	6	0.60 ± 0.15
Dimethyl phthalate	18	100	—	—	blanks
2,4-Dimethylphenol	18	83	—	17	0.56 ± 0.14
2,4-Dinitrophenol	18	72	—	28	0.47 ± 0.22
2,4-Dinitrotoluene	18	100	—	—	0.68 ± 0.04

Table D-31. (Cont.)

Matrix . Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Silicate Materials (Cont.)					
2,6-Dinitrotoluene	18	100	—	—	0.67
Ethylbenzene	25	100	—	—	0.96 ± 0.10
Ethylene dibromide	25	100	—	—	1.20
Fluoranthene	18	94	6	—	0.70 ± 0.07
Fluorene	18	94	—	6	0.57
Hexachlorobenzene	18	100	—	—	blanks
Hexachlorobutadiene	18	100	—	—	blanks
Hexachlorocyclopentadiene	18	100	—	—	blanks
Hexachloroethane	18	72	11	17	0.55 ± 0.09
2-Hexanone	25	76	4	20	0.54 ± 0.13
Indeno[1,2,3-*cd*]pyrene	18	94	6	—	0.52
Isophorone	18	100	—	—	1.08
Isopropylbenzene	25	100	—	—	0.94 ± 0.11
4-Isopropyltoluene	25	96	—	4	0.97
Methyl iodide	25	100	—	—	blanks
4-Methyl-2-pentanone	25	100	—	—	1.08 ± 0.20
2-Methyl-4,6-dinitrophenol	18	100	—	—	blanks
Methylene chloride	25	100	—	—	1.00 ± 0.28
2-Methylnaphthalene	18	100	—	—	blanks
4-Methylphenol	18	100	—	—	blanks
2-Methylphenol	18	100	—	—	0.76 ± 0.07
Naphthalene	18	94	6	—	0.61
2-Nitroaniline	18	100	—	—	blanks
3-Nitroaniline	18	100	—	—	blanks
4-Nitroaniline	18	83	—	17	0.26 ± 0.08
Nitrobenzene	18	100	—	—	blanks
4-Nitrophenol	18	100	—	—	0.63
2-Nitrophenol	18	78	17	6	0.55 ± 0.05
N-Nitrosodi-*n*-propylamine	18	94	—	6	0.59
N-Nitrosodimethylamine	18	100	—	—	blanks
N-Nitrosodiphenylamine	18	94	—	6	0.60 ± 0.13
Pentachlorophenol	18	100	—	—	0.72 ± 0.03
Petroleum Hydrocarbons, Total Recoverable	8	100	—	—	1.09 ± 0.19
Phenanthrene	18	94	6	—	0.65
Phenol	18	100	—	—	0.71
Propylbenzene	25	96	4	—	0.76 ± 0.12
Pyrene	18	94	—	6	0.65 ± 0.21
Styrene	25	100	—	—	0.92 ± 0.07
1,1,2,2-Tetrachloroethane	25	100	—	—	0.98
1,1,1,2-Tetrachloroethane	25	100	—	—	1.13
Tetrachloroethylene	25	100	—	—	1.00 ± 0.08
Toluene	25	100	—	—	0.94 ± 0.10
1,1,2-Trichloro-1,2,2-trifluoroethane	25	100	—	—	blanks
1,2,4-Trichlorobenzene	18	100	—	—	blanks
1,1,2-Trichloroethane	25	100	—	—	0.82

Table D-31. (Cont.)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Silicate Materials (Cont.)					
1,1,1-Trichloroethane	25	100	—	—	blanks
Trichloroethene	25	96	—	4	1.03 ± 0.14
Trichlorofluoromethane	25	100	—	—	blanks
2,4,5-Trichlorophenol	18	94	6	—	0.63
2,4,6-Trichlorophenol	18	100	—	—	0.73
1,2,3-Trichloropropane	25	100	—	—	1.46
1,3,5-Trimethylbenzene	25	100	—	—	blanks
1,2,4-Trimethylbenzene	25	100	—	—	blanks
Vinyl acetate	17	59	—	41	0.39
Vinyl chloride	25	100	—	—	blanks
Mixed-Xylenes (*o* + *m* + *p*)	25	96	—	4	0.97 ± 0.21
Water					
Acenaphthene	8	75	13	13	0.57 ± 0.06
Acenaphthylene	8	100	—[a]	—	blanks
Acetone	21	71	5	24	0.62 ± 0.20
Aniline	8	100	—	—	blanks
Anthracene	8	75	13	13	0.60
Mixed-Aroclor	15	80	—	20	1.18 ± 1.27
Aroclor 1242	15	100	—	—	0.82
Aroclor 1254	15	93	—	7	1.27 ± 1.16
Aroclor 1260	15	87	—	13	1.22 ± 1.58
Azobenzene	8	100	—	—	blanks
Benzene	21	95	—	5	1.03
m-Benzidine	8	100	—	—	blanks
Benzo[*a*]anthracene	8	100	—	—	blanks
Benzo[*a*]pyrene	8	75	25	—	0.56
Benzo[*b*]fluoranthene	8	100	—	—	blanks
Benzo[*g,h,i*]perylene	8	100	—	—	blanks
Benzo[*k*]fluoranthene	8	100	—	—	blanks
Benzoic acid	8	88	13	—	blanks
Benzyl alcohol	8	38	—	63	0.54
Bis(2-chloroethoxy)methane	8	100	—	—	blanks
Bis(2-chloroethyl)ether	8	88	—	13	0.42
Bis(2-chloroisopropyl)ether	8	100	—	—	blanks
Bis(2-ethylhexyl)phthalate	8	75	—	25	blanks
Bromobenzene	21	95	5	—	0.91 ± 0.18
Bromochloromethane	21	100	—	—	0.86
Bromodichloromethane	21	100	—	—	0.89 ± 0.09
Bromoform	21	95	—	5	0.95 ± 0.18
Bromomethane	21	100	—	—	blanks
4-Bromophenylphenyl ether	8	100	—	—	0.66
2-Butanone	21	67	24	10	2.52 ± 4.27
Butyl benzyl phthalate	8	50	—	50	0.13 ± 0.02
tert-Butylbenzene	21	100	—	—	0.86 ± 0.15
n-Butylbenzene	21	100	—	—	blanks
sec-Butylbenzene	21	100	—	—	0.83 ± 0.13
Carbon disulfide	21	95	5	—	0.82 ± 0.24

Table D-31. (Cont.)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Water (Cont.)					
Carbon tetrachloride	21	95	5	—	0.65 ± 0.09
4-Chloro-3-methylphenol	8	100	—	—	blanks
4-Chloroaniline	8	75	—	25	0.47
Chlorobenzene	21	100	—	—	0.67
Chlorodibromomethane	21	86	—	14	blanks
Chloroethane	21	100	—	—	blanks
Chloroform	21	100	—	—	0.83 ± 0.07
Chloromethane	21	100	—	—	blanks
2-Chloronaphthalene	8	88	—	13	0.36
o-Chlorophenol	8	100	—	—	blanks
4-Chlorophenylphenyl ether	8	88	13	—	0.56
o-Chlorotoluene	21	95	5	—	0.80 ± 0.19
p-Chlorotoluene	21	100	—	—	0.81
Chrysene	8	100	—	—	blanks
Di-*n*-butyl phthalate	8	100	—	—	blanks
Di-*n*-octyl phthalate	8	88	—	13	0.34
Dibenzo[*a*,*h*]anthracene	8	100	—	—	blanks
Dibenzofuran	8	88	—	13	0.41
1,2-Dibromo-3-chloropropane	21	100	—	—	blanks
Dibromomethane	21	100	—	—	0.90 ± 0.11
o-Dichlorobenzene (1,2)	29	97	—	3	0.84 ± 0.30
m-Dichlorobenzene (1,3)	29	97	—	3	0.44
p-Dichlorobenzene (1,4)	29	90	7	3	0.67 ± 0.13
3,3'-Dichlorobenzidine	8	100	—	—	blanks
Dichlorodifluoromethane	21	100	—	—	blanks
1,2-Dichloroethane	21	95	—	5	blanks
1,1-Dichloroethane	21	100	—	—	1.05
trans-1,2-Dichloroethene	21	95	—	5	0.74 ± 0.10
1,1-Dichloroethene	21	100	—	—	blanks
cis-1,2-Dichloroethylene	21	95	—	5	0.78 ± 0.04
2,4-Dichlorophenol	8	63	13	25	0.56 ± 0.07
2,2-Dichloropropane	21	90	5	5	0.56 ± 0.08
1,2-Dichloropropane	21	100	—	—	1.01 ± 0.11
1,3-Dichloropropane	21	100	—	—	0.96 ± 0.13
1,1-Dichloropropene	21	100	—	—	blanks
trans-1,3-Dichloropropene	21	90	—	10	1.02 ± 0.13
cis-1,3-Dichloropropene	21	95	—	5	1.52
Diethyl phthalate	8	75	—	25	0.15
Dimethyl phthalate	8	100	—	—	blanks
2,4-Dimethylphenol	8	88	—	13	0.39
2,4-Dinitrophenol	8	88	—	13	blanks
2,4-Dinitrotoluene	8	100	—	—	blanks
2,6-Dinitrotoluene	8	100	—	—	0.65
Ethylbenzene	21	100	—	—	0.69
Ethylene dibromide	21	100	—	—	0.81
Fluoranthene	8	88	—	13	0.43
Fluorene	8	88	13	—	0.67 ± 0.07

Table D-31. (Cont.)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Water (Cont.)					
Hexachlorobenzene	8	88	—	13	blanks
Hexachlorobutadiene	8	100	—	—	blanks
Hexachlorocyclopentadiene	8	88	—	13	0.33
Hexachloroethane	8	88	—	13	0.48
2-Hexanone	21	95	—	5	0.71 ± 0.13
Indeno[1,2,3-*cd*]pyrene	8	100	—	—	blanks
Isophorone	8	100	—	—	blanks
Isopropylbenzene	21	86	10	5	0.66 ± 0.08
4-Isopropyltoluene	21	86	10	5	0.74 ± 0.19
Methyl iodide	21	100	—	—	blanks
4-Methyl-2-pentanone	21	95	5	—	1.25 ± 0.56
2-Methyl-4,6-dinitrophenol	8	100	—	—	blanks
Methylene chloride	21	100	—	—	1.01 ± 0.20
2-Methylnaphthalene	8	75	13	13	0.51
4-Methylphenol	8	100	—	—	0.67
2-Methylphenol	8	100	—	—	blanks
Naphthalene	8	88	—	13	0.36
2-Nitroaniline	8	100	—	—	0.81
4-Nitroaniline	8	100	—	—	0.76
3-Nitroaniline	8	100	—	—	blanks
Nitrobenzene	8	88	—	13	0.44
4-Nitrophenol	8	100	—	—	blanks
2-Nitrophenol	8	100	—	—	blanks
N-Nitrosodi-*n*-propylamine	8	100	—	—	0.82
N-Nitrosodimethylamine	8	100	—	—	blanks
N-Nitrosodiphenylamine	8	88	—	13	0.61 ± 0.22
Pentachlorophenol	8	88	—	13	blanks
Petroleum Hydrocarbons, Total Recoverable	1	100	—	—	0.88
Phenanthrene	8	100	—	—	0.70
Phenol	8	75	25	—	0.54
Propylbenzene	21	95	—	5	0.80 ± 0.09
Pyrene	8	50	—	50	0.34 ± 0.06
Styrene	21	86	10	5	0.70 ± 0.11
1,1,1,2-Tetrachloroethane	21	100	—	—	1.02 ± 0.13
1,1,2,2-Tetrachloroethane	21	100	—	—	1.05
Tetrachloroethylene	21	100	—	—	0.66
Toluene	21	100	—	—	0.73
1,1,2-Trichloro-1,2,2-trifluoroethane	21	100	—	—	blanks
1,2,4-Trichlorobenzene	8	100	—	—	blanks
1,1,1-Trichloroethane	21	100	—	—	0.64
1,1,2-Trichloroethane	21	100	—	—	0.72
Trichloroethene	21	100	—	—	0.67
Trichlorofluoromethane	21	100	—	—	blanks
2,4,6-Trichlorophenol	8	88	—	13	0.44
2,4,5-Trichlorophenol	8	88	—	13	0.41

Table D-31. (Cont.)

Matrix Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Water (Cont.)					
1,2,3-Trichloropropane	21	95	—	5	0.78 ± 0.28
1,2,4-Trimethylbenzene	21	100	—	—	blanks
1,3,5-Trimethylbenzene	21	100	—	—	blanks
Vinyl acetate	12	58	8	33	1.17 ± 0.53
Vinyl chloride	21	100	—	—	blanks
Mixed-Xylenes ($o + m + p$)	21	90	—	10	0.78 ± 0.25

Table D-32. Radiochemical Detection Limits for Analyses of Typical Environmental Samples

Parameter	Approximate Sample Volume or Weight	Count Time	Detection Limit Concentration	
Air Sample				
Tritium	3 m^3	30 min	1×10^{-12}	µCi/mL
^{131}I	3.0×10^2 m^3	1×10^3 s	1×10^{-11}	µCi/mL
^{238}Pu	2.0×10^4 m^3	8×10^4 s	4×10^{-18}	µCi/mL
$^{239,240}Pu$	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
^{241}Am	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	µCi/mL
Gross alpha	6.5×10^3 m^3	100 min	4×10^{-16}	µCi/mL
Gross beta	6.5×10^3 m^3	100 min	4×10^{-16}	µCi/mL
^{234}U	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
^{235}U	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	µCi/mL
^{238}U	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
Water Sample				
Tritium	0.005 L	30 min	4×10^{-7}	µCi/mL
^{90}Sr	0.5 L	200 min	3×10^{-9}	µCi/mL
^{137}Cs	0.5 L	5×10^4 s	4×10^{-8}	µCi/mL
^{238}Pu	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
$^{239,240}Pu$	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
^{241}Am	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
Gross alpha	0.9 L	100 min	3×10^{-9}	µCi/mL
Gross beta	0.9 L	100 min	3×10^{-9}	µCi/mL
Soil Sample				
Tritium	1 kg	30 min	0.003	pCi/g
^{90}Sr	2 g	200 min	2	pCi/g
^{137}Cs	100 g	5×10^4 s	0.1	pCi/g
^{238}Pu	10 g	8×10^4 s	0.002	pCi/g
$^{239,240}Pu$	10 g	8×10^4 s	0.002	pCi/g
^{241}Am	10 g	8×10^4 s	0.002	pCi/g
Gross alpha	2 g	100 min	3	pCi/g
Gross beta	2 g	100 min	3	pCi/g
U (delayed neutron)	2 g	20 s	0.2	µg/g

Table D-33. Summary of EM-9 False Positive/False Negative QC Samples for EM-8 Samples Run in 1993

Matrix/Analyte	False Positive	False Negative	Total QC Samples
RADIOCHEMICAL ANALYSES			
Biologicals			
^{137}Cs	0	0	14
^{238}Pu	0	0	13
^{239}Pu	4	0	13
^{90}Sr	0	0	11
U	0	0	7
235	0	0	1
^{238}U	0	0	1
Filters			
Alpha	0	0	158
^{241}Am	0	0	16
Beta	0	0	155
^{238}Pu	0	0	19
^{239}Pu	0	0	19
^{234}U	2	0	13
^{235}U	0	0	13
^{238}U	1	0	13
Soils			
Alpha	0	0	8
^{241}Am	0	0	19
Beta	0	0	8
^{137}Cs	0	0	20
Gamma	0	1	32
^{3}H	8	0	21
^{238}Pu	1	0	31
^{239}Pu	7	0	30
^{90}Sr	1	0	11
U	0	0	26
^{234}U	0	0	8
^{235}U	0	0	8
^{238}U	0	0	8
Waters			
Alpha	0	0	255
^{241}Am	0	0	10
Beta	1	0	253
^{137}Cs	2	0	67
Gamma	1	0	222
^{3}H	2	0	215
^{238}Pu	0	0	27
^{239}Pu	0	0	27
Ra	0	0	1
^{226}Ra	0	0	1
^{90}Sr	0	0	31
U	0	0	83
$^{235/238}U$	0	0	1
^{238}U	0	0	2

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
INORGANIC ANALYSES			
Biologicals			
B	0	0	1
Filters			
Be	0	0	16
Bulk Materials			
Ag	0	1	1
As	0	0	1
Ba	0	0	1
Cd	0	0	1
Cr	0	0	1
Flashpoint	0	0	1
Hg	0	0	1
Pb	0	0	1
Se	0	0	1
Soils			
Al	0	0	7
As	0	0	23
B	0	0	2
Ba	0	0	17
Be	0	0	21
Cd	0	0	13
Co	0	0	3
Cr	0	0	19
Cu	0	0	6
Fe	0	0	7
Ga	0	0	4
H_2O- (unbound water)	0	0	8
Hg	0	1	31
Mn	0	0	2
Mo	0	0	1
Ni	0	0	14
Pb	0	1	27
Sb	0	0	13
Se	0	0	4
Sr	0	0	1
Th	0	0	4
V	0	0	2
Zn	0	0	2
Waters			
Ag	0	4	224
Al	1	0	82
As	1	2	306
B	2	0	80
Ba	3	0	244
Be	4	0	246
Br	0	0	1
Ca	0	0	50

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
INORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
Cd	0	1	248
Cl	0	0	93
CN	0	0	2
Co	0	0	84
Chemical Oxygen Demand	0	0	3
Conductivity	0	0	55
Cr	1	1	257
Cu	2	0	117
F	0	0	58
Fe	0	0	74
Ga	0	0	5
Hardness	0	0	26
Hg	0	0	166
K	0	0	43
Li	1	0	62
Mg	0	0	51
Mn	0	0	98
Mo	1	0	98
Na	0	0	47
NH_3-N (Ammonia Nitrogen)	0	0	4
Ni	1	0	194
NO_3-N (Nitrate Nitrogen)	0	0	71
Oil and Grease	0	0	9
P	0	0	2
Pb	2	0	283
pH	0	0	60
PO_4-P (Phosphate Phosphorus)	0	0	49
Sb	1	1	140
Se	0	1	304
SiO_2	0	0	58
Sn	0	0	54
SO_4	0	0	68
Sr	0	0	82
Total Alkalinity	0	0	49
Total Dissolved Solids	0	0	62
Th	0	0	4
Ti	0	0	5
Total Kjeldahl Nitrogen	0	0	2
Tl	0	0	167
TSS	0	0	13
V	0	0	98
Zn	0	0	107

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES			
Filters			
Mixed-Aroclor	0	1	15
Aroclor 1242	0	1	15
Aroclor 1254	0	0	15
Aroclor 1260	0	0	15
Bulk Materials			
Acetone	1	0	8
Mixed-Aroclor	1	3	101
Aroclor 1242	0	2	100
Aroclor 1254	1	1	100
Aroclor 1260	1	1	100
Benzene	0	0	10
Bromobenzene	0	0	8
Bromochloromethane	0	0	8
Bromodichloromethane	0	0	8
Bromoform	0	0	8
Bromomethane	0	0	8
2-Butanone	4	0	8
n-Butylbenzene	0	0	8
sec-Butylbenzene	0	0	8
tert-Butylbenzene	0	0	8
Carbon disulfide	0	0	8
Carbon tetrachloride	0	0	8
Chlorobenzene	0	0	10
Chlorodibromomethane	0	0	8
Chloroethane	0	0	8
Chloroform	0	0	8
Chloromethane	0	0	8
o-Chlorotoluene	0	0	8
p-Chlorotoluene	0	0	8
1,2-Dibromo-3-chloropropane	0	0	8
Dibromomethane	0	0	8
o-Dichlorobenzene (1,2)	0	0	8
m-Dichlorobenzene (1,3)	0	0	8
p-Dichlorobenzene (1,4)	0	0	8
Dichlorodifluoromethane	0	0	8
1,1-Dichloroethane	0	0	10
1,2-Dichloroethane	0	0	8
1,1-Dichloroethene	0	0	8
trans-1,2-Dichloroethene	0	0	8
cis-1,2-Dichloroethylene	0	0	8
1,2-Dichloropropane	0	0	8
1,3-Dichloropropane	0	0	8
2,2-Dichloropropane	0	0	8
1,1-Dichloropropene	0	0	8
cis-1,3-Dichloropropene	0	0	8
trans-1,3-Dichloropropene	0	0	8

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES			
Bulk Materials (Cont.)			
Ethylbenzene	0	0	8
Ethylene dibromide	0	0	8
2-Hexanone	0	0	8
Isopropylbenzene	0	0	8
4-Isopropyltoluene	0	0	8
Methyl iodide	0	0	8
4-Methyl-2-pentanone	0	0	8
Methylene chloride	3	0	8
Propylbenzene	0	0	8
Styrene	0	0	8
1,1,1,2-Tetrachloroethane	0	0	8
1,1,2,2-Tetrachloroethane	0	0	8
Tetrachloroethylene	0	0	8
Toluene	0	0	10
1,1,2-Trichloro-1,2,2-trifluoroethane	2	0	8
1,1,1-Trichloroethane	0	0	8
1,1,2-Trichloroethane	0	0	8
Trichloroethene	0	0	10
Trichlorofluoromethane	1	0	8
1,2,3-Trichloropropane	0	0	8
1,2,4-Trimethylbenzene	0	0	8
1,3,5-Trimethylbenzene	0	0	8
Vinyl acetate	0	0	5
Vinyl chloride	0	0	8
Mixed-Xylenes ($o + m + p$)	0	0	8
Soils			
Acenaphthene	0	0	42
Acenaphthylene	0	0	42
Acetone	7	0	79
Aniline	0	0	42
Anthracene	0	0	42
Mixed-Aroclor	0	0	14
Aroclor 1242	0	0	14
Aroclor 1254	0	0	14
Aroclor 1260	0	0	14
Azobenzene	0	0	42
Benzene	0	0	79
m-Benzidine	0	0	42
Benzo[*a*]anthracene	0	0	42
Benzo[*a*]pyrene	0	0	42
Benzo[*b*]fluoranthene	0	0	42
Benzo[*g,h,i*]perylene	0	0	42
Benzo[*k*]fluoranthene	0	0	42
Benzoic acid	0	1	42
Benzyl alcohol	0	0	42

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
Bis(2-chloroethoxy)methane	0	0	42
Bis(2-chloroethyl)ether	0	0	42
Bis(2-chloroisopropyl)ether	0	0	42
Bis(2-ethylhexyl)phthalate	0	0	42
Bromobenzene	0	0	79
Bromochloromethane	0	0	79
Bromodichloromethane	0	0	79
Bromoform	0	0	79
Bromomethane	0	0	79
4-Bromophenylphenyl ether	0	0	42
2-Butanone	0	0	79
Butyl benzyl phthalate	0	0	42
n-Butylbenzene	0	0	79
sec-Butylbenzene	0	0	79
tert-Butylbenzene	0	0	79
Carbon disulfide	1	0	79
Carbon tetrachloride	0	0	79
4-Chloro-3-methylphenol	0	0	42
4-Chloroaniline	0	1	42
Chlorobenzene	0	0	79
Chlorodibromomethane	0	0	79
Chloroethane	0	0	79
Chloroform	0	0	79
Chloromethane	0	0	79
2-Chloronaphthalene	0	0	42
o-Chlorophenol	0	0	42
4-Chlorophenylphenyl ether	0	0	42
o-Chlorotoluene	0	0	79
p-Chlorotoluene	0	0	79
Chrysene	0	0	42
Di-*n*-butyl phthalate	7	0	42
Di-*n*-octyl phthalate	0	0	42
Dibenzo[*a*,*h*]anthracene	0	0	42
Dibenzofuran	0	0	42
1,2-Dibromo-3-chloropropane	1	0	79
Dibromomethane	0	0	79
o-Dichlorobenzene (1,2)	1	0	121
m-Dichlorobenzene (1,3)	1	0	121
p-Dichlorobenzene (1,4)	1	0	121
3,3'-Dichlorobenzidine	0	0	42
Dichlorodifluoromethane	0	0	79
1,1-Dichloroethane	0	0	79
1,2-Dichloroethane	0	0	79
1,1-Dichloroethene	0	0	79
trans-1,2-Dichloroethene	0	0	79
cis-1,2-Dichloroethylene	0	0	79

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
2,4-Dichlorophenol	0	0	42
1,2-Dichloropropane	0	1	79
1,3-Dichloropropane	0	0	79
2,2-Dichloropropane	0	0	79
1,1-Dichloropropene	0	0	79
cis-1,3-Dichloropropene	0	0	79
trans-1,3-Dichloropropene	0	1	79
Diethyl phthalate	0	0	42
Dimethyl phthalate	0	0	42
2,4-Dimethylphenol	0	0	42
2,4-Dinitrophenol	0	0	42
2,4-Dinitrotoluene	0	0	42
2,6-Dinitrotoluene	0	0	42
Ethylbenzene	0	0	79
Ethylene dibromide	0	0	79
Fluoranthene	0	0	42
Fluorene	0	0	42
Hexachlorobenzene	0	0	42
Hexachlorobutadiene	0	0	42
Hexachlorocyclopentadiene	0	0	42
Hexachloroethane	0	0	42
2-Hexanone	0	0	79
Indeno[1,2,3-*cd*]pyrene	0	0	42
Isophorone	0	0	42
Isopropylbenzene	0	0	79
4-Isopropyltoluene	0	1	79
Methyl iodide	0	0	79
4-Methyl-2-pentanone	0	0	79
2-Methyl-4,6-dinitrophenol	0	0	42
Methylene chloride	9	0	79
2-Methylnaphthalene	0	0	42
2-Methylphenol	0	0	42
4-Methylphenol	0	0	42
Naphthalene	0	0	42
2-Nitroaniline	0	0	42
3-Nitroaniline	0	0	42
4-Nitroaniline	0	0	42
Nitrobenzene	0	0	42
2-Nitrophenol	0	0	42
4-Nitrophenol	0	0	42
N-Nitrosodi-*n*-propylamine	0	0	42
N-Nitrosodimethylamine	0	0	42
N-Nitrosodiphenylamine	0	0	42
Pentachlorophenol	0	0	42
Petroleum Hydrocarbons, Total Recoverable	0	0	8

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
Phenanthrene	0	0	42
Phenol	0	0	42
Propylbenzene	0	0	79
Pyrene	0	0	42
Styrene	0	0	79
1,1,1,2-Tetrachloroethane	0	0	79
1,1,2,2-Tetrachloroethane	0	0	79
Tetrachloroethylene	0	0	79
Toluene	0	0	79
1,1,2-Trichloro-1,2,2-trifluoroethane	1	0	79
1,2,4-Trichlorobenzene	0	0	42
1,1,1-Trichloroethane	0	0	79
1,1,2-Trichloroethane	0	0	79
Trichloroethene	1	0	79
Trichlorofluoromethane	0	0	79
2,4,5-Trichlorophenol	0	0	42
2,4,6-Trichlorophenol	0	0	42
1,2,3-Trichloropropane	0	0	79
1,2,4-Trimethylbenzene	0	0	79
1,3,5-Trimethylbenzene	0	0	79
Vinyl acetate	0	6	46
Vinyl chloride	0	0	79
Mixed-Xylenes ($o + m + p$)	0	0	79
Charcoal Tubes			
Acetone	1	0	28
Benzene	0	0	85
Bromobenzene	0	1	85
Bromochloromethane	6	0	28
Bromodichloromethane	0	0	28
Bromoform	0	0	28
Bromomethane	0	0	28
2-Butanone	0	0	28
Carbon disulfide	0	0	28
Carbon tetrachloride	0	0	85
Chlorobenzene	0	0	85
Chlorodibromomethane	0	0	28
Chloroethane	0	0	28
Chloroform	0	0	85
Chloromethane	0	0	28
Dibromomethane	2	0	28
o-Dichlorobenzene (1,2)	0	0	28
m-Dichlorobenzene (1,3)	0	0	28
p-Dichlorobenzene (1,4)	0	0	28
Dichlorodifluoromethane	0	0	28
1,1-Dichloroethane	0	0	28
1,2-Dichloroethane	0	0	28

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Charcoal Tubes (Cont.)			
1,1-Dichloroethene	0	0	28
trans-1,2-Dichloroethene	0	0	28
cis-1,2-Dichloroethylene	0	0	28
1,2-Dichloropropane	0	0	28
1,1-Dichloropropene	0	0	28
cis-1,3-Dichloropropene	0	0	28
trans-1,3-Dichloropropene	0	0	28
Ethylbenzene	0	0	85
2-Hexanone	0	0	28
4-Methyl-2-pentanone	0	0	28
Methylene chloride	2	0	28
Propylbenzene	0	0	28
Styrene	3	0	28
1,1,1,2-Tetrachloroethane	0	0	28
1,1,2,2-Tetrachloroethane	0	0	28
Tetrachloroethylene	0	0	85
Toluene	0	0	85
1,1,2-Trichloro-1,2,2-trifluoroethane	0	0	28
1,1,1-Trichloroethane	0	0	85
1,1,2-Trichloroethane	0	0	28
Trichloroethene	0	0	85
Trichlorofluoromethane	0	0	28
1,2,4-Trimethylbenzene	0	0	85
1,3,5-Trimethylbenzene	0	0	28
Vinyl chloride	2	0	28
Mixed-Xylenes ($o + m + p$)	0	0	85
Waters			
Acenaphthene	0	0	34
Acenaphthylene	0	0	30
Acetone	2	0	61
Aniline	0	1	30
Anthracene	0	1	30
Mixed-Aroclor	0	1	20
Aroclor 1242	0	0	20
Aroclor 1254	0	1	20
Aroclor 1260	0	0	20
Azobenzene	0	0	30
Benzene	1	0	61
m-Benzidine	0	0	30
Benzo[*a*]anthracene	0	0	30
Benzo[*a*]pyrene	0	0	30
Benzo[*b*]fluoranthene	0	0	30
Benzo[*g,h,i*]perylene	0	0	30
Benzo[*k*]fluoranthene	0	0	30
Benzoic acid	0	1	30
Benzyl alcohol	4	0	30

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
Bis(2-chloroethoxy)methane	0	0	30
Bis(2-chloroethyl)ether	0	0	30
Bis(2-chloroisopropyl)ether	0	0	30
Bis(2-ethylhexyl)phthalate	2	0	30
Bromobenzene	0	0	61
Bromochloromethane	0	0	61
Bromodichloromethane	0	0	61
Bromoform	6	0	61
Bromomethane	0	0	61
4-Bromophenylphenyl ether	0	0	30
2-Butanone	2	0	61
Butyl benzyl phthalate	0	0	30
n-Butylbenzene	0	0	61
sec-Butylbenzene	0	0	61
tert-Butylbenzene	0	0	61
Carbon disulfide	0	0	61
Carbon tetrachloride	0	0	61
4-Chloro-3-methylphenol	0	0	34
4-Chloroaniline	0	0	30
Chlorobenzene	0	0	61
Chlorodibromomethane	8	0	61
Chloroethane	0	0	61
Chloroform	0	0	61
Chloromethane	0	0	61
2-Chloronaphthalene	0	0	30
o-Chlorophenol	0	0	34
4-Chlorophenylphenyl ether	0	0	30
o-Chlorotoluene	0	0	61
p-Chlorotoluene	0	0	61
Chrysene	0	0	30
Di-*n*-butyl phthalate	0	0	30
Di-*n*-octyl phthalate	0	0	30
Dibenzo[*a*,*h*]anthracene	0	0	30
Dibenzofuran	0	0	30
1,2-Dibromo-3-chloropropane	3	0	61
Dibromomethane	0	0	61
o-Dichlorobenzene (1,2)	1	0	91
m-Dichlorobenzene (1,3)	1	0	91
p-Dichlorobenzene (1,4)	1	0	95
3,3'-Dichlorobenzidine	0	0	30
Dichlorodifluoromethane	0	0	61
1,1-Dichloroethane	0	0	61
1,2-Dichloroethane	1	0	61
1,1-Dichloroethene	0	0	61
trans-1,2-Dichloroethene	0	1	61
cis-1,2-Dichloroethylene	1	0	61

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
2,4-Dichlorophenol	0	0	30
1,2-Dichloropropane	0	0	61
1,3-Dichloropropane	0	0	61
2,2-Dichloropropane	0	0	61
1,1-Dichloropropene	0	0	61
cis-1,3-Dichloropropene	0	1	61
trans-1,3-Dichloropropene	2	0	61
Diethyl phthalate	0	1	30
Dimethyl phthalate	0	0	30
2,4-Dimethylphenol	0	0	30
2,4-Dinitrophenol	0	1	30
2,4-Dinitrotoluene	1	0	34
2,6-Dinitrotoluene	0	0	30
Ethylbenzene	0	0	61
Ethylene dibromide	0	0	61
Fluoranthene	0	0	30
Fluorene	0	0	30
Hexachlorobenzene	0	1	30
Hexachlorobutadiene	0	0	30
Hexachlorocyclopentadiene	0	0	30
Hexachloroethane	0	0	30
2-Hexanone	0	1	61
Indeno[1,2,3-*cd*]pyrene	0	0	30
Isophorone	0	0	30
Isopropylbenzene	0	1	61
4-Isopropyltoluene	0	1	61
Methyl iodide	0	0	61
4-Methyl-2-pentanone	0	0	61
2-Methyl-4,6-dinitrophenol	0	0	30
Methylene chloride	4	0	61
2-Methylnaphthalene	0	0	30
2-Methylphenol	0	0	30
4-Methylphenol	0	0	30
Naphthalene	0	0	30
2-Nitroaniline	0	0	30
3-Nitroaniline	0	0	30
4-Nitroaniline	0	0	30
Nitrobenzene	0	0	30
2-Nitrophenol	0	0	30
4-Nitrophenol	0	0	34
N-Nitrosodi-*n*-propylamine	0	0	34
N-Nitrosodimethylamine	0	0	30
N-Nitrosodiphenylamine	0	0	30
Pentachlorophenol	0	1	34
Petroleum Hydrocarbons, Total Recoverable	0	0	1
Phenanthrene	0	0	30

Table D-33. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
Phenol	0	0	34
Propylbenzene	1	0	61
Pyrene	0	0	34
Styrene	0	1	61
1,1,1,2-Tetrachloroethane	0	0	61
1,1,2,2-Tetrachloroethane	0	0	61
Tetrachloroethylene	0	0	61
Toluene	0	0	61
1,1,2-Trichloro-1,2,2-trifluoroethane	0	0	61
1,2,4-Trichlorobenzene	0	0	34
1,1,1-Trichloroethane	0	0	61
1,1,2-Trichloroethane	0	0	61
Trichloroethene	0	0	61
Trichlorofluoromethane	2	0	61
2,4,5-Trichlorophenol	0	0	30
2,4,6-Trichlorophenol	0	0	30
1,2,3-Trichloropropane	0	0	61
1,2,4-Trimethylbenzene	0	0	61
1,3,5-Trimethylbenzene	0	0	61
Vinyl acetate	0	4	32
Vinyl chloride	0	0	61
Mixed-Xylenes ($o + m + p$)	0	0	61

GLOSSARY OF TERMS

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.
ALARA	As low as reasonably achievable. The term that describes an approach to radiation exposure control or management whereby the exposures and resulting doses are maintained as far below the limits specified for the appropriate circumstances as economic, technical, and practical considerations permit.
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.
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 and the US Nuclear Regulatory Commission).
artesian well	A well in which the water rises above the top of the water-bearing bed.
atom	Smallest particle of an element capable of entering into a chemical reaction.
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; global 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*.
confined aquifer	An aquifer bounded above and below by low-permeability rock or soil layers.
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.)
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.
equivalent dose	A term used in radiation protection that expresses all types of radiation (alpha, beta, and so on) on a common scale for calculating the effective absorbed dose. It is the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the rem.)
maximum boundary dose	The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to a hypothetical individual who is in an uncontrolled area where the highest dose rate occurs. It assumes that the hypothetical individual is present 100% of the time (full occupancy), and it does not take into account shielding (for example, by buildings).
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).
dosimeter	A portable detection device for measuring the total accumulated exposure to ionizing radiation.
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 surveillance	The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media to determine environmental quality of an industry or community. It is commonly performed at sites containing nuclear facilities.
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 radiation. (The unit of exposure is the roentgen).
external radiation	Radiation originating from a source outside the body.
fission products	Atoms created by the splitting of larger atoms into smaller ones accompanied by release of energy.
friable asbestos	Asbestos that is brittle or readily crumbled.
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. A radionuclide of hydrogen with a half-life of 12.3 years. The very low energy of its radioactive decay makes it one of the least hazardous radionuclides.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two

half-lives, one-fourth of the original activity remains (1/2 × 1/2), after three half-lives, one-eighth (1/2 × 1/2 × 1/2), and so on.

hazardous waste — Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.

hazardous waste constituent — The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.

HSWA — Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

internal radiation — Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms.

ion — An atom or compound that carries an electrical charge.

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).

LDR	Land Disposal Restrictions (land ban). A regulatory program that identifies hazardous wastes that are restricted from land disposal. The regulations incorporate a phasing-in of restrictions in three stages.
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-4). The MCLs are specified by the EPA.
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 (10^{-3} rem). 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.
nonpoint source	Any nonconfined area from which pollutants are discharged into a body of water (e.g., agricultural run off, construction run off, and parking lot drainage).
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.
PA	Performance Assessment. A systematic analysis of the potential risks posed by waste management systems to the public and environment, and a comparison of those risks to established performance objectives.
part B permit	Part of the RCRA permitting process that is submitted by organizations that treat, store, or dispose of hazardous wastes. It covers in detail the procedures followed at a facility to protect human health and the environment.

PCBs Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. They are also produced in certain combustion processes. 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. In general, PCBs are not as toxic in acute short-term doses as some other chemicals, although acute and chronic exposure can cause liver damage. PCBs have also caused cancer in laboratory animals. When tested, most people show traces of PCBs in their blood and fatty tissues.

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.

point source Any confined and discrete conveyance from which pollutants are discharged into a body of water (e.g., pipe, ditch, well, or stack).

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. A unit of radiation exposure that expresses exposure in terms of the amount of ionization produced by x rays in a volume of air. One roentgen (R) is 2.58×10^{-4} coulombs per kilogram of air.

rad — A unit of absorbed dose from ionizing radiation. A dose of 1 rad equals the absorption of 100 ergs of radiation energy per gram of absorbing material.

radiation — The emission of particles or energy as a result of an atomic or nuclear process.

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.

reagent — Any substance used in a chemical reaction to detect or measure another substance or to convert one substance into another.

release — Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.

rem — The unit of radiation dose equivalent that takes into account different kinds of ionizing radiation and permits them to be expressed on a common basis. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the necessary modifying factors.

RPS — Radiation Protection Standards. See PDL.

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. Potential

release sites include, for example, 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).

TCLP — Toxicity Characteristic Leaching Procedure. An analytical method designed to determine the mobility of both organic and inorganic compounds present in liquid, solid, and multi-phase wastes. It is used to determine applicability of the LDR to a waste.

TDS — Total Dissolved Solids. The portion of solid material in a waste stream that is dissolved and passed through a filter.

terrestrial radiation — Radiation emitted by naturally occurring radionuclides such as ^{40}K; the natural decay chains of ^{235}U, ^{238}U, or ^{232}Th; or cosmic-ray-induced radionuclides in the soil.

TLD — Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that, after being exposed to radiation, luminesces upon being heated. The amount of light the material emits is proportional to the amount of radiation (dose) to which it was exposed.

TRU — Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and NRC. 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.

TSP — Total suspended particulates. Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

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 spaces 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.

WLM — Working level month. A unit of exposure to ^{222}Rn and its decay products. Working level (WL) is any combination of the short-lived ^{222}Rn decay products in 1 L of air that will result in the emission of 1.3×10^5 MeV potential alpha energy. At equilibrium, 100 pCi/L of ^{222}Rn corresponds to 1 WL. Cumulative exposure is measured in working level months, one of which is equal to 170 working level hours.

worldwide fallout — Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

ACRONYMS AND ABBREVIATIONS

ACIS	automated chemical inventory system
ADS	activity data sheet
AEC	Atomic Energy Commission
AIP	agreement in principle
AL	Albuquerque Operations Office (DOE)
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
AO	administrative order
AQCR	Air Quality Control Regulation (New Mexico)
AR	administrative requirement
BEIR	biological effects of ionizing radiation
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOD	biochemical/biological oxygen demand
BP	biometric pressure
BRET	Biological Resource Evaluation Team (EM-8)
Btu	British thermal unit
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAI	controlled-air incinerator
CAS	Chemical Abstract Service
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CGS	Canadian Geologic Survey
CMR	Chemistry and Metallurgy Research (LANL building)
CO	compliance order
COC	chain-of-custody
COD	chemical oxygen demand
CSU	Colorado State University
CWA	Clean Water Act
CY	calendar year
CYRSL	current year's regional statistical reference level
DAC	derived air concentration (DOE)
DAHRT	Dual Axis Radiographic Hydrotest
DCG	derived concentration guide (DOE)
D&D	decontamination and decommissioning
DEC	DOE environmental checklist
DoD	Department of Defense
DOE	Department of Energy
DOE-EM	DOE, Environmental Management
DOT	Department of Transportation
EA	environmental assessment
EARE	Environmental Assessments & Resource Evaluations
ECD	electron capture detection
EES	Earth and Environmental Sciences (LANL Division)
EES-1	Geology and Geochemistry Group
EIS	environmental impact statement
EM	Environmental Management (LANL Division)
EM-7	Waste Management Group

EM-8	Environmental Protection Group
EM-9	Environmental Chemistry Group
EM-13	Environmental Restoration Group
EMP	Environmental Monitoring Plan
EMSL-CI	Environmental Monitoring and Support Laboratory - Cincinnati
EO	executive order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Restoration Program
ERAM	Ecological Risk Assessment Model
ERDA	Energy, Research, and Development Administration
EIS	Environmental Impact Statement
ES&H	Environment, Safety, and Health
FDA	Food and Drug Administration
FFCA	Federal Facilities Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FFC	Federal Facilities Compliance Act
FONSI	Finding of No Significant Impact
FY	fiscal year
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GPS	global positioning system
HAP	hazardous air pollutant
HE	high-explosive
HEPA	high-efficiency particulate air (filter)
HPGe	high-purity germanium detector
HPIC	high-pressure ion chamber
HPTL	High-Pressure Tritium Laboratory
HS	Health and Safety (LANL Division)
HSWA	Hazardous and Solid Waste Amendments
HWMR	Hazardous Waste Management Regulations (New Mexico)
HWTU	hazardous waste treatment unit
ICPMS	inductively-coupled plasma mass spectrometry
ICPES	inductively-coupled plasma emission spectroscopy
ICRP	International Commission on Radiological Protection
IH	industrial hygiene
JCI	Johnson Controls Inc.
JENV	JCI Environmental
KPA	kinetic phosphorimetric analysis
LAAO	Los Alamos Area Office
LAMPF	Los Alamos Meson Physics Facility (a.k.a. Clinton P. Anderson Meson Physics Facility - LANL building)
LANL	Los Alamos National Laboratory (or the Laboratory)
LA/NTS	Los Alamos/Nevada Test Site
LDR	land disposal restrictions
LET	linear energy transfer
LLW	low-level radioactive waste
LTRSL	long-term regional statistical reference level
MCL	maximum contaminant level
MDA	minimum detectable amount (activity)
MDL	minimum detection limit
MEI	maximum exposed individual
MOU	memorandum of understanding
MS	mass spectrometry

MWDF	Mixed Waste Disposal Facility
MWRSF	Mixed Waste Receiving and Storage Facility
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology (formerly National Bureau of Standards)
NMDA	New Mexico Department of Agriculture
NMED	New Mexico Environment Department
NMEIB	New Mexico Environmental Improvement Board
NMHWA	New Mexico Hazardous Waste Act
NMLWD	New Mexico Liquid Waste Disposal
NMWQCA	New Mexico Water Quality Control Act
NMWQCC	New Mexico Water Quality Control Commission
NOD	notice of deficiency
NOI	notice of intent
NON	notice of noncompliance
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OB/OD	open burning/open detonated
ODS	ozone depleting substance
O&G	oil and gas
OHL	Occupational Health Laboratory (LANL building)
OSHA	Occupational Safety and Health Act/Administration
OU	operable unit
PAT	purge-and-trap gas chromatography/mass spectrometry
PCB	polychlorinated biphenyl
PDL	public dose limit
PHERMEX	pulsed high-energy radiographic machine
ppb	parts per billion
ppm	parts per million
PPOA	pollution prevention opportunity assessment
PRS	potential release site
PWA	process waste assessment
QA	quality assurance
QAP	quality assurance program
QAPP	quality assurance program plan
QC	quality control
RAS	radiochemistry and alpha spectrometry
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RD&D	research, development, and demonstration
RFA	RCRA facility assessment
RFI	RCRA facility investigation
ROD	record of decision
RPS	radiation protection standard (now PDL)
SAL	screening action level
SARA	Superfund Amendments and Reauthorization Act
SCYLLA	LA/NTS Explosive Pulsed Power Experiment
SDWA	Safe Drinking Water Act
SHPO	state historic preservation officer (New Mexico)
SIC	standard industrial classification
SIO	Stakeholder Involvement Office

SLD	Scientific Laboratory Division (New Mexico)
SLP	single link protocol
SODAR	sound, distance, and ranging
SOP	standard operating procedure
SOP	stratospheric ozone protection
SPCC	spill prevention, control, and countermeasures
SRM	standard reference material
SR	state road
SVOC	semivolatile organic compound
SW	solid waste
SWPP	storm water pollution prevention
SWSC	sanitary wastewater systems consolidation
SWDA	Solid Waste Disposal Act
SWMU	solid waste management unit
TA	technical area
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
THM	trihalomethane
TLD	thermoluminescent dosimeter
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSS	total suspended solids
TU	tritium unit
TWISP	Transuranic Waste Inspectable Storage Project
UC	University of California
ULB	upper limit background
USGS	United States Geological Survey
UST	underground storage tank
UV	ultraviolet
VCA	voluntary corrective action
VOC	volatile organic compound
WCTF	Weapons Component Testing Facility
WETF	Weapons Engineering Tritium Facility
WIPP	Waste Isolation Pilot Plant
WL	working level
WLM	working level month
WM	waste minimization
WM	waste management
WSC	waste stream characterization
WQCC	Water Quality Control Commission

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	Phosphate (as Phosphorus)	PO_4-P
Calcium	Ca	Phosphorus	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	Uranium	U
Lithium	Li	Tungsten	W
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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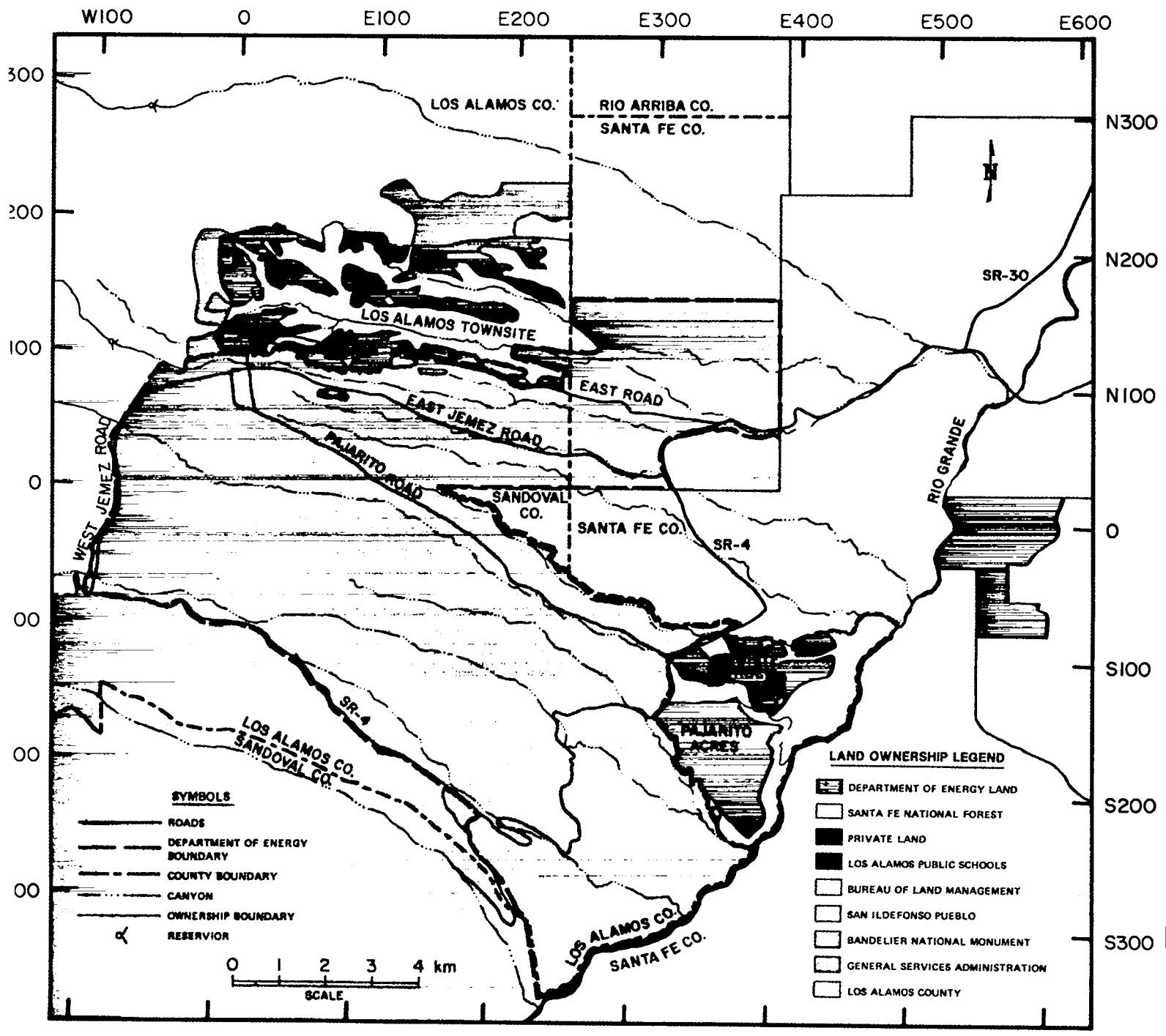

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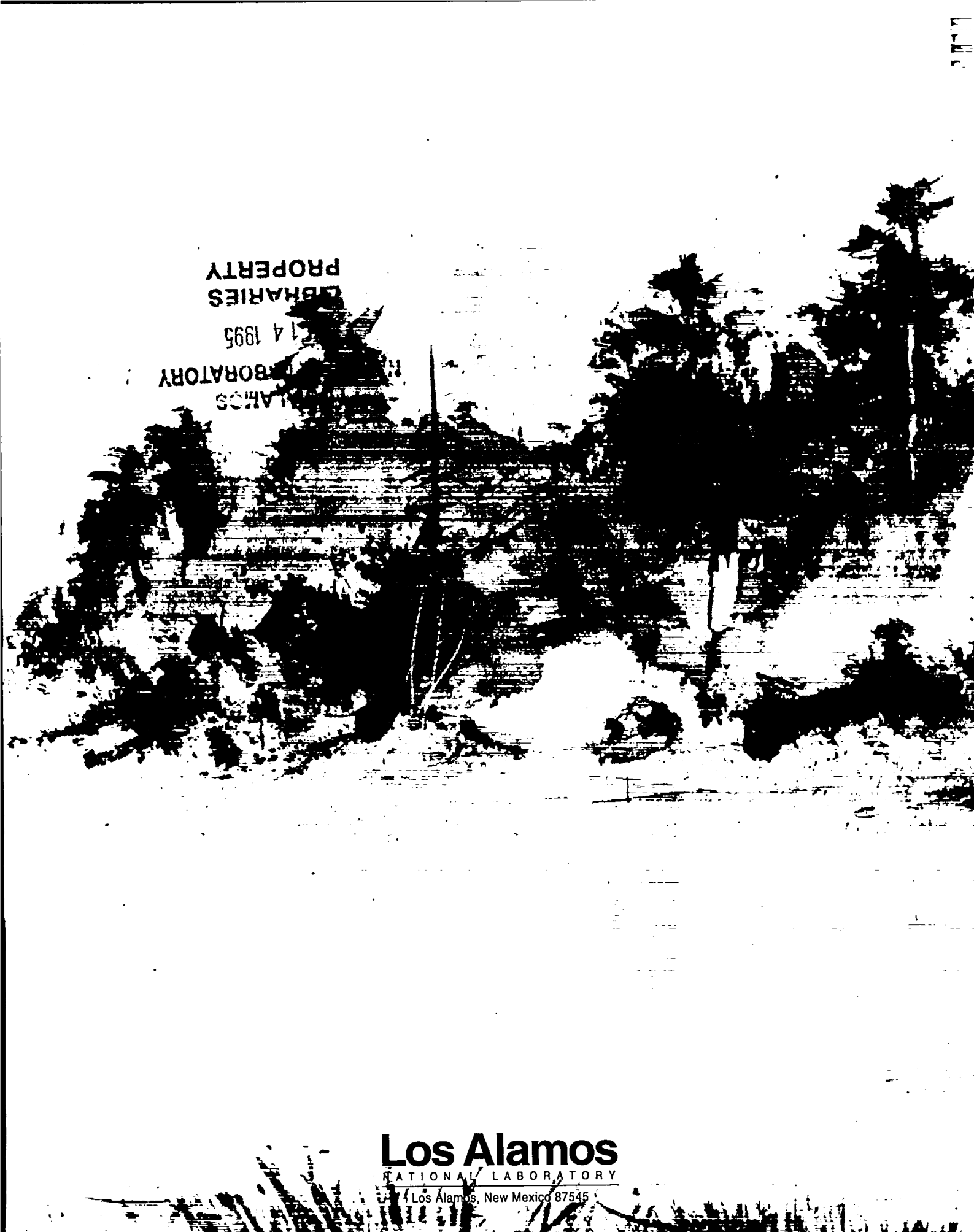

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