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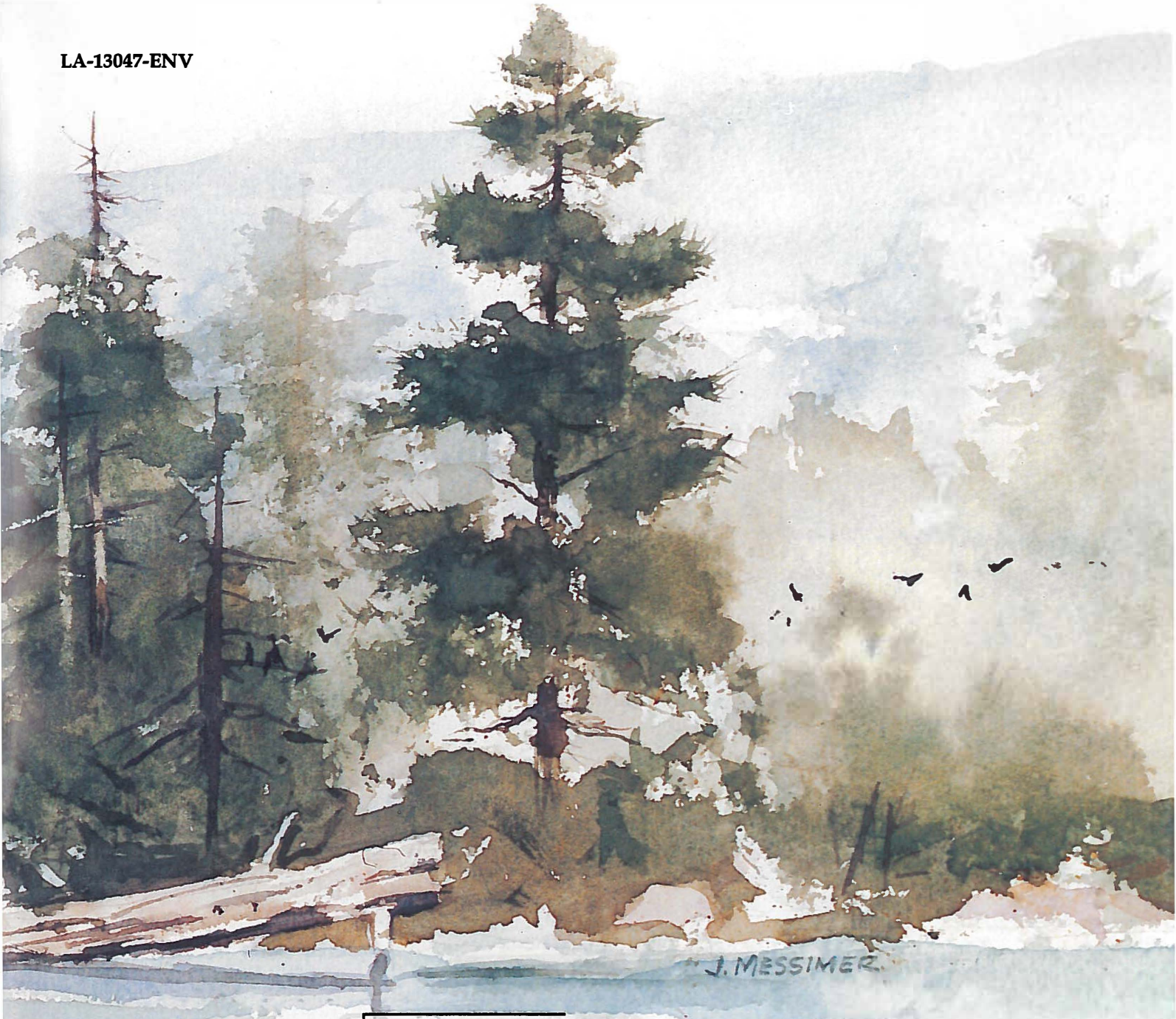

Environmental Surveillance at Los Alamos during 1994

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

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.

LA-13047-ENV

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Issued: July 1996

Environmental Surveillance at Los Alamos during 1994

Environmental Assessments and Resource Evaluations Group

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545

Edited by Louisa Lujan-Pacheco, Group CIC-1

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Table of Contents

Table of Contents

FIGURES

TABLES

APPENDIX TABLES

Appendix A

Appendix B

Appendix D

Acknowledgments

Karen Lyncoln and Julie Johnston compiled this report with contributions from members of the Environment, Safety, and Health (ESH) Division. Personnel in ESH who contributed to this report include the following:

James Alarid
Michael Alexander
Joan Archuleta
Dennis Armstrong
April Baldonado
Delilah Baldonado
Alice Barr
Alice Baumann
Pat Beaulieu
Kathryn Bennett
James Biggs
Suzanne Carden
Jeff Carmichael
Michelle Cash
Stephanie Cohen
Ron Conrad
Melissa Coronado
Saul Cross
Jean Dewart
Sue Duffy
Daniel Dunham
Craig Eberhart
Jack Ellvinger
Shirley Fillas
Teralene Foxx
Philip Fresquez
Bruce Gallaher
Kathy Garduno-Paul
Anne Garnett
Ernest Gladney
Tony Grieggs
Belinda Gutierrez
Todd Haagenstad
Tim Haarmann
Steve Hoagland
Darrel Holt
Keith Jacobson
David Jardine
David Keller
Robert Keys
Eric Koenig
David Kraig
Susan Kreiner
Beverly Larson
Joe Lochamy
Max Maes
Leland Maez
Kari Manz
Harold Martinez
Jake Martinez
Ellen McGehee
Stephen McLin
Eric McNamara
Allen Meddles
Jerry Merkey
Scotty Miller
Terry Morgan
Ken Mullen
Mary Mullen
Louie Naranjo
Linda Nelson
Sally Olguin
William Olsen
John Pienziazek
Margaret Powers
Steven Rae
Rubén Rangel
Carolyn Robinson
Rhonda Robinson
David Rogers
Mike Saladen
Mary Salisbury
Eric Sandoval
Paul Schumann
Pat Shanley
Ann Sherrard
Barbara Sinha
Doug Stavert
Alan Stoker
Greg Stone
Steven Story
Allen Treadaway
David Waechter
Rebecca Wechsler
James White
Neil Williams

Belinda Gutierrez (ESH-20) assembled this report and completed its layout. Nancy Teague (OAS) assisted with the word processing. Louisa Lujan-Pacheco (CIC-1) edited the report and assisted with writing and compiling. The following groups provided environmental data: Air Quality (ESH-17), Water Quality and Hydrology (ESH-18), Hazardous and Solid Waste (ESH-19), Environmental Assessments and Resource Evaluations (ESH-20), Environmental Restoration (EM/ER), and Facility Risk Management (ESH-3).

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

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 1994 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 Assessments and Resource Evaluations Group:

Environmental Assessments and Resource Evaluations Group
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, NM 87545
Attn: Julie Johnston
Mail Stop M887
Telephone: (505) 665-0231

Report Contributors

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.

Section	Authors
I. Executive Summary	K. Lyncoln
II. Introduction	
A. Los Alamos National Laboratory	K. Lyncoln
B. Geographic Setting	A. Stoker
C. Geology and Hydrology	D. Rogers
D. Climatology	G. Stone
E. Ecology	T. Haarmann
F. Cultural Resources	K. Manz
G. Population Distribution	K. Jacobson
III. Compliance Summary	
A. Introduction	J. Johnston, K. Lyncoln
B. Compliance Status	J. Alarid, M. Alexander, R. Beers, J. Carmichael, T. Foxx, B. Gallaher, T. Haarmann, K. Manz, A. Puglisi, S. Rae, R. Reynolds, D. Rogers, M. Saladen, B. Sinha, D. Stavert, J. White, N. Williams
C. Current Issues and Actions	K. Jacobson, K. Lyncoln, A. Puglisi, S. Rae, M. Saladen, D. Stavert, J. White
IV. Environmental Program Information	
A. Major Environmental Programs	J. Johnston, K. Lyncoln
B. National Environmental Policy Act Assessments	B. Sinha
C. Other Significant Environmental Activities at Los Alamos	L. Anderman, M. Burns, R. Conrad, M. Cox, R. Ferenbaugh, P. Fresquez, B. Gallaher, T. Haarmann, D. Hollis, D. Kraig, M. Maes, S. McLin, R. Rangel, D. Rogers, G. Stone
V. Environmental Radiological Program Information	D. Armstrong, R. Beers, P. Fresquez, B. Gallaher, K. Jacobson, S. McLin, R. Rangel, D. Rogers
VI. Environmental Nonradiological Program Information	M. Alexander, R. Beers, P. Fresquez, B. Gallaher, K. Jacobson, S. McLin, M. Saladen
VII. Groundwater Protection Management Program	A. Adams, B. Gallaher, F. Goff, P. Longmire, M. Maes, S. McLin, D. Rogers, A. Stoker
VIII. Quality Assurance And Sampling Procedures	P. Beaulieu, J. Johnston

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1994

ABSTRACT

This report describes the environmental surveillance program at Los Alamos National Laboratory (LANL or the Laboratory) during 1994. 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 1994 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.

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, foodstuffs, and soil for radiation, radioactive materials, and hazardous chemicals. Every year, the data are 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 1994. Each year more than 11,000 environmental samples are the subject of over 200,000 analyses for radioactive and nonradioactive constituents.

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

Type of Monitoring	Off Site		On Site		Total
	Regional	Perimeter Area	Laboratory	Waste Disposal Area	
External radiation	4	23	51	88	166
Air	6[a]	13	22	9	50[b]
Surface waters[c,d]	6	10	12	0[e]	28
Groundwater[c]	0	32	19	15	66
Soils	7	6	9	1	23
Sediments	11	19	29	21	80
Foodstuffs	13	11	21	1	46
Meteorology	0	1	7	0	8

[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 and 13 wells at the Pueblo of San Ildefonso 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.

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.

Radiation Doses. Radiological doses are calculated 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 CY94, the estimated maximum committed EDE due to Laboratory operations was 3.5 mrem, taking into account shielding by buildings (30% reduction) and occupancy (100% for residences, 25% for businesses). It is 3.5% 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 1994 Laboratory operations. The estimated maximum EDE from Laboratory operations is about 1% of the 348 mrem received from background radiation and radioactivity in Los Alamos during 1994 (Figure I-2).

The EPA-approved method of calculating EDE, which is used to demonstrate compliance with National Emissions Standards for Hazardous Air Pollutants requirements, does not allow the Laboratory to take into account shielding or occupancy factors. In 1994, that EDE was 7.62 mrem, which is in compliance with EPA standards of 10 mrem/yr from the air pathway.

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,

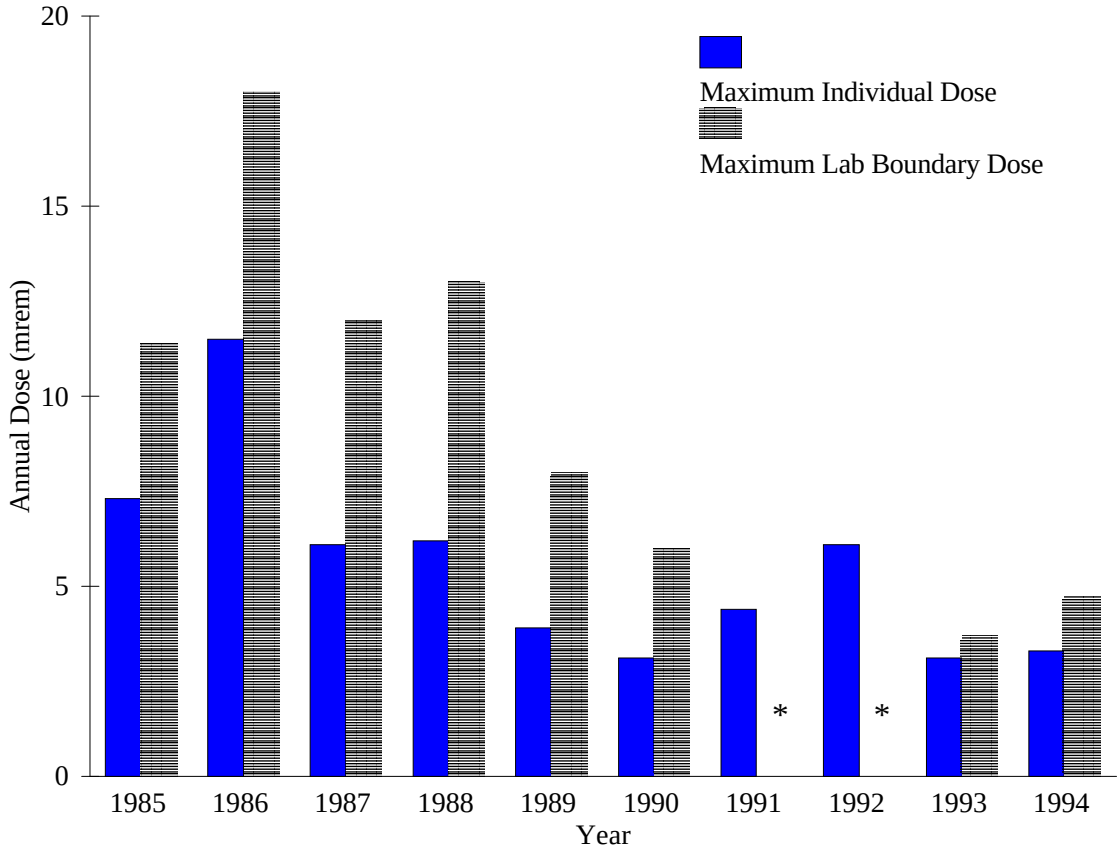


Figure I-1. Summary of estimated maximum individual and maximum Laboratory boundary doses from external penetrating radiation generated by Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources). Maximum individual dose calculated with DOE-approved methods that take building shielding and occupancy into account.
*No above-background Laboratory boundary doses were recorded during 1991 or 1992.

Table I-2. Summary of Annual Effective Dose Equivalents Attributable to 1994 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	3.5 mrem	0.27 mrem	0.06 mrem	4 person-rem
Location	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km of the Laboratory
Background	348 mrem	348 mrem	336 mrem	72,000 person-rem
DOE Public Dose Limit	100 mrem	—	—	—
Percentage of Public Dose Limit	3.5%	0.27%	0.06%	—
Percentage of Background	1.0%	0.077%	0.018%	0.006%

[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.

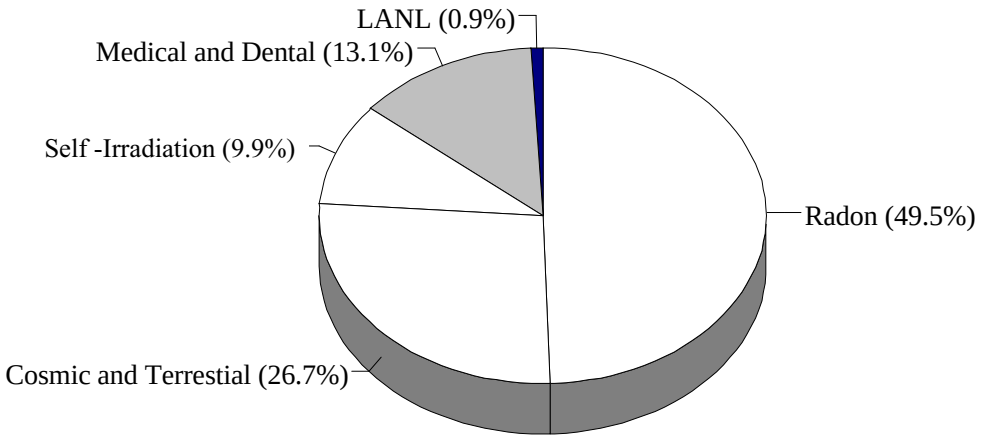


Figure I-2. Total contributions to 1994 dose at the Laboratory's maximum exposed individual location.

the risk of contracting some form of cancer is 1 chance in 4. Because of the radiation released by 1994 Laboratory operations, Los Alamos and White Rock residents may 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 using thermoluminescent dosimeters (TLDs) at 166 stations located both on and off site. Annual averages for the TLDs were generally the same in 1994 as in 1993, consistent with the variability in natural background radiation observed at the monitoring stations. 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 1994. Ambient air is routinely sampled for tritium, plutonium, americium, uranium, radioiodine, and gross alpha and beta activity. Total radioactive airborne emissions during 1994 increased slightly from those in 1993. Table I-4 presents both the 1993 and 1994 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 1994, the maximum dose to a member of the public of 7.62 mrem from airborne releases was calculated using the EPA-approved computer program CAP-88. More than 95% of the modeled 1994 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 DOE reported to EPA that LANL did not meet the requirements of 40 CFR 61, Subpart H. In response, EPA issued LANL a Notice of Noncompliance (NON). As a result of the NON, the DOE and EPA initiated negotiations to enter into a Federal Facilities Compliance Agreement (FFCA). The FFCA will include schedules that the Laboratory will follow to come into compliance with the Clean Air Act and will continue to address the issues raised in the 1991 NON.

Unplanned Airborne Releases. There were three unplanned airborne radiological releases reported during 1994. 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 measure nonradiological ambient air quality; this includes monitoring for beryllium, acid precipitation, and visibility. These data are collected for environmental surveillance reasons and are not required by federal or state environmental regulations.

Table I-3. Added Individual Lifetime Cancer Mortality Risks Attributable to 1994 Radiation Exposure

Exposure Source	EDE Used in Risk Estimate (mrem)[a]	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.27	less than 1 in 1,000,000
White Rock area	0.06	less than 1 in 1,000,000
Natural Radiation		
Cosmic, terrestrial, self-irradiation, and radon exposure[b]		
Los Alamos	348	1 in 7,000[c]
White Rock	336	1 in 8,000[c]
Medical X-Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in 43,000

[a]1 mrem = 0.01 mSv.

[b]An EDE of 200 mrem (2.00 mSv) was used to estimate the risk from inhaling ^{222}Rn and its transformation products.

[c]The risks from natural radiation from nonradon sources were estimated to be 1 chance in 15,000 in Los Alamos and 1 chance in 17,000 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).

Table I-4. Comparison of 1993 and 1994 Radionuclides from Laboratory Operations

Airborne Emissions[a]

		Activity Released		Ratio
Radionuclide	**Units**	**1993**	**1994**	**1994:1993**
Tritium	Ci	2,100	1,100	0.5
Uranium	µCi	270[b]	380[b]	1.4
Plutonium	µCi	6	13	2.2
Gaseous mixed activation products	Ci	32,100	50,200	1.6
Mixed fission products	µCi	1,360	450	0.3
Particulate/vapor activation products	Ci	13	0.4	0.03
Total	Ci	34,200	51,300	

Liquid Effluents

		Activity Released (mCi)		Ratio
Radionuclide	**Units**	**1993**	**1994**	**1994:1993**
Tritium	mCi	2,660.00	2,230.00	.84
$^{82,85,89,90}Sr$	mCi	7.64	37.00	4.84
^{137}Cs	mCi	8.17	8.5	1.04
^{234}U mCi	0.12	.12		1
$^{238,239,240}Pu$	mCi	1.08	3.25	3.01
^{241}Am	mCi	11.20	3.06	.273
Total	mCi	2,688.21	2,281.93	

[a]Detailed data are presented in Tables V-4 and V-5 for airborne emissions.

[b]Does not include dynamic testing.

Compliance with the Federal Clean Air Act and the New Mexico Air Quality Control Act. These acts establish ambient air quality standards, require permits for new and modified sources, set acceptable emissions limits and require operational controls on some Laboratory processes. During 1994, the Laboratory's operations that emit nonradioactive air pollutants were in compliance with all applicable federal and state air quality regulations.

Surface Water and Groundwater Monitoring. The Laboratory monitors surface waters and groundwaters to detect potential or known transport of contaminants from the Laboratory. Measureable concentrations of radionuclides from Laboratory operations (primarily historical) are transported by surface water off site in 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), and one location beneath Mortandad Canyon (Test Well 8).

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 two wells into the main aquifer at the Laboratory and two wells in Los Alamos Canyon. 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 three 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 three primary programs at the Laboratory established to comply with the Clean Water Act (CWA) are the National Pollutant Discharge Elimination System (NPDES) program, the Spill Prevention Control and Countermeasure (SPCC) program, and the sewage sludge monitoring program.

The Laboratory's new NPDES permit became effective August 1, 1994. The new NPDES permit included additional monitoring requirements and more stringent effluent limits. In CY94, the Laboratory was in compliance with the NPDES permit in 100% of the analyses sampled at sanitary wastewater discharges and 98.6% at the industrial wastewater discharges.

The Laboratory has an SPCC Plan, as required by 40 CFR 112. This plan provides the Laboratory with specific requirements for secondary containment and spill prevention for aboveground storage tanks, drums, other containers, and material handling operations to control accidental oil and chemical spills from reaching the environment.

In 1994, sewage sludge generated at the Laboratory's Technical Area (TA) 46 Sanitary Waste Stream Consolidation plant was in full compliance with the federal standards (40 CFR Part 503) governing the beneficial reuse and land application of sewage sludge.

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).

On September 9, 1992, EPA published the final General Permits for storm water discharges associated with industrial and construction activity. The Laboratory chose to apply for coverage under the General Permit. Currently the Laboratory has five NPDES General Permits for its storm water discharges. One permit is for the Laboratory site and includes the following industrial activities: hazardous waste treatment, storage, or disposal facilities, operating under interim status or a permit under Subtitle C of the Resource Conservation and Recovery Act (RCRA), (this category includes solid waste management units); landfills, land application sites, and open dumps including those that are subject to regulation under Subtitle D of RCRA; and steam electric power generating facilities. The other four permits are for construction activities disturbing more than five acres. These projects are the TA-53 Lagoon Elimination project; the Los Alamos Integrated Communication System project; the Dual Axis Radiographic Hydrotest facility; and the Small Arms Firing Range remediation.

Compliance with the Safe Drinking Water Act. Samples are collected and analyzed from the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems and the Laboratory's water

supply wellheads on a routine basis in order to determine the levels of microbiological organisms, organic and inorganic chemical constituents, asbestos, and radioactivity in the drinking water. During 1994, all parameters regulated under the Safe Drinking Water Act were in compliance with the maximum containment levels established by regulation, with the exception of a microbiological violation in January 1994.

Unplanned Liquid Releases. There was one unplanned potential radioactive liquid release reported during 1994. At TA-21, Building 3 a corroded radioactive liquid waste line was found to have a hole. Further investigation revealed that the corroded line was contained by a concrete trench. Discharge from the leaking line did not reach the environment.

There were 23 unplanned nonradioactive liquid releases reported during 1994. These releases were minor in nature and were contained on Laboratory property; none was found to be of any threat to health or the environment.

Soil Monitoring. Soils are monitored both on and off site for radioactive tritium, strontium, cesium, uranium, plutonium, americium, alpha and beta particles, and gamma rays. All levels were within acceptable values, and no action was required to reduce levels of any radioactive element in the soil. In soil samples, one on-site higher-than-background concentration of plutonium was recorded, but this concentration was still far below the screening action level. Soils are analyzed for trace and heavy metals, such as iron, lead, mercury, and aluminum. In 1994, all samples were within acceptable levels for the Los Alamos region. Although some on-site readings for beryllium and arsenic were above background levels, the sources were natural; therefore, no action was required by the Laboratory.

Sediments Monitoring. Measurements of radioactivity and chemicals in samples of 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 radioactive 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. This act regulates hazardous wastes from generation through disposal. As of 1994, the EPA has given full authority for administering the RCRA, with the exception of the Hazardous and Solid Waste Amendments of 1984, to NMED. NMED administers its hazardous waste program under RCRA and NM Hazardous Waste Act (NMHWA) authorities. LANL had frequent interactions with federal and state RCRA/NMHWA personnel during 1994. DOE and the EPA signed an FFCA addressing mixed waste storage and treatment subject to land disposal restrictions on March 15, 1994. NMED conducted its annual waste compliance inspection the week of September 14, 1994. NMED issued a RCRA compliance order (CO) to DOE/LANL in 1994 based upon a self-reported incident; another CO was issued as a result of findings from the 1993 multimedia inspection, which included NMED's annual RCRA compliance inspection. Proposed fines totaled $273,000. All required actions were completed. The final negotiated penalties totaled $75,770.

No underground storage tanks were removed during 1994. During 1994, the Laboratory's Environmental Restoration program submitted four RCRA facility investigation (RFI) work plans and two addenda to RFI work plans. Other laws regulating hazardous material management and 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. Foodstuffs are collected from Laboratory and surrounding communities to determine the impact of LANL operations on the human food chain. Most produce, milk, fish, and honey samples from Laboratory and/or perimeter locations showed no radioactivity distinguishable from that attributable to natural sources or worldwide fallout. Some honey samples from on-site locations, particularly from TA-53, had elevated tritium concentrations (1,300 pCi/mL) as compared to background (0.37 pCi/mL). However, honey from hives on Laboratory property is not available for public consumption.

Resource Assessments. In accordance with the National Environmental Policy Act of 1969, federal agencies must consider the environmental impacts of proposed activities. In 1994, the Laboratory's Environmental Assessments and Resource Evaluations 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.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, US priorities, and the world community have changed. Los Alamos is a multiprogram laboratory with the central mission of reducing the nuclear danger. The central mission at the Laboratory has evolved beyond the nuclear weapons research, development, and testing role to now include five major elements:

- environmental stewardship of the Department of Energy (DOE) complex;
- nuclear materials stewardship through protection, disposition, and fabrication technologies;
- stockpile stewards;
- support for the enduring stockpile; and
- prevention, detection, and analysis of nuclear weapons proliferation.

Today we use the core technical competencies developed for defense programs to carry out both our national security responsibilities and our broadly based programs to improve

- the quality of the environment;
- energy recovery and usage;
- our national infrastructure;
- our economic and industrial competitiveness;
- leadership in research; and
- the quality of science and technology through improved education and research opportunities and training.

We emphasize an intermediate role for the Laboratory—between academic and industrial research—that will help expedite the development and commercialization of emerging technologies. In all our programs, we continue to maintain an intellectual environment that is open to new ideas. In addition, we are committed to ensuring that all our activities are designed to protect employees, the public, and the environment (LANL 1994).

The operating cost of the Laboratory for fiscal year 1994 (FY94) was $1,002 million, with an additional $43 million for capital equipment and $5 million for construction. In FY94, $868 million of the operating cost was spent on DOE programs, including $388 million on defense programs, $192 million on Environmental Restoration and Waste Management, and $86 million on Nonproliferation and International Security. Approximately $134 million is spent on work for others, including $78 million on Department of Defense projects.

In August 1994, the Laboratory employed more than 6,500 persons in permanent positions; approximately 39% of these employees are technical staff members, 7% are managers, 12% are support staff members, 26% are technicians, and 16% are either office or general support. The Laboratory also employed another 2,500 people in special programs such as work-study programs, graduate research positions, and 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 technical and support offices.

II. Introduction

During 1994, the Laboratory's organization structure was altered in an effort to eliminate several layers of management. The Director is supported by a Deputy Director; both the Director and the Deputy Director are supported by Special Assistants. The current Laboratory management structure consists of 18 division offices, 10 program offices, and 6 institutional offices.

The Environmental Management (EM) Division was also reorganized and renamed during 1994. Groups that had been involved in environmental protection and surveillance activities were reorganized as follows:

- The Waste Management Group (EM-7) first became part of the Chemical Science & Technology (CST) Division and was further divided into groups within the Division that correlated roughly to the sections in the original EM-7 Group:

CST-5	Chemical and Mixed Waste Science
CST-7	Transuranic Characterization & Treatment & Decontamination
CST-13	Liquid Waste & Radioactive Liquid Waste Treatment Facility Project Office
CST-14	Radioactive Waste
CST-16	Thermal Destruction Science & Technology
CST-18	Technology Implementation
CST-27	Facility Management Office

- The Environmental Protection Group (EM-8) first became part of the newly organized Environmental, Safety, and Health (ESH) Division and was further divided into groups that correlate roughly to sections in the original EM-8 Group.

ESH-17	Air Quality
ESH-18	Water Quality & Hydrology
ESH-19	Hazardous & Solid Waste
ESH-20	Environmental Assessments and Resource Evaluations

In addition, two project offices were created

Site-Wide Environmental Impact Statement (SWEIS); and
Order Compliance & Self-Assessment.

- The Environmental Chemistry Group (EM-9) first became CST-9 and was later divided into smaller groups:

CST-3	Analytical Services
CST-9	Inorganic Trace Analysis
CST-11	Nuclear & Radiochemistry
CST-12	Organic Analysis

In 1994, the ESH Division was the primary Laboratory support program for environmental protection and surveillance activities. Groups in ESH Division initiate and promote Laboratory programs for environmental protection and are responsible for environmental surveillance and regulatory compliance. Although the Laboratory Director has primary responsibility for ESH management, ESH Division provides line managers with assistance in preparing and completing environmental documentation such as reports required by the National Environmental Policy Act (NEPA) of 1969 and the federal Resource Conservation and Recovery Act and its NM counterpart, the NM Hazardous Waste Act. With assistance from the Laboratory Counsel, ESH Division helps to define and recommend Laboratory policies with regard to applicable federal and state environmental regulations and laws and DOE orders and directives.

The ESH Division is responsible for 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 ESH Identification Process, which in 1994 replaced the Environmental, Safety, and Health Questionnaire Review Committee,

provides reviews of proposed projects to ensure that appropriate environmental, as well as health and safety, issues are properly addressed. In 1994, the committee reviewed 234 questionnaires. The Laboratory Environmental Review Committee reviews NEPA documentation for projects before submitting the documents to DOE. The Environmental, Safety, and Health 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 m (25 mi) northwest of Santa Fe (Figure II-1). The 111-km^2 (43-mi^2) Laboratory site is situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west oriented canyons cut by intermittent streams (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 (TAs) 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 White Rock 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 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.
- 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.

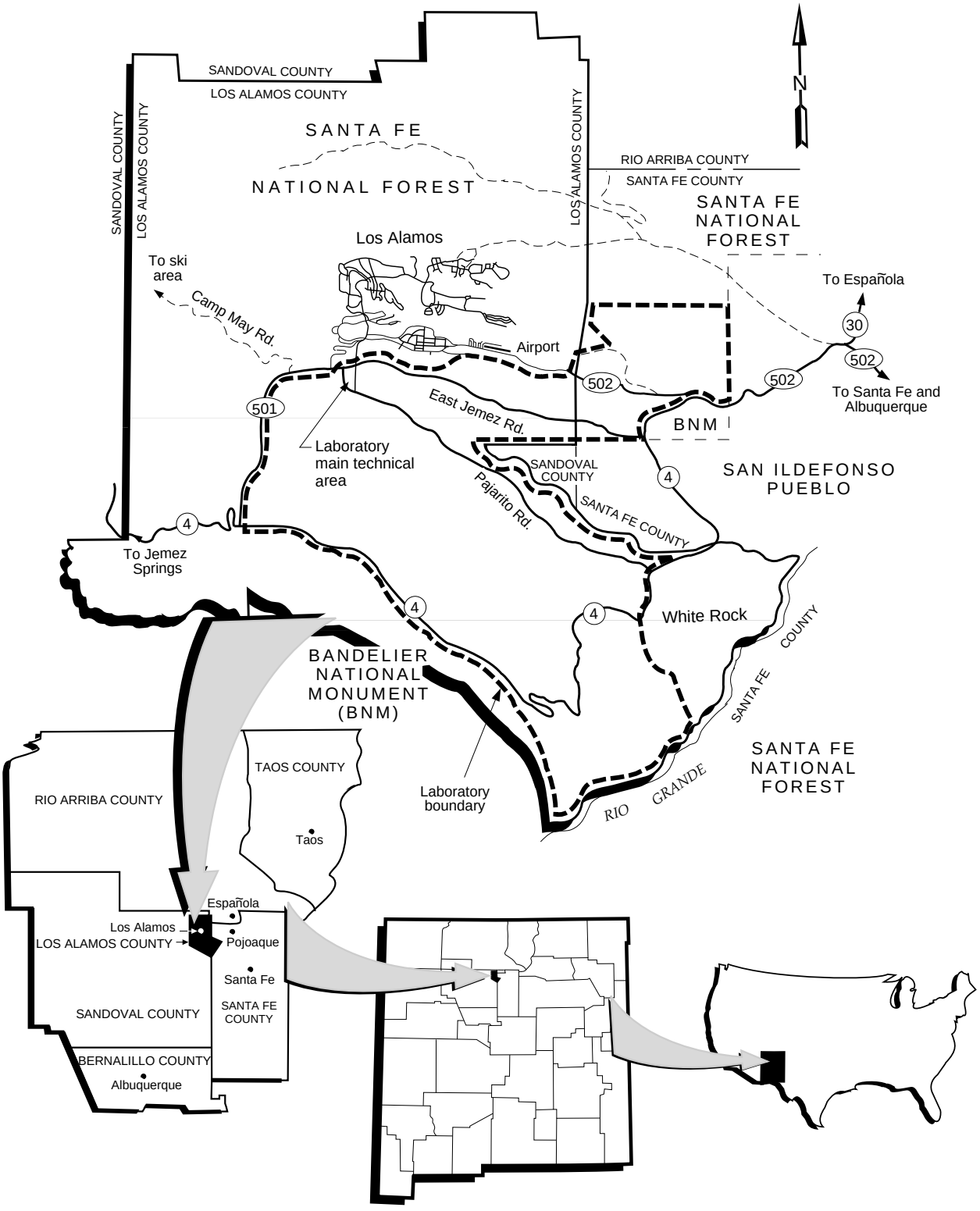


Figure II-1. Regional Location of Los Alamos National Laboratory.

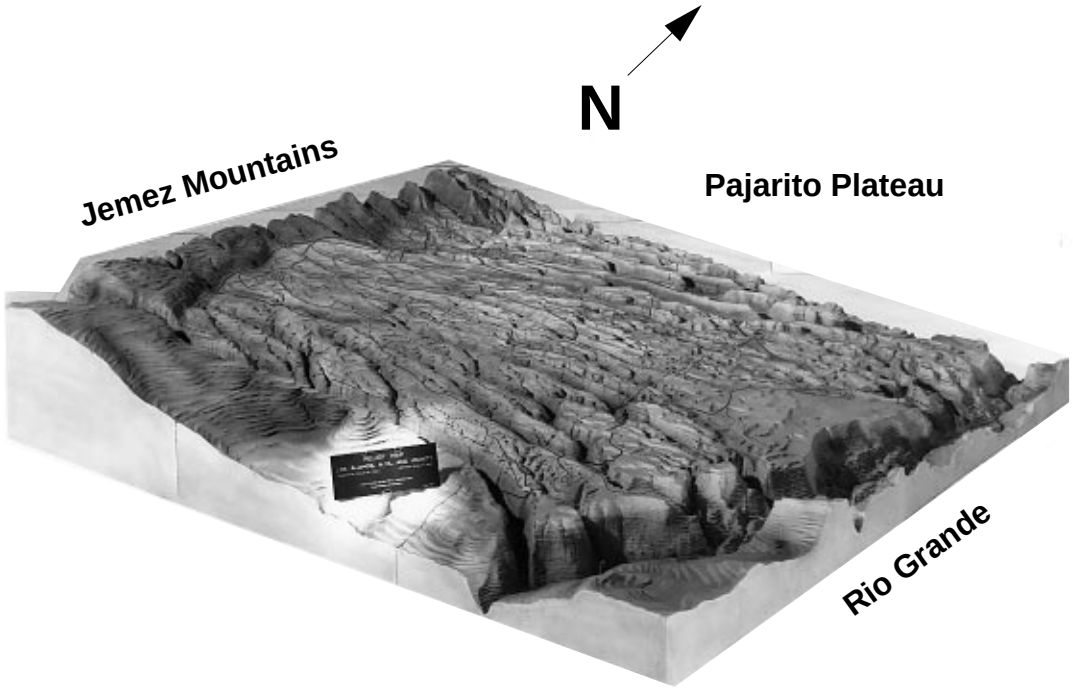


Figure II-2. Topography of the Los Alamos area.

- 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.

The NERP program was inactive in 1994 because of funding constraints.

Environmental Impact Statement. An environmental impact statement 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. Since then, the environmental impacts of major new or revised Laboratory projects and facilities have been evaluated individually under NEPA.

In 1994, DOE initiated work on an updated SWEIS for the LANL facility. In November 1994, DOE held a series of public meetings throughout northern New Mexico in order to identify issues and concerns that would be addressed in the new LANL SWEIS. In December, the Laboratory established its SWEIS Project Office in order to support DOE and to be a single point of contact within the Laboratory in both collecting and disseminating information.

The purpose of the new SWEIS is to provide a comprehensive and cumulative look at the environmental impacts of both ongoing Laboratory activities and projected future activities of the Laboratory. The SWEIS will address operations and planned activities foreseen within the next five to ten years. It will enable the Laboratory to become a better steward of the environment and a better planner for the future. The SWEIS will describe the major activities at the Laboratory and the most important impacts as determined through a scoping process involving the

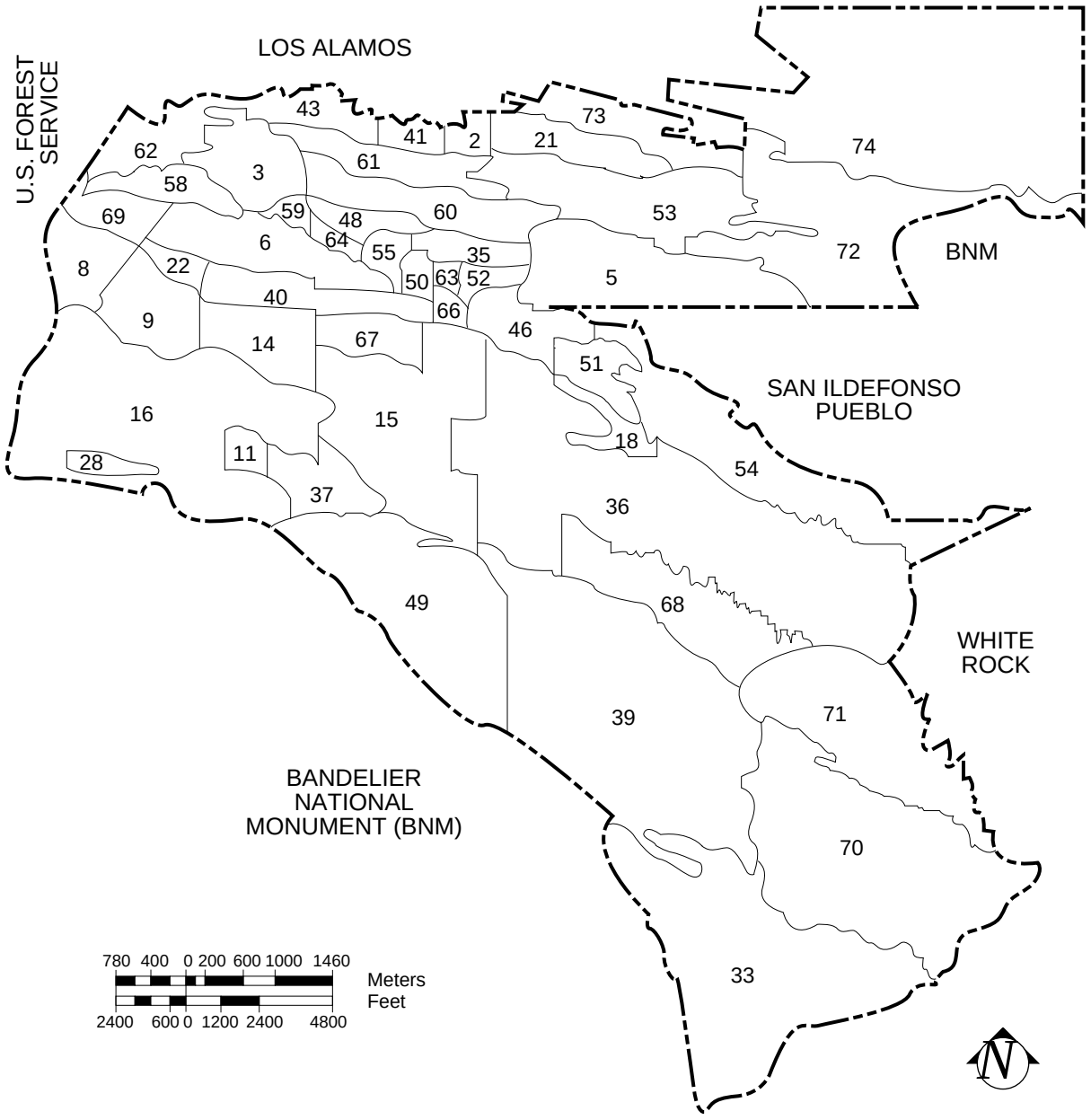


Figure II-3. Technical areas (TAs) of Los Alamos National Laboratory in relation to surrounding landholdings.

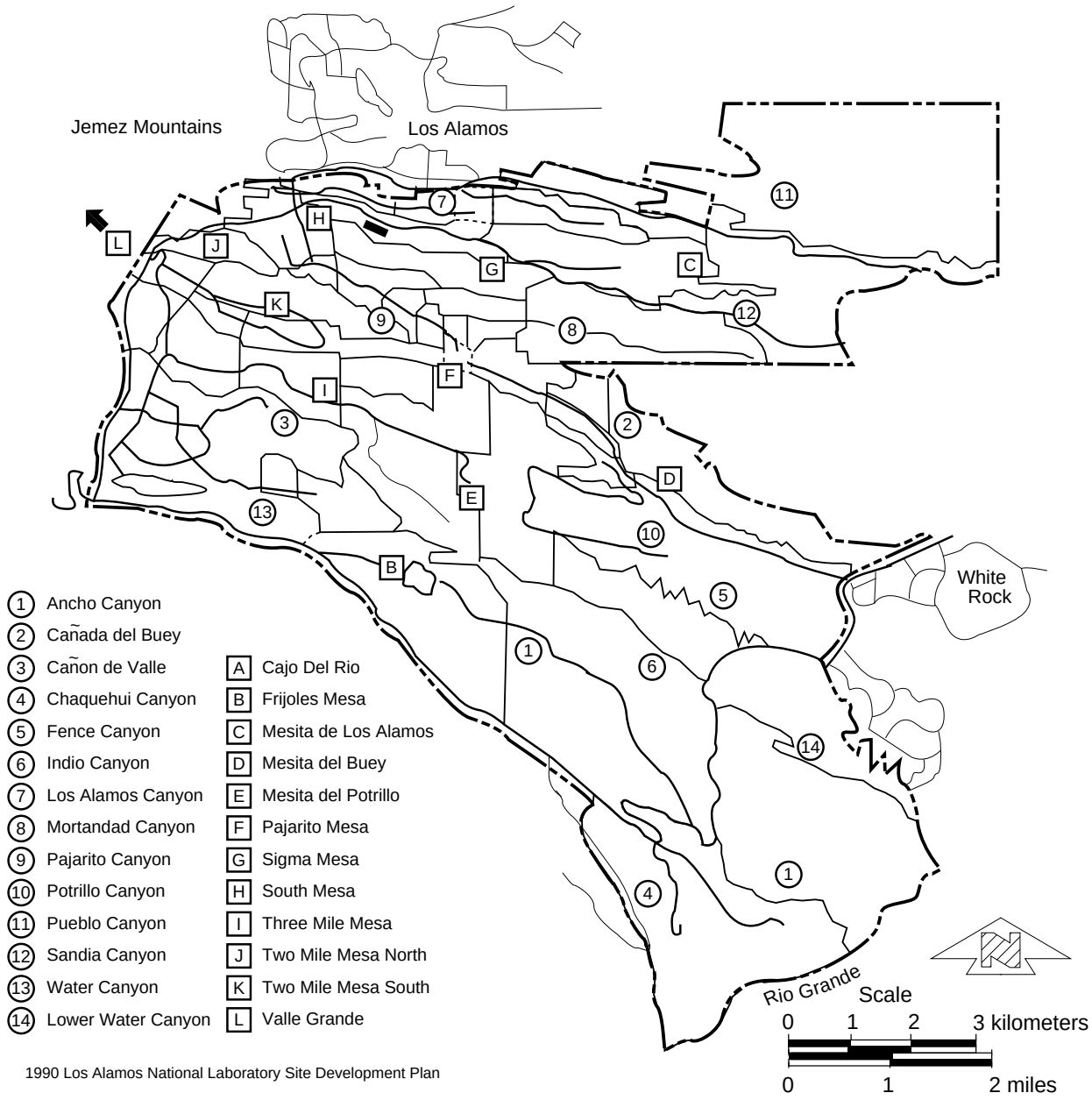


Figure II-4. Major canyons and mesas.

public. While the SWEIS is in preparation during 1995 and 1996, major new initiatives cannot take place unless they are justified independently and are the subject of separate NEPA documentation.

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 more than 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 short-lived or intermittent reaches of streams. Perennial springs on the flanks of the Jemez Mountains supply base flow into upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the Laboratory site before they are depleted by evaporation, transpiration, and infiltration. 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.

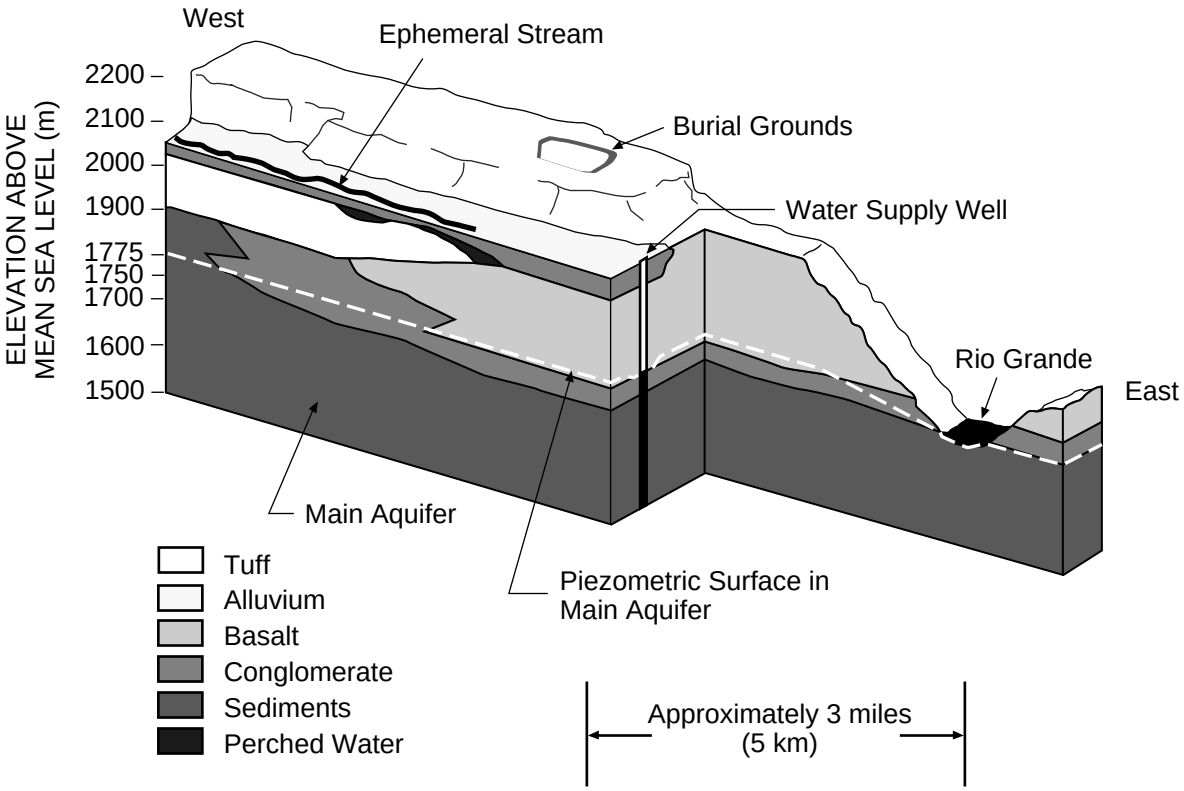


Figure II-5. Conceptual illustration of geologic and hydrologic relationship in Los Alamos area.

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.

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 los Frijoles receives an estimated 5.3 to 6.8 x 10^6 m^3 (4,300 to 5,500 ac-ft) annually from the aquifer.

D. Climatology

Bowen (1990) published a comprehensive climatology of the Los Alamos area based on observations at several meteorological-observing stations within the Laboratory's boundary. This early work was followed by a summary document (Bowen 1992) that used more recent observations. These documents should be consulted for detailed analyses and station-to-station comparisons.

The climate description presented here summarizes some of the Bowen analyses supplemented with recent observations of wind patterns in Los Alamos canyon and evapotranspiration. The material is organized in sections that discuss the meteorological variables related to (1) the state of the atmosphere (its temperature, pressure, and moisture), (2) precipitation, (3) wind conditions, and (4) the exchange of energy at the surface. Normal values are based on observations taken at the official Los Alamos meteorological-observing station from 1961 to 1990. When extremes are given, the entire record is used. Although the location of the "official" station has changed over the years, all locations are within 30 m (100 ft) of each other in elevation and 5 km (3 mi) in distance. The composite record from the official station is used to describe the climate of the Pajarito Plateau, at an elevation of approximately 2,250 m (7,400 ft) above sea level.

In general terms, Los Alamos has a temperate mountain climate with four distinct seasons. Spring tends to be windy and dry. Summer begins with warm, often dry, conditions in June, followed by a two-month rainy season. In the autumn there is a return to drier, cooler, and calmer weather. And in winter, mid-latitude storms drop far enough south to keep the ground covered with snow for about two months. Details of the climate are presented below.

Atmospheric State. In July, the warmest month of the year, the temperature ranges from an average daily high of 27.2˚C (81˚F) to an average daily low of 12.8˚C (55˚F). The extreme daily high temperature in the record is 35˚C

(95˚F). In January, the coldest month, the temperature ranges from an average daily high of 4.4˚C (40˚F) to a low of –8.3˚C (17˚F). The extreme daily low temperature in the record is –27.8˚C (–18˚F). The large daily range in temperature results from the site's relatively dry, clear atmosphere, which allows strong solar heating during the daytime and rapid radiative cooling at night.

Although the dry atmosphere promotes rapid nighttime cooling near the ground, this cooling is somewhat counterbalanced by the flux of heat from above, generated by turbulence in the drainage flow. Therefore, the strong surface-based temperature inversions often observed in valleys are not observed on the Pajarito Plateau. Inversions of 3˚C (5.4˚F) more than 100 m (328 ft) are typical, and these are generally destroyed in less than 2 hours after sunrise.

Average atmospheric pressure at the official observing station is 776 mbar (22.92 in. of mercury), which is 76% of standard sea level pressure. The average near-surface air density for the site is 0.958 kg/m^3; this is based on a calculation using the mean pressure and temperature at the official observing station.

Although relative humidity can vary considerably over 24 hours, monthly average values vary little during the year. Monthly average relative humidity ranges from a low of 39% in June to a high of 56% in December, averaging 51% over the entire year. Absolute humidity, a better indicator of atmospheric moisture content, ranges from a low of 2.4 g of water/m^3 of air in January to a high of 8.7 g/m^3 in July and August, when moist, subtropical air invades the region during the rainy season. Fog in Los Alamos is very rare, occurring less than five times a year on average.

Precipitation. ***T***he average annual precipitation (rainfall plus the water-equivalent of frozen precipitation) is 47.6 cm (18.7 in.). However, the annual total fluctuates considerably from year to year; the standard deviation of these fluctuation is 12.2 cm (4.8 in.). 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.). The maximum 15-min precipitation in the record is 2.3 cm (0.9 in.).

Because of the eastward slope of the terrain, there is a large east-to-west gradient in precipitation across the plateau. White Rock often receives 13 cm (5.1 in.) less annual precipitation than does the official observing station, and the eastern flanks of the Jemez often receive 13 cm (5.1 in.) more.

About 36% of the annual precipitation falls from convective storms during July and August. Most of these convective storms are of the single-cell type; local conditions do not support the development of supercells and the severe weather associated with them.

This summertime precipitation maximum is often referred to as the "monsoon" season. However, the signature of a true monsoon circulation, namely large and persistent changes in wind direction, is not observed. "Rainy season" is probably a more accurate characterization of the July–August period.

Lightning occurs frequently in Los Alamos. In an average year Los Alamos experiences 61 thunderstorm days a year, about twice the national average. (A thunderstorm day is defined as a day on which thunder is heard or a thunderstorm occurs.) Only in the southeastern part of the country is this frequency exceeded. In addition to lightning, hail often accompanies these summertime convective storms. Hailstones of 0.6 cm (0.25 in.) are common, but stones of 2.54 cm (1 in.) have been reported. Hail has caused significant damage to property and vegetation, and localized accumulations of 7.6 cm (3 in.) have been observed.

Winter precipitation occurs mostly as snow; freezing rain is rare. The snow is generally dry; on average 20 units of snow is equivalent to 1 unit of water. Annual snowfall averages 150 cm (59 in.) but is quite variable. The standard deviation of fluctuations in the annual value is 71 cm (28 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.). In a typical winter season, snowfalls equal to or exceeding 2.6 cm (1 in.) occur on 14 days, and snowfalls equal to or exceeding 10.2 cm (4 in.) occur on four days. The extreme single-storm snowfall in the record is 122 cm (4 ft).

Wind Conditions. Los Alamos winds are generally light, having an annual average (at the Technical Area [TA] 6 station) of 2.5 m/s (5.5 mi/h). However, the period from mid-March to early June is apt to be windy. During this windy period, sustained wind speeds exceeding 4 m/s (8.8 mi/h) occur 20% of the time during the daytime, and the daily maximum wind gust exceeds 14 m/s (31 mi/h) about 20% of the time. The highest wind gust in the record is 34.4 m/s (77 mi/h). High winds are associated with frontal passages, thunderstorms, and mid-latitude storm systems. No tornadoes are known to have touched ground in the Los Alamos area; however, funnel clouds have been observed in Los Alamos and Santa Fe counties.

Winds over the plateau show considerable spatial structure and temporal variability. The relatively dry climate promotes strong solar heating during the daytime and radiative cooling by night. And because the topography is

very complex, the heating and cooling rates are uneven over the area. When the large-scale pressure gradient is weak, thermally generated local flows develop and respond to the heating/cooling cycle.

During sunny, light-wind days, an upslope flow often develops over the plateau in the morning hours. This flow is more pronounced along the western edge of the plateau, where it is 200 to 500 m (650 to 1,650 ft) deep. By noon, southerly flow usually prevails over the entire plateau.

The prevailing nighttime flow over the western portion of the site is west-southwesterly to northwesterly. These nighttime westerlies result from cold air drainage off the Jemez Mountains and the Pajarito Plateau; the drainage layer is typically 50 m (165 ft) deep in the vicinity of TA-6. At stations farther from the mountains, the nighttime direction is more variable but usually has a relatively strong westerly component. Just above the drainage layer, the prevailing nighttime flow is southwesterly.

Analysis of observations taken at TA-41 in Los Alamos Canyon shows that atmospheric flow in canyons is quite different from flow over the plateau. During the nighttime, down-canyon drainage flow is observed about 75% of the time. This gravity flow is steady and continues for an hour or two after sunrise, when it abruptly ceases and is followed by an unsteady up-canyon flow for a couple of hours. The up-canyon flow usually gives way to the development of what appears to be a rotor that fills the canyon when the wind over the plateau has a strong cross-canyon component. When the rotor occurs, southwesterly (or southeasterly) flow over the plateau results in northwesterly (or northeasterly) flow at the canyon bottom. Down-canyon flow begins again around sunset, but the onset time appears to be more variable than cessation time in the morning. Rotors have been observed at night, but they are very rare.

Turbulence intensity—when expressed as the standard deviation of fluctuations in the horizontal wind direction—has a median value of 22° during the day. Other things being equal, this value is larger than would be observed over flatter, smoother sites. At night, when the atmosphere is stable, the median value of the standard deviation of wind direction fluctuations drops to 15°.

Atmospheric dispersion potential is often related to a stability parameter that ranges from A to F (good to poor mixing potential). When this parameter is based on wind direction fluctuations measured at the TA-6 station, the frequency of occurrence of different stability parameter values is A: 16.5%, B: 11.8%, C: 15.7%, D: 22.5%, E: 14.2%, and F: 19.3%. Statistics vary from station to station.

Energy Exchange at the Surface. Solar irradiance measurements show that Los Alamos receives more than 75% of possible sunshine annually. (Possible sunshine is defined as the amount received when the sky is cloud-free.) During most of the year, when there is no snow on the ground, about 80% of this incoming solar energy is absorbed at the surface. About half of this absorbed shortwave energy is offset by longwave radiation to space. The remainder of the radiant energy, called the net all-wave radiation, is dissipated by heating the soil, heating the lower layer of the atmosphere, and evaporating water from the soil and plants (called evapotranspiration). Preliminary analyses suggest that monthly total evapotranspiration reaches a maximum value of 6.4 cm (2.5 in.) in July. Monthly totals during the winter months are less than 0.6 cm (0.25 in.). Over the entire year, it appears that evapotranspiration totals approximately 90% of the annual precipitation.

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 65% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and close to 1,500 sites have been recorded. More than 85% of the ruins date from the 14th and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% lying between 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 1994, the estimated population of Los Alamos County was approximately 18,000 (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 6,000 residents. About 40% of the people employed by UC, DOE, and Laboratory contractors commute from outside Los Alamos County. It is estimated that approximately 234,000 persons lived within an 80-km (50-mi) radius of the Laboratory in 1994 (Table II-1).

Table II-1. Projected 1994/1995 Population within 80 km of Los Alamos National Laboratory[a]

	Distance from TA-53 (km)									
Direction	**0-1**	**1-2**	**2-4**	**4-8**	**8-15**	**15-20**	**20-30**	**30-40**	**40-60**	**60-80**
N	7	68	240	129	0	13	87	917	786	566
NNE	7	61	83	16	2	10	2,311	386	646	296
NE	4	7	0	0	1	1,185	14,165	2,436	2,363	3,483
ENE	0	0	0	0	540	1,456	4,282	3,426	1,369	1,493
E	0	0	0	1	313	1,291	3,852	362	21	401
ESE	0	0	0	0	7	11	652	7,408	679	2,108
SE	0	1	0	4,552	496	0	947	69,214	7,129	640
SSE	2	3	0	604	354	0	289	5,397	2,444	101
S	3	3	0	0	21	0	15	127	381	2,962
SSW	3	3	0	0	31	1	711	1,244	6,463	49,597
SW	3	11	0	0	4	1	0	0	2,037	164
WSW	1	16	29	0	7	0	26	355	2,340	4
W	0	3	83	216	0	6	61	267	57	68
WNW	2	15	969	6,155	0	0	24	28	58	2,427
NW	5	31	887	1,407	0	2	23	47	418	553
NNW	7	63	639	288	0	5	19	253	154	284
1995 Pop. Distribution	44	285	2,930	13,368	1776	3,981	27,464	91,867	27,345	65,147

[a]Total projected 1994/1995 population within 80 km of Los Alamos National Laboratory is 234,207.

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) and NM Hazardous Waste Act (NMHWA) personnel during 1994. The Department of Energy (DOE) and the Environmental Protection Agency (EPA) signed a Federal Facilities Compliance Agreement (FFCA) addressing mixed waste storage and treatment subject to land disposal restrictions (LDRs) on March 15, 1994. Seventeen of the FFCA's 47 milestones requiring studies, work-off plans, design of new facilities, and on- and off-site treatment of backlogged wastes in storage were due during 1994. DOE and LANL successfully complied with all 17 milestones on time. DOE and LANL received two RCRA/NMHWA compliance orders (COs) from the New Mexico Environment Department (NMED) during 1994. NMHWA COs 94-09 and 94-12 alleged violations of the act, required corrective actions, and proposed fines totaling $273,000. All required corrective actions were implemented on time or were resolved through negotiations. The final negotiated penalties totaled $75,770.

No underground storage tanks (USTs) were removed or installed during the year. An UST inspection was conducted on January 25, 1994, by the NMED. DOE received a field notice of violation (NOV) on February 24, 1994, from the inspection. The finding from the NOV was corrected on March 4, 1994. There was no petroleum release associated with this finding.

In 1994, the Laboratory was in compliance with its on-site liquid discharge requirements in 100% of the samples from its sanitary effluent outfalls and in 98.6% of the samples from its industrial effluent outfall. Concentrations of chemical and radiological constituents in the drinking water distribution system remained within federal and state water supply standards. In January, the Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) for bacteria at the North Community Fire Station (FS No. 4) and Ponderosa Estates subdivision were exceeded. The coliform contamination was eliminated by flushing the distribution systems serving these areas. Sewage sludge generated in 1994 at the Laboratory's Technical Area (TA) 46 Sanitary Waste Stream Consolidation (SWSC) plant was in full compliance with the federal standards (40 CFR Part 503) governing the beneficial reuse and land application of sewage sludge.

In September 1994, the Laboratory received notice from the Army Corps of Engineers that erosion from a road and sewer line was causing damage to Sandia Canyon wetlands. The Laboratory plans to complete the erosion control for this area in 1995.

The Laboratory was in compliance with all federal nonradiological ambient air quality standards. The Laboratory's 1994 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 is calculated to be 7.62 mrem using EPA-approved methods.

During 1994, the Laboratory prepared 131 DOE Environmental Checklists (DECs) for the National Environmental Policy Act (NEPA) and submitted them to DOE. In addition, Laboratory archaeologists evaluated 904 proposed actions for possible effects on cultural resources, which required 32 intensive field surveys. Laboratory biologists reviewed 395 proposed actions for potential impacts on threatened and endangered species; 59 actions required additional study. During 1994, 465 proposed actions were reviewed for effect on floodplains and wetlands. Two proposed projects may be inside floodplain or wetland boundaries; floodplain or wetland assessments are being prepared for these projects.

III. Compliance Summary

A. Introduction

Many Laboratory activities and operations involve or produce liquids, solids, and gases that contain radioactive and/or nonradioactive hazardous materials. Laboratory policy directs its employees to protect the environment and address compliance with applicable federal and state environmental protection regulations. This policy fulfills DOE requirements to protect the public, environment, and worker health and to comply with applicable environmental laws, regulations, and orders.

Federal and state environmental laws address handling, transport, release, and disposal of contaminants, pollutants, and wastes, as well as protection of ecological, archaeological, historic, atmospheric, and aquatic resources. Regulations provide specific 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 and serves as an outline for the first section of this chapter. EPA, DOE, and NMED are the principal authorities administering the regulations to implement these laws. The environmental permits issued by these organizations and the specific operations and/or sites affected are presented in Table III-2.

The Compliance Summary is divided into two sections: Compliance Status and Current Issues and Actions. The Compliance Status section discusses the major environmental acts that the Laboratory operated under in 1994. The Current Issues and Actions section discusses other compliance issues that are not covered under the Compliance Status section.

B. Compliance Status

1. Resource Conservation and Recovery Act.

a. Introduction. EPA or an authorized state grants RCRA permits to specifically regulate 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 units and methods. A facility that has submitted a RCRA Part A permit application for an existing unit is allowed to manage hazardous or mixed wastes under transitional regulations known as the Interim Status Requirements pending issuance of a RCRA Operating Permit (Note: The term unit as it is used in this section refers to RCRA hazardous waste management areas). The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous or mixed waste management that require permitting. DOE/UC was granted a hazardous waste facility permit on November 8, 1989. Table D-1 lists the hazardous waste management facilities at the Laboratory.

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 created in the NMHWA and Hazardous Waste Management Regulations (HWMR). However, NMED has not yet obtained authorization for implementing the majority of the 1984 Hazardous and Solid Waste Amendments (HSWA). The HWMR has adopted, with a few minor exceptions, the federal codification for regulations in effect on July 1, 1993, concerning the generation and management of hazardous waste. On July 25, 1990, the State of New Mexico's Hazardous Waste Program was authorized by the EPA to regulate mixed waste in lieu of the federal program. 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 and for several planned new hazardous and mixed waste facilities in October 1993. Negotiations with NMED on the submittal of permit modifications for the interim status units are continuing.

The Laboratory is currently negotiating with NMED a schedule to submit permit applications and modifications. The applications will address several categories of waste handling units, including the following: development of new treatment capabilities and associated support units for compliance with the EPA FFCA and Federal Facilities Compliance Act (FFCAct); 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) Project. Competition for funding of these permitting activities is driven by compliance needs. The permit modification for the retrieval of mixed transuranic (TRU) waste from TA-54, Area G, storage pads 1, 2, and 4 was conditionally approved by NMED on May 11, 1994.

Table III-1. Major Environmental Acts under which the Laboratory Operated in 1994

Legislation	Federal 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 Federal Facilities Compliance Act Amendments 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) Designation, Reportable Quantities, and Notification 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 NMED/WQCC	National Pollutant Discharge Elimination System (NPDES) 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
	40 CFR 110–113	EPA	Oil Pollution Prevention Spill Prevention Control and Countermeasures (SPCC)
	40 CFR 116	EPA	Designation of Hazardous Substances

Table III-1. Major Environmental Acts under which the Laboratory Operated in 1994 (Cont.)

Legislation	Federal Regulatory Citation	Responsible Agency	Related Legislation and Regulations
Clean Water Act (CWA) (Cont.)	40 CFR 117	EPA	Determination of Reportable Quantities for Hazardous Substances
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 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
		National Advisory Council on Historic Preservation	EO 11593
Archaeological Resources Protection Act (ARPA)	43 CFR 7	Not Applicable	
American Indian Religious Freedom Act (AIRFA)	None	Not Applicable	
Native American Graves Protection and Repatriation Act (NAGPRA)	None	Not Applicable	
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 Clean Water Act, Section 404, Rivers and Harbors Act
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 1994

Category/Agency	Approved Activity	Issue Date	Expiration Date	Administering
RCRA hazardous waste facility[a]	Hazardous waste storage, treatment, and disposal permit	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 July 1991 (TA-53 Surface Impoundments [3])	—	NMED
		Revised Part A application submitted October 1993	—	NMED
	Two RD&D Permits for Packed Bed Reactor/ Silent Discharge Plasma Treatment Unit and Hydrothermal Processing Unit	Both issued on April 21, 1994		NMED
HSWA	RCRA Corrective Activities	March 1990	December 1999	EPA
PCBs[b]	Disposal of PCBs at TA-54, Area G	June 5, 1980	—	EPA
PCB oil (TSCA)	Incineration of PCB oils[c]	October 9, 1992	October 9, 1997	EPA
NPDES[d], Los Alamos	Discharge of industrial and sanitary liquid effluents	Modified permit New permit effective August 1, 1994	March 1, 1991[e]	EPA
	Storm water associated with industrial activity	General permit submitted September 29, 1992 authorization received August 25, 1993	October 1, 1997	EPA

Table III-2. Environmental Permits or Approvals under which the Laboratory Operated in 1994 (Cont.)

Category/Agency	Approved Activity	Issue Date	Expiration Date	Administering
	Storm water associated with construction activity			
		A-53 Sanitary Pipeline submitted October 1, 1992	[f]	EPA
		US West Ductbank submitted October 1, 1992	[f]	EPA
		DARHT Facility submitted May 20, 1994	[f]	EPA
		Small Arms Firing Range submitted August 18, 1994	[f]	EPA
NPDES, Fenton Hill	Discharge of industrial liquid effluents	October 15, 1979	June 30, 1983[d]	EPA
NMLWD Regulations[g]	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[h]
Groundwater discharge plan, TA-46 Sanitary Wastewater Treatment Plant	Discharge to groundwater	July 20, 1992	July 20, 1997	NMED
Air Quality (NESHAP)[i]	Construction and operation of five beryllium facilities	December 26, 1985; March 19, 1986[i]; September 8, 1987; July 1, 1994		NMED

Table III-2. Environmental Permits or Approvals under which the Laboratory Operated in 1994 (Cont.)

Category/Agency	Approved Activity	Issue Date	Expiration Date	Administering
Open Burning (AQCR 301)	Fuel fire for ordnance testing, TA-11	June 16, 1994	June 16, 1995	NMED
Open Burning (AQCR 301)	Burning of scrap wood from experiments, TA-36	June 14, 1993 July 21, 1994	June 14, 1994 July 21, 1995	NMED 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
Open Burning (AQCR 301)	Burning of wood for Light Imaging Radar Testing, TA-33 and TA-39	August 11, 1994	August 11, 1995	NMED
Open Burning (AQCR 301)	Burning of metals for ordnance testing, TA-41	August 11, 1994	August 11, 1995	NMED

[a]See Table D-1 for specific permitted activities.
[b]Polychlorinated biphenyls.
[c]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.
[f]Dates vary depending on individual permits.
[g]New Mexico Liquid Waste Disposal Regulations.
[h]New Mexico Oil Conservation Division.
[i]National Emission Standards for Hazardous Air Pollutants.
[j]Two permits issued on same date.

Current permitting issues include the acceptance and approval by NMED of permit modifications requested by LANL in April 1993. Among them is the "off-site waste" issue. This issue involves LANL's ER Project's need to bring hazardous and mixed waste generated at the Los Alamos townsite and other off-site locations in Los Alamos County and immediate environs to the Laboratory's permitted waste handling locations at TA-54.

The application LANL submitted for the modification of TRU pads 1, 2, 4 and the addition of TRU storage domes A, B, C, and D was conditionally approved. A waste analysis plan and a schedule for further characterization of the TRU wastes on pads 1, 2, and 4 that will respond to all of the state's requirements will be provided to NMED by March 31, 1995.

The application for the Hazardous Waste Treatment Facility (12 storage tanks) and the Chemical Plating Waste Skid was withdrawn and is being revised. This revision involves the addition of two storage buildings, several storage sheds, and the addition of design information not included in the RCRA Part A application submitted on October 8, 1993, as well as updates due to organizational changes at the Laboratory.

LANL is in the process of developing an application for a RCRA-permitted treatment, storage, and disposal (TSD) facility that will be used primarily for the disposal of mixed wastes generated by the ER Project. The complex will consist of waste and wastewater treatment facilities, treatment, and associated storage. The submittal date was previously fall 1994; the delay in the schedule is due to the revision of the Title I Design to include treatment. Because this is a new construction project, completion of an application will depend on the development of construction drawings. Preliminary plans have been completed and final design plans are underway, at least in part, to finalize the application.

An emergency permit was granted to the Laboratory on June 2, 1994, by NMED in response to an application submitted earlier for the treatment of nitrated cheesecloth rags. All of the waste was treated, the facility was closed, and the permit has expired.

A set of modifications are being prepared for the permit to address changes in design at the TRU Waste Inspectable Storage Project (TWISP). These design changes were required as a result of the completion of the Fire Hazard Analysis. DOE orders require all buildings over 5,000 ft^2 to have fire suppression systems in place. The changes necessary to comply with this requirement demand substantial changes to the RCRA Part A application that was submitted for this project.

Other RCRA permitting activities currently underway include the following:

- possible submission of modifications to the permit to address changes that have occurred at the Controlled Air Incinerator (CAI);
- revision of the 1988 application for the TA-16 Open Burning/Open Detonation units;
- development of an application for the TA-67 facility that includes a landfill, storage in tanks and containers, treatment by thermal desorption and stabilization, and a wastewater treatment operation to handle the leachate collected from the landfill.

The Laboratory received two approved Research, Development, and Demonstration permits from NMED in 1994. The permits for the Packed Bed Reactor/Silent Discharge Plasma Unit at TA-35 and the Hydrothermal Processing Unit at TA-9, were received on April 21, 1994. The permit applications for these units were submitted to NMED in December 1992 and March 1993, respectively. These permits will allow the Laboratory to test two new and innovative technologies for the treatment of hazardous waste. The two units, however, did not begin to conduct treatment operations with hazardous waste in 1994.

A permit modification is in preparation to reflect the relocation of the Packed Bed Reactor/Silent Discharge Plasma Unit to another building within TA-35. The unit was moved without NMED notification or approval and without NEPA review. A modification request has been written and is being reviewed. A NEPA review is pending.

b. Solid Waste Disposal. The Laboratory has a Special Waste Subtitle D landfill located at TA-54, Area J. This landfill also has three active disposal shafts that receive administratively controlled or classified waste from Laboratory operations. LANL/DOE completed the required Solid Waste Facility Annual Report for calendar year (CY) 93. The TA-54, Area J landfill received 287 m^3 (10,131 ft^3) of solid waste in 1994. The landfill is used as a staging area for nonradioactive asbestos (approximately 165 m^3 [5,824 ft^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 disposal cell at TA-54, Area G. Monofill means this cell receives only one type of waste.

On October 11, 1994, LANL/DOE submitted a suspension of groundwater monitoring requirements request to NMED for this landfill. The suspension request offered vadose zone (the subsurface above the main aquifer) monitoring in place of groundwater monitoring. 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 Los Alamos 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 18% of the total volume of trash landfilled at this site during CY94 with the remainder contributed by Los Alamos County residents. DOE works with both LANL and Los Alamos County landfill managements regarding operations, permit applications, and LANL waste stream acceptance criteria. LANL also sent 6,558 tons of concrete/rubble, 400,090 tons of construction and demolition debris, 74 tons of brush for composting, and 126 tons of metal for recycling to the county landfill construction and demolition area.

Table III-3 presents a summary of the materials recycled by Johnson Controls, Inc. (JCI), the Laboratory's support services subcontractor, in FY94. This waste minimization program, which continues to be expanded, conforms to RCRA Subtitle D requirements.

Table III-3. Johnson Controls World Services, Inc. FY94 Recycling Volumes

Type	Volume	
Paper	337,667 kg	(742,868 lb)
Photographic film	1,490 kg	(3,280 lb)
Lead	28,727 kg	(63,200 lb)
Lead acid batteries	7,425 kg	(16,335 lb)
Electric cable	156,338 kg	(343,944 lb)
Aluminum shavings	1,100 kg	(2,420 lb)
Scrap steel/tin	352,553 kg	(775,616 lb)
Aluminum solid	10,252 kg	(22,555 lb)
Copper	749 kg	(1,648 lb)
Stainless steel	15,244 kg	(33,537 lb)
Brass	459 kg	(1,009 lb)
Tires	9,363 kg	(20,600 lb)
Waste oil	50,386 L	(13,100 gal.)

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 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 the state subsequently gave oral approval to proceed with closure activities. 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 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 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 Notice of Deficiency (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 on two grounds: (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.

An NOD was received for the TA-35-85 surface impoundment from NMED in May 1994. LANL requested extensions to the 30-day required response time, which were granted by NMED. All NOD comments were addressed and submitted to NMED by mid-August 1994. Additional field work to support closure is scheduled for 1995.

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 on November 1, 1993, which started a 30-day period for receiving comments from the public.

An amendment to the closure plan was submitted to NMED in February 1993. Additional closure activities were conducted between September and December 1994 to remove localized contamination. A closure report was to be submitted to NMED in March 1995.

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 proceed with the closure of these vessels in anticipation of 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 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 to demonstrate clean closure will be performed in conjunction with the HSWA permit corrective measures study scheduled during 1999.

TA-16, Landfill at Material Disposal Area, 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 Project, 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 Project 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. NMED 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.

An NOD for the August 1993 closure plan was received in June 1994. Responses to the NOD, as well as a request for a 120-day extension to address groundwater issues, was submitted to NMED. NMED issued a notice to the public in early August 1994 that LANL intended to close TA-16, material disposal area (MDA), Area P per the

1993 closure plan. During this time, LANL conducted a brief cost/benefit study on clean closing versus capping TA-16, MDA, Area P. The study concluded that clean closing the landfill would be the most cost effective and environmentally sound option. Therefore, LANL withdrew the August 1993 closure plan. A new closure plan was submitted to NMED in early February 1995, and identifies TA-16, Area P as a waste pile to allow for clean closure under 40 CFR 265.250. The closure plan is currently under review by NMED.

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.

A revised closure plan for the two surface impoundments was submitted to NMED in early September 1994. An NOD on this closure plan was received by LANL in late October 1994. A response to the NOD was submitted to NMED in mid December 1994. Additional clarifying information on the closure plan was submitted to NMED in early March 1995.

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 RCRA permit. This unit is located in Building 1 at TA-50 and consists of an enclosed 1,923 L (508 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 activity information was submitted to NMED in a final closure report on September 1, 1994. NMED acknowledged the clean closure on September 15, 1994.

d. Underground Storage Tanks. The Laboratory's USTs are regulated under the New Mexico Underground Storage Tank Regulations (USTR). At the end of CY94, the Laboratory has 13 regulated USTs. Out of those 13 USTs, 11 USTs and their ancillary equipment must be upgraded or taken out of service by the end of CY98.

No USTs were removed in CY94. USTs TA-55-17 and TA-16-205, which were removed in CY93, finally met the USTR closure requirements in CY94.

UST TA-18-PL30, contained 2,117 L (560 gal.) of diesel fuel and was removed in September 1993. The UST site is still under corrective action for site contamination. Because of shallow groundwater (approximately 4.6 m [15 ft] below land surface) two groundwater monitoring wells were installed in March 1994. For three quarters of CY93, groundwater data were collected in CY93 from this former UST site. The groundwater data show concentrations of benzo-a-pyrene and naphthalenes below the concentration found in Part 3 of the New Mexico Water Quality Control Commissions (NMWCC) regulations.

In July 1994, the top of UST TA-16-1456 (containing 37,800 L [9,980 gal.] of unleaded gasoline) was excavated to conduct routine repairs on the tank. During the excavation, light soil staining and a faint odor of gasoline in the soil near the UST's fuel inlet pipe and vent line were noted. On August 3, 1994, NMED was notified regarding gasoline release from UST TA-6-1456. Several factors were determined to be the source of the gasoline contamination, but the main factor was that two other USTs had been located in the same area as UST TA-16-1456 in the 1980s prior to their removal. In 1987, UST TA-16-196 was removed. This UST formerly held 15,120 L (3,992 gal.) of leaded gasoline. Upon removal, it was observed that the UST was extensively corroded and was leaking. Remediation actions involved the removal of several truckloads of contaminated soil from the site, but removal of all the soil was unsuccessful. Currently, the UST site is still under investigation to determine the extent of the former UST TA-16-196 gasoline contamination.

A UST inspection was conducted on January 25, 1994, by the NMED. From this inspection, DOE received one notice of violation (NOV) on February 24, 1994. The NOV contained one finding that stated that the line leak detector on UST TA-16-197 had not been adequately tested. On March 4, 1994, a test was conducted on the capability of a line leak detector. The test determined that the leak detector was functioning properly. On June 28, 1994, a Certification of Compliance document was sent to NMED with a check for $100 for the fine associated with the NOV. There was no petroleum release associated with this NOV finding.

e. Other RCRA Activities. TA-54, Area L, located on Mesita del Buey, had been used for disposal of hazardous waste prior to the time when such disposal became regulated under RCRA/NMHWA. TA-54, Area G has been used for the disposal of radioactive waste. Information related to a groundwater monitoring waiver request 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 CAI for treating hazardous wastes 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, but waste treatment operations have not been conducted in the CAI since that time. The CAI has been upgraded to improve its reliability so that waste can be routinely burned. A modification to the permit incorporating the upgrades has been submitted and must be approved before the facility can be restarted, and a public hearing must be held in connection with the permit modification application. NMED is kept aware of changes in the permit through scheduled meetings and has agreed to this process in order to get the CAI permit current.

f. RCRA Compliance Inspection. NMED conducted its annual hazardous waste compliance inspection September 14–22, 1994. NMED inspectors visited hazardous waste satellite accumulation, storage, and treatment facilities located throughout the Laboratory. Several potential issues were identified by the inspectors, including unlabeled or improperly labeled containers, storage of certain wastes in excess of regulatory time limits, incomplete records, insufficiency of decontamination equipment, and other potential issues.

EPA Multimedia Inspection. Between August 3 and 12, 1993, the EPA conducted a site-wide multimedia inspection of the Laboratory, which encompassed regulations promulgated pursuant to RCRA, Clean Water Act (CWA), SDWA, Clean Air Act (CAA), Toxic Substances Control Act (TSCA), and Emergency Planning and Community Right-to-Know Act (EPCRA) (see Table III-4). The EPA-led team was headed by a representative of Region 6 and was staffed by personnel working for the EPA National Enforcement Investigations Center and for the NMED. The EPA-led team visited many 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, 1993, several apparent RCRA findings were reported involving noncompliance including inadequately labeled containers, open containers, inadequate training records, incomplete waste characterization, and missing notifications. None of the findings appear to have a significant impact on human health or the environment.

Table III-4. Environmental Inspections and Audits Conducted at the Laboratory in 1994

Date	Purpose	Performing Agency
January 11, 1994	Annual inspection of permitted and registered beryllium machining operations	NMED
January 25, 1994	UST inspection at TA-16	NMED
April 22, 1994	Spill cleanup investigations	NMED/AIP
July 11-15, 1994	Waste Stream Characterization Program/ NPDES permit program evaluation	DOE/AL
July 21, 1994	NPDES permit program evaluation	EPA
September 8, 1994	NPDES permit program evaluation	EPA
September 14–22, 1994	Hazardous waste compliance inspection	NMED
September 26-27, 1994	Use study tour of the Laboratory's canyons	USFWS[a]
October 17–27, 1994	Monitoring of environmental programs	DOE/AL
October 27–28, 1994	NPDES permit compliance inspection	NMED
November 16, 1994	FIFRA inspection	NMDA[b]

[a]US Fish and Wildlife Service.
[b]New Mexico Department of Agriculture.

NMHWA Order 94-09, issued on September 2, 1994, documented the RCRA findings from the EPA-led multimedia inspection. NMHWA Order 04-09 alleged some 45 violations of waste characterization, disposal, labeling, storage, manifesting, safety equipment, and other hazardous waste management requirements. It required 28 corrective actions and proposed a fine of $247,000. Corrective actions were implemented on time or were otherwise resolved, and the final negotiated penalty amount was $62,750.

DOE and LANL received a second RCRA CO from the State of New Mexico during 1994. NMHWA Order 94-12 was issued on August 12, 1994, following a self-reported incident involving the placement of soils from an ER Project into a non-RCRA-permitted low-level radioactive waste landfill on site. LANL subsequently discovered the soils had contained trace quantities of volatile organic constituents (VOCs). The CO alleged violations of RCRA transportation and disposal requirements. It required corrective actions and proposed a fine of $26,040. Corrective actions were implemented on time. The final negotiated penalty amount was $13,020.

g. RCRA Training. During 1994, ESH Training (ESH-13), in conjunction with Hazardous & Solid Waste (ESH-19), updated the Laboratory's RCRA training program. In addition to RCRA personnel training, a five-hour introductory course for TSD and less-than-90-day storage area workers, the RCRA refresher training course began in October. RCRA personnel must take refresher training courses annually. The 1994–95 RCRA refresher training course focuses on changes to statutes, regulations, permits, permit applications, and Laboratory policies that affect work assignments of facility personnel that relate to RCRA; organizational changes affecting the Laboratory's waste management structure and processes; a review of characterization of hazardous and mixed waste; and identifying recurring problems of noncompliance with the RCRA-required inspection process. During 1994, 285 workers were trained in RCRA personnel training, and 78 received the RCRA Refresher Training course between October 1994 and the end of the year. Both courses will be given monthly throughout 1995.

In 1994, 1,026 workers were trained in Waste Generation Overview, instruction for hazardous and mixed waste generators. Waste Documentation Forms, the "how to" course on forms completion, underwent major revisions beginning at the end of 1994 to reflect changes to the forms themselves. A workshop, entitled Waste Documentation Update, was designed to acquaint current users of the forms with the revised forms; 412 workers were trained in both courses during 1994.

A RCRA facility-specific training workshop took place in early 1994, and 39 training coordinators attended. This workshop was designed to acquaint training personnel at the facilities with the RCRA permit itself, and permit application training requirements, particularly those additional facility-specific topics for which training must be offered and documented.

RCRA TSD personnel who must take Hazardous Waste Operations (HAZWOPER) training have been doing so at LANL for the last several years. In October 1994, ESH-13 developed a HAZWOPER refresher course specific to TSD workers. The course meets the regulatory requirements for both HAZWOPER and RCRA refresher training and is offered monthly throughout the year.

The RCRA training program, as described in the Hazardous Waste Facility Permit, is complete and will only undergo modifications and revisions in 1995 to reflect regulatory, organizational, and programmatic changes.

Generator Handbook. ESH-19 completed 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 was distributed to waste management coordinators and waste generators in 1994.

h. Waste Minimization. Subchapter I of the Solid Waste Disposal Act 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 rates of hazardous and mixed waste generation during 1994 were significantly higher than 1993 because during the first part of 1993, there was a moratorium on the generation of mixed waste. A total of 182,714 kg (401,971 lb) of hazardous waste was generated in 1994 versus 70,420 kg (154,923 lb) in 1993. A total of 68,372 kg (150,418 lb) of mixed waste was generated in 1994 versus 7,517 kg (16,537 lb) in 1993. A full description of the moratorium is found in "Environmental Surveillance at Los Alamos during 1993" (EARE 1995b).

i. HSWA Compliance Activities. In 1994, the ER Project remained in compliance with Module VIII of the RCRA permit. In April 1994, EPA transmitted a revised copy of the permit to incorporate new language based on

the Class 3 permit modification submitted by the ER Project in February 1993. The permit was again updated in September 1994 to incorporate minor changes identified by the ER Project.

During 1994, four RFI work plans and two addenda to RFI work plans were submitted to EPA. Ten work plans were approved by EPA in 1994, and two more were approved in early 1995. In May 1995, an RFI work plan addressing Los Alamos and Pueblo canyons will be submitted. Another RFI work plan addressing issues common to all canyons will be submitted in October 1995. All upcoming work plans specific to individual canyons will tier to this document. Depending on the availability of funding, an RFI work plan for Mortendad Canyon will be submitted in November 1995.

A Class 3 permit modification will be submitted in early March 1995 to remove 89 SWMUs that require no further action (NFA). In addition, 23 SWMUs will be added to the permit at EPA's request, based on its review of RFI work plans. Approximately 280 Areas of Concern that are not on the HSWA permit will be recommended for NFA during the same public comment period.

Progress continued in the design of the Laboratory's proposed Mixed Waste Disposal Facility. The facility is planned to treat and dispose of mixed waste generated during the ER Project remediation process. The facility will exclude Laboratory operational waste. The Title I Design was revised in 1994 to include waste treatment in the scope of the project. The Value Engineering Study was completed in 1994. By the end of 1994, drilling of the initial boreholes and test wells neared completion. The Environmental Assessment (EA) and a draft Performance Assessment for the facility are currently underway.

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

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

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

Title III, Section 313, of the EPCRA requires facilities that meet certain standard industrial classification (SIC) code criteria to submit an annual toxic chemical release inventory (TRI) report. This TRI report describing the use of and emissions from Section 313 chemicals must be submitted to EPA and the New Mexico Emergency Management Bureau every July for the preceding CY.

Although the Laboratory does not meet the SIC code criteria for reporting, it has voluntarily submitted annual TRI reports since 1987. All research operations at the Laboratory are exempt under provisions of the regulation, and only pilot plants, production, or manufacturing operations at the Laboratory are reported. Regulated chemical use at the Plutonium Processing Facility (TA-55) is the only operation at the Laboratory for which chemical releases are reported under Section 313. This facility uses a reportable chemical (nitric acid) in amounts greater than the Section 313 reporting threshold.

On August 3, 1993, the President of the United States issued Executive Order 12856 requiring all federal facilities regardless of SIC code to report under Title III, Section 313, of EPCRA. Research operations remain exempt. This requirement does not go into effect until the July 1995 reporting deadline for the preceding 1994 CY. The Laboratory, along with the DOE, elected to begin reporting under the new guidelines, beginning with the 1994 report. Two additional chemicals, in addition to nitric acid, required release reporting: chlorine for water treatment and sulfuric acid used to deionize water at the power plant (TA-3-22).

The 1994 report presented here covers the releases of chlorine, nitric acid, and sulfuric acid during 1993. About 6,091 kg (13,400 lb) of nitric acid were used for plutonium processing, resulting in air emissions of approximately 78 kg (171 lb). The amount of nitric acid released to the atmosphere was estimated using EPA emission factors and good engineering judgment. The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in wastewater treatment operations. In addition, 9,613 kg (21,149 lb) of chlorine were used in water purification operations involving noncontact cooling water, sewage treatment, and drinking water, resulting in air emissions of 381 kg (839 lb) of chloroform and 12 kg (26 lb) of chlorine. An estimated 2,482 kg (5,460 lb) of chlorine were released with the discharged water. Finally, 24,430 kg (53,745 lb) of sulfuric acid were used to deionize water at the Laboratory's main power plant, resulting in less than a pound of air emissions. The remaining sulfuric acid was completely neutralized before discharge to the environment.

4. Toxic Substances Control Act.

Unlike other statutes which regulate chemicals and their risk after they have been introduced into the environment, the Toxic Substances Control Act (TSCA) was intended to require testing and risk assessment before a chemical is introduced into commerce. TSCA also establishes record keeping and reporting requirements for new information regarding adverse health and environmental effects of chemicals; governs the manufacture, use, storage, handling, and disposal of polychlorinated biphenyls (PCBs); and sets standards for PCB spill clean ups. 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, slurries, soils, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to transformers, capacitors, and other PCB items with concentrations above a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to items with PCB concentrations of 50 ppm or greater.

In 1994, 17 transformers containing greater than 500 ppm PCBs were replaced with non-PCB transformers and 6 low concentration (50-500 ppm PCBs) transformers were reclassified to non-PCB status. The remaining 7 high concentration PCB transformers are scheduled for replacement in 1995. Specifications for the reclassification of the remaining 18 low concentration PCB transformers will be written in 1995.

The Laboratory's inventory of PCB-containing items is constantly changing as items are disposed and new items are discovered during the on-going survey. Eighty-three PCB items were added to the survey in 1994. This brought the total number of PCB items at LANL to 418. The types of items inventoried by the survey include transformers, various pumps, oil-filled switches, light ballasts, generators, small transformers, and capacitors. Most items are scheduled for disposal as soon as they are discovered. The survey for PCB items at LANL involves record searches, sample collection, and laboratory analytical testing.

Analytical testing for PCBs is also performed for other TSCA compliance activities such as waste characterizations and transformer concentration verifications. A total of 340 samples was analyzed for PCBs at the Laboratory in 1994. Analytical results are attached to waste tracking forms and the item tested is appropriately marked.

Once identified, inventoried, and marked, waste materials with 50 ppm PCBs or greater which do not contain radioactive constituents are transported off site for treatment and disposal in accordance with TSCA. In 1994, the Laboratory had 16 off-site shipments of PCB waste. The total weight of PCBs in those shipments was 101,355 kg (222,981 lbs). The PCB waste is sent to EPA-permitted disposal and treatment facilities. The wastes disposed were 61 capacitors, 20 drums of light ballasts, 18 transformers, 5 drums of water, 5 electrical chokes and switches, 29,439 kg (64,766 lb) of PCB oil, and 13 drums of concrete or other debris. All wastes are tracked from the point of generation to final disposal. Documentation, such as waste manifests and verification of shipment receipts, is kept on file. Certificates of Destruction for each waste are sent to the Laboratory by all treatment or disposal facilities.

Liquids containing greater than 50 ppm PCBs and radioactive constituents are stored at the TA-54, Area L TSCA storage facility. These wastes must be stored due to the lack of any EPA-approved disposal facility for this type of waste. Many of these items have exceeded TSCA's one year storage limit. This noncompliance issue is well documented and numerous communications have been taking place between EPA Region 6 and LANL/DOE representatives. Nonliquid wastes containing greater than 50 ppm PCBs and radioactive constituents are disposed at the Laboratory's EPA-authorized TSCA landfill located at TA-54, Area G.

The Laboratory's TSCA disposal facility at TA-54, Area G disposed 13.6 kg (30 lb) of radioactively contaminated PCB waste during 1994. Although the volume of this type of waste is expected to be minimal over the next several years, there are few if any other disposal options for this waste. LANL has therefore requested renewal of the 1980 EPA authorization for on-site PCB waste disposal. Representatives of the Laboratory met with EPA officials in the fall of 1994 to discuss renewal conditions. The new authorization is expected to be final in the fall of 1995.

Compliance documents pertaining to the above activities are compiled and written on a routine basis. The two primary compliance documents are the Annual PCB Document (includes the annual inventory log and disposal records required by 40 CFR 180) and the Semi-annual PCB Report (required by Condition 6 of the EPA approval for LANL to operate a PCB Landfill).

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 New Mexico Department of Agriculture (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 certified applicators apply pesticides under the direction of the Laboratory's Pest Control Program Administrator. The Laboratory Pest Control Management Plan, which includes programs for vegetation, insects, and small animals, was established in 1984 and is 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-21 presents data on the amount of herbicides, insecticides, and rodenticides used at the Laboratory during 1994.

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 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 seven 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 five covering storm water discharges (Table III-2). The University of California (UC) and DOE are co-owners 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.

During 1994, the Laboratory's NPDES permit for Los Alamos included 2 sanitary wastewater treatment facilities and 122 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 at the end of the monitoring period for each representative outfall category to EPA and NMED. During 1994, effluent limits were not exceeded in any of the 154 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 28 times in the 2,045 samples collected from the industrial outfalls. As shown in Figure III-1, overall compliance for the sanitary and industrial waste discharges during 1994 was 100% and 98.6%, respectively. Tables D-3 through D-6 present monitoring standards and Laboratory exceedances from those standards. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1994. On November 10, 1994, the Laboratory received a copy of EPAs Federal Facilities Compliance Report (Region 6) for the period July 1, 1994 through September 30, 1994. The Laboratory was removed from the list of significantly noncompliant federal facilities for CWA violations.

b. Business Plan for NPDES Permit Compliance and Outfall Reduction. The Water Quality and Hydrology Group (ESH-18) in coordination with DOE/LAAO developed a Business Plan for NPDES permit compliance and outfall reduction as a result of the Administrative Order (AO) received in 1994 for repetitive non-compliances. The Business Plan enhanced the Laboratory's existing plan to ensure compliance with regulations and outlined the program necessary to achieve 100% compliance, improve environmental awareness across the Laboratory, and establish ownership for compliance. It also instills accountability within the Laboratory, sets aggressive goals for employees and divisions, and improves root cause analysis of occurrences. A primary function of the Business Plan is to establish cross-functional teams to address and improve operational, technical, and regulatory facets of the Laboratory's NPDES compliance record.

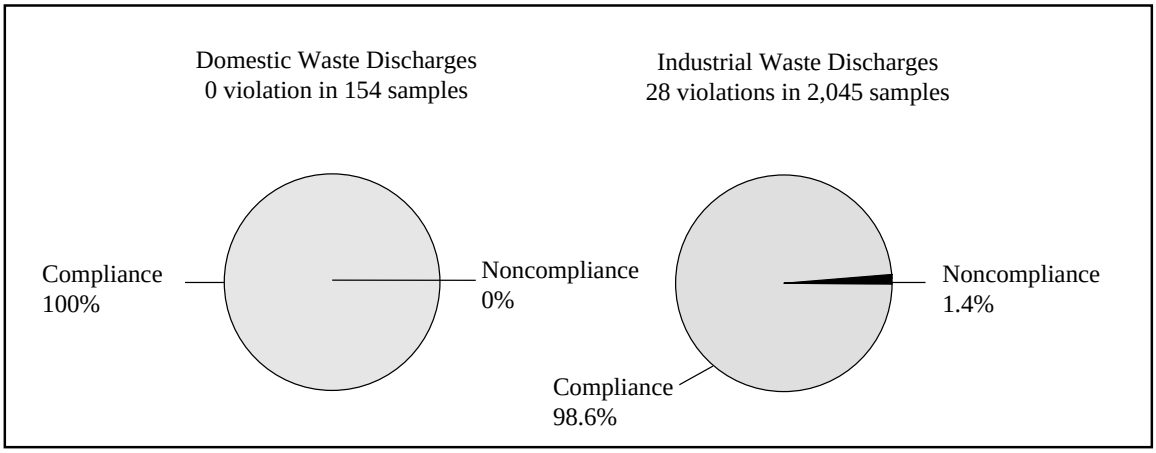


Figure III-1. Overall compliance for the sanitary and industrial waste discharges during 1994.

c. Waste Stream Characterization. The Waste Stream Characterization (WSC) program is a Laboratory-wide effort to identify noncomplying waste streams and potential unpermitted outfalls that discharge to the environment contrary to those authorized in the Laboratory's NPDES permit. The WSC program is required by AO Docket No. VI -94-1242, which allowed for the continued operation of noncomplying facilities until WSC studies and final reports were completed.

ESH-18 provided assistance to the Laboratory's operating groups in identifying noncomplying waste streams and potential unpermitted outfalls that discharge to the environment. Preliminary copies of each WSC report, including the findings and recommendations, were reviewed by ESH-18 and facility representatives in 1993 and 1994. Additional follow-up investigations were conducted in 1994 if discrepancies were noted during the reviews. Eighty-three WSC reports were finalized and distributed to the responsible Division Directors for facilities under their management in March 1994. Target dates and contact persons were requested so that corrective actions could be documented, tracked, and submitted by ESH-18 to EPA, as required by the AO.

Seventy-five unpermitted outfalls were found throughout the Laboratory during the WSC surveys. DOE and EPA requested that the Laboratory eliminate these unpermitted outfalls by the end of 1994. The Laboratory successfully eliminated 74 of the 75 unpermitted outfalls by December 31, 1994; the last unpermitted outfall was eliminated in January 1995.

AO Docket No. VI-94-1242 required the Laboratory to complete 25% of the corrective actions that were recommended by the WSC study by September 1994 and 50% by September 1995. Both of these requirements have been met. The Laboratory must be in 100% compliance by October 1, 1997, pursuant to the AO.

The Laboratory has secured funding of approximately $3 million dollars to complete some of the corrective actions needed to bring facilities into compliance with the NPDES permit program. ESH-18 is managing this funding to complete the highest priority projects before the October 1, 1997, deadline. Operating groups will be responsible for corrective actions not completed by this funding. ESH-18 has developed a database for tracking the WSC corrective actions.

d. 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).

On September 9, 1992, EPA published the final General Permits for storm water discharges associated with industrial and construction activity. The Laboratory chose to apply for coverage under the General Permit. Currently the Laboratory has five NPDES General Permits for its storm water discharges (Table III-2). One permit is for the Laboratory site and includes the following industrial activities: hazardous waste treatment, storage, or disposal facilities, operating under interim status or a permit under Subtitle C of RCRA and NMHWA, (this category includes SWMUs); landfills, land application sites, and open dumps including those that are subject to regulation under Subtitle D of RCRA; and steam electric power generating facilities. The other four permits are for construction activities disturbing more than five acres. These projects are the TA-53 Lagoon Elimination project,

the Los Alamos Integrated Communication System project, the Dual Axis Radiographic Hydrotest (DARHT) facility, and the Small Arms Firing Range remediation.

The conditions of the General Permit require the development and implementation of a Storm Water Pollution Prevention (SWPP) Plan. During 1994, ESH-18 developed and initiated implementation of 18 SWPP Plans for SWMUs. ESH Division has assumed ownership of SWMUs that are regulated under the NPDES General Permit and the subsequent SWPP Plans.

Under the General Permit, monitoring activities are required of EPCRA facilities and land disposal units/ incinerators. In 1994 monitoring was conducted at TA-54, Area G with proposed monitoring sites in 1995 at TA-55; TA-54, Area J; and at two SWMU landfills. This analytical data must be submitted annually to EPA in the form of a Discharge Monitoring Report (DMR). The Laboratory submitted its 1994 DMR to EPA on October 28, 1994.

The installation and operation by the US Geological Survey stream monitoring stations on the canyons entering and leaving the Laboratory is another project related to the NPDES Storm Water Program. In 1994, there were a total of 16 stations on the various watercourses at the Laboratory. Information gathered by the USGS will be published in the NM Water Resources Data, Water Year 1994.

e. 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 third version of the SPCC Plan was completed in September 1993; a training course for Spill Coordinators was presented in 1994 and is offered quarterly.

f. Sanitary Sewage Sludge. In December 1992, the EPA promulgated 40 CFR Part 503: *The Standards for Use or Disposal of Sewage Sludge.* The purpose of these regulations is to establish numerical, management, and operational standards for the beneficial use or disposal of sewage sludge through land application or surface disposal. Under the Part 503 regulations, the Laboratory is required to collect representative samples of sewage sludge in order to demonstrate that it is not a hazardous waste and that it meets the minimum federal standards for pollutant concentrations. In addition, sewage sludge is monitored for radioactivity in order to demonstrate that it meets the standards set forth in the Laboratory's Administrative Requirement (AR) 3-5. During 1994, approximately 26 dry tons of sewage sludge were generated at the TA-46 Sanitary Wastewater System Consolidation (SWSC) Plant as part of routine wastewater treatment operations; analytical monitoring of this sludge in 1994 demonstrated 100 percent compliance with the minimum federal and Laboratory standards for land application.

Also during 1994, approximately 20.3 dry tons of sewage sludge generated at the SWSC plant in 1993 were land applied at TA-54, Area G.

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 and from the Laboratory's water supply wellheads to ensure compliance with the federal SDWA (40 CFR 141). The DOE provides drinking water to Los Alamos County and Bandelier National Monument. The EPA has established MCLs for microbiological organisms, organic and inorganic constituents, asbestos, and radioactivity in drinking water. These standards have been adopted by the State of NM and are included in the NM 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 at four state certified laboratories: NM Health Department's Scientific Laboratory Division (SLD) in Albuquerque for VOCs, synthetic organic constituents (SOCs), inorganic constituents, and radioactivity; the Soil, Water, and Air Testing (SWAT) Laboratory at New Mexico State University in Las Cruces, New Mexico, for SOCs; Triangle Laboratories in Durham, North Carolina, for dioxin; and QuanTEM Laboratories in Oklahoma City, Oklahoma, for asbestos. The SLD and SWAT laboratories report their analytical results directly to NMED. Triangle and QuanTEM laboratories report their analytical results to ESH-18, who, in turn, transmit the results to NMED. The JCI Environmental (JENV) Laboratory also collects

samples from the Laboratory, Los Alamos County, and Bandelier National Monument's distribution systems and tests them for microbiological contamination, as required under the SDWA. The JENV Laboratory is certified by NMED for microbiological testing of drinking water.

During 1994, all chemical, radiological, and microbiological parameters regulated under the SDWA were in compliance with the MCLs established by regulation, with the exception of a four-day microbiological violation in January 1994. The analytical results for SDWA compliance sampling in 1994 are presented in the following tables: radioactivity (Table V-22), radon (Table V-23), inorganic constituents (Table VI-9), total trihalomethanes (Table VI-10), lead and copper (Table VI-11), VOCs (Table VI-12), SOCs (Table VI-13), asbestos fibers (Table VI-14), and bacteria (Table VI-15).

Radon sampling was performed at wellheads and points of entry of water from the two well fields into the distribution system. This sampling was done to collect information prior to 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 during 1994, an average of 48 microbiological samples was collected at designated sample taps in the Laboratory, County, and Bandelier National Monument's water distribution systems. The microbiological samples are analyzed for free chlorine residual and the presence or absence of total coliform, fecal coliform, and noncoliform bacteria. Sample collection and analysis were performed by personnel from the JENV Laboratory. During 1994, of the total of 581 samples analyzed, 5 indicated the presence of total coliforms, and 2 indicated the presence of fecal coliforms. Noncoliforms were present in 27 of the microbiological samples. Monthly data for 1994 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 January 1994, there was a violation of the SDWA MCL for coliform bacteria at the North Community Fire Station (FS #4) and the Ponderosa Estates subdivision adjacent to FS #4 in the North Community. Drinking water samples collected from a janitor's mop sink at FS #4 on January 10, 1994, showed the presence of total and fecal coliform bacteria. On January 13, a sample collected from a new residence in the Ponderosa Estates subdivision showed the presence of total coliform bacteria.

The coliform contamination at FS #4 and Ponderosa Estates subdivision are believed to be separate, coincidental, episodes caused by local contamination. The source of contamination at FS #4 was identified as a hose connected to the janitor's sink; the hose provided a direct conduit for the transmission of bacteria from a mop bucket to the sink faucet where the sample was collected. The contamination at the Ponderosa Estates subdivision was attributed to a lack of line flushing, the presence of dirt in the distribution lines, and a low free chlorine residual in the drinking water (<1.0 mg/L Cl_2). Ponderosa Estates, at that time, had very few occupied houses served by the affected line. Lack of use allowed water in the pipe to stagnate.

Repeat samples collected from the janitor's sink at FS #4 on January 11, 12, and 13, 1994, showed the absence of both total and fecal coliforms. Samples collected on those same days at several other taps at FS #4 showed no coliform contamination, suggesting that the problem was localized to the janitor's sink piping.

The coliform contamination at the Ponderosa Estates subdivision was eliminated by the flushing of the subdivision's water mains. A repeat sample collected from the Ponderosa Estates subdivision on January 14, 1994, showed an absence of total coliform contamination and a free chlorine residual of 0.2 mg/L Cl_2. The Laboratory has suggested that Los Alamos County implement a corresponding flushing program for the County's portion of the distribution system. No other violations were noted in the Laboratory's municipal and industrial water supply program in 1994.

8. Groundwater.

a. Groundwater Protection Compliance Issues. Groundwater monitoring and protection efforts at the Laboratory have evolved from the early programs initiated by the USGS to present efforts. As a DOE facility, the Laboratory is required to conduct its operations in an environmentally safe manner. DOE Order 5400.1 establishes environmental protection program requirements, authorities, and responsibilities for all DOE facilities. The goal of this order is to ensure that operations at DOE facilities comply with all applicable environmental laws and regulations, executive orders, and departmental policies. The major regulations, orders, and policies pertaining to groundwater are as follows.

DOE Order 5400.1. DOE Order 5400.1 requires the Laboratory to prepare a Groundwater Protection Management Program Plan (GWPMPP). The program was required by the order to (1) document the groundwater regime with respect to quantity and quality; (2) design and implement a groundwater monitoring program to support resource management and comply with applicable environmental laws and regulations; (3) establish a management program for groundwater protection and remediation, including specific SDWA, RCRA and CERCLA actions; (4) summarize and identify areas that may be contaminated with hazardous substances; (5) develop strategies for controlling sources of these contaminants; (6) establish a remedial action program that is part of the site CERCLA program required by DOE 5400.4; and (7) have in place decontamination and decommissioning and other remedial programs contained in DOE directives.

The Laboratory completed a major revision of the draft GWPMPP in 1994. The GWPMPP focuses on protection of groundwater resources in and around the Los Alamos area and ensures that all groundwater-related activities comply with the applicable federal and state regulations.

The GWPMPP also fulfills the requirements of Chapter IV, Section 9 of DOE Order 5400.1. This section requires development of a Groundwater Monitoring Plan (GMP) as a specific element of the GWPMPP. The GMP identifies all DOE requirements and regulations applicable to groundwater protection and includes monitoring strategies for sampling, analysis, and data management. The general requirements outlined in Section 9b for the GWPMPP include: (1) determination of baseline groundwater quality and quantity conditions; (2) demonstration of compliance with, and implementation of, all applicable regulations and DOE orders; (3) providing data that will allow early detection of groundwater pollution or contamination; (4) providing a reporting mechanism for detection of groundwater pollution or contamination; (5) identifying existing and potential groundwater contamination sources and to maintain surveillance of these sources; and (6) providing data upon which decisions can be made concerning land disposal practices and the management and protection of groundwater resources.

The GWPMPP contains a business plan in which a prioritized list of activities and studies addresses these above requirements. The business plan also shows the suggested organization for accomplishing the tasks, the proposed funding sources, and a preliminary cost estimate.

Section 9c of Chapter IV of the DOE Order 5400.1 requires that groundwater monitoring needs be determined by site-specific characteristics and, where appropriate, groundwater monitoring programs be designed and implemented in accordance with 40 CFR Part 264, Subpart F, or 40 CFR Part 265, Subpart F. The section also requires that monitoring for radionuclides be in accordance with DOE Orders in the 5400 series dealing with radiation protection of the public and the environment.

RCRA Permit/HSWA Module. LANL's RCRA/NMHWA Part B Operating Permit requires the Laboratory to follow specific procedures in the handling, treatment, monitoring, and disposal of hazardous wastes.

Module VIII of the RCRA Operating Permit, i.e. the HSWA Module, Task III requires the Laboratory to collect information to supplement and verify existing information on the environmental setting at the facility and collect analytical data on groundwater contamination. Under Task III, Section A.1, the Laboratory is required to conduct a program to evaluate hydrogeologic conditions. Under Task III, Section C.1, the Laboratory is required to conduct a groundwater investigation to characterize any plumes of contamination at the facility.

The Laboratory continued an ongoing study of the hydrogeology and stratigraphy of the region. In 1993, two bore holes (LADP-3 and LADP-4) were drilled near TA-21 to investigate the occurrence of intermediate perched groundwater zones and to add to the knowledge of the geology of the area.

The Laboratory updated results of analyses of groundwater samples for tritium (Refer to Section VII or EARE 1994b for more information). The analyses were performed using a new method that enabled detection of very minute amounts of tritium. This data helps to further understand various hydrogeologic characteristics as required by the HSWA Module and DOE Order 5400.1.

The Laboratory also completed part of an ongoing study of environmental geochemistry for surface and subsurface waters in the Pajarito Plateau and outlying areas (Blake 1995). The study included major element, trace element, and isotope analyses of 130 water samples from 94 different springs, wells, and water bodies in the area. This study contributes information needed to understand background water quality and recharge information required by the HSWA Module.

A study of fracture characterization of the Bandelier Tuff was also completed in 1994 (Wohletz 1995). This study focused on fractures in the Tshirege Member in Los Alamos Canyon. This study contributes information needed to understand the occurrence and nature of fractures as required by the HSWA Module.

New Mexico Water Quality Control Commission Regulations. NMWQCC regulations control liquid discharges onto or below ground surface to protect all groundwater of the State of New Mexico. Under the provisions, a groundwater discharge plan must be submitted to the NMWQCC by the facility and approved by the commission director. Subsequent discharges must be consistent with the terms and conditions of the plan.

NMWQCC regulations require site-specific background information for the groundwater discharge plans including site characterization, depth to groundwater, geologic stratigraphy, and the number of wells. The Laboratory also needs to determine potential pathways through which effluent could enter the regional aquifer or the intermediate and alluvial perched groundwater zones. The regulations also protect surface waters that are fed by groundwater inflow.

New Mexico Solid Waste Management Regulations. SWMR requires that landfills establish groundwater monitoring programs and that other solid waste facilities demonstrate that groundwater will be protected. The Laboratory has several Solid Waste Disposal Areas which operate under SWMR regulations. During 1994 the Laboratory submitted documentation for a groundwater monitoring suspension request for MDA J at TA-54 and proposed a vadose zone monitoring plan instead. The plan proposed would emplace a vadose zone monitoring network to detect any downward movement of contaminants. Because groundwater is at a depth of 305 m (1,000 ft) beneath unsaturated tuff, the Laboratory maintains that vadose zone monitoring would be more efficient in detecting possible contamination migration before it could reach the regional aquifer than the groundwater monitoring required under the SWMR.

Safe Drinking Water Act. The SDWA requires that the Laboratory and Los Alamos County water distribution systems meet specific standards for maximum contaminant levels for organic, inorganic and radiochemical constituents.

The Laboratory conducts annual sampling at many points in the distribution system. In addition, the Laboratory also samples annually groundwater from all supply wells. These samples are analyzed for the organic, inorganic, and radioactive constituents required by the SDWA.

National Pollutant Discharge Elimination System Permit. NPDES was established by the CWA and requires permitting of all point-source effluent discharges into the nation's waters. The primary goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Specific criteria for an effluent must be met before that effluent can be discharged into the environment.

Anticipated Regulatory Requirements. The Laboratory needs to be able to comply with anticipated state regulatory requirements. Under the NMWQCC regulations, which pertain to industrial and municipal discharges onto or below the surface of the ground, the NMED can request a Groundwater Discharge Plan for new and existing facilities. The plan would require a site investigation, characterization of the waste stream, and justification that discharge activities will not degrade groundwater.

The Laboratory has two sanitary treatment facilities and more than 100 industrial outfalls. A Groundwater Discharge Plan could be requested by the NMED for any of these facilities, and the Laboratory would need to comply within 120 days after the request.

The Laboratory has two approved Groundwater Discharge Plans to meet NMWQCC regulations, one for TA-57 (Fenton Hill) and one for the TA-46 Sanitary Wastewater Treatment Plant which is the location for the sanitary wastewater systems consolidation (SWCS) Project (DOE 1992).

In addition, 10 CFR 834 is scheduled to become law. It is anticipated that the content will be similar to DOE Order 5400.5, which addresses radiation doses to the public. Ninety days after the document is presented for public review, it could become law. LANL will be required to be in compliance with the specified date stated in 10 CFR 834.

9. 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,
- Stratospheric Ozone Protection (SOP); and
- Operating Permit Program.

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 effective dose equivalent to any member of the public from radioactive airborne releases from DOE facilities, including LANL, to 10 mrem/yr. The 1994 effective dose equivalent to a member of the public was 7.62 mrem/yr, primarily from the LAMPF operations. Any construction or modifications undertaken at LANL that will increase airborne radioactive emissions require preconstruction approval from EPA. In 1994, 102 such projects were received by Air Quality (ESH-17) or Environmental Protection (ESH-8) for Laboratory review; only four of these were determined to require preconstruction approval.

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. As a result of the NON, the DOE is negotiating a FFCA with EPA Region 6. The FFCA will include schedules that the Laboratory will follow to come into compliance with the Clean Air Act and will continue to address the issues raised in the 1991 NON.

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. Johnson Controls Incorporated (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 concerning the type of recovery/recycling equipment to be used and the procedures for using this equipment became effective on July 13, 1993.

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. ESH-17 worked 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 may be dangerous. Provisions of this regulation allow DOE and the Laboratory to burn waste explosives. In 1994, the Laboratory had six open burning permits: one for the open burning of jet fuel for ordnance testing at TA-11, K Site; another for the open burning of metals 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; one for burning explosive-contaminated wood at TA-36; and one for burning small piles of wood for Light Imaging Radar testing at TA-33 and TA-39 (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. Opacity is read during these switches. Only one exceedance of the opacity standard occurred in 1994; it occurred at the TA-16 steam plant. Notification procedures as required by AQCR 801 were followed, thereby preventing any compliance actions.

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 2.5×10^8 Btu/hr. Oil burning equipment of this capacity must emit less than 0.03 lb per million Btu of particulate. Although the Laboratory boilers use oil as a backup fuel, all have maximum rated heat capacities below this level; consequently, this regulation does not apply. The TA-3 power plant operates the three highest heat capacity boilers, each of which had an observed maximum capacity of 210 million Btu/h.

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. Only the TA-3 steam plant has the capacity to operate at this level. While the TA-3 steam plant has the capacity to operate at this level, it never has and is therefore not an applicable source for this regulation. However, stack tests done in 1994 indicate that the TA-3 power plant meets the emission standard.

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 uses oil as a backup fuel, no oil-fired equipment exceeds this threshold heat input rate. Therefore, this regulation did not apply during 1994 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 uses oil as a backup fuel, no oil-fired equipment exceeds this threshold heat input rate. Therefore, this regulation did not apply during 1994 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 1994, more than 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 in 1994 have resulted in emission increases considered "significant," and they were 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 1994, no Laboratory operation produced visible asbestos emissions.

The Laboratory is also required to notify NMED of asbestos removal activities and disposal quantities. Such activities involving less than 15 m^2 (160 ft^2) or 74 m (260 lin ft) are covered by an annual small job notification to NMED. For projects involving greater than these amounts of asbestos, separate notification to NMED is required in advance of each project. NMED is notified of asbestos wastes (both small and large jobs) on a quarterly basis, which includes any material contaminated, or potentially contaminated, with radionuclides. Radioactively contaminated material is disposed of on site in a designated radioactive asbestos burial area. Nonradioactive asbestos is transported off site to designated asbestos disposal areas.

During 1994, LANL shipped off site for disposal 36.62 m^3 (1,292 ft^3) of small job asbestos waste. JCI disposed of approximately 16.85 m^3 (595 ft^3) of potentially radioactive contaminated material from small job activity during 1994. One large decontamination and decommissioning job that was begun in 1993 accounted for an additional 83.6 m^3 (2,950 ft^3) of potentially radioactive, friable and nonfriable, asbestos waste during the year. No material from the large job was shipped off site.

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. The beryllium machining operations conducted at TA-55 were modified to allow diamond-saw cutting. This and other minor modifications were approved by NMED on July 1, 1994.

NMED inspected three permitted beryllium operations and reviewed filter testing records on all permitted operations in January 1994. There were no findings resulting from this audit. 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 airfilters to control emissions, with efficiencies of 99.95%. 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 Operating Permit Program was approved by EPA in December 1994. This regulation requires major sources of air pollution to obtain an operating permit with the NMED. Because of LANL's potential to emit regulated air pollutants (primarily from the steam plants), LANL is considered a major source. The permit will specify the operational terms and limitations required to meet all federal and state air quality regulations. During 1993 and 1994, the Laboratory 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 is due to the NMED in December 1995.

AQCR 771—Fees. As part of the new Operating Permit Program, the State of NM will begin to charge yearly fees to sources of air pollution that are required to obtain an operating permit. Fees will depend on the amount of air pollutants described in the source's permit.

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 before or within 24 hours of the occurrence, followed by written notification within 10 days of the occurrence. One incident of excess particulate emissions was recorded in 1994. This occurred at the TA-16 steam plant during fuel switching procedures. Notification procedures as required by AQCR 801 were followed. 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, enhanced monitoring, 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.

10. National Environmental Policy Act.

a. Introduction. NEPA of 1969 (42 U.S.C. 4331 *et seq.*) mandates that federal agencies consider the environmental impact of their proposed major actions and allow public input before making a final decision on what actions to take. The DOE is the sponsoring agency for most LANL activities, and it is DOE's policy to follow the letter and spirit of NEPA. DOE uses the regulations for implementing NEPA published by the Council on Environmental Quality at 40 CFR Parts 1500 –1508 and its own NEPA Implementing Procedures as published at 10 CFR Part 1021. Under these regulations and DOE Orders 5440.1D and 5440.1E, DOE reviews proposed LANL activities and determines whether the activity is categorically excluded from the requirements or if one of the following need to be prepared:

- an EA, evaluating environmental impacts, leading to either a finding of no significant impact (FONSI) if the impacts are indeed found to be not significant or requiring an Environmental Impact Statement (EIS) if the impacts are significant,
- an EIS, in which impacts of proposed and alternative actions are evaluated and mitigation measures proposed. The EIS is followed by a record of decision in which the agency decides if and how to proceed with a project.

If an EA or and EIS is required, the DOE is responsible for directing its preparation.

LANL project personnel initiate NEPA reviews by completing environment, safety, and health identification documents, which form the basis of a DEC written by the Environmental Assessments and Resource Evaluation group (ESH-20) using the format specified by the DOE Albuquerque Field Office (DOE/AL). As part of the NEPA review process, proposed projects are evaluated for possible effects on cultural resources (archeological 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. The DEC is submitted to DOE Los Alamos Area Office (DOE/LAAO), which uses it to assist DOE in determining the appropriate level of NEPA documentation. In 1994, LANL prepared 131 DECs for DOE review. Also in 1994, DOE categorically excluded 103 actions and determined that 10 other actions were covered under existing NEPA documents. Other actions were awaiting DOE decisions. DOE issued one FONSI in 1994. DOE did not require an EA on any projects for which a DEC was submitted in 1994, but it did determine that six projects for which DECs were submitted in previous years would require EAs. A short description of projects requiring an EA or EIS is given in Section IV.B

11. National Historic Preservation Act and Native American Graves Protection and Repatriation Act.

In accordance with the Native American Graves Protection and Repatriation Act, LANL cultural resource staff began an inventory of all burial remains excavated from DOE land since 1943. One tour of archaeological artifacts removed from DOE land and now curated at the Museum of New Mexico in Santa Fe was conducted for tribal representatives from the Pueblo of San Ildefonso. Final report preparation and further consultation will continue into 1995 and 1996.

12. Endangered, Threatened, and Protected Species.

The DOE and the Laboratory must comply with the Endangered Species Act, the Migratory Bird Treaty Act, and the Bald Eagle Protection Act. The Laboratory also considers plant and animal species listed under the New Mexico Conservation Act and the Endangered Species Act. During 1994, ESH-20 reviewed 395 proposed Laboratory actions for potential impact on threatened and endangered species. Of these, 185 proposed actions were identified through the ESH Questionnaire system. The Ecological Studies Team (EST) of ESH-20 identified 40 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. EST also identified 15 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, EST identified four projects (Table III-5) that required an intensive survey designed to determine the presence or absence of a threatened or endangered species at the project site (Level III

Table III-5. Projects Identified in 1994 that Require a Species Specific Survey

Project Name	Species Surveyed
Site Characterization, OU 1079, ISF gas line	Peregrine falcon Mexican spotted owl Jemez Mountains salamander
High-Explosive Wastewater Treatment Facility	Goshawk Southwestern Willow flycatcher Mexican spotted owl
RCRA Mixed Waste Disposal Facility, TA-67	Goshawk Mexican spotted owl
Site Characterization, OU 1098	Mexican spotted owl

survey). The Laboratory adhered to protocols and permit requirements of the New Mexico State Game and Fish Department.

EST 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 1994. However, highly suitable habitat exists for many of these species (e.g., goshawk, Jemez Mountains salamander, meadow jumping mouse) within some project sites.

13. Floodplain and Wetland Protection.

The Laboratory must comply with EO 11988, Floodplain Management, and EO 11990, Protection of Wetlands (EPA 1989a). During 1994, 465 proposed Laboratory actions were reviewed for impact to floodplains and wetlands. Two proposed projects will require a Floodplain and Wetland Assessment: the High-Explosive (HE) Wastewater Treatment Facility and the Printed Circuit Board Facility. Both projects involve eliminating effluent outfalls that support man-induced wetlands (artificially created wetlands from Laboratory effluents). In compliance with 10 CFR 1022, a Floodplain and Wetland Notice of Involvement and Statement of Findings for these projects were submitted to the DOE in October and November of 1994.

In September 1994, the Laboratory received notice from the Army Corps of Engineers that erosion from a road and sewer line crossing was causing damage to Sandia Canyon wetlands. This represents noncompliance with soil stabilization requirements under the Nationwide Permit, which authorized the construction of the road and sewer line across the Sandia Canyon wetland. Pursuant to Section 404 of the CWA, the Corps requested that the Laboratory repair the erosion and stabilize the slopes in question. The Laboratory plans to complete the erosion control project for this area in 1995.

C. Current Issues and Actions

1. Compliance Agreements.

a. Mixed Waste FFCA. 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) found in Section 3004(j) of the RCRA and 40 CFR Section 268.50. The draft FFCA was released for public review and comment on July 27, 1993. The FFCA was signed by DOE and EPA on March 15, 1994. The FFCA provides a plan and schedule for the treatment of mixed wastes; it

includes some 47 specific compliance milestones, 17 of which were due in 1994. DOE and LANL successfully complied with all 17 milestones. Under a mandate in the FFCAct, DOE has been negotiating, with the State of New Mexico, issues similar to those negotiated in the FFCA. A Consent Agreement or CO implementing the FFCAct is expected to be in effect in late 1995.

b. NPDES FFCA and AO. In March 1993, EPA proposed an FFCA, Docket No. VI-92-1305 to DOE that eliminated the discrepancies between LANL's existing AO (Docket No. VI-94-1242) and the previous DOE FFCA (Docket No. VI-91-1328). The FFCA was reviewed by DOE and UC, but not finalized by EPA. The FFCA still does not reflect the schedules for the new AO (Docket VI-94-1242). The schedules for completing the HE Wastewater Treatment Facility and the Waste Stream Characterization (WSC) projects required under the AO are presented in Table D-7.

In May 1993, EPA served AO Docket No. VI-93-0178 on the Laboratory 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 AO, Docket No. VI-94-1210 to UC. The AO stated that LANL had failed to meet the HE Wastewater Treatment Facility schedule for outfall 05A. The AO included a revised compliance schedule for completion of the WSC project. This order replaced AO Docket No. VI-92-1306, which was closed on December 6, 1993.

AO Docket No. VI-94-1242, issued to the Laboratory on June 15, 1994, incorporated the revised HE Wastewater Treatment Facility schedule and the schedule for completion of the remaining corrective actions for the WSC Project. This order replaced AO Docket No. VI-92-1210, which was closed on June 15, 1994. AO Docket No. VI-94-1051 was issued to the Laboratory on July 6, 1994. The scope of this AO required the Laboratory to present corrective actions and plans to eliminate the NPDES permit violations that occurred at the Laboratory from 1990 through 1993 in a "show cause" meeting. The show cause meeting took place in Dallas, Texas, at EPA Region 6 on August 25, 1994. No further action was taken by EPA.

c. NESHAP FFCA. In 1991 and 1992 the Laboratory received two NONs from the EPA for not meeting all provisions of 40 CFR 61, Subpart H. Specific findings of the NONs included deficiencies in LANL's identification and evaluation of release sources, noncompliant stack monitoring equipment on all point release sources, incomplete quality assurance programs, and incomplete reporting. As well, the 1992 NON stated that LANL had used a shielding factor without prior EPA approval and as such exceeded the 10 mrem/yr standard. Currently, the Laboratory is negotiating an FFCA with EPA Region 6, which will provide an enforceable mechanism to bring the Laboratory into compliance with these requirements. However, the Laboratory has been actively engaged in a program to achieve compliance with the provisions of 40 CFR 61, Subpart H as the FFCA is being finalized. Progress toward full compliance includes the following:

- A comprehensive inventory of point release sources has been completed. An inventory of diffuse (nonpoint) release sources has 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 has been upgraded to meet the requirements of 40 CFR 61, Subpart H, monitoring requirements. All tritium stacks are in physical compliance. As scheduled, upgrades have begun on stack monitoring equipment at TA-3, TA-48, TA-50, and TA-55; these upgrades are in various stages of completion. Upgrades at other facilities throughout the Laboratory are scheduled.
- For monitoring radioactive air emissions at LAMPF, a quality assurance (QA) project plan has been completed, approved by DOE, and implemented. This plan has been audited by DOE and found to be in compliance. QA project plans are being developed for monitoring radioactive air emissions and tritium facilities. In addition, an overall QA project plan has been drafted for the management of radioactive air emissions; necessary procedures have been written, approved, and updated.

LANL ceased using the shielding factor in 1992. The LANL dose to the public has not exceeded the 10 mrem/yr standard since 1991. The FFCA is expected to be completed and signed in 1995.

d. 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 originally 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. The AIP is up for renewal in 1995; DOE and NMED are negotiating a five-year extension to this agreement.

During 1994, the NMED AIP staff conducted oversight of several of the Laboratory's environmental programs. Highlights of these activities are presented below (NMED 1995).

Hydrogeological: NMED AIP staff continued development of an updated conceptual hydrogeological model for the site.

Spill Closures: NMED AIP staff accompanied the ESH-18 staff during unplanned liquid release cleanup verifications. Upon verification of adequate cleanup of release sites, the NMED AIP staff administratively closed out the spills. In 1994, NMED AIP staff administratively closed 22 of 24 releases which occurred in 1994.

Sampling: Extensive sampling activities were conducted at LANL in 1994. Sampling is done in coordination with the LANL Environmental Surveillance Program and NPDES Permit Program in order to obtain split or duplicate samples. Split samples are submitted to the state SLD and independent laboratories for analysis. The activities included sampling of groundwater, NPDES outfalls, springs, stream bed sediment, snowmelt and rainwater runoff, and foodstuffs.

Samples were collected from approximately 50 environmental monitoring stations at LANL, 5 independent stations, and 5 stations at the Pueblo of San Ildefonso. No soil samples were collected in 1994. NMED AIP personnel continued study of aquatic life in the perennial reaches of interrupted streams at LANL. In 1994, two environmental sampling and surveillance trips in White Rock Canyon were conducted. Analytical results of sampling activity in 1994 at LANL revealed no unexpected concerns.

Environmental Restoration: One of the major accomplishments of the AIP program in 1994 was the ranking and prioritization of individual potential disposal sites in order to focus on the most serious sites among the more than 2,000 that exist in LANL's ER Project.

NMED/AIP staff at LANL developed recommendations on the content and format of LANL ER reports in order to standardize and clarify reports to the state. NMED/AIP-initiated national ER electronic communications system received added support from DOE in 1994, and the effort to broaden the availability of "best ideas" in the ER Project continued.

Waste Management: NMED/AIP staff reviewed reports of the Laboratory's Waste Stream Characterization program for compliance with the NPDES permit. The reports verify proper identification of all waste streams at LANL.

Quality Assurance: NMED/AIP staff reviewed internal QA and quality control procedures for environmental monitoring activities in 1994. AIP staff made recommendations to ESH-20 regarding standardization of the site selection process that were implemented to facilitate inter-canyon comparisons. NMED/AIP staff recalculated public doses from a proposed waste drum facility at TA-54 as part of reviewing a LANL application to EPA; dose calculations were in agreement with those reported by LANL.

Releases and Corrective Actions: On November 29, 1994, a hole in a radioactive liquid waste line located at TA-21-3 North was found. The hole was found during an investigation to determine the reason for decreased flow to the TA-21 radioactive liquid waste collection system. AIP personnel were involved in the planning of corrective activities for the leaking pipe. The sinks and drains associated with the leaking pipe were all disconnected. The leaking pipe was contained by a concrete containment trench.

2. Corrective Activities.

- *HE Wastewater Treatment Facility.* This project consists of an HE Wastewater Treatment Facility. No collection system will be utilized; all wastewater will be trucked to the treatment facility. Title I design for the facility was completed in FY94; 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 1994. As of the end of December, 114 of the 363 Laboratory buildings with potable water service, or about 31%, had been surveyed. In 1994, the CCC Survey completed three critical buildings in the survey: Chemistry and Metallurgy Research; Sigma; and TA-59, Building 01. These buildings are among the largest and most complex buildings at LANL, and their completion was a significant milestone for the survey. As of the end of

December, 844 potential cross connections or other identifiable plumbing deficiencies had been identified by the survey; 430 of the most critical problems have been fixed, while the remaining 414 problems have been backlogged pending the availability of additional resources.

- *Drinking Water Lead Survey.* This survey was initiated in 1993 by ESH-18 as a best management practice and Tiger Team Corrective Action because some drinking fountains at the Laboratory had demonstrated lead levels higher than the EPA action level of 15 parts per billion (ppb). In the summer of 1994, 1,300 drinking water taps at the Laboratory were sampled for lead; 61 of those taps sampled demonstrated lead levels equal to or greater than the EPA action level of 15 ppb and were resampled for confirmation purposes in the fall of 1994. Final reports and recommended corrective actions will be issued in early 1995.
- *Waste Stream Characterization Survey.* This survey of all Laboratory buildings was completed on October 8, 1993. Reports were finalized in March 1994 and distributed to Division Directors for facilities under their management. ESH-18 has been working with user groups to complete the remaining corrective actions recommended in the WSC reports. See Table D-7 for schedule for completion of corrective activities required by AO Docket No. VI-94-1242.

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 includes emergency planning, emergency preparedness, and effective response capabilities for responding to and mitigating the consequences of an emergency. The Laboratory's Emergency Management Plan is a document that describes of the entire process of planning, responding to, and mitigating the potential consequences of an emergency. The most recent revision of the plan was distributed in July 1993; future revisions will be distributed on an 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. The surface impoundments at TA-53 are currently planned for clean closure under RCRA and therefore will not require groundwater monitoring.

5. Significant Accomplishments.

The LANL Air Quality Group (ESH-17) and the DOE have made significant progress toward obtaining an FFCA with EPA Region 6. Publication of the draft FFCA and Compliance Plan is anticipated for the summer of 1995 followed by public comment.

ESH-17 has made significant progress in developing the CAA Operating Permit Application. Under the guidance of NMED, ESH-17 is developing an application that will include voluntary emission caps that will better define the Laboratory's emissions of regulated air pollutants. The Operating Permit Application is due to the NMED by December 1995. It is anticipated that LANL will meet this deadline.

LANL was successful in obtaining formal EPA approval of representative sampling and the use of the shrouded probe as an alternative radionuclide sampling method. This new technology may be used in some of LANL's facilities to demonstrate compliance with 40 CFR 61, Subpart H "Radionuclide Emission Other than Radon from DOE Facilities."

ESH-19 was proactive in supporting DOE in complying with the mixed waste FFCA requirements and with completion of DOE's draft FFCA with EPA. LANL successfully developed 17 documents that were both timely and complete to comply with the FFCA. Other accomplishments include the approval of modifications to the RCRA permit for the TWISP at TA-54, Area G and issuance of an emergency RCRA permit for treatment of cheesecloth rags that had been nitrated at TA-55.

ESH-18 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

- elimination of 74 unpermitted outfalls discovered through the WSC program,
- finalized 83 WSC reports documenting WSC findings,
- developed a WSC corrective action tracking data base, and
- completed 25% of the WSC corrective actions.

In addition, the Laboratory's new NPDES permit was approved and issued by EPA.

The NEPA staff in ESH-20 implemented a more effective method for identifying and reviewing new Laboratory projects was implemented. The ESH-20 EST published three reports: "Radionuclide Concentrations in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory," "Tritium Concentrations in Bees and Honey at Los Alamos National Laboratory," and "Aquatic Macroinvertebrates and Water Quality of Sandia Canyon," Los Alamos National Laboratory.

The LANL Site-Wide Environmental Impact Statement (SWEIS) project office was opened in October 1994 in order to support DOE and its contractor by identifying baseline environmental, programmatic, facility and operations, project-specific, and socioeconomic data. The project office is expected to be operational for two and a half years during the course of the development, drafting, and approval of the SWEIS.

6. Significant Problems.

a. Lawsuits. In late 1994 local citizen's groups sued DOE seeking to enjoin construction of DARHT on the basis that NEPA had not been complied with. In early 1995 an injunction was granted pending completion of an EIS already in progress.

In 1994, a citizen's group sued the DOE and the Laboratory under the Clear Air Act. The group is concerned about the time it is taking for the Laboratory to achieve compliance with 40 CFR 61 Subpart H.

b. Other Issues. NMED notified DOE and LANL that they did not have a waste analysis plan that would properly characterize the waste stored on the TRU pads at TA-54, Area G. LANL has prepared a new waste analysis plan that should meet the criteria identified by NMED in their NOD . That plan will be submitted by March 31, 1995.

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-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.

The Laboratory was restructured in 1994. Of the 49 action plans (comprising 90 Tiger Team findings) for which the Laboratory's former Environmental Management Division was responsible, 18 action plans (31 findings) have been transferred to other divisions. Of the 31 action plans (59 findings) remaining in the Environment, Safety and Health (ESH) Division, 17 are of high priority and 14 are lower priority.

Of the high-priority action plans, 2 are closed, 11 are open and behind schedule (with no work reported completed), 1 is open but on schedule, and 3 are in various stages of completion (some findings completed, some late). Of the low priority action plans, none are late, 1 is closed, 1 is reported completed (awaiting paperwork to close), 11 are open but on schedule, and 1 is partly completed.

Because of limited indirect funding, a number of action plans that were initially designated as high priority did not receive funding in accordance with completion schedules. For this and other reasons, work has not progressed in accordance with original schedules. Nevertheless, some Tiger Team work was accomplished in 1994.

Tiger Team action plans are being incorporated into activity data sheets (ADSs) with other activities of similar nature and impact in the FY96-2000 ESH Management Plan (formerly the Five-Year Plan). The ADSs are subjected to the Laboratory's risk/cost-benefit prioritization process, which results in funding the higher priority activities. Where ADSs were funded, some funding was applied to Tiger Team action plans. The budget process has been modified to the extent that indirect funds no longer assign specific program codes to Tiger Team Action Plans. This allows the ESH Division more discretion in applying indirect funding to essential projects. Where possible, work is continuing in pursuit of resolving important environmental, safety, and health, and compliance-related activities in both funded and unfunded action plans. In the latter case, existing operational resources are used wherever possible.

8. DOE/HQ Audits and Assessments.

The DOE Albuquerque Field Office prepares an Annual Performance Appraisal of Los Alamos each year. The 1994 report ranked the overall environmental management program at the Laboratory as "meeting expectations." The environmental protection programs were described as "meeting expectations" and "showing improvement" over the 1993 performance.

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. Each year, more than 11,000 environmental samples are analyzed.

The Laboratory managed approximately 2,675 m^3 (94,428 ft^3) of radioactive wastes, 255 m^3 (9,000 ft^3) of hazardous wastes, and 1,500 m^3 (52,950 ft^3) of nonhazardous wastes.

The Environmental Restoration (ER) Project 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.

No new draft Environmental Assessments (EAs) were submitted to US Department of Energy (DOE) for review during 1994; several EAs were being revised according to DOE comments. During 1994, DOE published an Advance Notice of Intent (ANOI) to prepare a Site-Wide Environmental Impact Statement (SWEIS) for the Laboratory in the Federal Register.

In addition to routine environmental surveillance activities, the Laboratory carried out a number of special studies during 1994, which provide valuable supplementary environmental information.

A. Major Environmental Programs

1. Environmental Protection Program.

The Environment, Safety, and Health (ESH) Division 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 DOE Orders 5400.1 (DOE 1988a) and 5484.1 (DOE 1990a).

Personnel in the LANL environmental protection programs prepare permits, interpret regulations, provide technical advice, and conduct cultural and biological investigations across the site. They are responsible for environmental monitoring: collecting, analyzing, and interpreting samples of air, water, soil, sediments, food, and hazardous materials. Data are also gathered from measurements of natural radiation and LANL radiation sources. Weather conditions are monitored to assess the transport of airborne contaminants to the environment. The results of these analyses help identify impacts of LANL operations on the environment.

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

- Off-site locations included

  Regional stations were 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.

Over 450 sampling locations were used for routine environmental monitoring (Table IV-1). 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.

Additional samples were collected and analyzed to obtain information about particular events, such as major surface runoff events, nonroutine releases, or special studies. Each year, over 200,000 analyses for chemical and radiochemical constituents were conducted on more than 11,000 environmental samples. Data from these analyses were used for dose calculations, comparisons with standards and background levels, and interpretations of the relative risks associated with Laboratory operations, as presented in Sections V, VI, and VII.

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.

The waste management function at LANL was formed in 1948 as part of the Los Alamos Area Office of the Atomic Energy Commission. Waste management activities have been focused on minimizing the adverse effects of radioactive wastes on the environment, maintaining compliance with regulations and permits, and ensuring that wastes are managed safely. The Chemical Sciences and Technology Division at LANL became responsible for waste management activities during 1994.

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

Low-Level Radioactive Waste. The level of radioactive contamination in low-level waste (LLW) is not strictly defined. Rather, LLW is defined by what it is not. It does not include nuclear fuel rods, wastes from processing nuclear fuels, transuranic (TRU) waste, or uranium mill tailings.

LLW at LANL includes solid waste contaminated with radioactive materials, including plutonium, americium, uranium, or tritium from weapons design and test work; tracer and medical isotopes from scientific studies; mixed fission materials from nuclear energy work; and activation products from physics experiments. (Activation

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

Type of Monitoring	Off Site		On Site		Total
	Regional	Perimeter Area	Laboratory	Waste Disposal Area	
External radiation	4	23	51	88	166
Air	6[a]	13	22	9	50[b]
Surface waters[c,d]	6	10	12	0[e]	28
Groundwater[c]	0	32	19	15[e]	66
Soils	7	6	9	1	23
Sediments	11	19	29	21	80
Foodstuffs	13	11	21	1	46
Meteorology	0	1	7	0	8

[a]Includes three monitoring stations located on pueblos.

[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 and 13 wells at the Pueblo of San Ildefonso 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.

products are formed when a substance is struck by protons or neutrons. The atoms of the original substance are converted to another element that is unstable and, therefore, radioactive.)

LLW includes items such as equipment, paper, rags, radiation protective clothing, demolition debris from decontamination and decommissioning activities, and contaminated soils and debris from environmental cleanup activities. LLW handled at LANL may require special handling and shielding to protect workers and the public. Most LLW generated at LANL is disposed of on site in pits and shafts designed and engineered for this purpose within Technical Area (TA) 54, Area G. Approximately 2,460 m^3 (86,838 ft^3) of LLW were managed at the Laboratory in FY94.

Transuranic Waste. TRU waste consists or rags, equipment, solidified wastewater treatment sludge, paper, and protective clothing that contain radioactive elements heavier than uranium above a designated threshold. The major radioactive contaminants at LANL, plutonium and americium, both have long half-lives. Less than 100 m^3 (3,530 ft^3) of TRU waste were managed at LANL during FY94

Mixed Waste. Mixed waste contains low-level radioactive elements mixed with nonradioactive hazardous waste. Low-level mixed waste (LLMW) at LANL includes gases, liquids, and solids, such as gas cylinders of hydrogen with a tracer radioactive isotope; contaminated solvents and oils; spent solutions from electroplating operations; contaminated lead shielding; or solid chemicals that react violently with water. Solid LLMW is stored at the site pending the availability of off-site commercial treatment or the development of technologies to treat those wastes that cannot be treated by the commercial sector. Liquid LLMW generated at LANL is stored on site. TRU mixed wastes at LANL are solids. The major hazardous component is solvent contamination or the presence of heavy metals like cadmium or lead. Approximately 115 m^3 (4,060 ft^3) of mixed waste were managed at the Laboratory in FY94.

Hazardous Waste. Hazardous special wastes are defined by regulations under the Resource Conservation and Recovery Act (RCRA) and the NM Hazardous Waste Act (NMHWA). Hazardous wastes at LANL include gases, liquids, and solids such as compressed gas cylinders containing combustible gases; acids, bases, solvents; out-of-date laboratory chemicals; and lead bricks. At present, no disposal facility for hazardous chemical waste exists at LANL. Hazardous wastes are shipped off site for further treatment and disposal to facilities designated in accordance with RCRA.

Nonhazardous Special Waste. Nonhazardous waste is waste that does not fall under the technical definition of hazardous waste but still requires special handling. Other regulations apply to some of these wastes, such as asbestos, infectious wastes, oils, coolants, and other materials that are controlled for reasons of health, safety, or security. Approximately 1,500 m^3 (52,950 ft^3) of nonhazardous waste were managed by LANL in FY94.

3. Environmental Restoration Project.

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 stakeholders' environmental health and safety (DOE 1990b). The Laboratory's ER Project 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 project provides formal and informal mechanisms through which all interested parties (e.g., DOE, Environmental Protection Agency [EPA], and New Mexico Environment Department [NMED]) can participate in the corrective action review process at the Laboratory. The ER Project is part of the Environmental Management Division.

The ER Project 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 Hazardous and Solid Waste Amendments (HSWA) in 1984, prescribes a specific corrective action process for all potentially contaminated sites. In accordance with these laws, the Laboratory's operating permit included provisions for mitigating releases from facilities currently in operation and for cleaning up inactive sites. More than 2,000 potential release sites (PRSs) have been identified at the Laboratory. 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 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 making decisions based on risk that take 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" for LANL provides a detailed account of the process (IWP 1993).

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 Project during 1994.

B. National Environmental Policy Act Activities

The National Environmental Policy Act (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.

An EA presents the purpose of the proposed action, then describes the proposed action and reasonable alternatives. The EA includes a description of the affected environment and evaluates impacts to air quality (radioactive and nonradioactive emissions), water quality, and human health. The impacts to cultural and biological resources are discussed. The DOE submits draft EAs to the NMED and to potentially affected Native American tribes for review before making a determination. After that decision—a Finding of No Significant Impact (FONSI) or an Environmental Impact Statement (EIS)—has been made, DOE places copies of the EAs in public reading rooms in Los Alamos and Albuquerque. The depth and breadth of analysis of impacts in an EIS is greater than in an EA, and there are more opportunities for public input.

Table IV-2 presents the status of the Laboratory's major NEPA documentation as of December 1994. A description of each project follows the table. One project received a FONSI in 1994. No new draft EAs for proposed actions were submitted to DOE for review during 1994. Several EAs were being revised according to DOE comments during 1994. DOE published an ANOI to prepare the SWEIS in the Federal Register on August 10, 1994, as discussed in Section III. In the ANOI, nine specific projects were proposed to be included in the SWEIS. Of those projects, one had previously been determined to require an EIS, and the remaining eight had previously been determined to require an EA.

Radioactive Liquid Waste Treatment Facility. The proposed action is to build and operate a new facility to replace an existing 30-year-old radioactive wastewater treatment plant. The existing plant is still capable of operating safely and reliably for a few more years but is approaching the end of its design life and cannot be upgraded to meet the more stringent discharge limits. The proposed new treatment facility would be designed to more effectively segregate, treat, and minimize radioactive liquid waste streams consolidated at the facility from throughout the Laboratory. The alternative actions include building the facility at a Laboratory location other than the preferred TA-50 site, treating waste streams at the source, or continuing to use the existing plant until closure is required. Environmental, safety and health issues include worker exposure to radiation, air quality, water quality,

Table IV-2. Status of NEPA Documentation as of December 30, 1994

Status	Project
Project for which DOE determined in 1993 that an EIS would be required; EIS not initiated by LANL in 1994	Radioactive Liquid Wastewater Treatment Facility[a]
EA that received FONSI during 1994	Low-Level Waste Drum Staging Facility
EA submitted in 1993; project on hold	Uranium Oxide Reduction
EAs submitted to DOE before 1994; being reviewed by DOE in 1994	Actinide Source-Term Waste Test Program (formerly TRU Waste Source-Term Test Program) Deactivate, Disassemble, and Decontaminate the High-Pressure Tritium Laboratory[a] Expansion of TA-54, Area G[a] Hazardous Waste Treatment Unit and Mixed Waste Receiving and Storage Facility High-Explosive Materials Test Facility[b] Low Energy Accelerator Laboratory (formerly Accelerator Prototype Laboratory) Medical Radioisotope Production[c] Mixed Waste Disposal Facility[a] TRU Waste Drum Storage Building[d] Weapons Component Testing Facility Relocation
EA being written (still in draft form) during 1994	High-Explosive Wastewater Treatment Facility
Projects for which DOE determined in 1994 that an EA would be required; EA not completed in 1994	Chemical and Metallurgy Research Building Upgrades-Phase II[a] Expanded Operations at the CAI[a] Fire-Resistant Pit Program[a] New Sanitary Landfill[a] Nuclear Material Storage Facility Upgrade[a]

[a]Project included in ANOI.
[b]Project cancelled in 1994.
[c]Scope change in 1994.
[d]Future uses included in ANOI.

cumulative long-term impacts, and waste management. The DOE had previously determined that an EIS is required for the proposed action. Rather than preparing a separate EIS, the construction and operation of this proposed treatment facility was identified in the ANOI for the Laboratory's SWEIS as an action that would be analyzed in the SWEIS.

Low-Level Waste Drum Staging Facility. The proposed action is to erect a 10-ft by 15-ft building adjacent to the Weapons Engineering Tritium Facility (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 useable 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.

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. 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.

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. The proposed study is required to fulfill EPA requirements for the Waste Isolation Pilot Plant. 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. This EA is in the final revisions and is expected to receive a FONSI early in 1995.

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), (Building 86 at TA-33), decontaminate it, and demolish the shell. All tritium repackaging activities in the HPTL were suspended in October 1990 and were subsequently transferred to the new Weapons Engineering Tritium Facility. 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 risks to individuals from the emissions of tritiated water vapor and the volume of solid LLW that would be disposed. Rather than preparing a separate EA, the deactivation, disassembly, and decontamination of the High-Pressure Tritium Laboratory was identified in the ANOI for LANL's SWEIS as an action that would be analyzed in the SWEIS.

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. Rather than preparing a separate EA, the expansion of Area G was identified in the ANOI for LANL's SWEIS as an action that would be analyzed in the SWEIS.

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 (FFCA) 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.

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. This project has been canceled, so no further activity is expected on the draft EA.

Low-Energy Accelerator Laboratory (formerly ***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 develop 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 to 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.

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. During 1994, the project was rescoped. DOE proposes to produce targets at LANL. 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 Annular Core Research Reactor at Sandia National Laboratories and the desired radioisotopes would be separated from the mixed fission products in the adjacent hot cell facility. The ^{99}Mo and ^{125}I radioisotopes would be packaged for shipment to commercial radiopharmaceutical suppliers for final purification. 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 Project anticipates generating approximately 363,375 m^3 (12,827,000 ft^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 Project-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. Rather than preparing a separate EA, the future use of the proposed Mixed Waste Disposal Facility to treat and dispose of operational (non-ER generated) mixed wastes was identified in the ANOI for LANL's SWEIS as an action that would be analyzed in the SWEIS.

TRU Waste 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 using a prefabricated, concrete-floored, metal building for temporary storage of drums of solid TRU waste that is pending certification and transport to a longer term storage area. Alternatives to the proposed action include constructing a new building or continuing operations under current conditions. Some of the potential environmental, safety, and health issues include air emissions, worker safety, on-site TRU waste management, and TRU waste transportation.

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 useable 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.

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 would consist of minimizing the use of water in HE processes and treating all remaining HE-contaminated water at a new treatment facility. No untreated wastewater would be released to the environment. The proposed treatment facility would remove organic contaminants by passing the water through activated carbon filters. The alternative would consist of constructing two treatment facilities and a system of pipes to collect HE-contaminated wastewater and deliver it to the treatment facilities. This alternative would not minimize water use in HE processes. The principal issues include air and water quality, soils, wetlands, wildlife, and safety.

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 line 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. Rather than preparing a separate EA, the CMR Building upgrades were identified in the ANOI for LANL's SWEIS as an action that would be analyzed in the SWEIS.

Expanded Operations at the Controlled Air Incinerator. LANL proposes to expand the function of the Controlled Air Incinerator (CAI) beyond research and development 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. Rather than preparing a separate EA, the expanded operations at the CAI were identified in the ANOI for LANL's SWEIS as an action that would be analyzed in the SWEIS.

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. Rather than preparing a separate EA, the fire-resistant pit program was identified in the ANOI for LANL's SWEIS as an action that would be analyzed in the SWEIS.

New Sanitary Landfill. The proposed action is to construct and operate a new sanitary landfill for nonradioactive, 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. Rather than preparing a separate EA, the new sanitary landfill was identified in the ANOI for LANL's SWEIS as an action that would be analyzed in the SWEIS.

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. Rather than preparing a separate EA, the Nuclear Material Storage Facility upgrade was identified in the ANOI for LANL's SWEIS as an action that would be analyzed in the SWEIS.

C. Other Significant Environmental Activities at Los Alamos

1. Studies to Measure External Radiation. (Rubén Rangel, ESH-17)

a. Comparison of Thermoluminescent Dosimeters. In addition to the Laboratory's external penetrating radiation monitoring program described in Section V.B.1, special studies were conducted during 1994. One such study is a continuation of work initiated in 1990 to compare results of LANL thermoluminescent dosimeters (TLDs) with those of TLDs obtained from a commercial vendor.

The study involves placing vendor environmental dosimeters next to Laboratory dosimeters. There are a total of 42 vendor TLDs collocated with LANL TLDs at TLDNET locations. The vendor's TLDs are set out and collected following the vendor's specifications and in conjunction with the LANL TLD changeout schedule. No information is provided to the vendor regarding the TLD locations and possible environmental radiation fields. The vendor TLDs are analyzed and processed by the commercial vendor. The analytical results are later provided to LANL.

In previous environmental surveillance reports, the LANL TLD results were graphically compared with contract vendor's TLD results. If the response of the LANL TLDs was within the range of the values reasonably expected to be received by a collocated vendor's TLD, then the two TLD programs were assumed to produce similar results. To more definitively compare the data, the comparison is now 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 used, the TLD results from each program that are spatially and temporally comparable are used. Individual quarterly data were evaluated this year instead of the summed annual results used in previous years. For the first time since the program was initiated, there was a statistical and systematic difference in the results of the two data sets. Considering 146 paired data values, the vendor TLDs were indicating an average of 5 mrem/qtr higher exposure than that indicated by the collocated LANL TLDs. LANL scientists will continue to study the results of this intercomparison program in an attempt to determine the cause of the apparent discrepancy.

b. Highly Sensitive Dosimeters. Current literature indicates that the new dosimeters under study by LANL are nearly 30 times more sensitive than the presently used lithium fluoride (LiF) type of dosimeter. The test TLDs are composed of Al_2O_3 and are located next to the regular Los Alamos Meson Physics Facility (LAMPF) TLDs at the Laboratory boundary north of LAMPF (Figure V-1). The test TLDs are placed so that they will monitor LAMPF emissions during a run cycle. Preliminary data from this study indicate that the particular batch of dosimeters that were used were not as sensitive as expected and produced results with higher than expected uncertainty values. Laboratory scientists will continue to evaluate this new technology with a new batch of dosimeters, and the results will be forthcoming in future reports as data are compiled and analyzed.

2. Meteorological Monitoring. (Greg Stone, ESH-17)

a. Program Description. As required by DOE, the Laboratory conducts a routine meteorological monitoring program. This program provides the data needed to characterize the Laboratory's meteorological environment. Dispersion calculations, which use the wind data, are used for emergency planning, measuring the effects of routine emissions, and for estimating the consequences of accidental releases of hazardous and radioactive materials. The database is also extensively used in a variety of other applications, including environmental assessments, hydrological and biological studies, engineering design, and guiding weather-sensitive operations.

The program consists of four major components: measurements, data management, analysis, and plume modeling. Details of these program components are given in section 13 of the current "Los Alamos Environmental Monitoring Plan" (EARE 1995a). The measurements activity includes routine operation of a network of five towers, an acoustic wind profiler, and three supplementary precipitation stations. In all, this network consists of approximately 100 instruments. All instrumentation is operated continuously to high standards, achieving better than 95% good data recovery.

Data management includes all the software development, computer systems management, routine data processing and reporting, and maintaining the archive. The program annually archives approximately 55 MB of data. The data are collected every 15 minutes and summarized in plots and tables that are available at the Internet address http://weather.lanl.gov.

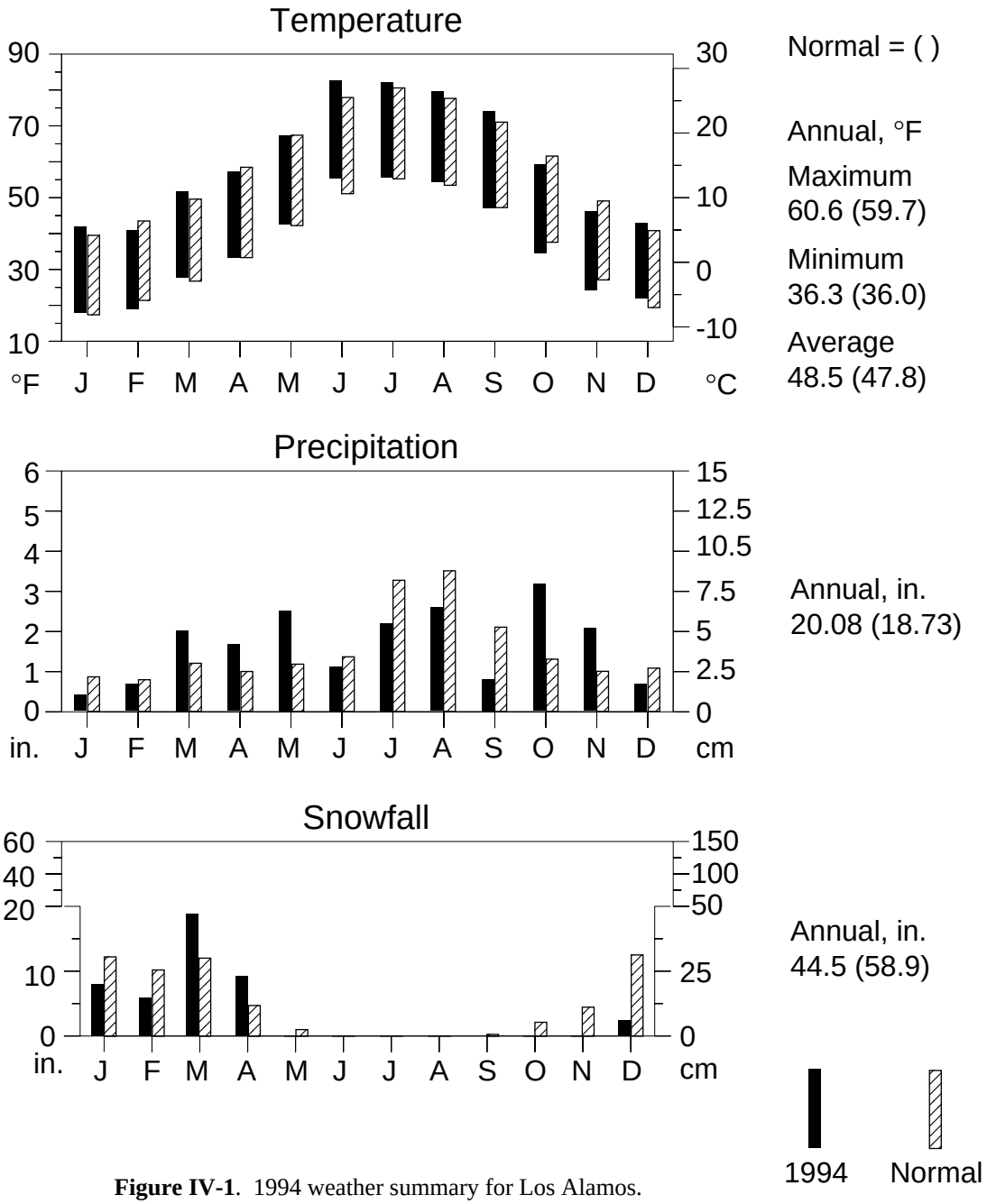


Figure IV-1. 1994 weather summary for Los Alamos.

Program meteorologists conduct special analysis projects—usually on an as-time-permits basis. For example, in 1994, special meteorological input files were developed for the radioactive lanthanum dose reconstruction project. When conditions warrant, special weather forecasts are developed to guide weather-sensitive activities such as scheduling construction, snow removal operations, etc.

The plume modeling activity centers around the Meteorological Information Dispersion Assessment (MIDAS) system. This system is designed to quickly compute dose or toxicity from accidental releases using observed meteorological conditions. Several new features were added to the MIDAS system in 1994.

b. Monitoring Results for 1994. A summary of the temperature and precipitation pattern during 1994 is given in Figure IV-1. On the average, the year was slightly warmer and wetter than normal. Snowfall for the year totaled 113 cm (44.5 in.), which is only 76% of the normal amount. More than 60% of the snow fell in March and April. Other significant departures from climatic normals are as discussed below.

The spring months were unusually wet, with May precipitation totaling twice the normal amount for that month. Summer was much warmer and drier than usual. During June, the average daily maximum temperature was 2.8°C (5°F) higher than normal, and three new high-temperature records were set. Although fall began with warm and very dry weather in September, both October and November were colder and wetter than normal. October was especially wet, with precipitation totaling 2.4 times the normal precipitation for that month. The winter months were unusually dry and somewhat warmer than normal.

Statistics of the wind measured 11 m (36 ft) above the ground for 1994 are presented in Figures IV-2 and IV-3. In these wind rose plots, the length of each spoke is proportional to the amount of time that the wind blew from the indicated 22.5 degree sector. The spoke representing each wind direction sector is partitioned into segments, and the length of each segment is proportional to the percentage of time the wind speed fell within the indicated range.

3. Water Monitoring at the Fenton Hill Site. (Bruce Gallaher and Max Maes, 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 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-4,) 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 1994 the samples were collected on December 1 and 21.

The results of the radiological analyses are presented in Tables IV-3 and IV-4; the results of the general chemical analyses are presented in Tables IV-5 and IV-6; and the results of trace metal analyses are presented in Tables IV-7 and IV-8.

All radiological results are below the DOE derived concentration guides (DCGs) that limit potential exposure to the public from ingestion of water to levels below the DOE public dose limit (PDL) (see Appendix A). The majority of the results are near or below the detection limits of the analytical methods used. 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). There were no significant changes in the chemical quality or trace metal quality of surface water and groundwater at the individual stations from previous years (Purtymun 1988a).

4. Environmental Studies at the Pueblo of San Ildefonso. (David Rogers, Stephen McLin, and Max Maes, ESH-18)

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

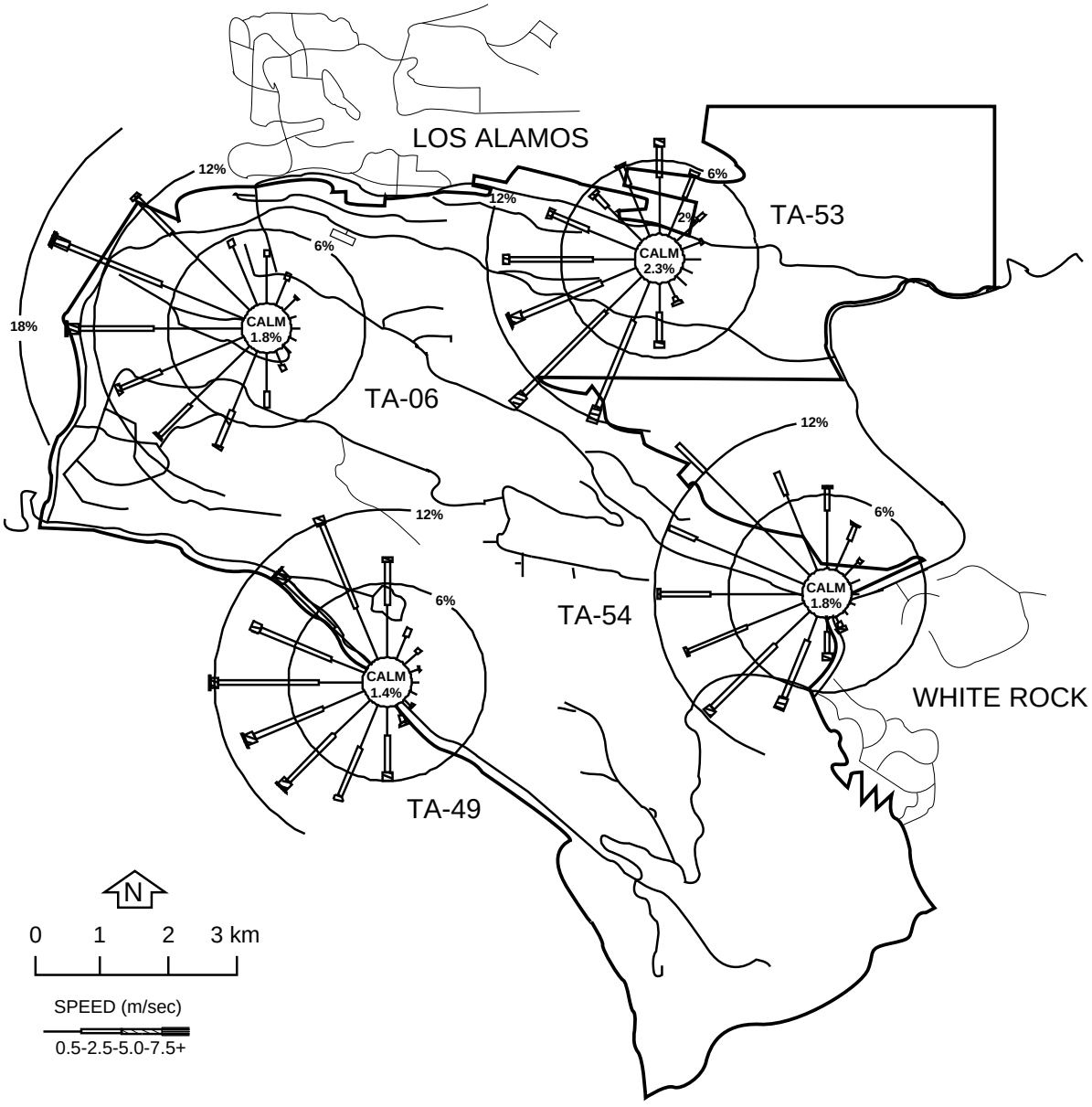


Figure IV-2. Nighttime wind roses for 1994, based on winds measured at 11 m (36 ft) above the ground on the Pajarito Plateau.

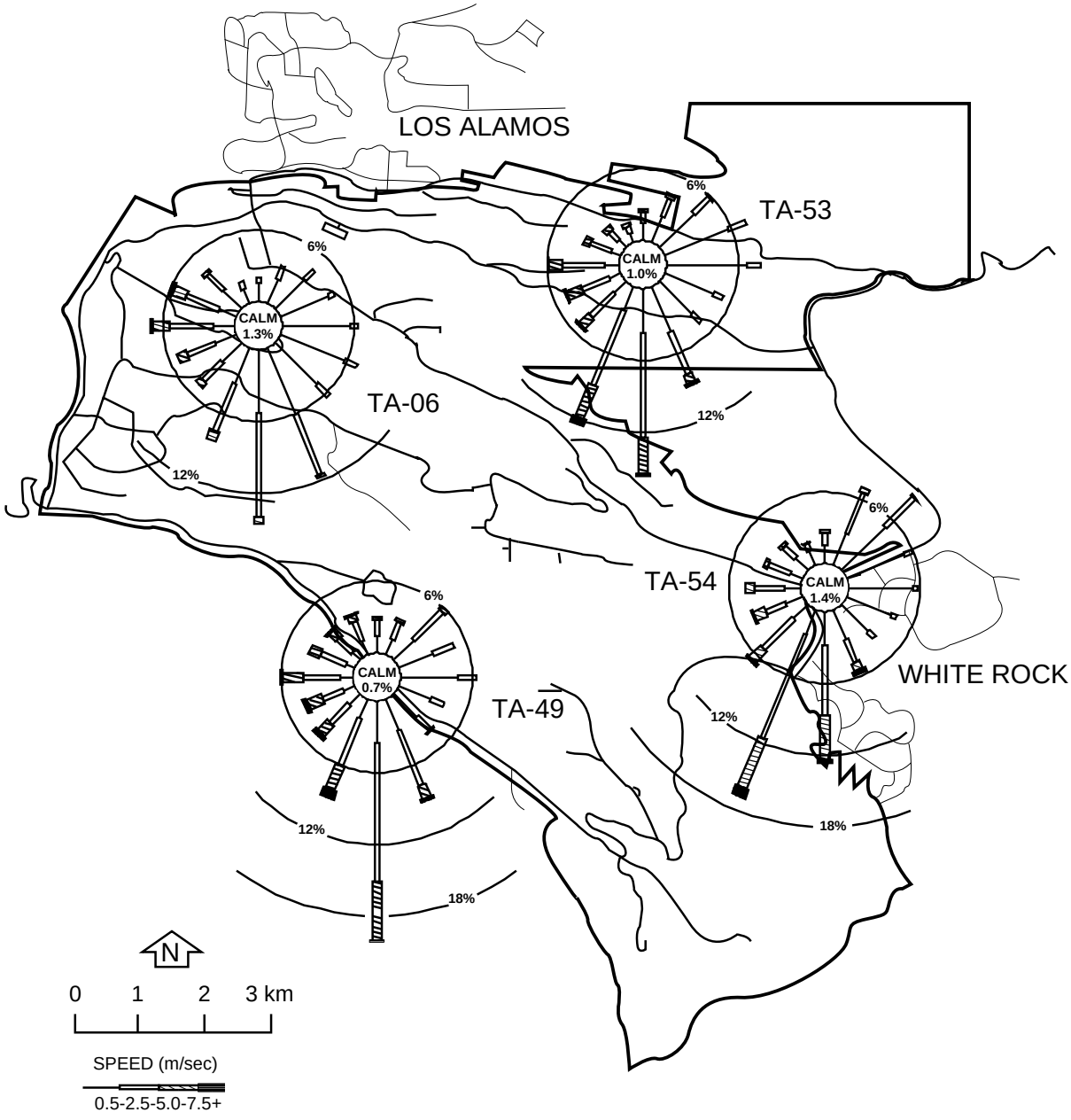


Figure IV-3. Daytime wind roses for 1994, based on winds measured at 11 m (36 ft) above the ground on the Pajarito Plateau.

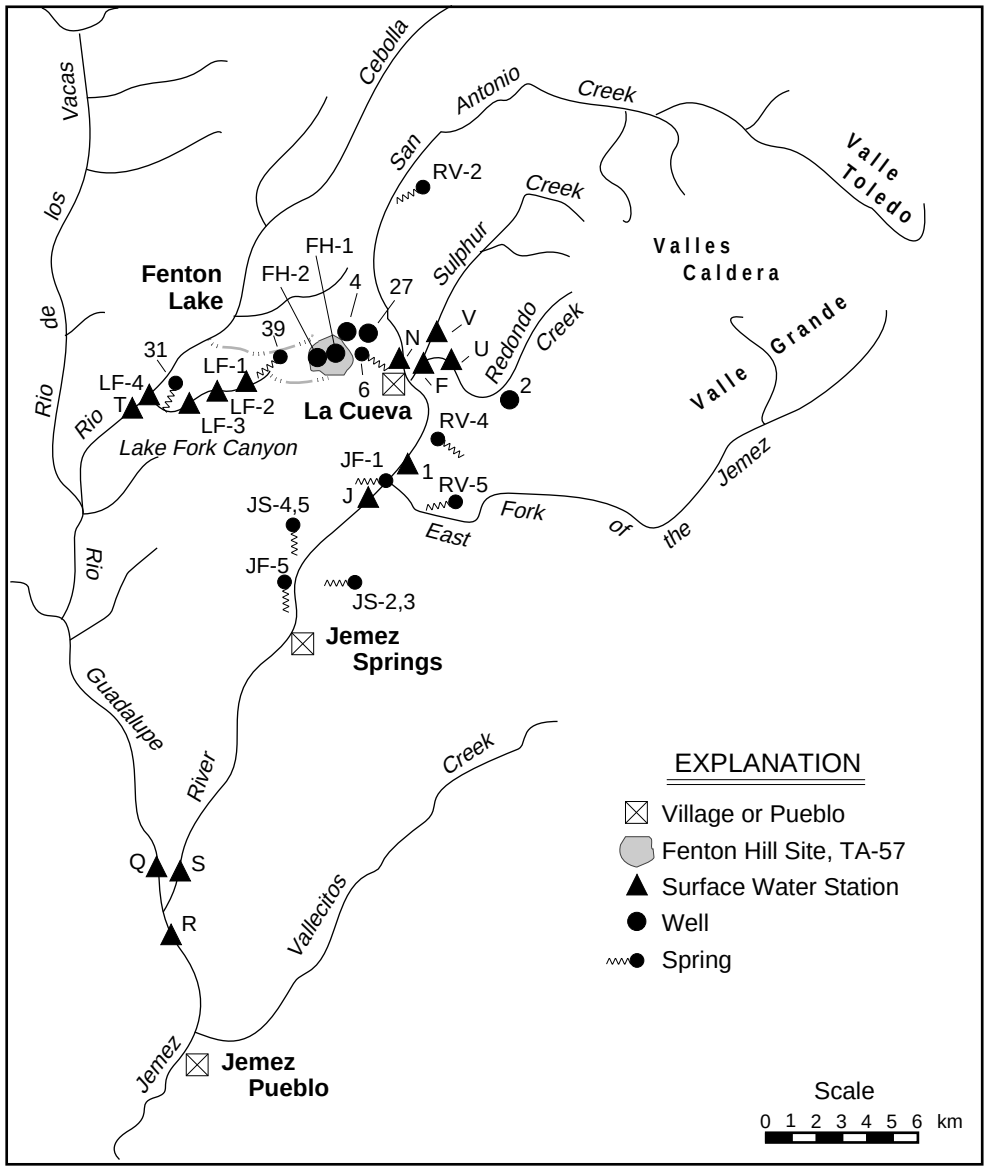


Figure IV-4. Sampling stations for surface water and groundwater near the Fenton Hill Site (TA-57). (Map denotes general locations only.)

Table IV-3. Radiochemical Analysis of Surface Water near Fenton Hill for 1994

Location	^{3}H (nCi/L)	^{90}Sr (pCi/ L)	^{137}Cs (pCi/ L)	Total Uranium (mg/ 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	0.0 (0.3)[a]	-0.4 (1.0)	< 0.3[b]	0.5 (0.1)	0.013 (0.011)	0.047 (0.016)	0.020 (0.017)	1 (1)	2 (0)	70 (50)
(N) San Antonio Creek	-0.2 (0.3)	0.3 (0.9)	0.8 (0.3)	0.4 (0.0)	-0.003 (0.010)	0.005 (0.010)	0.008 (0.021)	1 (1)	3 (0)	60 (50)
(Q) Rio Guadalupe	0.1 (0.3)	0.7 (0.9)	< 1.1	3.6 (0.4)	-0.008 (0.002)	0.009 (0.010)	0.023 (0.014)	5 (1)	4 (1)	20 (50)
(S) Jemez River Above Rio Guadalupe	0.0 (0.3)	0.2 (1.0)	< 0.8	0.6 (0.1)	0.015 (0.009)	0.014 (0.010)	0.033 (0.020)	19 (4)	16 (2)	40 (50)
(LF-1) Lake Fork 1	-0.4 (0.3)	1.4 (0.9)	2.0 (0.7)	2.0 (0.3)	0.025 (0.018)	0.049 (0.020)	0.024 (0.015)	5 (1)	8 (1)	60 (50)
(LF-2) Lake Fork 2	-0.5 (0.3)	0.0 (1.0)	< 1.1	0.5 (0.1)	0.023 (0.015)	0.045 (0.017)	0.037 (0.021)	1 (1)	3 (1)	40 (50)
(LF-3) Lake Fork 3	-0.5 (0.3)	-0.2 (1.1)	< 0.5	0.4 (0.0)	-0.001 (0.010)	0.028 (0.014)	0.040 (0.021)	-0 (0)	3 (0)	70 (50)
(LF-4) Lake Fork 4	-0.2 (0.3)	-0.9 (0.8)	< 0.7	0.4 (0.0)	0.006 (0.008)	0.043 (0.017)	0.031 (0.017)	-0 (0)	2 (0)	20 (50)
Limits of Detection[c]	0.4	1	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose[c]	2,000	1,000	3,000	800	40	60	30			
DOE Drinking Water System DCG[c]			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard[c]	20	8		20				15		
EPA Screening Level[c]									50	

[a]Radioactivity counting uncertainties are shown in parentheses.

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

[c]Standards given here for comparison only, see Appendix A.

Table IV-4. Radiochemical Analysis of Groundwater near Fenton Hill

Location	^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (mg/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)[a]	0.8 (1.1)	0.7 (0.4)	1.0 (0.1)	-0.001 (0.010)	0.009 (0.010)	0.024 (0.017)	2 (1)	4 (1)	10 (50)
(FH-1) Fenton Hill (Well)	<0.0 (0.1)[b]	N/A[c]	<2.0	N/A	0.003 (0.005)	0.002 (0.004)	N/A	9 (5)	7 (3)	N/A
JF-1 Jemez Canyon Hot Spring										
Limestone Spring	0.0 (0.3)	0.5 (1.1)	0.7 (0.4)	16.4 (1.6)	0.007 (0.011)	-0.009 (0.007)	-0.021 (0.017)	-31 (7)	18 (2)	70 (50)
JF-5 Jemez Canyon Hot Spring										
Soda Dam	-0.1 (0.3)	0.6 (1.3)	1.6 (0.6)	3.5 (0.7)	0.050 (0.018)	0.072 (0.020)	0.015 (0.016)	-9 (2)	660 (70)	200 (50)
(4) La Cueva Spring										
Hofhein's House	-0.3 (0.3)	0.2 (3.5)	1.0 (0.5)	0.5 (0.1)	-0.006 (0.008)	0.011 (0.011)	0.041 (0.015)	1 (1)	4 (1)	80 (50)
(6) La Cueva Spring										
Little Shed	-0.3 (0.3)	0.8 (0.8)	0.6 (0.3)	1.4 (0.2)	0.000 (0.016)	0.049 (0.050)	0.092 (0.023)	2 (1)	5 (1)	60 (50)
(RV-4) Spence Hot Spring	-0.5 (0.3)	0.6 (1.0)	<1.1	0.7 (0.1)	0.016 (0.012)	0.007 (0.009)	-0.018 (0.012)	0 (1)	1 (0)	100 (50)
(31) Cold Spring Lake										
Fork Canyon	-0.2 (0.3)	0.0 (0.8)	0.9 (0.4)	3.9 (0.4)	0.040 (0.016)	0.023 (0.014)	0.048 (0.019)	3 (1)	5 (1)	100 (50)
(39) Lake Fork Tank										
(Spring)	-0.1 (0.3)	-0.4 (1.0)	<0.9	0.0 (0.1)	0.006 (0.011)	0.139 (0.026)	0.052 (0.019)	-0 (0)	2 (0)	30 (50)
Limits of Detection	0.4	1	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose[d]	2,000	1,000	3,000	800	40	60	30			
DOE Drinking Water System DCG[d]			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard[d]	20	8		20				15		
EPA Screening Level[d]									50	
NMWQCC Groundwater Limit[d]				5,000						

[a]Radioactivity counting uncertainties are shown in parentheses.

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

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

[d]Standards given here for comparison only, see Appendix A.

Table IV-5. Chemical Quality of Surface Waters near Fenton Hill for 1994

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 mS/cm
(J)	Jemez River at Battleship Rock	57	13	2.7	3	15	5	1.1	<5[c]	61	0.0	16	0.13	<0.01	154	43	7.9	169
(N)	San Antonio Creek	59	11	1.8	1	11	3	1.4	<5	54	0.0	9	<0.04	<0.01	142	35	7.9	335
(Q)	Rio Guadalupe	26	52	6.0	3	13	9	0.5	<5	177	0.1	8	<0.04	<0.01	198	150	8.2	340
(S)	Jemez River Above Rio Guadalupe	54	35	4.5	12	60	84	1.2	<5	134	<0.0	12	0.04	<0.01	392	110	8.5	577
(LF-1)	Lake Fork 1	54	26	5.2	5	11	4	1.1	<5	66	0.2	6	0.11	<0.01	144	86	7.1	136
(LF-2)	Lake Fork 2	54	15	2.6	3	10	4	1.1	<5	66	0.1	7	0.17	<0.01	190	48	7.1	131
(LF-3)	Lake Fork 3	54	15	2.5	3	11	4	1.1	<5	67	0.0	6	0.27	<0.01	166	47	7.5	135
(LF-4)	Lake Fork 4	54	16	2.6	3	11	4	1.1	<5	69	<0.0	6	0.19	<0.01	254	50	7.6	134
EPA Primary Drinking Water Standard[d]								4					10	0.2				
EPA Secondary Drinking Water Standard[d]							250					250			500		6.8-8.5	
EPA Health Advisory[d]						20												
NMWQCC Groundwater Limit[d]							250	1.6										

[a]Total dissolved solids.

[b]Standard units.

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

[d]Standards given here for comparison only, see Appendix A.

Table IV-6. Chemical Quality of Groundwater near Fenton Hill for 1994 (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	83	26	4.3	3	39	18	1.2	<5	152	<0.0	10	0.24	<0.01	310	82	7.9	343
(FH-1)	Fenton Hill Well	29	76	8.5	6	25	53	<0.1	<10	203	<0.0	10	1.60	0.03	<386	226	7.9	570
JF-1	Jemez Canyon Hot Spring Limestone Spring	20	51	22.0	18	310	3	2.2	46	682	0.2	53	<0.04	<0.01	908	220	9.1	1250
JF-5	Jemez Canyon Hot Spring Soda Dam	49	290	23.0	220	860	372	3.7	<5	1,260	<0.0	32	<0.04	<0.01	395	811	6.5	5900
(4)	La Cueva Spring Hofhein's House	68	21	3.8	4	14	4	0.5	<5	81	<0.0	6	0.95	<0.01	226	68	7.1	163
(6)	LaCueva Spring Little Shed	63	26	8.0	5	17	12	0.5	<5	115	0.1	12	3.20	0.02	296	97	7.2	246
(RV-4)	Spence Hot Spring	71	5	1.6	<1	41	7	0.7	<5	113	0.0	12	<0.04	<0.01	242	18	8.4	230
(31)	Cold Spring Lake Fork Canyon	50	19	2.9	4	9	3	1.2	<5	57	0.0	5	0.20	<0.01	250	59	7.7	123
(39)	Lake Fork Tank (Spring)	25	15	3.0	2	6	6	0.1	<5	42	1.0	16	0.19	<0.01	158	49	6.5	128
EPA Primary Drinking Water Standard[d]								4					10	0.2				
EPA Secondary Drinking Water Standard[d]							250					250		500		6.8-8.5		
EPA Health Advisory[d]						20												
NMWQCC Groundwater Limit							250	1.6										

[a]Total dissolved solids

[b]Standard Units

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

[d]Standards given here for comparison only, see Appendix A.

Table IV-7. Total Recoverable Trace Metals in Surface Water near Fenton Hill for 1994 (mg/L)

	Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
(J)	Jemez River at Battleship Rock	<0.01[a]	0.74	0.009	0.020	0.027	<0.003	<0.003	<0.008	<0.009	<0.010	0.37	<0.0002
(N)	San Antonio Creek	<0.01	0.76	<0.003	<0.010	0.034	<0.003	<0.003	<0.004	<0.007	<0.010	0.45	<0.0002
(Q)	Rio Guadalupe	<0.01	0.55	<0.003	0.047	0.110	<0.003	<0.003	<0.005	<0.006	<0.010	0.31	<0.0002
(S)	Jemez River Above Rio Guadalupe	<0.01	0.75	0.076	0.680	0.064	<0.003	<0.003	<0.004	<0.004	<0.010	0.38	<0.0002
(LF-1)	Lake Fork 1	<0.01	11.00	0.010	0.029	0.370	<0.003	<0.003	0.012	0.011	0.008	29.00	<0.0002
(LF-2)	Lake Fork 2	<0.01	1.00	<0.002	<0.010	0.045	<0.003	<0.003	<0.004	<0.004	<0.004	2.20	<0.0002
(LF-3)	Lake Fork 3	<0.01	0.12	<0.002	<0.010	0.023	<0.003	<0.003	<0.004	<0.004	0.005	0.29	<0.0002
(LF-4)	Lake Fork 4	<0.01	<0.10	<0.002	0.012	0.022	<0.003	<0.003	<0.004	<0.004	0.005	0.15	<0.0002
EPA Primary Drinking Water Standard[b]				0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard[b]			0.05-0.2									0.3	
EPA Action Level[b]											1.3		
Livestock Wildlife Watering Limit[b]			5.0	0.2	5.0			0.05	1.0	1.0	0.5		0.01

*Additional data on additional trace metals in surface waters are presented on the following page.

Table IV-7. Total Recoverable Trace Metals in Surface Water near Fenton Hill for 1994 (mg/L) (Cont.)

	Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
(J)	Jemez River at Battleship Rock	0.016	<0.020[a]	<0.01	<0.002	<0.002	<0.001	<0.03	0.068	<0.002	<0.01	<0.02
(N)	San Antonio Creek	0.016	<0.008	<0.03	<0.002	<0.002	<0.001	<0.03	0.058	<0.002	<0.01	<0.02
(Q)	Rio Guadalupe	0.019	<0.008	<0.02	<0.002	<0.002	0.001	<0.03	0.210	<0.002	0.01	<0.02
(S)	Jemez River Above Rio Guadalupe	0.029	<0.008	<0.02	0.003	<0.002	<0.001	<0.03	0.160	0.003	0.01	<0.02
(LF-1)	Lake Fork 1	4.300	<0.008	<0.02	0.031	<0.001	0.004	<0.03	0.140	<0.001	0.02	0.14
(LF-2)	Lake Fork 2	0.400	<0.008	<0.01	0.003	<0.001	<0.001	<0.03	0.073	<0.001	<0.00	<0.02
(LF-3)	Lake Fork 3	0.042	<0.008	<0.01	0.008	<0.001	<0.001	<0.03	0.071	<0.001	<0.00	<0.02
(LF-4)	Lake Fork 4	0.018	<0.008	<0.01	<0.001	<0.001	<0.001	<0.03	0.073	<0.001	<0.00	<0.02
EPA Primary Drinking Water Standard[b]				0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard[b]		0.05										5.0
EPA Action Level[b]					0.015							
EPA Health Advisory[b]									25-90		0.08-0.11	
Livestock Wildlife Watering Limit[b]					0.1						0.1	25.0

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]Standards given here for comparison only, see Appendix A.

Table IV-8. Total Recoverable Trace Metals in Groundwater near Fenton Hill for 1994 (mg/L)

	Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
JS-4,5	Jemez Village Spring Forest Service Office	<0.0100a	<0.100	0.0300	0.1600	0.0380	<0.0030	<0.0030	<0.0040	<0.0060	0.0140	<0.10	<0.0002
(FH-1)	Fenton Hill Well	<0.0040	< 0.013	<0.0050	0.7180	<0.1550	<0.0010	<0.0026	<0.0040	<0.0042	<0.0020	0.23	<0.0002
JF-1	Jemez Canyon Hot Spring Limestone Spring	<0.0100	55.000	0.0160	0.3900	0.3800	<0.0030	<0.0030	0.0310	0.0690	0.0340	48.00	<0.0002
JF-5	Jemez Canyon Hot Spring Soda Dam	<0.0100	<0.100	1.3000	12.0000	0.4100	0.0050	<0.0030	<0.0040	<0.0040	0.0070	<0.10	<0.0002
(4)	La Cueva Spring Hofhein's House	<0.0100	0.140	<0.0020	0.0130	0.0460	<0.0030	<0.0030	<0.0040	<0.0040	0.0120	0.45	<0.0002
(6)	La Cueva Spring Little Shed	<0.0100	< 0.100	0.0030	0.0110	0.2600	<0.0030	<0.0030	<0.0040	<0.0040	0.0050	0.29	<0.0002
(RV-4)	Spence Hot Spring	<0.0100	0.160	0.0530	0.0930	<0.0040	<0.0030	<0.0030	<0.0040	<0.0040	<0.0100	< 0.10	<0.0002
(31)	Cold Spring Lake Fork Canyon	<0.0100	4.700	0.0020	<0.0100	0.0690	0.0040	<0.0030	<0.0040	<0.0040	0.0130	4.90	<0.0002
(39)	Lake Fork Tank (Spring)	<0.0100	<0.100	<0.0020	<0.0100	0.0230	<0.0030	<0.0030	<0.0040	<0.0040	0.0050	<0.10	<0.0002
EPA Primary Drinking Water Standard[b]				0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard[b]			0.05-0.2									0.3	
EPA Action Level[b]											1.3		
Livestock Wildlife Watering Limit[b]			5.0	0.2	5.0			0.05	1.0	1.0	0.5		0.01
NMWQCC Groundwater Limit[b]		0.05		0.1	0.75	1.0		0.01	0.05	0.05	1.0		0.002

*Additional data on trace metals in groundwater are presented on the following page.

Table IV-8. Total Recoverable Trace Metals in Groundwater near Fenton Hill for 1994 (mg/L) (Cont.)

	Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
JS-4,5	Jemez Village Spring Forest Service Office	<0.0030[a]	0.013	<0.0200	<0.0020	<0.0020	<0.0010	<0.030	0.160	0.0030	< 0.01	0.200
(FH-1)	Fenton Hill Well	<0.0034	< 0.027	<0.0307	0.0057	<0.0030	<0.0040	<0.001	0.268	<0.0014	< 0.01	4.630
JF-1	Jemez Canyon Hot Spring Limestone Spring	0.8700	0.016	0.0450	0.0400	<0.0020	0.0010	<0.030	0.330	0.0050	0.13	0.200
JF-5	Jemez Canyon Hot Spring Soda Dam	0.5200	< 0.008	<0.0200	0.0040	<0.0020	0.0060	<0.030	1.400	0.0050	< 0.00	<0.020
(4)	La Cueva Spring Hofhein's House	0.0070	< 0.008	<0.0100	0.0110	<0.0010	<0.0010	<0.030	0.100	0.0010	0.01	1.100
(6)	La Cueva Spring Little Shed	0.0380	< 0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.140	<0.0010	0.01	<0.020
(RV-4)	Spence Hot Spring	<0.0030	0.049	<0.0200	<0.0020	<0.0020	<0.0010	<0.030	0.023	<0.0020	< 0.01	<0.020
(31)	Cold Spring Lake Fork Canyon	0.3700	< 0.008	<0.0200	0.0150	<0.0010	0.0030	<0.030	0.098	<0.0010	< 0.01	0.054
(39)	Lake Fork Tank (Spring)	<0.0030	< 0.008	<0.0100	0.0130	<0.0010	<0.0010	<0.030	0.086	<0.0010	< 0.00	<0.020
	EPA Primary Drinking Water Standard[b]			0.1		0.006	0.05			0.002		
	EPA Secondary Drinking Water Standard[b]	0.05										5.0
	EPA Action Level[b]				0.015							
	EPA Health Advisory[b]								25-90		0.08-0.11	
	Livestock Wildlife Watering Limit[b]				0.1						0.1	25.0
	NMWQCC Groundwater Limit[b]		1.0		0.05		0.05					

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]Standards given here for comparison only, see Appendix A.

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 air, 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. See Section V.B.1 for TLD measurements. See Section V.B.2 for air measurements. 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, EARE 1995b). Additional information relating to groundwater age dating and low-level tritium sampling results are presented in Section VII.E.1.b of this report.

High nitrate levels were discovered in samples taken during 1994 from several Los Alamos area test wells and from water supply wells at Pueblo of San Ildefonso. These results are discussed in Section VII.E.5.

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 for the Los Alamos distribution system was in September 1991. Three of the wells (Figure IV-5) have been turned over to the Pueblo of San Ildefonso: LA-1B (to be used cooperatively with BIA as a long-term monitoring well), LA-2 (as a possible production well), and LA-5 (which was 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) 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 1995a).

In 1994, water samples were collected from 13 groundwater wells on Pueblo of San Ildefonso lands (Figure IV-5). Samples were collected by Laboratory personnel in the company of personnel from the Pueblo of San Ildefonso Governor's Office, the BIA, and the NMED DOE Oversight Bureau on July 27, 28, and August 2. The BIA did not collect duplicate samples in 1994. Water samples were taken from the Don Juan Playhouse, Eastside

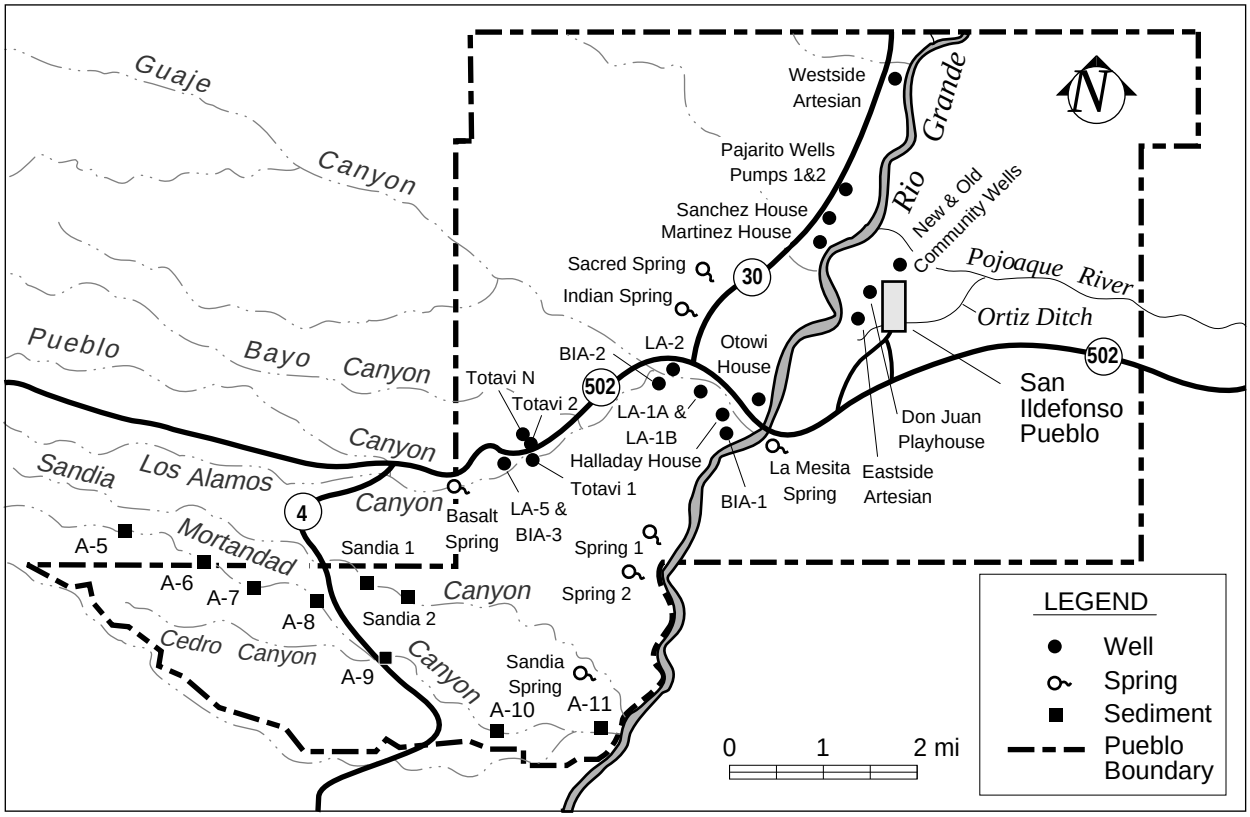


Figure IV-5. Sediment and groundwater stations and springs on Pueblo of San Ildefonso land. (Map denotes general locations only; see Table IV-9 for cross-referencing to specific loactions.)

Artesian, Pajarito Pump No. 1, Old Community, Martinez House, Westside Artesian, Pajarito Pump No. 2, and the Sanchez House wells on July 27; from Sacred, La Mesita, and Basalt Spring, the Otowi House and Halladay House wells, and Los Alamos Well Field Well LA-5 on July 28; and from Los Alamos Well Field Wells LA-1A and LA-1B on August 2.

Alluvial Observation Wells BIA #1, BIA #2, BIA #3, Totavi BIA North, and Totavi BIA in lower Los Alamos Canyon were not sampled in 1994. 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.

On July 27, 1994, sediments from Mortandad Canyon were collected from seven permanent sampling stations, as seen in Figure IV-5. The results of these sample analyses for radiochemicals and trace metals are generally comparable to sediment data collected from these same stations in previous years; furthermore, these results are comparable to sediment samples collected in adjacent canyons. There are no trends apparent in the 1994 sediment data, and the results do not indicate the presence of any contaminants from Laboratory operations. These findings are consistent with current and previous measurements of sediments from these canyons where they exit the Laboratory facility at State Road 502.

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-9 to permit cross-referencing with other sections of this report.

a. Groundwater. Radiochemical analyses of the 1994 groundwater samples are shown in Table IV-10. As reported for 1993 (EARE 1995b), the major difference from previous results are the ^{137}Cs measurements, which

Table IV-9. Locations on Pueblo of San Ildefonso Land for Water and Sediment Sampling that are Included in the Routine Monitoring Program

Station Identification	Map	See this Table for Results
Water Sampling Locations		
Surface Water		
Rio Grande at Otowi	Figure V-13, No. 3	V-20, and VI-8, -9
Springs in White Rock Canyon		
Sandia Spring	Figure IV-8	VII-1, -2, -3
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

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

are all much lower than reported prior to 1992. The ^{137}Cs measurements for 1992 –1994 were 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 1994 exceed the DOE DCG for water supply systems or the proposed EPA maximum contaminant level; all were less than about 3% of the DCG of 120 pCi/L.

In 1992 (EPG 1994), analyses of several of the samples for plutonium and americium indicated that they contained levels exceeding the average detection limits of the analytical method. Those for Pajarito Pump No. 1, Pajarito Pump No. 2, Otowi House, Sanchez House, and Martinez House were as much as 2 to 3 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, and (2) results of BIA duplicate samples for 1992 sent to an independent laboratory did not confirm the results.

Five results from the 1994 samples show levels above detection limits (0.02 pCi/L) for samples taken at the following locations (all the same wells were sampled in July 1994): for ^{238}Pu, the Westside Artesian, Martinez House, Otowi House, and Pajarito Pump No. 1 wells, and for americium, the Westside Artesian well. The largest of the ^{238}Pu values (0.085 pCi/L) is just 5.3% of the DOE DCG of 1.6 pCi/L, and the americium value (0.050 pCi/L) is 4.2% of the DOE DCG of 1.2 pCi/L. The analytical uncertainty (standard deviation) for all of these values is $\pm$ 0.03 pCi/L. Thus, the 1994 data appear to confirm the 1992 result that samples for the Martinez House, Otowi House, and Pajarito Pump No. 1 wells contained levels of plutonium exceeding the average detection limits.

The Westside Artesian, Old Community, and LA-1A wells had uranium concentrations near or exceeding the EPA primary drinking water standard of 20 µg/L. Uranium concentrations at the Pajarito Pump No. 1 and Sanchez House wells were about half of the EPA standard. These measurements are consistent with the levels in previous samples and with relatively high levels of natural uranium in other wells and springs in the area (EPG 1993, EPG 1994, EARE 1995b).

The gross alpha level in samples from the Old Community and Sanchez House wells exceeded the EPA primary drinking water standard of 15 pCi/L. Gross alpha levels in the samples from the Eastside Artesian, Otowi House, LA-1B, and LA-1B 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 high levels of uranium.

The chemical quality of the groundwater, shown in Table IV-11, is consistent with previous observations. The samples from the Westside Artesian, Pajarito Pump No. 1, Sanchez House, and LA-1B wells exceeded or were near the drinking water standard for total dissolved solids (TDS); these levels are similar to those previously measured (EPG 1993, EPG 1994, EARE 1995b). The fluoride values for these four wells (Westside Artesian, Pajarito Pump No. 1, Sanchez House, and LA-1B) are near or (for Westside Artesian and LA-1B) greatly exceed the New Mexico Water Quality Control Commission (NMWQCC) groundwater standard of 1.6 mg/L, again similar to previous values (EPG 1994, EARE 1995b). 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, EARE 1995b).

Trace metal analyses are shown in Table IV-12. As was reported for 1993 (EE 1995), several wells and springs show high values for trace metals, exceeding values previously reported (EPG 1994). We believe that the high trace metal values are due to several factors: (1) the samples were not filtered before analysis, (2) the technique by which samples were prepared for analysis is for total recoverable metals, which partially digests the suspended sediment, and (3) these elements are commonly either adsorbed onto suspended sediments, or (4) several of these metals are constituents of the suspended sediment particles themselves. In particular, aluminum, iron, and manganese values for some of the samples were high.

Well LA-1B and Pajarito Pump No. 1 had arsenic values of about 0.04 mg/L, just below the EPA drinking water standard of 0.05 mg/L. A similar value was reported for LA-1B in 1993 (EARE 1995b). The arsenic concentration for Pajarito Pump No. 1 appears to have increased since 1991: the values for recent years were <0.03 mg/L in 1990, 0.005 mg/L in 1991, and 0.0186 mg/L in 1992. The well was not sampled in 1993.

Boron values in two wells exceeded the NMWQCC groundwater limit of 0.75 mg/L: Westside Artesian and Pajarito Pump No. 1. These values are similar to those of past years. Antimony concentrations in the Eastside Artesian and Pajarito Pump No. 2 wells exceeded the EPA primary drinking water standard of 0.006 mg/L. Three

Table IV-10. Radiochemical Analysis of Groundwater on Pueblo of San Ildefonso Land for 1994

Location	^{3}H (nCi/L)	^{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)
San Ildefonso Wells										
Don Juan Playhouse	0.0 (0.3)[a]	0.6 (0.6)	1.2 (0.6)	6.1 (0.6)	0.000 (0.03)	0.004 (0.02)	-0.003 (0.030)	4 (2)	2 (0)	10 (50)
Eastside Artesian Well	0.1 (0.3)	0.3 (0.7)	1.9 (0.8)	2.8 (0.3)	-0.014 (0.03)	0.008 (0.02)	0.003 (0.030)	9 (5)	2 (1)	0 (50)
Westside Artesian Well	0.3 (0.3)	0.2 (0.8)	1.2 (0.7)	18.5 (2.2)	0.050 (0.03)	0.020 (0.02)	0.050 (0.030)	-1 (1)	15 (2)	-10 (50)
Halladay Well	0.3 (0.3)	0.5 (0.8)	<0.4[b]	1.3 (0.1)	0.003 (0.03)	0.009 (0.02)	0.030 (0.030)	0 (1)	2 (0)	60 (50)
Martinez Well	0.3 (0.3)	0.0 (0.9)	<1.1	7.0 (0.7)	0.047 (0.03)	0.010 (0.02)	0.022 (0.030)	1 (0)	7 (1)	30 (50)
Old Community Well	0.2 (0.3)	0.6 (0.6)	2.2 (0.7)	35.2 (4.2)	-0.012 (0.03)	0.004 (0.02)	0.012 (0.030)	21 (5)	17 (2)	30 (50)
Otowi House Well	0.1 (0.3)	0.4 (0.8)	<0.9	3.6 (0.4)	0.042 (0.03)	0.020 (0.02)	0.009 (0.030)	5 (2)	6 (1)	70 (50)
Pajarito Well Pump 1	0.4 (0.3)	0.1 (0.7)	1.9 (0.7)	10.7 (1.3)	0.085 (0.03)	0.024 (0.02)	0.031 (0.030)	-7 (2)	13 (2)	60 (50)
Pajarito Well Pump 2	0.0 (0.3)	0.4 (0.7)	1.2 (0.5)	6.0 (0.6)	0.003 (0.03)	0.023 (0.02)	-0.004 (0.030)	-150 (70)	6 (1)	-10 (50)
Sanchez House Well	0.2 (0.3)	0.4 (0.6)	<1.2	10.8 (1.1)	-0.002 (0.03)	0.000 (0.02)	0.027 (0.030)	40 (10)	11 (1)	20 (50)
LA-1A	-0.1 (0.3)	0.6 (0.8)	<0.7	16.2 (1.6)	0.025 (0.03)	0.023 (0.02)	0.010 (0.017)	10 (5)	9 (1)	20 (50)
LA-1B	0.3 (0.3)	1.7 (0.7)	<0.8	3.8 (0.5)	-0.013 (0.03)	-0.012 (0.02)	0.002 (0.011)	9 (5)	8 (1)	50 (50)
LA-5	0.1 (0.3)	0.1 (0.7)	<0.7	1.0 (0.1)	-0.014 (0.03)	0.023 (0.02)	0.028 (0.030)	1 (1)	4 (1)	50 (50)
Springs										
Basalt Spring	0.3 (0.3)	0.4 (0.8)	<0.9	0.6 (0.1)	-0.011 (0.03)	0.014 (0.02)	0.038 (0.030)	1 (1)	8 (1)	20 (50)
Indian Spring	-0.1 (0.3)	0.6 (0.7)	<1.1	0.6 (0.1)	-0.009 (0.03)	-0.021 (0.02)	0.037 (0.017)	0 (2)	6 (1)	40 (50)
La Mesita Spring	0.1 (0.3)	1.6 (0.8)	1.0 (0.5)	14.7 (1.5)	0.053 (0.03)	0.028 (0.02)	0.016 (0.030)	12 (3)	10 (1)	40 (50)
Sacred Spring	-0.3 (0.3)	0.7 (0.8)	<1.1	0.8 (0.1)	0.006 (0.03)	0.040 (0.02)	0.026 (0.030)	1 (0)	3 (1)	30 (50)
Limits of Detection	0.4	1	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose[c]	2,000	1,000	3,000	800	40	60	30			
DOE Drinking Water System DCG[c]			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard[c]	20	8		20				15		
EPA Screening Level[c]									50	
NMWQCC Groundwater Limit[c]				5,000						

[a]Radioactivity counting uncertainties are shown in parentheses

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

[c]Standards given here for comparison only, see Appendix A.

Table IV-11. Chemical Quality of Groundwater on Pueblo of San Ildefonso Land for 1994 (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)
San Ildefonso Wells																	
Don Juan Playhouse Well	25	7	0.5	1	64	3	0.7	14	143	<0.0[c]	14	2.90	<0.01	262	16	8.9	309
Eastside Artesian Well	21	3	0.2	<1	85	3	0.9	15	193	<0.0	16	8.60	<0.01	278	8	9.1	390
Westside Artesian Well	24	15	0.8	2	350	355	5.2	<5	326	<0.0	80	5.70	<0.01	1,174	41	8.3	1,900
Halladay Well	29	5	<0.0	<1	42	5	0.5	<5	86	<0.0	13	1.10	<0.01	138	11	8.8	195
Martinez Well	42	51	3.0	5	54	17	0.6	<5	156	0.0	32	15.80	<0.01	384	140	8.0	474
Old Community Well	22	63	5.1	4	25	9	0.3	<5	182	<0.0	18	2.00	<0.01	290	180	8.1	405
Otowi House Well	62	85	6.2	4	43	42	0.3	<5	222	0.0	22	10.80	<0.01	382	235	7.5	560
Pajarito Well Pump 1	34	61	6.4	6	330	210	1.9	<5	563	0.1	48	7.70	<0.01	1,118	180	7.9	1,670
Pajarito Well Pump 2	37	30	1.7	2	95	37	1.1	<5	201	<0.0	20	19.00	<0.01	418	80	8.0	528
Sanchez House Well	40	40	2.8	3	100	40	1.5	<5	215	<0.0	56	9.50	<0.01	488	110	8.0	640
LA-1A	36	31	0.8	3	85	13	0.6	<5	196	0.0	27	1.50	<0.01	408	80	8.1	436
LA-1B	40	7	0.3	3	130	16	3.3	<5	294	<0.0	31	6.30	<0.01	518	18	8.2	596
LA-5	43	21	0.8	2	14	4	0.5	<5	75	<0.0	6	0.76	<0.01	174	55	8.8	169
Springs																	
Basalt Spring	72	37	9.4	8	46	35	0.3	<5	92	0.2	21	15.00	<0.01	330	130	7.3	419
Indian Spring	55	37	5.7	3	26	21	0.5	<5	97	<0.0	7	0.83	<0.01	206	115	7.9	259
La Mesita Spring	30	38	2.8	4	31	8	0.3	<5	127	0.0	14	5.80	0.01	188	105	7.6	269
Sacred Spring	22	25	0.9	4	24	3	0.6	<5	106	2.5	6	1.80	<0.01	140	65	7.3	190
EPA Primary Drinking Water Standard[d]							4					10	0.2				
EPA Secondary Drinking Water Standard[d]						250					250			500		6.8-8.5	
EPA Health Advisory[d]					20												
NMWQCC Groundwater Limit[d]						250	1.6					10					

[a]Total dissolved solids.

[b]Standard Units.

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

[d]Standards given here for comparison only, see Appendix A.

Table IV-12. Total Recoverable Trace Metals in Groundwater on Pueblo of San Ildefonso Lands for 1994 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
San Ildefonso Wells												
Don Juan Playhouse Well	<0.010[a]	<0.10	0.006	0.080	<0.004	<0.001	<0.003	<0.004	0.013	<0.004	<0.10	<0.0001
Eastside Artesian Well	<0.010	<0.10	0.009	0.130	<0.004	<0.001	<0.003	<0.004	<0.004	<0.004	1.10	<0.0001
Westside Artesian Well	<0.010	<0.10	0.008	1.700	0.041	<0.001	<0.003	<0.004	<0.004	<0.004	0.20	<0.0001
Halladay Well	<0.200	<0.10	0.011	0.044	0.037	<0.003	<0.003	<0.004	0.013	<0.004	0.14	0.0001
Martinez Well	0.040	<0.10	0.010	0.130	0.200	<0.003	<0.003	<0.004	<0.004	0.011	<0.10	<0.0001
Old Community Well	0.044	<0.10	0.002	0.031	0.170	<0.003	<0.003	<0.004	<0.004	0.009	<0.10	<0.0001
Otowi House Well	<0.200	<0.10	0.004	0.047	0.330	<0.003	<0.003	<0.004	0.008	<0.004	0.32	0.0001
Pajarito Well Pump 1	<0.030	<0.10	0.041	1.600	0.130	<0.003	<0.004	<0.004	0.008	0.006	9.60	<0.0001
Pajarito Well Pump 2	<0.030	<0.10	0.014	0.320	0.120	<0.003	<0.003	<0.004	0.006	0.007	<0.10	<0.0001
Sanchez House Well	0.040	<0.10	0.013	0.230	0.110	<0.003	<0.003	<0.004	<0.004	0.015	<0.10	<0.0001
LA-1A	<0.200	1.90	0.003	0.170	0.230	<0.003	<0.003	<0.004	0.023	<0.004	5.60	<0.0001
LA-1B	<0.200	<0.10	0.042	0.240	0.040	<0.003	<0.003	<0.004	0.027	<0.004	0.44	0.0001
LA-5	<0.200	<0.10	0.003	<0.010	0.058	<0.003	<0.003	<0.004	0.026	<0.004	0.21	0.0001
Springs												
Basalt Spring	<0.020	0.14	0.005	0.210	0.084	<0.003	<0.003	<0.004	0.005	<0.004	0.18	0.0001
Indian Spring	<0.200	<0.10	0.004	0.020	0.100	<0.003	<0.003	<0.004	<0.004	<0.004	<0.10	0.0001
La Mesita Spring	<0.020	4.70	0.002	0.038	0.160	<0.003	<0.003	0.007	0.019	<0.004	4.40	0.0001
Sacred Spring	<0.020	0.75	0.002	0.031	0.180	<0.003	<0.003	<0.004	0.005	<0.004	0.73	0.0001
EPA Primary Drinking Water Standard[b]			0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard[b]	0.05-0.2										0.3	
EPA Action Level[b]										1.3		
Livestock Wildlife Watering Limit[b]		5.0	0.2	5.0			0.05	1.0	1.0	0.5		0.01
NMWQCC Groundwater Limit[b]	0.05		0.1	0.75	1.0		0.01	0.05	0.05	1.0		0.002

*Additional data on trace metals in groundwaters on Pueblo of San Ildefonso lands is presented on the following page.

Table IV-12. Total Recoverable Trace Metals in Groundwater on Pueblo of San Ildefonso Lands for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
San Ildefonso Wells											
Don Juan Playhouse Well	<0.002[a]	<0.008	0.01	<0.002	<0.002	0.002	<0.030	0.092	<0.002	0.02	<0.020
Eastside Artesian Well	0.017	<0.008	<0.01	<0.002	0.008	<0.002	<0.030	0.041	<0.002	0.01	<0.020
Westside Artesian Well	0.011	0.047	<0.01	<0.002	<0.002	<0.002	<0.030	0.330	<0.002	0.01	<0.020
Halladay Well	<0.003	<0.008	<0.20	<0.005	0.002	0.002	<0.030	0.130	<0.001	0.02	<0.030
Martinez Well	<0.003	<0.008	<0.01	<0.002	<0.002	0.005	<0.030	0.650	<0.002	0.02	0.040
Old Community Well	<0.003	<0.008	<0.01	<0.002	<0.002	<0.002	<0.030	0.480	<0.002	<0.00	<0.020
Otowi House Well	0.004	<0.008	<0.20	<0.005	<0.001	<0.002	<0.030	0.950	<0.001	0.01	0.097
Pajarito Well Pump 1	0.008	<0.008	<0.01	0.006	<0.002	0.003	<0.030	1.500	<0.002	0.06	0.190
Pajarito Well Pump 2	<0.003	<0.008	<0.01	<0.002	0.007	0.003	<0.030	0.490	<0.002	0.03	<0.020
Sanchez House Well	<0.003	0.014	<0.01	0.003	<0.002	<0.002	<0.030	0.390	<0.002	0.01	0.027
LA-1A	0.140	<0.008	<0.20	<0.005	<0.001	0.002	<0.030	0.740	<0.001	0.02	0.034
LA-1B	0.019	0.021	<0.20	<0.005	<0.001	0.002	<0.030	0.150	<0.001	0.04	<0.030
LA-5	0.008	<0.008	<0.20	<0.005	<0.001	<0.002	<0.030	0.210	<0.001	0.01	0.086
Springs											
Basalt Spring	0.036	<0.020	<0.01	0.001	0.001	<0.002	<0.030	0.200	<0.001	0.01	0.022
Indian Spring	<0.003	<0.008	<0.20	<0.005	0.002	0.002	<0.030	0.380	<0.001	0.01	0.450
La Mesita Spring	0.110	<0.020	<0.01	0.004	<0.001	0.002	<0.030	0.860	<0.001	0.02	0.019
Sacred Spring	0.042	<0.020	<0.01	0.001	<0.001	<0.002	<0.003	0.530	<0.001	<0.00	0.025
EPA Primary Drinking Water Standard[b]			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard[b]	0.05										5.0
EPA Action Level[b]				0.015							
EPA Health Advisory[b]								25-90		0.08-0.11	
Livestock Wildlife Watering Limit[b]				0.1						0.1	25.0
NMWQCC Groundwater Limit[b]		1.0		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.

wells showed silver concentrations of 0.04 mg/L, just below the NMWQCC groundwater limit of 0.05 mg/L: the Martinez House, Old Community, and Sanchez House wells.

b. Sediments. The radioactive waste treatment plant at TA-50 periodically releases treated liquid effluent into the upper reaches of Mortandad Canyon. This surface water effluent, containing traces of radionuclides and other chemicals, commingles with natural runoff. These combined flows travel along the canyon floor for several miles before they infiltrate directly into channel bedrock or alluvial sediments below the stream channel. These waters enter the shallow groundwater perched on the underlying tuff in the upper and middle reaches of the canyon within Laboratory boundaries. Most of the radionuclides present in the effluent are quickly adsorbed or attached to the sediments in the stream channel. Hence the principal means of radionuclide migration is from sediment transport via surface runoff. The Mortandad Canyon watershed is completely contained on the Pajarito Plateau, with headwaters originating within TA-3. The watershed is long and narrow, with a small catchment area. The channel 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 effluent releases since 1963, when the treatment plant began operating.

In accordance with the MOU, sediments from Mortandad Canyon were collected on July 27, 1994, from seven permanent sampling stations, as seen in Figure IV-5. Station A-5 is located slightly west of the Pueblo of San Ildefonso-Laboratory boundary, while the remaining six locations (i.e., stations A-6 through A-11) are within the Pueblo. The results of these sample analyses for radiochemicals and trace metals are shown in Tables IV-13 and IV-14, respectively. Results from adjacent canyon stations are reported in Tables V-24 and VI-19, respectively. Overall, there are no trends apparent in the 1994 Mortandad Canyon sediment data, and results are generally comparable to sediment data collected from these same stations in previous years. Furthermore, these results are within the ranges expected from worldwide fallout or are comparable to natural background concentrations.

The tritium values for moisture in sediments collected at Stations A-8, A-10, and the composite sample collected near station A-6 along the San Ildefonso-Laboratory boundary in Mortandad Canyon and at Stations 2 and 3 in Sandia Canyon, are somewhat elevated (0.5 to 1.9 nCi/L) above the limit of detection for tritium in water (0.400 nCi/L). While these tritium concentration values are well below the Laboratory's ER Screening Action Level (SAL) as seen in Table IV-13, the exact source of these slightly elevated values is unknown. They suggest, however, a Laboratory origin because natural levels in precipitation are much lower (a mean of about 0.06 nCi/L). Nevertheless, these tritium values are still comparable to historical data collected at these same locations. For the interested reader, a more complete discussion of these SALs is presented in Section V.B.5 (Sediment Monitoring).

None of the Pueblo of San Ildefonso sediment stations in Mortandad Canyon showed levels of ^{90}Sr, ^{137}Cs, total uranium, ^{241}Am, gross alpha, gross beta, or gross gamma concentrations that exceeded the statistically derived comparison values for fallout in soils and sediments in northern New Mexico. The highest level of $^{239,240}Pu$ was obtained at Station A-7 (located on Pueblo of San Ildefonso property adjacent to the boundary with the Laboratory). This sample contained about twice the statistically derived $^{239,240}Pu$ comparison value for fallout in northern New Mexico. Similarly, the ^{238}Pu values for Stations A-7 and A-8 were between three and four times larger than the comparison value for fallout in northern New Mexico. Except for Station A-7 with a plutonium isotope ($^{239,240}Pu/^{238}Pu$) ratio of 2.16, no other ratios for these samples were computed because individual isotope concentrations are either at or below the respective limits of detection (see Table D-14). Hence this computation would not be sufficiently accurate. In sediment samples dominated by worldwide fallout at these low concentration levels, 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 Pueblo of San Ildefonso sediment sampling locations in Bayo, Sandia, and Mortandad canyons are all within the range of values expected from worldwide fallout. These results do not indicate the presence of any contaminants from Laboratory operations. These findings are consistent with current and previous measurements of sediments from these canyons where they exit the Laboratory facility at or near State Road 502. The samples of sediments collected from the Pueblo of San Ildefonso in 1994 were also analyzed for trace metals, as reported in Table IV-14. The results, which are within the general ranges expected for geologic materials, will provide a basis for future comparisons.

Table IV-13. Radioactivity in Sediments on Pueblo of San Ildefonso Land for 1994

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)										
Other Areas										
Bayo at SR-4	N/A[a]	0.1 (0.1)[b]	<0.0[c]	2.2 (0.2)	0.008 (0.001)	0.005 (0.001)	0.003 (0.001)	2 (1)	2 (0)	2 (0)
Sandia Canyon										
Station 1	-0.1 (0.3)	-0.3 (0.6)	<0.0	1.4 (0.2)	0.001 (0.001)	0.002 (0.001)	0.006 (0.002)	3 (1)	2 (0)	1 (0)
Station 2	1.9 (0.7)	0.3 (0.2)	0.0 (0.0)	2.4 (0.2)	<0.001 (0.001)	0.002 (0.004)	0.002 (0.001)	5 (1)	3 (0)	2 (0)
Station 3	1.9 (0.7)	0.0 (0.2)	<0.0	1.7 (0.2)	0.002 (0.001)	0.002 (0.001)	0.003 (0.001)	3 (1)	2 (0)	1 (0)
Mortandad Canyon on San Ildefonso Lands										
Mortandad A-6	0.1 (0.4)	N/A	0.2 (0.1)	1.2 (0.1)	0.000 (0.000)	0.005 (0.001)	N/A	N/A	N/A	N/A
Mortandad A-7	-0.2 (0.3)	0.3 (0.2)	0.1 (0.0)	2.1 (0.2)	0.019 (0.003)	0.041 (0.004)	0.010 (0.002)	4 (1)	5 (1)	2 (0)
Mortandad A-8	1.1 (0.3)	0.3 (0.2)	0.2 (0.1)	3.6 (0.4)	0.025 (0.005)	0.013 (0.002)	0.005 (0.001)	8 (2)	6 (1)	3 (0)
Mortandad at SR-4 (A-9)	N/A	0.1 (0.4)	<0.0	2.1 (0.3)	0.003 (0.001)	0.002 (0.001)	0.004 (0.001)	3 (1)	3 (0)	2 (0)
Mortandad A-10	0.5 (0.3)	0.1 (0.2)	0.0 (0.0)	1.6 (0.2)	0.002 (0.001)	0.002 (0.001)	0.002 (0.001)	3 (1)	3 (0)	0 (0)
Mort SI Sed Transect94 COMP	0.5 (0.3)	0.8 (0.3)	0.3 (0.1)	3.8 (0.4)	0.001 (0.001)	0.015 (0.002)	0.005 (0.002)	10 (2)	8 (1)	3 (0)
ON-SITE STATIONS										
Acid-Pueblo Canyons										
Pueblo at State Route	0.2 (0.3)	5.0 (0.4)	<0.1	3.2 (0.7)	0.019 (0.004)	0.925 (0.022)	0.031 (0.005)	4 (1)	2 (0)	7 (1)
DP-Los Alamos Canyons										
Los Alamos at SR-4	N/A	0.2 (0.1)	0.6 (0.1)	1.9 (0.2)	0.014 (0.002)	0.091 (0.005)	0.072 (0.006)	4 (1)	4 (0)	3 (0)
Mortandad Canyon										
Mortandad at MCO-13 (A-5)	0.2 (0.3)	0.0 (0.2)	0.5 (0.1)	2.9 (0.3)	0.004 (0.001)	0.020 (0.002)	0.006 (0.002)	7 (1)	6 (1)	3 (0)
Background[d]		0.87	0.44	4.4	0.006	0.023				7.9
SAL[e]	20.0	5.9	4.0	95.0	20.0	18.0	17.0			

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

[b]Radioactivity counting uncertainties are shown in parentheses.

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

[d]W.D.Purtymun 1987; standards given here for comparison only. Background is defined as mean plus two times the standard deviation.

[e]Screening Action Level, Environmental Restoration Group 1994 FIMAD database; standards given here for comparison only.

Table IV-14. Total Recoverable Trace Metals in Sediments on Pueblo of San Ildefonso Land for 1994 (μg/g)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
PERIMETER STATIONS (OFF SITE)												
Other Areas												
Bayo at SR-4	<1.0[a]	2,000.0	0.4	2.9	32.0	<0.08	<0.4	1.9	2.8	3.0	3300.0	<0.02
Sandia Canyon												
Station 1	<1.0	1,600.0	0.8[b]	3.0	18.0	<0.08	<0.4	1.2	4.6	2.2	2400.0	<0.02[b]
Station 4	<1.0	1,900.0	1.0[b]	<1.0	27.0	0.08	<0.4	2.1	6.2	2.6	2900.0	<0.02[b]
Station 3	<1.0	2,800.0	10.0[b]	1.0	39.0	0.11	<0.4	1.9	3.0	2.7	3300.0	<0.02[b]
Mortandad Canyon												
Mortandad A-6	<1.0	1,400.0	<0.5	1.0	15.0	0.17	<0.4	1.0	1.2	<0.5	4200.0	<0.02
Mortandad A-7	<1.0	3,600.0	2.0[b]	<1.0	61.0	0.47	<0.4	3.0	3.2	3.8	5900.0	<0.02[b]
Mortandad A-8	<1.0	4,000.0	2.0[b]	<1.0	63.0	0.46	<0.4	2.8	3.3	3.5	5600.0	<0.02[b]
Mortandad at SR-4 (A-9)	<1.0	3,900.0	1.3	3.0	62.0	0.22	<0.4	5.0	9.2	6.2	4800.0	<0.02
Mortandad A-10	<1.0	5,900.0	2.0[b]	<1.0	100.0	0.60	<0.4	5.0	5.0	5.0	7200.0	<0.02[b]
Mortandad Transect 94 COMP	<1.0	6,300.0	2.4[b]	<1.0	110.0	0.89	0.7	5.9	5.5	7.7	9200.0	<0.02[b]
ON-SITE STATIONS												
Acid-Pueblo Canyons												
Pueblo at State Route	<1.0	1,300.0	0.6	<1.0	14.0	0.02	<0.4	1.7	6.1	2.5	25000.0	<0.02
DP-Los Alamos Canyons												
Los Alamos at SR-4	<1.0	2,300.0	0.6	2.5	22.0	<0.08	<0.4	1.4	3.1	3.0	3900.0	<0.02
Mortandad Canyon												
Mortandad at MCO-13 (A-5)	<1.0	2,900.0	1.0[b]	<1.0	35.0	0.24	<0.4	2.8	2.4	3.1	3600.0	<0.02[b]

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
PERIMETER STATIONS (OFF SITE)											
Other Areas											
Bayo at SR-4	110.0	1.40	2.0	<4.0	<0.2	<0.3	<4.0	7.5	<0.2	5.6	11.0
Sandia Canyon											
Station 1	97.0	<0.90	2.0	5.0	<0.3	0.3	6.0	2.9	<0.3	2.7	18.0
Station 2	140.0	<0.90	2.0	9.0	<0.3	0.5	6.0	3.5	<0.3	3.5	22.0
Station 3	160.0	<0.90	2.0	4.0	<0.3	0.6	4.0	6.8	0.3	4.5	20.0
Mortandad Canyon											
Mortandad A-6	160.0	<2.00	<2.0	<4.0	N/A[c]	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad A-7	300.0	<0.90	4.0	10.0	<0.3	0.6[b]	4.0	9.4	<0.3	7.6	33.0
Mortandad A-8	290.0	1.00	3.0	9.0	<0.3	0.4[b]	6.0	8.8	<0.3	7.1	31.0
Mortandad at SR-4 (A-9)	300.0	2.50	4.6	8.2	<0.2	<0.3	<4.0	7.8	<0.2	6.9	18.0
Mortandad A-10	310.0	<0.90	5.0	9.0	<0.3	0.5[b]	6.0	18.0	<0.3	12.0	34.0
Mortandad Transect 94 COMP	420.0	1.10	4.0	15.0	<0.3	0.5[b]	5.0	20.0	<0.3	12.0	330.0
ON-SITE STATIONS											
Acid-Pueblo Canyons											
Pueblo at State Route	520.0	14.00	<2.0	8.1	<0.2	<0.3	<4.0	2.6	<0.2	13.0	140.0
DP-Los Alamos Canyons											
Los Alamos at SR-4	160.0	1.80	<2.0	9.5	<0.2	<0.3	<4.0	4.8	<0.2	3.7	31.0
Mortandad Canyon											
Mortandad at MCO-13 (A-5)	150.0	<0.90	<2.0	6.2	<0.3	0.5	5.8	6.8	0.3	4.7	23.0

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]Result is the mean of more than one sample analysis.
[c]N/A means analysis not performed, lost in analysis or not completed.

5. Sampling of Perimeter Surface Soils at Technical Area 54, Area G. (Ron Conrad, ESH-19)

During FY94, 110 surface soil samples were collected from the perimeter of TA-54, Area G. The locations of these surface soil samples were established so that they could indicate whether contaminants were moving outside the Area G perimeter fence under the influence of surface water runoff. That is, each sampling point was located in an obvious (but small) drainage channel just outside the perimeter fence. These sampling locations were thus biased to best determine movement of contaminated soil being carried by surface water runoff from within the confines of Area G to beyond the Area G fence (Conrad 1995).

During FY94, the radioactive constituents measured in these surface soil samples included ^{241}Am, ^{137}Cs, isotopic plutonium, total uranium, and tritium. In addition, 21 soil samples were analyzed for the metals silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, and selenium.

The analytical results of the FY94 surface soil sampling are found in Tables IV-15 and IV-16. Table IV-15 indicates that the perimeter soils at Area G are generally elevated above background levels for tritium and plutonium. The most elevated concentrations of tritium in soils are prevalent in the locations that are adjacent to the tritium shafts (sample series G-27-33) and the TRU pads (sample series G-38-50). Isotopic plutonium and ^{241}Am activity appear to be only slightly elevated in those perimeter locations adjacent to the TRU pads. Cesium-137 and uranium are uniformly distributed in the perimeter locations, and there is no evidence for localized elevated levels of either of these constituents in the perimeter soils sampled.

The concentrations of metals on those soils sampled indicated that there is no elevated distribution of any of the metals on the perimeter soils (Table IV-16).

The results of the perimeter surface soil sampling performed during FY94 indicate that in the areas of the tritium shafts and TRU pads, soils, contaminated to varying degrees by tritium and plutonium, are being moved by surface water runoff from the TA-54, Area G disposal area to outside the perimeter fence. These findings are consistent with analogous measurements taken in FY93.

The perimeter sampling will continue in FY95.

6. Radionuclide Concentrations in Vegetation at Radioactive Waste Disposal Area G during the 1994 Growing Season. (Philip R. Fresquez, ESH-20)

Overstory (piñon pine) and understory (grass and forb) vegetation (unwashed) samples were collected within and around selected points at TA-54, Area G, a low-level radioactive solid waste disposal facility at Los Alamos National Laboratory for the analysis of tritium, ^{90}Sr, ^{238}Pu and ^{239}Pu, ^{137}Cs, ^{241}Am, and total uranium (Fresquez 1995a).

Results of the analysis are presented in Table IV-17. In general, most of the radiological concentrations in overstory and understory vegetation collected from within and around Area G were higher than upper-limit background values. The upper-limit background concentration is defined as the analytical result plus two sigma. Tritium ranged in concentration from 2.5 to 5,800 pCi/mL and from 35.6 to 952.5 pCi/mL in overstory and understory samples, respectively. The highest tritium concentration was detected in an overstory sample collected just outside the fence west of the tritium shafts; this suggests some subsurface migration of tritium out of Area G.

Tritium has been reported to be moving from the tritium shafts in the vapor phase along the contact points of two ash flows (penetrated by the tritium shafts), open joints, and open pores in the tuff matrix (Purtymun 1973b). In 1985, from 2,200 to 4,800 pCi/mL in overstory vegetation was reported in this same tritium shaft area (Jacobson 1992).

Concentrations of ^{90}Sr ranged from 2.0 to 11.2 pCi/g ash in vegetation collected from within and around Area G. Most samples were around two times the background levels for ^{90}Sr; however, there was one sample, a grass and forb composite sample collected just north of the fence line from the TRU waste pads, that contained ^{90}Sr levels over five times the background level.

Total uranium concentrations in vegetation collected from Area G ranged from 0.89 to 3.29 μg/g ash. Most vegetation samples collected over Area G contained approximately five times more uranium than background samples. The highest amount of uranium was detected in piñon trees growing near the new waste pit. In 1980, total uranium in vegetation collected within and around Area G ranged from 0.09 to 1.0 μg/g ash (Mayfield 1983).

Concentrations of both ^{238}Pu and ^{239}Pu were highest in understory vegetation samples collected outside the fence north of TRU pads. Values of ^{238}Pu and ^{239}Pu collected north of the TRU pads measured 0.452 and 0.153 pCi/g ash, respectively, which were approximately 110 and 50 times background. Overstory and understory

Table IV-15. Radionuclide Analysis of Surface Soil Samples Taken from Technical Area 54, Area G Perimeter in 1994

Sampling Location [a]	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	Total U µg/g	^{238}Pu pCi/g	^{239}Pu pCi/g
G-5-1	690	0.075	<.52[b]	7	0.03	0.094
G-5-2	620	0.014	<.28	5.4	0.006	0.024
G-6-1	600	0.005	<.23	3.7	0.004	0.006
G-7-1	840	0.003	<.33	4.1	0.005	0.007
G-8-1	370	0.006	<.32	3.8	0.001	0.007
G-8-2	540	0.03	<.36	4.4	0.001	0.01
G-9-1	1,000	0.03	<.56	5.6	0.007	0.1
G-10-1	520	0.102	<.38	4.6	0.004	0.009
G-10-2	920	0.026	<.39	5.1	0.007	0.067
G-11-1	620	0.007	<.3	4.2	0.007	0.013
G-12-1	1,170	0.013	<.21	4	0.003	0.012
G-12-3	1,360	0.03	<.47	4.5	0.007	0.09
G-13-1	1,010	0.007	<.34	3.8	0.0007	0.02
G-13-9	970	0.011	<.3	5.1	0.005	0.028
G-14-1	590	0.013	<.16	2.6	0.007	0.008
G-15-1	790	0.014	<.31	5	0.016	0.043
G-15-2	1,550	0.018	0.58	4.1	0.015	0.06
G-15-2R	1,130	0.01	<.34	4.1	0.02	0.031
G-16-1	2,110	0.011	0.32	3.4	0.004	0.019
G-17-1	1,800	0.008	<.36	4.3	0.004	0.006
G-17-2	2,360	0.021	<.36	5.1	0.009	0.079
G-17-3	2,070	0.013	<.26	4.4	0.004	0.029
G-18-1	1,430	0.01	<.38	5.2	0.004	0.024
G-19-1	1,240	0.134	<.37	5	0.011	0.037
G-19-2	2,490	0.008	<.31	3.5	0.003	0.01
G-20-1	5,470	0.017	1.05	4.5	0.009	0.038
G-20-2	4,410	0.006	<.26	4.2	0.003	0.009
G-21-1	2,560	0.013	0.84	4	0.014	0.013
G-21-1R	2,340	0.016	<.34	4	0.02	0.028
G-22-1	3,630	0.003	<.33	3.6	0.005	0.002
G-23-1	2,180	0.003	<.36	4.1	0.002	0.007
G-23-2	8,550	0.015	<.3	4	0.007	0.042
G-24-1	2,490	0.007	<.33	3.8	0.005	0.012
G-24-2	2,520	0.01	<.36	4.3	0.006	0.027
G-25-1	2,590	0.021	1.68	4.9	0.007	0.057
G-26-1	3,310	0.018	1.75	4.8	0.006	0.065
G-27-1	13,330	0.017	1.4	4.2	0.004	0.033
G-28-1	19,960	0.01	<.33	3.5	0.004	0.023
G-28-2	30,760	0.015	<.37	4.1	0.009	0.029
G-29-1	253,300	0.009	<.22	2.8	0.023	0.011
G-29-2	1,097,620	0.018	<.4	4.4	0.026	0.045
G-29-3	1,715,560	0.006	<.39	4.4	0.005	0.015
G-30-1	205,310	0.007	<.31	3.3	0.009	0.025
G-31-1	404,100	0.032	1.89	5.4	0.024	0.117
G-31-1R	403,030	0.027	0.81	4.8	0.019	0.096
G-31-2	201,950	0.006	<.31	4.3	0.009	0.01
G-31-3	115,680	0.006	<.26	3	0.007	0.01
G-32-1	53,840	0.076	<.39	5.4	0.022	0.392

Table IV-15. Radionuclide Analysis of Surface Soil Samples Taken from Technical Area 54, Area G Perimeter in 1994 (Cont.)

Sampling [a] Location	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	Total U µg/g	^{238}Pu pCi/g	^{239}Pu pCi/g
G-32-2	47,160	0.01	<.32	4.1	0.007	0.027
G-32-3	31,130	0.025	<.31	4.5	0.01	0.058
G-33-1	14,100	0.02	<.38	4.4	0.016	0.122
G-34-1	6,320	0.008	<.39	4	0.006	0.012
G-34-2	4,700	0.016	<.33	4.4	0.005	0.046
G-34-3	3,900	0.008	<.28	4.8	0.004	0.04
G-34-4	4,200	0.016	<.28	4.4	0.02	0.05
G-34-5	8,210	0.017	<.39	3.3	0.05	0.049
G-34-6	2,870	0.015	<.52	4.7	0.017	0.088
G-34-7	5,110	0.007	<.4	3.8	0.009	0.023
G-34-8	4,210	0.033	<.46	4.8	0.008	0.048
G-34-9	6,400	0.012	<.36	4.7	0.008	0.065
G-34-10	3,830	0.412	0.7	4.7	0.106	2.773
G-34-11	3,980	0.09	<.54	4.9	0.052	0.542
G-34-12	4,140	0.006	<.39	4	0.006	0.007
G-34-13	17,690	0.012	<.44	4.1	0.259	0.028
G-34-14	4,080	0.006	<.43	3.2	0.098	0.022
G-34-15	3,820	0.011	<.48	3.7	0.157	0.028
G-35-1	5,480	0.084	1.26	4.2	0.01	0.125
G-35-2	8,660	0.053	<.31	4.1	0.016	0.643
G-36-1	2,730	0.053	0.54	5.1	0.009	0.122
G-36-1R	3,070	0.047	0.65	4.5	0.014	0.115
G-36-2	3,120	0.015	<.35	4.1	0.005	0.034
G-38-1	3,920	0.014	<.48	4	0.005	0.031
G-38-2	79,620	0.181	<.39	4.5	0.211	0.982
G-39-1	11,430	0.042	<.39	3.7	0.681	0.203
G-39-2	8,100	0.021	<.43	3.1	0.042	0.068
G-40-1	4,490	0.068	<.55	5.1	2.489	0.281
G-40-2	3,020	0.059	<.39	4.6	3.434	0.295
G-41-2	3,170	0.051	<.46	4.4	1.163	0.156
G-42-1	5,110	0.082	<.42	4.5	0.385	1.031
G-43-1	8,200	0.249	<.46	4.2	0.574	1.814
G-43-1R	9,410	0.106	<.47	4.3	0.687	0.481
G-43-2	9,240	0.119	<.48	3.9	0.508	0.711
G-44-1	158,550	0.242	<.44	4.3	15.778	0.588
G-45-1	436,560	0.27	<.46	4.4	1.266	0.639
G-46-1	49,400	0.336	<.43	5.2	16.683	1.173
G-46-2	27,750	0.249	<.53	4.5	1.863	1.093
G-47-1	4,800	0.242	<.46	3.7	0.078	1.782
G-48-1	5,400	0.05	<.68	4.3	0.131	0.297
G-48-2	5,070	0.103	<.69	4.8	0.081	0.579
G-48-3	4,990	0.126	<.45	4.3	0.085	1.157
G-49-1	1,870	0.055	<.42	2.7	0.028	0.216
G-50-1	31,160	1.546	<.14	3.8	0.142	1.063
G-50-2	30,100	0.102	<.12	3.9	0.033	0.075
G-51-1	5,420	0.015	<.14	4.5	0.017	0.031
G-52-1	4,200	0.008	<.14	4.3	0.006	0.011
G-52-2	5,990	0.007	<.14	3.2	0.009	0.031

Table IV-15. Radionuclide Analysis of Surface Soil Samples Taken from Technical Area 54, Area G Perimeter in 1994 (Cont.)

Sampling Location [a]	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	Total U µg/g	^{238}Pu pCi/g	^{239}Pu pCi/g
G-52-3	6,690	0.02	<.14	3.9	0.031	0.05
G-53-1	2,330	0.014	0.89	4.5	0.015	0.043
G-54-1	6,760	0.007	0.29	4.2	0.016	0.019
G-54-2	3,900	0.012	<.16	4.1	0.008	0.033
G-55-1	3,530	0.014	0.23	3.7	0.007	0.044
G-55-1R	2,190	0.02	<.13	3.9	0.006	0.098
G-57-1	1,900	0.012	1.14	4.4	0.008	0.037
G-58-1	2,420	0.008	0.3	4.2	0.052	0.025
G-59-1	1,280	0.01	1.17	5.4	0.005	0.029
G-60-1	930	0.009	0.58	4.4	0.003	0.022
G-62-1	760	0.003	<.18	4.6	0.002	0.013
G-64-1	830	0.012	<.22	5.2	0.005	0.029
G-65-1	530	0.013	1.28	4.1	0.006	0.057
G-65-2	860	0.006	<.17	4.5	0.003	0.008

[a]Samples were taken between July 14–21, 1994.
[b]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Table IV-16. Metal Analysis (µg/g) of Surface Soil Samples Taken from Technical Area 54, Area G Perimeter in 1994

Sampling Location [a]	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Se
G-9-1	<.63[b]	3.3	110	<.88	<1	6.5	<.02	<3.8	23.8	<.63
G-10-1	<.62	<1.9	86.9	1.7	<.47	6.8	0.22	<4.2	13.9	<.62
G-17-3	<.61	<1.9	74.3	<.74	<.9	8.5	<.02	<5.2	11.6	<.61
G-21-1	<.61	<1.4	44.9	<.41	<.53	3.5	<.04	<1.2	7	<.61
G-21-1R	<.6	<1	44	<.39	<.52	3.1	<.03	<2	6.2	<.6
G-24-2	<.64	3.1	178	1.7	<1.4	13.7	<.02	9.2	15.7	<.64
G-34-2	<.61	<1.4	70.5	<.65	<.58	3.7	0.14	<1.3	8.4	<.61
G-35-2	<.61	<1.7	116	<.74	<.78	6	<.04	<3.5	12.8	<.61
G-38-1	<.61	3.4	87.2	<.89	<.6	5.8	<.02	<5.8	8.4	<.61
G-38-2	<.61	<1.5	78.5	<.52	<.68	4.3	<.02	<3.8	8.9	<.61
G-40-2	<.61	<2	51.1	<.5	<.37	2.8	<.02	<3.6	7.6	<.61
G-43-1	0.62	<1.3	59	<.55	<.21	3.5	<.02	<3.1	8.6	<.62
G-43-1R	<.62	<.83	57.7	<.49	<.51	4.3	<.02	<3.4	8.7	<.62
G-44-1	<.61	<1.4	<31.8	<.34	<.2	2.6	<.02	<1.2	5.9	<.61
G-45-1	<.61	2.8	52.6	<.51	<.75	4	<.02	<2.3	9.7	<.61
G-46-1	<.94	<1.8	58.6	<.47	<.48	7.7	<.02	<4.1	14.9	<.62
G-48-3	<.62	2.4	74	<.46	<.77	5.6	<.02	<4.2	11.7	<.32
G-50-2	<.6	<.84	51.1	<.42	<.36	3.9	<.02	<1.9	5.9	<.6
G-51-1	<.61	2.5	99.7	<.81	<.52	5.6	<.02	<4.4	11.9	<.61
G-54-1	<.6	<1.3	45.3	<.5	<.25	4.1	<.02	<1.5	7.5	<.6
G-58-1	<.6	2.9	65.7	<.53	<.39	4.9	<.02	<3.5	9.6	<.6

[a]Samples were taken between July 14–21, 1994.
[b]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Table IV-17. Radionuclide Concentrations in Vegetation Collected from Technical Area 54, Area G during the 1994 Growing Season

Location	Tritium (pCi/mL)[a]		^{90}Sr (pCi/g ash)		Uranium (mg/g ash)		^{238}Pu (pCi/g ash)		^{239,240}Pu (pCi/g ash)		^{137}Cs (pCi/g ash)		^{241}Am (pCi/g ash)	
Radioactive Waste Disposal Area G														
#1 Tritium Shafts (south of the shafts just outside the fence)														
Overstory	119.1	(7.2)[b]	4.0	(0.6)	1.19	(0.26)	0.003	(0.002)	0.007	(0.002)	0.22	(0.22)	0.004	(0.002)
Understory	201.1	(0.0)	3.5	(0.4)	2.05	(0.58)	0.023	(0.006)	0.021	(0.004)	0.21	(0.18)	0.010	(0.006)
#2 Tritium Shafts (west of the shafts just outside the fence)														
Overstory	5,800.0	(200.0)	5.0	(0.6)	1.31	(0.52)	0.003	(0.001)	0.006	(0.002)	0.25	(0.26)	0.003	(0.002)
Understory	328.0	(13.8)	5.4	(0.8)	1.58	(0.32)	0.006	(0.002)	0.013	(0.004)	0.36	(0.24)	0.008	(0.002)
#3 Waste Pits (east of the new pit inside the fence)														
Overstory	9.2	(1.0)	2.6	(0.4)	3.29	(1.72)	0.028	(0.006)	0.024	(0.006)	0.15	(0.16)	0.006	(0.002)
Understory	38.2	(3.8)	4.2	(0.6)	0.89	(0.18)	0.022	(0.004)	0.013	(0.004)	0.16	(0.16)	0.003	(0.002)
#4 TRU Pads (north of pads just outside the fence)														
Overstory	2.5	(1.0)	6.0	(0.8)	0.94	(0.18)	0.044	(0.008)	0.012	(0.004)	0.05	(0.06)	0.008	(0.002)
Understory	35.6	(3.6)	11.2	(1.4)	1.62	(0.92)	0.452	(0.040)	0.153	(0.016)	0.39	(0.24)	0.090	(0.010)
#5 TRU Pads (west side of the pad)														
Understory	177.3	(9.2)	3.3	(0.4)	1.23	(0.24)	0.012	(0.004)	0.014	(0.004)	0.07	(0.08)	0.008	(0.002)
#6 TRU Pads (east side of the pad)														
Understory	952.5	(30.6)	2.0	(0.4)	1.72	(0.34)	0.003	(0.002)	0.009	(0.001)	0.14	(0.14)	0.006	(0.002)
Regional (Background)														
Overstory	1.2	(0.6)	2.0	(0.4)	0.33	(0.06)	0.000	(0.002)	0.000	(0.002)	0.10	(0.10)	0.002	(0.002)
ORSRL[c]	1.8		2.4		0.39		0.002		0.002		0.20		0.004	
Understory	1.1	(0.8)	1.8	(0.4)	0.36	(0.08)	0.002	(0.002)	0.001	(0.002)	0.13	(0.14)	0.002	(0.002)
URSRL[d]	1.9		2.2		0.44		0.004		0.003		0.27		0.004	

[a]mL of tissue moisture.

[b](±2 counting uncertainty); values are the uncertainty of the analytical results at the 95% confidence level.

[c]ORSRL = Overstory regional statistical reference level (i.e., the upper-limit background concentration based on the mean + 2 counting uncertainties).

[d]URSRL = Understory regional statistical reference level (i.e., the upper-limit background concentration based on the mean + 2 counting uncertainties).

vegetation collected from this general location north of the TRU pads in 1980 contained ^{239}Pu at concentrations ranging from 0.57 to 3.28 and from 0.52 to 1.55 pCi/g ash, respectively (Mayfield 1983). Mayfield and Hanson (1983) attributed the higher ^{239}Pu levels in understory vegetation collected from Area G, compared with vegetation collected from background areas, to occasional spills during disposal operations and/or to surface storage and holding practices.

Cesium-137 ranged in concentration from 0.07 to 0.39 pCi/g ash in vegetation collected from Area G. With the exception of two understory samples, one collected west of the tritium shafts and the other collected outside the fence north of the TRU pads, most vegetation samples were within or very close to background levels. Similarly, most ^{241}Am concentrations in vegetation samples collected at Area G were within or just above background ^{241}Am levels. The highest ^{241}Am value was detected in understory vegetation collected just outside the fence line north of the TRU pads.

7. Air Quality Impacts Analysis for Technical Area 54, Area G. (Dave Kraig, ESH-17)

During 1994, a study was performed to evaluate the impact of diffuse (nonstack) radioactive emissions from the disposal site, TA-54, Area G, in support of site characterization for the Area G performance assessment and for radioactive air emissions management. Diffuse emissions of tritiated water and contaminated windblown dust were considered. Data from an extensive field measurement program were used to estimate annual emissions of tritiated water. Dust models were used to calculate estimates of the annual emissions of windblown dust. These estimates were combined with data on contamination levels in surface soils to develop annual emission rates for specific radionuclides: tritium, ^{238}U, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, and ^{90}Sr. The CAP-88 (EPA 1990b) atmospheric transport model was used to predict areas potentially affected by long-term dust deposition and atmospheric concentrations.

The annual emission rate of tritiated water was estimated from the field data to be 14 Ci/yr (520 Gbq/yr). The emission rate of soil-borne radionuclides from open areas and from soils-handling operations totaled less than 1×10^{-4} Ci/yr (3.7 Mbq/yr). The CAP-88 results were used to develop EDEs for receptor locations downwind of Area G. All EDEs were several orders of magnitude below the national standard of 10 mrem/yr. Diffuse air emissions from Area G were found not to pose a significant health threat to persons living or working downwind of the facility.

8. Measurement of Air Quality within Storage Domes in Technical Area 54, Area G. (Dave Kraig, ESH-17)

Concentrations of volatile organic compounds (VOCs) and tritium inside storage domes at TA-54, Area G were measured to assess worker exposure and to support TA-54 site characterization. Samples were collected at 2 or 3 locations within domes 48, 49, and 153 on up to six days during the summer of 1994. Samples were collected to evaluate three scenarios: (1) normal working activities with the domes open; (2) after domes were closed overnight; and (3) after domes were closed for three days. Eight-hr integrated samples were collected and analyzed in analytical laboratories.

Tritium activities from 17.1 to 69,900 pCi/m^3 (0.63 Bq to 2.59 kBq) were measured. About two dozen individual VOCs were identified in each sample, but most of the concentration levels were very low (e.g., <1 to 10 ppbv). The highest concentrations measured were bromomethane (56.5 ppbv), 1,1,1-trichloroethane (75.4 ppbv), propane (958 ppbv), methylene chloride (1,450 ppbv), and toluene (22.8 ppbv). The measured VOC concentrations were well below the action levels developed by the NMED, and the measured tritium concentrations were well below the DOE's derived air concentration. The variability in concentration within a dome during a single sampling episode was small. The concentrations were about 10 times higher after the domes had been closed overnight than when the domes were open. Closing the domes over the weekend did not result in significantly higher concentrations (e.g., >20%) than when the domes were closed only overnight. The data were used to generate estimated annual dome emission rates of 0.3 Ci/yr (11 Bq/yr) of tritium and less than 100 lb/yr of VOCs.

The measured VOC concentrations were collected during the warmest months of the year and therefore should represent worst-case air impacts. Based on the results of this study, the domes are relatively insignificant emitters of VOCs and tritium. The air quality within the domes does not pose a significant health risk to workers nor does it contribute a significant portion of the allowable annual exposure.

9. Measurement of Emission Fluxes from Technical Area 54, Areas G and L. (Dave Kraig, ESH-17)

As a part of the Area G site characterization for the Area G performance assessment and for radioactive air emissions management, emission fluxes (mass/time-area) of tritiated water, radon, and VOCs from TA-54 were measured. Emission fluxes of tritium were measured at over 180 locations during the summers of 1993 and 1994, including randomly selected locations across Area G, three areas of suspected contamination at Area G, and the property surrounding TA-54. Emission fluxes of radon were measured at 6 locations, and emission fluxes of VOCs were measured at 30 locations. Monitoring was performed at each location over a several-hour period using the US EPA flux chamber approach. Separate samples for tritiated water, radon, and VOCs were collected and analyzed in off-site laboratories.

The tritiated water emission fluxes varied over several orders of magnitude, from background levels of about 3 $pCi/m^2 \cdot min$ (0.1 $Bq/m^2 \cdot min$) to 9.69 ± 10^6 $pCi/m^2 \cdot min$ (359 $kBq \cdot min$) near a disposal shaft. Low levels of tritiated water were found to have migrated into Pajarito Canyon, directly south of Area G. The tritium flux data were used to generate an estimated annual emission rate of 14 Ci/yr for all of Area G, with the majority of this activity being emitted from relatively small areas near several disposal shafts. The estimated total annual release is less than 1% of the total tritium release from all LANL in 1992 and results in a negligible off-site dose. Based on the limited data available, the average emission flux of radon from Area G is estimated to be 8.1 $pCi/m^2 \cdot min$ (0.30 $Bq/m^2 \cdot min$). The measured emission fluxes of VOCs were <100 $mg/m^2 \cdot min$, which is small compared with fluxes typically measured at hazardous waste landfills.

10. Ambient Monitoring of Volatile Organic Compounds at Technical Area 54, Areas G and L. (Dave Kraig, ESH-17)

Ambient air monitoring of VOCs at TA-54 was conducted to characterize nonradioactive air emissions. This study was performed to determine if the Laboratory's waste operations are releasing significant amounts of VOCs to the ambient environment. Samples were collected at four locations along the northern fence line (dominant downwind side) of Areas G and L and at a background site located in Bandelier National Monument. Eight-hour integrated samples were collected in evacuated canisters during daylight hours on each of eight days during the summer of 1994, for a total of 40 samples. The samples were analyzed by gas chromatography, following EPA Method TO-14, for a target list of 68 analytes.

In general, about two dozen VOCs were identified in each sample, including those collected at the background site, but the concentration levels were very low. The average total nonmethane hydrocarbon concentration ranged from 4.3 to 22.8 ppbv at the Area G and L sites, compared with an average of 4.2 ppbv at the background site. The measured concentrations were compared with action levels developed by NMED and were well below the action levels in all cases. Methanol and benzene were the only compounds that ever exceeded 1% of the action level. The measured VOC concentrations were collected during the warmest months of the year and therefore should represent worst-case air impacts. Based on the results of this study, VOC emissions from Areas G and L have an insignificant impact on local air quality and pose negligible health risk to workers or nearby populations.

11. Evaluation of Site-Specific Acceptability of AIRNET Stations. (Dave Kraig, ESH-17)

The AIRNET program evaluated site-specific characteristics of all ambient air sampling stations to assess whether airflow around the stations' locations was being affected by nearby obstacles or topography. The stations were compared with the criteria from applicable sections in DOE/EH-0173T (DOE 1991a) and 40 CFR 58 App. E (EPA 1992).

The primary site-specific criteria were favorable surface characteristics, no airflow obstructions, and good topography. A favorable surface is one that is stabilized by vegetation or other cover such that the local generation of wind-borne dusts and dust-loading of the air filters are minimized. The criteria applied to trees, buildings, topography, and other potential obstructions are intended to ensure that airflow from a source or sources toward the sampler is not obstructed.

As a result of the study, several stations were relocated to better sites and some sites were modified, primarily by trimming or removing nearby vegetation. LANL plans to review the stations each year to ensure optimal airflow and sampling.

12. Performance Assessments. (Diana Hollis, CST-14)

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 (LLW that also contains nonradioactive hazardous waste components) management at DOE facilities. The order requires a performance assessment (PA) of each active LLW disposal site to demonstrate compliance with specific performance objectives to accomplish the following:

- protecting public health and safety;
- ensuring external exposure to the waste and concentrations of radioactive material that may be released into surface water, groundwater, or the 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.

The nominal compliance period considered for the PA is 10,000 years postclosure. This compliance period assumes that the federal government maintains active institutional control over the site for 100 years after closure, then loses control, such that members of the public may inadvertently use the site under various scenarios. Dose projections are made for hypothetical human receptors outside the facility boundary for the entire compliance period, and for inadvertent intruders between 100 and 10,000 years postclosure. The doses are calculated according to exposure pathways and land use scenarios appropriate for evaluating compliance for the various performance objectives. All pathways are evaluated, including ingestion, inhalation, and immersion.

The PA is a "living" document describing the continuous process of evaluating the radiological performance of the TA-54, Area G LLW Disposal Facility over its operational lifetime; the PA will be considered final only after facility closure. The analysis is updated as often as necessary to address changing requirements, increasing inventory, enhanced modeling capabilities, additional site characterization data, etc.

The PA is reviewed by the DOE Peer Review Panel (PRP), which advises DOE/HQ as to the adequacy of the analysis. The PRP includes subject matter experts from both the DOE and the EPA and Nuclear Regulatory Commission.

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.

A preliminary draft PA was submitted to the PRP in August, 1995. Assuming approval from the PRP, the PA of the LANL TA-54, Area G LLW Disposal Facility, Revision 0, will be forwarded to DOE/HQ in December 1996.

The results of the preliminary analysis show that LANL is in compliance with all of the performance objectives, with a large margin of safety. In particular, only two radionuclides are shown to enter the deep aquifer within the compliance period—^{14}C and ^{237}Np. The doses projected to evaluate the protection of hypothetical off-site receptors are 4 to 50 times less than the applicable performance objectives. Those doses estimated to evaluate the protection of hypothetical inadvertent intruders are between 2 and 100 times less than the performance objectives, depending on the land use scenario considered. The radionuclides contributing to the intruder doses are largely decay products of ^{235}U and ^{238}U. Table IV-18 shows the application of PA performance objectives to TA-54, Area G.

Performance Assessment for the Mixed Waste Disposal Facility (MWDF). The principal goal of the MWDF is to dispose of solid mixed waste in compliance with the regulatory and operational requirements of RCRA and DOE. The PA for the MWDF, proposed to be located at TA-67, was initiated in 1992. It was suspended in 1995, pending resolution of funding.

Based on the results of the TA-54, Area G PA, and the proposed cementitious waste form, the TA-67 MWDF PA can be expected to show complete compliance with the performance objectives. Complete compliance can be expected because the radionuclides in the TA-67 inventory will be the same as those in the TA-54 inventory, most of which become less mobile in the presence of cement, because of its high inorganic mineral content, and its effect on chemical properties of water that may percolate through it.

Table IV-18. Application of Department of Energy Performance Assessment Performance Objectives to Technical Area 54, Area G

Hypothetical Receptor	Exposure Pathway	Performance Objective	Time Period
maximally exposed off-site resident	all[a]	25 mrem/yr	all
maximally exposed off-site resident	atmospheric	10 mrem/yr	all
nearest off-site resident	groundwater	4 mrem/yr	all
inadvertent on-site intruder	all		
	chronic exposure	100 rem/yr	post-institutional control
	acute exposure	500 mrem	

[a]Ingestion, inhalation, immersion

13. 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.

A comprehensive study was conducted over an area that will house two proposed facilities: the Radioactive Liquid Waste Treatment Facility at TA-63 and the Hazardous Waste Treatment Facility at TA-52 (Fresquez 1993).

A description of floodplains/wetlands; threatened, endangered, and sensitive species; vegetative understory (grass and forbs) and overstory (trees); invertebrates (insects); and wildlife (birds and small mammals) inhabiting these areas can be found in Haarmann (1995). In general, the proposed construction sites are in a relatively disturbed area bordered by roads and technical sites. There are no floodplains or wetlands found in the area and the proposed sites have little likelihood of containing habitat for any threatened, endangered, or sensitive species.

Also, soil samples from the area(s) were collected and analyzed for baseline concentrations of various radionuclides and heavy metals (Tables IV-19 and IV-20). In general, tritium, ^{90}Sr, and ^{137}Cs activity in all soil samples were within regional statistical reference (background) levels. Some individual sites, however, contained uranium, ^{238}Pu, ^{239}Pu and ^{241}Am levels above background concentrations. Americium-241 levels, in particular, were from 9 to 17 times higher than background. Levels of silver, arsenic, cadmium, nickel, antimony, and selenium were all within background concentrations; whereas, barium, beryllium, mercury, and lead appear to be slightly higher than regional background concentrations.

Table IV-19. Baseline Radiochemical Analyses of Soils Collected from Around the Proposed Radioactive Liquid Waste Treatment Facility at Technical Area 63 and the Hazardous Waste Treatment Facility at Technical Area 52

Location	Tritium (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)
Site 1	1.3 (0.3)	0.5 (0.7)	0.36 (0.11)	4.5 (0.31)	0.007 (0.003)	0.093 (0.014)	0.28 (0.09)
Site 2	1.2 (0.3)	0.4 (0.7)	0.19 (0.09)	3.4 (0.24)	0.004 (0.002)	0.013 (0.004)	0.21 (0.09)
Site 3	1.5 (0.4)	0.3 (0.7)	0.29 (0.10)	4.8 (0.34)	0.006 (0.003)	0.079 (0.012)	0.36 (0.10)
Site 4	1.1 (0.3)	0.4 (0.8)	0.54 (0.12)	4.4 (0.31)	0.009 (0.003)	0.105 (0.012)	0.39 (0.10)
Site 5	3.0 (0.5)	0.4 (0.8)	0.67 (0.14)	7.1 (0.50)	0.008 (0.003)	0.260 (0.020)	0.40 (0.10)
RSRL[b]	7.2	0.88	1.10	3.4	0.005	0.025	0.02

[a](+2 counting uncertainty); values are the uncertainty of the analytical result at the 95% confidence level.

[b]Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev) from Purtymun 1987a.

Tables IV-20. Total Recoverable Trace and Heavy Metals (μg/g) (ppm) in Soils Collected from Around the Proposed Radioactive Liquid Waste Treatment Facility at Technical Area 63 and the Hazardous Waste Treatment Facility at Technical Area 52[a]

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se
Site 1	<1[b]	3.4	610	1.78	<0.7	20.1	0.01	9	23	<4	0.2
Site 2	<1	3.1	615	1.68	<0.7	20.2	0.01	10	21	<4	0.2
Site 3	<1	3.8	617	1.74	<0.7	20.0	0.01	9	21	<4	0.2
Site 4	<1	3.3	590	1.80	<0.7	19.2	<0.01	9	24	<4	<0.3
Site 5	<1	2.4	477	1.84	<0.7	14.7	<0.01	7	25	<4	<0.2
RSRL[c]	<3.9	6.4	228	0.96	<0.5	17.9	<0.04	16	22	<0.30	<1.3

[a]Analysis by EPA Method 3051 for total recoverable metals.
[b]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.
[c]Regional Statistical Reference Level; this is the upper-limit background concentration (mean + 2 std dev) from Fresquez 1995.

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

a. Introduction. The Ecological Studies Team (EST) 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 1994.

Aquatic Invertebrates. For the past five years, EST conducted field studies of stream macro-invertebrate communities associated with outfalls of organic 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 1994, EST started sampling aquatic invertebrates associated with other industrial outfalls in numerous areas of the Laboratory.

In addition to the study in Sandia Canyon, EST began collecting aquatic macroinvertebrates from three sampling stations in Los Alamos and Guaje Canyon. The data collected from these stations will provide baseline data of aquatic macroinvertebrates in these locations. In addition, data comparisons were made between Los Alamos Canyon (on-site canyon) and Guaje Canyon (off-site canyon). Initial data analysis 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. Tables D-9 and D-10 list all the macroinvertebrates that have been collected and identified in these studies.

Terrestrial Invertebrates. EST conducted studies of terrestrial insects in Los Alamos Canyon, Guaje Canyon, and Puye Mesa during 1994. Pit traps for terrestrial insects yielded large numbers of insect 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 significant difference in the arthropods of Los Alamos Canyon and those in Guaje Canyon for equivalent time periods and equivalent number of trapping days. Table IV-21 is a list of the insect families that have been collected on LANL property as of December 1994, and Table IV-22 lists the noninsect anthropods collected.

Reptiles and Amphibians. During 1994, the populations of reptiles and amphibians were monitored in Pajarito Canyon. The plateau whiptail lizard was the most abundant reptile captured, and the chorus frog was the most abundant amphibian. Table IV-23 lists the species captured during the 1994 field season.

Birds. During the 1994 field season, 8 bird surveys were performed. Surveys covered areas of Los Alamos, Guaje, Cañada del Buey, Sandia, Pajarito Canyons, and Puye Mesa, and 73 species of resident birds were encountered. Table IV-24 lists the species identified in these surveys.

Table IV-21. Terrestrial Insects Found on Los Alamos National Laboratory Property as of December 1994

ORDER	FAMILY	COMMON NAME
Thysanura (Bristletails)	Lepismatidae	Silverfish
	Machilidae	Jumping bristletail
Collembola (Springtails)	Sminthuridae	Globular springtail
	Entomobryidae	Slender springtail
	Isotomidae	Smooth springtail
	Hypogastruridae	Elongate-Bodied springtail
Odonata (Dragon and damselflies)	Aeshnidae	Darner
	Libellulidae	Common skimmer
	Coenagrionidae	Narrow-winged damselfly
	Gomphidae	Clubtail
Phasmida (Walkingsticks)	Heteronemiidae	Common walkingstick
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
	Coreidae	Squash bug
	Nabidae	Damsel bug
Homoptera (Cicadas and kin)	Cicadidae	Cicada
	Aphididae	Aphids
	Cercopidae	Spittlebugs
	Cicadellidae	Leafhoppers
	Coccidae	Soft Scales
	Delphacidae	Planthoppers
	Eriosomatidae	Gall-making aphids
	Psyllidae	Jumping plantlice
Neuroptera (Net-veined insects)	Myrmeleontidae	Antlion
	Hemerobiidae	Brown Lacewings
	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

Table IV-21. Terrestrial Insects Found on Los Alamos National Laboratory Property as of December 1994 (Cont.)

ORDER	FAMILY	COMMON NAME
	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
	Curculionidae	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
	Noctuidae	Noctuid moth
	Sphingidae	Sphinx moth
	Saturniidae	Giant silkworm moth
	Gelechiidae	Gelechiid moth
	Geometridae	Measuring worms
	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
Siphonaptera (Fleas)	Pulicidae	Dog fleas
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-22. Noninsect Terrestrial Arthropods Found on Los Alamos National Laboratory Property as of December 1994

CLASS/ORDER	FAMILY
Chilopoda (centipedes)	Geophilidae
	Lithobiidae
Diplopoda (millipedes)	Julidae
Arachnida/Acarina (spiders/mites)	Bdellidae
	Ascidae
	Bryobiidae
	Calligonellidae
	Cryptognathidae
	Cunaxidae
	Erythraeidae
	Eupodidae
	Gymnodamaeidae
	Laelapidae
	Nanorchestidae
	Paratydaeidae
	Phytoseiidae
	Rhagidiidae
	Rhaphignathidae
	Scutacaridae
	Stigmaeidae
	Tenuipalpidae
	Terpnacaridae
	Trombidiidae
	Tydeidae
	Tarsonemidae
	Zerconidae
Archnida/Araneida	Agelenidae
	Amaurobiidae
	Anyphaenidae
	Araneidae
	Clubionidae
	Dictynidae
	Gnaphosidae
	Hahniidae
	Linyphiidae
	Lycosidae
	Micryphantidae
	Miryphantidae
	Oonopidae
	Pholcidae
	Tetragnathidae
	Salticidae
	Theridiidae
	Thomisidae
Arachnida/Opiliones	Phalangiidae

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. Additionally in 1994, surveys were begun to determine the presence of the Mexican spotted owl and the southwestern willow flycatcher, species protected under the federal Endangered Species Act, in all suitable habitat. Following the 1995 survey season all suitable habitat will have been surveyed for these species. No nesting goshawks were found on LANL lands; however, portions of LANL lands were determined to be northern goshawk post-fledgling management areas. No Mexican spotted owls or southwestern willow flycatchers were found to be nesting on LANL lands in 1994. The lands of LANL do nevertheless contain suitable nesting habitat for these species. All areas of the Laboratory with suitable threatened endangered or sensitive species habitat will continue to be monitored and managed.

Small Mammals. Small mammals were sampled at two waste burial sites (Sites 1 and 2) at TA-54, Area G and a control site outside Area G (Site 3) to identify radionuclides that may be present within surface and subsurface soils, to compare the amount of radionuclide uptake at waste burial sites to a control site, and to identify the primary mode of contamination to small mammals. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total uranium, and gamma spectroscopy (including ^{137}Cs). Significantly higher (parametric t-test at $p = 0.05$) levels of total uranium, ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{40}K were detected in pelts as compared to the carcasses of small mammals at TA-54. Concentrations of remaining radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. Site 1 had significantly higher total uranium concentrations in carcasses than Sites 2 and 3. Site 2 had significantly higher ^{239}Pu concentrations in carcasses than either Site 1 or Site 3. A significant difference in ^{90}Sr concentration existed between Sites 1 and 2. Concentrations of ^{40}K at Site 1 were significantly different from Site 3. Deer mice (*Peromyscus maniculatus*) was the only species captured at Sites 1 and 2. Deer mice and piñon mice (*P. trueii*) were captured at the control site. The highest densities of animals occurred on Sites 1 and 2 with very low capture rates at the control site. Density estimates of rodents occurring at Sites 1 and 2 were calculated by regressing the number of daily captures onto the cumulative number of captures for each day and based on a 100 x 100 m grid with an additional 5-m boundary strip to help account for animals being drawn into the grid due to the bait.

Small mammals were trapped in Mortandad Canyon, and their tissues were analyzed for contaminants. Three 10 x 10 m grids were set up in the canyon, and animals were collected and processed similar to those in Area G. This is the first of two years of data collection, and therefore, the results will be reported in the 1995 Environmental Surveillance Report. In June of 1994, the EST conducted field surveys on Puye Mesa within Los Alamos Laboratory property for an ecological risk assessment. The trapping sites were located in one habitat type: piñon pine/juniper. Three replicate webs with 148 trap stations at each were laid out, and Program DISTANCE was used to estimate density of each web and all webs combined. Very poor capture rates were experienced during trapping, which was not only evident in these trapping locations but elsewhere at the Laboratory during other live-trap sampling. Deer mice, brush mice (*Peromyscus boylii*), and piñon mice were the most commonly captured species. There were almost twice as many males captured than females. Since this was the first year of data collection on mesa tops and only one mesa top selected for sampling, yearly and locational comparisons could not be made. This area will be sampled in the future.

Table IV-23. Species of Amphibians and Reptiles Captured in Pajarito Canyon during 1994

Scientific Name	Common Name	Number Caught	Relative Abundance
Cnemidophorous velox	Plateau whiptail	73	52.14%
Eumeces multivirgatus	Many-lined skink	34	24.29%
Pseudacris triseriata	Chorus frog	12	8.57%
Thamnophis elegans	Western terrestrial garter snake	9	6.43%
Sceloporous undulatus	Eastern fence lizard	5	3.57%
Spea couchii	Couch's spadefoot toad	3	2.14%
Bufo woodhousii	Woodhouse toad	2	1.43%
Ambystoma tigrinum	Tiger salamander	1	0.71%
Eumeces obsoletus	Great Plains skink	1	0.71%
TOTAL		140	

Table IV-24. Species Identified in Bird Surveys during 1994

Scientific Name	Species Code	Common Name
Melanerpes formicivorus	ACWO	Acorn Woodpecker
Falco sparverius	AMKE	American Kestrel
Turdus migratorius	AMRO	American Robin
Myiarchus cinerascens	ATFL	Ash-throated Flycatcher
Hirundo rustica	BASW	Barn Swallow
Archilochus alexandri	BCHU	Black-chinned Hummingbird
Polioptila caerulea	BGGN	Blue-gray Gnatcatcher
Molothrus ater	BHCO	Brown-headed Cowbird
Pheucticus melanocephalus	BHGR	Black-headed Grosbeak
Guiraca caerulea	BLGR	Blue Grosbeak
Euphagus cyanocephalus	BRBL	Brewer's Blackbird
Selasphorus platycercus	BTHU	Broad-tailed Hummingbird
Psaltriparus minimus	BUSH	Bushtit
Pipilo fuscus	CATO	Canyon Towhee
Catherpes mexicanus	CAWR	Canyon Wren
Spizella passerina	CHSP	Chipping Sparrow
Nucifraga columbiana	CLNU	Clark's Nutcracker
Hirundo pyrrhonota	CLSW	Cliff Swallow
Accipiter cooperii	COHA	Cooper's Hawk
Corvus corax	CORA	Common Raven
Junco hyemalis	DEJU	Dark-eyed Junco
Picoides pubescens	DOWO	Downy Woodpecker
Empidonax oberholseri	DUFL	Dusky Flycatcher
Sturnus vulgaris	EUST	European Starling
Otus flammeolus	FLOW	Flamulated Owl
Bubo virginianus	GHOW	Great-horned Owl
Empidonax wrightii	GRFL	Gray Flycatcher
Dendroica graciae	GRWA	Grace's Warbler
Picoides villosus	HAWO	Hairy Woodpecker
Catharus guttatus	HETH	Hermit Thrush
Carpodacus mexicanus	HOFI	House Finch
Passer domesticus	HOSP	House Sparrow
Troglodytes aedon	HOWR	House Wren
Passerina cyanea	INBU	Indigo Bunting
Carduelis psaltria	LEGO	Lesser Goldfinch
Anas platyrhynchos	MALL	Mallard Duck
Oporornis tolmiei	MAWA	MacGillivray's Warbler
Parus gambeli	MOCH	Mountain Chickadee
Zenaida macroura	MODO	Mourning Dove
Colaptes auratus	NOFL	Northern Flicker
Mimus polyglottos	NOMO	Northern Mockingbird
Gymnorhinus cyanocephalus	PIJA	Piñon Jay
Carduelis pinus	PISI	Pine Siskin
Parus inornatus	PLTI	Plain Titmouse
Sitta pygmaea	PYNU	Pygmy Nuthatch
Sitta canadensis	RBNU	Red-breasted Nuthatch
Regulus calendula	RCKI	Ruby-crowned Kinglet
Pipilo erythrophthalmus	RSTO	Rufous-sided Towhee
Buteo jamaicensis	RTHA	Red-tailed Hawk

Table IV-24. Species Identified in Bird Surveys during 1994 (Cont.)

Scientific Name	Species Code	Common Name
Selasphorus rufus	RUHU	Rufous Hummingbird
Agelaius phoeniceus	RWBL	Red-winged Blackbird
Sayornis saya	SAPH	Say's Phoebe
Aphelocoma coerulescens	SCJA	Scrub Jay
Melospiza melodia	SOSP	Song Sparrow
Vireo solitarius	SOVI	Solitary Vireo
Cyanocitta stelleri	STJA	Steller's Jay
Piranga ruber	SUTA	Summer Tanager
Myadestes townsendi	TOSO	Townsend's Solitaire
Cathartes aura	TUVU	Turkey Vulture
Tachycineta thalassina	VGSW	Violet-green Swallow
Vermivora virginiae	VIWA	Virginia's Warbler
Vireo gilvus	WAVI	Warbling Vireo
Sitta carolinensis	WBNU	White-breasted Nuthatch
Sialia mexicana	WEBL	Western Bluebird
Tyrannus verticalis	WEKI	Western Kingbird
Piranga ludoviciana	WETA	Western Tanager
Sphyrapicus thyroideus	WISA	Williamson's Sapsucker
Wilsonia pusilla	WIWA	Wilson's Warbler
Zonotrichia albicollis	WTSP	White-throated Sparrow
Aeronautes saxatalis	WTSW	White-throated Swift
Contopus sordidulus	WWPE	Western Wood-Pewee
Dendroica petechia	YEWA	Yellow Warbler
Dendroica coronata	YRWA	Yellow-rumped Warbler

In July and August of 1994, the EST conducted field surveys in Guaje and Los Alamos Canyons, as a continuation of data collected in 1993 for the ecological risk assessment. It included conducting live-capture and release studies on rodent populations. The trapping sites were located in two habitat types: Mixed conifer and Ponderosa pine, and a transition zone of these two. Six 12 x 12 grids with 144 trap stations at each were laid out in the canyon bottoms. Program CAPTURE was used to estimate population size and density. Very poor capture rates were experienced during 1994. Analysis (ANOVA and SNK multiple range test) showed that the mean daily capture rates observed during the four consecutive years are statistically different (alpha = 0.05). Capture rates for 1991 were significantly higher than the subsequent years, and 1992 rates were significantly higher than 1993 and 1994. Capture rates were not significantly different between 1993 and 1994. Deer mice were captured in all trapping locations except middle Los Alamos Canyon. Shrews and voles were only captured in the upper locations of each canyon and deer mice and a small number of harvest mice were the only species captured in the Ponderosa pine habitat of the lower portions of each canyon. The upper portions of the canyon systems had a much higher species diversity and a much greater number of captures compared to the lower areas resulting in higher population estimates and densities in those locations. The relative percentage of males was much higher than females, but overall mean body weights appeared similar. The mean body weights of males ranged from 9.8 g for harvest mice to 19.3 g, 14.4 g, and 27.3 g for brush mice, deer mice, and long-tailed voles, respectively. Mean body weights for females ranged from 8.7 g, 22.3 g, 15.6 g, and 31 g, for harvest mice, brush mice, deer mice, and long-tailed voles, respectively. The upper areas of both canyons had the highest species diversity with essentially only one species being recorded in the middle portions of each canyon. The overall species diversity was similar for both canyons. The mean body weights of all nocturnal species combined were compared between canyons and by year. There were no significant differences in 1993 between upper Guaje Canyon and upper Los Alamos Canyon, and there were no significant differences between the mean body weights of lower Guaje Canyon and lower Los Alamos Canyon. However, there was a significant difference in the mean body weights between the upper canyon sites compared to the lower canyon sites. In 1994, there were no significant differences in mean body weights between sites.

Small mammal studies were also conducted in Sandia Canyon. Three trapping webs were used to estimate densities and species composition. Physical characteristics were recorded along with a complete body composition analysis (percent body fat, lean body mass, percent body water). This was the first of at least two years of data collection, therefore, the results will be reported in the "Environmental Surveillance at Los Alamos during 1995." Table IV-25 lists small mammal species captured during the 1994 studies by location.

15. Ecological Risk Assessment. (Roger Ferenbaugh, EES-15)

During 1994, the focus of the Ecological Risk Assessment program had two objectives. One was to perform the preliminary ecological risk screening assessments for all of the Environmental Restoration Project operable units (OUs). The other was to develop the methodology that will be needed to perform ecological risk assessments in those cases when the preliminary ecological risk screening assessment cannot support a No Further Action alternative at a given PRS.

The first step in performing the preliminary risk screening assessments was to develop Ecotoxicological Screening Action Levels (ESALs) against which to compare soil concentrations of Contaminants of Potential Concern (COPCs) at a PRS. The ESALs are based on toxicological data obtained from the EPA's IRIS and HEAST toxicology databases. The toxicological information obtained from these databases was incorporated into a spreadsheet model using body weights, metabolic rates, and fraction of food ingested as soil to obtain ESALs for mammals, birds, and reptiles of different sizes and feeding habits.

After the ESALs were calculated, preliminary soil data comparisons were made for those OUs for which soil data was present in the Facility Information Management, Analysis, and Display system. Twenty-four preliminary screening reports were issued in October 1994, one for each OU (e.g., Ebinger 1994). The appendices in these screening reports contain detailed information on how the ESALs were calculated, as well as extensive tables of ESALs as a function of COPC, animal type (mammal/bird/reptile), feeding habits, and body weight.

Development continued on two ecological models that will be used for ecological risk assessment. The Ecological Risk Assessment Model (ERAM) is a somewhat more sophisticated screening tool than the spreadsheet model previously described. It is a deterministic model that estimates transport of potential contaminants through ecological food chains using partition coefficients either found in the literature or determined experimentally. (A partition coefficient is the ratio of the concentration of a potential contaminant in one trophic level to the concentration in a lower trophic level. It is an estimate of the extent to which a contaminant moves through the food chain.) The ERAM output indicates which species are at risk and which species may cause species in a higher trophic level to be at risk. The model is more versatile than the spreadsheet model in that it can incorporate additional information such as the percentage of an animal's home range that lies within the PRS.

ECOTRAN is a dynamic simulation model that contains eight modules representing climate, air, soil, hydrogeology, aquatic systems, plants, animals, and humans. The modules feed information back and forth, and

Table IV-25. Small Mammals Captured during 1994 Surveys

	Location			
Species	Guaje Canyon	Los Alamos Canyon	Area G	Puye Mesa
Deer mouse	x	x	x x[a] x	x
Piñon mouse			x	x
Brush mouse	x	x		x
Mexican woodrat	x			x
Long-tailed vole	x	x		
Harvest mouse		x		
Vagrant shrew	x			
Water shrew	x			
unidentified shrew		x		
Weasel		x		

[a]Area G includes 3 sites

the model can simulate ecological conditions through time as well as spatially. The major drawback of this model is that it is data intensive. However, it can be used to perform very sophisticated ecosystem simulations, and it also can be used to perform probabilistic risk assessments using distribution functions of input parameters in what is essentially a Monte Carlo-type process.

16. Stakeholder Involvement.

In order to develop a more open and participatory culture, the Laboratory has committed itself to ensuring that stakeholders receive appropriate information on existing and planned facilities, programs, and technologies. Successful interaction and dialogue are based upon honesty and forthrightness, and enable stakeholders to understand issues important to their welfare, to participate in the decision-making process, and to interact with the Laboratory in a climate fostering trust and cooperation.

Recognizing that an increase in public involvement initiatives would require carefully planned and coordinated efforts, in November 1993, the Laboratory established the Stakeholder Involvement Office (SIO) to form strong and lasting relationships with internal customers and external stakeholders that are based on mutual respect and trust. The Laboratory's stakeholders include neighboring individuals and groups, local and state governments, tribal governments, special interest groups, the UC, DOE, federal agencies, and Laboratory staff.

One of the primary responsibilities of the SIO was to oversee the public involvement-related activities of Laboratory programs from an institutional perspective to ensure consistency and quality across programs, and that technical information be provided at a level appropriate for its intended audience. Other core responsibilities in 1994 included the following:

- stakeholder involvement guidance and support to technical divisions, program offices, operational divisions, resources organizations, and for institutional efforts;
- development and implementation of Laboratory policy and vehicles for stakeholder involvement and information dissemination;
- stakeholder inreach and relationship building with DOE, LANL, and UC;
- communication and relationship building with tribal governments, local governments, and special interest groups; and
- administration of the Laboratory's Native American Program.

Public Involvement Policy

In July 1994, the SIO office drafted a Public Participation Policy, for the Laboratory Director's signature that defined public participation in the Laboratory planning and decision-making processes. The policy establishes SIO as the central office to handle public involvement contacts from other institutions, and to encourage and support interactive communication between the Laboratory and the public.

Public Meetings

During 1994, the SIO successfully planned and coordinated 82 public meetings on topics such as the Mixed Waste Site Treatment Plan; environment, safety and health vulnerability related to plutonium; the Dual Axis Radiographic Hydrotest Facility (DAHRT); and strategic thinking. This was up from 20 public meetings in 1993.

The SIO coordinated and managed public involvement for 47 projects, including the formation of the Northern New Mexico Citizens' Advisory Board to DOE and LANL; the Laboratory's Diversity Strategic Plan and Strategic Thinking Process; and the DOE's five PEISs, pre-scoping meetings for the SWEIS, and the DAHRT EIS.

The SIO will continue to collaborate with Laboratory technical programs to sponsor special public briefings and tours of waste management facilities, sampling sites for the ER Project, facilities selected in the non-nuclear consolidation of the DOE Weapons Complex, and facilities for aboveground experimentation.

Tribal Government Liaison

Through the Tribal Government Liaison, the SIO supports the LANL/Tribal Environmental Quality Working Group and the Tribal Cooperative Agreement Implementation Team.

Rio Grande Intergovernmental Council

The SIO played a key role in the establishment of the Rio Grande Intergovernmental Council, composed of government representatives from eleven municipalities and five counties within a 60-mile radius. Monthly meetings address issues of mutual concern to local governments and the Laboratory.

Tours and Queries

The SIO is the primary Laboratory recipient of queries having environmental, safety, and health; technical; or programmatic content; and all queries from local and tribal governments and special interest groups. Some vehicles for involvement include public and special meetings, and specialized tours. The SIO provided tours for interested members of neighboring pueblos, special interest groups, local government officials and community leaders, of facilities or areas related to issues such as aboveground testing, expedited cleanup, expansion of a waste disposal site, and hyrodynamic testing.

Community Reading Room

In June 1993, the Laboratory relocated its Community Reading Room to a more visible and accessible location in the Los Alamos Museum Parke Center. As a result, visitation increased from 225 visitors in 1992 at the old location to 1,249 in 1994. The Reading Room serves as a repository for documents of interest to the public about the Laboratory's activities. Other repositories for information were established in public libraries in Santa Fe, Española, Taos, and Las Vegas.

Public Information

Some primary vehicles for information dissemination include the Community Reading Room, fact sheets, special publications, quarterly reports, briefings, advertisements, stakeholder mail list and data base, and access to SIO via electronic bulletin board/Internet. In addition to primary telephone banks, toll-free telephone lines are maintained for receiving queries (1-800-508-4400).

The new Los Alamos National Laboratory Home Page on the Internet presents an opportunity to reach a world-wide audience for the Laboratory, while at the same time posing a challenge to put forth public information in a way that is timely, appropriate, and unique from other DOE national laboratories. The SIO is committed to using this type of communication tool to create a viable access point for the public to the Laboratory and disseminating information that is accurate, complete, and timely.

Our Common Ground

Four years ago, a group of Laboratory employees saw a need for an environmental ethic that would change our perspective and guide our decisions and actions. From that concern grew the employee initiative known as Our Common Ground which reached out to the public and adopted the new spirit of openness that has been championed by the Secretary of Energy.

In 1994, Our Common Ground

- in conjunction with the SIO and the ESH Division, co-sponsored two talks and panel discussions featuring Dr. Helen Caldicott. There were approximately 150 people at each session.
- with the SIO, Public Affairs, and the National Security Working Group, co-sponsored a public forum titled, "Los Alamos, National Security, and the Next 50 Years: Involving the Public and the Media."
- made suggestions for the DOE gas pipeline project on how to prevent the excess clearing of trees as the pipeline was being installed.

The basic principles upon which Our Common Ground is built are that we must address the environmental consequences of past Laboratory operations and engage in open and respectful dialogue with co-workers, other organizations and the public. To pursue these ends, Our Common Ground will communicate openly and honestly with the public, conveying uncertainties as well as facts and judgments, and listen to and learn from the public.

17. Waste Minimization and Pollution Prevention. (Michelle Burns, EM/WM-P^{3}O)

Today, DOE and the LANL conduct business in an atmosphere of sharply declining budgets and increasing public scrutiny, which mandate that operations become both more cost effective and environmentally aware.

Incorporation of waste minimization (WMin) methodologies into the daily conduct of operations can provide significant returns in avoided waste management costs, both for the waste generating programs and the LANL Waste Management (WM) Program, as well as increases in employee productivity.

The existence of a functional, proactive, pollution prevention program is necessary to comply with the New Mexico State HSWA permit, the FFCA, RCRA Subtitle A, Superfund Amendments and Reauthorization Act (SARA) Subtitle 313, DOE Order 5400.1, and other regulations. As such, pollution prevention is an essential element of the LANL Waste Management Program. Additionally, due to the limited amount of waste disposal capacity remaining in current WM on-site facilities, pollution prevention is a primary component in WM strategic planning. The LANL Pollution Prevention Program Office (P^3O) activities provide for a comprehensive program designed to address the requirements of DOE orders as well as Federal environmental regulations and executive orders.

The organization of the LANL pollution prevention program is modeled after the guidance provided in the DOE Pollution Prevention Crosscut Plan. This plan sets forth the responsibilities of the various DOE departments and establishes what activities they are responsible for funding. As a result, the P^3O utilizes a variety of funding sources to conduct, coordinate, and track waste minimization/pollution prevention (WMin/PP) efforts at LANL. Pollution prevention accomplishments at LANL during 1994 include

- continuation of LANL recycling efforts;
- initiated recycling of used fluorescent light bulbs, and identified nonhazardous bulbs to be used for replacements;
- reduction in LANL annual sulfuric acid use by 12,727 kg (28,000 lb) (an approximate 50% reduction);
- reduction in annual hydrochloric acid use by 318 kg (700 lb);
- reduction in tetrachloroethylene use from 2,727 kg (6,000 lb) to only 72 kg (158 lb);
- elimination of lead melting and casting operations reduced LANL lead emissions by 99% as compared to 1991 levels;
- elimination of the use of all toluene-based paints;
- development of a Pollution Prevention Action Plan, including the identification of priority waste types and priority waste generating facilities;
- establishment of a LANL waste generation baseline and development of methods to track avoided wastes;
- completion and submittal to DOE of the CY93 Annual Report of Waste Generation and Waste Minimization Progress (DOE cited the LANL report as a model for other DOE-complex sites to emulate);
- conducted pollution prevention awareness efforts, such as funding environmental science competitions in the public schools, presentation of Earth Day exhibits, development and publication of a pollution prevention newsletter, implemented an employee cash incentive awards program, and improvement of LANL ESH training for WMin/PP;
- development and implementation of the WMin/PP chargeback system to provide a financial incentive for WMin/PP actions at LANL by assessing a “tax” on wastes generated, as well as to provide a pool of funding to support the accomplishment of specific waste reduction activities;
- completion of the WM-200 WMin Annual Work Plan in compliance with FFCA requirements;
- completion and submittal to DOE of the LANL Pollution Prevention Awareness Plan;
- participation in a DOE-wide avoidable waste management costs study;
- initiation of Pollution Prevention Opportunity Assessments on all LANL mixed waste generating processes; and

- review of Safe Operating Procedures and ESH Questionnaire forms for pollution prevention concerns.

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

The Laboratory maintains an extensive training program of ESH courses that meet compliance requirements under Occupational Safety and Health Act (OSHA), EPA, and Department of Transportation (DOT) regulations, as well as the DOE orders and LANL's Radiological Control Manual. These courses are designed, developed, delivered, and/or coordinated by the ESH Training Group (ESH-13). In 1994, training was available in the following categories: radiation safety training, including courses for radiological workers and radiological control technician; safety training, including courses on electrical safety, cranes, forklifts, lasers, 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 on 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 ESH topics, including OSHA Rights and Responsibilities, Industrial Hygiene, Industrial Safety, Fire Protection, Emergency Management, 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 monitored at approximately 90 release points on Laboratory property. In addition, 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. During 1994, the largest airborne release of radioactive material was 50,200 Ci (1,860 Tbq) of short-lived (8-s to 20-min half-life) air activation products from the Los Alamos Meson Physics Facility (LAMPF). Water effluent from the liquid waste treatment plant is sampled to determine the release of radionuclides. Total releases increased in 1994. No radioactive contribution in foodstuffs posed a threat to the health or safety of the public. The maximum individual effective dose equivalent (EDE) to a member of the public from 1994 Laboratory operations is estimated to be 3.5 mrem/yr (0.035 mSv/yr). The average doses to individuals in Los Alamos and White Rock were 0.27 and 0.06 mrem (0.0027 and 0.0006 mSv), 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 aspect of the Laboratory's environmental surveillance program is monitoring the environment for ionizing radiation from Laboratory-related sources. Ionization is the process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. Only ionizing radiation is considered in this chapter.

Alpha and beta particles and x-rays and gamma rays are different types of ionizing radiation. These radiation types can penetrate matter and be absorbed in living tissues to varying degrees potentially causing cellular damage. Alpha radiation penetrates poorly; a piece of paper or the outer layer of dead skin can stop it. Beta radiation has low-to-moderate penetrating ability and can be stopped by the equivalent of a few sheets of paper. X-rays and gamma radiation have much greater penetrating ability but can be reduced greatly by dense material, such as lead or concrete.

Radiation is emitted both by naturally occurring and man-made materials. LANL background radiation is composed of the natural component and man-made radiation exclusive to Laboratory operations. Examples of natural background radiation sources include naturally occurring radon gas and naturally occurring uranium and thorium in regional rock and soil. An example of man-made background radiation is radioactive fallout from historical nuclear weapons testing programs around the world. Ionizing radiation is also produced by medical diagnostic and treatment procedures, and accounts for the largest radiation dose to the American public from man-made radiation. Consumer products such as tobacco products, smoke detectors, and television sets may also be sources of ionizing radiation. Other sources of exposure to ionizing radiation include radiological occupations, the processing and storing of nuclear fuels, and scientific research at facilities such as LANL.

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 naturally occurring ^{40}K and radionuclides in the decay chains of naturally occurring thorium and uranium. Terrestrial radiation varies diurnally, seasonally, and geographically.

External radiation levels can vary from 15% to 25% at a given location because of changes in soil moisture and snow cover (NCRP 1975b). There is also spatial variation due to topographical and geological variations (ESG 1978).

Natural ionizing radiation from cosmic sources increases with elevation because of reduced atmospheric shielding. At sea level, cosmic sources yield between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km (1.4 mi), receives about 75 mrem/yr (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 of 45 to 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-rays and gamma rays and charged-particle contributions from cosmic, terrestrial, and man-made sources) are measured with thermoluminescent dosimeters (TLDs), pressurized ionization chambers, and high-purity germanium (HPGe) detectors. LANL's environmental monitoring of external penetrating radiation is made up of three networks. These networks are used to measure natural and man-made radiation exposures (1) on site (the Laboratory) and off site (perimeter and regional), (2) at the Laboratory boundary north of the 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 due to external penetrating radiation from LANL operations.

Laboratory and Regional Areas (TLDNET). This environmental network consists of 53 stations divided into three groups. The off-site regional group has 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 network. The off-site perimeter group consists of 24 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 of the TLD system is 3 mrem. TLD network sampling methodology is explained in Section VIII.B.1. Station #52 at Taos Pueblo was discontinued in the fourth quarter of 1993 and not used in 1994 because of the repeated loss of TLDs from the station. Changes in administrative procedures will allow for data to be collected from this location in 1995. Some of the other TLD stations are lacking one or more quarters of data. Vandalism, animal predation, processing error, new TLD mid-year placement, and removal requests by the public all can result in loss of data for a given quarter.

The range of values observed in each network of stations is consistent with the expected variability in natural background radiation and is consistent with the range of results observed in 1993. Of the stations having a complete set of data, the 1994 annual dose at off-site regional stations ranged from 110 to 153 mrem. Annual measurements at off-site perimeter stations ranged from 101 to 165 mrem.

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. The network consists of 24 TLD stations. Twelve monitoring TLD stations are directly across from TA-53 to measure LAMPF emissions. The stations are 800 km (0.5 mi) north and downwind from LAMPF. The other 12 TLDs are background sites and 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 approximately the same elevations. The use of a t-test to statistically compare data determined no statistical difference between the TLD results observed at LAMPF and those observed at the background locations. In addition to the TLDs, there is a network of three HPGe detector systems installed on the north side of Los Alamos Canyon and located north of, north-northeast of, and northeast of LAMPF (Figure V-2). At each site, a photon energy spectrum is collected hourly and analyzed for various radionuclides and the resulting exposure rate. In addition to providing for rapid data analysis, these systems have a very low detection level and are quite sensitive to changes in ambient exposure levels. Along with

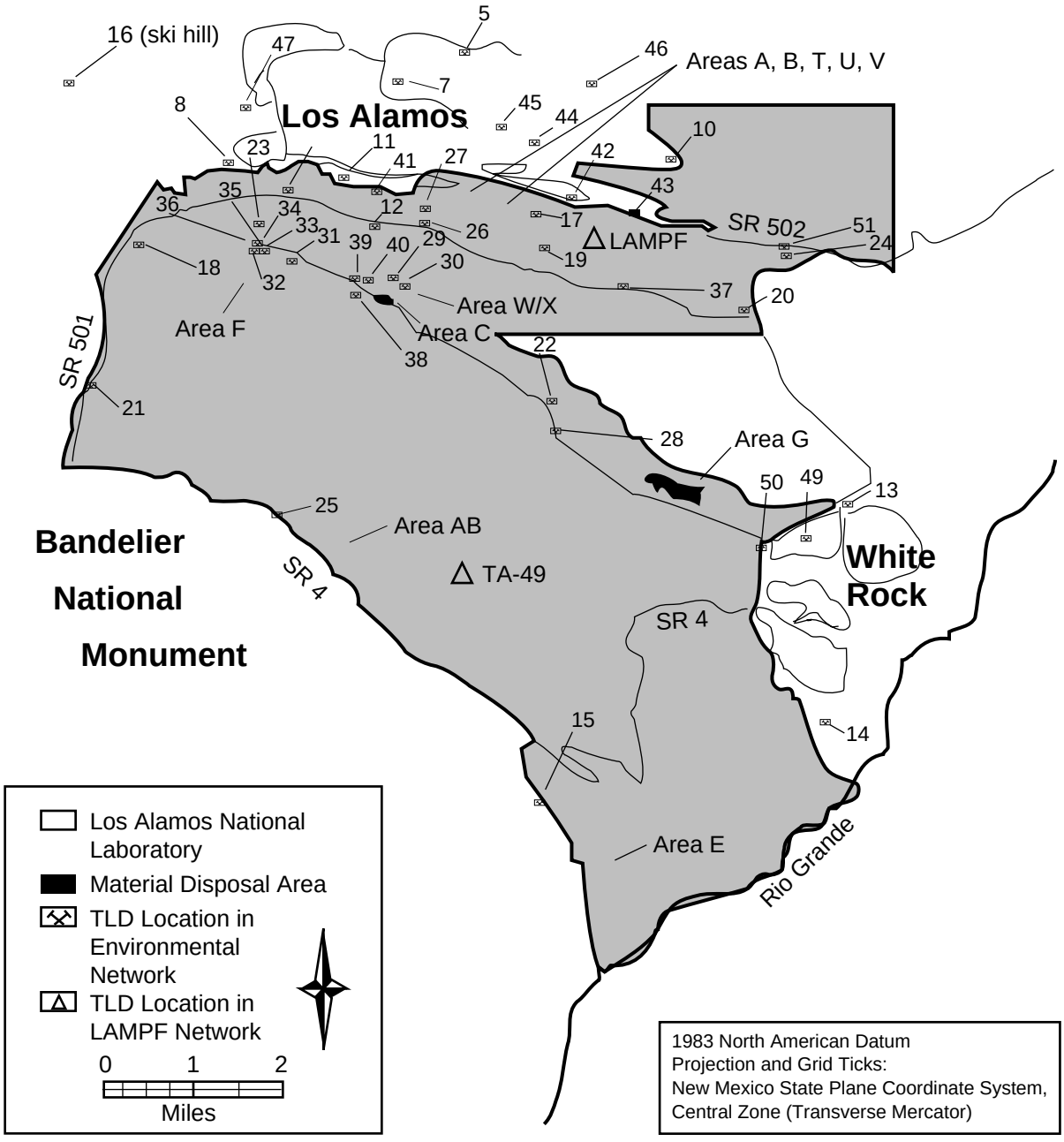


Figure V-1. Off-site perimeter and on-site Laboratory TLD Locations. (Does not show off-site regional stations.)

Table V-1. TLD Measurements for 1994

Station ID #	Location	1994 Annual Dose (mrem)[a]	1993 Annual Dose mrem)[a]
REGIONAL			
1.	Española	76[b] (± 13)	105 (± 12)
2.	Pojoaque	118 (± 13)	82[b] (± 10)
3.	Santa Fe	122 (± 12)	109 (± 12)
4.	Fenton Hill	152 (± 13)	157 (± 12)
52.	West Taos Pueblo	out of service	27[c] (± 6)
53.	San Ildefonso Pueblo	113 (± 13)	50[d] (± 10)
54.	Jemez Pueblo	110 (± 13)	66[d] (± 8)
PERIMETER			
5.	Barranca School, Los Alamos	118 (± 13)	112 (± 12)
7.	Cumbres School, Los Alamos	125 (± 10)	124 (± 9)
8.	48th Street, Los Alamos	132 (± 10)	126 (± 9)
9.	Los Alamos Airport	110 (± 10)	79[b] (± 7)
10.	Bayo Canyon, Los Alamos	145 (± 13)	148 (± 12)
11.	Shell Station, Los Alamos	140 (± 10)	174 (± 9)
12.	Royal Crest Trailer Court, Los Alamos	133 (± 13)	117 (± 12)
13.	White Rock	124 (± 10)	113 (± 11)
14.	Pajarito Acres, White Rock	122 (± 14)	126 (± 12)
15.	Bandelier Nat'l Monument Lookout Station	143 (± 11)	138 (± 9)
16.	Pajarito Ski Area	118 (± 13)	120 (± 12)
20.	Well PM-1 (SR4 and Truck Rt.)	148 (± 13)	154 (± 12)
41.	McDonald's Restaurant, Los Alamos	128 (± 10)	121 (± 9)
42.	Los Alamos Airport-South	123 (± 13)	116 (± 12)
43.	East Gate Business Park, Los Alamos	114 (± 13)	104 (± 12)
44.	Big Rock Loop, Los Alamos	165 (± 13)	147 (± 12)
45.	Cheyenne Street, Los Alamos	160 (± 13)	139 (± 12)
46.	Los Pueblos Street, Los Alamos	139 (± 13)	82[b] (± 11)
47.	Urban Park, Los Alamos	135 (± 13)	82[b] (± 10)
48.	Los Alamos County Landfill	122 (± 13)	116 (± 12)
49.	Piñon School, White Rock	124 (± 13)	103 (± 12)
50	White Rock Church of the Nazarene	101 (± 13)	81 (± 12)
51.	Bayo Canyon Well, Los Alamos	103 (± 12)	112 (± 13)
ON-SITE			
17.	TA-21 (DP West)	152 (± 10)	139 (± 9)
18.	TA-6 (Two Mile Mesa)	134 (± 10)	82 (± 11)
19.	TA-53 (LAMPF)	152 (± 10)	142 (± 12)
21.	TA-16 (S-Site)	99[b] (± 12)	129 (± 11)
22.	Booster P-2	144 (± 13)	117 (± 12)
23.	TA-3 East Gate of SM 43	132 (± 13)	109 (± 12)
24.	State Highway 4	98[b] (± 11)	147 (± 12)
25.	TA-49 (Frijoles Mesa)	119 (± 10)	113 (± 9)
26.	TA-2 (Omega Stack)	135 (± 13)	121 (± 11)
27.	TA-2 (Omega Canyon)	159 (± 13)	201 (± 12)
28.	TA-18 (Pajarito Site)	127 (± 13)	128 (± 12)
29.	TA-35 (Ten Site A)	114 (± 13)	91[b] (± 11)
30.	TA-35 (Ten Site B)	140 (± 13)	119 (± 12)
31.	TA-59 (Occupational Health Lab)	138 (± 13)	119 (± 9)
32.	TA-3-16 (Van de Graaff)	145 (± 13)	123 (± 12)

Table V-1. TLD Measurements for 1994 (Cont.)

Station ID #	Location	1994 Annual Dose (mrem)[a]		1993 Annual Dose mrem)[a]	
ON-SITE					
33.	TA-3-316 (Ion Beam Bldg.)	142	(± 13)	130	(± 12)
34.	TA-3-440 (CAS)	129	(± 13)	110	(± 12)
35.	TA-3-420 (CMR Bldg. West Fence)	115	(± 13)	109	(± 12)
36.	TA-3-102 (Shop)	119	(± 13)	116	(± 12)
37.	TA-72 (Pistol Range)	146	(± 13)	135	(± 12)
38.	TA-55 (Plutonium Facility South)	133	(± 13)	143	(± 12)
39.	TA-55 (Plutonium Facility West)	140	(± 14)	107	(± 10)
40.	TA-55 (Plutonium Facility North)	135	(± 13)	150	(± 12)

[a]The uncertainty of each measurement, shown in parentheses, is the propagated error of the quarterly measurements.
[b]Annual dose is the sum of three quarters.
[c]Only 4th quarter data available.
[d]Annual dose is the sum of two quarters.

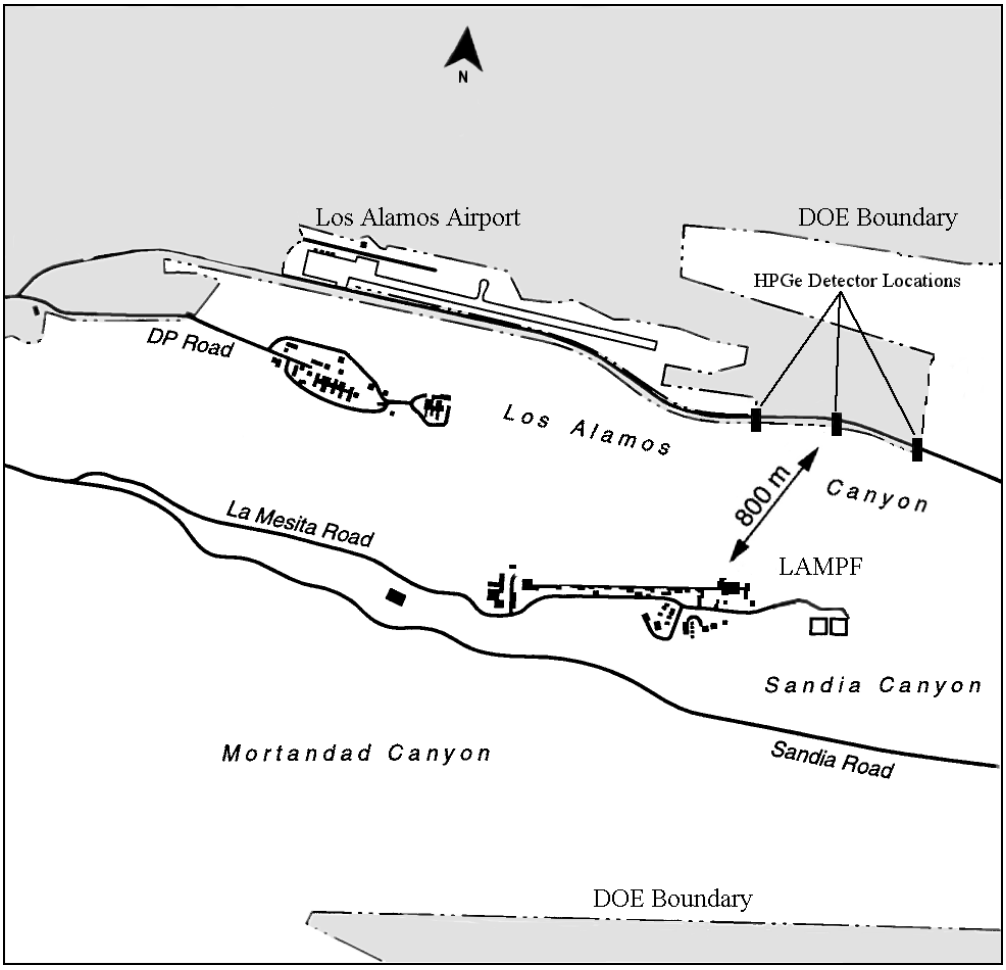


Figure V-2. High-Purity Germanium Detector Monitoring network at LAMPF, TA-53.

the HPGe systems, a high-pressure ion chamber is present as a backup system at the center north-northeast station. Figure V-3 presents an example of the hourly dose rate measured during a typical month of the 1994 LAMPF facility operating cycle. Figure V-4 presents summary data on the contribution of external penetrating radiation to the maximum individual dose and the maximum Laboratory boundary dose. The maximum Laboratory boundary dose assumes continued occupancy at the site, whereas the maximum individual dose incorporates adjustments for occupancy and shielding.

Low-Level Radioactive Waste Management Areas Network (WASTENET). Environmental TLDs are placed at 86 locations at LANL to monitor external penetrating radiation at 11 low-level radioactive waste management areas. Only one of these areas was active in 1994. The waste management areas are controlled-access areas and are not accessible to the general public. The average annual dose at each location is calculated from a set of TLDs located at each site. Annual doses at the waste management areas are presented in Table V-2. The annual average doses at all waste management areas during 1994 ranged from 105 to 160 mrem. Exposure data for Waste Area F at TA-6 are not available for 1994. Extensive and detailed geophysical sampling and characterization of the site disrupted the monitoring program for the year. Monitoring of Waste Area F will resume in 1995 upon completion of the site characterization study. The highest WASTENET annual average dose for 1994 was measured at TA-54, Area G, LANL's only active low-level radioactive waste area. The 25 TLDs of Area G are located within the waste site and along the perimeter fence. The highest dose was measured close to TRU waste storage areas. These areas were uncovered and the contents retrieved during 1994 in conjunction with a plan to build new domes for the temporary storage of TRU waste materials. The higher exposures measured near the mounds are attributed to contaminated dirt particles, which became airborne when the mounds were disturbed. Since the other TLDs placed around Area G received exposures similar to those observed at the regional stations, the exposure due to the active storage area is deemed to be highly localized within Area G.

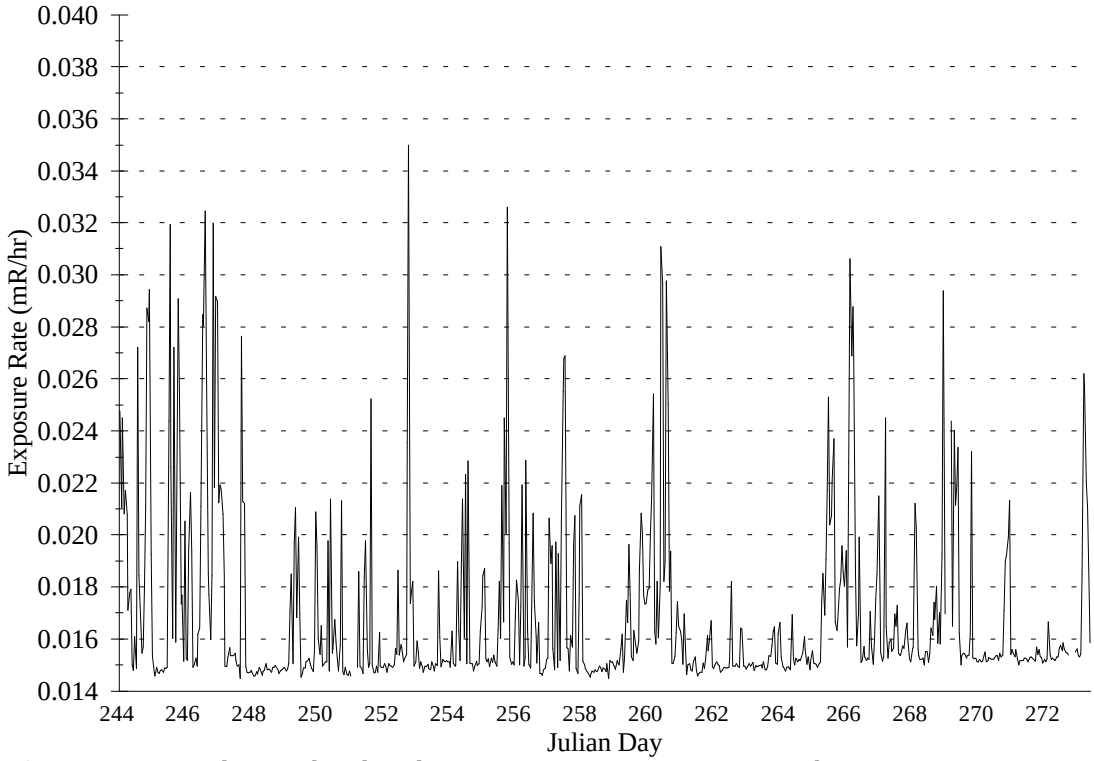


Figure V-3. Typical TA-53 hourly radiation exposure rate at East Gate with LAMPF in operation.

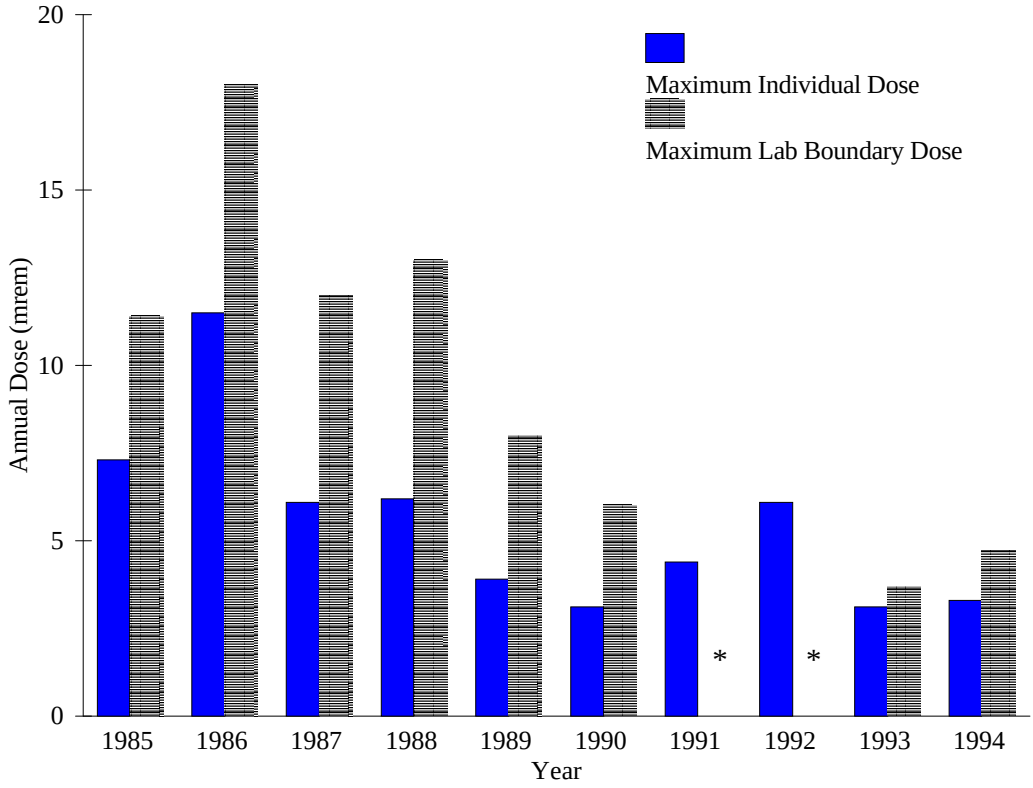


Figure V-4. Summary of estimated maximum individual and maximum Laboratory boundary doses from external penetrating radiation generated by Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources). Maximum individual dose calculated with DOE-approved modeling and measurement 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 V-2. Doses Measured by TLDs at On-Site Waste Disposal Areas during 1994

Waste Disposal Area	Number of TLD Locations	Annual Doses (mrem) Mean	Minimum	Maximum	Uncertainty[a]
TA-21, Area A	5	129	123	135	13
TA-21, Area B	14	135	120	145	13
TA-50, Area C	10	113	163	136	13
TA-33, Area E	4	139	149	146	13
TA-6, Area F	N/A[b]	N/A	N/A	N/A	—
TA-54, Area G	25	160	36	370	13
TA-21, Area T	7	159	123	275	14
TA-21, Area U	4	131	125	141	14
TA-21, Area V	4	105	89	131	12
TA-35, Area W	3	110	105	113	13
TA-49, Area AB	10	126	80	160	13

[a]Uncertainty is the propagated error of the quarterly measurements.
[b]Not monitored in 1994 because of geophysical study.

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.

The radiological air sampling network at the Laboratory is designed to measure environmental levels of airborne radionuclides that may be released from Laboratory operations. Laboratory emissions include microcurie quantities of plutonium and americium, millicurie quantities of uranium, and curie (Ci) quantities of tritium and activation products.

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 (1 mSv).

The quantities of airborne radioactivity released depend on the types of research activities and can vary markedly from year to year (Figures V-5 to V-7). During 1994, emissions reported from Laboratory stacks amounted to 51,300 Ci (1,900 TBq). These emissions include 50,200 Ci (1,860 TBq) of air activation products from LAMPF. A list of 1994 emissions is provided in Tables V-4 and V-5, and a comparison of emissions during 1993 and 1994 is provided in Table V-6.

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

Radioactive Constituent	Units	Santa Fe[a] 1988–1993	New Mexico[b] 1994	DOE DAC Guide for Uncontrolled Area[c]
Gross beta	10^{-15} µCi/mL[d]	12.0 (8.0)[e]	3.0 (4.2)	9,000
Tritium	10^{-12} µCi/mL	NA	1.3 (8.4)	100,000
Uranium (natural)	1 pg/m^3	54.6 (38.9)	74.2 (127)	100,000
^{234}U	10^{-18} µCi/mL	20.7 (5.3)	16.8 (20.6)	90,000
^{235}U	10^{-18} µCi/mL	0.8 (0.7)	1.4 (2.4)	100,000
^{238}U	10^{-18} µCi/mL	18.2 (13.0)	16.7 (20.6)	100,000
^{238}Pu	10^{-18} µCi/mL	0.2 (0.3)	2.4 (6.1)	30,000
^{239,240}Pu	10^{-18} µCi/mL	0.2 (0.3)	4.2 (6.6)	20,000
^{241}Am	10^{-18} µCi/mL	NA	4.9 (5.1)	20,000

[a]EPA (1989–1993), Reports 53 through 73. Data are from the EPA Santa Fe, New Mexico, sampling location and were taken from January 1988 through March 1993. Data for 1994 were not available at time of publication.

[b]Data are annual averages from the regional stations (Española, Pojoaque, Santa Fe) and were taken by the Laboratory during CY94.

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

[d]1 µCi/mL = 37 kBq/mL

[e]Uncertainties (2s) are in parentheses.

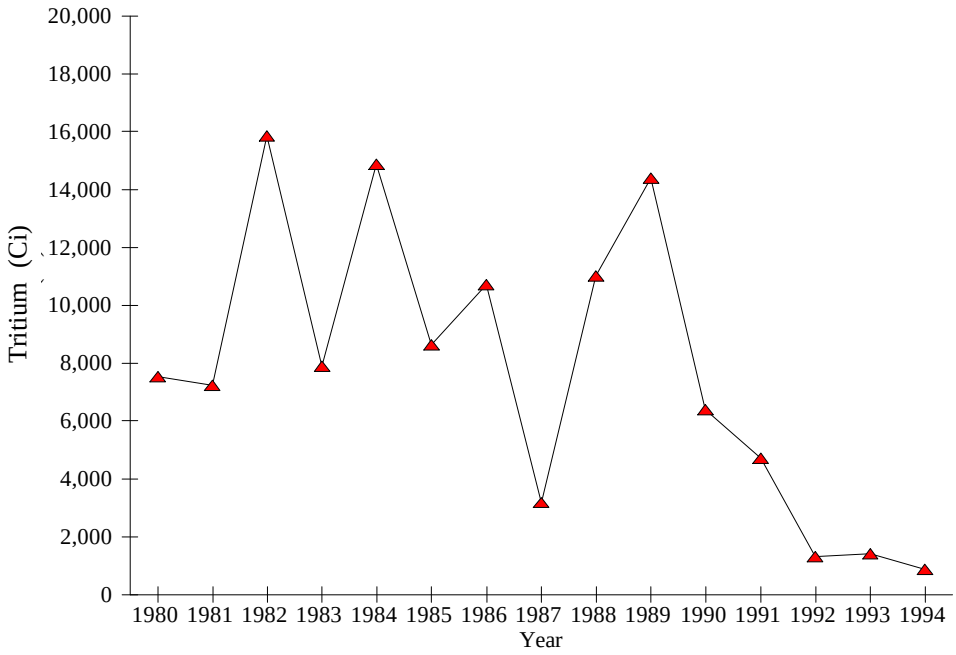


Figure V-5. Tritium in airborne stack effluents.

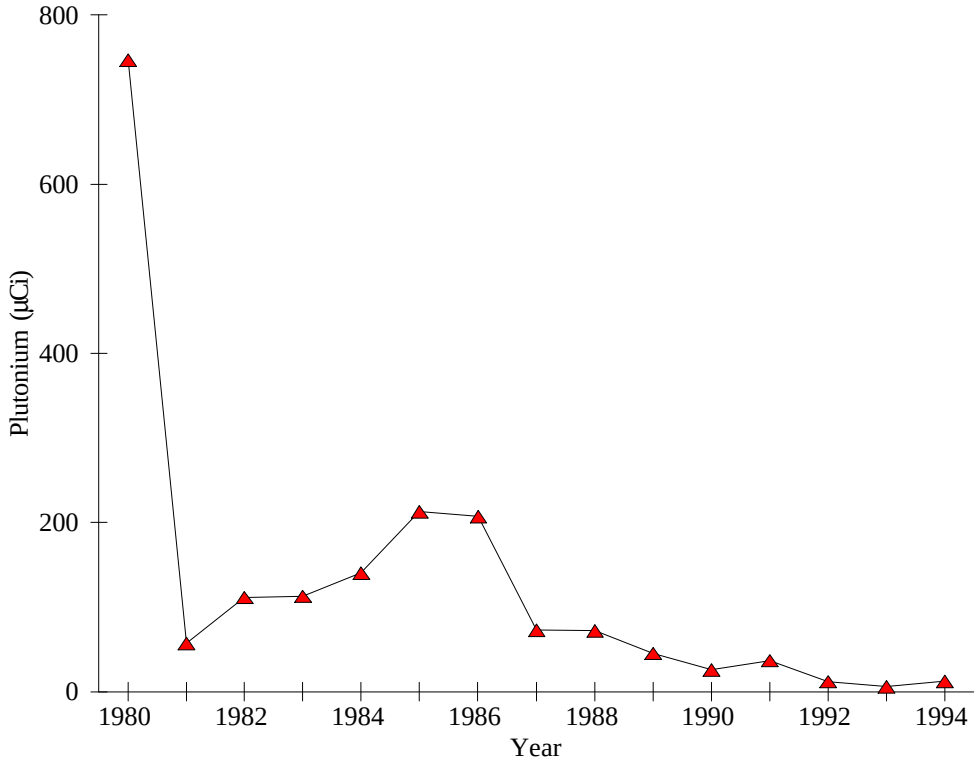


Figure V-6. Plutonium in airborne stack effluents.

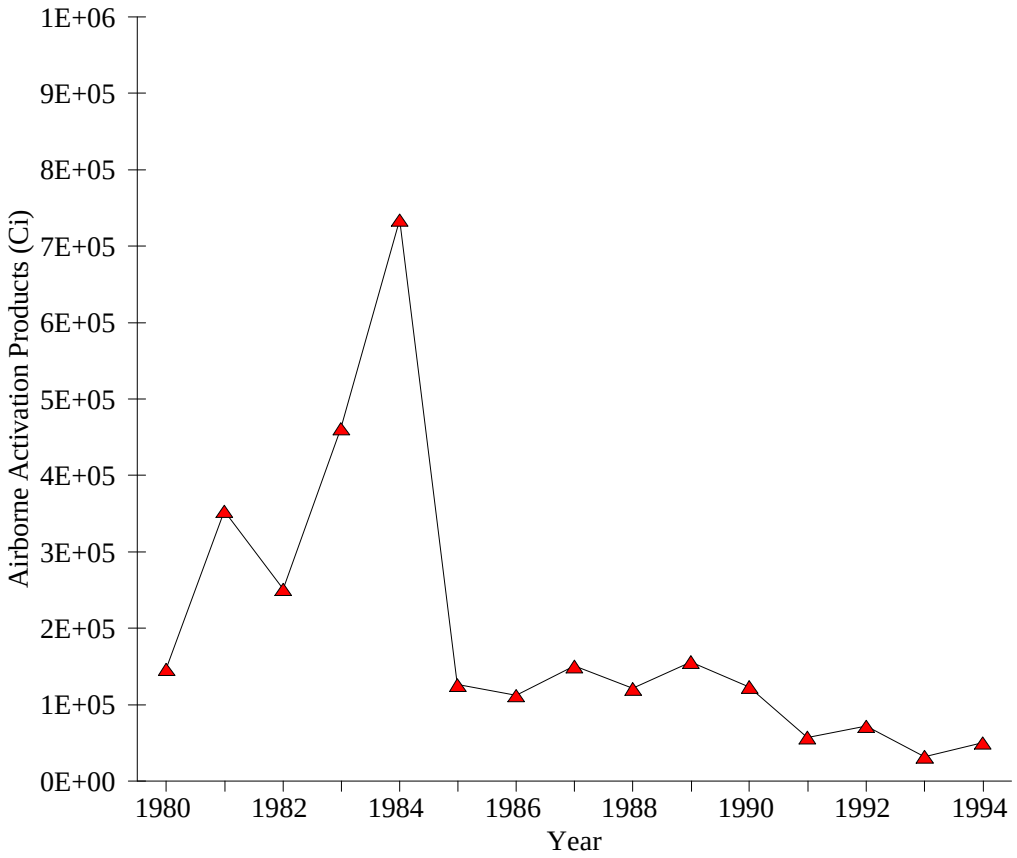


Figure V-7. Emissions of airborne gaseous mixed activation products (principally ^{10}C, ^{11}C, ^{13}N, ^{16}N, ^{14}O, ^{15}O, and ^{41} Ar) from LAMPF.

Table V-4. Airborne Radioactive Emissions from Laboratory Operations in 1994 (in Ci)

Radionuclide	TA-3	TA-15[a]	TA-16	TA-21	TA-33	TA-35
Tritium[b]	5.38×10^{1}		2.46×10^{1}	3.32×10^{2}	4.56×10^{2}	
^{10}C						
^{11}C						
^{13}N						
^{16}N						
^{14}O						
^{15}O						
UBE[c]						
^{41}Ar						
MFP[d]	3.84×10^{-5}			5.00×10^{-8}		
^{234}U		4.0×10^{-3}				
^{235}U	1.34×10^{-4}	1.7×10^{-4}		1.82×10^{-4}		
^{238}U	6.20×10^{-5}	3.7×10^{-3}				
Pu[e]	6.00×10^{-6}			2.40×10^{-6}		3.90×10^{-7}
P/VAP[f]						

Radionuclide	TA-41	TA-43	TA-48	TA-50	TA-53	TA-54	TA-55	Totals
Tritium[b]	1.72×10^{2}				1.46×10^{1}		2.26×10^{1}	1.08×10^{3}
^{10}C					2.12×10^{3}			2.12×10^{3}
^{11}C					1.41×10^{4}			1.41×10^{4}
^{13}N					6.93×10^{3}			6.93×10^{3}
^{16}N					1.80×10^{3}			1.80×10^{3}
^{14}O					7.29×10^{2}			7.29×10^{2}
^{15}O					2.43×10^{4}			2.43×10^{4}
UBE		9.61×10^{-6}						9.61×10^{-6}
^{41}Ar					2.84×10^{2}			2.84×10^{2}
MFP			3.90×10^{-4}	6.79×10^{-6}				4.35×10^{-3}
^{234}U								4.00×10^{-3}
^{235}U			4.00×10^{-7}					4.87×10^{-4}
^{238}U								3.76×10^{-3}
Pu	2.00×10^{-8}		3.22×10^{-6}	3.10×10^{-7}		1.00×10^{-8}	1.20×10^{-7}	1.25×10^{-5}
P/VAP			8.13×10^{-2}		3.14×10^{-1}			3.96×10^{-1}

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

[b]1994 tritium releases reported from TA-16, TA-21, and TA-53 were 51%, 52%, and 100% tritium oxide respectively. All remaining tritium releases were of indeterminate form.

[c]UBE = Unidentified beta emitters.

[d]MFP = mixed fission products.

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

[f]P/VAP = particulate/vapor activation products. These include 13 radionuclides at TA-53 dominated by ^{82}Br, ^{7}Be, ^{54}Mn, and ^{77}Br; and 7 radionuclides at TA-48 dominated by ^{72}As, ^{75}Se, and ^{77}Br. Individual radionuclide totals for 1994 emissions are shown in Table V-5.

Table V-5. Detailed Listing of Activation Products from Laboratory Operations in 1994 (in Ci)

Mixed Activation Products	Radionuclide	Location	
		TA-53	TA-48
Particulate/Vapor (P/VAP)	^{72}As		1.11×10^{-2}
	^{73}As		1.90×10^{-2}
	^{74}As		3.75×10^{-3}
	^{68}Ge		1.70×10^{-3}
	^{7}Be	2.53×10^{-2}	7.67×10^{-6}
	^{77}Br	1.17×10^{-2}	2.37×10^{-2}
	^{75}Se	4.83×10^{-4}	2.21×10^{-2}
	^{82}Br	2.52×10^{-1}	
	^{60}Co	6.28×10^{-5}	
	^{195}Hg	9.69×10^{-4}	
	^{195}Hg	4.02×10^{-3}	
	^{54}Mn	1.83×10^{-2}	
	^{185}Os	2.39×10^{-4}	
	^{44}Sc	1.62×10^{-4}	
	^{48}Sc	6.03×10^{-5}	
	^{182}Ta	1.13×10^{-3}	
	^{48}V	1.94×10^{-4}	
Gaseous Mixed (GMAP)	^{41}Ar	2.84×10^{2}	
	^{10}C	2.12×10^{3}	
	^{11}C	1.41×10^{4}	
	^{83}Kr	1.50×10^{2}	
	^{13}N	6.93×10^{3}	
	^{16}N	1.80×10^{3}	
	^{14}O	7.29×10^{2}	
	^{15}O	2.43×10^{4}	

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 1994, the following emissions were estimated from diffuse sources.

Tritium (as water vapor):	86 Ci
Plutonium:	0.55 µCi
Uranium:	4.3 mCi
Americium-241	0.12 µCi
Mixed fission products:	4.4 nCi
Gaseous mixed activation products:	1,000 Ci
Particulate/vapor activation products:	0.01 µCi

In 1994, 98% of LANL's emissions were gaseous mixed activation products that diffused from several buildings through the Laboratory, primarily from TA-53. Reductions in diffuse emissions from TA-53 were accomplished through the use of engineering controls, including sealing migration pathways throughout the facility. A list of selected nuclides and their half-lives is given in Table D-11.

Radioactive air emissions at the Laboratory are monitored according to DOE/EH-0173T "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991a) and 40 CFR (Code of Federal Regulations) Part 61, Subpart H, "National Emission Standards for Emissions of

Table V-6. Comparison of 1993 and 1994 Release of Radionuclides from Laboratory Operations

Airborne Emissions[a]

Radionuclide	Units	Activity Released 1993	Activity Released 1994	Ratio 1994:1993
Tritium	Ci	2,100	1,100	0.5
Uranium	μCi	270[b]	380[b]	1.4
Plutonium	μCi	6	13	2.2
Gaseous mixed activation products	Ci	32,100	50,200	1.6
Mixed fission products	μCi	1,360	450	0.3
Particulate/vapor activation products	Ci	13	0.4	0.03
Total	Ci	34,200	51,300	

Liquid Effluents

Radionuclide	Units	Activity Released 1993	Activity Released 1994	Ratio 1994:1993
Tritium	mCi	2,660.00	2,230.00	.84
$^{82,85,89,90}Sr$	mCi	7.64	37.00	4.84
^{137}Cs	mCi	8.17	8.5	1.04
^{234}U	mCi	0.12	.12	1
$^{238,239,240}Pu$	mCi	1.08	3.25	3.01
^{241}Am	mCi	11.20	3.06	.273
Total	mCi	2,688.21	2,281.93	

[a]Detailed data are presented in Tables V-4 and V-5 for airborne emissions.
[b]Does not include dynamic testing.

Radionuclides Other than Radon from DOE 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 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. On November 27, 1991, EPA Region 6 issued the DOE a notice of noncompliance (NON) with 40 CFR 61, Subpart H, specifically stating the following:

1. Every release source from an operation that uses radionuclides has not been evaluated using the approved EPA computer model to determine the dose received by the public, as required by 40 CFR 61.93(a).
2. DOE has failed to comply with 40 CFR 61.93(b)(4) because it has not determined each release point that has the potential to deliver more than 1% of the EDE standard.
3. The facility has not installed stack monitoring equipment on all its regulated point sources in accordance with the above analysis and 40 CFR 61.93 (b)(2)(ii) and (iii).
4. The facility has not conducted, and is not in compliance with, the appropriate quality assurance programs pursuant to 40 CFR 61.93 (b)(2)(iv).
5. The facility is in violation of 40 CFR 61.94 "Compliance and Reporting" because it has not calculated the highest EDE in accordance with the regulations cited above.

As a result of the NON, the DOE is negotiating a Federal Facility 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. The FFCA is expected to be signed before the end of 1995.

b. Monitoring Network. The sampling network for ambient airborne radioactivity consists of 52 continuously operating air sampling stations with 3 stations added and 2 stations discontinued in 1994. 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 13 perimeter stations located within 4 km (2.5 mi) of the Laboratory boundary.

Thirty-three on-site stations are within the Laboratory boundary (Figure V-8, Table D-12). Two samplers are collocated or replicate samplers, one at Station #27 at TA-54 and one at Station #26 at TA-49, for quality assurance purposes. 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 1988). The active waste site, TA-54, Area G, is an example of a controlled area.

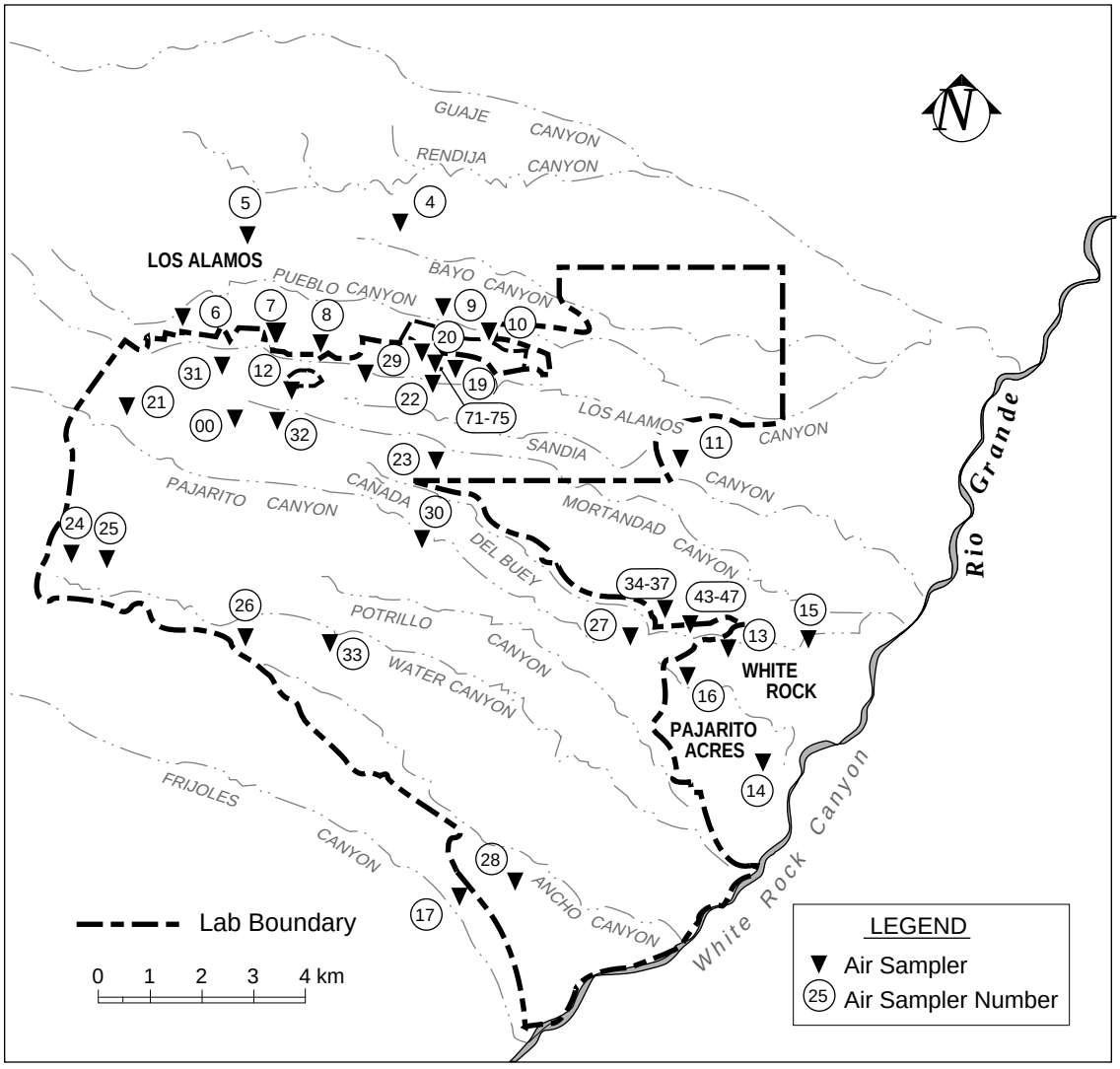


Figure V-8. Approximate locations for off-site perimeter and on-site Laboratory stations for sampling airborne radionuclides. (Does not show Regional Stations; see Table D-12 for specific locations.)

History of Changes in Sampling Stations. In addition to Station #27, which is part of the routine air sampling network, four site-specific stations were located at the active radioactive waste disposal site at TA-54, Area G in October 1984. In August 1992, five stations for sampling ^{131}I in air were added to the air monitoring network, with an additional station being added in January 1993. These ^{131}I stations are collocated with other stations. 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 (ER) Project. 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). Also 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 1994, three stations were installed to monitor potential emissions from the PHERMEX and R-306 firing sites. The station located on the roof of the TA-59 Occupational Health Laboratory was discontinued in 1994, and at the request of residents of the area, Station #14, Pajarito Acres, was discontinued in 1994. Station #1, Española, was moved to an alternate location in the City of Española during 1994 because of a change in property ownership.

c. Analytical Results.

Gross Alpha and Beta Radioactivity. Gross alpha and beta analyses are used in evaluating general radiological air quality and identifying potential trends in the data. 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-9, which plots the results from one regional and one perimeter station. The National Council on Radiation Protection and Measurements (NCRP) estimated average concentration of long-lived gross alpha activity in air to be 2.0×10^{-15} µCi/mL (74 µBq/m^3). The primary alpha activity is due to polonium-210 (a decay product of radon gas) and other naturally occurring radionuclides (NCRP 1987a). The NCRP also estimated average concentration levels of long-lived gross beta activity in air to be 20.0×10^{-15} µCi/mL

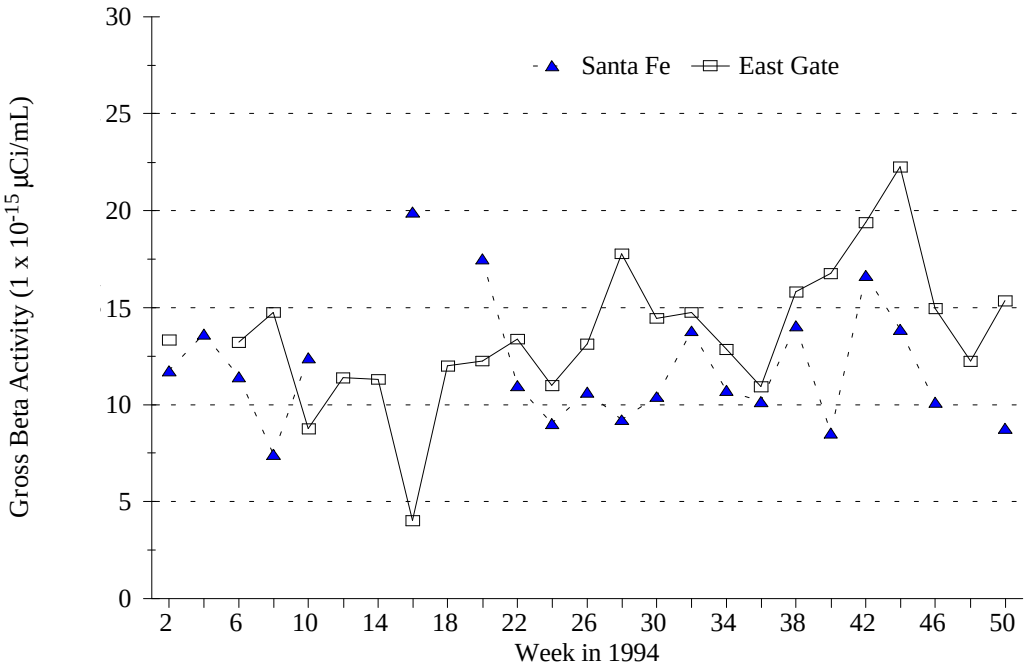


Figure V-9. Gross beta activity in air at one regional and one perimeter location.

(740 μBq/m^3). This activity is primarily due to the presence of ^{210}Pb and ^{210}Bi (decay products of radon), and other naturally occurring radionuclides. There were more than 1,000 air samples collected in 1994 and analyzed for gross alpha and gross beta activity (Table V-7 and Table V-8 respectively). No unusual above-background average annual results were observed in 1994.

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 cosmogenic process (Kathren 1984). Sampling results are presented in Table V-9. About 5% of the off-site samples were above the upper limit background (ULB) or the regional samplers' mean plus two standard deviations value of 9.7 x 10^{-12} mCi/mL (0.36 Bq/m^3). The maximum off-site concentration was recorded at Station #16, the Nazarene Church. The calculated tritium dose based on local mean air concentration at Station #16 was 0.19% of the EPA's public dose limit (PDL) of 10 mrem (0.1 mSv) per year. Elevated concentrations were observed by Station #35, G-2, at the TA-54, Area G waste site near shafts where tritium-contaminated waste is disposed. However, the maximum concentration observed at Station G-2 is less than 0.001% of the DOE DAC for controlled areas. All annual mean concentrations were well below the applicable EPA and DOE guidelines.

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). Sampling results for ^{238}Pu are presented in Table V-10. Although 1% of the off-site sample results above the ULB value of 8.5 x 10^{-18} μCi/mL (0.31 μBq/m^3) were recorded in 1994, none of the annual means for on-site or off-site exceeded the UBL. Sampling results for ^{239,240}Pu are presented in Table V-11. About 3% of the off-site sample results were above the ULB value of 10.6 x 10^{-18} μCi/mL (0.392 μBq/m^3). The maximum on-site value of ^{239,240}Pu was recorded during the second quarter at Station #36, G-3, TA-54, Area G, and is less than 0.02% of the DOE DAC for controlled areas. All annual mean concentrations were well below the applicable EPA and DOE guidelines.

Americium. Since americium often occurs along with plutonium, a subset of plutonium samples is also submitted for this analysis; results are presented in Table V-12. Seven percent of the off-site sampling results were above the ULB value of 10.0 x 10^{-18} μCi/mL (0.37 μBq/m^3). The highest off-site concentrations occurred at Station #10, East Gate, and Station #16, Nazarene Church. The ^{241}Am doses at Stations #10 and #16 were 0.37% and 0.32%, respectively, of the EPA's PDL of 10 mrem (0.1 mSv)/year. All other annual mean concentrations were also well below the applicable EPA and DOE guidelines.

Uranium. Uranium is released from the Laboratory in mCi (μBq) amounts and is naturally occurring in rocks and soil; please refer to a general discussion regarding uranium in the environment in a previous annual report (EARE 1995b). Tables V-13 to V-15 present radioisotopic results for ^{234}U, ^{235}U, and ^{238}U respectively. About 6% of the off-site samples for ^{234}U were greater than the ULB value of 37.5 x 10^{-18} μCi/mL (1.39 μBq/m^3). The maximum off-site value was recorded at Station #15; White Rock Fire Station. The ^{234}U dose at Station #15 was 0.16% of the EPA's Public Dose Limit (PDL). About 4% of the off-site samples for ^{235}U exceeded the ULB value of 3.8 x 10^{-18} μCi/mL (0.14 μBq/m^3). The maximum off-site value was also recorded at Station #15; the corresponding ^{235}U dose was 0.065% of the EPA's PDL. The elevated reading for Station #42, Taos Pueblo, is unexplained at this time. Seven percent of the off-site sampling results for ^{238}U were above the ULB value of 39.2 x 10^{-18} μCi/mL (1.45 μBq/m^3). The highest off-site values were observed in the White Rock townsite. Stations #13, #15, and #16 had ^{238}U doses rates that are respectively 0.021%, 0.020%, and 0.019% of the EPA's PDL. All annual mean concentrations were well below the applicable EPA and DOE guidelines. 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 reports.

In addition to 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 111 kg (246 lb) of depleted uranium containing about 0.08 Ci (3 Gbq) of radioactivity was used in such experiments in 1994 (Table V-17). Most of the debris from these experiments was deposited on the ground in the vicinity of the firing sites. Limited experimental data show that no more than about 10% of the uranium becomes airborne in a high-explosive test (Dahl 1977). Dispersion calculations indicate that resulting maximum airborne concentrations would be greater than concentrations attributable to the natural abundance of uranium that is resuspended in dust particles; however, the predicted values were not detected at on-site stations or off-site stations. The actual amount released is likely to be smaller than the values given in Table V-17. Additional air sampling conducted near the active firing sites supports this conclusion.

Table V-7. Airborne Long-Lived Gross Alpha Concentrations for 1994

1 fCi/m^3 = 1 x 10^{-15} μCi/mL = 3.7 x 10^{-5} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s
Regional Stations							
1 Española	33,800	15	0	4.8	2.2	3.4	1.7
2 Pojoaque	57,100	42	1	4.4	0.2	2.7	1.9
3 Santa Fe	57,700	23	2	4.9	0.0	2.4	2.6
Group Summary		62	3	4.9	0.0	2.8	2.3
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	24	0	5.6	0.8	2.8	2.1
42 Taos Pueblo	6,900	3	1	6.1	-0.0	2.9	6.2
48 Jemez Pueblo	29,900	7	0	2.2	0.6	1.7	1.4
Group Summary		34	1	6.1	-0.0	2.6	2.6
Perimeter Stations							
4 Barranca School	59,700	25	0	4.8	0.8	3.0	2.2
5 Urban Park	53,800	22	1	4.6	0.2	2.4	1.8
6 48th Street	58,600	25	0	5.2	0.4	3.0	2.5
7 Los Alamos Shell	54,100	23	0	5.1	0.9	3.1	2.4
8 McDonald's	60,300	25	0	5.5	1.8	3.4	2.0
9 Los Alamos Airport	61,500	25	0	5.5	0.6	3.2	2.3
10 East Gate	59,500	25	1	4.7	0.0	3.0	2.0
11 Well PM-1	58,700	25	0	5.6	1.4	3.6	2.0
12 Royal Crest	57,800	25	0	5.6	1.6	3.4	2.2
13 Piñon School	56,900	23	0	5.0	1.1	3.1	2.2
15 White Rock Fire Station	60,200	25	0	5.3	1.8	3.3	1.8
16 Nazarene Church	56,700	25	0	7.5	0.7	3.2	2.9
17 Bandelier	49,200	23	0	5.7	1.6	3.5	1.9
Group Summary		316	2	7.5	0.0	3.2	2.2
On-Site Stations							
19 TA-21, DP Site	54,100	24	0	7.0	1.4	3.3	2.6
20 TA-21, Area B	56,000	22	0	5.1	0.4	3.2	2.5
21 TA-6	61,000	25	1	4.2	0.0	2.3	2.3
22 TA-53, LAMPF	55,300	24	0	7.2	1.2	3.6	2.6
23 TA-52, Beta	60,600	25	0	4.7	1.3	3.2	1.8
25 TA-16-450	56,900	24	2	8.8	-0.0	2.9	3.7
26 TA-49	56,900	25	2	8.8	-0.0	2.9	3.7
27 TA-54, Area G	59,000	19	2	5.2	0.1	2.8	2.6
28 TA-33 HP Site	48,900	18	2	8.3	0.0	2.3	3.7
29 TA-2, Omega	42,000	22	0	6.7	0.6	3.3	3.0
30 Booster P-2	55,000	25	0	5.9	1.6	3.1	2.3
31 TA-3	62,200	16	0	8.4	1.9	3.4	2.6
32 County Landfill	36,700	25	0	5.2	2.2	3.5	1.8
33 Area AB	60,100	13	0	3.7	0.6	2.0	1.7
Group Summary		307	9	8.8	-0.0	3.0	2.6

Table V-7. Airborne Long-Lived Gross Alpha Concentrations for 1994 (Cont.)

1 fCi/m3 = 1 x 10^{-15} µCi/mL = 3.7 x 10^{-5} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s
Area G Fenceline							
34 Area G-1	58,900	23	2	5.3	0.0	2.7	2.9
35 Area G-2	58,700	24	2	4.6	0.1	2.7	2.2
36 Area G-3	51,800	21	4	4.5	0.0	2.2	2.9
37 Area G-4	56,100	21	3	9.5	-0.0	2.7	4.1
Group Summary		89	11	9.5	-0.0	2.6	3.1
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	10	0	10.7	0.5	3.3	5.9
44 Area G (S Perimeter)	60,000	25	1	9.5	0.4	2.9	3.7
45 Area G (SE Perimeter)	59,700	25	1	9.5	0.2	3.0	3.8
46 Area G (E Perimeter)	60,000	25	0	9.5	0.6	3.3	3.3
47 Area G (N Perimeter)	59,600	25	1	10.5	0.3	3.4	4.5
Group Summary		110	3	10.7	0.2	1.6	4.0
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	25	0	5.5	0.8	3.4	2.3
72 TA-21.02	58,500	25	0	6.1	1.5	3.9	2.0
73 TA-21.03	58,400	25	0	8.8	1.4	3.8	3.0
74 TA-21.04	58,600	25	1	8.4	0.0	3.3	3.5
75 TA-21.05	56,500	24	1	5.2	0.0	3.0	2.5
Group Summary		124	2	8.8	0.0	2.3	2.7
TA-15 Firing Sites							
76 TA-15-NNW	51,500	19	0	8.5	1.6	4.0	2.4
77 TA-15-NNE	43,100	16	2	8.4	-0.0	3.1	3.9
78 TA-15-N	40,700	15	2	10.4	-0.0	4.2	6.3
Group Summary		50	4	10.4	-0.0	3.8	5.0

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	20,000
Uncontrolled Area DOE Derived Air Concentration guide	2,000
LANL Minimum Detection Limit	0.4

The concentration guide for Plutonium-239 is used for gross alpha*.
Concentration guides are for above-background values.

Table V-8. Airborne Long-Lived Gross Beta Concentrations for 1994

1 fCi/m^3 = 1 x 10^{-15} μCi/mL = 3.7 x 10^{-5} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s
Regional Stations							
1 Española	33,800	15	0	18.8	8.7	12.2	4.6
2 Pojoaque	57,100	24	1	18.2	1.2	11.9	7.7
3 Santa Fe	57,700	23	2	19.9	0.1	10.9	9.1
Group Summary		62	3	19.9	0.1	11.6	7.6
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	24	0	35.5	2.7	14.0	12.5
42 Taos Pueblo	6,900	3	1	14.0	0.2	9.0	15.3
48 Jemez Pueblo	29,900	7	0	25.4	3.2	13.6	15.7
Group Summary		34	1	35.5	0.2	13.4	13.3
Perimeter Stations							
4 Barranca School	59,700	25	0	19.0	3.5	12.3	7.3
5 Urban Park	53,800	22	0	16.8	1.6	10.0	7.3
6 48th Street	58,600	25	0	22.7	2.7	11.8	8.2
7 Los Alamos Shell	54,100	23	0	20.9	4.7	11.9	6.1
8 McDonald's	60,300	25	0	20.9	9.3	13.6	6.1
9 Los Alamos Airport	61,500	25	0	20.5	2.2	12.8	8.0
10 East Gate	59,500	25	1	22.3	0.0	13.0	8.9
11 Well PM-1	58,700	25	0	20.0	6.6	13.9	6.1
12 Royal Crest	57,800	25	0	21.5	5.8	13.6	6.3
13 Piñon School	56,900	23	0	16.5	3.6	11.7	6.0
15 White Rock Fire Sta.	60,200	25	0	18.8	9.4	12.9	5.1
16 Nazarene Church	56,700	25	0	19.6	4.2	12.5	7.4
17 Bandelier	49,200	23	0	20.8	8.8	13.8	5.4
Group Summary		316	1	22.7	0.0	12.6	6.9
On-Site Stations							
19 TA-21, DP Site	52,300	24	0	28.9	7.4	12.6	8.7
20 TA-21, Area B	51,400	22	0	21.1	1.1	12.7	9.1
21 TA-6	61,000	25	1	16.2	0.0	10.1	8.0
22 TA-53, LAMPF	55,300	24	0	31.7	4.5	14.3	9.8
23 TA-52, Beta	60,600	25	0	18.5	8.4	12.5	5.0
25 TA-16-450	56,900	24	2	34.6	0.0	11.6	13.2
26 TA-49	59,000	25	2	20.1	-0.1	11.4	9.6
27 TA-54, Area G	48,900	19	1	25.3	1.2	12.4	10.8
28 TA-33, HP Site	42,000	18	0	19.5	2.0	12.9	7.5
29 TA-2, Omega	55,000	22	0	22.5	8.5	12.7	6.5
30 Booster P-2	62,200	25	1	30.6	6.2	13.6	9.1
31 TA-3	36,700	16	0	15.5	9.2	11.9	3.4
32 County Landfill	60,100	25	0	16.1	4.4	10.7	5.3
33 Area AB	49,000	13	0	34.6	7.4	15.2	14.1
Group Summary		307	7	34.6	-0.1	12.4	9.1

Table V-8. Airborne Long-Lived Gross Beta Concentrations for 1994 (Cont.)

1 fCi/m^3 = 1 x 10^{-15} μCi/mL = 3.7 x 10^{-5} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s
Area G Fenceline							
34 Area G-1	56,300	23	2	21.2	0.0	11.6	11.6
35 Area G-2	56,100	24	1	18.1	0.6	11.6	7.0
36 Area G-3	49,200	21	2	18.4	0.4	10.5	9.5
37 Area G-4	51,300	21	2	22.5	0.0	11.5	10.6
Group Summary		89	7	22.5	0.0	11.3	9.7
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	10	0	37.0	2.0	12.6	19.5
44 Area G (S Perimeter)	60,000	25	1	19.6	0.9	11.0	8.0
45 Area G (SE Perimeter)	59,700	25	1	19.6	1.0	12.2	9.0
46 Area G (E Perimeter)	60,000	25	2	18.2	-0.1	12.3	8.8
47 Area G (N Perimeter)	59,600	25	1	34.9	0.8	13.3	11.3
Group Summary		110	5	37.0	-0.1	12.2	10.5
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	25	0	19.2	3.9	12.4	6.8
72 TA-21.02	58,500	25	0	19.0	9.9	13.7	4.8
73 TA-21.03	58,400	25	0	28.0	7.6	14.1	8.4
74 TA-21.04	58,600	25	2	31.7	-0.3	12.5	11.2
75 TA-21.05	56,500	24	1	16.3	-0.2	11.9	7.6
Group Summary		124	3	31.7	-0.3	12.9	8.0
TA-15 Firing Sites							
76 TA-15-NNW	51,500	19	0	36.0	11.0	16.2	13.5
77 TA-15-NNE	43,100	16	1	27.4	-0.2	14.1	11.9
78 TA-15-N	40,700	15	1	37.4	0.0	19.1	19.4
Group Summary		50	2	37.4	-0.2	16.4	15.3

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	2,000,000
Uncontrolled Area DOE Derived Air Concentration guide	9,000
LANL Minimum Detection Limit	0.4

The concentration guide for Plutonium-239 is used for gross alpha*.
Concentration guides are for above-background values.

Table V-9. Airborne Tritium as Tritiated Water Concentrations for 1994

1 pCi/m^3 = 1 x 10^{-12} μCi/mL = 3.7 x 10^{-2} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (PCi/m^3)	Minimum (pCi/m^3)	Mean (PCi/m^3)	2s
Regional Stations							
1 Española	60	15	14	19.3	-0.5	1.7	9.8
2 Pojoaque	105	24	21	20.1	-1.0	1.3	8.5
3 Santa Fe	97	22	21	18.4	-0.5	1.1	7.8
Group Summary		61	56	20.1	-1.0	1.3	8.5
Pueblo Stations							
41 Pueblo of San Ildefonso	92	24	22	23.8	-0.9	1.5	9.6
42 Taos Pueblo	24	1	1	0.1	0.1	0.1	0.1
48 Jemez Pueblo	57	7	5	2.6	-0.4	0.6	2.5
Group Summary		32	28	23.8	-0.9	1.3	8.4
Perimeter Stations							
4 Barranca School	105	25	22	33.3	-0.6	1.9	13.2
5 Urban Park	91	21	18	6.3	-0.9	0.9	3.0
6 48th Street	99	24	19	35.8	-0.2	2.3	14.4
7 Los Alamos Shell	96	23	21	20.0	-0.3	1.5	8.1
8 McDonald's	102	24	15	32.3	0.0	3.2	13.1
9 Los Alamos Airport	101	23	19	16.8	-0.4	2.2	9.0
10 East Gate	105	25	19	15.0	0.0	2.1	6.8
11 Well PM-1	100	24	20	35.5	-2.5	2.4	14.3
12 Royal Crest	94	23	19	11.2	-0.1	1.5	5.1
13 Piñon School	89	20	15	25.3	-0.4	2.6	11.6
15 White Rock Fire Station	103	24	22	15.7	-0.2	1.4	6.2
16 Nazarene Church	94	23	16	36.2	-0.4	3.0	14.8
17 Bandelier	84	23	22	16.2	-0.9	1.4	6.6
Group Summary		302	247	36.2	-2.5	2.0	10.4
On-Site Stations							
19 TA-21, DP Site	95	25	7	42.1	-0.2	6.0	20.1
20 TA-21, Area B	99	24	16	14.5	-0.5	2.0	5.9
21 TA-6	108	25	23	25.7	-0.5	1.5	10.2
22 TA-53, LAMPF	93	23	17	15.5	-0.2	1.9	6.5
23 TA-52, Beta	103	24	19	6.9	0.2	1.5	2.9
25 TA-16-450	96	23	11	120.0	0.1	9.1	50.5
26 TA-49	104	25	20	19.4	-0.6	1.8	8.3
27 TA-54, Area G	95	22	7	26.4	0.3	9.7	17.2
28 TA-33, HP Site	85	20	14	7.0	0.2	1.8	3.5
29 TA-2, Omega	76	17	6	25.4	0.0	4.2	11.8
30 Booster P-2	96	22	20	41.6	-0.2	2.7	17.5
31 TA-3	61	15	11	9.1	-0.1	2.0	4.8
32 TA-48	102	24	20	11.6	-0.5	1.4	4.7
33 Area AB	90	14	13	6.7	0.0	1.1	3.3
Group Summary		303	204	120.0	-0.6	3.4	18.0

Table V-9. Airborne Tritium as Tritiated Water Concentrations for 1994 (Cont.)

1 pCi/m^3 = 1 x 10^{-12} μCi/mL = 3.7 x 10^{-2} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	2s
Area G Fenceline							
34 Area G-1	108	25	6	73.7	0.6	13.9	35.4
35 Area G-2	103	24	2	1140.0	0.6	250.0	650.0
36 Area G-3	100	24	16	420.0	-1.4	19.5	170.0
37 Area G-4	99	23	10	46.9	0.1	5.1	19.3
Group Summary		96	34	1140.0	-1.4	72.0	390.0
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	41	10	6	6.4	0.5	2.3	3.6
44 Area G (S Perimeter)	100	24	10	25.7	0.0	5.9	13.4
45 Area G (SE Perimeter)	101	24	9	28.4	0.0	4.4	12.1
46 Area G (E Perimeter)	106	25	7	31.0	0.4	8.2	15.5
47 Area G (N Perimeter)	105	25	4	45.6	0.7	11.7	23.3
Group Summary		108	36	45.6	0.0	7.1	16.9
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	99	24	18	21.6	0.0	2.9	10.4
72 TA-21.02	103	25	17	15.4	0.2	2.7	7.1
73 TA-21.03	103	25	14	13.5	-1.7	3.1	6.5
74 TA-21.04	100	24	14	10.2	0.3	2.8	5.8
75 TA-21.05	104	25	16	31.3	-0.1	4.3	13.6
Group Summary		123	79	31.3	-1.7	3.1	9.1
TA-15 Firing Sites							
76 TA-15-NNW	87	17	12	13.9	-0.2	2.3	7.6
77 TA-15-NNE	80	15	12	8.0	0.0	1.3	4.0
78 TA-15-N	68	14	12	8.6	0.2	1.6	5.5
Group Summary		46	36	13.9	-0.2	1.8	5.9

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	20,000,000
Uncontrolled Area DOE Derived Air Concentration guide	100,000
EPA 40 CFR 61 Concentration guide	1,500
LANL Minimum Detection Limit	2

Table V-10. Airborne Plutonium-238 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	2	6.1	-2.3	1.7	8.4
2 Pojoaque	59,200	4	3	3.3	1.0	1.9	2.0
3 Santa Fe	57,700	4	2	8.8	0.3	3.4	8.0
Group Summary		11	7	8.8	-2.3	2.4	6.1
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	4	2.2	0.1	1.2	1.8
42 Taos Pueblo	20,600	2	2	2.6	-0.1	1.2	3.9
48 Jemez Pueblo	32,500	3	3	0.9	-1.2	-0.1	2.1
Group Summary		9	9	2.6	-1.2	0.8	2.4
Perimeter Stations							
4 Barranca School	59,700	4	3	3.2	-1.0	1.4	3.7
5 Urban Park	53,800	4	3	3.1	-0.4	0.9	3.0
6 48th Street	58,600	4	4	0.9	-0.8	-0.0	1.6
7 Los Alamos Shell	54,100	3	2	3.5	-1.9	0.5	5.5
8 McDonald's	60,300	4	4	2.5	-4.5	-1.2	5.7
9 Los Alamos Airport	61,500	4	3	4.6	1.4	2.3	3.1
10 East Gate	59,500	4	2	5.9	0.1	2.5	5.1
11 Well PM-1	58,700	4	4	1.8	-0.5	0.8	1.9
12 Royal Crest	57,800	4	4	-0.1	-2.4	-1.0	2.3
13 Pinon School	56,900	4	4	0.0	-1.8	-0.7	1.5
15 White Rock Fire Station	60,200	4	4	1.9	-0.6	0.4	2.2
16 Nazarene Church	56,700	4	4	2.4	-1.1	0.3	3.0
Group Summary		51	44	5.9	-4.5	0.6	4.0
On-Site Stations							
19 TA-21, DP Site	54,100	4	3	3.1	-0.4	1.6	3.5
20 TA-21, Area B	56,000	4	3	4.7	-1.0	1.5	4.8
21 TA-6	61,000	4	4	-0.1	-0.8	-0.4	0.6
22 TA-53, LAMPF	55,300	4	3	4.0	-0.9	1.0	4.3
23 TA-52, Beta	60,600	4	4	1.1	-0.4	0.4	1.6
25 TA-16-450	56,900	4	4	1.0	-3.6	-0.9	4.0
26 TA-49	59,000	4	3	3.1	0.1	1.6	2.6
27 TA-54, Area G	53,900	4	3	4.1	0.4	2.5	3.1
28 TA-33, HP Site	48,000	4	3	3.1	-2.1	0.2	4.4
29 TA-2, Omega	56,800	4	4	1.3	-0.9	0.2	1.8
30 Booster P-2	62,200	4	4	2.0	-1.2	0.4	3.4
31 TA-3	36,700	3	3	1.4	-0.6	0.3	2.0
32 County Landfill	60,100	4	3	3.7	0.1	1.6	3.0
33 Area AB	51,100	4	4	1.8	-1.1	0.0	2.5
Group Summary		55	48	4.7	-3.6	0.7	3.3

Table V-10. Airborne Plutonium-238 Concentrations for 1994 (Cont.)

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34Area G-1	61,300	4	3	8.7	0.0	3.1	7.7
35 Area G-2	58,700	4	4	2.9	-1.2	0.5	3.5
36 Area G-3	56,400	4	2	9.2	0.3	4.4	8.6
37 Area G-4	44,400	3	3	1.5	0.2	0.9	1.3
Group Summary		15	12	9.2	-1.2	2.3	6.5
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	1	3.9	-0.3	1.8	6.0
44 Area G (S Perimeter)	60,000	4	3	3.1	0.2	1.2	2.7
45 Area G (SE Perimeter)	59,700	4	4	0.8	-1.2	-0.2	1.8
46 Area G (E Perimeter)	60,000	4	1	6.0	3.4	4.8	2.3
47 Area G (N Perimeter)	59,600	4	3	7.5	0.6	2.7	6.4
Group Summary		18	12	7.5	-1.2	2.1	5.0
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	4	1.5	-0.2	0.5	1.5
72 TA-21.02	58,500	4	4	0.4	-2.6	-0.8	2.5
73 TA-21.03	58,400	4	1	8.2	1.1	4.4	6.0
74 TA-21.04	58,600	4	3	5.5	0.1	1.9	5.0
75 TA-21.05	58,700	4	4	3.0	-2.2	0.7	4.6
Group Summary		20	16	8.2	-2.6	1.3	5.2
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	3	4.2	-0.7	1.0	4.4
77 TA-15-NNE	43,100	4	2	8.4	-0.4	3.9	8.5
78 TA-15-N	40,700	4	3	4.1	-7.8	-0.3	10.4
Group Summary		12	8	8.4	-7.8	1.5	8.2

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	3,000,000
Uncontrolled Area DOE Derived Air Concentration guide	30,000
EPA 40 CFR 61 Concentration guide	2,100
LANL Minimum Detection Limit	4

Table V-11. Airborne Plutonium-239,240 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL= 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	1	10.9	0.7	5.2	10.4
2 Pojoaque	59,200	4	2	5.4	1.5	3.1	3.6
3 Santa Fe	57,700	4	3	9.3	2.1	4.3	6.8
Group Summary		11	6	10.9	0.7	4.1	6.5
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	2	5.2	-0.1	2.1	5.1
42 Taos Pueblo	20,600	2	1	5.0	0.0	2.5	7.0
48 Jemez Pueblo	32,500	3	2	3.7	-2.4	0.6	6.1
Group Summary		9	5	5.2	-2.4	1.7	5.3
Perimeter Stations							
4 Barranca School	59,700	4	4	2.6	1.8	2.3	0.8
5 Urban Park	53,800	4	4	1.5	-0.7	0.7	2.0
6 48th Street	58,600	4	3	3.2	0.9	2.0	2.3
7 Los Alamos Shell	54,100	3	3	2.6	0.4	1.9	2.5
8 McDonald's	60,300	4	3	10.2	0.5	3.3	9.3
9 Los Alamos Airport	61,500	4	2	4.6	0.1	2.5	4.4
10 East Gate	59,500	4	3	4.1	-0.3	1.4	3.9
11 Well PM-1	58,700	4	4	1.7	-0.3	0.9	1.9
12 Royal Crest	57,800	4	4	2.7	-0.7	0.9	3.0
13 Piñon School	56,900	4	4	1.9	-0.7	0.6	2.9
15 White Rock Fire Station	60,200	4	3	7.1	-0.9	2.1	7.0
16 Nazarene Church	56,700	4	3	4.3	-0.3	1.1	4.3
17 Bandelier	50,100	4	3	4.1	-1.9	1.0	5.0
Group Summary		51	43	10.2	-1.9	1.6	4.0
On-Site Stations							
19 TA-21, DP Site	54,100	4	2	4.5	0.0	2.6	3.9
20 TA-21, Area B	56,000	4	1	8.5	0.3	3.8	6.9
21 TA-6	61,000	4	4	2.5	-2.4	0.8	4.5
22 TA-53, LAMPF	55,300	4	3	3.2	-0.4	1.5	3.4
23 TA-52, Beta	60,600	4	4	2.8	-0.6	0.8	3.0
25 TA-16-450	56,900	4	4	1.0	-1.9	0.0	2.6
26 TA-49	59,000	4	2	5.1	0.5	2.7	4.0
27 TA-54, Area G	53,900	4	1	8.5	-0.7	5.7	8.5
28 TA-33, HP Site	48,000	4	3	4.1	-3.7	0.3	6.4
29 TA-2, Omega	56,800	4	2	5.9	0.5	2.9	4.5
30 Booster P-2	62,200	4	2	6.8	1.2	3.8	4.9
31 TA-3	36,700	3	2	5.9	0.9	2.9	5.4
32 County Landfill	60,100	4	3	7.7	1.4	3.4	5.8
33 Area AB	51,100	4	3	4.1	-0.4	0.9	4.3
Group Summary		55	36	8.5	-3.7	2.3	5.5

Table V-11. Airborne Plutonium-239,240 Concentrations for 1994 (Cont.)

1 aCi/m^3 = 1 x 10^{-18} µCi/mL= 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34 Area G-1	61,300	4	1	6.6	1.1	3.7	4.5
35 Area G-2	58,700	4	2	7.8	1.3	3.8	5.7
36 Area G-3	56,400	4	2	33.2	1.1	10.1	30.9
37 Area G-4	44,400	3	3	2.5	0.5	1.8	2.2
Group Summary		15	8	33.2	0.5	5.0	16.1
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	1	6.5	0.9	3.7	8.0
44 Area G (S Perimeter)	60,000	4	1	5.4	0.6	3.6	4.5
45 Area G (SE Perimeter)	59,700	4	2	5.1	1.0	3.0	4.4
46 Area G (E Perimeter)	60,000	4	2	12.1	0.2	4.6	10.6
47 Area G (N Perimeter)	59,600	4	2	6.3	1.9	3.4	4.1
Group Summary		18	8	12.1	0.2	3.6	5.9
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	1	9.0	0.6	4.4	7.0
72 TA-21.02	58,500	4	1	8.1	0.1	5.2	7.2
73 TA-21.03	58,400	4	2	10.0	2.6	5.3	6.8
74 TA-21.04	58,600	4	1	17.1	3.0	9.3	12.0
75 TA-21.05	58,700	4	1	15.0	2.5	6.8	11.2
Group Summary		20	6	17.1	0.1	6.2	8.9
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	4	0.7	-2.2	-0.6	2.5
77 TA-15-NNE	45,200	4	2	28.1	-0.3	7.8	27.2
78 TA-15-N	40,700	4	3	3.9	-4.1	0.7	6.8
Group Summary		12	9	28.1	-4.1	2.6	16.6

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	2,000,000
Uncontrolled Area DOE Derived Air Concentration guide	20,000
EPA 40 CFR 61 Concentration guide	2,000
LANL Minimum Detection Limit	3

Table V-12. Airborne Americium-241 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
3 Santa Fe	57,700	4	1	6.6	1.1	4.9	5.1
Perimeter Stations							
9 Los Alamos Airport	61,500	4	0	9.9	3.4	5.8	5.7
10 East Gate	59,500	4	1	13.5	1.8	7.1	10.3
12 Royal Crest	57,800	4	0	7.8	2.6	4.5	4.6
13 Piñon School	56,900	4	0	7.1	2.7	4.0	4.2
15 White Rock Fire Station	60,200	4	0	7.0	2.1	5.2	4.5
16 Nazarene Church	56,700	4	1	13.5	1.9	6.1	10.5
Group Summary		24	2	13.5	1.8	5.4	6.7
On-Site Stations							
19 TA-21, DP Site	54,100	4	0	12.1	2.3	7.3	9.9
20 TA-21, Area B	56,000	4	1	10.1	1.6	6.1	7.5
21 TA-6	61,000	4	1	6.6	1.6	4.1	4.6
22 TA-53, LAMPF	55,300	4	2	7.2	1.8	3.9	5.2
26 TA-49	59,000	4	2	12.3	0.7	4.6	10.7
27 TA-54, Area G	53,900	4	0	14.0	5.1	11.4	8.4
30 Booster P-2	62,200	4	1	4.1	1.9	3.0	1.9
31 TA-3	36,700	3	0	9.8	3.3	5.8	7.0
Group Summary		23	6	14.0	0.7	5.5	8.4
Area G Fenceline							
34 Area G-1	61,300	4	0	8.6	2.9	5.2	5.1
35 Area G-2	58,700	4	1	9.7	1.3	6.6	7.3
36 Area G-3	56,400	4	0	9.4	4.0	6.0	4.8
37 Area G-4	44,400	3	0	8.1	4.1	5.5	4.5
Group Summary		15	1	9.7	1.3	5.8	5.1
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	0	7.9	3.2	5.5	6.7
44 Area G (S Perimeter)	60,000	4	0	8.7	2.9	5.3	5.0
45 Area G (SE Perimeter)	59,700	4	0	10.9	2.2	6.2	7.2
46 Area G (E Perimeter)	60,000	4	1	7.4	1.5	5.6	5.5
47 Area G (N Perimeter)	59,600	4	1	10.2	0.3	5.4	8.3
Group Summary		18	2	10.9	0.3	5.6	5.8
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	3	0	7.5	5.0	6.7	2.9
72 TA-21.02	58,500	3	0	3.4	2.8	3.2	0.5
73 TA-21.03	58,400	3	0	13.9	3.2	8.0	10.8
74 TA-21.04	58,600	3	0	8.1	3.0	5.8	5.2
75 TA-21.05	58,700	3	0	5.2	3.4	4.6	2.0
Group Summary		15	0	13.9	2.8	5.6	5.8

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	2,000,000
Uncontrolled Area DOE Derived Air Concentration guide	20,000
EPA 40 CFR 61 Concentration guide	1,900
LANL Minimum Detection Limit	4

Table V-13. Airborne Uranium-234 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	0	9.9	5.9	8.4	4.4
2 Pojoaque	59,400	4	0	33.8	5.7	21.4	28.1
3 Santa Fe	57,700	4	0	26.9	8.7	18.2	15.3
Group Summary		11	0	33.8	5.7	16.7	20.8
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	0	48.2	16.5	26.4	29.7
42 Taos Pueblo	20,600	2	1	39.4	0.6	20.0	54.9
48 Jemez Pueblo	32,500	3	0	25.4	14.4	20.9	11.6
Group Summary		9	1	48.2	0.6	23.2	27.9
Perimeter Stations							
4 Barranca School	59,700	4	1	14.5	2.7	6.3	11.0
5 Urban Park	53,800	4	1	13.6	-0.2	6.1	12.0
6 48th Street	58,600	4	1	10.3	2.0	5.8	7.4
7 Los Alamos Shell	54,100	3	0	14.7	7.5	12.0	7.9
8 McDonald's	60,300	4	2	7.4	1.2	4.3	6.2
9 Los Alamos Airport	61,500	4	0	30.4	3.1	11.5	25.7
10 East Gate	59,500	4	0	23.1	5.7	12.1	15.2
11 Well PM-1	58,700	4	0	8.8	3.1	5.2	5.0
12 Royal Crest	57,800	4	1	6.5	3.1	4.6	3.1
13 Piñon School	56,900	4	0	21.5	4.2	9.3	16.4
15 White Rock Fire Station	60,200	4	0	97.8	4.2	28.8	92.1
16 Nazarene Church	56,700	4	1	18.6	0.9	7.1	15.8
17 Bandelier	50,100	4	2	44.1	1.7	14.2	40.2
Group Summary		51	9	97.8	-0.2	9.7	29.7
On-Site Stations							
19 TA-21, DP Site	54,100	4	1	13.6	3.2	6.2	9.9
20 TA-21, Area B	56,000	4	2	5.8	1.3	3.6	4.1
21 TA-6	61,000	4	0	34.7	3.3	12.4	29.8
22 TA-53, LAMPF	55,300	4	0	9.4	4.4	7.1	5.0
23 TA-52, Beta	60,600	4	2	12.8	1.3	5.7	11.1
25 TA-16-450	56,900	4	1	19.9	2.7	10.3	14.2
26 TA-49	59,000	4	2	8.8	1.4	4.0	6.6
27 TA-54, Area G	53,900	4	0	51.1	20.3	39.0	27.3
28 TA-33, HP Site	48,000	4	2	10.2	1.5	5.5	8.7
29 TA-2, Omega	56,800	4	0	10.1	3.5	7.3	5.7
30 Booster P-2	62,200	4	1	22.1	1.4	8.8	18.4
31 TA-3	36,700	3	0	20.5	5.6	12.7	15.0
32 County Landfill	60,100	4	0	24.4	14.9	20.8	8.2
33 Area AB	51,100	4	1	20.5	1.5	10.5	18.4
Group Summary		55	12	51.1	1.3	11.0	22.0

Table V-13. Airborne Uranium-234 Concentrations for 1994 (Cont.)

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34 Area G-1	61,300	4	0	58.9	6.8	26.2	45.4
35 Area G-2	58,700	4	0	37.1	4.1	17.3	29.8
36 Area G-3	56,400	4	0	780.0	29.5	230.0	740.0
37 Area G-4	44,400	3	0	19.1	6.7	12.9	12.4
Group Summary		15	0	780.0	4.1	76.5	390.0
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	0	41.3	19.2	30.3	31.4
44 Area G (S Perimeter)	60,000	4	0	32.1	14.8	23.9	16.6
45 Area G (SE Perimeter)	59,700	4	0	35.5	19.4	25.4	14.5
46 Area G (E Perimeter)	60,000	4	0	24.6	12.5	16.7	10.8
47 Area G (N Perimeter)	59,600	4	0	40.1	14.8	22.6	23.5
Group Summary		18	0	41.3	12.5	23.1	18.2
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	1	17.0	2.9	9.9	15.4
72 TA-21.02	58,500	4	0	300.0	12.6	85.8	280.0
73 TA-21.03	58,400	4	0	19.9	6.1	11.4	12.8
74 TA-21.04	58,600	4	0	25.3	8.9	14.2	15.3
75 TA-21.05	58,700	4	1	9.3	1.4	6.6	7.1
Group Summary		20	2	300.0	1.4	25.	130.0
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	1	12.0	1.2	7.5	9.2
77 TA-15-NNE	45,200	4	1	23.5	1.9	12.2	17.8
78 TA-15-N	40,700	4	0	30.0	4.2	18.0	25.7
Group Summary		12	2	30.0	1.2	12.6	19.2

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	20,000,000
Uncontrolled Area DOE Derived Air Concentration guide	90,000
EPA 40 CFR 61 Concentration guide	7,700
LANL Minimum Detection Limit	4

Table V-14. Airborne Uranium-235 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	3	2.8	0.6	1.5	2.4
2 Pojoaque	59,400	4	4	3.0	0.4	1.6	2.5
3 Santa Fe	57,700	4	4	2.2	-0.9	1.0	2.8
Group Summary		11	11	3.0	-0.9	1.4	2.4
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	4	2.0	0.3	1.0	1.4
42 Taos Pueblo	20,600	2	1	11.7	-1.5	5.1	18.6
48 Jemez Pueblo	32,500	3	3	1.5	-0.2	0.5	1.7
Group Summary		9	8	11.7	-1.5	1.7	7.7
Perimeter Stations							
4 Barranca School	59,700	4	4	0.6	-0.1	0.3	0.6
5 Urban Park	53,800	4	4	1.2	-0.2	0.6	1.2
6 48th Street	58,600	4	4	1.3	0.5	0.8	0.8
7 Los Alamos Shell	54,100	3	3	1.5	0.7	1.1	0.7
8 McDonald's	60,300	4	4	1.9	0.1	0.7	1.7
9 Los Alamos Airport	61,500	4	4	0.3	-1.3	-0.5	1.4
10 East Gate	59,500	4	4	0.2	-0.3	-0.0	0.5
11 Well PM-1	58,700	4	4	2.1	-0.6	0.8	2.3
12 Royal Crest	57,800	4	4	0.9	-0.4	0.3	1.4
13 Piñon School	56,900	4	4	1.8	-0.5	0.2	2.1
15 White Rock Fire Station	60,200	4	3	14.9	0.3	4.6	13.8
16 Nazarene Church	56,700	4	4	1.5	-1.2	0.3	2.4
17 Bandelier	50,100	4	2	7.7	0.6	3.0	6.6
Group Summary		51	48	14.9	-1.3	0.9	4.8
On-Site Stations							
19 TA-21, DP Site	54,100	4	4	1.5	-0.9	0.7	2.3
20 TA-21, Area B	56,000	4	4	2.4	-0.2	0.8	2.3
21 TA-6	61,000	4	4	0.1	-0.7	-0.3	0.7
22 TA-53, LAMPF	55,300	4	4	1.2	-0.3	0.5	1.3
23 TA-52, Beta	60,600	4	4	0.3	-0.6	-0.2	0.8
25 TA-16-450	56,900	4	4	0.6	-0.3	0.2	0.8
26 TA-49	59,000	4	4	0.1	-0.5	-0.2	0.6
27 TA-54, Area G	53,900	4	2	6.0	0.0	2.4	5.5
28 TA-33, HP Site	48,000	4	4	1.3	-0.2	0.7	1.3
29 TA-2, Omega	56,800	4	4	1.3	-1.2	0.2	2.2
30 Booster P-2	62,200	4	4	0.9	-0.1	0.4	1.1
31 TA-3	36,700	3	3	1.6	0.9	1.2	0.8
32 County Landfill	60,100	4	4	1.5	-0.2	0.6	1.8
33 Area AB	51,100	4	3	3.5	-0.2	1.2	3.2
Group Summary		55	53	6.0	-1.2	0.6	2.4

Table V-14. Airborne Uranium-235 Concentrations for 1994 (Cont.)

$1 aCi/m^3 = 1 \times 10^{-18}$ μCi/mL = 3.7×10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34 Area G-1	61,300	4	4	1.9	-0.2	1.1	1.8
35 Area G-2	58,700	4	3	2.7	-0.3	1.8	2.8
36 Area G-3	56,400	4	3	23.4	1.5	7.5	21.3
37 Area G-4	44,400	3	3	2.5	-0.2	1.1	2.6
Group Summary		15	14	23.4	-0.3	3.0	11.5
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	1	3.0	0.5	1.7	3.6
44 Area G (S Perimeter)	60,000	4	4	1.9	0.0	0.7	1.7
45 Area G (SE Perimeter)	59,700	4	3	3.5	0.8	1.7	2.4
46 Area G (E Perimeter)	60,000	4	4	2.5	-0.5	1.0	2.5
47 Area G (N Perimeter)	59,600	4	4	2.5	1.3	1.8	1.2
Group Summary		18	16	3.5	-0.5	1.3	2.1
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	4	2.3	0.1	1.3	2.0
72 TA-21.02	58,500	4	3	7.9	0.8	2.9	6.7
73 TA-21.03	58,400	4	4	0.6	-0.4	0.2	0.9
74 TA-21.04	58,600	4	3	4.6	-0.5	1.3	4.5
75 TA-21.05	58,700	4	4	1.2	-0.5	0.4	1.5
Group Summary		20	18	7.9	-0.5	1.2	3.9
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	4	2.4	-0.4	1.1	2.3
77 TA-15-NNE	45,200	4	4	1.4	-0.8	-0.1	2.1
78 TA-15-N	40,700	4	4	1.2	-1.0	0.4	2.0
Group Summary		12	12	2.4	-1.0	0.5	2.2

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	20,000,000
Uncontrolled Area DOE Derived Air Concentration guide	100,000
EPA 40 CFR 61 Concentration guide	7,100
LANL Minimum Detection Limit	4

Table V-15. Airborne Uranium-238 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	0	15.5	9.8	12.4	5.8
2 Pojoaque	59,400	4	0	41.2	5.4	23.4	31.1
3 Santa Fe	57,700	4	0	25.8	8.8	17.4	14.1
Group Summary		11	0	41.2	5.4	18.2	21.0
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	0	43.4	15.4	24.0	26.2
42 Taos Pueblo	20,600	2	1	24.8	1.5	13.1	33.0
48 Jemez Pueblo	32,500	3	0	27.7	17.0	21.4	11.1
Group Summary		9	1	43.4	1.5	20.7	22.5
Perimeter Stations							
4 Barranca School	59,700	4	0	9.5	3.2	6.0	6.2
5 Urban Park	53,800	4	2	14.2	2.9	7.6	11.2
6 48th Street	58,600	4	0	10.0	5.0	7.7	4.6
7 Los Alamos Shell	54,100	3	0	17.0	5.0	12.6	13.3
8 McDonald's	60,300	4	1	6.6	1.9	5.2	4.4
9 Los Alamos Airport	61,500	4	1	13.1	1.3	6.1	10.3
10 East Gate	59,500	4	0	14.5	7.6	9.9	6.4
11 Well PM-1	58,700	4	0	10.9	3.4	7.1	6.4
12 Royal Crest	57,800	4	1	8.4	2.5	5.1	4.9
13 Piñon School	56,900	4	2	60.0	2.2	16.3	50.0
15 White Rock Fire Station	60,200	4	0	49.9	3.3	15.8	45.5
16 Nazarene Church	56,700	4	2	50.0	1.1	15.0	50.0
17 Bandelier	50,100	4	1	15.3	2.4	6.9	11.8
Group Summary		51	10	60.0	1.1	9.3	23.5
On-Site Stations							
19 TA-21, DP Site	54,100	4	0	6.7	4.3	5.6	2.2
20 TA-21, Area B	56,000	4	2	5.2	1.0	3.1	3.5
21 TA-6	61,000	4	1	25.2	1.8	9.6	21.2
22 TA-53, LAMPF	55,300	4	1	18.7	2.1	8.7	14.2
23 TA-52, Beta	60,600	4	0	50.0	4.3	16.7	45.1
25 TA-16-450	56,900	4	1	20.6	1.9	11.0	17.9
26 TA-49	59,000	4	2	12.1	0.9	5.2	9.9
27 TA-54, Area G	53,900	4	0	140.0	18.4	70.0	110.0
28 TA-33, HP Site	48,000	4	0	8.1	4.9	6.3	2.7
29 TA-2, Omega	56,800	4	0	9.0	3.8	7.0	4.8
30 Booster P-2	62,200	4	1	70.0	2.2	22.4	70.0
31 TA-3	36,700	3	0	28.1	3.5	13.4	25.9
32 County Landfill	60,100	4	0	37.4	19.4	30.1	17.5
33 Area AB	51,100	4	0	19.9	3.9	13.0	13.7
Group Summary		55	8	140.0	0.9	16.2	49.4

Table V-15. Airborne Uranium-238 Concentrations for 1994 (Cont.)

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34 Area G-1	61,300	4	0	60.0	13.1	27.5	50.0
35 Area G-2	58,700	4	0	100.0	5.2	33.4	90.0
36 Area G-3	56,400	4	0	70.0	12.6	46.1	50.0
37 Area G-4	44,400	3	0	47.2	5.7	19.6	50.0
Group Summary		15	0	100.0	5.2	32.5	60.0
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	0	48.3	37.9	43.1	14.7
44 Area G (S Perimeter)	60,000	4	0	37.9	17.1	31.2	9.6
45 Area G (SE Perimeter)	59,700	4	0	43.8	22.5	28.4	20.5
46 Area G (E Perimeter)	60,000	4	0	31.0	11.2	21.9	21.2
47 Area G (N Perimeter)	59,600	4	0	75.0	13.8	24.9	21.0
Group Summary		18	0	75.0	11.2	28.5	21.7
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	1	8.2	2.1	5.7	5.7
72 TA-21.02	58,500	4	1	5.3	1.8	3.8	3.3
73 TA-21.03	58,400	4	1	14.3	2.8	6.6	10.5
74 TA-21.04	58,600	4	1	8.3	2.9	6.4	4.9
75 TA-21.05	58,700	4	1	10.5	1.2	5.7	7.7
Group Summary		20	5	14.3	1.2	5.6	6.4
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	0	39.6	9.0	19.5	28.1
77 TA-15-NNE	45,200	4	0	60.0	4.7	31.2	44.4
78 TA-15-N	40,700	4	0	170.0	4.6	80.4	170.0
Group Summary		12	0	170.0	4.6	43.7	110.0

Concentration Guidelines	
Controlled Area DOE Derived Air Concentration guide	20,000,000
Uncontrolled Area DOE Derived Air Concentration guide	90,000
EPA 40 CFR 61 Concentration guide	8,300
LANL Minimum Detection Limit	4

Table V-16. Airborne Uranium Concentrations Conversion Factors

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

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

Element	1994 Total Usage	Fraction Released [a] (%)	Annual Average (4 km)[b]	Concentration (8 km)[b]	Applicable Standard[c]
^{234}U	3.96×10^{-2} Ci	10	5×10^{-17}	2×10^{-17}	9×10^{-14} μCi/mL
^{235}U	1.74×10^{-3} Ci	10	2×10^{-18}	7×10^{-19}	1 x 10-^{13} μCi/mL
^{238}U	3.72×10^{-2} Ci	10	4×10^{-17}	2×10^{-17}	1×10^{-13} μCi/mL

[a](Dahl 1977)
[b]Distance downwind.
[c](DOE 1990)

Iodine. With the shutdown of the Omega West research reactor in December 1992, the potential for ^{131}I emissions from LANL is practically eliminated. Data from all six ^{131}I sampling stations are presented in Table V-18. All concentrations measured in 1994 were below the minimum detection limit (MDL) of 10×10^{-12} μCi/mL (0.37 Bq/m^3).

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. In May 1993, five new stations were established to monitor potential emissions resulting from the uncovering and repackaging of 16,500 barrels of TRU waste at the TWISP site. This recovery effort is expected to last through FY 2002. All samplers measure air concentrations of tritium, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239,240}Pu, and ^{241}Am. Samplers are located near active waste handling and disposal operations. The measured air concentrations reflecting operations for 1994 are given in Tables V-7 to V-15. Some air concentrations are slightly above background but are less than 0.02% 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 1994 also are less than 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-10. 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 median air concentration at Station G-2 for 1994 was 147×10^{-12} μCi/mL (5.4 Bq/m^3). All other air samplers at TA-54, Area G measured tritium concentrations within the range of those observed elsewhere. Air sampler #35, G-2, 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

Table V-18. Airborne Iodine-131 Concentrations for 1994

$pCi/m^3 = 1 \times 10^{-12}$ μCi/mL = 3.7×10^{-2} Bq/m^3

Location	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Perimeter Stations						
8 McDonald's	32	32	1.3	-0.1	0.4	0.4
16 Nazarene Church	33	33	1.8	-0.4	0.5	0.6
On-Site Stations						
20 TA-21 Area B	35	35	1.8	-0.2	0.4	0.5
21 TA-6	27	27	1.5	-0.2	0.4	0.5
31 TA-3	24	24	2.2	-0.3	0.6	0.7
32 County Landfill	34	34	1.0	0.0	0.4	0.5
Concentration Guidelines						
Uncontrolled Area DOE Derived Air Concentration guide						400.0
EPA 40 CFR 61 Concentration guide						0.2
LANL Minimum Detection Limit						10.0

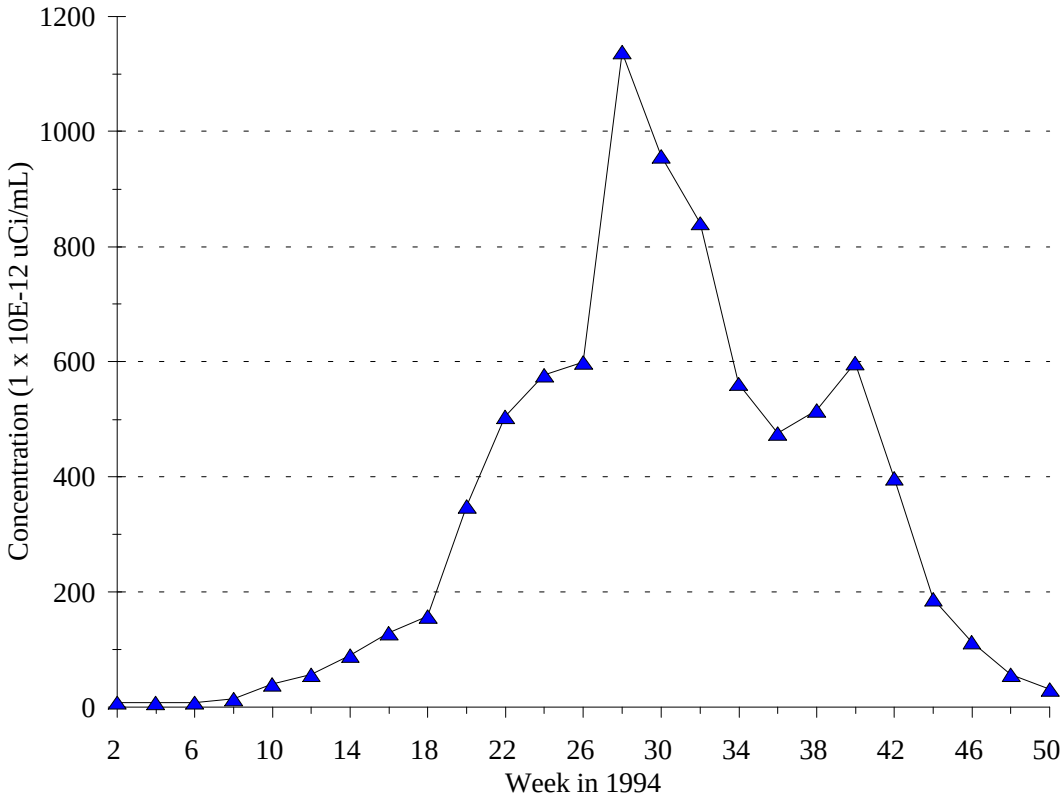


Figure V-10. Tritium in air at sampler #35, G-2.

work. These structures were used mainly for nuclear chemistry involving uranium enriched in ^{235}U and may have residual radionuclides. By combining the air sampling results with site-specific meteorology, an atmospheric dispersion model, and the measured stack emissions, an upper limit on the nonstack air emissions for 1994 can be calculated; these estimates are given in Table V-19.

Table V-19. 1994 Airborne Emissions from TA-21

Radionuclide	Stack Emissions (μCi)	Nonstack Emissions (μCi)
^{235}U	182	<100
^{239}Pu	2.40	<100

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 continues 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 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 124 National Pollutant Discharge Elimination System (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-46 Sanitary Wastewater Systems Consolidation (SWSC) Plant. In 1994, 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-11 and V-12 and are listed in Table D-13.

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 (1895–1905 and 1909–1994) has ranged from a minimum of 1.7 m^3/s (60 ft^3/s) in 1902 to 683 m^3/s (24,110 ft^3/s) in 1920. The discharge for water year 1994 (October 1993 through September 1994) ranged from 7.5 m^3/s (263 ft^3/s) in August to 242 m^3/s (8,543 ft^3/s) in May (USGS 1995).

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 1994 ranged from 7.3 m^3/s (257 ft^3/s) in August to 165 m^3/s (5,824 ft^3/s) in May.

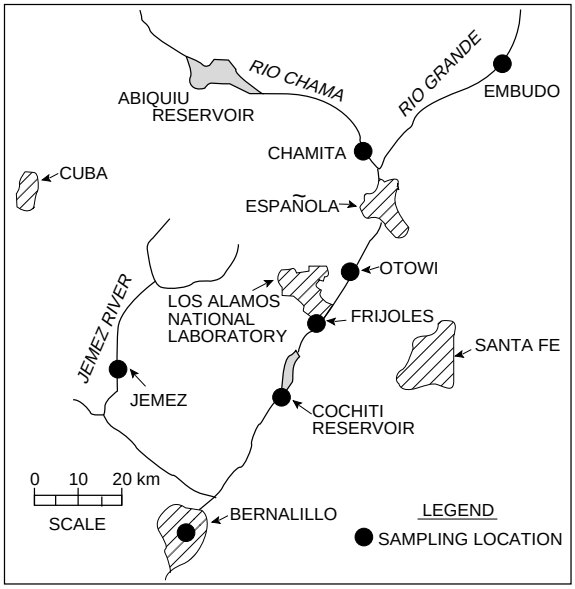


Figure V-11. Off-site regional surface water sampling locations. (Map denotes general locations only; see Table D-13 for specific coordinates.)

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 1994, discharge (as measured at the gage 3.5 mi north of Jemez) ranged from 0.2 m^3/s (7 ft^3/s) in July to 8.9 m^3/s (314 ft^3/s) in May. The river is a tributary of the Rio Grande downstream from Los Alamos.

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 (see Section V.B.5 for further information). 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 about 1,190 m (3,900 ft) west of the Los Alamos-Santa Fe County Line. 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 Pu (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 Pueblo of San Ildefonso 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

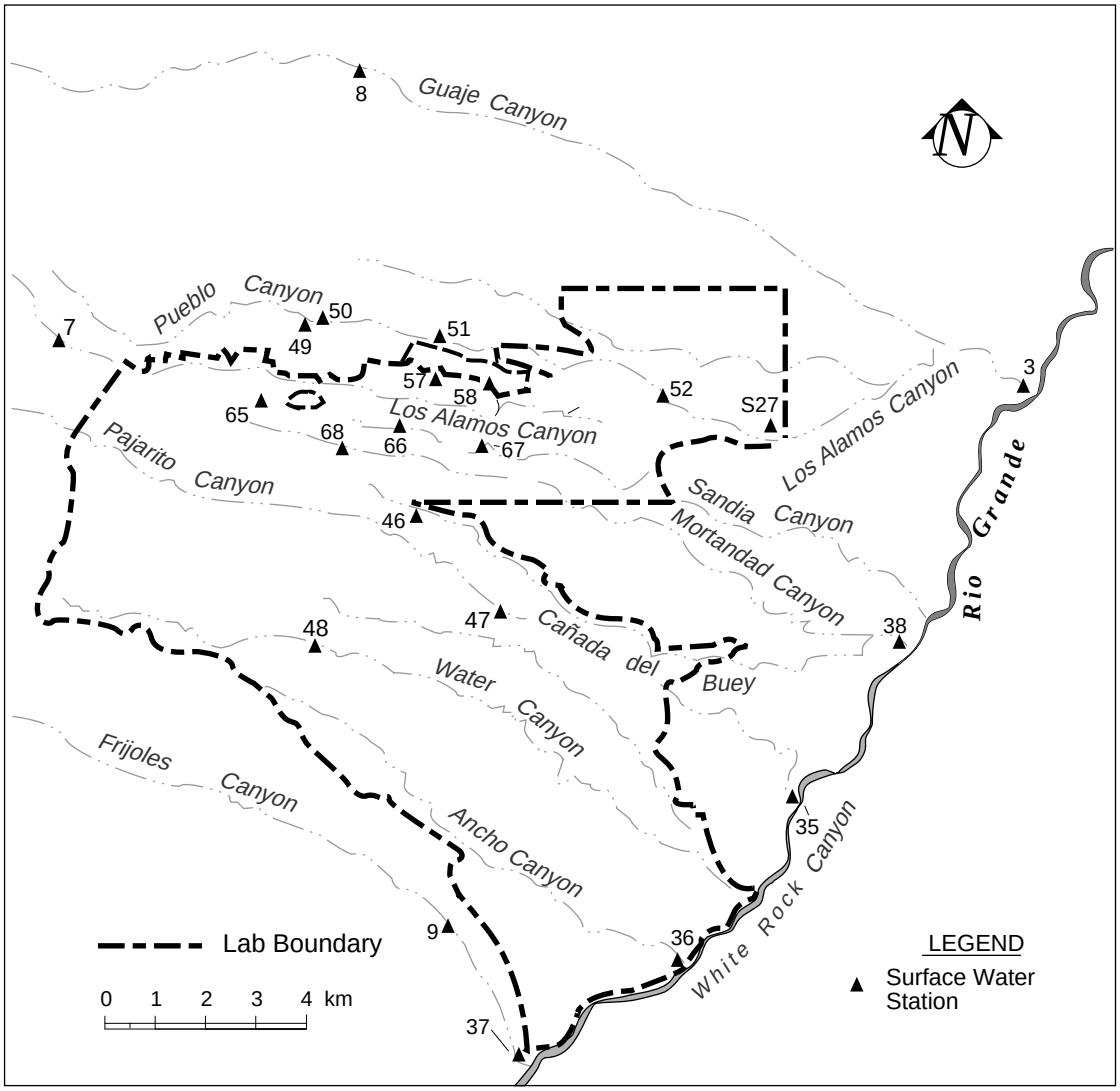


Figure V-12. Surface water sampling locations for off-site perimeter and on-site Laboratory sites. (Map denotes general locations only. See Table D-13 for specific locations.)

(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. (See Section V.B.5 for related information.) 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 Los Alamos 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-12).

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 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 TRU contaminants (about 400 μCi) 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 known 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 2.3 km (1.4 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 contain 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 1994 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 dose limit (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 ^{241}Am analyses for Chaquehui Canyon at the Rio Grande and for Frijoles at Rio Grande were slightly above detection limits. The tritium level in this year's sample from Frijoles Stream at the Rio Grande is slightly above detection limit levels, but several orders of magnitude below the DOE DCG.

Measurements of radioactivity in surface water runoff in Pueblo and Los Alamos canyons, as well as several additional locations, are presented in Table V-21. Samples collected on May 16, 1994, were analyzed for the dissolved concentrations of radioactivity in solution, while analyses of runoff waters collected on May 20, 1994, were additionally made on the suspended solids filtered from the water samples. (Radioactivity in solution refers to the filtrate that passes through a 0.45-μm-pore-size filter; radioactivity on suspended sediments refers to the residue retained by the filter.) This was done in order to estimate the fraction of activity associated with the liquid and suspended solid fractions.

Nearly all of the dissolved radioactity measurements of runoff are below detection limits. Runoff from Los Alamos and Pueblo Canyons are slightly elevated in the dissolved concentrations of tritium and ^{137}Cs, in comparison with the canyons that have not received radioactive effluent discharges (Frijoles, Pajarito and Sandia Canyons). Although the concentrations of ^{137}Cs downstream of radioactive effluent areas appear to be elevated approximately 10 times above-background levels, they are less than 25% of the DOE guide for ^{137}Cs for 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). 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 1994, there were no releases from the TA-21 plant or the TA-53 total retention lagoons. Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon, where effluent affected 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-micron membrane filter) in surface water in Pueblo Canyon (a former release area) are depicted in Figure V-13. 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 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

Table V-20. Radiochemical Analysis of Surface Water for 1994

LOCATION	Tritium (nCi/L)	^{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)
OFF-SITE STATIONS										
REGIONAL STATIONS										
Rio Chama at Chamita	0.0 (0.3)[a]	0.5 (0.7)	1.0 (0.5)	0.7 (0.1)	-0.019 (0.030)	-0.021 (0.020)	0.028 (0.030)	2 (2)	37 (4)	30 (50)
Rio Grande at Embudo	0.1 (0.3)	0.4 (0.7)	1.9 (0.7)	1.6 (0.2)	0.012 (0.030)	0.033 (0.020)	0.004 (0.030)	4 (1)	18 (2)	60 (50)
Rio Grande at Otowi	0.1 (0.3)	0.1 (0.7)	<0.6[b]	2.4 (0.2)	-0.014 (0.030)	0.035 (0.022)	N/A [c]	3 (1)	5 (1)	20 (50)
Rio Grande at Frijoles	0.2 (0.3)	-0.2 (0.7)	<0.8	0.2 (0.0)	0.012 (0.030)	0.042 (0.020)	0.054 (0.030)	-0 (0)	1 (0)	180 (50)
Rio Grande at Cochiti	0.0 (0.3)	0.3 (0.8)	1.9 (0.7)	1.6 (0.2)	-0.017 (0.030)	-0.014 (0.020)	0.017 (0.030)	3 (1)	11 (1)	10 (50)
Rio Grande at Bernalillo	-0.2 (0.3)	0.5 (0.7)	1.5 (0.8)	2.0 (0.2)	0.018 (0.030)	-0.006 (0.020)	0.011 (0.030)	3 (1)	10 (1)	30 (50)
Jemez River	0.1 (0.3)	0.7 (0.8)	<1.4	1.2 (0.1)	0.012 (0.030)	0.017 (0.020)	0.040 (0.030)	13 (3)	19 (2)	-10 (50)
PERIMETER STATIONS										
Acid-Pueblo Canyons										
Acid Weir	0.3 (0.3)	6.0 (0.7)	<1.3	0.8 (0.1)	0.037 (0.030)	1.962 (0.138)	0.170 (0.030)	2 (1)	7 (1)	10 (50)
Pueblo 1	0.4 (0.3)	0.5 (0.8)	0.7 (0.4)	0.0 (0.0)	-0.004 (0.030)	-0.005 (0.020)	N/A	2 (1)	4 (1)	-10 (50)
Los Alamos Canyon										
Los Alamos Canyon Reservoir	-0.2 (0.3)	0.0 (0.7)	<1.0	0.1 (0.0)	0.029 (0.019)	0.005 (0.012)	0.034 (0.014)	0 (0)	1 (0)	70 (50)
Other Areas										
Pajarito at Rio Grande	0.5 (0.3)	2.1 (8.5)	1.5 (0.6)	0.9 (0.2)	-0.005 (0.030)	0.010 (0.020)	0.037 (0.030)	0 (1)	3 (1)	40 (50)
Frijoles at Monument HQ	<0.0 (0.1)	N/A	<1.9	N/A	0.006 (0.007)	<0.002 (0.003)	N/A	2 (2)	0 (2)	N/A
Frijoles at Rio Grande	0.8 (0.3)	-0.2 (0.6)	1.7 (0.8)	1.0 (0.2)	0.010 (0.030)	-0.004 (0.020)	0.026 (0.030)	25 (5)	3 (0)	200 (50)
Chaquehui at Rio Grande	0.3 (0.3)	1.9 (0.8)	<1.1	1.4 (0.1)	0.020 (0.030)	0.029 (0.020)	0.060 (0.030)	2 (1)	2 (0)	0 (50)
ON-SITE STATIONS										
Mortandad Canyon										
Mortandad at GS-1	2.9 (0.5)	10.2 (0.7)	5.7 (1.4)	0.5 (0.1)	0.465 (0.052)	0.162 (0.030)	0.533 (0.059)	3 (1)	35 (4)	50 (50)
DP-Los Alamos Canyons										
DPS-1	0.2 (0.3)	6.5 (0.8)	1.4 (0.3)	0.2 (0.0)	0.028 (0.030)	0.054 (0.020)	0.525 (0.058)	2 (1)	20 (2)	20 (50)
DPS-4	0.3 (0.3)	0.4 (0.7)	1.2 (0.4)	1.1 (0.2)	0.009 (0.030)	0.044 (0.020)	0.070 (0.030)	0 (2)	46 (5)	80 (50)
Los Alamos at Gaging Station 1	0.6 (0.1)	N/A	<1.9	N/A	0.015 (0.012)	0.009 (0.010)	N/A	2 (3)	12 (4)	N/A
Los Alamos at SR 4	0.3 (0.1)	N/A	<1.6	N/A	0.005 (0.008)	0.005 (0.011)	N/A	3 (3)	15 (4)	N/A
Other Areas										
Cañada Del Buey	0.3 (0.3)	1.1 (0.8)	N/A	0.3 (0.1)	0.007 (0.030)	0.008 (0.020)	0.023 (0.030)	2 (1)	6 (1)	-10 (50)
Pajarito Canyon	<0.1 (0.1)	N/A	<1.7	N/A	0.001 (0.009)	0.001 (0.004)	N/A	1 (3)	3 (3)	N/A
Ancho at Rio Grande	0.3 (0.3)	0.9 (0.7)	<1.0	0.3 (0.1)	0.005 (0.030)	0.005 (0.020)	0.043 (0.030)	0 (0)	2 (0)	80 (50)

Table V-20. Radiochemical Analysis of Surface Water for 1994 (Cont.)

LOCATION	Tritium (nCi/L)	^{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)
ON-SITE STATIONS (Cont.)										
Sandia Canyon										
SCS-1	0.4 (0.3)	0.3 (0.9)	<0.8	0.5 (0.1)	0.006 (0.030)	0.012 (0.020)	0.017 (0.014)	-1 (1)	10 (1)	40 (50)
SCS-2	0.3 (0.3)	0.1 (0.7)	<1.0	0.8 (0.2)	0.017 (0.030)	0.002 (0.020)	0.066 (0.023)	1 (1)	10 (1)	0 (50)
SCS-3	0.0 (0.3)	0.1 (0.6)	<1.1	1.0 (0.1)	-0.001 (0.030)	0.028 (0.020)	0.062 (0.024)	1 (1)	9 (1)	-20 (50)
Sandia st SR4	0.1 (0.1)	N/A	<1.8	N/A	<0.002 (0.007)	0.002 (0.005)	N/A	0 (2)	1 (3)	N/A
Limits of Detection	0.4	1	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose [d]	2000	1000	3000	800	40	60	30			
DOE Drinking Water System DCG [d]			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard [d]	20	8		20				15		
EPA Screening Level [d]									50	

[a]Radioactivity counting uncertainties are shown in parentheses.
[b]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[c]N/A means analysis not performed, lost in analysis or not completed.
[d]Standards given here for comparison only, see Appendix A.

Table V-21 Radiochemical Analysis of Spring Runoff Surface Water in 1994

Location Date	Tritium (nCi/L)	^{137}Cs (pCi/L)	Total Uranium (μg/L)	^{238}Pu Aqueous (pCi/L)	^{238}Pu Suspended (pCi/g)	^{239}Pu Aqueous (pCi/L)	^{239}Pu Suspended (pCi/g)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
OFF-SITE PERIMETER STATIONS										
Los Alamos Canyon										
Los Alamos Canyon Reservoir										
05/16	0.3 (0.3)[a]	1.3 (5.4)	0.1 (0.0)	0.001 (0.030)	N/A[b]	-0.001 (0.020)	N/A	1 (0)	3 (0)	50 (60)
DP-Los Alamos Canyons										
Los Alamos at Totavi										
05/16	0.6 (0.3)	28.5 (12.6)	0.8 (0.1)	0.003 (0.030)	N/A	0.011 (0.020)	N/A	1 (1)	11 (1)	20 (60)
Other Areas										
Frijoles at Monument HQ										
05/20	0.0 (0.1)	<1.9[c]	N/A	0.006 (0.007)	N/A	-0.002 (0.003)	N/A	2 (2)	0 (2)	N/A
ON-SITE STATIONS										
Acid-Pueblo Canyons										
Pueblo Canyon at Gaging Station										
05/16	0.2 (0.3)	21.0 (13.3)	0.5 (0.1)	0.001 (0.030)	N/A	0.014 (0.020)	N/A	1 (1)	16 (2)	140 (60)
DP-Los Alamos Canyons										
Los Alamos At Gaging Station										
05/16	0.6 (0.3)	15.2 (11.8)	0.4 (0.1)	0.006 (0.030)	N/A	0.083 (0.020)	N/A	2 (1)	8 (1)	50 (60)
05/20	0.3 (0.1)	<1.0	<1.0	0.009 (0.95)	0.182 (0.019)	0.006 (0.085)	2.034 (0.077)	1 (4)	13 (7)	N/A
05/25	0.6 (0.1)	<1.9	N/A	0.015 (0.012)	N/A	0.009 (0.009)	N/A	2 (2)	12 (3)	N/A
Los Alamos at State Route 4										
05/20	0.3 (0.1)	<1.6 (0.0)	N/A	0.005 (0.008)	0.119 (0.006)	0.005 (0.011)	1.986 (0.075)	3 (3)	15 (4)	N/A
Other Areas										
Pajarito Canyon										
05/20	-0.05 (0.1)	<1.7	N/A	0.001 (0.009)	0.012 (0.016)	0.001 (0.004)	0.041 (0.022)	1 (3)	3 (3)	N/A
Sandia Canyon										
Sandia at State Route 4										
05/20	0.1 (0.1)	<1.8	N/A	-0.002 (0.007)	0.007 (0.002)	0.002 (0.005)	0.035 (0.003)	0 (2)	1 (3)	N/A

[a]Radioactivity counting uncertainties are shown in parentheses.

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

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

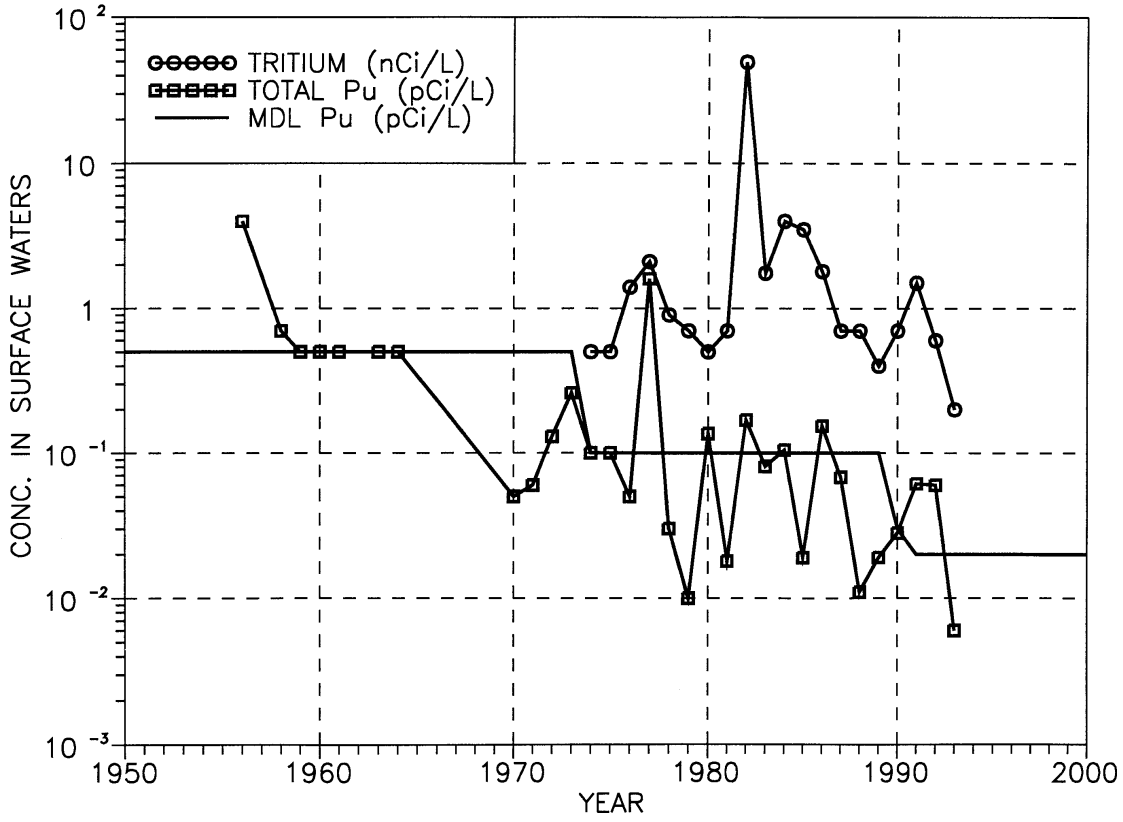


Figure V-13. Tritium and plutonium concentrations at the Pueblo-3 sampling station.

residuals to be detected. 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 the following section covering sediment and soil monitoring.

4. Drinking Water.

This program includes sampling from various points in the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems and from the Laboratory's water supply wellhead to ensure compliance with the federal Safe Drinking Water Act (SDWA) (40 CFR 141).

When gross alpha and beta activity measurements are below the screening limits, the Laboratory does not need to perform further isotopic analyses or perform dose calculations. In 1994 the concentrations of gross alpha activity were less than the screening level of 5 pCi/L, and the concentrations of gross beta activity measurements were less than the screening limit of 50 pCi/L. These results are summarized in Table V-22. It should be noted that gross alpha and beta monitoring of the water supply wells is also conducted by the Laboratory's Environmental Surveillance Program (See Table VII-1 of this report).

Radon is a naturally occurring radionuclide produced during the decay of geological sources of uranium. In 1994, radon sampling was performed at wellheads and points of entry of water from the two 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-23, the radon concentrations ranged from 188 to

Table V-22. Radioactivity in Drinking Water (pCi/L)

Sample Location Calibration Standard	Gross Alpha Value	 (Uncertainty)	Gross Beta Value	 (Uncertainty)
ENTRY POINTS				
Pajarito Booster #2				
^{241}Am	0.50	(0.40)		
Natural U	0.50	(0.40)		
^{137}Cs			1.60	(1.00)
^{90}Sr, ^{90}Y			1.60	(1.00)
Guaje Booster #2				
^{241}Am	0.80	(0.40)		
Natural U	0.90	(0.40)		
^{137}Cs			2.40	(1.00)
^{90}Sr, ^{90}Y			2.40	(1.00)
Pajarito Well Field PM-1				
^{241}Am	2.60	(0.70)		
Natural U	3.00	(0.80)		
^{137}Cs			5.10	(1.20)
^{90}Sr, ^{90}Y			4.80	(1.10)
Pajarito Well Field PM-3				
^{241}Am	1.30	(0.50)		
Natural U	1.50	(0.60)		
^{137}Cs			3.50	(1.30)
^{90}Sr, ^{90}Y			3.20	(1.20)
WELLHEADS				
Pajarito Well Field PM-1				
^{241}Am	3.80	(1.20)		
Natural U	4.80	(1.40)		
^{137}Cs			3.80	(1.10)
^{90}Sr, ^{90}Y			3.70	(1.00)
Pajarito Well Field PM-2				
^{241}Am	0.70	(0.40)		
Natural U	0.70	(0.40)		
^{137}Cs			0.60	(0.80)
^{90}Sr, ^{90}Y			0.60	(0.80)
Pajarito Well Field PM-3				
^{241}Am	0.20	(0.50)		
Natural U	0.30	(0.60)		
^{137}Cs			3.40	(0.90)
^{90}Sr, ^{90}Y			3.20	(0.90)
Pajarito Well Field PM-4				
^{241}Am	0.20	(0.30)		
Natural U	0.20	(0.30)		
^{137}Cs			2.80	(1.00)
^{90}Sr, ^{90}Y			2.80	(0.90)
Pajarito Well Field PM-5				
^{241}Am	1.20	(0.50)		
Natural U	1.30	(0.50)		
^{137}Cs			2.10	(1.00)
^{90}Sr, ^{90}Y			2.10	(1.00)

Table V-22. Radioactivity in Drinking Water (pCi/L) (Cont.)

Sample Location	Gross Alpha		Gross Beta	
Calibration Standard	**Value**	**(Uncertainty)**	**Value**	**(Uncertainty)**
Guaje Well Field G-1				
^{241}Am	0.20	(0.20)		
Natural U	0.20	(0.30)		
^{137}Cs			2.70	(0.70)
^{90}Sr, ^{90}Y			2.60	(0.60)
Guaje Well Field G-1A				
^{241}Am	0.00	(0.30)		
Natural U	0.00	(0.40)		
^{137}Cs			1.90	(0.90)
^{90}Sr, ^{90}Y			1.90	(0.90)
Guaje Well Field G-2				
^{241}Am	1.00	(0.50)		
Natural U	1.20	(0.60)		
^{137}Cs			2.00	(1.10)
^{90}Sr, ^{90}Y			1.90	(1.00)
Guaje Well Field G-6				
^{241}Am	0.70	(0.40)		
Natural U	0.70	(0.40)		
^{137}Cs			2.40	(0.90)
^{90}Sr, ^{90}Y			2.40	(0.90)
Maximum Contaminant Level	15.00		[a]	
EPA Screening Action Limit	5.00		50.00	

[a]MCL for gross beta is a dose limit of 4 mrem/yr.

Table V-23. Radon in Drinking Water (pCi/L)

Sample Location	Value	(Uncertainity)
ENTRY POINTS		
Pajarito Booster #2	461.	19.
Guaje Booster #2	188.	14.
Pajarito Well Field PM-1	254.	17.
Pajarito Well Field PM-3	256.	17.
WELL HEADS		
Pajarito Well Field PM-1	262.	18.
Pajarito Well Field PM-2	629.	36.
Pajarito Well Field PM-3	293.	20.
Pajarito Well Field PM-4	529.	22.
Pajarito Well Field PM-5	499.	29.
Guaje Well Field G-1A	372.	16.
Guaje Well Field G-1	393.	23.
Guaje Well Field G-2	408.	24.
Guaje Well Field G-6	366.	22.
Proposed EPA Maximum Contaminant Level		300

629 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 sediments transported by surface waters. Sheet erosion of soils and the movement of suspended and bed load sediments in surface runoff or canyon stream channels are responsible for the transport of many substances. Many contaminants attach to soil and 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 the Laboratory.

There are no standards directly applicable to radioactive contamination of soils or sediments. Instead, 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. These interpretations assume the contaminated particles are either ingested or inhaled. See Section V.C.2 (Methods for Dose Calculations) for further information. 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 soil and sediment samples from off-site regional stations routinely collected from 1974 through 1986 were used to establish statistical units 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 concentration. Furthermore, the screening action levels (SALs) are used by the Laboratory's ER Project office to identify the presence of contaminants of concern at PRS. 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 the EPA Integrated Risk Information System (IRIS) database and Health Effects Assessment Summary Tables (HEAST) along with EPA guidance (EPA 1988) and the EPA's proposed computational methodology (EPA, 1990b). SALs for a variety of media are available for the Laboratory (IWP 1993) and some of the most recent updates are listed in Table V-24.

b. Monitoring Network. The sediment sampling locations are shown in Figure V-14 (off-site regional). Figure V-15 (off-site perimeter and on-site), and Figure V-16 a and b (solid waste management areas). These locations are also listed in Table D-14. 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 stream 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 different locations within each of three reservoirs. These reservoirs include Abiquiu Reservoir and Heron Lake on the Rio Chama upstream from Los Alamos, and Cochiti Reservoir on the Rio Grande downstream of Los Alamos. These 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 $^{239,240}Pu$ analyses. 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.

Off-site Perimeter Stations. Sediment sampling stations for the radioactive effluent release areas are located to monitor off-site drainages effected by transport of residuals from past releases, as discussed in the previous section. The off-site areas in Acid-Pueblo Canyons contain an estimated 150 mCi of plutonium from

Table V-24. Radioactivity in Sediments for 1994

Location	Tritium (nCi/L)		^{90}Sr (pCi/g)		^{137}Cs (pCi/g)		Total Uranium (mg/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)	
REGIONAL STATIONS																				
Regional																				
Chamita	0.2	(0.3)[a]	-1.7	(1.9)	0.1	(0.0)	1.0	0.4)	0.001	(0.030)	0.004	(0.020)	0.004	(0.030)	3	(1)	3	(0)	2	(0)
Rio Grande at Otowi	-0.3	(0.3)	0.2	(0.3)	7.7	(0.7)	1.5	(0.4)	0.000	(0.030)	0.001	(0.020)	0.004	(0.030)	2	(0)	1	(0)	-0	(0)
Rio Grande at Frijoles	0.3	(0.4)	0.4	(0.3)	0.0	(0.1)	2.0	(0.5)	0.005	(0.001)	0.005	(0.001)	0.008	(0.003)	2	(1)	1	(0)	3	(0)
Rio Grande at Bernalillo	-0.1	(0.3)	1.2	(0.2)	<0.0[b]		1.4	(0.3)	0.002	(0.030)	0.001	(0.020)	0.005	(0.030)	3	(1)	2	(0)	2	(0)
Jemez River	-0.6	(0.3)	0.1	(0.2)	<0.1		0.7	(0.1)	0.000	(0.030)	0.002	(0.020)	0.005	(0.030)	4	(1)	3	(0)	2	(0)
Rio Grande in White Rock Canyon																				
Rio Grande at Sandia	-0.4	(0.4)	0.0	(0.3)	0.0	(0.0)	2.7	(0.6)	0.008	(0.003)	0.011	(0.003)	0.003	(0.001)	4	(1)	3	(0)	4	(1)
Rio Grande at Pajarito	0.0	(0.4)	0.0	(0.4)	0.1	(0.0)	2.3	(0.4)	0.000	(0.001)	0.002	(0.001)	0.004	(0.001)	4	(1)	4	(1)	3	(0)
Rio Grande at Water	-0.1	(0.4)	0.2	(0.3)	0.1	(0.0)	3.3	(1.3)	0.001	(0.001)	0.009	(0.001)	0.004	(0.001)	7	(3)	6	(1)	4	(1)
Rio Grande at Ancho	-0.4	(0.4)	0.0	(4.1)	0.1	(0.0)	2.3	(0.7)	0.004	(0.001)	0.004	(0.001)	0.004	(0.001)	4	(1)	4	(1)	3	(0)
Rio Grande at Chaquehui	0.0	(0.4)	1.4	(3.5)	0.1	(0.0)	2.6	(0.5)	0.001	(0.001)	0.009	(0.001)	0.003	(0.001)	5	(1)	4	(1)	3	(0)
PERIMETER STATIONS (OFF SITE)																				
Acid-Pueblo Canyons																				
Acid Weir	0.3	(0.3)	0.4	(0.2)	0.3	(0.1)	1.6	(0.2)	0.054	(0.030)	11.800	(0.400)	0.330	(0.030)	11	(2)	3	(0)	1	(0)
Pueblo 1	-0.2	(0.3)	0.1	(0.2)	0.0	(0.0)	1.0	(0.1)	0.001	(0.030)	0.005	(0.020)	0.002	(0.030)	3	(1)	2	(0)	0	(0)
Pueblo 2	0.9	(0.7)	0.2	(0.3)	0.1	(0.0)	1.6	(0.4)	0.011	(0.002)	1.310	(0.060)	0.036	(0.004)	4	(1)	2	(0)	2	(0)
DP-Los Alamos Canyons																				
Los Alamos at Totavi	0.3	(0.3)	0.1	(0.2)	0.1	(0.0)	0.8	(0.1)	0.003	(0.030)	0.071	(0.020)	0.011	(0.030)	1	(0)	2	(0)	0	(0)
Los Alamos at LA-2	0.3	(0.3)	0.1	(0.4)	0.1	(0.0)	1.2	(0.1)	0.005	(0.030)	0.172	(0.020)	0.020	(0.030)	4	(1)	3	(0)	1	(0)
Los Alamos at Otowi	0.0	(0.0)	0.1	(0.2)	0.1	(0.0)	1.4	(0.2)	0.003	(0.030)	0.180	(0.020)	0.018	(0.030)	2	(1)	N/A[c]		1	(0)
Other Areas																				
Guaje At SR 4	0.1	(0.3)	0.1	(0.3)	<0.1		1.9	(0.2)	0.015	(0.030)	0.013	(0.020)	0.000	(0.030)	3	(1)	3	(0)	1	(0)
Bayo at SR 4	N/A		0.1	(0.1)	<0.0		2.2	(0.2)	0.008	(0.001)	0.005	(0.001)	0.003	(0.001)	2	(1)	2	(0)	2	(0)
Sandia at Rio Grande	-0.1	(0.4)	0.1	(0.3)	0.1	(0.0)	2.4	(0.8)	0.003	(0.006)	0.001	(0.006)	0.002	(0.001)	3	(1)	3	(0)	3	(0)
Cañada Ancha at Rio Grande	-0.1	(0.4)	0.1	(0.3)	0.0	(0.0)	2.2	(0.5)	0.004	(0.001)	0.001	(0.001)	0.000	(0.001)	4	(1)	4	(1)	3	(0)
Pajarito at Rio Grande	-0.1	(0.4)	0.0	(0.3)	0.0	(0.0)	1.3	(0.3)	0.001	(0.001)	0.002	(0.001)	0.003	(0.001)	1	(0)	1	(0)	2	(0)
Water at Rio Grande	-0.3	(0.4)	0.2	(0.3)	0.7	(0.1)	2.1	(0.7)	0.001	(0.001)	0.014	(0.003)	0.005	(0.003)	7	(3)	7	(1)	4	(1)
Ancho at Rio Grande	-0.3	(0.4)	0.8	(0.3)	0.2	(0.1)	4.8	(0.5)	0.023	(0.003)	0.010	(0.001)	0.004	(0.003)	17	(6)	10	(1)	4	(1)
Chaquehui at Rio Grande	3.3	(1.7)	0.2	(0.4)	0.1	(0.0)	1.4	(0.3)	0.004	(0.001)	0.006	(0.003)	0.003	(0.001)	3	(1)	3	(0)	3	(0)
Frijoles at Monument HQ	-0.2	(0.3)	0.1	(0.2)	0.1	(0.0)	1.5	(0.2)	0.004	(0.030)	0.006	(0.020)	0.003	(0.030)	4	(1)	5	(1)	2	(0)
Frijoles at Rio Grande	-0.2	(0.4)	0.1	(0.3)	0.0	(0.0)	1.5	(0.4)	0.000	(0.006)	0.007	(0.011)	0.000	(0.001)	2	(1)	1	(0)	2	(0)

Table V-24. Radioactivity in Sediments for 1994 (Cont.)

Location	Tritium (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (mg/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) (Cont.)										
Other Areas (Cont.)										
Sta 1 Sandia Can SI Seds	-0.1 (0.3)	-0.3 (0.6)	<0.0	1.4 (0.2)	0.001 (0.001)	0.002 (0.001)	0.006 (0.002)	3 (1)	2 (0)	1 (0)
Sta 2 Sandia Can SI Seds	1.9 (0.7)	0.3 (0.2)	0.0 (0.0)	2.4 (0.2)	<0.001	0.002 (0.004)	0.002 (0.001)	5 (1)	3 (0)	2 (0)
Sta 3 Sandia Can SI Seds	1.9 (0.7)	0.0 (0.2)	<0.0	1.7 (0.2)	0.002 (0.001)	0.002 (0.001)	0.003 (0.001)	3 (1)	2 (0)	1 (0)
Mortandad Canyon on San Ildefonso Lands										
Mortandad A-6	0.1 (0.4)	N/A	0.2 (0.1)	1.2 (0.1)	0.000 (0.000)	0.005 (0.001)	N/A	N/A	N/A	N/A
Mortandad A-7	-0.2 (0.3)	0.3 (0.2)	0.1 (0.0)	2.1 (0.2)	0.019 (0.003)	0.041 (0.004)	0.010 (0.002)	4 (1)	5 (1)	2 (0)
Mortandad A-8	1.1 (0.3)	0.3 (0.2)	0.2 (0.1)	3.6 (0.4)	0.025 (0.005)	0.013 (0.002)	0.005 (0.001)	8 (2)	6 (1)	3 (0)
Mortandad at SR-4 (A-9)	N/A	0.1 (0.4)	<0.0	2.1 (0.3)	0.003 (0.001)	0.002 (0.001)	0.004 (0.001)	3 (1)	3 (0)	2 (0)
Mortandad A-10	0.5 (0.3)	0.1 (0.2)	0.0 (0.0)	1.6 (0.2)	0.002 (0.001)	0.002 (0.001)	0.002 (0.001)	3 (1)	3 (0)	0 (0)
Mortandad at Rio Grande (A-11)	-0.3 (0.4)	0.2 (0.3)	0.1 (0.0)	2.3 (0.4)	0.006 (0.001)	0.007 (0.001)	0.003 (0.001)	4 (1)	3 (1)	2 (0)
Mortandad SI Sed										
Transect 94 COMP	0.3 (0.3)	0.8 (0.3)	0.3 (0.1)	3.8 (0.4)	0.001 (0.001)	0.015 (0.002)	0.005 (0.002)	10 (2)	8 (1)	3 (0)
ON-SITE STATIONS										
Acid-Pueblo Canyons										
Hamilton Bend Spring	0.0 (0.3)	0.2 (0.3)	0.1 (0.0)	1.1 (0.2)	0.015 (0.002)	0.852 (0.023)	0.043 (0.004)	3 (1)	2 (0)	2 (0)
Pueblo 3	-0.2 (0.3)	0.0 (0.2)	<0.1	1.3 (0.1)	0.008 (0.001)	0.257 (0.009)	0.010 (0.003)	2 (0)	2 (0)	1 (0)
Pueblo at State Route	0.2 (0.3)	5.0 (0.4)	<0.1	3.2 (0.7)	0.019 (0.004)	0.925 (0.022)	0.031 (0.005)	4 (1)	2 (0)	7 (1)
DP-Los Alamos Canyons										
DPS-1	0.1 (0.3)	1.0 (0.3)	1.9 (0.3)	1.0 (0.2)	0.043 (0.030)	0.155 (0.020)	0.250 (0.030)	2 (0)	5 (1)	3 (0)
DPS-4	-0.1 (0.3)	4.0 (0.6)	1.9 (0.3)	0.9 (0.1)	0.024 (0.030)	0.094 (0.020)	0.147 (0.030)	3 (1)	6 (1)	2 (0)
Los Alamos at Bridge	-0.4 (0.3)	0.2 (0.2)	0.0 (0.0)	1.7 (0.4)	0.002 (0.001)	0.003 (0.001)	0.005 (0.002)	2 (1)	2 (0)	1 (0)
Los Alamos at LAO-1	0.0 (0.0)	0.3 (0.2)	0.1 (0.0)	1.0 (0.2)	<0.000	0.063 (0.008)	0.187 (0.013)	2 (0)	1 (0)	1 (0)
Los Alamos at GS-1	0.0 (0.0)	0.2 (0.2)	1.1 (0.1)	0.8 (0.2)	0.016 (0.002)	0.110 (0.006)	0.101 (0.007)	2 (0)	2 (0)	2 (0)
Los Alamos at LAO-3	0.3 (0.4)	0.1 (0.2)	1.0 (0.1)	0.9 (0.2)	0.034 (0.003)	0.242 (0.009)	0.183 (0.009)	2 (1)	2 (0)	1 (0)
Los Alamos at LAO-4.5	0.0 (0.0)	0.1 (0.2)	1.2 (0.2)	1.1 (0.2)	0.024 (0.002)	0.164 (0.007)	0.187 (0.013)	3 (1)	3 (0)	2 (0)
Los Alamos at SR-4	N/A	0.2 (0.1)	0.6 (0.1)	1.9 (0.2)	0.014 (0.002)	0.091 (0.005)	0.072 (0.006)	4 (1)	4 (0)	3 (0)
Mortandad Canyon										
Mortandad Near CMR Bldg.	-0.1 (0.3)	0.1 (0.2)	<0.0	1.0 (0.2)	0.014 (0.030)	0.009 (0.020)	0.002 (0.030)	3 (1)	2 (0)	1 (0)
Mortandad West of GS-1	-0.1 (0.3)	0.1 (0.2)	0.1 (0.0)	0.9 (0.1)	0.005 (0.030)	0.004 (0.020)	0.002 (0.030)	1 (0)	1 (0)	0 (0)
GS-1	40.1 (2.0)	0.1 (0.2)	7.0 (0.6)	1.0 (0.1)	1.760 (0.042)	1.780 (0.043)	3.610 (0.360)	6 (1)	10 (1)	8 (1)

Table V-24. Radioactivity in Sediments for 1994 (Cont.)

Location	Tritium (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (mg/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.)										
Mortandad Canyon (Cont.)										
Mortandad at MCO-5	22.7 (1.9)	1.7 (0.2)	14.2 (1.4)	1.0 (0.1)	2.770 (0.110)	7.800 (0.030)	7.990 (0.280)	22 (5)	24 (2)	14 (1)
Mortandad at MCO-7	9.4 (0.9)	1.0 (0.2)	12.0 (1.2)	1.2 (0.1)	1.390 (0.060)	4.330 (0.170)	5.190 (0.230)	17 (3)	18 (2)	14 (1)
Mortandad at MCO-9	-0.7 (0.4)	0.2 (0.2)	0.3 (0.1)	2.1 (0.2)	0.002 (0.001)	0.025 (0.002)	0.009 (0.002)	6 (1)	6 (1)	12 (1)
Mortandad at MCO-13 (A-5)[d]	-0.3 (0.4)	0.1 (0.3)	0.5 (0.1)	2.4 (0.3)	0.005 (0.002)	0.018 (0.003)	0.006 (0.003)	7 (1)	6 (1)	3 (1)
Other Canyons										
Sandia at SR-4	N/A	0.8 (0.2)	0.1 (0.0)	2.0 (0.2)	0.005 (0.001)	0.002 (0.001)	0.003 (0.002)	2 (1)	2 (0)	2 (0)
Cañada Del Buey at SR-4	N/A	0.1 (0.2)	<0.0	1.9 (0.2)	0.003 (0.001)	0.002 (0.001)	0.004 (0.001)	4 (1)	<3 (0)	2 (0)
Pajarito at SR-4	-0.1 (0.3)	0.2 (0.2)	0.2 (0.0)	2.7 (0.4)	0.010 (0.001)	0.009 (0.001)	0.004 (0.002)	5 (1)	7 (1)	3 (0)
Potrillo at SR-4	N/A	0.1 (0.2)	0.1 (0.0)	1.8 (0.2)	0.003 (0.001)	0.004 (0.001)	0.003 (0.002)	1 (0)	2 (0)	2 (0)
Fence at SR-4	-0.2 (0.3)	0.4 (0.2)	0.1 (0.0)	2.4 (0.2)	0.007 (0.001)	0.005 (0.001)	0.004 (0.002)	4 (1)	4 (0)	3 (0)
Water at SR-4	N/A	0.4 (0.2)	0.0 (0.0)	1.8 (0.2)	0.000 (0.001)	0.003 (0.001)	0.002 (0.002)	2 (1)	1 (0)	3 (0)
Indio at SR-4	0.1 (0.3)	0.3 (0.2)	0.2 (0.1)	1.2 (0.2)	0.002 (0.030)	0.004 (0.020)	0.002 (0.030)	3 (1)	3 (0)	3 (0)
Ancho at SR-4	N/A	0.1 (0.2)	<0.1	1.9 (0.2)	0.008 (0.002)	0.003 (0.001)	0.007 (0.003)	2 (0)	2 (0)	3 (0)
Ancho at Ancho Spring	N/A	0.1 (0.3)	0.0 (0.0)	2.1 (0.8)	0.003 (0.001)	0.005 0.003)	0.004 (0.001)	4 (1)	3 (1)	2 (0)
TA-54, Area G										
G-1	0.2 (0.3)	0.2 (0.2)	0.2 (0.1)	1.7 (0.2)	0.008 (0.030)	0.030 (0.020)	0.009 (0.002)	6 (1)	5 (1)	2 (0)
G-2	1.8 (0.4)	0.1 (0.2)	<0.1	0.6 (0.1)	0.002 (0.030)	0.003 (0.020)	0.002 (0.001)	3 (1)	3 (0)	1 (0)
G-3	0.8 (0.3)	0.4 (0.2)	0.4 (0.1)	1.6 (0.2)	0.011 (0.030)	0.016 (0.020)	0.009 (0.002)	6 (1)	5 (1)	2 (0)
G-4	4.3 (0.6)	0.2 (0.2)	0.1 (0.0)	0.8 (0.1)	0.007 (0.030)	0.019 (0.020)	0.014 (0.002)	3 (1)	3 (0)	2 (0)
G-5	2.0 (0.4)	0.0 (0.2)	0.2 (0.1)	1.4 (0.3)	0.009 (0.030)	0.067 (0.020)	0.023 (0.003)	4 (1)	3 (0)	2 (0)
G-6	0.8 (0.3)	0.5 (0.2)	0.6 (0.1)	1.5 (0.2)	0.014(0.030)	0.150 (0.020)	0.035 (0.003)	7 (1)	7 (1)	2 (0)
G-7	N/A	0.0 (0.2)	0.1 (0.0)	2.1 (0.2)	0.173 (0.030)	0.087 (0.020)	0.027 (0.003)	4 (1)	3 (0)	2 (0)
G-8	1.8 (0.6)	0.4 (0.2)	0.6 (0.1)	2.0 (0.2)	0.104 (0.030)	0.229 (0.020)	0.038 (0.003)	6 (1)	7 (1)	2 (0)
G-9	N/A	0.0 (0.2)	<0.1	0.4 (0.0)	0.003 (0.030)	0.004 (0.020)	0.003 (0.001)	2 (0)	2 (0)	-0 (0)
TA-49, Area AB										
AB-1	-0.2 (0.3)	0.4 (0.2)	0.3 (0.0)	2.4 (0.2)	0.003 (0.030)	0.017 (0.020)	0.011 (0.030)	7 (1)	6 (1)	2 (0)
AB-2	-0.1 (0.3)	0.4 (0.2)	<0.1	2.2 (0.3)	0.004 (0.030)	0.029 (0.020)	0.008 (0.030)	6 (1)	5 (1)	1 (0)
AB-3	0.0 (0.3)	0.3 (0.2)	0.3 (0.0)	2.6 (0.5)	0.031 (0.030)	1.606 (0.049)	0.420 (0.030)	4 (1)	5 (1)	2 (0)
AB-4	0.1 (0.3)	0.4 (0.3)	0.3 (0.0)	2.6 (0.3)	0.002 (0.030)	0.024 (0.020)	0.009 (0.030)	6 (1)	8 (1)	2 (0)
AB-4A	0.0 (0.3)	0.1 (0.2)	0.3 (0.3)	2.0 (0.2)	0.003 (0.030)	0.017 (0.020)	0.013 (0.030)	7 (1)	7 (1)	2 (0)
AB-5	-0.1 (0.3)	0.4 (0.2)	0.6 (0.0)	1.8 (0.2)	0.006 (0.030)	0.028 (0.020)	0.015 (0.030)	7 (2)	7 (1)	2 (0)

Table V-24. Radioactivity in Sediments for 1994 (Cont.)

Location	Tritium (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (mg/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.)										
Other Canyons (Cont.)										
AB-6	-0.3 (0.3)	0.1 (0.2)	0.3 (0.0)	2.2 (0.2)	0.004 (0.001)	0.013 (0.002)	0.007 (0.030)	8 (2)	7 (1)	2 (0)
AB-7	0.0 (0.3)	0.5 (0.2)	0.3 (0.0)	2.1 (0.2)	0.013 (0.002)	0.016 (0.002)	0.006 (0.030)	6 (1)	6 (1)	2 (0)
AB-8	0.1 (0.3)	0.1 (0.2)	<0.0	1.0 (0.1)	0.002 (0.001)	0.001 (0.001)	0.004 (0.030)	6 (1)	5 (1)	1 (0)
AB-9	-0.1 (0.3)	2.5 (0.2)	0.4 (0.0)	1.6 (0.2)	0.001 (0.001)	0.014 (0.002)	0.010 (0.030)	2 (0)	2 (0)	2 (0)
AB-10	0.0 (0.3)	0.2 (0.2)	0.4 (0.0)	1.9 (0.2)	0.002 (0.001)	0.013 (0.002)	0.008 (0.030)	7 (2)	7 (1)	2 (0)
AB-11	0.0 (0.3)	-0.3 (1.9)	0.3 (0.0)	1.9 (0.2)	0.006 0.030)	0.015 (0.020)	0.003 (0.030)	6 (1)	5 (1)	2 (0)
Background[e]		0.87	0.44	4.4	0.006	0.023				7.9
SAL[f]	20.0	5.9	4.0	95.0	20.0	18.0	17.0			

[a]Radioactivity counting uncertainties are shown in parentheses.

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

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

[d]Results averaged from more than one sample analysis

[e]W.D.Purtymun 1987a, standards given here for comparison only.

[f]Screening Action Level, Environmental Restoration Group 1994 FIMAD database; standards given here for comparison only.

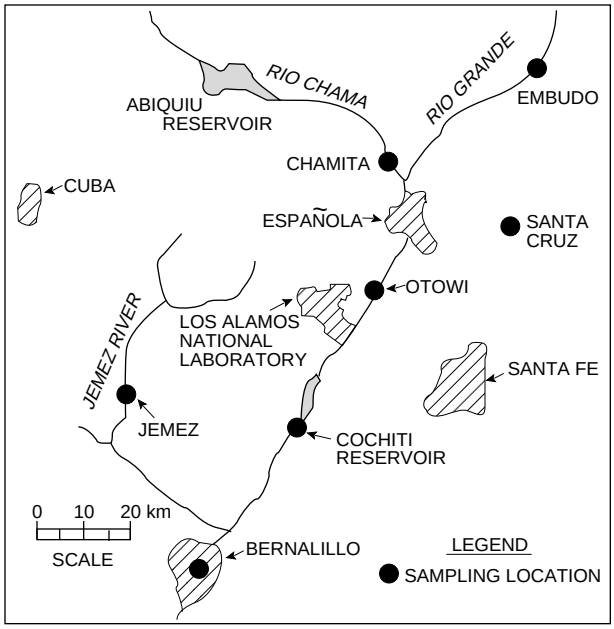


Figure V-14. Off-site regional sampling locations for sediments and soil. (Additional sediment samples are taken from the Rio Grande between Otowi and Cochiti, see Tables D-14 and D-15 and Figure V-15.)

effluent releases 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 Stations Pueblo 1 and Pueblo 2.

The off-site portion of Los Alamos Canyon contains an estimated 30 mCi of plutonium. Table D-14 (See EARE 1995b) 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 for 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 downgradient 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 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 in Section V.B.5.e (Transport of Radionuclides in Sediments from Surface Runoff). No off-site transport of contaminated sediments from Mortandad Canyon has ever 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-16a), 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 materials 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 resulted (Purtymun 1987b, ESG 1988). Eleven sediment stations were established in 1972 to monitor surface sediments in natural drainages surrounding the experiment area. Another station (AB-4A) was added in 1981 as the drainage changed (Figure IV-16b). 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 these canyons are located upgradient of this highway.

c. Radiochemical Analytical Results. The results of radiochemical analyses of sediment samples collected during 1994 from off-site (regional and perimeter) and on-site locations, including solid waste management areas,

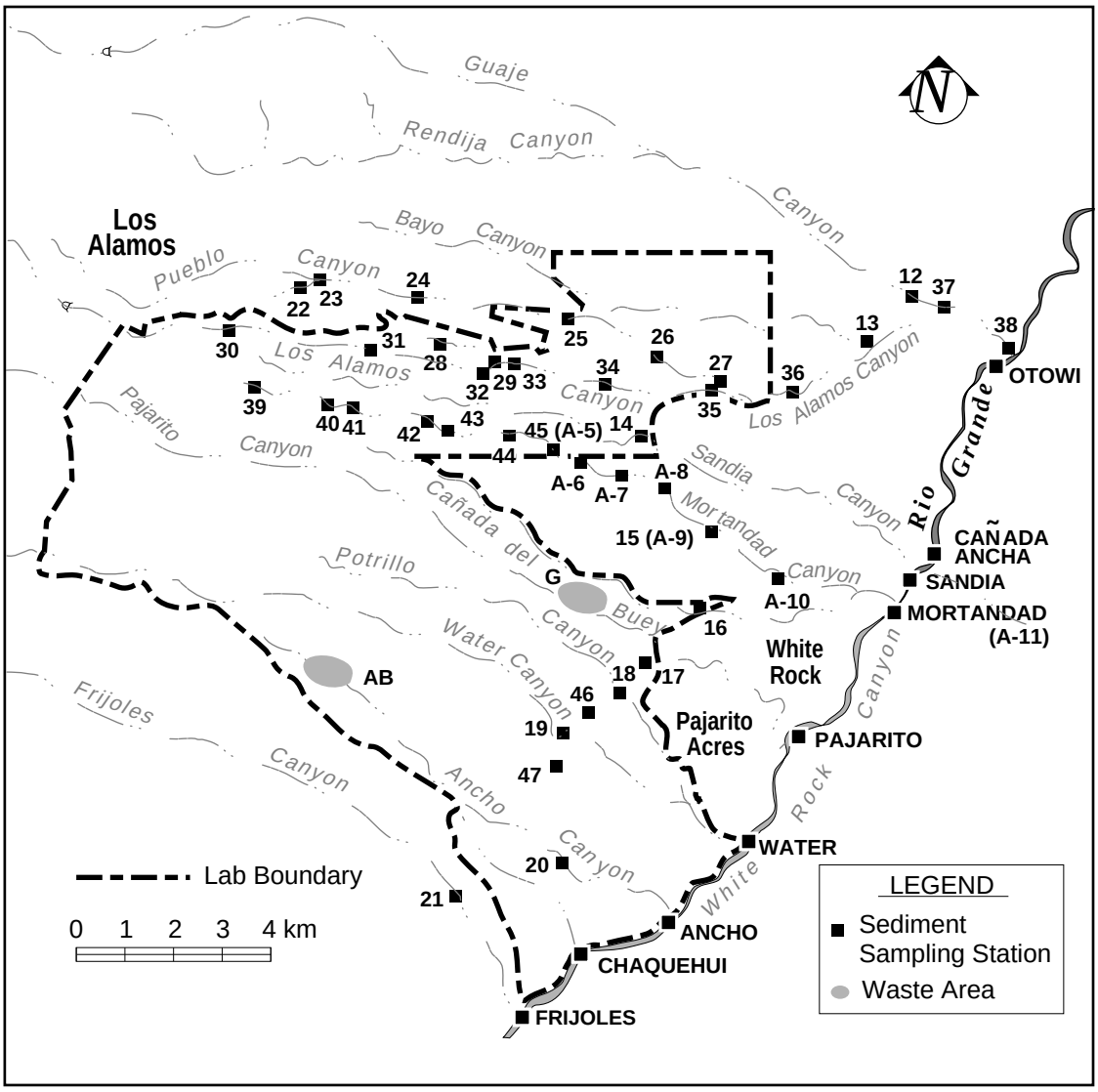
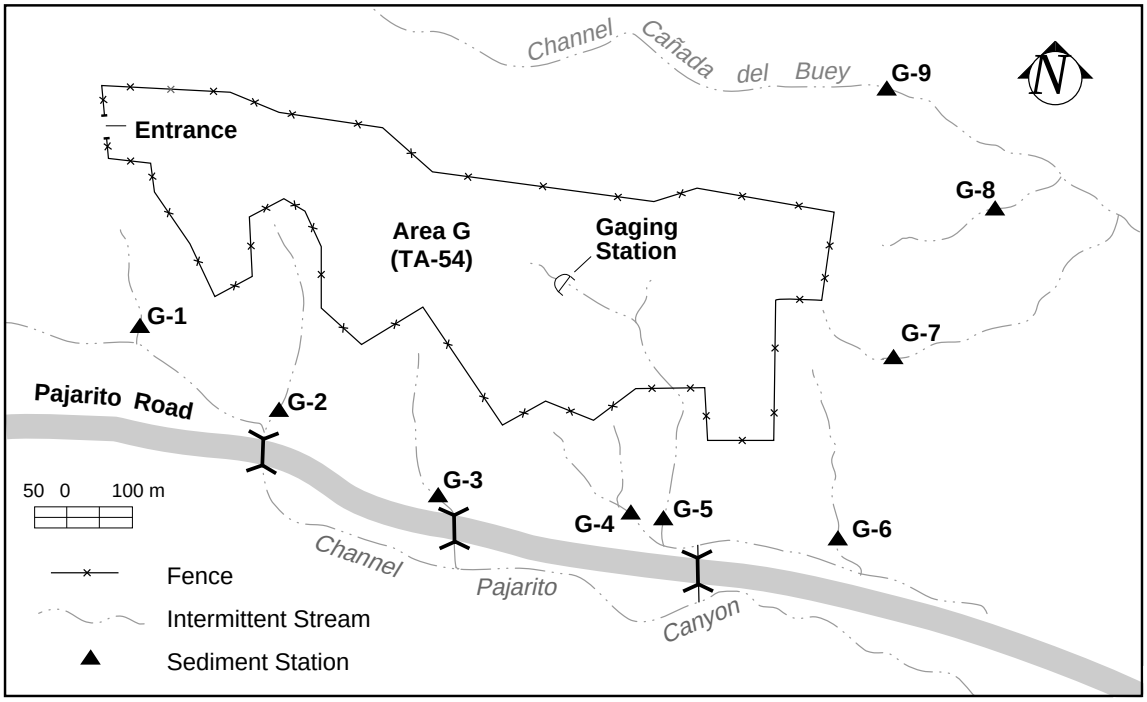


Figure V-15. Sediment sampling locations for off-site perimeter and on-site Laboratory stations. Solid waste management areas with multiple sampling locations are shown in Figure V-16. (Map denotes general locations only. See Table D-14 for specific coordinates).



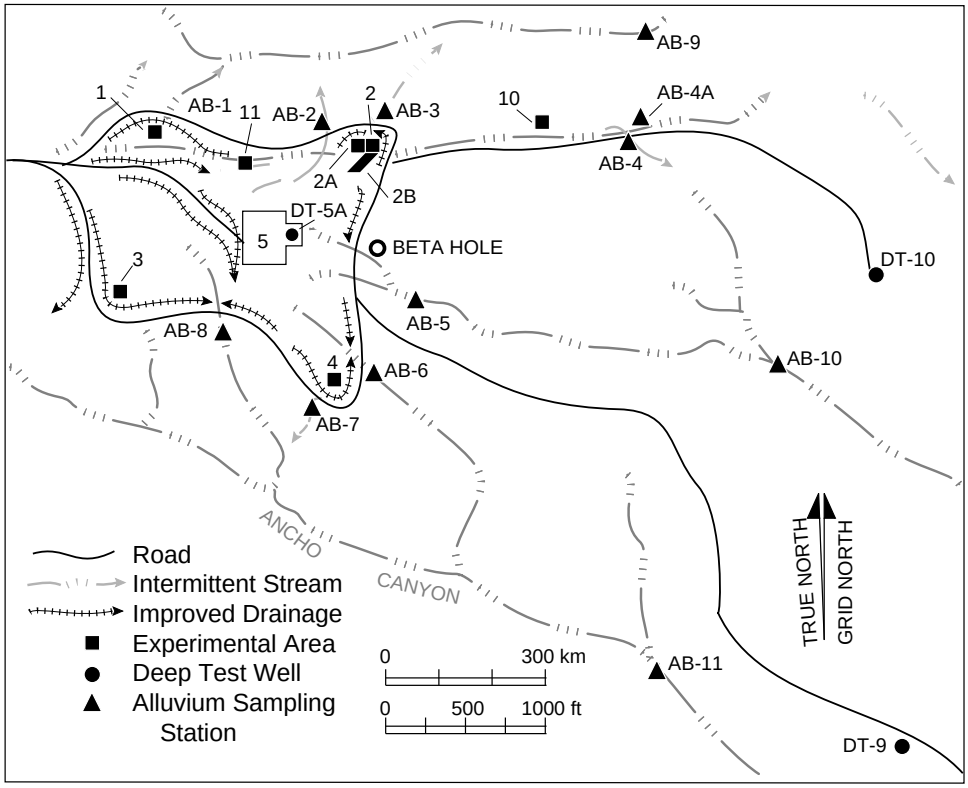


Figure V-16. Off-site perimeter and on-site sediment sampling locations on and near solid waste management areas.
a. Upper map shows the locations of alluvium sampling stations at TA-54, Area G.
b. Bottom map shows the location of experimental areas and sediment stations at TA-49, Area AB.

are listed in Table V-24. 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. Each of these values is computed as the mean plus twice the standard deviation. These background reference levels, along with the respective SALs, are shown in Table V-24.

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. However, none of the sediment samples collected in 1994 showed any concentration level that exceeded its respective SAL value.

Samples taken on San Ildefonso Pueblo land in Mortandad Canyon are discussed in detail in Section IV.C.4 (Environmental Studies at the Pueblo of San Ildefonso). As seen in Table V-24, only the samples from location A-7 and A-8 showed levels of ^{238}Pu and ^{239,240}Pu above the regional statistical reference levels for fallout.

For the regional stations, sediment samples from the Rio Grande at Bernalillo and Chaquehui showed ^{90}Sr somewhat above its background reference value. In addition, the sample from the Rio Grande at Otowi showed that ^{137}Cs was nearly 18 times larger than its background reference level. Finally, the ^{238}Pu value for the Rio Grande at Sandia slightly exceeded its background reference level. All of these variations, however, are consistent with data from previous years.

At the off-site perimeter stations, a number of sediment samples from Acid-Pueblo Canyon, DP-Los Alamos Canyon, and stations from other areas had ^{238}Pu and ^{239,240}Pu values above the background reference levels for these isotopes. Sediments from Water Canyon at the Rio Grande showed slightly elevated total uranium in comparison to its established background reference level. However, all of these values are consistent with historic data. In addition, several samples in this group had elevated ^{241}Am and gross alpha values, even though there are no established background reference levels for these parameters.

For the on-site stations, all of the sediment samples in Acid-Pueblo Canyons showed ^{238}Pu and ^{239,240}Pu values above the respective background reference levels. In DP-Los Alamos Canyons, a number of stations exceeded background reference levels for ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239,240}Pu. In addition, several of these samples showed elevated ^{241}Am values. In Mortandad Canyon, a number of stations exceeded background reference levels for ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239,240}Pu and gross gamma; furthermore tritium, ^{241}Am gross alpha, and gross beta levels were elevated, even though there are no established background reference levels for these parameters. At TA-54 Area G, a number of stations exceeded background reference levels for ^{137}Cs, ^{238}Pu and ^{239,240}Pu. In addition some of these stations also showed elevated tritium values. At TA-49 Area AB, several stations exceeded the ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239,240}Pu background reference levels, while station AB-3 showed slightly elevated ^{241}Am levels, even though there are no comparison standards for this isotope. In summary, all of the 1994 sediment samples appeared to be consistent with previous years results. Furthermore, no SALs were exceeded.

Nonradiological Analyses. Results of nonradiological analyses of sediment samples collected during 1994 are contained in Section VI.A.4 (Nonradiological Sediment Monitoring).

d. Long-Term Trends. The concentrations of radioactivity in sediments from Acid, Pueblo, and Los Alamos Canyons that are or may be transported off site were studied extensively about 15 years ago as part of the Formerly Utilized Sites Remedial Action Program and are fully documented (ESG 1981; Ferenbaugh 1994). Data gathered from selected locations as part of a routine monitoring program indicate that the concentrations of radionulclides in drainage sediments 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-17. The first location is Acid Weir, the location of 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 before 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 mechanism for radionuclides from canyons that have received radioactive effluents (Acid-Pueblo, DP-Los Alamos, and Mortandad

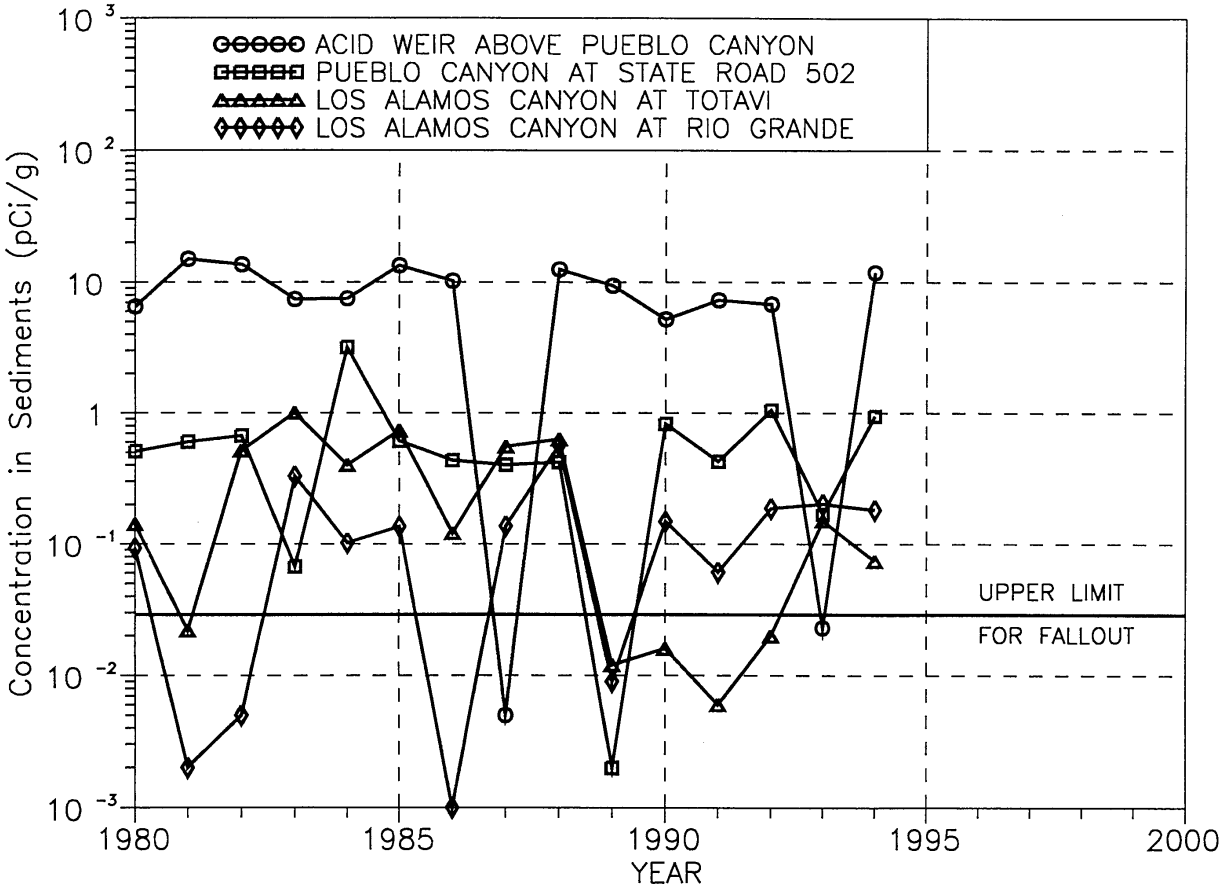


Figure V-17. Total plutonium concentrations in sediments.

Canyons) is by surface runoff. Residual radionuclides in the effluents may become adsorbed or attached to sediment articles in the stream channels. Concentrations of radioactivtiy in the alluvium are generally highest near the effluent outfall and decrease downstream in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and natural surface stormwater and snowmelt 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. See Section V.B.3.b (Surface Water Monitoring Network) for additional historic information. Over the years, some of that radioactivity has been transported off site into lower Los Alamos Canyon largely by seasonal 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 1994 (except mid-June to early August) and typically extended to a location between Totavi (just east of the DOE-Pueblo of San Ildefonso boundary) down to 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 in solution refers to the filtrate that passes through a 0.45-micron pore-size filter. Radioactivity on suspended sediments refers to the residue retained by the filter. The samples collected from runoff contained above

background amounts of cesium, strontium, 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; results for these other canyons are discussed below.

Concentration of plutonium in the suspended sediments from Pueblo and Los Alamos Canyons were above background, although these 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-24; measurements from locations in lower Los Alamos Canyon are shown in Figure V-17. Runoff from summer thunderstorms and extended 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 are well below DOEs applicable PDLs. See Section V.C.3.e (Doses to Individuals from Ingestion of Foodstuffs) 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-20 and V-21. These results are for unfiltered samples and represent total concentrations, including both dissolved and suspended solid components.

Radionuclides in Water and Sediment from Mortandad Canyon. Residual radionuclides are released in effluent from the treatment plant at TA-50 into Mortandad Canyon (see 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 (see Section V.B.3.b (Surface Water Monitoring Network) and Section VII.B (Monitoring Network) for additional information. 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's 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 1994, only routine samples were collected. Furthermore, very little sediment in-filling of the sediment traps occurred during 1994.

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 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 1994, there were no releases from the TA-21 plant or the TA-53 total retention lagoons.

f. Special Reservoir Sediment Studies. Analytical results of the large (1 kg) sediment samples collected in 1994 from Abiquiu, Heron, and Cochiti reservoirs are presented in Tables V-25 and V-26. Results are similar to those from past years. The ^{238}Pu level from the lower station in Heron Reservoir exceeded the statistically established regional fallout reference level (Purtymun 1987a). Furthermore, ^{239,240}Pu levels from Heron and

Table V-25. Radioactivity in Sediments from Reservoirs on the Rio Chama and Rio Grande for 1994

	Tritium (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (mg/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)
Abiquiu Lake										
Upper	-0.2 (0.3)[a]	0.1 (0.5)	<0.07[b]	3.6 (0.6)	0.0004 (0.0001)	0.0008 (0.0003)	0.002 (0.030)	4 (1)	4 (1)	2 (1)
Middle	-0.1 (0.3)	0.0 (0.2)	<0.07	1.9 (0.2)	0.0000 (0.0001)	0.0002 (0.0001)	0.000 (0.030)	8 (3)	6 (1)	1 (0)
Lower	-0.3 (0.3)	0.0 (0.2)	<0.08	2.4 (0.5)	0.0001 (0.0001)	0.0004 (0.0001)	-0.001 (0.030)	4 (1)	4 (0)	1 (0)
Cochiti Lake										
Upper	-0.1 (0.3)	0.1 (0.2)	0.21 (0.07)	1.7 (0.2)	0.0001 (0.0001)	0.0027 (0.0002)	0.002 (0.030)	4 (1)	4 (1)	1 (0)
Middle	-0.1 (0.3)	0.3 (0.2)	0.32 (0.10)	3.2 (0.4)	0.0006 (0.0001)	0.0128 (0.0004)	0.008 (0.030)	11 (3)	9 (1)	2 (0)
Lower	-0.2 (0.3)	0.2 (0.2)	0.28 (0.10)	2.9 (0.3)	0.0005 (0.0001)	0.0123 (0.0006)	0.005 (0.030)	70 (20)	13 1)	1 (0)
Heron Lake										
Upper	-0.2 (0.3)	0.1 (0.2)	0.14 (0.06)	3.2 (0.3)	0.0002 (0.0001)	0.0049 (0.0002)	0.002 (0.030)	7 (2)	6 (1)	2 (0)
Middle	0.0 (0.3)	0.3 (0.2)	0.14 (0.05)	2.8 (0.2)	0.0003 (0.0002)	0.0029 (0.0005)	0.006 (0.030)	8 (2)	7 (1)	2 (0)
Lower	0.1 (0.3)	0.5 (0.2)	0.30 (0.10)	3.2 (0.3)	0.0009 (0.0001)	0.0079 (0.0003)	0.006 (0.030)	8 (2)	6 (1)	2 (0)
Background [c]		0.87	0.44	4.4	0.006	0.023				7.9
SAL[d]	20.0	5.00	4.0	95.0	20.0	18.0	17.0			

[a]Counting uncertainties (± 1 standard deviation) are in parenthesis.
[b]Less than symbol (<) means measurement was below the specified limit of the detection of the analytical method.
[c]Background (Purtymun 1987a); background defined as mean plus two times standard deviation.
[d]Screening Action Level; Environmental Restoration Group, 1994 FIMAD database; standards for comparison only.

Table V-26. 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	Mean	(s)	0.7	(0.2)[b]	12.7	(1.1)	18.1
1985	Mean	(s)	0.7	(0.2)	8.8	(0.8)	12.6
1986	Mean	(s)	0.3	(0.1)	7.5	(0.3)	25.0
1987	Mean	(s)	0.2	(0.0)	3.7	(0.2)	18.5
1988	Mean	(s)	0.3	(0.1)	7.4	(0.3)	24.7
1989	Mean	(s)	0.4	(0.1)	3.7	(0.2)	9.2
1990	Mean	(s)	0.1	(0.1)	2.6	(0.2)	26.0
1991	Mean	(s)	0.3	(0.2)	7.2	(0.4)	24.0
1992	Mean	(s)	0.1	(0.0)	0.8	(0.0)	8.0
1993	Mean	(s)	0.2	(0.1)	5.1	(0.4)	25.5
1994	Upper		0.4	(0.1)	0.8	(0.3)	2.0
	Middle		0.0	(0.1)	0.2	(0.1)	
	Lower		0.1	(0.1)	0.4	(0.1)	4.0
	Mean	(s)	0.2	(0.1)	0.5	(0.2)	2.5
Cochiti Reservoir (Rio Grande)							
1984	Mean	(s)	0.7	(0.1)	19.7	(1.1)	28.1
1985	Mean	(s)	1.6	(0.3)	24.1	(0.8)	15.1
1986	Mean	(s)	1.3	(0.1)	21.6	(0.3)	16.6
1987	Mean	(s)	0.8	(0.1)	17.5	(0.2)	21.9
1988	Mean	(s)	1.7	(0.2)	12.1	(0.3)	7.1
1989	Mean	(s)	2.5	(0.2)	49.3	(0.2)	19.7
1990	Mean	(s)	3.2	(0.1)	17.6	(0.2)	5.5
1991	Mean	(s)	0.2	(0.1)	4.1	(0.4)	20.1
1992	Mean	(s)	1.9	(0.2)	13.4	(0.0)	7.1
1993	Mean	(s)	4.1	(0.4)	30.5	(0.4)	7.4
1994	Upper		0.1	(0.1)	2.7	(0.2)	27.0
	Middle		0.6	(0.1)	12.8	(0.4)	21.3
	Lower		0.5	(0.1)	12.3	(0.6)	24.6
	Mean	(s)	0.4	(0.1)	9.3	(0.4)	23.3
Background							
(1974–1986)[c]			6.0		23.0		

[a]Samples were collected August 3, 1994, at Abiquiu Reservoir and August 2, 1994, at Cochiti Reservoir.

[b]Counting uncertainties (±1 standard deviation) are in parentheses.

[c]Purtymun (1987a).

Cochiti Reservoirs in the samples from the upper, middle, and lower stations exceeded the statistically established regional fallout reference levels. However, none of the other samples exceeded any statistically derived background level for any other radionuclide listed in Table V-25.

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 1990b). This study analyzed 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 Pu 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 radionuclide 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 the Pu at all reservoir locations studied is predominantly from worldwide fallout.

The data from the 1994 Pu analyses are shown in a long-term context in Table V-26. 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 1994 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 Pu 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 Pu levels in sediments in the Rio Grande in the vicinity of Los Alamos indicate 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 sometime between 1941 to 1968 was collected from a floodplain near Buckman (just south of Cañada Ancha in Figure V-15). This sample was subjected to a very sensitive analysis (detection limits as little as 0.0001 pCi/g) of plutonium isotopes by the Isotope Geochemistry Group at the Laboratory. They found that the plutonium levels in sediments at the Buckman site contained a ratio of ^{239}Pu to ^{240}Pu consistent with approximately an equal weight amount of plutonium on sediments from worldwide fallout and from sediments originating in the Acid-Pueblo-Los Alamos canyon system. The total level of ^{239}Pu plus ^{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 1991a). 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 stations are located mostly downwind from the major potential contaminant sources in an effort to intercept any contamination related to Laboratory operations. Perimeter stations are located on the north (two), south (one), east (two), and southwest (one) side of the Laboratory. All 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-14). All are over 15 km (9 mi) from the Laboratory (DOE 1991a) 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-18 and Table D-15). 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. Soil samples from 10 on-site stations are collected; they are mostly located near and downwind of Laboratory facilities that are the principal sources of airborne emissions or that could be potential contaminant sources (FigureV-18 and Table D-15).

c. Radiochemical Analytical Results. Table V-27 shows data from soils collected in 1994. The average concentrations of tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239,240}Pu and gross beta activity in soils collected from perimeter stations were not significantly ($p < 0.05$) different than radionuclide concentrations and activity in soil samples collected from regional (background) locations. The average levels of uranium (3.16 μg/g) in perimeter soils were significantly higher than background soils (1.91 μg/g). Although the average levels of uranium in perimeter soils were significantly higher than background, it was still within the long-term regional statistical reference level (RSRL) of 3.4 μg/g. The RSRL is the average background concentration plus twice the standard deviation of the mean from 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).

The average levels of ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, total uranium, and gross alpha and beta activity in soils collected from on-site stations were not significantly ($p < 0.05$) different than radionuclide concentrations and

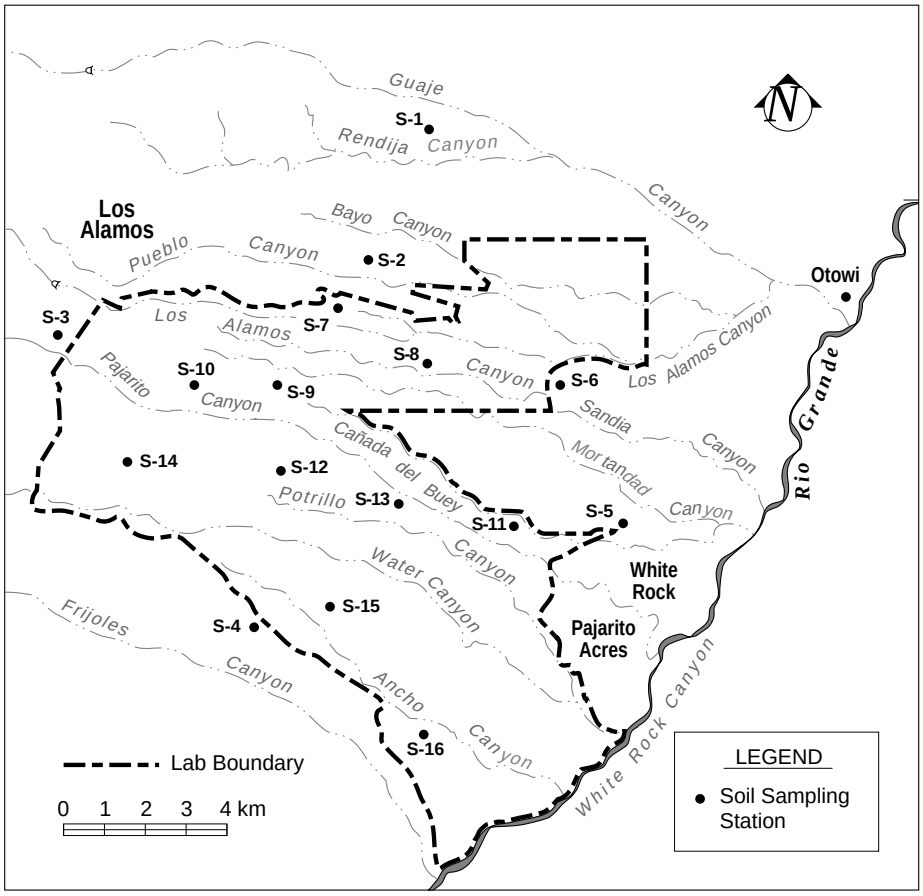


Figure V-18. Off-site perimeter and on-site Laboratory soil sampling locations. (Map denotes general locations only. Refer to Table D-15 for specific coordinates.)

activity in soil samples collected from regional (background) locations. Only tritium was found to be significantly higher in on-site soils (0.13 pCi/mL) versus off-site (background) soils (-0.59 pCi/mL), albeit by less than 1 pCi. On-site soils are still within the long-term background average of 7.2 pCi/mL of tritium, however, and were less than last year's tritium concentration (1.4 pCi/mL).

A comparison of individual radionuclide detectable values (where the analytical result was greater or equal to two sigma) in soils collected from on-site and perimeter stations versus the RSRL and SAL's (LANL SALs) show:

Tritium. No detectable tritium values were found in any of the soil samples collected, including on-site soils. Accordingly, all soil samples collected from either on-site and perimeter stations were far below the Laboratory's SAL (<820 pCi/g soil).

Cesium-137. One perimeter (TA-8/GT site) and two on-site soil samples (Two-Mile Mesa and near TA-33) contained detectable ^{137}Cs activity higher than the RSRL. All detectable values, however, were far below the SAL (<4.0 pCi/g).

Total Uranium. One perimeter (Tsankawi) and three on-site soil samples (TA-50, R-Site Road East, and near Test Well DT-9) contained detectable uranium activity higher than the RSRL. The highest value (114 μg/g) was detected at the R-Site Road East station and was over 33 times higher than last year's value and background. However, all uranium detectable values, including that detected at R-Site Road East, were far below the Laboratory's SAL of 185 μg/g.

Plutonium-238. Two perimeter (White Rock [East] and Tsankawi) and four on-site soil samples (TA-21 [DP Site], West of TA-53, TA-50, and near Test Well DT-9) contained detectable ^{238}Pu activity that exceeded the RSRL; the highest concentration (0.009 pCi/g) was only 0.003 pCi/g higher than the RSRL. All soil samples containing detectable ^{238}Pu activity were far below the Laboratory's SAL (<20 pC/g).

Table V-27. Radiochemical Analyses of Soils Collected in 1994

Location	Tritium (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	-0.10 (0.60)[ab]	0.50 (0.40)	0.19 (0.08)	1.54 (0.30)	0.001 (0.002)	0.008 (0.002)	0.006 (0.002)	3.8 (1.8)	5.4 (1.2)	2.0 (0.6)
Embudo	-1.50 (1.20)	0.40 (0.40)	0.38 (0.14)	1.34 (0.80)	0.004 (0.002)	0.023 (0.004)	0.008 (0.002)	4.3 (2.0)	5.1 (1.2)	2.4 (0.6)
Otowi	-0.60 (0.60)	0.70 (0.40)	0.17 (0.08)	2.51 (0.66)	0.003 (0.002)	0.009 (0.004)	0.008 (0.004)	3.4 (1.6)	3.2 (0.8)	3.3 (0.8)
Santa Cruz	-0.20 (0.60)	0.20 (0.40)	0.31 (0.12)	2.24 (0.44)	0.008 (0.002)	0.010 (0.002)	0.003 (0.002)	6.0 (2.0)	8.6 (1.8)	3.3 (0.8)
Cochiti	-0.60 (0.60)	0.40 (0.40)	0.22 (0.10)	1.92 (0.88)	0.003 (0.002)	0.009 (0.002)	0.004 (0.002)	5.0 (2.0)	5.7 (1.2)	3.0 (0.6)
Bernalillo	-0.30 (0.60)	0.80 (0.40)	0.03 (0.06)	1.32 (0.30)	0.003 (0.002)	0.006 (0.002)	0.001 (0.002)	2.5 (1.2)	2.1 (0.6)	1.5 (0.4)
Jemez	-0.80 (0.80)	0.40 (0.40)	0.33 (0.12)	2.51 (1.10)	0.010 (0.004)	0.013 (0.004)	0.006 (0.002)	4.0 (2.0)	4.7 (1.0)	3.6 (0.8)
Mean (+2SD)	-0.59 (0.95)	0.49 (0.41)	0.23 (0.24)	1.91 (1.05)	0.005 (0.006)	0.011 (0.011)	0.005 (0.005)	4.1 (2.3)	5.0 (4.1)	2.7 (1.6)
RSRL[c]	7.20	0.88	1.10	3.40	0.005	0.025	0.023			
SAL[d]	820.00[e]	5.90	4.00	185.10	20.000	18.000	17.000			
OFF-SITE PERIMETER STATIONS										
L.A. Sportsman Club	-0.20 (0.60)	0.30 (0.40)	0.26 (0.10)	3.40 (0.82)	0.004 (0.004)	0.018 (0.006)	0.005 (0.004)	6.0 (2.0)	6.7 (1.4)	3.3 (0.8)
North Mesa	-0.10 (0.60)	0.20 (0.40)	0.07 (0.06)	2.54 (1.38)	0.004 (0.002)	0.005 (0.002)	0.003 (0.004)	4.5 (2.0)	3.2 (0.8)	3.5 (0.8)
TA-8/GT Site	0.10 (0.60)	1.10 (0.40)[f]	0.75 (0.20)	3.30 (1.26)	0.000 (0.002)	0.000 (0.002)	0.010 (0.006)	6.0 (2.0)	6.3 (1.4)	3.6 (0.8)
TA-49	-0.10 (0.60)	0.50 (0.40)	0.42 (0.14)	2.45 (0.58)	0.002 (0.002)	0.020 (0.004)	0.008 (0.006)	6.0 (2.0)	5.8 (1.2)	3.4 (0.8)
White Rock (East)	-0.30 (0.60)	0.10 (0.40)	0.21 (0.10)	2.45 (0.54)	0.008 (0.002)[f]	0.011 (0.002)	0.003 (0.002)	6.0 (2.0)	5.1 (1.2)	3.4 (0.8)
Tsankawi	-0.50 (0.60)	0.70 (0.40)	0.10 (0.08)	4.83 (0.96)[f]	0.005 (0.002)[f]	0.006 (0.002)	0.002 (0.002)	3.8 (1.6)	3.4 (0.8)	5.1 (1.0)
Mean (+2SD)	-0.18 (0.41)	0.48 (0.74)	0.30 (0.51)	3.16 (1.85)[g]	0.004 (0.005)	0.010 (0.016)	0.005 (0.003)	5.4 (2.0)[g]	5.1 (3.0)	3.7 (1.4)[g]
ON-SITE STATIONS										
TA-21 (DP Site)	0.10 (0.60)	0.30 (0.40)	0.01 (0.02)	2.34 (0.46)	0.005 (0.002)[f]	0.009 (0.004)	0.001 (0.004)	6.0 (2.0)	4.2 (1.0)	3.5 (0.8)
West of TA-53	0.30 (0.60)	0.40 (4.20)	0.05 (0.04)	2.47 (0.50)	0.007 (0.002)[f]	0.019 (0.004)	0.002 (0.002)	5.0 (2.0)	4.4 (1.0)	3.7 (0.8)
TA-50	0.40 (0.60)	0.30 (0.40)	0.08 (0.06)	3.74 (1.58)[f]	0.009 (0.004)[f]	0.032 (0.006)[f]	0.016 (0.012)	4.0 (1.0)	5.0 (2.0)	3.4 (0.8)
Two-Mile Mesa	-0.20 (0.60)	0.90 (0.60)[f]	0.90 (0.24)	1.86 (0.64)	0.006 (0.002)[f]	0.039 (0.006)[f]	0.018 (0.008)	5.0 (2.0)	5.9 (1.2)	3.4 (0.8)

Table V-27. Radiochemical Analyses of Soils Collected in 1994 (Cont.)

Location	Tritium (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	0.60 (0.60)	0.20 (0.40)	0.10 (0.06)	2.16 (0.44)	0.003 (0.002)	0.005 (0.002)	0.004 (0.004)	4.1 (1.8)	4.0 (0.8)	3.4 (0.8)
R-Site Road East	0.10 (0.60)	0.70 (0.40)	0.31 (0.12)	114.00 (24.00)[f]	0.002 (0.002)	0.016 (0.004)	0.008 (0.004)	44.0(18.0)	67.0 (14.0)	4.3 (1.0)
Potrillo Drive	-0.40 (0.60)	0.50 (0.40)	0.20 (0.10)	2.78 (0.56)	0.002 (0.002)	0.009 (0.004)	0.005 (0.004)	6.0 (2.0)	4.5 (1.0)	3.3 (0.8)
S-Site (TA-16)	-0.10 (0.60)	0.50 (0.40)	0.15 (0.08)	2.96 (0.66)	0.002 (0.004)	0.007 (0.004)	0.001 (0.004)	5.0 (2.0)	4.5 (1.0)	3.2 (0.8)
Near Test Well DT-9	0.00 (0.60)	0.80 (0.40)	0.94 (0.24)	5.18 (1.04)[f]	0.007 (0.002)[f]	0.031 (0.006)[f]	0.013 (0.006)	9.0 (4.0)	8.1 (1.8)	3.8 (0.8)
Near TA-33	0.50 (0.80)	1.10 (0.40)[f]	0.61 (0.18)	2.57 (0.72)	0.003 (0.002)	0.022 (0.004)	0.011 (0.004)	6.0 (2.0)	5.9 (1.2)	3.5 (0.8)
Mean (+2SD)	0.13 (0.64)[g]	0.57 (0.59)	0.34 (0.71)	14.00 (70.30)	0.005 (0.005)	0.019 (0.024)	0.008 (0.013)	9.4(24.5)	11.4 (39.2)	3.6(0.6)[g]

[a]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[b](+2 counting uncertainty); values are the uncertainty of the analytical result at the 95% confidence level.
[c]RSRL (Regional Statistical Reference Level; this is the upper limit background concentration [mean + 2 std dev] from Purtymun 1987a).
[d]SAL (Los Alamos National Laboratory Screening Action Level).
[e]820 pCi/dry g soil; therefore, all values were evaluated on a dry weight basis and all were below the SAL. The highest tritium value in the data set (0.60 pCi/mL detected from East of TA-54, for example, contained approximately 12% moisture; thus, 0.60 x 0.12/1 x 0.88 = 0.08 pCi/dry g soil.
[f]Detectable value (where the analytical results is equal or greater than two sigma) and equal or higher than the RSRL.
[g]Statistically significant (mean) from background (mean) using a Student's t-test at the 0.05 probability level.

Plutonium-239, 240. Three detectable ^{239,240}Pu values that were higher than the RSRL were observed in soils collected from on-site areas TA-50, Two-Mile Mesa, and near Test Well DT-9. Last year a soil sample collected from TA-54 exceeded the RSRL for ^{239,240}Pu by almost 90 times. This year ^{239,249}Pu concentrations at TA-54 were observed within background concentrations; this value was attributed as 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 showed no large quantities of ^{239,240}Pu. All soil samples, including detectable concentrations of ^{239,240}Pu, collected from on-site stations were far below the Laboratory's SAL for ^{239,240}Pu (<18 pCi/g).

Americium-241. No detectable amounts of ^{241}Am were detected in any of the soil samples collected from either perimeter or on-site areas. Accordingly, all soil samples were below the Laboratory's SAL of 17 pCi/g.

Soils were also analyzed for heavy metals; analytical results can be found in Table VI-18.

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) in foodstuffs between on-site LANL and off-site perimeter against regional areas and (2) calculate a total CEDE 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.e. Information on trace and heavy metals in various foodstuffs (produce and fish) can be found in Section VI.A.5.

b. Monitoring Network.

Produce and honey. Fruits, vegetables, grains, 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-19 and V-20, and Table D-17). Samples of foodstuffs were also collected from the pueblos of Cochiti and San Ildefonso, which are located in the general vicinity of LANL. Regional or background samples are collected from gardens >15 km (9 mi) from the Laboratory; these areas are located around the Española, Santa Fe, and Jemez areas. The regional sampling locations are sufficiently distant from the Laboratory to be unaffected by airborne emissions.

Fish. Fish are collected annually upstream and downstream of the Laboratory (Figure V-19). 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.

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*).

Game animals. Road kills of elk are collected on an annual basis and the meat and bone are analyzed for various radionuclides. Three elk (*Cervus elaphus*) were collected during the winter of 1994/1995. Results of these animals, however, will be reported in the report "Environmental Surveillance at Los Alamos during 1995."

Milk. There are no milk production facilities within 15 km (9 mi) of the Laboratory; the closest working dairy, located in the Pojoaque Valley, is approximately 40 km (25 mi) away. However, because milk is considered one of the most important and universally consumed foodstuffs and because dairy animals may have consumed vegetation (hay) grown in the vicinity of the Laboratory, the analysis of milk may yield information as to the deposition of small amounts of radionuclides over a relatively large area. Accordingly, various radionuclides in milk from the Pojoaque Valley dairy were analyzed and compared to milk collected from a (background) dairy located in Albuquerque, NM.

c. Radiochemical Analytical Results.

Produce. Concentrations of radionuclides in produce collected from on-site, off-site perimeter, and off-site regional (background) locations during the 1994 growing season can be found in Table V-28. The average

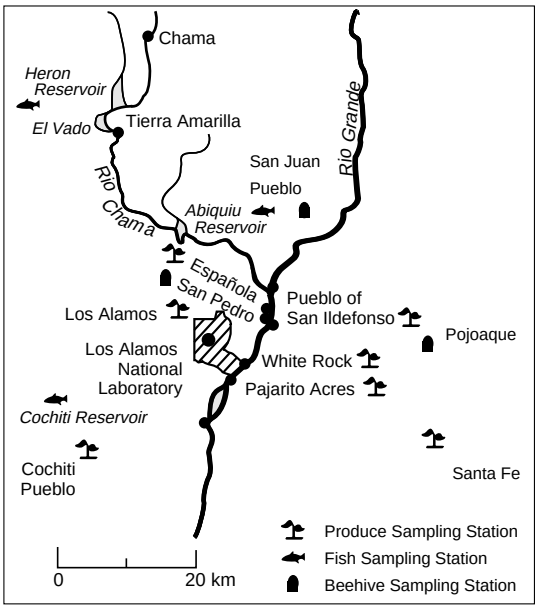


Figure V-19. Produce, fish, and beehive off-site (regional and perimeter) sampling locations. (Map denotes general locations only.)

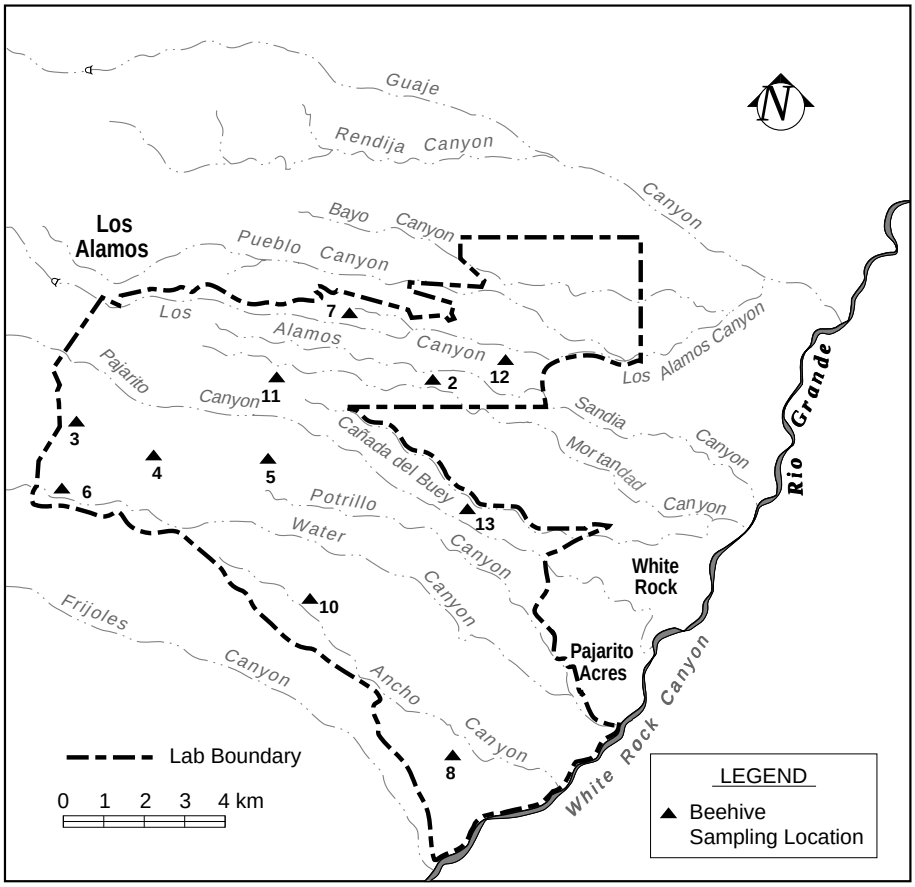


Figure V-20. Locations of beehives in on-site Laboratory areas. (Map denotes general locations. Specific locations are presented in Table D-17.)

Table V-28. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1994 Growing Season[a]

	Tritium (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												
Espanola/Santa Fe/Jemez												
apples	0.2	(0.6)[b]	20.8	(20.8)	0.52	(1.04)	10.4	(312.0)	5.2	(208.0)	14.0	(107.2)
pears	0.0	(0.6)	15.5	(12.4)	0.93	(0.62)	0.0	(186.0)	0.0	(124.0)	1.5	(11.8)
squash	-0.4	(0.6)[c]	33.2	(33.2)	8.30	(1.66)	-8.3	(498.0)	8.3	(332.0)	11.6	(88.0)
apples	0.1	(0.6)	10.0	(20.0)	1.00	(1.00)	-5.0	(300.0)	0.0	(200.0)	-3.0	(23.0)
apricots	-0.1	(0.6)	79.8	(106.4)	5.32	(1.60)	0.0	(1,596.0)	0.0	(1,064.0)	23.9	(180.8)
corn	0.1	(0.6)	5.6	(11.2)	0.56	(0.56)	-2.8	(168.0)	2.8	(112.0)	-6.2	(47.0)
squash	0.1	(0.6)	124.0	(49.6)	9.92	(9.92)	24.8	(744.0)	24.8	(496.0)	50.8	(386.8)
apples	-0.1	(0.6)	11.2	(22.4)	1.68	(2.24)	0.0	(336.0)	0.0	(224.0)	-3.4	(25.8)
squash	-0.1	(0.6)	11.0	(44.0)	5.50	(2.20)	0.0	(660.0)	-11.0	(440.0)	25.3	(193.6)
squash	0.0	(0.6)	42.6	(56.8)	2.84	(2.84)	0.0	(852.0)	0.0	(568.0)	-7.1	(54.0)
Mean	-0.0	(0.4)[d]	35.4	(76.6)	3.66	(6.85)	1.9	(18.7)	3.0	(18.3)	10.7	(37.0)
RSRL[e]	16.9		75.6		38.20		35.4		67.9		690.1	
Perimeter												
Los Alamos												
cherries	0.8	(0.6)	25.2	(33.6)	1.68	(0.50)	0.0	(504.0)	0.0	(336.0)	7.6	(57.2)
apricots	0.2	(0.6)	26.8	(107.2)	5.36	(1.60)	0.0	(1,608.0)	0.0	(1,072.0)	24.1	(182.2)
squash	-0.1	(0.6)	95.9	(54.8)[f]	2.74	(2.74)	13.7	(822.0)	13.7	(548.0)	8.2	(63.0)
tomatoes	0.1	(0.6)	44.0	(44.0)	2.20	(2.20)	11.0	(660.0)	11.0	(440.0)	-9.9	(74.8)
Mean	0.3	(0.8)	48.0	(66.1)	3.00	(3.27)	6.2	(14.4)	6.2	(14.4)	7.5	(27.8)
White Rock/Pajarito Acres												
apples	-0.1	(0.6)	8.8	(8.8)	0.66	(0.88)	-6.6	(132.0)	4.4	(88.0)	-8.1	(62.0)
squash	0.2	(0.6)	46.2	(92.4)	4.62	(4.62)	-23.1	(1386.0)	23.1	(924.0)	-2.3	(18.4)
tomatoes	0.3	(0.6)	15.9	(63.6)	1.59	(1.28)	0.0	(954.0)	0.0	(636.0)	-6.4	(47.6)
squash	0.1	(0.6)	49.5	(66.0)	3.30	(6.60)	-33.0	(990.0)	-33.0	(660.0)	3.3	(26.4)
apples	-0.1	(0.6)	12.0	(12.0)	0.60	(1.20)	-6.0	(180.0)	3.0	(120.0)	-14.4	(109.8)
tomatoes	-0.1	(0.6)	36.0	(36.0)	2.70	(0.54)	-9.0	(540.0)	-9.0	(360.0)	-8.1	(61.2)
tomatoes	0.3	(0.6)	28.8	(38.4)	0.96	(1.92)	-28.8	(576.0)	0.0	(384.0)	-7.7	(57.6)
Mean	0.1	(0.4)	28.2	(33.0)	2.06	(3.06)	-15.2	(25.8)	-1.6	(33.8)	-6.2	(11.0)
Cochiti												
cucumbers	0.0	(0.6)	40.8	(54.4)	19.04	(5.44)	0.0	(816.0)	13.6	(544.0)	42.2	(321.0)
squash	-0.1	(0.6)	31.8	(63.6)	4.77	(3.18)	-15.9	(954.0)	0.0	(636.0)	39.7	(302.0)
corn	0.0	(0.6)	3.0	(12.0)	0.30	(0.24)	-3.0	(180.0)	-3.0	(120.0)	9.6	(73.2)
apples	-0.1	(0.6)	5.8	(11.6)	1.45	(0.58)	0.0	(174.0)	0.0	(116.0)	22.0	(168.2)
Mean	-0.0	(0.2)	18.0	(32.0)	5.38	(13.92)	-3.1	(12.8)	1.0	(14.0)	33.0	(28.8)[g]

Table V-28. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1994 Growing Season.[a] (Cont.)

	Tritium (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 (10-3pCi/dry g)	
OFF-SITE STATIONS (Cont.)												
San Ildefonso												
apples	0.2	(0.6)	0.0	(14.0)	0.70	(0.70)	-3.5	(210.0)	0.0	(140.0)	8.1	(61.6)
peaches	0.0	(0.6)	18.3	(73.2)	7.32	(3.66)	0.0	(1098.0)	0.0	(732.0)	22.0	(168.4)
squash	-0.3	(0.6)	87.6	(58.4)[f]	8.76	(2.92)	-29.2	(876.0)	14.6	(584.0)	87.6	(668.6)
apples	-0.2	(0.6)	9.6	(12.8)	1.60	(0.64)	6.4	(192.0)	-3.2	(128.0)	7.0	(53.8)
squash	0.0	(0.6)	34.0	(34.0)	18.70	(5.10)	0.0	(510.0)	-8.5	(340.0)	11.9	(90.2)
Mean	-0.1	(0.4)	29.9	(69.2)	7.42	(14.42)	-5.3	(27.8)	0.6	(17.2)	27.3	(68.4)
ON-SITE STATIONS												
LANL												
apples	0.4	(0.6)	31.0	(24.8)	1.24	(1.24)	0.0	(372.0)	0.0	(248.0)	1.2	(10.0)
peaches	0.4	(0.6)	8.0	(16.0)	0.80	(0.64)	0.0	(480.0)	0.0	(320.0)	-5.6	(43.2)
apples	0.3	(0.6)	11.9	(10.2)	1.36	(0.68)	5.1	(102.0)	-1.7	(68.0)	-0.2	(13.0)
peaches	3.5	(1.2)	18.0	(14.4)	3.60	(0.72)	-3.6	(216.0)	0.0	(144.0)	-5.8	(44.0)
cucumbers	0.3	(0.6)	-104.8	(655.0)	6.55	(7.86)	0.0	(786.0)	39.3	(524.0)	9.2	(70.8)
squash	0.5	(0.6)	40.0	(16.0)	5.60	(0.80)	-4.0	(240.0)	0.0	(160.0)	2.0	(15.2)
squash	0.3	(0.6)	32.9	(9.4)	1.88	(0.94)	4.7	(282.0)	4.7	(188.0)	-4.2	(32.0)
squash	0.2	(0.6)	54.0	(24.0)	3.60	(1.20)	-6.0	(360.0)	-6.0	(240.0)	-8.4	(64.8)
tomatoes	0.2	(0.6)	15.4	(13.2)	1.32	(1.32)	-11.0	(132.0)	4.4	(88.0)	-9.0	(24.6)
squash	2.7	(1.0)	59.0	(23.6)	4.72	(1.18)	5.9	(354.0)	5.9	(236.0)	4.1	(31.8)
Mean	0.9	(2.4)	16.5	(92.0)	3.07	(4.10)	-0.9	(10.8)	4.7	(25.4)	-1.7	(11.8)

[a]There are no concentration guides for produce; however, most mean radionuclide contents in produce collected 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](+2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.

[c]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

[d](+2 standard deviation).

[e]Regional Statistical Reference Level (this is the upper-limit background concentration [mean + 2 std dev] from Fresquez 1994d).

[f]Detectable value (where the analytical result was greater or equal to two sigma) and was equal or higher than than the RSRL.

[g]Statistically significant (mean) from background (mean) using a Student's t-test at the 0.05 probability level.

concentration of all radionuclides, including tritium, in produce collected from on-site and off-site perimeter locations were not significantly different than radionuclide concentrations in produce collected from background locations and were within values reported for these areas in past years (Fresquez 1994d). In past years, tritium in produce from on-site and off-site perimeter locations have almost always been higher than tritium concentrations in produce collected from background locations.

No significant differences were found in the levels of tritium, uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs between produce collected from gardens at the Pueblo of San Ildefonso and produce collected from the Española/Santa Fe/Jemez areas (Table V-28). Similarily, no significant differences, with the exception of ^{137}Cs, were detected in produce collected from Cochiti area. Although the average level of ^{137}Cs was significantly higher in produce from Cochiti Pueblo as compared to background, it was still below the RSRL for similar foodstuffs collected over a 16-yr period from gardens located in northern New Mexico (i.e., <690 pCi/dry g) (Fresquez 1994d). In addition, none of the seven individual ^{137}Cs values in produce from the Cochiti area contained detectable activity (where the analytical result was higher or equal to two sigma).

Honey. Honey data collected during the 1994 season are presented in Table V-29. Most detectable radionuclides (where the analytical value is greater or equal to two sigma), particulary ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{137}Cs, and uranium isotopes, in honey samples collected from on-site and perimeter areas were within the current year regional statistical reference level (CYRSRL) (mean + 2 std dev). Two detectable ^{239}Pu values—one of which occurred in a honey sample collected from the Los Alamos townsite (0.107 pCi/L)—were observed in higher concentrations than either the CYRSRL (0.055 pCi/L) and the long-term regional statistical reference level (LTRSRL) (0.103 pCi/L). Also, the highest detectable ^{90}Sr value (20.30 pCi/L) was found in honey collected from a beehive located in the Los Alamos townsite.

Tritium in honey collected from Laboratory beehives ranged from -0.30 (±0.60) pCi/mL at TA-16 to 1,300 (±1.00) pCi/mL at TA-53. Technical Area 53 and TA-54 (101.7 pCi/mL) contained the highest concentration of tritium in honey samples. Honey produced by the hives on Laboratory lands is not available for public consumption. The White Rock/Pajarito Acres/TA-36 hive contained higher detectable levels of tritium in honey (2.40 pCi/mL) than the CYRSRL which averaged 0.37 pCi/mL. The LTRSRL for honey is 21.22 pCi/mL.

Fish. Concentration of radionuclides in game and nongame fish collected upstream and downstream of the Laboratory are presented in Table V-30.

The concentrations of most radionuclides, with the exception of uranium, were not significantly different in game fish collected from Cochiti Reservoir as compared to game fish collected from reservoirs located upstream of the Laboratory. These results compare well with radionuclide contents in crappie, trout, and salmon from comparable (background) reservoirs and lakes in Colorado (Wicker 1972, Nelson 1969). Similarily, 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. One fish sample, a bottom-feeder from Cochiti Reservoir, contained elevated levels of ^{239}Pu (0.0235 pCi/dry g). Since the other eight fish samples from Cochiti did not contain ^{239}Pu, this high value was probably a result of processing (i.e., cleaning) or analytical anomalies and was not included in Table V-30.

Again, total uranium concentrations were found to be significantly higher in nongame fish from Cochiti as compared to background. Also, both game (6.64 ng/dry g) and non-game fish (20.42 ng/dry g) from Cochiti contained higher uranium concentrations than the RSRL's (Fresquez 1994a). 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 (1.197 ± 10^{-13} atoms/g ash) to ^{238}U (1.652 ± 10^{-15} atoms/g ash) in Cochiti Reservoir bottom-feeding fish were consistent with naturally occurring uranium (e.g., 0.0072) (Efurd 1995). 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). There was also no evidence of ^{236}U; this isotope does not occur in nature, and it is indicative of the presence of anthropogenic (man-made) uranium. 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 (Wicker 1982). The uranium concentrations from northern New Mexico and in Bandelier tuff around the Los Alamos area, for example, 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 an abandoned 25-acre uranium mine site approximately 9.7 km (6 mi) upstream of Cochiti Reservoir. The US Forest Service stated in an Environmental Assessment report that uranium, lead, and other materials may enter the Santa Fe River during a major storm event.

Table V-29 Radionuclides in Honey Collected from Off-Site and On-Site Beehives during 1994

	Tritium (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	-0.10[b]	-1.700	.017	-0.006	-7.33	2.57
	(0.60)[c]	(17.00)	(0.048)	(0.040)	(22.00)	(0.88)
Pojoaque	-0.40	-1.50	0.032	0.035	18.89	0.35
	(0.60)	(15.80)	(0.038)	(0.044)	(56.68)	(0.12)
San Juan	0.10	-0.10	-0.006	-0.005	46.67	1.40
	(0.60)	(9.40)	(0.020)	(0.030)	(140.02)	(0.48)
Mean[d]	-0.13	-1.10	0.014	0.008	19.41	1.44
	(0.50)	(1.74)	(0.038)	(0.047)	(54.01)	(2.22)
CYRSRL[e]	0.37	0.64	0.052	0.055	73.42	3.66
LTRSRL[f]	21.22	6.00	0.121	0.103	327.47	6.46
Perimeter						
Los Alamos	0.20	20.30[g]	0.021	0.107[h]	38.87	1.97
	(0.60)	(18.60)	(0.048)	(0.102)	(31.96)	(0.40)
White Rock/Pajarito Acres/TA-36	2.40[h]	8.80	0.019	0.019	30.00	1.44
	(1.00)	(27.00)	(0.056)	(0.056)	(27.34)	(0.60)
ON-SITE STATIONS						
TA-5	-0.20	8.90	0.017	0.021	4.89	0.38
	(0.60)	(25.80)	(0.026)	(0.030)	(14.68)	(0.12)
TA-8	0.10	6.20	0.016	-0.011	4.44	0.28
	(0.60)	(11.20)	(0.026)	(0.018)	(13.32)	(0.14)
TA-9	0.70 [h]	5.40	0.003	0.030	15.71	0.22
	(0.66)	(14.20)	(0.020)	(0.034)	(47.14)	(0.12)
TA-15	-0.20	5.00	0.009	0.001	-12.00	0.24
	(0.60)	(11.80)	(0.022)	(0.020)	(32.00)	(0.08)
TA-16	-0.30	5.20	0.000	-0.004	20.54	0.12
	(0.60)	(8.60)	(0.024)	(0.012)	(61.62)	(0.06)
TA-21	2.00[h]	13.70[g]	0.014	0.013	19.33	0.15
	(0.80)	(8.60)	(0.018)	(0.020)	(58.00)	(0.06)
TA-33	21.30[g]	-3.00	-0.012	0.040	14.23	0.18
	(2.80)	(31.00)	(0.044)	(0.078)	(16.62)	(0.06)
TA-35	0.60[h]	5.00	-0.003	-0.022	9.56	0.27
	(0.60)	(9.20)	(0.024)	(0.032)	(28.68)	(0.10)
TA-49	0.30	8.90	0.014	0.013	-0.53	0.28
	(0.60)	(11.00)	(0.030)	(0.030)	(0.16)	(0.10)
TA-53	1,300.00[g]	2.70	0.091[h]	0.401[g]	-4.00	0.64
	(1.00)	(27.20)	(0.084)	(0.228)	(12.00)	(0.36)
TA-54	101.70[g]	-1.10	0.000	0.003	34.64	0.33
	(6.60)	(8.60)	(0.010)	(0.008)	(30.36)	(0.16)

[a]pCi/mL of honey moisture; honey contains approximately 18% water and has a density of 1860 g/L.
[b]See Section VIII.C.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[c](± 2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.
[d](± 2 standard deviation).
[e]Current Year Regional Statistical Reference Level (this is the upper-limit background concentration [mean + 2 std dev]).
[f]Long-Term Regional Statistical Reference Level (this is the upper-limit background concentration [mean + 2 std dev] from Fresquez 1995a).
[g]Detectable value and higher than the LTRSRL.
[h]Detectable value (where the analytical result was greater or equal to two sigma) and higher than the CYRSRL.

Table V-30. Radionuclide Concentrations in Game (Surface-Feeding) and Nongame (Bottom-Feeding) Fish Upstream and Downstream of Los Alamos National Laboratory during 1994.

	^{90}Sr 10^{-2} pCi/dry g		^{137}Cs 10^{-2} pCi/dry g		Uranium 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, Walleye).										
Upstream (Abiquiu, Heron, and El Vado)										
N[a]	10		10		10		10		10	
Min	0.0	(7.2)[b]	2.9	(2.4)	-0.04[c]	(0.12)	-17.0	(120.0)	-4.0	(80.0)
Max	10.2	(6.8)	18.5	(8.0)	4.05	(2.40)	15.0	(1,020.0)	0.0	(680.0)
Mean	4.4	(7.0)[d]	10.8	(11.6)	0.91	(2.80)	-0.4	(15.2)	-0.4	(2.6)
RSRL[e]	17.0		27.7		6.50		23.6		28.3	
Downstream (Cochiti)										
N	6		6		6		6		6	
Min	3.8	(7.6)	0.4	(1.2)	4.00	(0.36)	0.0	(960.0)	0.0	(640.0)
Max	13.3	(7.6)	9.0	(27.0)	9.88	(2.66)	18.0	(1,140.0)	0.0	(760.0)
Mean	8.4	(7.6)	3.2	(6.6)	6.64	(5.14)[f]	3.0	(14.6)	0.0	(0.0)
NONGAME FISH (Bottom-Feeders: Catfish, Suckers, Carp)										
Upstream (Abiquiu, Heron, and El Vado)										
N	10		10		10		10		10	
Min	1.2	(1.6)	0.0	(0.0)	1.30	(0.26)	-6.0	(360.0)	0.0	(160.0)
Max	9.1	(5.2)	18.1	(7.8)	18.60	(6.96)	13.0	(840.0)	0.0	(560.0)
Mean	4.2	(5.2)	12.2	(13.4)	7.48	(12.40)	2.8	(14.2)	0.0	(0.0)
RSRL[e]	13.2		26.9		16.20		9.8		19.2	
Downstream (Cochiti)										
N	9		9		9		9		8[g]	
Min	1.2	(2.4)	-2.7	(1.4)	6.42	(2.64)	-13.0	(360.0)	0.0	(240.0)
Max	10.4	(5.2)	3.5	(10.6)	43.89	(15.96)	0.0	(1,260.0)	0.0	(560.0)
Mean	4.9	(6.2)	0.4	(3.8)	20.42	(21.42)[f]	-2.6	(10.2)	0.0	(0.0)

[a]N = number of composite samples.

[b](+2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.

[c]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

[d](+2 standard deviation).

[e]Regional Statistical Reference Level; this is the upper-limit background concentration (mean + 2 std dev) from Fresquez 1994a.

[f]Statistically significant from background using a Student's t-test at the 0.05 probability level.

[g]One sample was eliminated due to cross-contamination during sample preparation or analysis.

As expected, the bottomfeeders (nongame fish) from both downstream and upstream reservoirs contained higher average (weighted) uranium contents (14.00 ng/dry g) than the surfacefeeders (3.07 ng/dry g). The higher concentration of uranium in bottomfeeders as compared to surfacefeeders 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).

Game Animals. Analytical results of elk road kills collected during the winter of 1994/1995 will be reported in the FY95 Surveillance report. Two previous reports on elk collected on Laboratory land, however, are available for study (Meadows 1992, Fresquez 1995). The most current report includes data on total uranium ^{137}Cs, ^{90}Sr, ^{238}Pu, and ^{239}Pu concentrations detected in various tissue samples collected from on-site and off-site cow elk in 1992/1993. In general, 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.

Milk. Milk collected from the Pojoaque Valley and Albuquerque region are summarized in Table V-31. All radionuclides, with the exception of uranium, in milk collected from Pojoaque were within ULB concentrations (mean + 2 std dev). Tritium (0.10 pCi/mL) and ^{90}Sr (0.00 pCi/L) levels, in particular, compare well with tritium (ave. 0.16 pCi/mL) and ^{90}Sr levels (ave. 1.1 pCi/L) in milk from other states around the country (Nevada Test Site Annual Site Environmental Report 1993). Milk collected from both Pojoaque and Albuquerque dairies contained detectable uranium levels (where the analytical result was higher than two sigma). This is not unexpected as uranium is a natural element in all soils, and the degree to which it is found in milk depends on many factors including the geology, vegetation, and meterological (wind and rain) conditions of the area (Wicker and Schultz 1982). Although the uranium level in milk from the Pojoaque Valley (0.24 µg/L), was slightly higher than the uranium content in milk from Albuquerque (0.10 µg/L), it was still within (background) uranium concentrations found in milk from other parts of the country (e.g., 0.02 to 0.30 µg/L) (Fernald Environmental Restoration Management Corporation 1993).

8. Unplanned Releases.

a. Airborne Radioactivity. On January 25, 1994, an estimated 340 Ci (13 Tbq) of tritium was released during a pumping and sampling operation performed for a planned safe shutdown maintenance procedure at the high-pressure tritium laboratory (TA-33, Building 86). Potential doses were estimated using the meteorological conditions during the time of the release (PGL 1994). The estimated dose to the nearest public receptor was 3.3 x 10^{-4} mrem (3.3 x 10^{-6} mSv). The calculated dose to LANL's maximum exposed individual (MEI) location was 1.0 x 10^{-3} mrem (1.0 x 10^{-5} mSv).

On February 7, 1994, a HEPA filter was changed out of Building 4, FE-3, at the DP Site West (TA-21). The changeout resulted in a higher-than-normal stack release of ^{238}U. Approximately 160 µCi (5.9 MBq) were released during the week of February 4 to February 11, 1994 (LANL 1994). Potential doses were estimated using an EPA-approved dispersion code to be 3.44 x 10^{-2} mrem (3.44 x 10^{-4} mSv) to the nearest public receptor and 3.60 x 10^{-3} mrem (3.60 x 10^{-5} mSv) to the LANL MEI, (EPA 1990a).

Table V-31. Radionuclide Concentrations in Milk Collected in 1994[a]

	Pojoaque Valley		Albuquerque, NM	
^{238}Pu (pCi/L)	0.003	(0.060)[b]	0.000	(0.060)
^{239}Pu (pCi/L)	0.000	(0.040)	-0.013	(0.040)
^{90}Sr (pCi/L)	0.000	(0.200)	0.000	(0.200)
Total U (µg/L)	0.240	(0.040)	0.100	(0.020)
Tritium (pCi/mL)	0.100	(0.600)	-0.200	(0.600)
^{137}Cs (pCi/L)	3.100	(11.860)	2.410	(13.380)
^{131}I (pCi/L)	4.700	(11.600)	10.000	(15.760)

[a]All radionuclide contents in milk, with the exception of uranium, had non-detectable values (i.e., where the analytical result was less than two sigma).

[b](±2 counting uncertainties); values are the uncertainty in the analytical results at the 95% confidence level.

On December 5, 1994, during a process to recover ^{68}Ge from a target, containment of the distillation process was lost, resulting in a stack release of 1.18 mCi (44 MBq) from the radiochemistry site (TA-48, building 1) (LLNL 1994). Potential doses were estimated to be 3.03×10^{-6} mrem (3.03×10^{-8} mSv) to the nearest public receptor and 5.02×10^{-8} mrem (5.02×10^{-10} mSv) to the LANL MEI (LLNL 1994).

b. Radioactive Liquid Releases. There were no unplanned liquid releases at the Laboratory during 1994.

C. Radiological Doses

1. Introduction.

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

Standards exist which limit the EDE to the public (DOE 5400.5, 40 CFR Part 61. The DOE's PDL is 100 mrem/yr (1mSv/yr) EDE received from all pathways (i.e., ways in which people can be exposed to radiation, such as inhalation, ingestion, and immersion in water or air containing radioactive materials), and the dose received by air is restricted by the EPA's effective dose standard of 10 mrem/yr (0.10 mSv/yr) ([40 CFR Part 61] Appendix A). These values are in addition to exposures 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 the 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 1991a, 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-18. These factors are recommended by 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 particle size of 1 μm activity median aerodynamic diameter as well as the lung solubility category that will maximize the EDE (for comparison with DOE's 100 mrem/yr PDL). Similarly, the ingestion dose conversion factors are chosen to maximize the EDE 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.

External doses are calculated using the dose-rate conversion factors published by DOE (1988c) (Table D-19). These factors give the photon dose rate in millirems per year per unit radionuclide air concentration in microcuries

per cubic meter. If the conversion factor for a specific radionuclide of interest is not published in DOE 1988c, it is 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 measurements are used to estimate external penetrating radiation doses. The TLD measurements include background radiation and any external radiation contribution from Laboratory operations. Environmental background dose is subtracted from the environmental TLD measurements to determine the contribution from the Laboratory. Background radiation estimates at each site are based on historical data, consideration of other possible radioactive sources, 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 net annual TLD dose is assumed to represent the dose from Laboratory activities that would be received by an individual who spent 100% of the year at the monitoring location.

The final individual dose is derived by reducing the measured exposure by 20% to account for building shielding and by 30% to account for the self-shielding of the body. (Note: these reductions are not used for demonstrating compliance to the EPA standard; see Section C.4.b below.)

Neutron generating facilities at TA-18 had the potential for resulting in exposures from direct penetrating radiation to the public along Pajarito Road. The TA-18 site policy strictly follows as low as reasonably achievable (ALARA) principles; specifically, daytime operations are limited to producing less than 1 mrem per operation or 10 mrem per month at the site boundary. During 1994, operations at TA-18 that had the potential of producing a dose in excess of 1 mrem per operation were limited to nighttime or weekend operations with minimum site occupation. In addition, public access was restricted by closing Pajarito Road from White Rock to TA-51 during these operations at TA-18, thus eliminating the potential for dose to the public.

c. Inhalation Dose. Annual average air concentrations of tritium, ^{238}Pu $^{239,240}Pu$, ^{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 /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 MEI, and dose to the population living within 80 km (50 mi) of the site.

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 an estimated annual consumption rate 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 and the CEDE to the entire body (Table D-19).

To obtain the net positive difference for each radionuclide, the maximum CEDE (i.e., average + 2 sigma) at the regional stations is subtracted from the maximum CEDE at each monitoring location. Since one cannot receive a "negative exposure to radiation," all negative values are set to zero. The total net positive difference is the resulting CEDEs summed over all monitored radionuclides.

3. Estimation of Radiation Doses.

a. Doses from Natural Background. Published EDE values from natural background and from medical and dental uses of radiation are used to provide a comparison with doses resulting from Laboratory operations. Global fallout doses due to atmospheric testing of nuclear weapons are only a small fraction of total background doses (<0.3%, NCRP 1987a). Natural background radiation dose is due to exposure to the lungs from radon decay products and exposures from nonradon sources which affect the whole body.

External radiation comes from two sources of approximately equal magnitude: the cosmic radiation from space and terrestrial gamma radiation from radionuclides in the environment. Estimates of 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 less energetic gamma radiation from LANL sources.

Whole-body external dose is incurred from exposure to cosmic rays, external terrestrial radiation from naturally occurring radioactivity in the earth's surface, and from global fallout. The EDE from internal radiation is due to radionuclides naturally present in the body and inhaled and ingested radionuclides of natural origin.

Annual external background radiation exposures for sources other than radon vary depending on factors such as snow cover and the solar cycle (NCRP 1975b). Estimates of background radiation in 1994 from nonradon sources are based on TLD measurements of 132 mrem (1.32 mSv) in Los Alamos and 118 mrem (1.18 mSv) in White Rock. These measured doses were adjusted for structural shielding by reducing the cosmic ray component by 20%. The measured doses were also adjusted for self-shielding by the body by reducing the terrestrial component by 30%. The neutron dose from cosmic radiation and the dose from self-irradiation were then included to obtain the whole-body background dose of 148 mrem (1.48 mSv) at Los Alamos and 136 mrem (1.30 mSv) at White Rock from sources other than radon. Inhalation of ^{222}Rn produced by decay of ^{226}Ra, a member of the uranium series, results in a dose to the lung, which also must be considered. Uranium decay products occur naturally in soil and building construction materials. The EDE from ^{222}Rn decay products is assumed to be equal to the national average, 200 mrem/yr (2 mSv/yr). This estimate may be revised if a nationwide study of background levels of ^{222}Rn in homes is undertaken. Such a national survey has been recommended by the NCRP (NCRP 1984, 1987a).

In 1994 the EDE to residents was 348 mrem (3.48 mSv) at Los Alamos and 336 mrem (3.36 mSv) at White Rock (Table V-32) from all natural sources. The individual components of the background dose for Los Alamos and White Rock, and the average EDE of 53 mrem/yr (0.53 mSv/yr) to members of the US population from medical and dental uses of radiation (NCRP 1987a) are listed in Table V-33.

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.

Because of questions concerning the event-to-dose conversion algorithm, a comprehensive dose figure is currently not available from the East Gate air monitoring stations. Several different methods were applied to derive a dose estimate, but the resulting data could not be statistically proven accurate compared with data from a pressurized ion chamber gamma photon detector. The pressurized ion chamber is considered a primary standard for radiation measurement (NCRP 1978). Although the HPGe system used in the East Gate system is thought to be more sensitive than the pressurized ion chamber, the sensitivity does not currently withstand statistical scrutiny.

c. Doses to Individuals from Direct Penetrating Radiation. No direct penetrating radiation from Laboratory operations was detected by TLD monitoring of off-site locations. On-site TLD measurements of external penetrating radiation reflected Laboratory operations; however, they did not represent any significant public exposure since these areas were closed to the public.

d. Doses to Individuals from Inhalation of Airborne Emissions. The maximum individual EDEs attributable to inhalation of airborne emissions (Table V-34) are below the EPA air pathway standard of 10 mrem/yr (0.1 mSv/yr). Exposures to airborne tritium (as tritiated water vapor), ^{238}Pu, ^{239,240}Pu, ^{241}Am, ^{234}U, ^{235}U, ^{238}U,

Table V-32. Summary of Annual Effective Dose Equivalents Attributable to 1994 Laboratory Operations

	Maximum Dose to an Individual[a]	Average Dose to Nearby Residents		Collective Dose to Population within 80 km of the Laboratory (234,000 persons)
		Los Alamos	White Rock	
Dose[b]	3.5 mrem[c]	0.27 mrem[b]	0.06 mrem[b]	4 person-rem
Location	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
Background	348 mrem	348 mrem	336 mrem	77,0000 person-rem[d]
DOE Public Dose Limit	100 mrem			[e]
Percentage of Public Dose Limit	3.5 %	0.27%	0.06%	
Percentage of Background	1.0%	0.077%	0.018%	0.006%

[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.
[c]1 mrem = 0.01 mSv.
[d]Based on the collective dose from the CAP-88 model
[e]There is no dose limit for the collective dose; however, a 100 person-rem value for the population is found in the proposed 10 CFR 834.

Table V-33. Calculation of Total Effective Dose Equivalent (mrem/yr)

	Los Alamos	White Rock
Radon	200	200
Self-irradiation	40	40
Total External[a]	108	96
Total Effective Background Dose	**348**	**336**
Medical	53	53

[a]Includes correction for shielding

Table V-34. Estimated Maximum Individual 50-Year Dose Commitments from 1994 Airborne Radioactivity

Isotope	Location	Estimated Dose (mrem/yr)[a]	Percentage of Public Dose Limit
Tritium	Nazarene Church	0.02	0.2%
^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar	Residence North of LAMPF	3.5	35%
^{241}Am, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239,240}Pu$	White Rock Fire Station	0.022	0.22%

[a]1 mrem/yr = 0.01 mSv/yr.

and ^{131}I were 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, ^{234}U, ^{235}U, and ^{238}U occurred at the White Rock Fire station and was 0.022 mrem (0.022 mSv), or 0.022% of the DOE's PDL of 100 mrem/yr (1 mSv/yr), and 0.7% 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 1994 was estimated using the atmospheric transport model, CAP-88, to be 2.0 μrem/yr (0.02 μSv/yr), or 0.02% of the EPA radiation limit of 10 mrem/yr for the air pathway. Exposure from all other atmospheric releases of radioactivity (Table V-5) was also evaluated by theoretical calculations of airborne dispersion. All potential inhalation doses from these releases were less than 1.3% of the DOE's PDL of 100 mrem/yr (1 mSv/yr).

e. Doses to Individuals from Ingestion of Foodstuffs. Data from samples of produce, fish, honey, and milk were used in 1994 to estimate the committed effective dose equivalents (CEDEs) from the ingestion of foodstuffs. The CEDE is the committed effective 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 net difference for the CEDE between the regional background and the dose in food consumed for all food groups is 0.1% of the DOE's 100 mrem/yr (1 mSv/yr) public dose limit (PDL) (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, Santa Fe, and Jemez) locations, as well as pueblo lands (the Pueblo of San Ildelfonso and Cochiti) 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}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs. The CEDE values are based on an annual consumption rate for produce of 160 kg/yr (352 lb/yr) (Table V-35).

The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) from all sources in 0.514 mrem (5.1 μSv). The total net positive difference in the CEDE due to the consumption of 160 kg/yr (352 lb/yr) of produce from Cochiti, White Rock, Los Alamos, and the Pueblo of San Ildefonso is 0.016 mrem (0.16 μSv) (<0.02% of the DOE PDL), 0.001 mrem (0.01 μSv) (<0.002% of the DOE PDL), 0.006 mrem (0.06 μSv) (<0.007% of the DOE PDL) and 0.047 mrem (0.47 μSv) (<0.05%) of the DOE PDL) respectively. The total net positive difference between the CEDE for regional and on-site produce is 0.027 mrem (0.27 μSv). Ingestion of produce collected onsite is not a significant exposure pathway because of the small amount of edible material, low radionuclide concentrations, and limited access to these foodstuffs. The Student's t-test shows that there is no significant difference at the 95% level of confidence between the CEDEs from produce consumed from regional, perimeter, and on-site locations.

Table V-35. Total Committed Effective Dose Equivalent from the Ingestion of Produce Collected from Off-Site Areas during the 1994 Growing Season

Off-Site Stations	Total CEDE[a] (mrem/yr)	
Regional		
Española/Santa Fe/Jemez	0.149	(0.365)[b]
Perimeter Stations		
Cochiti Pueblo	0.091	(0.169)[b]
White Rock	0.061	(0.116)[b]
Los Alamos	0.147	(0.228)[b]
Pueblo of San Ildefonso	0.117	(0.300)[b]

[a]Based on DOE dose conversion factors (DOE 1988b).

[b] ± 2 sigma in parentheses; to convert to μSv, multiply by 10.

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 1994. These samples were analyzed for tritium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{137}Cs, and uranium. The CEDE values are based on an annual consumption rate of 5 kg (11 lbs) (Table V-36). The water content of honey is estimated at 18% (Winston 1991).

The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) from the ingestion of honey collected in Los Alamos and White Rock during 1994 is 0.027 mrem (0.27 μSv). To provide an assessment of the potential impact of Laboratory operations on this foodstuff, the net dose was determined by subtracting the regional background concentrations from the off-site perimeter stations. This total net positive difference for the Los Alamos and White Rock locations is 0.011 mrem (0.11 μSv) (0.01% of the DOE PDL) and 0.008 mrem (0.08 μSv) (0.01% of the DOE PDL), respectively. Honey that is collected from on-site Laboratory locations is not available for public consumption.

Fish. Fish samples were collected in 1994 from bottom and higher level feeders at locations upstream (Abiqui, Heron, and/or El Vado reservoirs) and downstream (Cochiti Reservoir) of the Laboratory. All samples collected are more than 10 km (6.2 mi) beyond Laboratory boundaries. These samples are analyzed by the Environmental Chemistry Group (CST-9) for the concentrations of uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs. The CEDE values are based on an annual consumption rate of 21 kg (46 lbs) (Table V-37).

The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) from bottom feeders is 0.153 mrem (1.5 μSv). The total net positive difference in the CEDE from the consumption of bottom feeders from these upstream and downstream locations using a 21 kg/yr (46 lb/yr) consumption rate is 0.017 mrem (0.17 μSv) (0.02% of the DOE

Table V-36. Total Committed Effective Dose Equivalent from the Ingestion of Honey Collected from Los Alamos and White Rock during 1994

Off-Site Stations	Total CEDE[a] (mrem/yr)	
Regional		
San Pedro	0.001	(0.010)[b]
Pojoaque	0.003	(0.014)[b]
San Juan	0.007	(0.023)[b]
Perimeter		
Los Alamos	0.015	(0.013)[b]
White Rock	0.008	(0.015)[b]

[a]Based on DOE dose conversion factors (DOE 1988b).
[b] ± 2 sigma in parentheses; to convert to μSv, multiply by 10.

Table V-37. Total Committed Effective Dose Equivalent from the Ingestion of Fish Collected during 1994

Off-Site Sampling Location	Total CEDE[a] (mrem/yr)	
Bottom Feeders		
Upstream (Abiqui, Heron, El Vado)	0.068	(0.085)[b]
Downstream (Cochiti Reservoir)	0.038	(0.074)[b]
Higher Level Feeders		
Upstream (Abiqui, Heron, El Vado)	0.059	(0.084)[b]
Downstream (Cochiti Reservoir)	0.072	(0.077)[b]

[a]Based on DOE dose conversion factors (DOE 1988b).
[b] ± 2 sigma in parentheses; to convert to μSv, multiply by 10.

PDL). Similarly for higher level feeders, the total net positive difference in the CEDE is 0.039 mrem (0.39 μSv) (0.04% of the DOE PDL). The Student's t-test shows that there is no significant difference at the 95% level of confidence between the CEDE from the consuming fish from these upstream and downstream locations.

Milk. Milk samples were collected from a dairy in Pojoaque Valley and a dairy in Albuquerque during 1994. All samples collected are more than 10 km (6.2 mi) beyond Laboratory boundaries. These samples were analyzed for ^{90}Sr, $^{239,240}Pu$, ^{137}Cs, tritium, ^{131}I, and uranium. The CEDE values are based on a maximum annual comsumption rate of 292 L (77 gal) (Table V-38).

The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) from the two dairies is 0.771 mrem (7.7 μSv). The total net positive difference in the CEDE from the consumption of milk produced at these two locations is 0.014 mrem (0.14 μSv) (0.01% of the DOE PDL). Based on the sample results and plus 2 counting uncertainties, these data sets overlap indicating that there is no significant difference between the CEDEs from consuming milk collected from these two dairies.

4. Total Maximum Individual Dose to a Member of the Public from 1994 Laboratory Operations.

a. Maximum Individual Dose. The maximum individual EDE to a member of the public from 1994 Laboratory operations is estimated to be 3.5 mrem/yr (0.035 mSv/yr). This is the total EDE from all pathways. This dose is 3.5% of the DOE's PDL of 100 mrem/yr (1 mSv/yr) EDE from all pathways (Table V-32) and 0.9% of the total annual dose contribution (Figure V-21). 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 1994 dose estimate is based on environmental measurements for doses. 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 for the Los Alamos and White Rock townsites. Doses from other exposure pathways were 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 the Los Alamos or White Rock townsites. 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 1994 meteorological data. The dose estimate took into account shielding by buildings (30% reduction for submersion dose, 10% for inhalation dose) (Kocher 1980) and occupancy (100% for residences, 25% for businesses). The contribution to the maximum individual off-site dose via each pathway is presented in Figure V-22. The average EDE to residents in the Los Alamos townsite that is attributable to Laboratory operations in 1994 was 0.27 mrem (0.0027 mSv). The corresponding dose to White Rock residents was 0.06 mrem (0.0006 mSv). The doses are approximately 0.27% and 0.06% of DOE's PDL of 100 mrem/yr (1.0 mSv/yr) (Table V-32).

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.

Table V-38. Total Committed Effective Dose Equivalent from the Ingestion of Milk Collected during 1994

Sampling Locations	Total CEDE[a] (mrem/yr)	
Dairy in the Pojoaque Valley	0.135	(0.490)[b]
Dairy in Albuqerque, NM	0.195	(0.576)[b]

[a]Based on DOE dose conversion factors (DOE 1988b).

[b] ± 2 sigma in parentheses; to convert to μSv, multiply by 10.

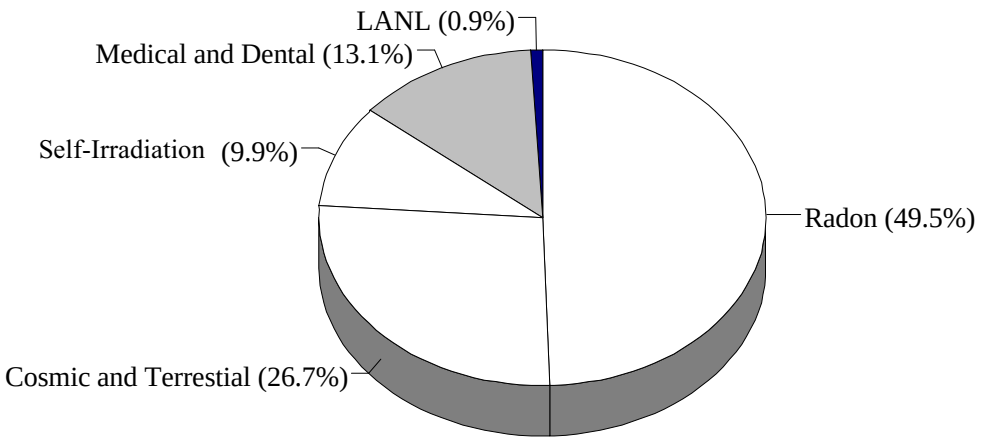


Figure V-21. Total contributions to 1994 dose at the Laboratory's maximum exposed individual location.

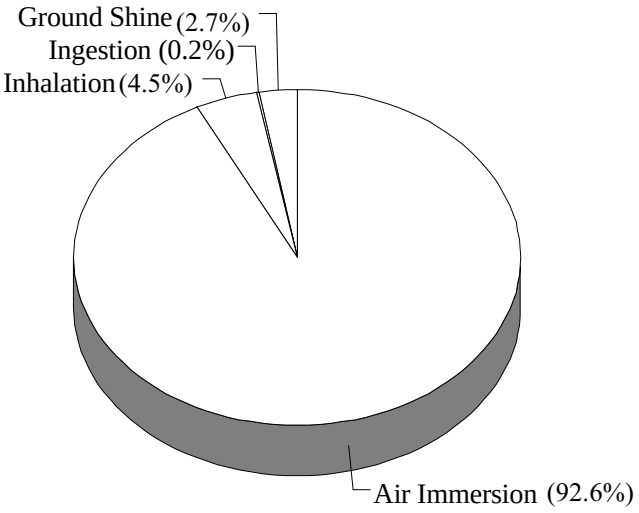


Figure V-22. The Laboratory's contribution to dose by pathway at the maximum exposed individual location.

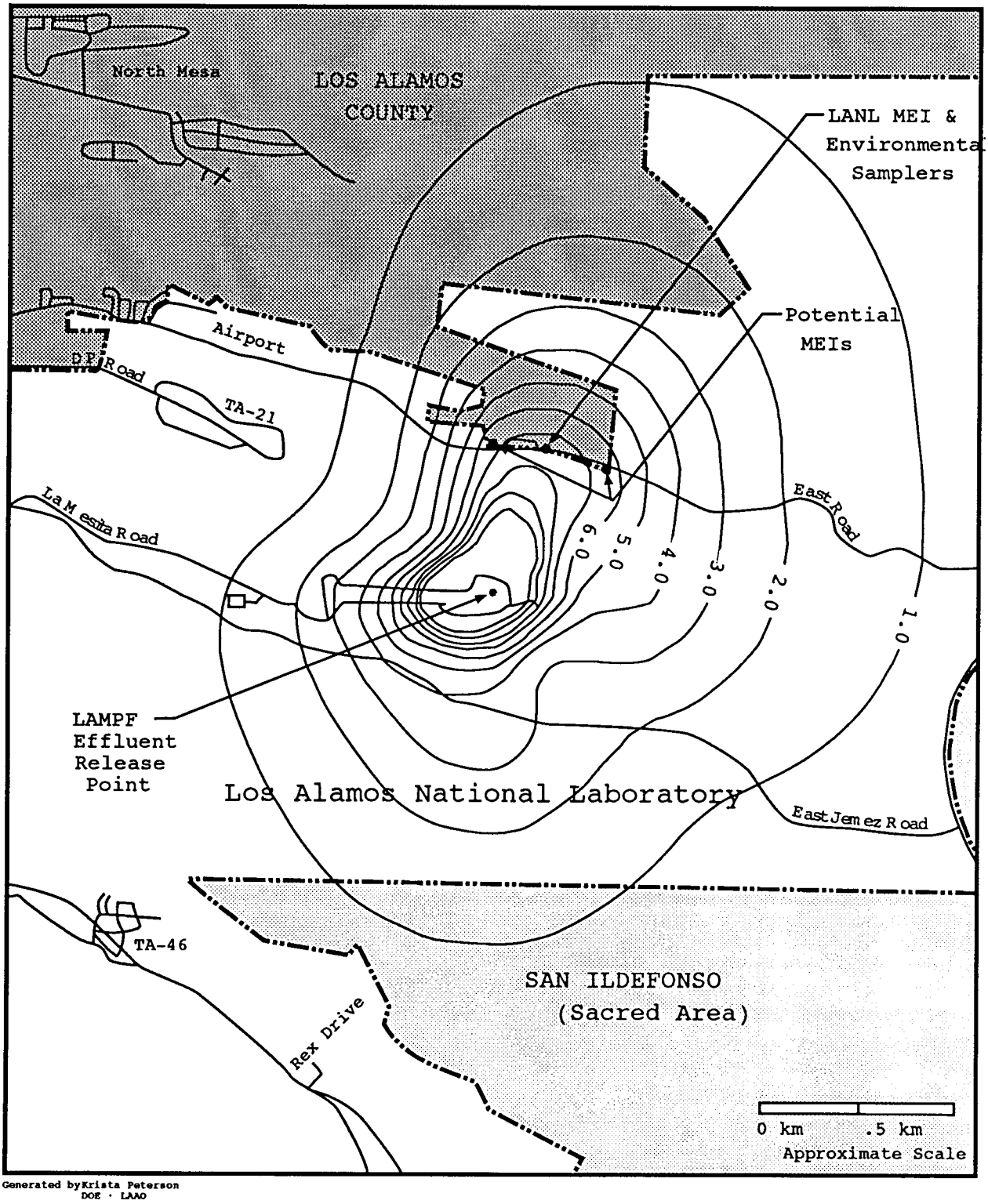


Figure V-23. CAP-88 calculated dose contours (mrem) for 1994 LAMPF airborne emissions.

Calculations for Laboratory airborne releases use the radionuclide emissions given in Tables V-4 and V-5. 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 7.62 mrem (0.0762 mSv). As expected, more than 98% of the maximum individual dose resulted from external exposure to air activation products from LAMPF. The maximum dose, which would occur in the area just northeast of LAMPF, is 76.2% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr) EDE. Presented in Figure V-23 is a contour plot of the estimated doses resulting from LAMPF air effluents in 1994. It should be noted that CAP-88 over estimates dose at the East Gate location because of the rough topography between the source and receptor, which is not accounted for in the computer code.

5. Collective Effective Dose Equivalents.

The collective EDE from 1994 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 1994 radioactive air emissions, their transport off-site, and the resulting radiation exposures that could occur.

The 1994 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 1994 population collective EDE attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory was calculated to be 4.0 person-rem (0.04 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-39).

The collective dose from Laboratory operations was calculated from measured radionuclide emission rates (Table V-5), atmospheric modeling using measured meteorological data for 1994, 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 (NCRP 1987a). The population distribution in Table II-3 was used in both these calculations to obtain the total collective dose.

Table V-39. Estimated Collective Effective Dose Equivalents during 1994 (person-rem)

Exposure Mechanism	Los Alamos County (18,400 persons)	80 km Region (234,000 persons)[a]
Total caused by Laboratory releases	3.7	4.0
Natural background		
Nonradon[b]	2,600	30,000
Radon	3,700	47,000
Totals caused by natural sources of radiation	6,300	77,000
Diagnostic medical exposures (~53 mrem/yr/person)[c]	1,000	12,000

[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). 1 person mrem = 0.01 person mSv

Also shown in Table V-39 is the collective EDE in Los Alamos County from Laboratory operations, natural background radiation, and medical and dental radiation. Approximately 90% of the total collective dose from Laboratory operations is to Los Alamos County residents. This dose is less than 0.1% of the collective EDE from background and 0.4% of the collective dose from medical and dental radiation, respectively.

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 vale, 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 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. Risk 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 nonradon 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 mrem. 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 is made for the leukemia risk. The risk is then averaged over male and female populations. The total risk estimate is 500 cancer (nonleukemia and leukemia) fatalities per 1×10^9 person-mrem (1×10^7 person mSv).

3. Risk 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 no 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 (3.7 Bq/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 (2 mSv/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 (2 mSv/yr). However, the 0.2 WLM/yr and the 200 mrem/yr (2 mSv/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 1994, persons living in Los Alamos and White Rock received an average EDE of 148 mrem (1.48 mSv) and 136 mrem (1.36 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 cancer mortality attributable to natural whole-body radiation in 1994 was approximately 1 chance in 15,000 in Los Alamos and approximately 1 chance in 17,000 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 was 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 approximately 1 chance in 14,000.

The total risk of cancer mortality from natural background radiation is approximately 1 chance in 8,000 for Los Alamos and White Rock residents (Table V-40). 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 1994 Laboratory activities were 0.27 and 0.06 mrem (0.0027 and 0.0006 mSv), respectively. These doses are estimated to add lifetime risks of cancer mortality of less than 1 in 1,000,000 (Table V-40). These risks are less than 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 approximately 1-in-4 chance of contracting cancer and approximately 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 50 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-40. Added Individual Lifetime Cancer Mortality Risks Attributable to 1994 Radiation Exposure

Exposure Source	EDE used in Risk Estimate (mrem)[a]	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.27	less than 1 in 1,000,000
White Rock area	0.06	less than 1 in 1,000,000
80-km region	0.02[b]	less than 1 in 1,000,000
Natural Radiation		
Cosmic, terrestrial, self-irradiation, and radon exposure[c]		
Los Alamos	348	1 in 7,000[d]
White Rock	336	1 in 6,000[d]
80-km region	329	1 in 6,000[d]
Medical X-Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in 38,000

[a]1 mrem = 0.01 mSv.

[b]Obtained by dividing the population dosse (Table V-39) by the number of people living within 80 km (50 mi) of the Laboratory.

[c]An EDE of 200 mrem (2.00 mSv) was used to estimate the risk from inhaling ^{222}Rn and its transformation products.

[d]The risks from natural radiation from nonradon sources were estimated to be 1 chance in 15,000 in Los Alamos and 1 chance in 17,000 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 conducting sampling, calculating and monitoring nonradioactive emissions and effluents, and evaluating unplanned releases.

Air pollutants are measured in the ambient air; all nonradioactive air emissions remained within federal limits during 1994. Other air quality indices, such as visibility and acidity of rainfall, are also measured by the Laboratory. These have no standards but are used in federal programs to track the effects of pollutants on other air-quality-related values.

Surface water is monitored to determine the Laboratory's impact on the environment; no observable effects are caused by Laboratory operations. Municipal and industrial water quality met federal and state standards during 1994.

Soils are monitored for trace metals; values for 1994 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. The nonradiological monitoring network consists of a variety of monitoring stations: 1 on-site primary (or "criteria") pollutant monitor, 17 beryllium monitors, 1 perimeter acid rain monitor, and 1 perimeter visibility monitoring station. In addition, the emissions from nonresearch sources are calculated annually because these sources are responsible for nearly all of the nonradiological air pollutant emissions at the Laboratory. Research sources vary continuously and have very low emissions. Therefore, emissions from these sources are not calculated annually; instead, each new or modified research source is addressed in the new source review process. The monitoring network and emissions calculations are described below.

b. Primary Pollutants Monitoring. Since 1990, the New Mexico Environment Department (NMED) has operated the Laboratory-owned criteria pollutant monitoring station at TA-49, adjacent to Bandelier National Monument. The original purpose of this site was to collect baseline data for Bandelier National Monument over a three-year period. In 1994, the National Park Service, NMED, and the Laboratory all agreed that the original purpose of the study was fulfilled and that the low levels of pollutants measured did not warrant further study at the site. Therefore, the monitoring was discontinued on September 30, 1994.

This station continuously monitored air concentrations of nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Particulate matter (PM) was not monitored continuously; instead, particles with a diameter of less than 10 microns (PM_{10}) were collected from filters every six days and weighed. The NMED analyzed all results and provided the results to the Laboratory. The data collected through September of 1994 are shown in Table VI-1. No federal ambient air quality standard was exceeded. The only state standard exceeded was the NM ambient hourly standard for ozone, which was exceeded in many areas of the state. The causes of these statewide levels 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, based on modeling results, as guidelines for setting allowable emission limits for regulated sources. At present, LANL is not affected by these emissions limits.

c. Beryllium Monitoring. The Laboratory conducts beryllium monitoring at 12 of the ambient radionuclide monitoring stations (AIRNET). The stations include 1 regional station, 5 perimeter stations, and 6 on-site stations.

Table VI-1. Nonradiological Ambient Air Monitoring Results for 1994

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary	Maximum Measured Concentration
Sulfur dioxide[a]	Annual arithmetic mean	ppm	0.02	0.03		0.001
	24 hours	ppm	0.10	0.14		0.009
	+ 3 hours	ppm			0.05	NC[b]
	+ 1 hour +	ppm				0.011
Particulate Matter$_{10}$[a]	Annual arithmetic mean	$\mu g/m^3$		50	50	8.2
	24 hours	$\mu g/m^3$		150	150	29
Ozone[a]	+ 1 hour +	ppm		0.12	0.12	0.090
Nitrogen dioxide[a]	Annual arithmetic mean	ppm	0.05	0.053	0.053	0.003
	24 hours	ppm	0.10			0.006
	+ 1 hour +	ppm				0.013
Beryllium[b]	Calendar quarter	ng/m^3				0.04
	30 day	ng/m^3	10			

[a]Measurements made at TA-49, near the boundary with Bandelier National Monument.
[b]NC = no concentration.

Biweekly samples are taken, composited quarterly, and analyzed; the data are shown for each site in Table VI-2. For 1994, all concentrations were well below the NM air standards.

d. Acid Precipitation Monitoring. LANL operates a wet deposition station that is part of the National Atmospheric Deposition Program (NADP) network. The station is located at the Bandelier National Monument perimeter station. In 1995, the National Park Service will begin operating the site, but the Laboratory will continue to pay for the analytical costs. The 1994 annual and quarterly deposition rates are presented in Table VI-3. The mean field pH is reported as a logarithmic mean. The NADP is in the process of analyzing the trend data for all stations; these data should be available by the end of 1995.

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 windblown 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.

e. Visibility Monitoring. Since October 1988, LANL, in conjunction with the National Park Service, has operated a visibility monitoring station, an optical transmissometer, on site (TA-49, TA-33) adjacent to Bandelier National Monument. Measurements are performed using protocols established for the National Park Service, the US 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 is expressed as visual range; the visual range for each season in 1994 is shown in Table VI-4. The National Park Service did not have statistics available for the entire calendar year, but based on data collected January through May of 1994, the visibility at the site is generally very good, with the visual range exceeding 104 km (64 mi) half of the time. On the clearest days (highest 10 percent of the data), visibility exceeds 133 km (82 mi).

Table VI-2. Airborne Beryllium Concentrations for 1994

Station	Location[a]	No. of Samples	Concentrations (ng/m^3) Maximum	Minimum	Mean	2s
REGIONAL STATION						
2	Pojoaque	4	0.032	0.002	0.017	0.025
PERIMETER STATIONS						
4	Barranca School	4	0.015	0.002	0.010	0.011
6	48th Street	4	0.012	0.002	0.007	0.010
7	Los Alamos Shell	3	0.012	0.009	0.010	0.003
12	Royal Crest	4	0.012	0.002	0.007	0.011
17	Bandelier	4	0.012	0.003	0.008	0.009
Group Summary		19	0.015	0.002	0.008	0.009
ON-SITE STATIONS						
23	TA-52 Beta Site	4	0.012	0.002	0.008	0.010
25	TA-16 S-Site	4	0.040	0.002	0.023	0.037
33	TA-3	4	0.016	0.002	0.010	0.012
Group Summary		12	0.040	0.002	0.014	0.025
TA-15 FIRING SITES						
76	TA-15-NNW	3	0.019	0.002	0.008	0.018
77	TA-15-NNE	3	0.025	0.002	0.012	0.024
78	TA-15-N	2	0.032	0.002	0.017	0.041
Group Summary		8	0.032	0.002	0.012	0.024

Table VI-3. Annual and Quarterly Wet Deposition Statistics for 1994

	Quarter				
	First	Second	Third	Fourth	Annual
Field pH (Log)					
Mean	5.6	5.0	4.7	5.2	5.1
Minimum	4.9	4.6	4.5	4.5	4.5
Maximum	6.3	5.6	4.9	5.9	6.3
Precipitation (microns)	6.75	9.66	13.17	14.96	44.54
Deposition (microequivalents per square meter)					
Ca	1,247.50	1,596.81	1,347.31	998.00	4,890.22
Mg	82.24	238.49	156.25	123.36	583.88
K	53.71	66.50	56.27	71.61	66.50
Na	100.04	356.66	152.23	361.01	969.94
NH_4	776.05	1,330.38	1,274.94	776.05	942.35
NO_3	387.16	1,790.61	2,758.51	1,129.21	6,162.28
Cl	56.41	310.23	225.83	338.44	958.91
SO_4	624.57	1,873.71	2,019.44	1,623.88	6,099.97
H(lab)	88.50	1,060.00	2,420.00	1,160.00	4,920.00
H(fld)	126.00	1,420.00	2,520.00	1,230.00	5,580.00

Table VI-4. Average Visibility Measured at Bandelier National Monument in 1994

Sampling Period	Visibility (km)	(mi)
Winter	107	66
Spring	106	66
Summer	118	73
Fall	138	86

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.

f. Emissions Calculations. The 1994 estimated emissions are shown in Table VI-5. These are sources that are typical of industries; the nonradiological emissions from research operations are insignificant compared with the listed "industrial" emissions sources.

The NO_x emissions from the TA-3 power plant are estimated based on a source test conducted on August 29, 1995. Emission factors for PM for the asphalt plant are calculated using the results of a source test conducted on August 25, 1993. The remainder of the emission factors were standard EPA factors (EPA 1993).

The largest single source of emissions at the Laboratory are the three plants (TA-3, TA-16, and TA-21) used to supply steam for heating. The steam plant at TA-3 also produces electricity when sufficient power from outside sources is not available; approximately one third of the emissions from TA-3 result from electricity production. The plants are primarily operated on natural gas but can use fuel oil as a backup. The only other significant sources of emissions at the Laboratory are also combustion sources. They are the standby generators that are each run about 168 hours per year for maintenance purposes, the large boilers (natural gas boilers of less than 5 million Btu/h design value are considered insignificant by NMED and are not included in the calculations), and a small incinerator burning mainly paper and rags.

2. Water and Effluent Monitoring.

a. Surface Water Monitoring. The results of major chemical constituents in surface water samples for 1994 are listed in Table VI-6. The results are generally consistent with those observed in previous years, with some expected variability. The measurements in waters from areas receiving effluents show an effect of these effluents.

The results of trace metal analyses on surface water samples for 1994 are listed in Table VI-7. The levels are generally consistent with previous observations. NM General Stream Standards for Livestock and Wildlife Watering (see Appendix A) were exceeded at a limited number of stations for aluminum, arsenic, and cadmium. None of these exceedances are believed to be significant, as they probably reflect natural environmental conditions. The aluminum standard was exceeded at the regional Rio Grande at Frijoles station, at the perimeter Chaquehui at Rio Grande station, and at the on-site Cañada del Buey station. The results invariably reflect the presence of suspended solids in the water samples. Because these metals analyses are performed on unfiltered water samples, the results will be artificially high due to naturally occurring metals (e.g., aluminum, arsenic, iron, manganese, selenium) associated with the suspended solids.

Table VI-5. Emissions by Source in 1994

Source Category	Emissions (tons/year) NO_x	SO_x	PM_{10}	CO	VOC
TA-3 Steam Plant	60	<1	2	18	1
TA-16 Steam Plant	2	<1	<1	<1	<1
TA-21 Steam Plant	4	<1	<1	1	<1
Stationary Generators	21	1	2	7	2
Boilers/Heaters	3	<1	<1	<1	<1
Incinerators	2	2	5	7	2
Asphalt Plan[a]	<1	<1	<1	<1	<1
Nonmaintenance Painting	<1	<1	1	<1	1
Total Other Sources	194	<9	<14	<37	<10

[a]Measured in 1993.

Table VI-6. Chemical Quality of Surface Water for 1994

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
REGIONAL STATIONS																	
Regional																	
Rio Chama at Chamita	14	35	7.8	2	12	3	0.1	<5[c]	82	0.1	48	8.50	<0.01	168	119	8.1	255
Rio Grande at Embudo	22	41	8.9	3	23	7	0.8	<5	123	<0.02	54	9.20	<0.01	242	138	8.1	349
Rio Grande at Otowi	17	34	2.7	4	28	5	0.3	<5	90	0.2	47	<0.04	<0.01	254	95	7.0	251
Rio Grande at Frijoles	43	210	16.0	6	13	5	0.3	<5	74	<0.02	22	<0.04	<0.01	186	104	8.3	175
Rio Grande at Cochiti	16	39	7.8	3	16	4	0.3	<5	97	0.02	48	5.90	<0.01	210	128	8.2	281
Rio Grande at Bernalillo	17	46	8.8	4	21	7	0.4	<5	109	0.04	54	9.70	<0.01	204	150	8.2	309
Jemez River	44	49	6.2	11	60	75	1.0	16	166	0.1	11	4.30	<0.01	364	146	8.8	508
PERIMETER STATIONS (OFF SITE)																	
Acid-Pueblo Canyons																	
Acid Weir	20	10	1.5	4	51	44	0.6	<5	57	0.4	8	<0.04	<0.01	200	30	7.0	260
Pueblo 1	22	16	3.1	5	48	47	0.2	<5	67	0.6	9	<0.04	<0.01	306	52	7.4	278
Los Alamos Canyon																	
Los Alamos Canyon Reservoir	36	9	3.0	<2	7	6	<0.1	<5	26	<0.02	4	1.60	<0.01	138	34	8.2	84
Other Areas																	
Pajarito at Rio Grande	68	<0.4	<0.2	<1	0.15	5	0.5	<5	88	0.1	6	0.72	<0.01	182	60	8.5	161
Frijoles at Monument HQ	48	11	3.3	<2	11	4	0.2	<10	55	0.1	3	2.00	<0.0	200	42	8.1	129
Frijoles at Rio Grande	60	10	3.4	3	12	5	0.2	<5	55	0.04	3	<0.04	<0.01	152	38	8.3	105
Chaquehui at Rio Grande	80	27	12.0	10	7	3	0.5	<5	60	0.02	3	<0.04	<0.01	136	41	7.9	105
ON-SITE STATIONS																	
Mortandad Canyon																	
Mortandad at GS-1	50	25	4.4	4	21	6	0.4	<5	84	0.1	7	5.00	<0.01	228	80	7.9	198
DP-Los Alamos Canyons																	
DPS-1	15	22	2.1	5	10	4	0.3	<5	53	0.2	5	<0.04	<0.01	120	63	7.9	110
DPS-4	23	15	1.8	7	29	20	1.1	<5	71	0.1	6	3.90	<0.01	170	44	7.1	211
Other Areas																	
Cañada del Buey	36	13	4.7	5	20	7	0.5	<5	58	0.05	10	1.90	0.02	432	51	6.8	145
Ancho at Rio Grande	76	15	3.8	3	12	3	0.4	23	75	<0.02	4	<0.04	<0.01	160	53	9.3	123

Table VI-6. Chemical Quality of Surface Water for 1994 (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
Sandia Canyon																	
SCS-1	100	25	5.1	11	86	111	1.6	<5	118	2.8	58	14.00	0.02	590	83	8.2	630
SCS-2	90	33	7.3	14	110	50	1.9	<5	139	2.7	63	20.00	<0.01	516	112	8.5	510
SCS-3	86	40	5.6	3	88	52	2.0	<5	143	2.6	48	10.00	<0.01	566	140	8.6	475
EPA Primary Drinking Water Standard[d]							4					10	0.2				
EPA Secondary Drinking Water Standard[d]						250					250			500		6.8-8.5	
EPA Health Advisory[d]					20												

[a]Total dissolved solids.
[b]Standard Units.
[c]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[d]Standards given here for comparison only, see Appendix A.

Table VI-7. Total Recoverable Trace Metals in Surface Water for 1994 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
REGIONAL STATIONS												
Regional												
Rio Chama at Chamita	<0.090[a]	3.60	0.004	<0.0100	0.070	<0.003	<0.003	<0.004	<0.0040	<0.004	2.10	0.0002
Rio Grande at Embudo	<0.090	0.20	0.003	0.0310	0.045	<0.003	<0.003	0.009	0.0060	0.008	0.14	<0.0001
Rio Grande at Otowi	<0.020	4.20	0.005	0.1400	0.370	0.050	0.051	0.050	0.2500	0.240	4.00	0.0001
Rio Grande at Frijoles	<0.010	14.00	0.003	0.0580	1.000	0.004	<0.003	0.029	0.0150	0.084	13.00	<0.0001
Rio Grande at Cochiti	<0.020	0.92	<0.002	0.0190	0.070	<0.003	<0.003	<0.003	0.0230	<0.004	0.75	0.0001
Rio Grande at Bernalillo	0.088	3.00	0.003	0.0350	0.190	<0.003	<0.003	<0.004	0.0460	<0.004	2.60	0.0001
Jemez River	<0.020	1.60	0.063	0.5700	0.100	<0.003	<0.003	<0.004	0.0460	<0.004	1.80	0.0001
PERIMETER STATIONS (OFF SITE)												
Acid-Pueblo Canyons												
Acid Weir	<0.010	2.90	0.003	0.0450	0.034	<0.003	<0.003	0.006	0.0060	0.014	1.90	0.0001
Pueblo 1	<0.010	1.80	0.003	0.0400	0.036	<0.003	<0.004	0.007	0.0060	0.014	1.40	0.0001
Los Alamos Canyon												
Los Alamos Canyon Reservoir	<0.030	2.00	<0.002	<0.0200	0.031	<0.003	<0.003	<0.004	<0.0040	<0.009	0.97	0.0001
Other Areas												
Pajarito at Rio Grande	0.096	0.23	0.002	0.2100	0.170	0.068	0.150	0.170	0.5100	0.520	0.26	<0.0001
Frijoles at Monument HQ[b]	<0.030	0.74	<0.005	<0.0297	0.019	<0.003	<0.003	<0.004	<0.0047	<0.009	0.48	<0.0002
Frijoles at Rio Grande	<0.010	0.17	<0.002	0.0110	0.022	<0.003	<0.003	<0.004	<0.0040	<0.004	0.24	<0.0001
Chaquehui at Rio Grande	<0.010	64.00	<0.002	<0.0100	0.620	0.005	<0.003	0.014	0.0360	0.033	60.00	<0.0001
ON-SITE STATIONS												
Mortandad Canyon												
Mortandad at GS-1	<0.020	4.70	0.002	0.0190	0.057	<0.001	<0.003	<0.004	<0.0040	0.012	2.50	<0.0001
DP-Los Alamos Canyons												
DPS-1	<0.010	4.60	0.003	0.0360	0.140	<0.003	<0.003	0.010	0.0170	0.021	3.70	0.0001
DPS-4	<0.010	2.90	0.003	0.0490	0.065	<0.003	<0.004	0.009	0.0080	0.013	1.80	0.0001
Other Areas												
Cañada Del Buey	0.013	19.00	0.005	0.0750	0.150	<0.003	<0.003	0.010	0.0180	0.070	13.00	0.0004
Pajarito Canyon	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
Ancho at Rio Grande	<0.010	0.93	<0.002	0.0110	0.043	<0.003	<0.003	<0.004	<0.0040	<0.004	0.89	<0.0001

*Data on additional trace metals from surface waters are presented on page 203.

Table VI-7. Total Recoverable Trace Metals in Surface Water for 1994 (mg/L) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
Sandia Canyon												
SCS-1	<0.200	2.00	<0.002	0.0420	0.047	<0.001	<0.003	<0.004	0.0220	0.023	1.50	0.0001
SCS-2	<0.200	3.30	0.005	0.4000	0.770	<0.001	0.150	0.160	0.7600	0.750	2.60	0.0001
SCS-3	<0.200	<0.10	0.006	0.0860	0.047	0.120	0.012	0.026	0.0170	0.024	0.09	<0.0001
EPA Primary Drinking Water Standard[d]			0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard[d]		0.05-0.2									0.3	
EPA Action Level[d]										1.3		
Livestock Wildlife Watering Limit[d]		5.0	0.2	5.0			0.05	1.0	1.0	0.5		0.01

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

[b]Results are the mean of more than one sample analysis.

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

[d]Standards given here for comparison only, see Appendix A.

*Data on additional trace metals from surface waters are presented on page 203.

Table VI-7. Total Recoverable Trace Metals in Surface Water for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
REGIONAL STATIONS											
Regional											
Rio Chama at Chamita	0.067	<0.008[a]	<0.200	<0.002	0.009	0.008	<0.03	0.270	<0.002	0.01	0.0220
Rio Grande at Embudo	0.040	0.016	<0.200	<0.002	0.003	0.008	<0.03	0.300	<0.002	0.02	<0.0200
Rio Grande at Otowi	0.330	0.051	0.250	0.005	<0.001	<0.002	<0.03	1.000	<0.001	0.04	0.0650
Rio Grande at Frijoles	1.600	<0.008	0.037	0.004	<0.001	<0.002	<0.03	0.420	<0.001	0.13	0.2100
Rio Grande at Cochiti	0.051	0.290	0.017	<0.001	<0.001	<0.002	<0.03	0.300	<0.001	0.00	0.0250
Rio Grande at Bernalillo	0.089	0.980	0.038	0.002	<0.001	<0.002	<0.03	0.350	<0.001	0.01	0.0240
Jemez River	0.069	<0.020	0.034	0.001	<0.001	<0.002	<0.03	0.210	<0.001	0.01	<0.0200
PERIMETER STATIONS (OFF SITE)											
Acid-Pueblo Canyons											
Acid Weir	0.012	<0.008	<0.010	0.004	<0.001	<0.002	<0.03	0.054	<0.001	<0.02	0.0270
Pueblo 1	0.099	<0.008	<0.010	0.002	<0.001	<0.002	<0.03	0.094	<0.001	<0.02	<0.0200
Los Alamos Canyon											
Los Alamos Canyon Reservoir	0.029	<0.010	<0.010	<0.002	<0.002	<0.002	<0.03	0.063	<0.002	<0.00	<0.0200
Other Areas											
Pajarito at Rio Grande	0.250	0.150	0.240	0.002	<0.001	<0.002	<0.03	0.510	<0.001	0.10	0.2500
Frijoles at Monument HQ[b]	0.032	<0.027	0.054	<0.002	<0.003	<0.004	<0.03	0.060	<0.002	<0.01	0.0639
Frijoles at Rio Grande	0.036	<0.008	<0.010	0.001	<0.001	<0.002	<0.03	0.066	<0.001	<0.00	<0.0200
Chaquehui at Rio Grande	0.870	<0.008	0.024	0.003	<0.001	<0.002	<0.03	0.060	<0.001	0.06	0.2300
ON-SITE STATIONS											
Mortandad Canyon											
Mortandad at GS-1	0.033	0.088	<0.010	<0.002	<0.002	<0.002	<0.03	0.077	<0.002	0.01	0.0240
DP-Los Alamos Canyons											
DPS-1	0.340	<0.008	<0.020	0.034	<0.001	<0.002	<0.03	0.098	<0.001	<0.02	0.1000
DPS-4	0.020	<0.008	<0.020	0.004	<0.001	<0.002	<0.03	0.088	<0.001	<0.02	<0.0200
Other Areas											
Cañada Del Buey	0.250	0.160	<0.020	0.011	<0.001	<0.002	<0.03	0.090	<0.001	0.02	0.1200
Pajarito Canyon	N/A[c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	0.024	<0.008	<0.010	0.006	<0.001	<0.002	<0.03	0.076	<0.001	0.01	<0.0200

Table VI-7. Total Recoverable Trace Metals in Surface Water for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Sandia Canyon											
SCS-1	0.067	0.820	0.027	0.006	<0.002	<0.002	<0.03	0.110	<0.002	0.02	0.0430
SCS-2	0.800	1.200	0.790	0.002	<0.002	<0.002	0.13	0.910	<0.002	0.09	0.2100
SCS-3	0.660	0.980	0.640	0.019	<0.002	<0.002	0.24	0.740	<0.002	0.08	0.1100
EPA Primary Drinking Water Standard[d]			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard[d]	0.05										5.0
EPA Action Level[d]				0.015							
EPA Health Advisory[d]								25-90		0.08-0.11	
Livestock Wildlife Watering Limit[d]				0.1						0.1	25.0

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

[b]Results are the mean of more than one sample analysis.

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

[d]Standards given here for comparison only, see Appendix A.

The arsenic stream standard was slightly exceeded at the Jemez River, consistent with the 1993 result. Arsenic is often found in elevated levels within volcanic settings like the Jemez Mountains. Cadmium values three times larger than the stream standard were detected at the perimeter Pajarito at Rio Grande station and at the on-site SCS-2 station. Sampling or analytical inaccuracies are suspected as the cause of the SCS-2 value, as none of the other stations upstream or downstream of SCS-2 within Sandia Canyon showed elevated levels on the same day. Results from the analysis of metals from the 1994 Pueblo 1 Perimeter Station meet stream standards, alleviating concerns raised by the 1993 sample result which showed values several times larger than the standards.

Analyses for organics in surface water were performed during 1994 at seven on-site stations (Cañada del Buey, Mortandad at GS-1, SCS-1, -2, and -3, and DPS-1 and -4), at two perimeter stations (Acid Weir, Pueblo 1), and at all regional stations. The parameters analyzed included the volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), except for the SCS stations which were tested only for VOCs (see Table D-22 for detailed listings of parameters). Of the 15 stations tested, 2 regional stations had traces of organic compounds detected. Possible traces of butyl-benzyl-phthalate were found in samples from the Jemez River and from the Rio Grande at Cochiti (both 11 ng/mL compared with the quantification limit of 10 ng/mL). At these trace levels, the source of the organics is likely to be from contamination of the water samples within the analytical laboratory, rather than being from the environment.

b. National Pollutant Discharge Elimination System. The Department of Energy (DOE) and the University of California have seven National Pollutant Discharge Elimination System (NPDES) permits. One permit covers the effluent discharges for 2 sanitary wastewater treatment facilities and 122 industrial outfalls at the Laboratory. A summary of these outfalls is presented in Table D-2. Another permit covers one industrial outfall at the hot dry rock geothermal facility located 50 km (30 mi) west at Fenton Hill. One permit covers storm water associated with industrial activity. Four additional permits are associated with construction activity. All 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 at the end of each monitoring period for each respective outfall category 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 1994. The new NPDES permit became effective on August 1, 1994.

During 1994, effluent limits were not exceeded in any of the 154 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 28 times in the 2,045 samples collected from the industrial outfalls. As shown in Figure III-1, overall compliance for the sanitary and industrial discharges during 1994 was 100% and 98.6%, respectively. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1994.

Administrative Order (AO) Docket No. VI-94-1242, issued to the Laboratory on June 15, 1994, incorporated the revised High Explosive (HE) Wastewater Treatment Facility schedule and the schedule for completion of the remaining corrective actions on the Waste Stream Characterization project. This order replaced AO VI-94-1210, which was closed on June 15, 1994.

AO Docket No. VI-94-1051 was issued to the Laboratory on July 6, 1994. The scope of this AO required the Laboratory to present corrective actions and plans to eliminate the NPDES permit violations that occurred at the Laboratory from 1990 through 1993 in a "show cause" meeting. The show cause meeting took place in Dallas, Texas, at EPA Region 6 on August 25, 1994. No further action has been taken by EPA.

TA-50 Liquid Waste Treatment Plant. Treated effluents from the liquid waste treatment plant at TA-50 are subject to NPDES permit limits. Table VI-8 presents information on the quality of effluent from the plant during 1994. The total effluent volume decreased slightly in 1994, with the majority of NPDES regulated constituents showing a decrease (see Section V.B.3.c 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

Table VI-8. Quality of Effluent Released from the TA-50 Radioactive Liquid Waste Treatment Plant in 1994

Mean Nonradioactive Constituents	Concentration (mg/L
Alkalinity-MO	422.
Alkalinity-P	7.
Al[a]	0.141
Sb	0.002
As[a]	0.00209
Ba	0.0128
Be	0.009
Cd[a]	0.00345
Ca	123.
Chloride	32.8
COD[a]	27.5
Conductivity	1,200.
CN	0.0525
Cu[a]	0.133
Fluoride	1.91
Fe[a]	0.174
Pb[a]	0.006
Mg	0.500
Hg[a]	0.00217
NH_3-N	5.50
Ni	0.0477
NO_2-N	1.18
NO_3-N	45.5
PO_4	0.334
K	11.2
Se[a]	0.00209
Ag[a]	0.00245
SO_4	46.6
N[a]	148.
TDS[b]	842.
Total cations	13.5
Total Cr[a]	0.0115
Total Hardness	124.
Va[a]	0.0615
Zn[a]	0.685
pH[a]	7.1 (su)
Total Effluent Volume (L)	2.08×10^7

[a]Regulated by NPDES permit.
[b]Total dissolved solids.

osmosis units are under evaluation to address their effectiveness in treating radioactive wastewater and providing better quality effluent.

c. 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, and from the Laboratory's water supply wellheads to ensure compliance with the federal 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, asbestos, and radioactivity in drinking water. These standards have been adopted by the State of NM 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 at four state certified laboratories: NM Health Department's Scientific Laboratory Division (SLD) in Albuquerque for VOCs, SOCs, inorganic constituents, and radioactivity; the Soil, Water, and Air Testing (SWAT) Laboratory at New Mexico State University in Las Cruces for synthetic organic compounds (SOCs), Triangle Laboratories of Durham, North Carolina, for dioxin; and QuanTEM Laboratories of Oklahoma City, Oklahoma, for asbestos. The SLD and SWAT laboratories report the analytical results directly to NMED. Triangle and QuanTEM laboratories report the analytical results to the Water Quality Group, who, in turn, transmits the results to NMED. The Johnson Controls, Inc. (JCI) Environmental (JENV) Laboratory also collects samples from the Laboratory, Los Alamos County, and Bandelier National Monument distribution systems and tests them 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. In 1994, the analytical results for inorganic constituents (Table VI-9), total trihalomethanes (Table VI-10), lead and copper (Table VI-11), VOCs (Table VI-12), SOCs (Table VI-13), and asbestos fibers (Table VI-14) in drinking water were all below the SDWA MCLs.

In 1994, inorganic constituents in drinking water were collected at each of the nine operating water supply wellheads and analyzed by SLD. Taps are flushed for several minutes so that samples represent water that is freshly drawn from the water main. As shown in Table VI-9, all locations and all parameters were below the MCLs.

In 1994, total trihalomethanes (TTHM) samples were collected during each quarter from six sites in the Laboratory and Los Alamos County water distribution systems. As is shown in Table VI-10, the annual average for TTHM was well below the SDWA MCL.

Table VI-9. Inorganic Constituents in Drinking Water in 1994 (mg/L)

	As	Ba	Be	Cd	Cr	F	CN	Hg	Ni	NO_3	SO_4	Se	Sb	Tl
Sample Location														
Wellheads														
Pajarito														
Well PM-1	<0.005[a]	<0.1	<0.001	<0.001	<0.005	0.3	<0.1	<0.0005	<0.01	0.4	7.0	<0.005	<0.001	<0.001
Well PM-2	<0.005	<0.1	<0.001	<0.001	<0.005	0.3	<0.1	<0.0005	<0.01	0.3	<5.0	<0.005	<0.001	<0.001
Well PM-3	<0.005	<0.1	<0.001	<0.001	0.004	0.3	<0.1	<0.0005	<0.01	0.4	7.0	<0.005	<0.001	<0.001
Well PM-4	<0.005	<0.1	<0.001	<0.001	0.005	0.3	<0.1	<0.0005	<0.01	0.3	<5.0	<0.005	<0.001	<0.001
Well PM-5	<0.005	<0.1	<0.001	<0.001	<0.005	0.3	<0.1	<0.0005	<0.01	0.3	<5.0	<0.005	<0.001	<0.001
Guaje														
Well G-1	0.008	<0.1	<0.001	<0.001	0.004	0.6	<0.1	<0.0005	<0.01	0.4	9.0	<0.005	<0.001	<0.001
Well G-1A	0.010	<0.1	<0.001	<0.001	0.007	0.6	<0.1	<0.0005	<0.01	0.4	6.0	<0.005	<0.001	<0.001
Well G-2	0.031	<0.1	<0.001	<0.001	0.007	0.9	<0.1	<0.0005	<0.01	0.4	6.0	<0.005	<0.001	<0.001
Well G-6	0.002	<0.1	<0.001	<0.001	0.002	0.3	<0.1	<0.0005	<0.01	0.4	<5.0	<0.005	<0.001	<0.001
EPA MCLs	0.05	2.0	0.004	0.005	0.10	4.0	0.20	0.002	0.1	10.0	250.0	0.05	0.006	0.002

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

Table VI-10. Total Trihalomethane Concentrations in Drinking Water in 1994 (μg/L)

	1994 Quarters			
Sampling Location	**First**	**Second**	**Third**	**Fourth**
Los Alamos Airport	4.10	5.80	9.20	13.40
White Rock Fire Station	N[a]	1.30	0.90	N
North Community Fire Station	3.60	1.60	2.50	N
S-Site Fire Station	0.70	2.90	4.80	1.20
Barranca School	1.30	1.80	1.80	2.90
TA-33, Bldg. 114	7.10	6.20	15.50	16.00
1994 Average	4.36 μg/L			
EPA MCL	100.00 μg/L			
Laboratory Practical Quantitation Level	2.00 μg/L			

[a]N = none detected above detection limit.

Table VI-11. Lead and Copper in Drinking Water in 1994

Values	**Lead**	**Copper**
Less than or equal to Detection Limit	65 samples	25 samples
Detectable but less than Action Level	3 samples	44 samples
Values greater than Action Level	1 sample	0 samples
Totals	69 samples	69 samples
Detection Limit	5 μg/L	50 μg/L
90th Percentile Value	<5 μg/L	160 μg/L
EPA Action Level	15 μg/L	1,300 μg/L

Table VI-12. Volatile Organic Compounds (VOCs) in Drinking Water in 1994

Sample Location	**VOC Group I 63 Compounds**
Pajarito Well Field	
Well PM-1	N[a]
Well PM-2	N[b]
Well PM-3	N
Well PM-4	N
Well PM-5	N[b]
Guaje Well Field	
Well G-1A	N
Well G-1	N
Well G-2	N
Well G-6	N

[a]N: None detected above detection limit.
[b]The presence of an unregulated compound was detected in the initial sample but not in the confirmation sample.

Table VI-13. Synthetic Organic Compounds (SOCs) in Drinking Water in 1994 (μg/L).

	EPA Method Number								
Sample Location	**525.1**	**515.1**	**505**	**549**	**548**	**547**	**531.1**	**1613A**	**504**
3rd Quarter 1994									
WELL HEADS									
Pajarito									
Well PM-1	N[a]	N	N	N	N	N	N	N	N
Well PM-2	N	N	N	N	N	N	N	N	N
Well PM-3	N	N	N	N	N	N	N	N	N
Well PM-4	N	N	N	N	N	N	N	N	N
Well PM-5	N	N	N	N	N	N	N	N	N
Guaje									
Well G1-A	N	N	N	N	N	N	N	N	N
Well G-1	2.10[b]	N	N	N	N	N	N	N	N
Well G-2	N	N	N	N	N	N	N	N	N
Well G-6	N	N	N	N	N	N	N	N	N
4th Quarter 1994									
WELL HEADS									
Pajarito									
Well PM-1	N	N	N	N	N	N	N	N	N
Well PM-2	N	N	N	N	N	N	N	N	N
Well PM-3	3.29[c]	N	N	N	N	N	N	N	N
Well PM-4	N	N	N	N	N	N	N	N	N
Well PM-5	N	N	N	N	N	N	N	N	N
Guaje									
Well G1-A	N	N	N	N	N	N	N	N	N
Well G-1	N	N	N	N	N	N	N	N	N
Well G-2	N	N	N	N	N	N	N	N	N
Well G-6	N	N	N	N	N	N	N	N	N

[a]N = No analyte was detected at sufficient concentrations to make an accurate quantitation.
[b]Bis(2-ethyhexyl)phthalate: MCL = 6.0 ppb
[c]Di(2-ethylhexyl)adipate: MCL = 400 ppb

Table VI-14. Asbestos Fibers in Drinking Water in 1994 (in MFL[a])

Sample Location	**Results** (MFL)
TA-53 Building 1	<0.2
TA-60 Building 1	<0.2
TA-15 Building 185	<0.2
TA-21 Building 229	<0.2
EPA MCL (Maximum Contaminant Level)	7

[a]MFL (Million Fibers per Liter, for fibers ≥10 microns in length)

In accordance with the requirements of the SDWA, the sampling program for lead and copper at residential taps that was initiated in 1992, continued in 1994. There is currently no set 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, then water suppliers must take prescribed actions to monitor and control the corrosivity of the water supplied to the customers. If 90% of the values for lead and copper are less than the action levels, then the system is in compliance without the need to implement corrosion control. As is shown in Table VI-11, during 1994, only one sample was above the EPA action level for lead, and none exceeded the action level for copper. Since the 90th percentile values for lead and copper were below the EPA action levels, the system is in compliance with the SDWA regulations for lead and copper in drinking water for 1994.

In 1994, VOC samples were collected from each of the nine operating water supply well heads and analyzed by SLD. As shown in Table VI-12, all locations were below the laboratory's detection limit and the MCL. At the PM-5 well, the presence of an unregulated compound was detected in the initial sample but was not found in the confirmation sample.

Microbiological Analyses of the Water Distribution System. Each month during 1994, an average of 48 samples was collected from the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the drinking water. During 1994, of the 581 samples analyzed, 5 indicated the presence of total coliforms, and 2 indicated the presence of fecal coliforms. Noncoliform bacteria were present in 27 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.

In the third and fourth quarters of 1994, sampling for SOCs was initiated at the nine operating water supply well heads, as required by the SDWA. Table VI-16 presents the nine categories of SOC contaminants and the laboratory conducting the analysis for each method.

Table VI-13 presents the analytical results for SOC sampling in the 3rd and 4th quarters of 1994; SOC concentrations at each of the nine well heads sampled were below the SDWA MCLs. In 2 of the method 525.1 analyses, phthalates or adipates were detected at concentrations greater than the minimum quantitation level of 2.0 ppb but below the compound's MCL. Phthalates and adipates are common plasticizers, present in most plastic products. Regulators from the NMED, Drinking Water Bureau, and analysts from the SLD laboratory have reported to LANL's Water Quality and Hydrology Group (ESH-18) that phthalates and adipates are routinely detected at low

Table VI-15. Bacteria in Drinking Water at Distribution System Taps in 1994

Month	Number of Samples Collected	Number of Positive Results		
		Coliform	Fecal Coliform	Noncoliform
January	68	3	2	8
February	47	0	0	2
March	46	0	0	0
April	46	0	0	2
May	45	0	0	2
June	45	0	0	0
July	46	0	0	0
August	48	0	0	2
September	53	2	0	4
October	45	0	0	5
November	45	0	0	1
December	47	0	0	1
Total	581	5	2	27
MCL		[a]	[b]	[c]

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

Table VI-16. Synthetic Organic Compounds (SOCs) Analytical Methods and Laboratories

	Contaminant	Laboratory	EPA Method
1.	Semivolatiles/Pesticides	SLD	525.
2.	Acid Herbicides	SLD	515.1
3.	PCBs & Endrin	SLD	505
4.	Diquat	SWAT[a]	549
5.	Endothall	SWAT[a]	548
6.	Glyphosate	SWAT[a]	547
7.	Carbamate Pesticides	SLD	531.1
8.	Dioxin	Triangle[b]	1613A
9.	EDB & DBCP	SLD	504

[a]New Mexico State University
Soil and Water Testing Laboratory (SWAT)
Las Cruces, NM
Accreditation:
NMED Approved Laboratory

[b]Triangle Labs of RTP, Inc.
Durham, NC
Accreditation:
NMED Approved Laboratory

concentrations due to sample contamination during collection or laboratory analysis. The Drinking Water Bureau and SLD support ESH-18's conclusion that their presence at low concentrations in two samples is most likely an indicator of sample contamination and not contamination of the groundwater. Personnel from ESH-18 are working closely with SLD analysts to eliminate all identifiable sources of phthalate and adipate contamination. Sampling for SOCs will continue during the 1st and 2nd quarters of 1995.

In 1994, as required by the SDWA, sampling for asbestos fibers in drinking water was initiated at four locations within the Laboratory which are served by asbestos-cement lines. Samples were submitted to QuanTEM Laboratories of Oklahoma City, OK, for analysis by Transmission Electron Microscopy (TEM), the method approved by the EPA. As is shown in Table VI-14, all locations sampled were below the MCL of 7 MFL (million fibers per liter, for fibers >10 microns in length). Asbestos sampling of the well heads will not be conducted unless a statewide waiver is lifted or until the NMED determines that the Los Alamos Water System has a vulnerability to source water contamination from asbestos.

d. Sewage Sludge Monitoring. This program includes sampling of the sewage sludge generated at the TA-46 Sanitary Wastewater System Consolidation (SWSC) plant as part of routine wastewater treatment operations. Sampling of sewage sludge is conducted in accordance with 40 CFR Part 503 regulations, which require that the Laboratory collect representative samples of sewage sludge prior to land application in order to demonstrate that the sludge is not a hazardous waste and that it meets the minimum standards for pollutant concentrations. Sludge samples are analyzed for Toxicity Characteristic Leaching Procedure (TCLP) metals and organics, total metals, physical parameters, agronomic parameters, and polychlorinated biphenyls (PCBs) by an EPA approved contract laboratory. Additionally, all samples are analyzed for radiochemistry by the Inorganic Trace Analysis Group's radiation laboratory. During 1994, all analytical results from the monitoring of SWSC plant sewage sludge were in full compliance with federal standards. Table VI-17 presents the analytical results of sludge monitoring conducted in 1994.

3. Soils Monitoring.

Soils were also analyzed for trace and heavy metals. These data will ultimately be used to establish a database of results comparable to those reported by other agencies such as the US Geological Survey (USGS); these data are meaningful from a Laboratory operation/effects standpoint as well as for geochemical process. The results of the 1994 soil sampling program are found in Table VI-18.

The average concentrations of all heavy metals measured in soils collected from perimeter and on-site areas, with the exception of beryllium, were not significantly higher than metals in soils collected from regional (background) stations. Most, in fact, are within the range of metals normally encountered in the Los Alamos area (Ferenbaugh 1990) and continental United States (Shacklette 1984). Beryllium concentrations, on the other hand, were significantly higher in both perimeter and on-site stations than in background soils. This was the same case as in 1993. Although the average concentrations of beryllium in soils collected from perimeter and on-site stations were significantly higher than background, they were still within the regional statistical reference level (RSRL) (<0.96 μg/g) and within the range of concentrations for beryllium in the Los Alamos area (1.1 to 3.3 μg/g) (Ferenbaugh 1990) and continental US (<1 to15 μg/g) (Shacklette 1984). Also, beryllium levels were far below the Laboratory's screening action level.

Table VI-17. Minimum, Mean, and Maximum Values for Sewage Sludge Analyses Conducted in 1994

Contaminant (Total)	Minimum (mg/kg)	Mean (mg/kg)	Maximum (mg/kg)	Pollutant Limits[a] (mg/kg)
Arsenic	2	4	5	75
Cadmium	4	5	6	85
Chromium	88	119	160	3,000
Copper	400	472	530	4,300
Lead	180	293	560	840
Mercury	1	5	9	57
Molybdenum	18	37	52	75
Nickel	18	22	26	420
Selenium	2	4	5	100
Zinc	3,500	3,967	4,700	7,500

[a]40 CFR Part 503 Table 1 Pollutant Ceiling Concentrations.

4. Sediment Monitoring.

a. Trace Metals. 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 USGS. 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 (Monitoring Network). All of the sediment sampling locations are shown in Figure V-14 (Off-Site Regional Stations), Figure V-15 (Off-Site Perimeter and On-Site Stations), and Figure V-16 (Solid Waste Management Areas). All of these locations are also listed in Table D-14.

Trace metal results for the sediment samples collected in 1994 are presented in Table VI-19. None of the results show any indication of any significant accumulations of metals above what can be attributed to natural concentrations. Before September 1992, at least two different sediment sample preparation procedures were employed by the Laboratory. Before March 1992, all soil and sediment samples were analyzed using the EPA's TCLP to determine whether any sediments or soils exceeded the criteria for hazardous wastes. None of these pre-1991 sediment samples exceeded or even approached the Resource Conservation and Recovery Act hazardous waste criteria. However, a more environmentally sensitive and meaningful surveillance database was sought. Around March 1992, the TCLP was modified to include nitric acid with small additions of hydrofluoric acid in glass digestion vessels; hence, this procedure represented a total digestion process. Beginning in September of 1992, all soil and sediment samples were prepared in the laboratory following EPA procedures specified in SW-846 Method 3050. Differences in individual station concentration values between 1992 and the 1993 and 1994 data sets for specific metals may occur due to variability in nature or in laboratory sample preparation procedures. Since there were no laboratory analytical or procedural changes between 1993 and 1994, the data from these sample times should reflect only natural variability. Some of the effects that these procedural differences can potentially have on metals data are summarized below.

Reported detection limits for antimony, mercury, and molybdenum increased during 1992 to 1994 (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 1994; in addition, the sediment sample preparation procedures also changed. The reported 1992 iron values were two to three times higher than their respective counterparts in 1994. In addition, the 1992 aluminum values were about 10 times larger than their 1994 counterparts. Note that the reported 1992 values for aluminum and iron in Table IV-22 of the "Environmental Surveillance at Los Alamos during 1992" (EPG 1994) should each be multiplied by a factor of 10; this omission resulted from a units conversion error. The concentration differences between aluminum and iron values are probably due to changes in sample preparation procedures mentioned above. A more complete analysis of all trace metal concentration levels will be made once the 1995 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

Tables VI-18. Total Recoverable Trace and Heavy Metals (μg/g) in Soils Collected in 1994[a]

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl
Rio Chama	4.7	N/A[b]	160.0	0.38	<0.40[c]	14.0	0.03	13.0	17.0	N/A	<0.30	N/A
Embudo	<1.0[c]	1.00	82.0	0.21	<0.40	9.3	0.03	7.7	8.5	N/A	<0.30	N/A
Otowi	<1.0	—	63.0	0.22	0.46	5.7	0.03	8.7	23.0	N/A	0.50	N/A
Santa Cruz	4.3	—	160.0	0.52	<0.40	14.0	0.03	11.0	14.0	N/A	<0.30	N/A
Cochiti	<1.0	—	130.0	0.46	<0.40	12.0	0.04	15.0	10.0	N/A	0.30	N/A
Bernalillo	<1.0	—	60.0	<0.08	<0.40	3.2	0.03	2.0	6.4	N/A	0.50	N/A
Jemez	<1.0	3.00	130.0	0.37	<0.40	8.1	0.02	9.4	4.7	N/A	0.60	N/A
Mean (± 2SD)	<2.0 (3.4)	2.00 (2.83)	112.1 (86.6)	<0.32 (0.31)	<0.41 (0.05)	9.5 (8.3)	0.03 (0.01)	9.5 (8.4)	11.9 (12.9)		<0.40 (0.26)	
RSRL[d]	<3.9	6.43	227.5	0.96	<0.54	17.9	<0.04	15.5	22.4	<0.30	<1.28	3.6
SAL[e]	400.0	6.43[f]	5,600.0	0.96[f]	80.00	400.0	24.00	1,600.0	500.0	32.00	400.00	6.4
OFF-SITE PERIMETER STATIONS												
Sportsman's Club	<1.0	4.00	160.0	0.82	<0.40	11.0	0.05	8.9	19.0	N/A	<0.30	N/A
North Mesa	<1.0	3.00	99.0	0.56	<0.40	8.3	0.03	6.8	6.9	N/A	<0.30	N/A
TA-8	<1.0	2.00	70.0	0.34	<0.40	6.7	0.05	4.9	9.2	N/A	<0.30	N/A
TA-49	<1.0	4.00	84.0	0.36	<0.40	9.0	0.04	4.6	17.0	N/A	<0.30	N/A
White-Rock	<1.0	2.00	130.0	0.76	<0.40	10.0	0.03	5.8	34.0[g]	N/A	<0.30	N/A
Tsankawi	<1.0	1.00	49.0	0.67	<0.40	4.2	0.02	3.7	16.0	N/A	<0.30	N/A
Mean (± 2SD)	<1.0 (0.0)	2.67 (2.42)	98.7 (81.2)	0.59 (0.40)[h]	<0.40 (0.00)	8.2 (4.9)	0.04 (0.02)	5.8 (3.7)	17.0 (19.1)		<0.30 (0.00)	
ON-SITE STATIONS												
TA-21	<1.0	6.0	130.0	0.83	<0.40	10.0	0.03	7.5	39.0[g]	N/A	<0.30	N/A
East of TA-53	<1.0	2.0	57.0	0.38	<0.40	6.6	0.02	4.0	14.0	N/A	<0.30	N/A
TA-50	<1.0	2.0	110.0	0.58	<0.40	8.1	0.02	5.6	11.0	N/A	<0.30	N/A
2-Mile Mesa	<1.0	2.0	76.0	0.17	0.50	4.0	0.03	3.0	14.0	N/A	<0.30	N/A
East of TA-54	<1.0	1.0	66.0	0.37	<0.40	5.7	0.02	4.6	11.0	N/A	<0.30	N/A
R-Site-RD-E	<1.0	3.0	140.0	0.74	0.46	11.0	0.03	9.1	17.0	N/A	<0.30	N/A
Potrillo-DR	<1.0	3.0	120.0	0.64	<0.40	8.8	0.03	7.9	11.0	N/A	<0.30	N/A
S-Site	<1.0	2.0	82.0	0.36	<0.40	6.8	0.04	4.1	10.0	N/A	<0.30	N/A
Near Well DT9	<1.0	3.0	150.0	0.63	<0.40	8.4	0.03	7.3	20.0	N/A	<0.30	N/A
Near TA-33	<1.0	2.0	80.0	0.62	<0.40	12.0	0.04	7.5	46.0 [g]	N/A	<0.30	N/A
Mean (± 2SD)	<1.0 (0.0)	2.6 (2.7)	101.1 (66.0)	0.53 (0.41)[h]	<0.42 (0.07)	8.1 (4.9)	0.03 (0.01)	6.1 (4.1)	19.3 (25.4)		<0.30 (0.00)	

[a]Analysis by EPA Method 3051 for total recoverable metals.

[b]Analysis not performed or lost in analysis.

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

[d]RSRL (Regional Statistical Reference Level; this is the upper-limit background concentration [mean + 2 std dev] from Fresquez 1995).

[e]SAL (Los Alamos National Laboratory Screening Action Level).

[f]The SAL guidelines refer the use of the upper-limit background concentration for these elements.

[g]Equal or higher than the RSRL.

[h]Statistically significant (mean) from background (mean) using a Student's t-test at the 0.05 probability level.

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
REGIONAL STATIONS												
Regional												
Rio Chama at Chamita	3.0	2,200.0	2.00	1.0	73.0	<0.08[a]	1.00	5.40	8.90	2.50	9,400.0	<0.02
Rio Grande at Embudo	3.0	4,300.0	4.00	<1.0	120.0	<0.08	0.90	6.60	12.00	11.00	14,000.0	0.02
Rio Grande at Otowi	<1.0	1,300.0	3.00	<1.0	46.0	<0.08	<0.40	2.30	5.70	<0.50	7,900.0	0.02
Rio Grande at Frijoles	<1.0	970.0	<0.50	<1.0	14.0	0.14	<0.40	0.96	0.55	2.40	2,100.0	0.03
Rio Grande at Bernalillo	3.0	200.0	3.00	3.0	64.0	<0.08	0.80	4.20	5.70	4.80	9,300.0	0.02
Jemez River	3.0	3,900.0	4.00	5.0	100.0	<0.08	0.60	6.80	7.20	3.20	6,800.0	0.02
Rio Grande in White Rock Canyon												
Rio Grande at Sandia	<1.0	3,300.0	1.90	<1.0	110.0	0.29	<0.40	2.40	4.60	3.90	5,400.0	0.03
Rio Grande at Pajarito	<1.0	4,700.0	2.10	2.6	94.0	0.47	0.63	3.20	7.20	2.60	7,400.0	0.03
Rio Grande at Water	<1.0	13,000.0	4.50	2.2	450.0	0.77	<0.40	6.90	13.00	6.20	12,000.0	0.06
Rio Grande at Ancho	<1.0	6,100.0	3.00	2.0	110.0	0.45	0.60	4.30	7.80	6.10	8,700.0	0.04
Rio Grande at Chaquehui	<1.0	4,000.0	2.10	<1.0	120.0	0.49	0.70	3.10	5.40	2.60	6,000.0	0.04
PERIMETER STATIONS (OFF SITE)												
Acid-Pueblo Canyon												
Acid Weir	<1.0	1,800.0	1.00	<1.0	38.0	<0.08	0.62	3.70	4.20	3.20	5,000.0	0.04
Pueblo 1	<1.0	1,100.0	0.50	<1.0	21.0	<0.08	0.79	1.30	1.80	2.90	2,700.0	0.02
Pueblo 2	4.0	1,800.0	0.50	<1.0	20.0	<0.08	0.60	1.60	2.00	2.00	8,000.0	0.02
DP-Los Alamos Canyon												
Los Alamos at Totavi	<1.5	1,300.0	<0.30	<1.0	27.0	<0.08	<0.40	0.79	1.60	2.00	2,200.0	<0.02
Los Alamos at LA-2	3.7	1,900.0	65.00	<1.0	39.0	<0.08	0.46	2.70	15.00	4.60	22,000.0	0.02
Los Alamos at Otowi	15.0	2,600.0	<0.30	<1.0	28.0	<0.08	<0.40	1.60	3.30	1.80	3,600.0	<0.02
Other Areas												
Guaje at SR 4	2.9	2,500.0	0.60	<1.0	53.0	<0.08	<0.40	2.60	12.00	7.30	17,000.0	<0.02
Bayo at SR 4	<1.0	2,000.0	0.40	2.9	32.0	<0.08	<0.40	1.90	2.80	3.00	3,300.0	<0.02
Sandia at Rio Grande	<1.0	3,600.0	1.00	<1.0	52.0	0.39	<0.40	1.70	3.70	4.30	4,700.0	<0.01
Cañada Ancha at Rio Grande	<1.0	5,800.0	13.00	<1.0	130.0	0.48	0.51	3.80	5.00	4.90	6,300.0	0.03
Pajarito at Rio Grande	<1.0	1,200.0	0.50	1.6	15.0	0.11	<0.40	0.79	2.90	2.40	2,600.0	0.04
Water at Rio Grande	<1.0	8,000.0	2.40	2.5	240.0	0.62	0.57	6.40	7.10	12.00	12,000.0	0.04
Ancho at Rio Grande	<1.0	7,700.0	2.80	2.4	140.0	0.59	<0.40	3.80	7.30	7.60	8,300.0	0.04
Chaquehui at Rio Grande	<1.0	3,100.0	0.70	<1.0	55.0	0.31	<0.40	2.60	3.10	5.00	6,000.0	0.03
Frijoles at Monument HQ	<1.5	2,600.0	1.00	<1.0	32.0	<0.08	<0.40	1.40	2.90	7.80	3,900.0	<0.02
Frijoles at Rio Grande	<1.0	380.0	<0.50	<1.0	4.9	0.10	<0.40	0.73	0.58	2.10	820.0	0.03
Sandia Canyon Stations												
Station 1	<1.0	1,600.0	0.80	3.0	18.0	<0.08	<0.40	1.20	4.60	2.20	2,400.0	<0.02
Station 2	<1.0	1,900.0	1.00	<1.0	27.0	0.08	<0.40	2.10	6.20	2.60	2,900.0	<0.02
Station 3	<1.0	2,800.0	10.00	1.0	39.0	0.11	<0.40	1.90	3.00	2.70	3,300.0	<0.02

*Data on additional trace metals from sediments are on page 217.

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
Mortandad Canyon on Pueblo of San Ildefonso Lands												
Mortandad A-6	<1.0	1,400.0	<0.50	1.0	15.0	0.17	<0.40	1.00	1.20	<0.50	4,200.0	<0.02
Mortandad A-7	<1.0	3,600.0	2.00	<1.0	61.0	0.47	<0.40	3.00	3.20	3.80	5,900.0	<0.02
Mortandad A-8	<1.0	4,000.0	2.00	<1.0	63.0	0.46	<0.40	2.80	3.30	3.50	5,600.0	<0.02
Mortandad at SR 4 (A-9)	<1.0	3,900.0	1.30	3.0	62.0	0.22	<0.40	5.00	9.20	6.20	4,800.0	<0.02
Mortandad A-10	<1.0	5,900.0	2.00	<1.0	100.0	0.60	<0.40	5.00	5.00	5.00	7,200.0	<0.02
Mortandad at Rio Grande (A-11)	<1.0	2,500.0	1.90	<1.0	80.0	0.29	0.58	2.50	4.40	4.20	4,800.0	0.04
Mortandad at Transect	<1.0	6,300.0	2.40	<1.0	110.0	0.89	0.70	5.90	5.50	7.70	9,200.0	<0.02
ON-SITE STATIONS												
Acid-Pueblo Canyons												
Hamilton Bend Spring	3.0	2,000.0	0.70	<1.0	30.0	<0.90	0.70	3.50	1.80	2.40	3,800.0	0.03
Pueblo 3	2.0	N/A[b]	0.60	N/A	N/A	<0.08	0.50	N/A	1.40	4.30	2,500.0	<0.02
Pueblo at State Route	<1.0	1,300.0	0.60	<1.0	14.0	0.02	<0.40	1.70	6.10	2.50	25,000.0	<0.02
DP-Los Alamos Canyons												
DPS-1	<1.5	1,700.0	1.00	<1.0	19.0	<0.08	<0.40	1.20	2.50	2.70	4,000.0	0.02
DPS-4	13.0	1,200.0	2.00	1.1	17.0	<0.08	<0.40	1.30	1.90	7.90	2,500.0	< 0.02
Los Alamos at Bridge	<1.0	1,700.0	1.00	<1.0	19.0	0.23	<0.40	4.20	2.60	1.90	4,200.0	<0.02
Los Alamos at LAO-1	<1.0	1,100.0	1.00	<1.0	14.0	0.14	<0.40	2.80	3.60	2.60	2,300.0	0.03
Los Alamos at GS-1	<1.0	1,500.0	0.70	2.5	19.0	0.20	<0.40	2.10	1.80	1.20	2,500.0	0.02
Los Alamos at LAO-3	<1.0	2,300.0	2.00	<1.0	27.0	0.34	0.54	4.20	3.60	2.10	5,300.0	0.02
Los Alamos at LAO-4.5	<1.0	1,600.0	1.00	<1.0	16.0	0.20	<0.40	2.10	2.40	11.00	3,900.0	0.03
Los Alamos at SR 4	<1.0	2,300.0	0.60	2.5	22.0	<0.08	<0.40	1.40	3.10	3.00	3,900.0	<0.02
Mortandad Canyon												
Mortandad Near CMR Building	<1.0	2,000.0	0.50	<1.0	18.0	<0.08	<0.40	2.20	3.40	2.50	4,200.0	<0.02
Mortandad West of GS-1	<1.0	860.0	0.30	1.3	10.0	<0.08	0.66	0.82	1.10	2.30	1,300.0	<0.02
Mortandad at GS-1	<1.0	2,600.0	0.70	<1.0	14.0	<0.08	<0.40	1.20	2.50	1.30	5,600.0	0.02
Mortandad at MCO-5	<1.0	1,600.0	0.40	<1.0	18.0	<0.08	0.49	0.83	1.40	3.50	2,500.0	<0.02
Mortandad at MCO-7	<1.0	2,800.0	0.50	<1.0	22.0	<0.08	<0.40	1.10	2.50	3.20	5,300.0	0.03
Mortandad at MCO-9	<1.0	6,200.0	2.00	1.5	63.0	0.48	0.70	2.90	4.50	5.10	6,800.0	<0.02
Mortandad at MCO-13 (A-5)[c]	<1.0	4,400.0	0.97	1.2	45.0	0.24	0.62	2.25	3.45	4.30	5,050.0	<0.02
Other Canyons												
Sandia at SR 4	<1.0	1,700.0	0.40	3.2	16.0	<0.08	<0.40	1.60	5.30	3.10	2,300.0	<0.02
Cañada Del Buey at SR 4	<1.0	2,700.0	0.70	2.1	41.0	<0.08	<0.40	2.30	1.90	3.00	2,600.0	<0.02
Pajarito at SR 4	<1.0	15,000.0	3.00	5.7	120.0	0.54	<0.40	11.00	14.00	12.00	14,000.0	<0.02
Potrillo at SR 4	<1.0	4,100.0	1.00	2.9	31.0	0.12	<0.40	2.80	3.40	3.40	5,300.0	<0.02
Fence at SR 4[c]	<1.0	7,250.0	1.70	2.8	72.5	0.76	<0.40	2.90	6.30	5.20	7,550.0	0.02
Water at SR 4	<1.0	2,900.0	1.10	4.8	41.0	<0.08	<0.40	2.00	2.50	3.20	4,200.0	<0.02
Indio at SR 4	<1.0	3,400.0	0.90	<1.0	27.0	0.15	<0.40	2.60	2.50	2.00	4,300.0	0.02
Ancho at SR 4	<1.0	3,400.0	0.80	2.4	20.0	<0.08	<0.40	<0.50	2.70	2.70	6,000.0	<0.02
Ancho at Ancho Spring	<1.0	770.0	<0.50	<1.0	9.9	0.18	<0.40	0.62	0.64	2.00	1,400.0	0.04

*Data on additional trace metals from sediments are on page 217.

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
TA-54, Area G												
G-1	<1.0	6,900.0	2.00	<1.0	59.0	0.34	<0.40	2.90	5.70	3.40	7,900.0	<0.02
G-2	<1.0	4,000.0	1.00	<1.0	57.0	0.17	<0.40	3.00	4.50	0.95	16,000.0	<0.02
G-3	<1.0	7,400.0	<0.50	1.5	83.0	0.48	<0.40	4.10	8.10	5.70	8,400.0	0.02
G-4	<1.0	6,000.0	1.00	<1.0	46.0	0.31	<0.40	4.30	8.20	1.50	12,000.0	<0.02
G-5	<1.0	8,800.0	<0.50	1.4	59.0	0.43	<0.40	3.60	6.90	2.60	8,300.0	<0.02
G-6	<1.0	1,1000.0	1.00	2.2	78.0	0.69	<0.40	2.90	9.20	6.50	11,000.0	0.02
G-7	<1.0	2,100.0	1.00	<1.0	39.0	0.21	<0.40	3.30	2.20	3.60	2,500.0	0.02
G-8	<1.0	5,000.0	1.00	1.3	29.0	1.10	1.10	3.70	4.90	<0.40	4,800.0	<0.02
G-9	<1.0	5,500.0	1.00	<1.0	57.0	0.56	<0.40	4.40	6.20	<0.50	8,200.0	<0.02
TA-49, Area AB												
AB-1	<1.0	13,000.0	3.00	1.8	140.0	2.10	1.70	6.70	13.00	12.00	12,000.0	0.02
AB-2	<1.0	10,000.0	4.00	<1.0	140.0	<1.00	<1.00	8.90	11.00	9.20	12,000.0	0.02
AB-3	<1.0	,700.0	2.00	<1.0	81.0	<1.00	<1.00	2.80	6.10	5.60	5,800.0	0.02
AB-4	<1.0	11,000.0	0.90	1.6	190.0	<1.00	<1.00	5.20	7.90	9.40	9,300.0	0.03
AB-4A	<1.0	8,700.0	2.00	<1.0	110.0	<1.00	<1.00	3.40	6.50	6.10	8,100.0	<0.02
AB-5	<1.0	19,000.0	1.00	1.6	160.0	1.40	<1.00	5.50	12.00	7.70	13,000.0	0.03
AB-6	<1.0	6,000.0	2.00	<1.0	90.0	<1.00	<1.00	2.90	5.20	7.10	7,200.0	0.02
AB-7	<1.0	14,000.0	<0.50	3.1	150.0	2.90	2.30	8.30	13.00	9.10	13,000.0	<0.02
AB-8	<1.0	2,500.0	2.00	<1.0	31.0	<1.00	<1.00	1.30	2.60	2.50	4,800.0	<0.02
AB-9	<1.0	4,400.0	2.00	<1.0	87.0	<1.00	<1.00	2.90	3.70	5.20	7,200.0	0.02
AB-10	<1.0	8,800.0	2.00	1.6	72.0	<1.00	<1.00	3.60	7.60	4.40	9,300.0	<0.02
AB-11	<1.0	5,700.0	2.00	<1.0	67.0	<1.00	<1.00	4.50	5.20	3.40	7,600.0	<0.02

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]N/A means analysis not performed, lost in analysis or not completed.
[c]Results averaged from more than one analysis.

*Data on additional trace metals from sediments are on page 217.

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
REGIONAL STATIONS											
Regional											
Rio Chama at Chamita	130.00	<0.90[a]	<2.00	<4.00	<0.50	<0.30	<4.00	21.0	<0.50	28.00	18.00
Rio Grande at Embudo	390.00	3.90	10.00	6.00	<0.50	<0.30	<4.00	26.0	<0.50	24.00	53.00
Rio Grande at Otowi	110.00	<0.90	<10.00	<10.00	<0.25	0.50	<4.00	9.5	<0.25	21.00	15.00
Rio Grande at Frijoles	97.00	<0.90	<2.00	<4.00	<0.20	<0.30	<4.00	3.4	< 0.20	1.50	14.00
Rio Grande at Bernalillo	160.00	<0.90	2.00	<4.00	<0.50	<0.30	<4.00	28.0	<0.50	19.00	20.00
Jemez River	290.00	<0.90	<2.00	<4.00	<0.50	<0.30	<4.00	36.0	<0.50	13.00	21.00
Rio Grande in White Rock Canyon											
Rio Grande at Sandia	110.00	<0.90	<2.00	<4.00	<0.20	2.70	<4.00	51.0	<0.20	12.00	13.00
Rio Grande at Pajarito	150.00	3.50	5.80	10.00	<0.20	1.90	<4.00	44.0	<0.20	15.00	19.00
Rio Grande at Water	340.00	2.20	11.00	10.00	<0.20	0.40	<4.00	220.0	<0.20	23.00	32.00
Rio Grande at Ancho	190.00	< 0.90	5.00	5.40	<0.20	<0.30	<4.00	57.0	<0.20	16.00	23.00
Rio Grande at Chaquehui	160.00	2.00	<2.00	11.00	<0.20	<0.30	<4.00	61.0	<0.20	13.00	18.00
PERIMETER STATIONS (OFF SITE)											
Acid-Pueblo Canyon											
Acid Weir	250.00	1.40	<10.00	33.00	<0.25	0.40	<4.00	4.1	<0.25	5.60	47.00
Pueblo 1	250.00	<0.90	<10.00	14.00	<0.25	0.50	<4.00	2.80	<0.25	2.50	28.00
Pueblo 2	220.00	< 0.90	<2.00	6.00	<0.50	<0.30	<4.00	4.90	<0.50	5.00	48.00
DP-Los Alamos Canyon											
Los Alamos at Totavi	83.00	0.49	4.00	<4.00	<0.20	0.50	<4.00	4.80	0.60	3.10	11.00
Los Alamos at LA-2	400.00	1.40	9.10	6.80	<0.20	68.00	<4.00	7.60	<0.20	42.00	93.00
Los Alamos at Otowi	110.00	<0.90	<10.00	<10.00	<0.25	<0.30	<4.00	8.00	<0.25	5.90	18.0
Other Areas											
Guaje at SR 4	320.00	1.40	9.10	8.30	<0.20	0.50	<4.00	12.00	<0.20	33.00	75.00
Bayo at SR 4	110.00	1.40	2.00	<4.00	<0.20	<0.30	<4.00	7.50	<0.20	5.60	11.00
Sandia at Rio Grande	120.00	<0.90	2.60	7.10	<0.20	<0.30	<4.00	17.00	<0.20	7.80	18.00
Cañada Ancha at Rio Grande	180.00	<0.90	4.00	5.90	<0.20	<0.30	<4.00	97.00	<0.20	12.00	17.00
Pajarito at Rio Grande	65.00	1.90	<2.00	11.00	<0.20	0.50	<4.00	3.70	<0.20	3.50	12.00
Water at Rio Grande	340.00	<0.90	8.60	12.00	<0.20	0.40	<4.00	95.00	<0.20	15.00	45.00
Ancho at Rio Grande	220.00	<0.90	6.10	9.80	<0.20	0.50	<0.04	81.00	<0.20	12.00	26.00
Chaquehui at Rio Grande	130.00	1.80	3.80	7.80	<0.20	<0.30	<4.00	10.00	<0.20	6.50	19.00
Frijoles at Monument HQ	150.00	<0.90	2.70	6.60	<0.20	0.60	<4.00	7.70	<0.20	5.40	30.00
Frijoles at Rio Grande	37.00	<0.90	<2.00	<4.00	<0.20	<0.30	<4.00	1.40	<0.20	<1.00	5.50
Sandia Canyon Stations											
Station 1	97.00	<0.90	2.00	5.00	<0.30	*0.30	6.00	2.90	<0.30	2.70	18.00
Station 2	140.00	<0.90	2.00	9.00	<0.30	*0.50	6.00	3.50	<0.30	3.50	22.00
Station 3	160.00	<0.90	2.00	4.00	<0.30	*0.60	4.00	6.80	0.30	4.50	20.00

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Mortandad Canyon on Pueblo of San Ildefonso Lands											
Mortandad A-6	160.00	<2.00	<2.00	<4.00	NA	NA	NA	NA	NA	NA	NA
Mortandad A-7	300.00	<0.90	4.00	10.00	<0.30	*0.60	4.00	9.40	<0.30	7.60	33.00
Mortandad A-8	290.00	1.00	3.00	9.00	<0.30	*0.40	6.00	8.80	<0.30	7.10	31.00
Mortandad at SR 4 (A-9)	300.00	2.50	4.60	8.20	<0.20	<0.30	<4.00	7.80	<0.20	6.90	18.00
Mortandad A-10	310.00	<0.90	5.00	9.00	<0.30	*0.50	6.00	18.00	<0.30	12.00	34.00
Mortandad at Rio Grande (A-11)	110.00	2.30	3.00	6.20	<0.20	<0.30	<4.00	36.00	<0.20	10.00	16.00
Mortandad at Transect	420.00	1.10	4.00	15.00	<0.30	*0.50	5.00	20.00	<0.30	12.00	330.00
ON-SITE STATIONS											
Acid-Pueblo Canyon											
Hamilton Bend Spring	150.00	<0.90	< 2.00	9.00	<0.50	<0.30	<4.00	7.00	<0.50	3.50	20.00
Pueblo 3	47.00	< 0.90	N/A[b]	N/A	< 0.50	0.50	N/A	N/A	<0.50	N/A	21.00
Pueblo at State Route	520.00	14.00	<2.00	8.10	<0.20	<0.30	<4.00	2.60	<0.20	13.00	140.00
DP-Los Alamos Canyon											
DPS-1	140.00	<0.90	<2.00	12.00	<0.20	0.40	<4.00	3.80	<0.20	4.30	32.00
DPS-4	110.00	1.60	<2.00	8.30	<0.20	<0.30	<4.00	3.10	<0.20	4.20	23.00
Los Alamos at Bridge	120.00	<0.90	2.10	<4.00	<0.30	0.40	<4.00	4.40	<0.30	4.40	26.00
Los Alamos at LAO-1	86.00	<0.90	2.60	<4.00	<0.30	<0.30	<4.00	3.50	<0.30	3.20	18.00
Los Alamos at GS-1	87.00	<0.90	<2.00	8.20	<0.30	<0.30	<4.00	4.90	<0.30	3.10	19.00
Los Alamos at LAO-3	210.00	1.30	2.10	19.00	<0.30	0.40	<4.00	5.20	<0.30	6.20	40.00
Los Alamos at LAO-4.5	140.00	<0.90	2.60	<5.00	<0.30	<0.30	<4.00	3.80	<0.30	6.90	23.00
Los Alamos at SR 4	160.00	1.80	<2.00	9.50	<0.20	<0.30	<4.00	4.80	<0.20	3.70	31.00
Mortandad Canyon											
Mortandad near CMR Building	79.00	<0.90	13.00	<10.00	<0.25	0.40	<4.00	7.30	0.31	5.50	46.00
Mortandad West of GS-1	140.00	2.50	<2.00	17.00	<0.25	0.50	<2.00	1.60	<0.25	<0.40	9.30
Mortandad at GS-1	220.00	1.80	<10.00	11.00	<0.25	<0.30	<4.00	2.00	<0.25	3.90	38.00
Mortandad at MCO-5	160.00	1.30	<10.00	<10.00	<0.25	<0.30	<4.00	2.00	<0.25	1.50	19.00
Mortandad at MCO-7	160.00	1.90	< 0.00	11.00	<0.25	<0.30	<4.00	3.80	<0.25	4.00	39.00
Mortandad at MCO-9	330.00	1.70	<10.00	14.00	0.25	0.30	<4.00	9.70	<0.25	7.70	43.00
Mortandad at MCO-13(A-5)[c]	240.00	2.60	<10.00	11.10	<0.30	0.47	5.80	7.40	0.30	5.75	34.00
OtherCanyons											
Sandia at SR 4	100.00	<0.90	<2.00	5.40	<0.20	<0.30	<4.00	2.90	<0.20	2.90	18.00
Cañada Del Buey at SR 4	170.00	<0.90	1.10	6.30	<0.20	<0.30	<4.00	5.00	<0.20	3.60	11.00
Pajarito at SR 4	280.00	5.50	8.40	37.00	<0.20	0.40	<4.00	31.00	0.20	19.00	140.00
Potrillo at SR 4	220.00	2.40	<2.00	6.80	<0.20	<0.30	<4.00	4.60	<0.20	6.00	31.00
Fence at SR 4[c]	225.00	1.10	6.50	9.40	<0.30	0.70	2.40	12.30	0.30	10.10	34.50
Water at SR 4	150.00	1.80	1.90	3.10	<0.20	<0.30	<4.00	4.30	<0.20	3.50	22.00
Indio at SR 4	150.00	<0.90	<2.00	<4.00	<0.30	<0.30	< 4.00	5.10	< 0.30	4.00	31.00
Ancho at SR 4	150.00	2.80	<2.00	2.90	<0.20	<0.30	<4.00	3.50	<0.20	6.50	26.00
Ancho at Ancho Spring	45.00	<0.90	<2.00	<4.00	<0.20	<0.30	<4.00	2.10	<0.20	1.40	5.90

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
TA-54, Area G											
G-1	270.00	<0.90	<2.00	8.00	<0.25	0.30	<4.00	12.00	0.25	12.00	36.00
G-2	620.00	< 0.90	<2.00	10.00	<0.25	0.40	<4.00	8.60	<0.25	14.00	89.00
G-3	360.00	<0.90	<2.00	43.00	<0.25	<0.30	<4.00	14.00	<0.25	11.00	55.00
G-4	320.00	<0.90	<2.00	7.40	<0.25	<0.30	<4.00	7.70	<0.25	25.00	58.00
G-5	320.00	<0.90	<2.00	6.60	<0.25	<0.30	<4.00	9.90	<0.25	12.00	45.00
G-6	330.00	<0.90	<2.00	16.00	<0.25	<0.30	<4.00	19.00	< 0.25	14.00	55.00
G-7	160.00	< 0.90	<2.00	5.10	<0.25	0.30	<4.00	9.20	<0.25	1.80	33.00
G-8	140.00	< 0.90	3.10	7.40	<0.25	<0.30	<4.00	6.90	<0.25	8.00	27.00
G-9	280.00	<0.90	4.80	6.80	<0.25	<0.30	<4.00	8.00	<0.25	16.00	30.00
TA-49, Area AB											
AB-1	520.00	<5.00	9.60	22.00	<0.20	0.30	<4.00	30.00	0.30	20.00	650.00
AB-2	480.00	<5.00	11.00	18.00	<0.20	<0.30	<4.00	30.00	<0.20	24.00	58.00
AB-3	250.00	<5.00	5.90	12.00	<0.20	<0.30	<4.00	14.00	<0.20	6.60	140.00
AB-4	380.00	<5.00	7.60	15.00	<0.20	0.30	<4.00	35.00	<0.20	16.00	35.00
AB-4A	250.00	< 5.00	7.00	17.00	<0.20	<0.30	<4.00	18.00	<0.20	2.00	31.00
AB-5	340.00	<5.00	9.40	18.00	<0.20	<0.30	<4.00	28.00	<0.20	21.00	48.00
AB-6	280.00	< 5.00	5.40	15.00	<0.20	0.40	<4.00	17.00	<0.20	11.00	390.00
AB-7	450.00	<5.00	11.00	17.00	<0.20	0.30	<4.00	31.00	0.20	25.00	130.00
AB-8	160.00	<5.00	3.60	9.50	<0.20	<0.30	<4.00	4.80	< 0.20	7.10	25.00
AB-9	300.00	<5.00	4.50	12.00	<0.20	<0.30	<4.00	17.00	<0.20	10.00	28.00
AB-10	270.00	<5.00	6.40	11.00	<0.20	0.30	<4.00	15.00	<0.20	16.00	34.00
AB-11	270.00	< 5.00	9.70	15.00	<0.20	<0.30	<4.00	11.00	<0.20	13.00	21.00

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]N/A means analysis not performed, lost in analysis or not completed.
[c]Results averaged from more than one analysis.

variability in trace metal concentrations or to variability due to differences in sample preparation methods. Differences in laboratory sample preparation procedures only apply to the 1992 and 1993 data. Except as mentioned above, the trace metal measurements reported for 1994 generally yielded results comparable to those obtained in both 1992 and 1993.

b. Organic Analyses. Beginning in 1993, sediments from known radioactive effluent release areas were also analyzed for VOCs, SVOCs, and PCBs. Lists of individual compounds that were analyzed in the laboratory are given in Tables D-21 (VOCs) and D-22 (SVOCs). These VOC, SVOC, and PCB analyses are scheduled to be repeated every three years for sediment samples. Details of the sediment monitoring network, including individual sample locations, are described in Section V.B.5.b (Monitoring Network). All of the sediment sampling locations are shown in Figure V-14 (Off-Site Regional Stations), Figure V-15 (Off-Site Perimeter and On-Site Stations), and Figure V-16 (Solid Waste Management Areas). All of these locations are also listed in Table D-14.

Beginning in 1994, sediment samples for VOC, SVOC, PCB, and pesticide analyses were collected at about one-third of the regional, perimeter, and on-site stations as reported in Table VI-20. Over the three year period from 1994-1996, these stations will be rotated so that all of the listed sediment stations will be sampled at least once. The analytical results confirmed that there were no PCB or pesticide compounds detected in any of the sediment samples collected during 1994. However, two samples from TA-49, Area AB, showed trace levels of the SVOC compounds benzo(ghi)perylene (Station AB-1 with 690 µg/kg), and benzo(a)pyrene (Station AB-3 with 500 µg/kg); the analytical laboratory Level-of-Quantitation (LOQ) for both of these compounds was 330 µg/kg. Both of these compounds are typically found in parking lot (asphalt) runoff waters. It was tentatively concluded that at these levels, the field samples became contaminated with SVOCs by surface runoff. Two Mortandad Canyon stations also showed positive results for the VOC acetone and methylene chloride. Sediments from station MCO-7 contained 39.2 µg/kg acetone (LOQ 20 µg/kg), and 11.4 µg/kg methylene chloride (LOQ 5 µg/kg), respectively; sediments from station MCO-13 contained 7.8 µg/kg of methylene chloride. The sample quality assurance/quality control trip blanks tested negative for both of these compounds; however, these compounds are common laboratory solvents. It was tentatively concluded that at these levels, the field samples became contaminated with acetone and methylene chloride during the laboratory analyses. None of the other sediment samples showed any VOC contamination levels above the respective LOQs.

Table VI-20. List of Sediment Stations Where Samples Were Collected in 1994 for Organic Analyses

Station Name
Chamita
Rio Grande at Bernalillo
Jemez River
Pueblo 2
Los Alamos at Otowi
Sandia at Rio Grande
Hamilton Bend Spring
DP-Los Alamos Canyons
DPS-1
DPS-4
Mortandad Near CMR Building
Mortandad West of GS-1
GS-1
Mortandad at MCO-5
Mortandad at MCO-7
Mortandad at MCO-9
Mortandad at MCO-13[c] (A-5)
Fence at SR-4
Indio at SR-4
TA-49, Area AB
AB-1
AB-2
AB-3
AB-4
AB-4A
AB-5
AB-6
AB-7
AB-8
AB-9
AB-10
AB-11

5. Foodstuffs Monitoring.

Various foodstuffs (produce and fish) were analyzed for trace and heavy metals during the 1994 season. In fact, this was the first time that trace and heavy metals have been analyzed and reported for produce collected within the Laboratory and the surrounding areas. This was the second time for fish—the first results were reported in the 1991 report (EPG 1993). These data will ultimately be used to establish a database and

are meaningful from a Laboratory operation/effects standpoint. The major contaminants of concern at firing sites, for example, are beryllium and lead, and the migration of these elements off site is a significant concern to the public. Section V.B.7.b presents information on the monitoring network used in this program. The results of the 1994 produce and fish sampling program are found in Tables VI-21 and VI-22, respectively.

a. Produce. Most trace and heavy metal elements, particularly arsenic, beryllium, antimony, and selenium, in produce from on-site, perimeter and regional locations were below the limit of detection. In those cases where some produce samples contained metals above the limit of detection (e.g., cadmium, chromium, and mercury), only cadmium showed statistical differences; levels of cadmium in produce collected from on-site and from the White Rock/Pajarito Acres area were significantly higher than cadmium levels in produce from the Española/Santa Fe/Jemez stations. These results should be viewed with caution. The mean values, for example, were estimated from less-than (<) values (censored data) and may be (biased) higher than otherwise expected (Gilbert 1987). Also, soil samples collected from these same areas did not contain higher cadmium (0.40 μg/dry g) than background soil samples (0.41 μg/dry g) (Table VI-18). In any case, the levels were still within the range of cadmium concentrations normally found in agricultural food crops around the country (Wolnik 1983, Wolnik 1985). No significant differences in any of the trace and heavy metal elements were found in produce collected from either Cochiti or San Ildefonso areas as compared to background concentrations.

b. Fish. Most trace and heavy metals in fish collected from Cochiti and Abiquiu reservoirs were below the limit of detection. For those elements that were above the limit of detection (e.g., barium, copper, mercury, and zinc), the levels were statistically ($p < 0.05$) similar in fish from Cochiti Reservoir as compared to fish collected from Abiquiu Reservoir. In addition, all of these metals, particularly beryllium, mercury, and lead, were similar to values reported in 1991 (EPG 1993). Mercury concentrations in fish from lakes and reservoirs in the State of NM have been of significant concern to the public for several years. However, the levels of mercury in 1991 in fish from Cochiti (0.350 μg/wet g) and Abiquiu Reservoirs (0.350 μg/wet g) were similar to mercury in fish from Cochiti (0.284 μg/wet g) and Abiquiu Reservoirs (0.371 μg/wet g) in 1994.

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

Title III, Section 313, of the Emergency Planning and Community Right-to-Know Act (EPCRA) requires facilities meeting certain Standard Industrial Classification (SIC) code criteria to submit annual Toxic Chemical Release Inventory (TRI) reports. NM facilities meeting the SIC code criteria must submit TRI reports to the EPA and the NM Emergency Management Bureau every July for the preceding calendar year.

The Laboratory does not meet the SIC code criteria for reporting but has voluntarily submitted annual TRI reports since 1987. Because all research operations are exempt under provisions of the regulation, the Laboratory reports only pilot plant, production, or manufacturing operations. The Laboratory's release reporting has therefore been limited to regulated chemical use at the Plutonium Processing Facility (TA-55), the only Laboratory operation that uses a reportable chemical (nitric acid) in amounts greater than the Section 313 reporting threshold.

On August 3, 1993, the President of the US issued Executive Order 12856, requiring all federal facilities, regardless of SIC code, to report under Title III, Section 313 of EPCRA. Research operations remain exempt. This requirement does not go into effect until the July 1995 reporting deadline for the 1994 calendar year. The Laboratory, along with the DOE, elected to begin reporting under the new guidelines beginning with the 1994 report. The new guidelines require that LANL report on two chemicals in addition to nitric acid—chlorine for water treatment and sulfuric acid used to deionize water at the power plant (TA-3-22).

The 1994 report addresses the releases of nitric acid, chlorine, and sulfuric acid during 1993. About 6,090 kg (13,400) lb of nitric acid were used for plutonium processing, with releases to the air of approximately 78 kg (171 lb). The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in waste water treatment operations. In addition, 9,602 kg (21,149 lb) of chlorine were used in water purification operations involving noncontact cooling water, sewage treatment, and drinking water, resulting in air emissions of 381 kg (839 lb) of chloroform and 12 kg (26 lb) of chlorine. An estimated 2,479 kg (5,460) lb of chlorine were released with the discharged water. Finally, 24,430 kg (53,745 lb) of sulfuric acid were used to deionize water at the Laboratory's main power plant, resulting in less than 0.45 kg (1 lb) of air emissions. The remaining sulfuric acid was completely neutralized before being discharged to the environment.

Table VI-21. Total Recoverable Trace and Heavy Metals (μg/dry g) (ppm) in Produce Collected in 1994[a]

	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl
OFF-SITE STATIONS												
Regional												
Española/Santa Fe/Jemez												
squash	N/A[b]	<0.50[c]	N/A	<0.08	<0.70	5.00	0.03	N/A	5.10	<0.20	<0.40	N/A
apricots	N/A	<0.50	N/A	<0.08	<0.40	1.30	0.02	N/A	<4.00	<0.20	<0.40	N/A
apples	N/A	<0.50	N/A	<0.08	0.56	1.10	0.02	N/A	<7.00	<0.20	<0.40	N/A
pumpkin	N/A	<0.50	N/A	<0.08	<0.40	<0.80	0.02	N/A	<6.00	<0.20	<0.40	N/A
pears	N/A	<0.50	N/A	<0.08	0.42	<1.00	0.01	N/A	<5.00	<0.20	<0.40	N/A
pumpkin	N/A	<0.50	N/A	<0.08	<0.50	<0.90	0.02	N/A	<4.00	<0.20	<0.40	N/A
apples	N/A	<0.50	N/A	<0.08	<0.50	<0.80	0.02	N/A	<5.00	<0.20	<0.40	N/A
squash	N/A	<0.50	N/A	<0.08	<0.40	<0.80	0.02	N/A	<7.00	<0.20	<0.40	N/A
Mean	N/A	<0.50	N/A	<0.08	<0.48	<1.46	0.02	N/A	<5.39	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.21)	(2.88)	(0.01)	(N/A)	(2.37)	(0.00)	(0.00)	(N/A)
RSRL[d]	N/A	<0.50	N/A	<0.08	<0.69	<4.34	0.03	N/A	<7.76	<0.20	<0.40	N/A
Perimeter												
Los Alamos												
tomatoes	N/A	<0.50	N/A	<0.08	<0.50	<1.20	0.02	N/A	<9.00[e]	<0.20	<0.40	N/A
apricots	N/A	<0.50	N/A	<0.08	<0.70[e]	2.00	0.02	N/A	<4.00	<0.20	<0.40	N/A
cherries	N/A	<0.50	N/A	<0.08	<0.40	1.40	0.02	N/A	<9.00[e]	<0.20	<0.40	N/A
Mean	N/A	<0.50	N/A	<0.08	<0.53	<1.50	0.02	N/A	<7.30	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.31)	(0.80)	(0.00)	(N/A)	(5.80)	(0.00)	(0.00)	(N/A)
White Rock/Pajarito Acres												
apples	N/A	<0.60[e]	N/A	<0.08	<1.00[e]	<0.80	0.02	N/A	<5.00	<0.20	<0.40	N/A
squash	N/A	<0.60[e]	N/A	<0.08	<0.90[e]	<0.80	0.02	N/A	<8.00[e]	<0.20	<0.40	N/A
squash	N/A	<0.60[e]	N/A	<0.08	<0.70[e]	<0.90	0.02	N/A	<8.00[e]	<0.20	<0.40	N/A
tomatoes	N/A	<0.60[e]	N/A	<0.08	<0.50	<0.90	0.01	N/A	<8.00[e]	<0.20	<0.40	N/A
Mean	N/A	<0.60	N/A	<0.08	<0.78[f]	<0.85	0.02	N/A	<7.30	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.44)	(0.12)	(0.01)	(N/A)	(3.00)	(0.00)	(0.00)	(N/A)
Cochiti												
corn	N/A	<0.60[e]	N/A	<0.08	<0.40	0.89	0.02	N/A	5.00	<0.20	<0.40	N/A
apples	N/A	<0.60[e]	N/A	<0.08	<0.50	<1.20	0.02	N/A	<8.00[e]	<0.20	<0.40	N/A
apples	N/A	<0.60[e]	N/A	<0.08	<0.70[e]	<0.80	0.02	N/A	<4.00	<0.20	<0.40	N/A
Mean	N/A	<0.60	N/A	<0.08	<0.53	<0.96	0.02	N/A	<5.70	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.31)	(0.42)	(0.00)	(N/A)	(4.20)	(0.00)	(0.00)	(N/A)
San Ildefonso												
peaches	N/A	<0.50	N/A	<0.08	<0.40	1.30	0.02	N/A	<8.00	<0.20	<0.40	N/A
apples	N/A	<0.50	N/A	<0.08	<0.80[e]	<0.80	0.02	N/A	<4.00	<0.20	<0.40	N/A
squash	N/A	<0.50	N/A	<0.08	<0.70[e]	1.00	0.02	N/A	<4.00	<0.20	<0.40	N/A
Mean	N/A	<0.50	N/A	<0.08	<0.63	<1.03	0.02	N/A	<5.30	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.42)	(0.50)	(0.00)	(N/A)	(4.60)	(0.00)	(0.00)	(N/A)
ON-SITE												
LANL												
peaches	N/A	<0.50	N/A	<0.08	<0.80[e]	0.90	0.02	N/A	<4.00	<0.20	<0.40	N/A
peaches	N/A	<0.50	N/A	<0.08	<0.50	0.52	0.02	N/A	<4.00	<0.20	<0.40	N/A
tomatoes	N/A	<0.50	N/A	<0.08	<1.00[e]	1.00	0.02	N/A	<4.00	<0.20	<0.40	N/A
squash	N/A	<0.50	N/A	<0.08	<0.50	0.89	0.02	N/A	<10.00[e]	<0.20	<0.40	N/A
pumpkin	N/A	<0.50	N/A	<0.08	<0.90[e]	<1.10	0.02	N/A	<4.00	<0.20	<0.40	N/A
Mean	N/A	<0.50	N/A	<0.08	<0.74[f]	<0.88	0.02	N/A	<5.20	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.46)	(0.44)	(0.00)	(N/A)	(5.40)	(0.00)	(0.00)	(N/A)

[a]Analysis by EPA Method 3051 for total recoverable metals.

[b]N/A = analysis not performed or lost in analysis.

[c]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method and/or sample.

[d]Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev).

[e]Higher than the RSRL.

[f]Statistically significant (mean) from background (mean) using a Student's t-test at the 0.05 probability level.

Table VI-22. Total Recoverable Trace and Heavy Metals in Fish (μg/wet g) (ppm) Collected in 1994

Element	Abiquiu Reservoir Mean[a]	Abiquiu Reservoir +2 std dev	Cochiti Reservoir Mean	Cochiti Reservoir +2 std dev
Silver	<0.700	0.000	<0.700	0.000
Arsenic	<0.500	0.000	<0.500	0.000
Barium	0.100[b]	0.220	0.061	0.078
Beryllium	<0.020	0.000	<0.020	0.000
Cadmium	<0.300	0.000	<0.300	0.000
Chromium	<0.300	0.000	<0.300	0.000
Copper	0.340	0.240	0.440	0.284
Mercury	0.371	0.562	0.284	0.640
Nickel	<1.000	0.000	<1.000	0.000
Lead	3.110	0.600	<3.000	0.000
Selenium	<0.500	0.000	<0.500	0.000
Zinc	4.060	1.24	3.860	1.040

[a]The average of seven fish each from Cochiti and Abiquiu reservoirs.

[b]There were no significant differences in barium, copper, mercury, lead, and zinc levels in fish collected from Cochiti as compared to fish collected from Abiquiu (background) using a Student's t-test at the 0.05 probability level.

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 are 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 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 1994 is summarized in Table VI-23.

B. Unplanned Releases of Nonradiological Materials

1. Airborne Releases.

There were no unplanned airborne nonradiological releases in 1994.

2. Liquid Releases.

During 1994, 24 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

Table VI-23. Herbicide and Insecticide Usage during 1994

Type	Brand Name	Annual Usage
Insecticides		
	Inspector (pyrethrin)	4.70 gallons
	Tempo (cyfluthrin)	21 grams
	BP100 (pyrethrin)	2.0 gallons
Herbicides		
	Velpar (hexazione)	350 gallons
	Confront (triclopyr)	4.0 gallons

Note: For purposes of reporting, the above volumes are stated as actual manufactured product, prior to mixing. The actual percent of active ingredient in each product is usually a small fraction of the respective application.

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 24 unplanned releases:

- fourteen releases of untreated sanitary sewage (all but two were less than 3,785 L (1,000 gal.) from the Laboratory's wastewater treatment plant collection systems;
- one release of ethylene glycol at TA-54, Area G of 5.7 L (1.5 gal.) on September 20, 1994;
- one hydraulic oil release at Guaje Pines of 5.7 L (1.5 gal.) on April 16, 1994;
- two releases of treated sanitary effluent: TA-46, Bldg. 333 of 18,927 L (5,000 gal.) on April 19, 1994; and TA-3, Bldg. 22 of 2,839 L (750 gal.) on October 18, 1994;
- one release of photo fixer at TA-35, Bldg. 87 of 151.4 L (40 gal.) on June 4, 1994;
- one release of treated cooling water at TA-53, Bldg. 3 of 378,541.2 L (100,000 gal.) on December 15, 1994;
- one release of diluted glycerin from fire sprinkler system at TA-3, Bldg. 38 of 567.8 L (150 gal.) on March 4, 1994;
- one release of sediment storm water in Los Alamos Canyon of runoff from gas line excavation;
- one release of mud and soil washings at TA-3, Sigma Mesa of 859,288.5 L (227,000 gal.) on August 2, 1994; and
- one release of ethylene glycol from a vehicle accident in Los Alamos Canyon, 11.3 L (3 gal.) on November 11, 1994.

All spills were investigated by ESH-18. Upon cleanup, personnel from NMED/Agreement in Principle inspected the spill sites to ensure adequate cleanup. NMED administratively closed 22 of the 24 spills which occurred in 1994.

ESH-18 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. ESH-18 also prepared a generalized NOI for the release of steam condensate and line disinfection 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 some contamination (i.e., concentrations of substances above background levels) of the main aquifer, particularly beneath Los Alamos and Pueblo Canyons. Here, signs of effluent from sewage treatment and past radioactive industrial releases have appeared in the top of the main aquifer. In the lower reaches of these canyons, streams have cut down through the Bandelier Tuff into the more permeable basalts and conglomerates directly overlying the main aquifer, facilitating seepage of contaminants into the aquifer formations. The radioactive contamination is restricted to trace amounts of tritium, an isotope of hydrogen, which moves through rocks much more readily than do other radionuclides. 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 to support Laboratory operations. 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 monitoring data indicate that DOE operations at the Laboratory have resulted in some contamination of the main aquifer, particularly beneath Los Alamos and Pueblo Canyons. The term contamination refers to the presence of substances whose concentrations exceed background values because of human actions, whether or not these substances significantly affect water quality. The term pollution applies to levels of contamination which are undesirable, for example because of possible adverse health effects (Freeze 1979). In Los Alamos and Pueblo Canyons, signs of effluent from sewage treatment and past radioactive industrial releases have appeared in the upper part of the main aquifer. In the lower reaches of these canyons, the streams have cut down through the Bandelier Tuff into the more permeable basalts and conglomerates directly overlying the main aquifer, facilitating seepage of contaminants into the aquifer formations. The radioactive contamination is generally restricted to trace amounts of tritium, an isotope of hydrogen, which moves through rocks much more readily than do other radionuclides. Tritium contamination within the main aquifer has been found at four locations in Los Alamos and Pueblo Canyons, and also one location in Mortandad Canyon (see Section VII.E.1). Three test wells, TW-3, TW-4 and TW-8, also showed unexpected levels of ^{90}Sr during 1994. Unexpectedly high levels of nitrate were also found at several of these locations during 1994 (see Section VII.E.5). These discoveries are a matter of concern to the Laboratory and will be followed up with detailed studies.

As a result of the testing done between 1991 and 1993, tritium contamination was discovered in four test wells which penetrate only a short distance into the top of the main aquifer (EARE 1995b) and in a former water supply well in lower Los Alamos Canyon. Some of these wells (in Pueblo and Los Alamos Canyons) draw water from formations a relatively short distance 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 possible. The wells are all located downstream of present or former sites of discharge of treated radioactive liquid industrial waste into Acid-Pueblo, DP-Los Alamos, 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. Confirmed evidence of tritium contamination has not been discovered in samples taken from any of the current public water supply wells (see Section VII.E.1).

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 DOE Order was issued. Formal documentation for the program, the "Groundwater Protection Management Program Plan," was issued in April 1990 and revised in 1995 (LANL 1995b). Several hundred reports and articles documenting studies and data germane to groundwater and the environmental setting of Los Alamos are listed in a bibliography (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 measure-ments. The most recent reports in this series are entitled "Water Supply at Los Alamos during 1992" and "Water Supply at Los Alamos during 1993" (Purtymun 1995b and 1995c).

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 groundwater in canyons; the intermediate depth perched systems in the basalt and the Puye conglomerate beneath parts of Pueblo, Los Alamos, and Sandia Canyons; and special studies relating to groundwater age and recharge mechanisms. See Section II.C for a general description of the hydrogeology of the Los Alamos area.

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 Appendix A). Concentrations of radioactivity in samples of water from the water supply wells completed in the Los Alamos main aquifer are also compared to New Mexico Environment Department (NMED), New Mexico 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 Los Alamos public water supply. The New Mexico Water Quality Control Commission (NMWQCC) has established standards for groundwater quality (NMWQCC 1993). 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, as well as the stream standards established by the NMWQCC (NMWQCC 1993, NMWQCC 1994).

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 from the 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.3.

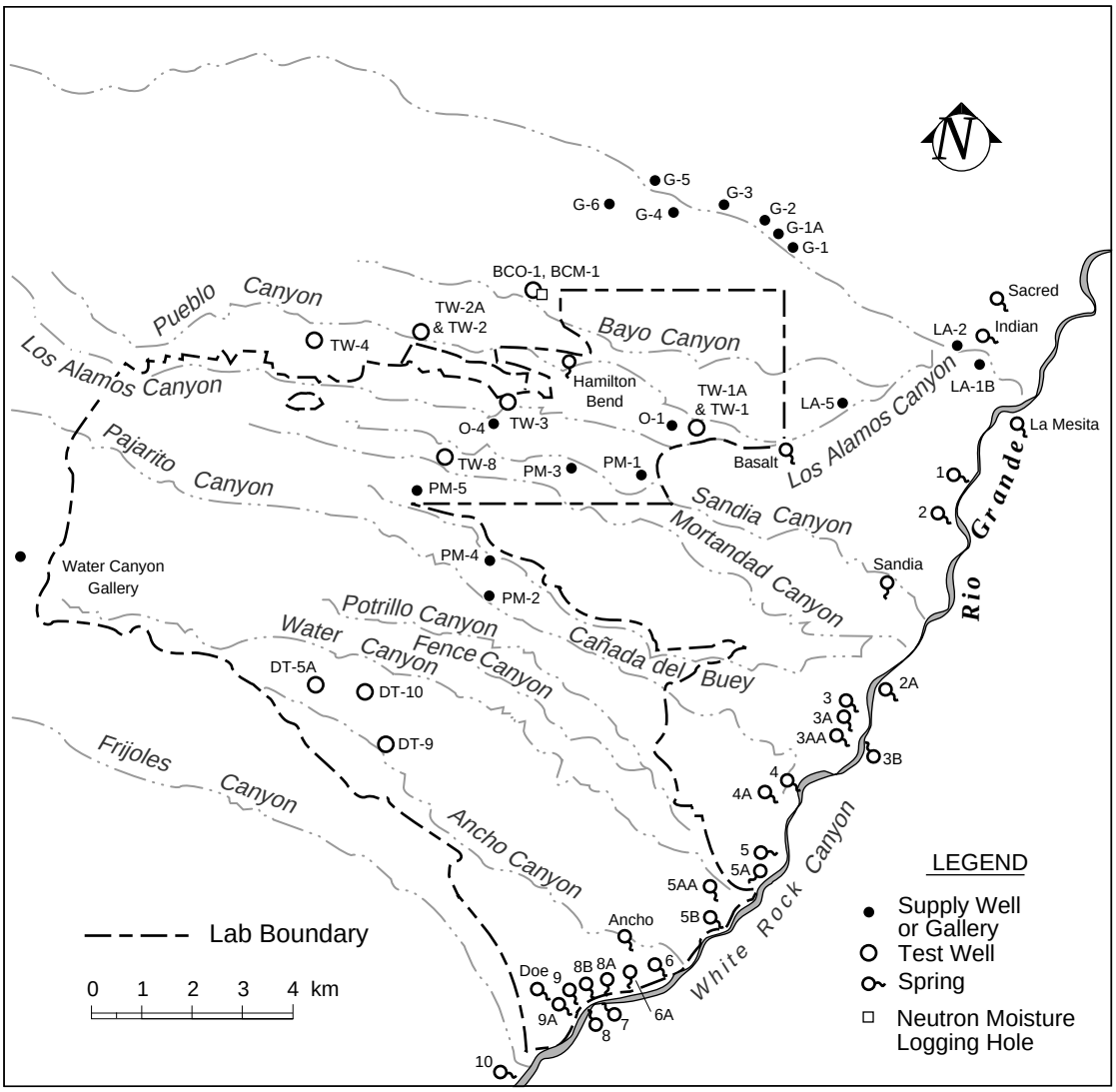


Figure VII-l. Springs and deep and intermediate wells used for groundwater sampling. (See Table D-16 for specific locations.)

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. 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 1994 was 243 m (798 ft). Perched water at an intermediate depth was observed in nearby Test Well 2A (see Section VII.B.3 for a detailed discussion of the intermediate-depth perched groundwater systems). 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 1994 was 359 m (1,177 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 1994 was 167 m (549 ft). Perched water at an intermediate depth

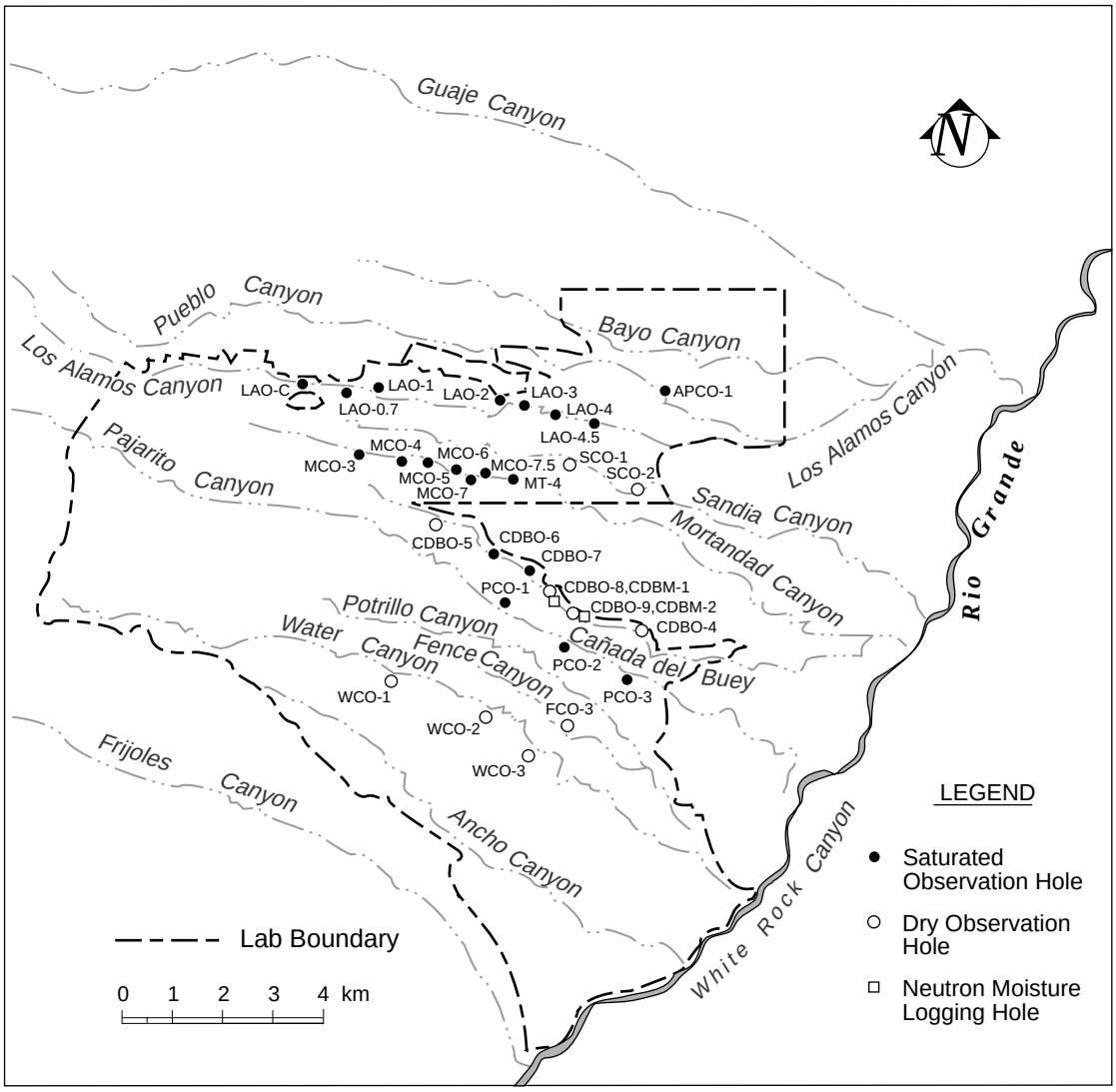


Figure VII-2. Alluvial observation wells and neutron moisture holes.

was observed in nearby Test Well 1A (see Section VII.B.3). Test Well 3, drilled in 1949, is in the middle reach of Los Alamos Canyon just upstream from the confluence with DP Canyon. Depth to water in 1994 was 238 m (781 ft). Test Well 8, drilled in 1960, is in the middle reach of Mortandad Canyon, downstream from the TA-50 radioactive liquid waste treatment plant outfall. Depth to water in 1994 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 1994 were 361 m (1,184 ft) at DT-5A, 340 m (1,116 ft) at DT-9, and 334 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 wells TW-3, TW-8, DT-5A, DT-9, and DT-10 were drilled.

Samples were also collected from eight deep water supply 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 1994. 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).

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 but was shut down due to pump failure during 1994. Wells Otowi-1 and Otowi-4 are 795 m and 855 m in depth (2,609 ft to 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 Indian Affairs (BIA), and the Pueblo of San Ildefonso.

Numerous springs near the Rio Grande were sampled because they are interpreted to be representative of natural discharge from the main aquifer (Purtymun 1980b). See Section II.C. for information on discharge into the Rio Grande. Based on their chemistry, the springs in White Rock Canyon are divided into four groups. 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 groundwater in five canyons was 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 thus no water samples can be obtained.

Acid Canyon, a small tributary of Pueblo Canyon, received untreated and treated industrial effluent that contained residual radionuclides from 1944 to 1964 (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, 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 2.0 m (6.6 ft).

The on-site reach of Los Alamos Canyon presently carries flow from the Los Alamos Reservoir to the 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 from snowmelt runoff and in late summer from 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 to 30 ft). Depth to water is typically in the range of 1.2 m to 4.6 m (4 to 15 ft).

Alluvial perched groundwater also occurs in the lower portion of Los Alamos Canyon on the Pueblo of San Ildefonso lands. This alluvium is not continuous with the alluvium within the Laboratory and can be sampled utilizing wells installed by the BIA. During 1994 this groundwater was not sampled at locations on Pueblo of San Ildefonso lands. See Section IV.C.4 for information on results obtained at the Pueblo of San Ildefonso.

Mortandad Canyon has a small drainage area that heads at TA-3. Its drainage area presently receives inflow from natural precipitation and a number of NPDES-permitted effluents including 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 thus 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 does 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 gauge 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 pre-operational 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 35 m (113 ft) in 1994.

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 1994. 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 was observed in the Puye Conglomerate 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]); in the basalts in water supply well PM-1 in Sandia Canyon (depth about 137 m [450 ft]); and in the Guaje Pumice at the base of the Bandelier Tuff during drilling of borehole LADP-3 (depth about 100 m [325 ft]) and borehole LAOI-1.1 (depth about 98 m [323 ft]) in Los Alamos Canyon.

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 1 to 2 months, with another 2 to 3 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 to the 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 4.40×10^4 m^3 (11.63 million gal. or 35.7 ac ft) 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 1990b). 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) in the tuff beneath mesa tops at depths greater than a few meters, the zone affected by seasonal moisture and evapotranspiration. This carries the implication 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 groundwater 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 groundwater investigations have been performed under various Resource Conservation and Recovery Act compliance require-ments. As part of these investigations, we have 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 B.2 of this section, 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 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 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 [1/4 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 11 m (36 ft), WCO-2 (about 0.6 km [1 mi] west of State Road 4) drilled to 12 m (39 ft), and WCO-3 (within about 0.2 km [1/4 m] of State Road 4) 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 del 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. Two of them, completed as 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 1994 are listed in Table VII-1. Discussion of the results will address the main aquifer, the canyon alluvial groundwater, and finally the intermediate perched groundwater system.

a. Radiochemical Constituents in the Main Aquifer. For samples from wells or springs in the main aquifer, most of the results for tritium, ^{90}Sr, uranium, ^{238}Pu, ^{239,240}Pu, ^{241}Am, and gross beta were below the DOE DCGs or the EPA or New Mexico standards applicable to a drinking water system. The exceptions are discussed below. In addition, most of the results were near or below the detection limits of the analytical methods used.

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 contamination of the main aquifer by plutonium or americium.

All of the uranium values were determined using the kinetic phosphonimetric analysis (KPA) method. In the past, uranium was evaluated with the induction coupled plasma emission spectroscopy (ICPES) method, which ordinarily gives high values for prepared standards; the alternative KPA method gives low values. La Mesita Spring and Spring 3B have high uranium concentrations; springs in this area have always contained a relatively high concentration of natural uranium (Purtymun 1980b). The uranium concentrations for these springs are both below the EPA primary drinking water standard MCL of 20 μg/L, however. These two springs also have high gross alpha values. Spring 3AA had a gross alpha value of 17 pCi/L, above the EPA primary drinking water standard of 15 pCi/L.

Three wells and one spring showed noticeable values of ^{90}Sr. For Test Well 4 (6.2 ± 3.4 pCi/L) and Test Well 8 (2.1 ± 0.7 pCi/L), the values are less than 2 to 3 times the radioactivity counting uncertainty and are therefore not a definite detection. Analysis of a split sample from Test Well 4 by the NMED/Agreement in Principle (AIP) showed a ^{90}Sr level of 6.6 ± 1.0 pCi/L, supporting a possible detection in that well.

The values of ^{90}Sr found in Spring 8 (19.7 ± 3.8 pCi/L) and Test Well 3 (35.1 ± 2.2 pCi/L) are well above the limits of analytical uncertainty and also above the EPA primary drinking water standard MCL of 8 pCi/L. However, these ^{90}Sr values are questionable because of the very low gross beta measurements for the samples, of 7 ± 1 pCi/L for Spring 8 and 2.2 ± 0.4 pCi/L for Test Well 3. The apparent detection of ^{90}Sr in Test Well 3 is plausible, as high levels of ^{90}Sr are present in the overlying Los Alamos Canyon alluvial groundwater.

In order to address these detections of ^{90}Sr, resampling of Test Wells 3, 4, and 8 will be conducted. Preliminary results of tests conducted during 1995 indicate no trace of strontium in any of these test wells. The samples were collected periodically during continual pumping of the wells, in order to ascertain the extent of possible contamination within the aquifer. All of the ^{90}Sr values were close to zero, less than 1 or 2 times the radioactivity counting uncertainty. These values are therefore viewed as nondetections.

All ^{137}Cs measurements of samples from the main aquifer wells and springs for 1994 are less than 5% of the DCG applicable to DOE Drinking Water Systems. 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 also

Table VII-1. Radiochemical Analysis of Groundwater for 1994

	Tritium (nCi/L)	^{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)
MAIN AQUIFER ON SITE										
Test Wells										
Test Well 1	0.4 (0.3)[a]	N/A[b]	-2.7 (4.0)	2.5 (0.3)	-0.001 (0.030)	0.008 (0.020)	N/A	2 (1)	4 (1)	20 (60)
Test Well 3	0.1 (0.3)	35.1 (2.2)	<2.0[c]	0.6 (0.1)	-0.009 (0.030)	-0.001 (0.020)	0.043 (0.030)	-1 (1)	2 (0)	20 (50)
Test Well 8	-0.1 (0.3)	2.1 (0.7)	<0.6	0.3 (0.1)	-0.003 (0.005)	0.188 (0.032)	0.034 (0.017)	1 (0)	3 (0)	10 (50)
Test Well DT-5A	-0.1 (0.3)	0.1 (0.8)	<1.0	0.3 (0.1)	0.001 (0.005)	0.018 (0.09)	0.054 (0.017)	1 (1)	2 (1)	110 (50)
Test Well DT-9	0.1 (0.3)	0.7 (0.7)	<1.2	0.2 (0.0)	-0.004 (0.030)	0.026 (0.020)	0.062 (0.030)	1 (1)	4 (1)	90 (50)
Test Well DT-10	-0.1 (0.3)	0.0 (0.7)	<1.1	0.2 (0.1)	0.001 (0.030)	0.010 (0.020)	0.031 (0.030)	0 (0)	3 (0)	30 (50)
Water Supply Wells										
O-4	-0.03 (0.1)	N/A	<2.3	<1.0	0.019 (0.017)	0.003 (0.007)	N/A	0 (2)	4 (2)	N/A
PM-1	-0.3 (0.3)	0.3 (0.8)	<1.0	1.0 (0.0)	-0.007 (0.005)	0.055 (0.017)	0.020 (0.020)	1 (1)	3 (1)	110 (50)
PM-2	-0.2 (0.1)	N/A	<1.7	<1.0	0.005 (0.009)	-0.003 (0.010)	N/A	0 (2)	3 (2)	N/A
PM-4	-0.1 (0.1)	N/A	<2.2	<1.0	0.002 (0.011)	-0.006 (0.012)	N/A	2 (3)	2 (3)	N/A
PM-5	0.04 (0.1)	N/A	<1.4	<1.0	-0.003 (0.016)	0.006 (0.011)	N/A	1 (2)	1 (2)	N/A
MAIN AQUIFER OFF SITE										
Test Wells										
Test Well 2	0.2 (0.3)	N/A	0.9 (11.0)	0.1 (0.0)	-0.011 (0.030)	-0.012 (0.020)	N/A	1 (0)	1 (0)	20 (60)
Test Well 4	0.4 (0.3)	6.2 (3.4)	<1.1	0.8 (0.1)	0.030 (0.030)	-0.010 (0.020)	0.021 (0.013)	3 (1)	8 (1)	10 (50)
Water Supply Wells										
G-1A	-0.02 (0.1)	N/A	<1.1	<1.0	0.021 (0.016)	-0.002 (0.006)	N/A	1 (2)	2 (2)	N/A
G-2	-0.1 (0.1)	N/A	<0.8	<1.0	0.015 (0.021)	0.014 (0.016)	N/A	1 (2)	4 (2)	N/A
G-4	-0.1 (0.1)	N/A	<0.8	N/A	0.012 (0.010)	-0.001 (0.006)	N/A	1 (2)	1 (2)	N/A
MAIN AQUIFER SPRINGS										
White Rock Canyon Springs Group I										
Sandia Spring	0.1 (0.3)	0.0 (0.7)	<0.5	1.1 (0.1)	0.011 (0.030)	0.037 (0.020)	0.025 (0.030)	1 (1)	8 (1)	120 (50)
Spring 3	0.2 (0.3)	0.1 (0.7)	<0.9	1.4 (0.2)	-0.003 (0.030)	0.021 (0.020)	-0.006 (0.030)	0 (1)	9 (1)	90 (50)
Spring 3A	0.4 (0.3)	-0.1 (0.7)	<0.5	1.1 (0.3)	-0.001 (0.030)	0.021 (0.020)	0.016 (0.030)	1 (1)	8 (1)	50 (50)
Spring 3AA	0.1 (0.3)	0.1 (0.8)	<1.2	5.8 (1.0)	-0.003 (0.030)	0.010 (0.020)	0.068 (0.030)	17 (5)	15 (2)	40 (50)
Spring 4	0.3 (0.3)	-0.5 (9.1)	<0.9	1.3 (0.3)	0.013 (0.030)	0.003 (0.020)	0.057 (0.030)	-1 (1)	3 (0)	50 (50)
Spring 4A	0.0 (0.3)	-0.2 (0.7)	1.4 (0.7)	0.9 (0.2)	0.004 (0.030)	0.018 (0.020)	0.079 (0.030)	-1 (1)	2 (0)	60 (50)
Spring 5	0.2 (0.3)	0.5 (0.7)	1.1 (0.5)	0.8 (0.1)	-0.001 (0.030)	0.001 (0.020)	0.035 (0.030)	1 (1)	2 (0)	150 (50)
Ancho Spring	0.5 (0.3)	0.0 (0.8)	<1.2	0.5 (0.1)	-0.007 (0.030)	0.032 (0.020)	0.008 (0.030)	1 (1)	3 (0)	-10 (50)
White Rock Canyon Springs Group II										
Spring 5A	0.4 (0.3)	0.2 (0.7)	1.6 (0.7)	6.6 (1.3)	0.006 (0.030)	0.022 (0.020)	0.070 (0.030)	11 (3)	14 (1)	-20 (50)
Spring 5B	0.5 (0.3)	-0.3 (0.7)	<1.3	3.6 (0.5)	-0.004 (0.030)	0.008 (0.020)	0.047 (0.030)	4 (1)	6 (1)	60 (50)
Spring 6	0.3 (0.3)	0.9 (0.9)	<1.1	0.4 (0.0)	0.025 (0.030)	0.052 (0.020)	0.071 (0.030)	-0 (1)	4 (1)	220 (50)
Spring 6A	0.3 (0.3)	0.9 (0.7)	<1.8	0.9 (0.1)	-0.002 (0.030)	0.010 (0.020)	0.033 (0.030)	1 (1)	4 (1)	10 (50)
Spring 7	0.5 (0.3)	0.2 (0.7)	<1.1	1.4 (0.1)	0.005 (0.030)	0.022 (0.020)	0.040 (0.030)	0 (0)	2 (0)	10 (50)
Spring 8	0.2 (0.3)	19.7 (3.8)	<1.2	2.0 (0.2)	0.001 (0.030)	0.013 (0.020)	0.046 (0.030)	6 (2)	7 (1)	80 (50)
Spring 8A	0.3 (0.3)	-0.3 (0.8)	1.2	0.4 (0.1)	-0.008 (0.030)	0.039 (0.020)	0.044 (0.030)	0 (1)	4 (1)	20 (50)
Spring 8B	0.5 (0.3)	0.0 (0.8)	<1.0	0.2 (0.0)	0.021 (0.030)	0.047 (0.020)	0.056 (0.030)	-1 (1)	3 (0)	50 (50)

Table VII-1. Radiochemical Analysis of Groundwater for 1994 (Cont.)

	Tritium (nCi/L)	^{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)
White Rock Canyon Springs Group II (Cont.)										
Spring 9	0.7 (0.3)	-0.2 (0.8)	<1.1	4.1 (0.8)	0.006 (0.030)	0.026 (0.020)	0.050 (0.030)	4 (1)	4 (1)	20 (50)
Spring 9A	0.6 (0.3)	1.4 (0.7)	<1.3	6.9 (1.5)	-0.017 (0.030)	0.008 (0.020)	0.004 (0.030)	9 (2)	14 (2)	300 (60)
Doe Spring	0.4 (0.3)	-0.4 (0.8)	<1.2	0.3 (0.1)	0.023 (0.030)	0.023 (0.020)	0.067 (0.030)	-0 (0)	3 (1)	300 (60)
Spring 10	0.2 (0.3)	-0.2 (0.8)	<1.1	5.3 (0.5)	0.016 (0.030)	0.040 (0.020)	0.059 (0.030)	3 (2)	11 (1)	230 (60)
White Rock Canyon Springs Group III										
Spring 1	-0.1 (0.3)	0.0 (7.0)	<0.9	3.2 (0.3)	0.004 (0.030)	0.022 (0.020)	0.040 (0.030)	1 (1)	4 (1)	60 (50)
Spring 2	0.1 (0.3)	0.3 (0.8)	<0.6	4.6 (0.9)	0.001 (0.030)	0.023 (0.020)	0.024 (0.030)	4 (2)	9 (1)	90 (50)
White Rock Canyon Springs Group IV										
La Mesita Spring	0.1 (0.3)	1.6 (0.8)	1.0 (0.5)	14.7 (1.5)	0.053 (0.030)	0.028 (0.020)	0.016 (0.030)	12 (3)	10 (1)	40 (50)
Spring 3B	-0.2 (0.3)	0.2 (0.7)	0.7 (0.4)	17.3 (4.0)	0.001 (0.030)	-0.007 (0.020)	0.054 (0.030)	36 (8)	14 (1)	120 (50)
Other Springs										
Sacred Spring	-0.3 (0.3)	0.7 (0.8)	<1.1	0.8 (0.1)	0.006 (0.030)	0.040 (0.020)	0.026 (0.030)	1 (0)	3 (1)	30 (50)
Indian Spring	-0.1 (0.3)	0.6 (0.7)	<1.1	0.6 (0.1)	-0.009 (0.030)	-0.021 (0.020)	0.037 (0.017)	0 (2)	6 (1)	40 (50)
CANYON ALLUVIUM GROUNDWATER										
DP-Los Alamos Canyons										
LAO-C	-0.3 (0.3)	0.9 (0.8)	<0.4	0.2 (0.0)	0.026 (0.012)	0.026 (0.013)	0.038 (0.015)	1 (0)	2 (0)	60 (50)
LAO-0.7	0.5 (0.3)	6.1 (3.8)	<1.4	4.9 (1.3)	0.007 (0.030)	0.559 (0.056)	0.017 (0.016)	45 (10)	32 (3)	50 (50)
LAOR-1	2.0 (0.4)	20.8 (1.4)	<0.4	3.3 (0.3)	0.030 (0.030)	0.060 (0.020)	0.113 (0.023)	3 (3)	52 (5)	50 (50)
LAO-1	1.6 (0.4)	6.8 (0.7)	0.7 (0.4)	-0.3 (0.1)	0.009 (0.030)	0.003 (0.020)	0.034 (0.034)	0 (2)	18 (2)	20 (50)
LAO-2	-0.1 (0.3)	0.0 (0.8)	1.3 (0.5)	0.3 (0.1)	0.011 (0.013)	-0.018 (0.009)	0.151 (0.030)	0 (0)	3 (0)	40 (50)
LAO-3	0.9 (0.3)	49.2 (3.2)	1.2 (0.5)	-0.3 (0.1)	0.009 (0.030)	0.003 (0.020)	0.044 (0.016)	-10 (4)	93 (9)	10 (50)
LAO-4	0.4 (0.3)	4.4 (0.8)	<1.0	-0.4 (0.1)	-0.007 (0.030)	-0.009 (0.020)	0.001 (0.030)	0 (1)	13 (1)	80 (50)
LAO-4.5	0.8 (0.3)	0.9 (0.8)	1.5 (0.6)	-0.3 (0.1)	-0.014 (0.030)	0.038 (0.020)	0.094 (0.030)	1 (1)	6 (1)	60 (50)
Mortandad Canyon										
MCO-4	16.8 (1.2)	42.7 (2.7)	9.5 (2.0)	1.8 (0.5)	1.308 (0.102)	3.657 (0.223)	10.910 (0.555)	29 (7)	140 (10)	100 (50)
MCO-5	22.5 (1.5)	27.9 (1.8)	2.2 (0.7)	2.1 (0.5)	0.077 (0.030)	0.108 (0.025)	0.427 (0.050)	11 (6)	110 (10)	100 (50)
MCO-6	28.5 (1.6)	50.7 (3.3)	1.2 (0.5)	2.7 (0.5)	0.012 (0.030)	0.028 (0.020)	0.496 (0.060)	6 (8)	140 (10)	80 (50)
MCO-7	32.1 (1.8)	1.9 (0.8)	<1.03	4.6 (0.4)	0.012 (0.030)	0.024 (0.020)	0.556 (0.059)	31 (8)	54 (6)	60 (50)
MCO-7.5	32.8 (1.8)	0.3 (0.9)	2.0 (0.6)	1.0 (0.1)	0.037 (0.030)	0.003 (0.020)	0.164 (0.038)	5 (3)	24 (2)	60 (50)
MT-4	54.7 (2.3)	N/A	N/A	5.1 (0.7)	N/A	N/A	N/A	N/A	N/A)	N/A
Pajarito Canyon										
PCO-1	0.4 (0.3)	0.9 (0.8)	1.8 (0.7)	0.3 (0.1)	-0.006 (0.030)	0.006 (0.020)	N/A	4 (2)	8 (1)	60 (50)
PCO-2	0.1 (0.3)	1.6 (0.7)	<1.0	6.5 (1.6)	0.004 (0.030)	-0.002 (0.020)	N/A	50 (10)	54 (6)	50 (50)
PCO-3	0.1 (0.3)	0.9 (0.8)	<1.0	0.2 (0.0)	-0.002 (0.006)	0.011 (0.012)	0.047 (0.015)	1 (0)	2 (0)	40 (50)
Acid/Pueblo Canyons										
APCO-1	0.1 (0.3)	1.3 (0.6)	<1.0	1.2 (0.2)	-0.004 (0.030)	0.404 (0.048)	0.093 (0.025)	9 (3)	19 (2)	40 (50)
Cañada del Buey										
CDBO-6	0.4 (0.3)	0.2 (0.8)	<1.1	1.2 (0.3)	0.030 (0.015)	0.039 (0.015)	0.041 (0.016)	26 (5)	23 (2)	60 (50)
CDBO-7	0.4 (0.3)	0.9 (0.7)	<1.1	2.9 (0.3)	0.034 (0.017)	0.010 (0.012)	0.024 (0.012)	6 (1)	10 (1)	80 (50)

Table VII-1. Radiochemical Analysis of Groundwater for 1994 (Cont.)

	Tritium (nCi/L)	^{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)
PERCHED SYSTEM IN PUEBLO/LOS ALAMOS CANYONS										
Test Well 1A	0.2 (0.3)	N/A	19.0 (10.9)	0.4 (0.1)	-0.002 (0.030)	0.007 (0.020)	N/A	0 (1)	7 (1)	40 (60)
Test Well 2A	2.6 (0.5)	N/A	1.1 (5.0)	0.8 (0.1)	-0.008 (0.030)	-0.004 (0.020)	N/A	1 (1)	3 (0)	20 (60)
Basalt Spring	0.3 (0.3)	0.4 (0.8)	<0.9	0.6 (0.1)	-0.011 (0.030)	0.014 (0.020)	0.038 (0.030)	1 (1)	8 (1)	20 (50)
PERCHED SYSTEM IN VOLCANICS										
Water Canyon Gallery	-0.01 (0.1)	N/A	<0.9	<1.0	0.003 (0.008)	-0.002 (0.007)	N/A	1 (2)	3 (2)	N/A
Limits of Detection[d]	0.4	1	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose[d]	2000	1000	3000	800	40	60	30			
DOE Drinking Water System DCG[d]			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard[d]	20	8		20				15		
EPA Screening Level[d]									50	
NMWQCC Groundwater Limit[d]				5000						

[a]Radioactivity counting uncertainties are shown in parentheses.
[b]N/A means analysis not performed, lost in analysis or not completed.
[c]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[d]Standards given here for comparison only, see Appendix A.

higher than typical environmental levels. A new method was implemented during 1992 by the Environmental Chemistry Group (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 tritium measurements made as part of a special study utilizing trace-level measurements of tritium to estimate the age of water in the main aquifer (see Section VII.E.1). In the case of the six water supply wells in the Guaje Well Field, the four wells in the Pajarito Well Field, and the Otowi-4 well in the Otowi Well Field, sampling conducted from 1991 through 1993 revealed no measurable tritium, even with the special method. An apparent detection of a trace amount of tritium in Well PM-3 was later discovered to have resulted from sample contamination in the laboratory (see Section VII.E.1), and subsequent detailed measurements confirm that water from Well PM-3 contains no measurable tritium. Trace-level measurements on the main aquifer springs also confirm that their tritium levels are far below the detection limit of the normal liquid scintillation analysis (see Section VII.E.1.e).

In 1993, 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, low-level measurements of a sample collected for this spring in September 1994 give a much lower tritium value of 2.7 ± 0.3 pCi/L (see Section VII.E.1.e).

b. Radiochemical Constituents in Alluvial Groundwater. None of the alluvial groundwater concentrations 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 all within the range of values observed in recent years.

The samples of the alluvial groundwater in Los Alamos Canyon show residual contamination, as has been seen since the original installation of the monitoring wells in the 1960s. In particular, for four of the wells, the concentration of ^{90}Sr is close to or exceeds the EPA primary drinking water standard MCL of 8 pCi/L. Residual tritium contamination resulting from the Omega West Reactor leak is also present, but mainly at levels below the detection limit of the EPA-specified liquid scintillation counting method and far below the present EPA tritium drinking water standard of 20,000 pCi/L (see Section VII.E.3).

In 1993, the sample from Los Alamos Canyon 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. 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. The 1994 sample results for Well LAO-2 show values 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. The levels of tritium, ^{90}Sr, ^{239,240}Pu, ^{241}Am, gross alpha, and gross beta exceed EPA drinking water criteria in many of the wells, but do not exceed the DOE DCGs for Public Dose for Ingestion of Environmental Water.

Pueblo Canyon Well APCO-1 again had a ^{239,240}Pu level (0.40 ± 0.05 pCi/L) above the detection limit. This well also had an ^{241}Am level (0.09 ± 0.025 pCi/L) above the detection limit. Pajarito Canyon Well PCO-2 and Pueblo Canyon Well APCO-1 had ^{90}Sr values above the detection limit. Well PCO-2 had high gross alpha and beta values of about 50 pCi/L, which were not supported by detection of specific radionuclides. Similarly, Cañada del Buey Well CDBO-6 had a high gross alpha value not supported by detection of specific radionuclides.

c. Radiochemical Constituents in Intermediate Perched Groundwater. The radioactivity measurements in samples from Test Wells 1A, 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 2.6 nCi/L. In previous years this has been confirmed by the low detection limit measurements of about 2.3 nCi/L (see Section VII.E.1). Test Well 1A showed traces of ^{137}Cs (19 pCi/L). This test well had ^{137}Cs activities of 37 pCi/L in 1990 and 56 pCi/L in 1991.

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

2. Nonradioactive Constituents.

The results of general chemical parameter analyses of groundwater samples for 1994 are listed in Table VII-2, and results of total recoverable metal analyses are listed in Table VII-3. Discussion of the results will address the main aquifer, the canyon alluvial groundwater, and the intermediate perched groundwater system. Finally, results of organic analyses will be discussed.

High nitrate levels were discovered in samples taken during 1994 from several Los Alamos area test wells and from water supply wells at the Pueblo of San Ildefonso. These results are discussed in Section VII.E.5.

a. Total Recoverable Metals Analyses. As was noted in the Environmental Surveillance at Los Alamos during 1993 (EARE 1995b) several wells and springs show high values for some 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, and (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, thallium, 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 total dissolved solids values confirm that suspended sediment is the probable source of the high metal concentrations. Total dissolved solids were determined by evaporation of filtered samples. For samples having high trace metals values, the total dissolved solids values are much lower than the sum of all of the analytes listed for the sample.

b. Nonradioactive Constituents in the Main Aquifer. A number of wells and springs have sodium concentrations greater than 20 mg/L, which is an EPA health advisory level.

Values for all parameters measured in the water supply wells were within drinking water limits, with the following exceptions. The arsenic level in Well G-2 was about 80% of the standard and was similar to previous measurements. The vanadium level in Well G-2 of 0.09 mg/L is at the lower end of the EPA health advisory range of 0.08 to 0.11 mg/L, but is lower than the 1993 value of 0.26 mg/L. Supply Well PM-1 had iron levels above the EPA secondary drinking water standard of 0.3 mg/L.

The test wells in the main aquifer showed levels of several constituents that exceed standards for drinking water distribution systems (see Section VII.E.1). However, the test wells are used for monitoring purposes only and are not part of the water supply system. 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 Wells 3 and 8; manganese was high in Test Wells 2 and DT-9; and zinc was high in Test Wells 4 and DT-10. Lead levels exceeded the EPA action level in all of the main aquifer test wells except Test Well 3 and 8 (see Section VII.E.1). Several of the test wells have occasionally had elevated lead levels in previous years, and unusually high lead values were reported for 1993 (EARE 1995b). The lead levels in the test wells are much lower for 1994.

Samples from a few springs (La Mesita Spring, Doe Spring, and Springs 1, 2, 3AA, 5A, 6, and 8) in White Rock Canyon showed aluminum levels that are higher than expected and that exceed New Mexico 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 most of the springs 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. Springs 2 and 4A had silver levels higher than the NMWQCC Groundwater Limit; Springs 2, 3AA, and 3B exceeded or approached the New Mexico Livestock and Wildlife Watering Standards for arsenic. Spring 3AA and 10 exceeded standards for barium, lead, and vanadium, as did Spring 10 for lead and Spring 1 for vanadium. Selenium levels were all again below the standard this year, discounting suspect levels from 1991 samples that were measured by a method with a much higher detection limit.

c. Nonradioactive Constituents in Alluvial Groundwater. Alluvial canyon groundwater 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. Mortandad Canyon alluvial

Table VII-2. Chemical Quality of Groundwater for 1994 (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	20	48	9.9	<3[c]	16	32	0.4	<10	103	<0.0	22	23.00	<0.0	<272	161	7.9	400
Test Well 3	N/A[d]	20	6.2	2	13	N/A	N/A	N/A	N/A	<0.0	N/A	0.97	<0.01	N/A	75	N/A	N/A
Test Well 8	45	7	2.6	<1	5	2	0.1	<5	32	<0.0	2	5.10	<0.01	84	29	8.6	36
Test Well DT-5A[e]	70	8	2.4	1	10	3	0.2	<5	54	0.0	3	0.33	<0.01	112	16	8.1	96
Test Well DT-9	76	10	2.6	1	10	3	0.3	<5	54	<0.0	3	0.28	<0.01	139	0	8.3	103
Test Well DT-10	57	11	3.2	2	11	3	0.3	<5	74	<0.0	3	0.22	<0.01	139	40	8.1	123
Water Supply Wells																	
O-4	37	20	8.0	<2	20	8	0.3	<10	118	<0.0	6	2.52	<0.0	<236	83	7.5	246
PM-1	77	22	5.9	3	15	3	0.2	<5	125	0.1	4	0.50	<0.01	276	79	7.7	213
PM-2[e]	33	9	<3.0	<1	11	2	0.3	<10	53	<0.0	2	1.36	<0.01	<158	35	8.0	116
PM-4[e]	29	14	<3.9	<2	13	3	0.3	<10	68	<0.0	3	1.84	<0.01	<166	52	8.1	157
PM-5	36	12	<4.5	<1	13	3	0.3	<10	68	<0.0	3	1.50	<0.0	<170	47	7.8	148
MAIN AQUIFER OFF SITE																	
Test Wells																	
Test Well 2	18	13	<3.5	<1	13	2	0.5	<10	63	<0.0	3	1.02	<0.01	<138	46	8.0	144
Test Well 4	58	13	6.3	3	10	2	0.2	<5	81	0.0	3	0.19	<0.01	284	58	8.0	128
Water Supply Wells																	
G-1A	28	10	<0.5	<2	32	3	0.6	<10	83	<0.0	4	1.97	<0.01	<188	26	8.4	176
G-2	29	10	<0.5	<2	37	3	0.8	<10	98	<0.0	4	1.60	<0.01	<192	27	8.5	202
G-4	24	18	<3.7	<2	12	3	0.3	<10	73	<0.0	3	2.01	<0.01	<146	59	8.2	171
MAIN AQUIFER SPRINGS																	
White Rock Canyon Springs Group I																	
Sandia Spring	47	26	1.6	3	14	4	0.5	<5	115	0.0	7	0.37	<0.01	114	71	8.0	182
Spring 3	52	22	1.9	3	16	4	0.5	<5	95	0.0	6	1.00	<0.01	130	62	8.4	159
Spring 3A	53	21	1.9	3	14	4	0.4	<5	85	<0.0	6	0.73	<0.01	110	63	8.3	157
Spring 3AA	42	99	6.9	5	24	3	0.5	<5	127	2.1	5	28.00	0.04	134	273	8.0	218
Spring 4	55	23	4.5	3	14	6	0.5	<5	86	<0.0	9	1.25	<0.01	126	73	7.9	179
Spring 4A	72	20	4.5	2	11	5	0.5	<5	82	0.1	6	0.90	<0.01	134	68	8.2	156
Spring 5	69	17	4.8	2	13	5	0.4	<5	77	<0.0	6	0.74	<0.01	160	61	8.4	155
Ancho Spring	79	12	3.0	2	10	3	0.4	<5	61	0.1	4	0.48	<0.01	156	42	7.9	108
White Rock Canyon Springs Group II																	
Spring 5A	61	44	4.6	4	16	5	0.4	<5	107	0.3	8	0.55	<0.01	140	128	7.9	188
Spring 5B	59	22	5.3	3	15	4	0.5	<5	78	<0.0	7	2.30	<0.01	164	75	8.2	167
Spring 6	71	14	5.2	3	12	3	0.4	<5	81	<0.0	4	0.13	<0.01	154	63	7.6	145

Table VII-2. Chemical Quality of Groundwater for 1994 (mg/L) (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)
White Rock Canyon Springs Group II (Cont.)																	
Spring 6A	75	13	2.9	3	12	3	0.5	<5	64	0.2	4	0.53	<0.01	152	44	7.8	115
Spring 7	77	12	3.0	3	15	3	0.3	<5	63	<0.0	5	0.47	<0.01	154	49	7.4	125
Spring 8	73	36	5.9	4	18	4	0.4	<5	111	0.3	8	0.54	<0.01	208	113	7.5	206
Spring 8A	80	13	3.4	2	11	3	0.5	<5	64	0.1	3	<0.04	<0.01	2100	46	8.2	115
Spring 8B	82	11	3.0	2	11	3	0.4	<5	66	0.0	3	0.15	<0.01	142	40	8.1	115
Spring 9	80	12	4.0	2	9	3	0.4	<5	60	0.1	3	0.28	<0.01	134	46	7.9	104
Spring 9A	76	17	3.7	2	12	3	0.5	<5	59	0.4	3	<0.04	<0.01	140	55	7.4	109
Doe Spring	78	19	7.2	6	5	3	0.5	<5	57	<0.0	3	0.13	<0.01	150	37	8.0	108
Spring 10	68	32	6.8	3	15	3	0.5	<5	85	0.1	5	0.45	<0.01	172	581	8.1	155
White Rock Canyon Springs Group III																	
Spring 1	34	36	4.7	5	31	4	0.6	<5	118	<0.0	7	0.24	<0.01	138	108	8.4	199
Spring 2	38	37	4.7	5	59	5	1.2	<5	170	0.2	8	<0.04	<0.01	208	111	8.5	289
White Rock Canyon Springs Group IV																	
La Mesita Spring	30	38	2.8	4	31	8	0.3	<5	127	0.0	14	5.80	0.01	188	105	7.6	269
Spring 3B	49	18	1.8	5	120	4	0.8	<5	298	0.0	16	1.40	<0.01	386	52	8.2	476
Other Springs																	
Sacred Spring	22	25	0.9	4	24	3	0.6	<5	106	2.5	6	1.80	<0.01	140	65	7.3	190
Indian Spring	55	37	5.7	3	26	21	0.5	<5	97	<0.0	7	0.83	<0.01	206	115	7.9	259
CANYON ALLUVIUM GROUNDWATER																	
DP-Los Alamos Canyon																	
LAO-C	29	8	2.3	2	4	6	<0.1	<5	28	0.1	5	<0.04	<0.01	122	28	7.0	77
LAO-0.7	34	48	6.4	9	45	76	0.3	<5	52	3.3	9	<0.04	<0.01	296	145	6.9	314
LAOR-1	39	26	5.6	7	39	61	0.3	<5	53	0.3	8	0.50	<0.01	244	86	6.9	348
LAO-1	38	21	4.0	4	41	68	0.2	<5	43	0.1	7	0.14	<0.01	202	68	6.9	343
LAO-2 [e]	41	16	3.7	5	21	32	0.8	<5	45	0.1	9	0.30	<0.01	171	55	6.9	220
LAO-3	44	25	5.1	8	42	54	0.9	<5	76	0.1	11	0.22	<0.01	184	83	7.4	377
LAO-4	40	17	4.6	5	32	48	0.6	<5	53	0.1	7	<0.04	<0.01	164	61	7.1	273
LAO-4.5	40	18	5.4	6	34	55	0.7	<5	46	0.2	8	<0.04	<0.01	184	67	6.8	290
Mortandad Canyon																	
MCO-4	33	23	2.1	12	71	12	1.8	<5	151	0.2	11	17.00	<0.01	396	66	7.8	415
MCO-5	34	28	3.7	21	100	16	1.9	<5	180	0.2	13	32.00	<0.01	506	84	7.6	584
MCO-6	36	42	4.4	28	120	20	1.8	<5	198	0.1	16	48.00	<0.01	296	123	7.5	723
MCO-7 [e]	37	46	11.7	16	125	19	1.3	<5	184	0.4	19	60.50	<0.01	509	162	7.2	826
MCO-7.5	37	54	15.0	26	130	22	1.1	<5	140	0.8	15	57.00	<0.01	480	197	7.1	727
MT-4	39	40	12.0	8	130	23	1.0	<5	130	0.9	19	46.70	0.02	480	150	7.4	740

Table VII-2. Chemical Quality of Groundwater for 1994 (mg/L) (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)
Pajarito Canyon																	
PCO-1	35	26	7.6	4	23	51	0.1	<5	59	0.1	9	2.80	<0.01	242	91	6.8	278
PCO-2	27	67	24.0	16	28	39	0.2	<5	80	3.1	12	5.00	<0.01	222	264	7.1	274
PCO-3	28	8	2.4	2	4	6	<0.1	<5	28	0.0	5	0.06	<0.01	11	29	7.0	79
Acid/Pueblo Canyon																	
APCO-1	76	27	5.0	15	62	38	0.7	<5	144	4.9	18	1.80	<0.01	396	87	7.1	399
Cañada del Buey																	
CDBO-6	53	13	5.1	7	21	13	0.2	<5	66	0.6	9	0.12	<0.01	196	53	7.0	180
CDBO-7	63	28	12.0	18	23	7	0.2	<5	85	0.3	6	0.08	<0.01	204	119	6.8	172
PERCHED SYSTEM IN PUEBLO/LOS ALAMOS CANYONS																	
Test Well 1A	21	28	8.5	7	60	41	0.6	<10	128	2.2	23	19.40	<0.0	<340	105	8.0	474
Test Well 2A	25	36	7.0	<3	24	40	0.2	<10	73	0.3	26	13.70	<0.01	<272	119	8.0	363
Basalt Spring	72	37	9.4	8	46	35	0.3	<5	92	0.2	21	15.00	<0.01	330	130	7.3	419
PERCHED SYSTEM IN VOLCANICS																	
Water Canyon Gallery	16	6	<2.7	<1	<5	1	<0.1	<10	28	<0.0	2	0.97	<0.0	<94	25	7.7	70
EPA Primary Drinking Water Standard[f]							4					10	0.2				
EPA Secondary Drinking Water Standard[f]						250					250			500		6.8-8.5	
EPA Health Advisory[f]					20												
NMWQCC Groundwater Limit[f]						250	1.6					10					

[a]Total dissolved solids
[b]Standard Units
[c]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[d]N/A means analysis not performed, lost in analysis, or not completed.
[e]Results averaged from more than one sample analysis
[f]Standards given here for comparison only, see Appendix A.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
MAIN AQUIFER ON SITE												
Test Wells												
Test Well 1	<0.004[a]	<0.039	<0.0050	<0.0658	<0.0719	<0.0010	<0.0020	<0.0061	<0.0040	<0.0028	0.58	<0.0002
Test Well 3	<0.010	0.120	0.0030	0.0190	0.0280	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.14	<0.0002
Test Well 8	<0.010	<0.100	<0.0030	<0.0200	<0.0040	<0.0030	<0.0030	<0.0040	<0.0040	<0.0080	<0.10	<0.0002
Test Well DT-5A[b]	<0.010	<0.100	<0.0030	0.0200	0.0218	<0.0030	<0.0030	0.0050	0.0330	0.0050	0.30	0.0001
Test Well DT-9	<0.010	<0.100	<0.0020	<0.0100	0.0160	<0.0030	<0.0030	<0.0040	<0.0040	0.0760	3.60	0.0001
Test Well DT-10	<0.010	<0.100	<0.0020	0.0500	0.0060	<0.0030	<0.0030	<0.0040	0.0050	0.1600	0.90	0.0001
Water Supply Wells												
O-4	<0.004	<0.009	<0.0050	<0.0490	<0.0366	<0.0010	<0.0021	<0.0040	<0.0045	<0.0020	<0.02	<0.0002
PM-1	<0.010	<0.100	<0.0030	0.0430	0.0690	<0.0030	<0.0030	<0.0040	<0.0070	0.0050	0.83	<0.0002
PM-2[b]	<0.004	<0.014	<0.0055	<0.0175	<0.0203	<0.0010	<0.0024	<0.0040	0.0163	<0.0020	<0.04	<0.0002
PM-4[b]	<0.004	<0.013	<0.0050	<0.0252	<0.0234	<0.0010	<0.0032	<0.0040	<0.0069	<0.0020	0.13	<0.0002
PM-5	<0.004	<0.019	<0.0050	<0.0192	<0.0272	<0.0010	<0.0020	<0.0040	<0.0040	<0.0020	<0.01	<0.0002
MAIN AQUIFER OFF SITE												
Test Wells												
Test Well 2	<0.004	<0.093	<0.0050	<0.0378	<0.0148	<0.0010	<0.0020	<0.0072	<0.0040	<0.0144	2.74	<0.0002
Test Well 4	<0.010	<0.100	<0.0020	0.0560	0.0520	<0.0010	0.0070	<0.0040	<0.0040	0.0120	0.56	<0.0001
Water Supply Wells												
G-1A	<0.004	<0.028	0.0119	<0.0422	<0.0326	<0.0010	<0.0020	<0.0040	<0.0082	<0.0020	<0.01	<0.0002
G-2	<0.004	<0.046	0.0427	<0.0438	<0.0585	<0.0010	<0.0038	<0.0040	<0.0091	<0.0136	<0.01	<0.0002
G-4	<0.004	<0.027	<0.0050	<0.0230	<0.0159	<0.0010	<0.0030	<0.0040	<0.0040	<0.0020	0.17	<0.0002
MAIN AQUIFER SPRINGS												
White Rock Canyon Springs Group I												
Sandia Spring	<0.010	0.300	0.0020	0.0200	0.1300	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.20	<0.0001
Spring 3	<0.010	0.100	0.0030	0.0200	0.0400	<0.0010	<0.0030	<0.0040	0.0040	<0.0040	0.10	<0.0001
Spring 3A	<0.010	0.100	0.0030	0.0400	0.0340	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.10	<0.0001
Spring 3AA	<0.010	7.700	0.0290	0.0500	0.8300	0.0030	<0.0030	0.0330	0.0330	0.0290	28.00	<0.0001
Spring 4	<0.010	<0.100	0.0020	0.0300	0.0530	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	<0.0001
Spring 4A	0.050	<0.100	<0.0020	0.0200	0.0400	<0.0010	<0.0030	<0.0040	0.0050	<0.0040	<0.10	<0.0001
Spring 5	<0.010	<0.100	0.0020	0.0440	0.0300	<0.0030	<0.0030	<0.0040	<0.0040	<0.0040	0.12	<0.0001
Ancho Spring	<0.010	0.400	<0.0030	0.0200	0.0300	<0.0010	<0.0030	<0.0040	0.0050	<0.0040	0.30	<0.0001
White Rock Canyon Springs Group II												
Spring 5A	<0.010	4.400	0.0030	0.0400	0.1500	<0.0010	<0.0030	<0.0040	0.0080	0.0050	3.90	<0.0001
Spring 5B	<0.010	1.800	0.0020	0.0190	0.0810	<0.0030	<0.0030	<0.0040	0.0080	<0.0040	1.70	<0.0001
Spring 6	<0.010	8.800	<0.0020	<0.0100	0.0870	<0.0030	<0.0030	<0.0040	0.0340	0.0080	11.00	<0.0001
Spring 6A	<0.010	2.400	0.0030	0.0200	0.0730	<0.0010	<0.0030	<0.0040	0.0070	0.0040	2.10	<0.0001

*Data on additional trace metals in groundwater are presented on page 244.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
White Rock Canyon Springs Group II (Cont.)												
Spring 7	<0.010	0.170	0.0020	0.0250	0.0260	<0.0030	<0.0030	<0.0040	<0.0040	<0.0040	0.14	<0.0001
Spring 8	<0.010	6.000	0.0040	0.0600	0.1400	<0.0010	<0.0030	<0.0040	0.0070	0.0070	5.10	<0.0001
Spring 8A	<0.010	0.600	<0.0030	0.0200	0.0350	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.60	<0.0001
Spring 8B	<0.010	<0.100	<0.0030	0.0200	0.0250	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	<0.0001
Spring 9	<0.010	3.900	<0.0030	<0.0100	0.0580	<0.0010	<0.0030	<0.0040	0.0190	0.0070	5.20	<0.0001
Spring 9A	<0.010	<0.100	0.0020	0.0020	0.0340	<0.0030	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	<0.0001
Doe Spring	<0.010	36.000	<0.0020	0.0700	0.3800	<0.0030	<0.0030	0.0090	0.0210	0.0190	29.00	<0.0001
Spring 10	<0.010	3.200	0.0090	0.1000	0.0940	<0.0030	0.0040	<0.0040	<0.0040	<0.0040	2.50	<0.0001
White Rock Canyon Springs Group III												
Spring 1	<0.010	8.500	0.0110	0.0500	0.3200	0.0010	<0.0030	0.0080	0.0280	0.0120	9.40	<0.0001
Spring 2	0.130	9.200	0.0310	0.0800	0.2500	0.0010	<0.0030	<0.0040	0.0040	0.0100	6.10	<0.0001
White Rock Canyon Springs Group IV												
La Mesita Spring	<0.020	4.700	0.0020	0.0380	0.1600	<0.0030	<0.0030	0.0070	0.0190	<0.0040	4.40	0.0001
Spring 3B	<0.010	0.200	0.0170	0.1500	0.0570	<0.0010	<0.0030	<0.0040	0.0210	<0.0040	0.40	<0.0001
Other Springs												
Sacred Spring	<0.020	0.750	0.0020	0.0310	0.1800	<0.0030	<0.0030	<0.0040	0.0050	<0.0040	0.73	0.0001
Indian Spring	<0.200	<0.100	0.0040	0.0200	0.1000	<0.0030	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	0.0001
CANYON ALLUVIUM GROUNDWATER												
DP-Los Alamos Canyon												
LAO-C	<0.010	1.700	<0.0030	<0.0200	0.0240	<0.0030	<0.0030	<0.0040	<0.0040	<0.0080	0.74	<0.0002
LAO-0.7	<0.010	6.700	0.0040	0.0570	3.1000	0.0070	0.0080	0.0290	<0.0040	0.0350	3.30	0.0001
LAOR-1	<0.010	15.400	0.0060	0.0630	0.1740	0.0030	0.0050	<0.0200	<0.0300	0.0300	11.10	<0.0001
LAO-1	<0.010	0.490	<0.0020	0.0370	0.0480	0.0014	<0.0030	<0.0200	<0.0300	0.0150	0.30	<0.0001
LAO-2[b]	<0.010	1.800	<0.0030	0.0800	0.0405	<0.0030	<0.0030	<0.0200	0.0400	<0.0080	0.84	<0.0002
LAO-3	<0.100	<0.100	<0.0020	0.0590	0.0750	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	<0.0001
LAO-4	<0.100	0.340	<0.0020	0.0500	0.0520	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.27	<0.0002
LAO-4.5	<0.100	0.540	<0.0020	0.0650	0.0530	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.42	<0.0002
Mortandad Canyon												
MCO-4	<0.020	2.200	0.0020	0.0530	0.0760	<0.0010	<0.0030	<0.0040	0.0280	0.0200	1.40	0.0002
MCO-5	<0.020	2.900	<0.0020	0.0500	0.1200	<0.0010	<0.0030	<0.0040	<0.0040	0.0130	1.80	0.0001
MCO-6	<0.010	0.025	<0.0020	0.0800	0.1400	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.05	<0.0001
MCO-7[b]	<0.010	9.140	0.0040	0.0850	0.4000	<0.0010	<0.0030	<0.0040	0.0200	0.1000	7.63	0.0001
MCO-7.5	<0.010	15.000	0.0020	0.0800	0.5400	<0.0010	<0.0030	0.0050	0.0170	0.0220	13.00	0.0001
MT-4	<0.010	16.000	0.0030	0.0900	0.9100	0.0120	<0.0030	0.0100	0.0110	0.0160	6.40	<0.0002

*Data on additional trace metals in groundwater are presented on page 244.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
CANYON ALLUVIUM GROUNDWATER (Cont.)												
Pajarito Canyon												
PCO-1	<0.020	0.150	<0.0020	0.0200	0.1300	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.26	0.0001
PCO-2	<0.020	99.000	0.0340	0.0250	2.6000	0.0120	<0.0030	0.0590	0.1300	0.0670	120.00	0.0003
PCO-3	<0.010	2.100	<0.0030	<0.0200	0.0290	<0.0030	<0.0030	<0.0040	<0.0040	<0.0080	1.10	<0.0002
Acid/Pueblo Canyons												
APCO-1	<0.010	0.850	0.0100	0.3600	0.1100	<0.0010	<0.0060	<0.0040	<0.0040	0.0080	0.48	<0.0001
Cañada del Buey												
CDBO-6	<0.010	27.000	0.0110	0.0390	0.2400	<0.0030	<0.0030	<0.0040	0.0120	0.0050	16.00	0.0002
CDBO-7	<0.010	89.000	0.0300	0.0590	1.6000	0.0100	<0.0030	0.0150	0.0460	0.0290	40.00	0.0002
PERCHED SYSTEM IN PUEBLO/LOS ALAMOS CANYONS												
Test Well 1A	<0.004	<0.009	<0.0050	0.1960	<0.0682	<0.0010	<0.0020	<0.0075	<0.0040	<0.0033	1.09	<0.0002
Test Well 2A	<0.004	<0.009	<0.0050	<0.0878	<0.0351	<0.0010	<0.0020	<0.0072	<0.0040	<0.0020	1.17	<0.0002
Basalt Spring	<0.020	0.140	0.0050	0.2100	0.0840	<0.0030	<0.0030	<0.0040	0.0050	<0.0040	0.18	0.0001
PERCHED SYSTEM IN VOLCANICS												
Water Canyon Gallery	<0.004	0.799	<0.0050	<0.0145	<0.0103	<0.0010	<0.0020	<0.0040	<0.0040	<0.0020	0.32	<0.0002
EPA Primary Drinking Water Standard[c]			0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard[c]		0.05-0.2									0.3	
EPA Action Level[c]										1.3		
Livestock Wildlife Watering Limit[c]		5.0	0.2	5.0			0.05	1.0	1.0	0.5		0.01
NMWQCC Groundwater Limit[c]	0.05		0.1	0.75	1.0		0.01	0.05	0.05	1.0		0.002

*****Data on additional trace metals in groundwater are presented on page 244.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
MAIN AQUIFER ON SITE											
Test Wells											
Test Well 1	0.0199	<0.027[a]	<0.0060	0.1780	<0.0192	<0.0040	<0.001	0.2610	<0.0010	<0.01	0.8890
Test Well 3	0.0050	<0.008	<0.0100	<0.0025	<0.0025	<0.0020	0.035	0.0910	<0.0025	0.01	0.0490
Test Well 8	<0.0030	<0.008	<0.0100	0.0040	<0.0020	<0.0020	<0.030	0.0350	<0.0020	<0.00	0.4600
Test Well DT-5A[b]	0.0108	<0.008	<0.0100	0.0130	0.0085	<0.0030	<0.030	0.0463	<0.0020	0.01	0.6475
Test Well DT-9	0.0480	<0.008	<0.0100	0.0140	<0.0020	<0.0020	<0.030	0.0480	<0.0020	0.01	0.4500
Test Well DT-10	0.0140	<0.008	0.0900	0.0950	<0.0020	<0.0020	<0.000	0.0450	<0.0020	0.00	4.0000
Water Supply Wells											
O-4	<0.0010	<0.027	<0.0060	<0.0015	<0.0030	<0.0040	<0.001	0.1080	<0.0010	<0.01	0.0602
PM-1	<0.0030	<0.008	<0.0100	0.0030	<0.0040	<0.0020	<0.030	0.1400	<0.0020	0.01	<0.0200
PM-2[c]	<0.0010	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0431	<0.0010	<0.01	<0.0050
PM-4[c]	<0.0133	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	0.1040	<0.0011	<0.01	<0.0036
PM-5	<0.0010	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0554	<0.0014	<0.01	<0.0041
MAIN AQUIFER OFF SITE											
Test Wells											
Test Well 2	0.0946	<0.027	<0.0060	0.0476	<0.0030	<0.0040	<0.001	<0.0568	<0.0010	<0.01	0.4950
Test Well 4	0.0380	<0.008	<0.0100	0.0520	<0.0020	<0.0020	<0.030	0.0530	<0.0020	<0.00	7.0000
Water Supply Wells											
G-1A	<0.0010	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0725	<0.0010	<0.04	<0.0081
G-2	<0.0010	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0787	<0.0010	0.09	<0.0147
G-4	<0.0134	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	0.1030	<0.0010	<0.01	<0.0044
MAIN AQUIFER SPRINGS											
White Rock Canyon Springs Group I											
Sandia Spring	0.0400	<0.008	<0.0100	0.0020	<0.0010	<0.0010	<0.030	0.4300	<0.0010	0.01	0.0300
Spring 3	0.0040	<0.008	<0.1000	0.0020	<0.0010	0.0010	<0.030	0.2400	<0.0010	0.02	<0.0200
Spring 3A	0.0060	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.2300	<0.0010	0.02	<0.0200
Spring 3AA	7.0000	<0.008	0.0300	0.0360	<0.0010	0.0010	<0.030	0.3500	<0.0010	0.11	0.0700
Spring 4	<0.0020	<0.008	<0.0100	<0.0010	<0.0010	0.0020	<0.030	0.1700	<0.0010	0.01	<0.0200
Spring 4A	0.0020	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.0960	<0.0010	0.01	0.0400
Spring 5	0.0030	<0.008	<0.0100	0.0010	<0.0010	<0.0002	<0.030	0.0910	<0.0010	0.01	<0.0200
Ancho Spring	0.0120	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.0580	<0.0010	0.01	<0.0200
White Rock Canyon Springs Group II											
Spring 5A	0.2300	<0.008	<0.0100	0.0060	<0.0010	0.0010	<0.030	0.2300	<0.0010	0.03	0.0300
Spring 5B	0.0690	<0.008	<0.0200	0.0040	<0.0010	<0.0020	<0.030	0.1300	<0.0010	0.02	<0.0200
Spring 6	0.0730	<0.008	0.0180	0.0010	<0.0010	<0.0020	<0.030	0.0810	<0.0010	0.03	0.0310
Spring 6A	0.1400	<0.008	<0.0100	0.0030	<0.0010	<0.0010	<0.030	0.0720	<0.0010	0.02	0.0200

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
White Rock Canyon Springs Group I (Cont.)											
Spring 7	0.0030	<0.008	<0.0100	0.0010	<0.0010	<0.0020	<0.030	0.0670	<0.0010	0.01	<0.0200
Spring 8	0.3100	<0.008	<0.0100	0.0120	<0.0010	<0.0020	<0.030	0.1900	<0.0010	0.02	0.0300
Spring 8A	0.0270	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.0590	<0.0010	0.01	<0.0200
Spring 8B	0.0040	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.0530	<0.0010	0.01	<0.0200
Spring 9	0.1600	<0.008	<0.0100	0.0030	<0.0010	0.0010	<0.030	0.0620	<0.0010	0.03	0.0200
Spring 9A	<0.0030	<0.008	<0.0100	0.0100	0.0010	<0.0020	<0.030	0.0770	<0.0010	0.01	<0.0200
Doe Spring	0.5400	<0.008	0.0190	0.0010	<0.0010	<0.0020	<0.030	0.0490	<0.0010	0.04	0.1300
Spring 10	0.1100	<0.008	<0.0100	0.1040	<0.0010	<0.0020	<0.030	0.2600	0.0010	0.01	<0.0200
White Rock Canyon Springs Group III											
Spring 1	0.2000	<0.008	0.0200	0.0120	<0.0010	<0.0010	<0.030	0.5100	<0.0010	0.16	0.0300
Spring 2	0.8500	<0.008	<0.0100	0.0110	<0.0010	<0.0010	<0.030	0.4500	<0.0010	0.05	0.0300
White Rock Canyon Springs Group IV											
La Mesita Spring	0.1100	<0.020	<0.0100	0.0040	<0.0010	0.0020	<0.030	0.8600	<0.0010	0.02	0.0190
Spring 3B	0.0100	0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.2700	<0.0010	0.04	<0.0200
Other Springs											
Sacred Spring	0.0420	<0.020	<0.0100	0.0010	<0.0010	<0.0020	<0.003	0.5300	<0.0010	<0.00	0.0250
Indian Spring	<0.0030	<0.008	<0.2000	<0.0050	0.0020	0.0020	<0.030	0.3800	<0.0010	0.01	0.4500
CANYON ALLUVIUM GROUNDWATER											
DP-Los Alamos Canyon											
LAO-C	0.0090	<0.008	<0.0100	<0.0020	<0.0020	<0.0020	<0.030	0.0480	<0.0020	<0.00	<0.0200
LAO-0.7	14.0000	<0.008	0.0630	0.0110	<0.0020	<0.0020	<0.030	0.4200	<0.0020	0.02	0.1500
LAOR-1	0.6800	0.062	<0.0100	0.0280	<0.0010	<0.0020	<0.030	0.1690	<0.0010	0.03	0.0820
LAO-1	0.0200	0.055	<0.0100	<0.0010	<0.0010	<0.0020	<0.030	0.1350	<0.0010	<0.02	<0.0200
LAO-2[b]	0.0090	0.440	<0.0200	<0.0020	<0.0020	<0.0020	<0.030	0.0750	<0.0020	<0.02	<0.0200
LAO-3	0.0060	0.250	<0.0100	<0.0020	<0.0010	<0.0020	<0.030	0.1500	<0.0010	<0.00	<0.0200
LAO-4	0.0130	0.038	<0.0100	<0.0020	<0.0010	<0.0020	<0.030	0.1200	<0.0010	<0.00	<0.0200
LAO-4.5	0.0300	<0.008	<0.0100	0.0040	<0.0010	<0.0020	<0.030	0.1200	<0.0010	<0.00	<0.0200
Mortandad Canyon											
MCO-4	0.1700	0.250	<0.0100	0.0060	<0.0020	<0.0020	<0.030	0.0750	<0.0020	0.01	0.0430
MCO-5	0.0450	0.260	<0.0100	0.0020	<0.0020	<0.0020	<0.030	0.1300	<0.0020	0.01	0.0340
MCO-6	<0.0020	0.250	<0.0100	<0.0020	<0.0020	<0.0020	<0.030	0.1900	<0.0020	<0.00	<0.0200
MCO-7	0.1870	0.050	<0.0100	0.0270	<0.0020	<0.0020	<0.0300	0.2850	<0.0020	0.03	0.0525
MCO-7.5	0.2900	0.060	<0.0100	0.0200	<0.0020	<0.0020	<0.0300	0.3500	<0.0020	0.02	0.0800
MT-4	0.7600	<0.020	0.1100	0.0580	<0.0010	<0.0020	<0.0300	0.2800	<0.0010	0.02	0.1000

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
CANYON ALLUVIUM GROUNDWATER (Cont.)											
Pajarito Canyon											
PCO-1	0.0500	<0.008	<0.0100	<0.0020	<0.0020	<0.0020	0.044	0.1800	<0.0020	<0.00	<0.0200
PCO-2	6.5000	<0.008	0.0980	0.1470	<0.0020	<0.0020	<0.030	0.5200	<0.0020	0.14	0.3300
PCO-3	0.0220	<0.008	<0.0100	0.0020	<0.0020	<0.0020	<0.030	0.0500	<0.0020	<0.00	<0.0200
Acid/Pueblo Canyon											
APCO-1	2.4000	<0.008	<0.0100	0.0030	<0.0020	<0.0020	<0.030	0.1300	<0.0020	0.02	0.0300
Cañada del Buey											
CDBO-6	0.2500	<0.008	<0.0100	N/A[d]	N/A	0.0030	<0.030	0.1000	N/A	0.03	0.0870
CDBO-7	1.7000	<0.008	0.0300	N/A	N/A	<0.0020	0.044	0.2600	N/A	0.07	0.2400
PERCHED SYSTEM IN PUEBLO/LOS ALAMOS CANYON											
Test Well 1A	0.1490	<0.027	<0.0116	0.0079	<0.0030	<0.0040	<0.001	0.1560	<0.0010	<0.01	3.2700
Test Well 2A	0.0592	<0.027	<0.0069	0.0093	<0.0030	<0.0040	<0.001	0.2000	<0.0010	<0.01	0.4140
Basalt Spring	0.0360	<0.020	<0.0100	0.0010	0.0010	<0.0020	<0.030	0.2000	<0.0010	0.01	0.0220
PERCHED SYSTEM IN VOLCANICS											
Water Canyon Gallery	<0.0022	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0414	<0.0010	<0.01	<0.0030
EPA Primary Drinking Water Standard[c]			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard[c]	0.05										5.0
EPA Action Level[c]				0.015							
EPA Health Advisory[c]								25-90		0.08-0.11	
Livestock Wildlife Watering Limit[c]				0.1						0.1	25.0
NMWQCC Groundwater Limit[c]		1.0		0.05		0.05					

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]Results are the mean of more than one sample analysis
[c]Standards given here for comparison only, see Appendix A.
[d]N/A means analysis not performed, lost in analysis, or not completed.

groundwater exceeds the NMWQCC Groundwater Limit for fluoride and nitrate. Nitrate is used in the treatment process at the TA-50 Radioactive Liquid Waste Treatment Plant. Mortandad Canyon alluvial groundwaters are also high in sodium. The trace metal data for the alluvial canyon groundwaters were particularly influenced by the effects of suspended sediment in unfiltered samples. The affected samples include the groundwater samples from Pajarito Canyon and Cañada del Buey. These effects include concentrations of aluminum, iron, and manganese that exceed the dissolved levels of these elements that are possible in unfiltered natural waters having pH between 6 and 8.

In particular, wells LAO-0.7, LAO-R1, PCO-2 and CDBO-7 had levels of some metals, including arsenic, barium, beryllium, cobalt, chromium, nickel, lead, and vanadium, which exceeded NMWQCC Groundwater Limits or EPA drinking water standards.

d. Nonradioactive Constituents in Intermediate Perched Groundwater. The nitrate values for Test Wells 1A, 2A, and Basalt Spring exceeded the NMWQCC Groundwater Limits or EPA drinking water standards. These results are discussed separately in Section VII.E.5.

Except for manganese and iron, none of the intermediate perched groundwater or the Water Canyon Gallery showed any concentrations of trace metals that are of concern.

e. Organic Constituents. Analyses for organic constituents were performed on most of the test wells, water supply wells, and alluvial observation wells in 1994. The analyses addressed the volatile organic compounds, semivolatile organic compounds, and polychlorinated biphenyls (see Tables D-20 and D-22 for detailed listings of parameters). The alluvial wells in Cañada del Buey were not sampled for organics. The samples where organics were detected are listed in Table VII-4. The two organic compounds detected (acetone and bis-2-ethylhexylphthalate) 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. Bis-2-ethylhexylphtha-late is a common contaminant found in samples that have come in contact with plastic laboratory and sampling equipment. The only organic detection not readily explained by trip or lab blank contamination was acetone in Test Well DT-5A.

D. Long-Term Trends

1. Main Aquifer.

The long-term trends of the water quality in the main aquifer have shown little impact resulting from Laboratory operations. Except for low levels of tritium contamination found at four locations in Los Alamos and Pueblo Canyons and one location in Mortandad Canyon, no concentrations of radionuclides above detection limits have been measured on water samples from the production wells or test wells that reach the main aquifer other than an

Table VII-4. 1994 Results for Samples with Detection of Organic Compounds

Well	Compound	Amount (μg/L)	Comments
Test Wells			
DT-5A	Acetone	22 ± 6.6	
TW-4	Bis-2-Ethylhexylphthalate	16 ± 4.8	lab contamination
Water Supply Wells			
PM-4	Bis-2-Ethylhexylphthalate	53 ± 15.9	common lab contaminant
Alluvial Observation Wells			
PCO-1	Bis-2-Ethylhexylphthalate	14 ± 4.2	lab contamination
PCO-2	Acetone	27 ± 8.1	trip blank contaminated
MCO-4	Acetone	23 ± 6.6	trip blank contaminated
MCO-5	Acetone	36 ± 6.6	trip blank contaminated
	Bis-2-Ethylhexylphthalate	<11	lab contamination
MT-4	Acetone	28 ± 8.4	lab blank contaminated

occasional analytical statistical outlier not confirmed by analysis of subsequent samples. The apparent detection of ^{90}Sr in Test Well 3 in 1994 presently appears to be due to analytical error, because the gross beta measurement does not support the strontium result. A follow-up sampling program to verify this result is underway.

Measurements of 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 a 0.01% of current drinking water standards, and are all less than levels that could be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations. Recent detection of lead in the main aquifer test wells appears to have resulted from contamination by well casings, pumps, and monitoring devices (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-0 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 wells in the Pajarito Field 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 they were drilled. 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 to within about 12 to 20 m (20 to 50 ft) of original levels in the vicinity of Wells LA-1B, LA-2, and LA-3. In the vicinity of Wells LA-4, LA-5, and LA-6 the water levels were within about 20 to 31 m (50 to 80 ft) of original levels. All remaining facilities in the Los Alamos Well Field were turned over to the Pueblo of San Ildefonso in July 1992.

2. Alluvial Perched Groundwater 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. Note that the current plutonium detection limit of 0.02 pCi/L applies to the separate analyses of ^{238}Pu and $^{239,240}Pu$, and might be doubled for the addition of these values, since results are often at or near the detection limit. The tritium concentration has fluctuated almost in direct response (with a time lag of about one year) to the average annual concentration of tritium in the TA-50 effluent.

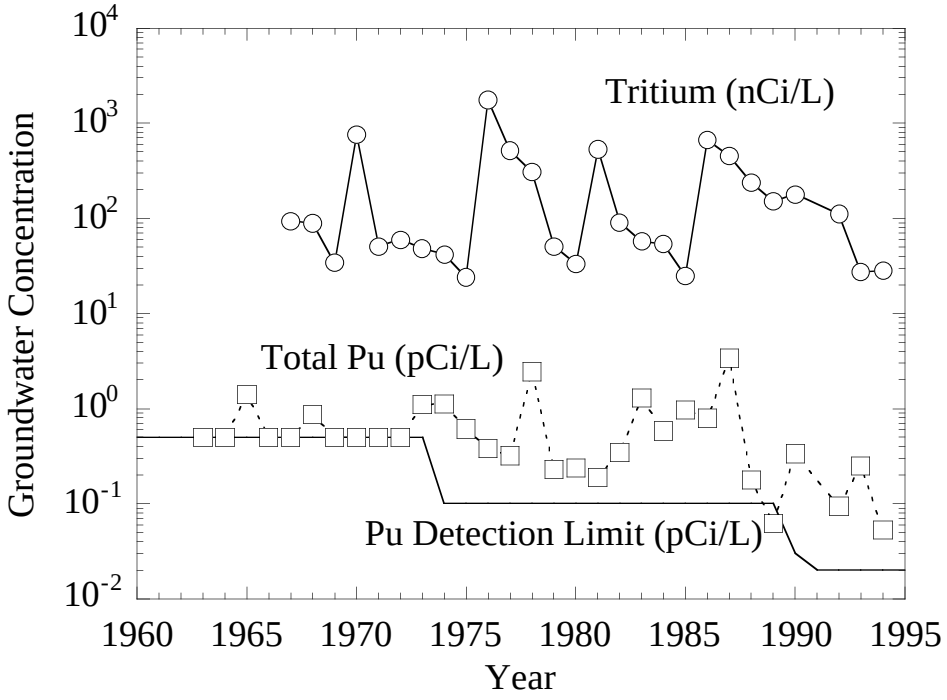


Figure VII-3. Tritium and plutonium concentrations in water samples from Mortandad Canyon Alluvial Observation Well MCO-6.

E. Special Studies

1. Main Aquifer Geochemistry.

a. Lead Evaluation in Test Well DT-5A (Max Maes and David Rogers, ESH-18)**.** In May of 1993, representatives of the NMED/AIP, the Geology and Geochemistry Group (EES-1), and the Environmental Protection Group (EM-8) collected water samples from several of the Laboratory's test wells (EARE 1995b). In July of 1993, 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 NMWQCC lead limit for groundwater is 0.05 mg/L). The results were a significant departure from previous lead measurements in Test Well DT-5A (EARE 1995b) and suggested a possible upward trend in lead concentrations. Lead levels higher than previous values were also measured at four other test wells. The production wells that supply drinking water to the Los Alamos community generally have not shown excessive lead levels.

The dissolved concentrations of lead in surface water and groundwater 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 the Laboratory and the NMED/AIP were unfiltered, however; thus the lead was possibly associated with suspended sediment particles. An analysis by EES-1 of a filtered sample showed a far lower lead concentration of 0.037 mg/L in Test Well DT-5A. For this well, the source of lead contamination was suspected to be the pump hardware (originally installed in Test Well 4 in the 1960s, then moved to DT-5A in the 1970s). 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 37 m (120 ft) deep. Materials dispersed by detonation of the high explosives remain at the bottom of the experimental holes. These materials include 40 kg (88 lb) of plutonium, 93 kg (205 lb) of enriched uranium, 82 kg

(180 lb) of depleted uranium, and 90,000 kg (198,000 lb) of lead which was used as shielding (Purtymun 1987b; LANL 1992b). 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 366 m (1,200 ft) below TA-49. Age dating of groundwater from test wells at TA-49 supports the conclusion that there is no component of recent recharge in this area (see Section VII.E.1.b.).

A follow-up study was conducted at Test Well DT-5A as a result of elevated lead levels discovered in 1993. Modifications were made to the DT-5A pump in 1992, and elevated lead concentrations were suspected to have resulted from particles loosened from the hardware during this procedure. An x-ray diffraction test was done on pipe samples and showed that the piping indeed had lead coating.

The pump test of DT-5A ran from November 21 through December 1, 1994. The purpose of the study was to determine the amount of dissolved lead, and to what extent lead was associated with particles suspended in the water samples. In order to evaluate the lead concentrations associated with particles of different sizes, a three-step filtration system was designed using 1.0 micron, 0.45 micron, and 0.20 micron filters. Nearly 134,615 L (35,000 gal.) of water were pumped from the well, and on average, filtered and unfiltered samples were collected daily to monitor lead concentrations. The total volume of water purged was 130,846 L (34,020 gal.) over the two week period. The discharge was carried out under NPDES Permit Guidance and approved by the NMED.

Lead concentrations in unfiltered water showed concentrations ranging from the detection limit, which varied from 2 to 40 μg/L, up to a value of 50 μg/L (Table VII-5 and Figure VII-4). The filtered water showed no lead concentrations above the detection limit, which ranged from about 2 to 40 μg/L.

The sharp decline of lead levels in both filtered and unfiltered samples, in comparison to 1993 values, indicates that the lead was associated with a small amount of particles within the well bore, rather than reflecting a larger quantity of the lead within the aquifer. It is probable that most of these lead particles were removed from the well bore during repeated sampling in 1993 and 1994.

Well DT-5A is part of the environmental surveillance network and is tested annually for lead, as well as other trace metals and radiochemistry.

b. Recharge Age of Water in Main Aquifer (David Rogers and Alan Stoker, ESH-18; Fraser Goff, EES-1; and Andrew Adams, CST-7)**.** In order to evaluate the risk and possible pathways of contamination for the main aquifer system at Los Alamos, in 1991 the Water Quality and Hydrology Group's Hydrology Team initiated a study to help define the sources of recharge to the aquifer (EPG 1993, EPG 1994, EARE 1995b). The cooperative study involves participation by researchers in other divisions at Los Alamos (Earth and Environmental Sciences and Chemical Science and Technology Divisions) and another DOE contractor (RUST GeoTech at Grand Junction, Colorado).

Table VII-5. Time Series Lead Concentrations (μg/L) from Test Well DT-5A

	Unfiltered Samples		Filtered Samples		
Date	Lead Concentration	Analytical Uncertainty	Lead Concentration	Analytical Uncertainty	Water Volume (gal.)
11/21/1994	43	2	<2	2	0
11/21/1994	13	2.2	<2.2	2.2	194.4
11/22/1994	<30	30	<30	30	5,883.2
11/23/1994	<30	30			9,720.0
11/24/1994	50	30			13,608.0
11/25/1994	40	30			17,496.0
11/28/1994	<30	30	<30	30	22,356.0
11/29/1994	37	30	<30	30	26,244.0
11/30/1994	<40	40			30,132.0
12/01/1994	<40	40	<40	40	34,020.0

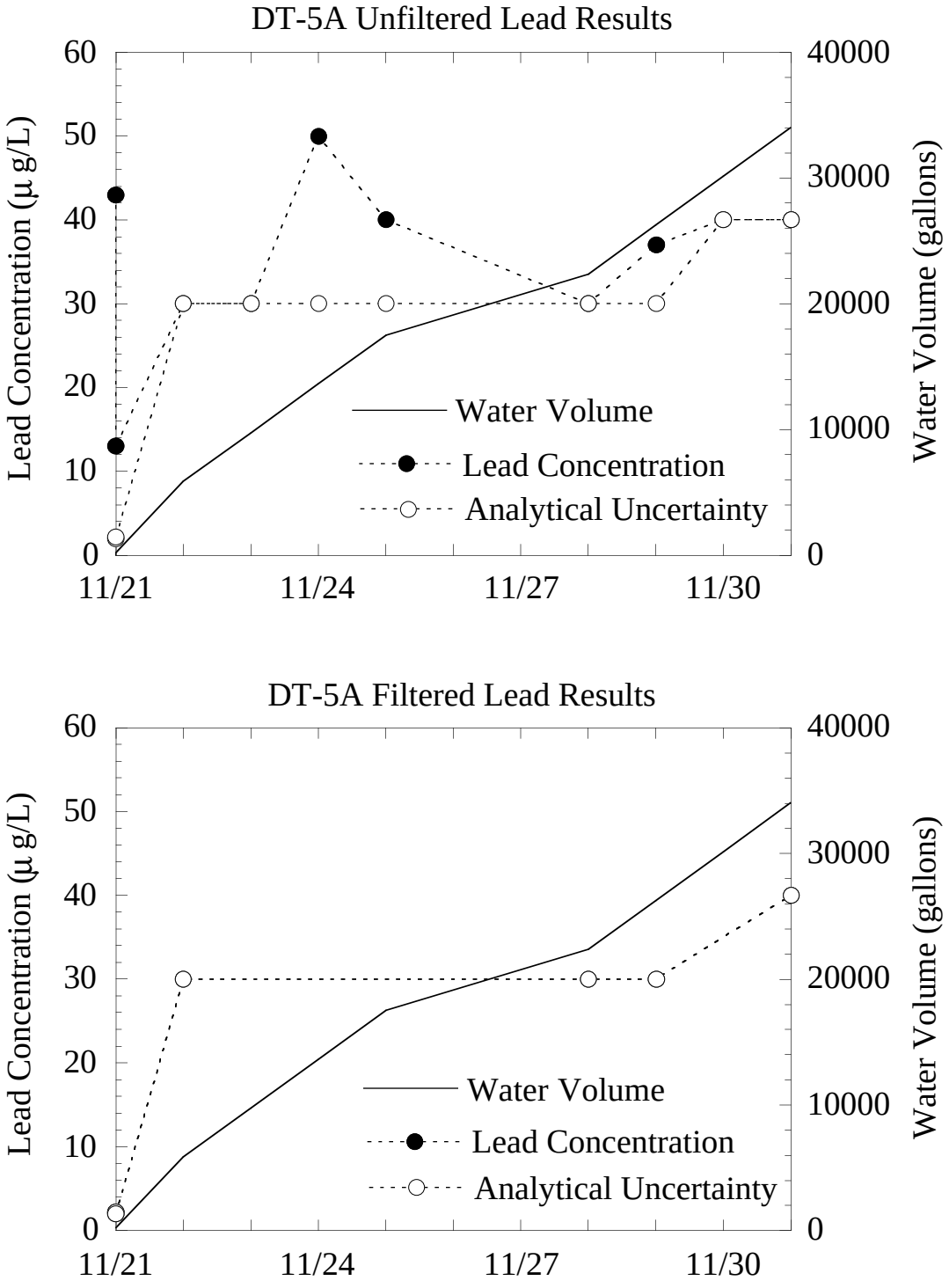


Figure VII-4. Unfiltered (top) and filtered (bottom) lead concentration time series from Test Well DT-5A at TA-49. The analytical uncertainty for each analysis is shown by open circles, and the lead concentration (where greater than the analytical uncertainty) is shown by solid circles. For the filtered analyses, measurements were at or below the detection limit so are not shown. The measurements were all below the analytical uncertainty; thus, the laboratory reported only the uncertainty values. The cumulative amount of water pumped from the well during the test is also indicated.

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. The measurements made starting in 1991 include several advanced techniques not commonly applied to groundwater samples. These techniques have much lower detection limits than can be achieved by conventional analytical methods and are used to quantify what are essentially trace levels of the isotopes in question. In some cases, the isotopic measurements permit estimates of the time it has taken water to move from the surface to the groundwater. Samples have been collected from the test wells and the water supply production wells that penetrate the main aquifer, and also from springs that issue along the Rio Grande. These springs have been interpreted to be discharging directly from the main aquifer (Purtymun 1980b).

This section is primarily concerned with the age dating results; the specific trace-level tritium measurements and some of the carbon-14 results are discussed in the following sections.

Use of Carbon-14 and Tritium as Age Indicators. An expanding database of measurements for trace-level tritium and carbon-14 is enhancing the knowledge of the groundwater processes in the vicinity of the Los Alamos National Laboratory. Some of the measurements confirm that there are pathways for transport of water from the land surface to the main groundwater aquifer beneath the Pajarito Plateau. In Los Alamos County the main aquifer lies hundreds of feet beneath the surface and is the source of municipal and industrial water supply for Los Alamos County, including both the Los Alamos National Laboratory and the adjacent community areas. The main aquifer also provides water for several residences in Los Alamos Canyon and discharges through springs into the Rio Grande in White Rock Canyon. Several household wells at the Pueblo of San Ildefonso also draw water from the main aquifer horizons, which are at a shallow level along the Rio Grande.

"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 carbon-14. Radioactive carbon-14 (or radiocarbon) comes from the interaction of cosmic rays with the atmosphere. Tritium is a naturally occurring isotope of hydrogen, produced in the atmosphere by cosmic rays, and by decay of naturally occurring radioactive elements in rocks. Tritium is also produced by nuclear reactors and as part of the development and testing of nuclear weapons. 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.

Perspective on Tritium Levels in Nature. Before discussing tritium measurements in the Los Alamos area deep wells, it is helpful to give some background on environmental tritium levels. Before atmospheric testing of nuclear weapons began, tritium levels in precipitation were about 20 pCi/L. This is 5 to 10 times the tritium levels detected in the Los Alamos public water supply wells. By the mid-1960s, tritium in atmospheric water in northern New Mexico reached a peak level of about 6,500 pCi/L because of aboveground nuclear testing. At present, general atmospheric levels in northern New Mexico are about 30 pCi/L, and those in the Los Alamos vicinity range from 20 to 450 pCi/L (Adams 1995).

For comparison, the present EPA tritium drinking water standard is 20,000 pCi/L; in 1991 the EPA issued regulations proposing to raise this to 60,000 pCi/L. Monitoring of compliance with the drinking water regulations uses the EPA-specified liquid scintillation counting method with a detection limit of about 300 to 700 pCi/L. The trace-level tritium measurements in our study were performed at the University of Miami and have a detection limit of about 1 pCi/L.

Tritium Age-Dating of Groundwater. 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-6). 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 carbon-14 ages are also available. Groundwater 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

Table VII-6. Summary of Carbon-14 and Tritium-Based Age Estimates for Wells in the Los Alamos Area

Well or Spring	Carbon-14 (% modern)	Carbon-14 Age Estimates Minimum[a]	Carbon-14 Age Estimates Maximum[b]	Tritium (pCi/L)	Tritium (T.U.[c])	Tritium Age Estimates[d] Piston Flow[e]	Tritium Age Estimates[d] Well-mixed[f]
Los Alamos Main Aquifer Water Supply Wells							
O-4	25.0	3,890	11,500	1.04	0.32	>50	>5,000
PM-1	18.5	5,620	14,000	1.65	0.51	>45	>3,000
PM-2	62.7	50	3,860	1.59	0.49	>45	>3,000
PM-3	23.9	4,950	11,800	0.45	0.14	>70	>9,000
PM-3 @ 987'	28.2	6,770	10,500	0.42	0.13	>70	>9,000
PM-3 @ 1,226'	24.5	7,700	11,600	0.26	0.08	>70	>10,000
PM-3 @ 1,650'	22.9	7,910	12,200	0.03	0.01	>100	>10,000
PM-3 @ 2,000'	23.9	6,390	11,800	0.10	0.03	>100	>10,000
PM-5	53.7	1,040	5,140	0.29	0.09	>70	>10,000
G-5	26.8	6,110	10,900	0.26	0.08	>70	>10,000
Los Alamos Main Aquifer Test Wells							
TW-1	237.2		Cont.[h]	366	113		Cont.[h]
TW-2	57.3	<0[g]	4,610	2.75	0.85	~40	>1,500
TW-3	40.45	921	7,480	2.88	0.89	~40	>1,500
TW-4	57.1	<0[g]	4,630	10.8	3.34	~35	~500
TW-8	—	—	—	89	27.6		Cont.[h]
DT-5A	57.6	1810	4,560	0.23	0.07	>80	>10,000
DT-9	69.1	163	3,060	0.45	0.14	>70	>9,000
DT-10	82.0	<0[g]	1,640	1.33	0.41	~55	>4,500
Intermediate Depth Perched Groundwater							
TW-1A	182.2		Cont.[h]	148	45.8	20-30	<20
TW-2A	—	—	—	2,265	699		Cont.[h]
LADP-3	—	—	—	5,830	1800		Cont.[h]
Basalt Spring	—	—	—	162	50	20-30	<20
Perched Water in Volcanics- Water Canyon Gallery							
Gallery Spring			12.8	6.48	2-40	5-100	
San Ildefonso Wells							
LA-1B	<0.9	>27,000	>39,000	0.58	0.18	>60	>8000
LA-1A	13.9	6,250	16,300	63.8	19.7	20-30	10-50
LA-2	27.2	5,850	10,800	13.1	4.04	35-40	~400
East Artesian	3.8	18,200	27,000	1.0	0.31	>50	>5000
West Artesian	0.0	>35,000	>45,000	0.39	0.12	>70	>10000
Halladay House	10.7	13,400	18,500	0.94	0.29	>50	>5,000
Pajarito Pump #2	30.9	1,280	9,700	3.05	0.94	~ 40	>1,500

[a]Assumes dilution by dead carbon from dissolution of carbonates, estimated by $\delta^{13}C$.
[b]Assumes radioactive decay only, no dissolution of carbonates.
[c]Tritium Units, one tritium atom in 10^{18} hydrogen atoms; 1 TU = 3.24 pCi/L.
[d]From Blake (1995).
[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.
[g]Applying dilution factor (footnote a) results in meaningless minimum age.
[h]"Contaminated" indicates sample contains recent contamination from the surface, because the concentration of tritium or carbon-14 is greater than could be attributed to any atmospheric or other natural source.

are ≥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 ≥10,000 years, but this is at the limit of tritium age determinations. Waters with tritium concentrations ≥1000 pCi/L and collected after 1990 cannot have their ages modeled, and can only be the result of contamination (Blake 1995).

Measurements of tritium by trace-level analytical methods show the presence of some recent recharge (meaning within the last four decades) in water samples from three locations in the main aquifer at Los Alamos. Because tritium has a short half-life of about 12.3 years and behaves chemically as do other isotopes of hydrogen, it is an extremely sensitive tracer for the movement of water. Recent recharge to intermediate depth perched groundwater beneath the Pajarito Plateau has also been indicated at four locations. Many other samples of well and spring water show no apparent recent recharge to the main aquifer. The levels measured range from about 1% to <0.01% of a percent of current drinking water standards, and most are far less than levels that could even be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations.

Carbon-14 Age-Dating of Groundwater. About 25 measurements of carbon-14 in samples of groundwater in the Los Alamos vicinity have been completed at present (Table VII-6). The measurement of carbon-14 in natural materials is an accepted and widely used method for estimating ages ranging from a few thousand to tens of thousands of years. These measurements indicate that the water in the main aquifer may have maximum ages ranging from a few thousand years in the central and western part of the Pajarito Plateau, up to as much as 40,000 years along the Rio Grande, near its confluence with Los Alamos Canyon.

The maximum possible ages (Table VII-6) result from a direct carbon-14 measurement, which gives an age based on the radioactive decay of carbon-14. This value is often greater than the actual age, because the amount of carbon-14 in relation to total carbon is frequently diluted in groundwater 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 assumptions about mixing. Calculating a minimum age based on the estimated dilution can lead to very young or meaningless ages if the carbonate geochemistry is not well characterized. It is also possible that carbon-14 from other sources such as Laboratory effluents could raise the amount of carbon-14 in a sample and lead to an inferred age that is very "young" or even negative. However, if the measured amount of carbon-14 present in the sample is greater than found in precipitation, then it is probably an indication of contamination.

Several of the Los Alamos vicinity groundwater samples indicated very young or meaningless ages, reflecting these possible complications (Table VII-6). The main aquifer sources with very young estimated ages include Supply Well PM-2 (50 years), Test Well 2 (negative age), Test Well 3 (921 years), Test Well 4 (negative age), Test Well DT-10 (negative age), and Test Well DT-9 (163 years). Most of these results are probably attributable to lack of complete understanding of the carbonate geochemistry because they are not confirmed by the presence of tritium. However, the result for Test Well 4 may be an indication of recent recharge because trace-level tritium was detected there. The results for Test Wells 2 and 3 also may be suspect as their tritium measurements were just at the detection limit. These wells will need to be studied further to resolve the questions.

The wells that clearly show carbon-14 contamination are Test Well 1, in the main aquifer, and Test Well 1A, an intermediate perched zone well. Both wells show significant recent recharge based on the tritium measurements.

Department of Health & Human Services Evaluation. The US Department of Health & Human Services Agency for Toxic Substances and Disease Registry (ATSDR) evaluated the trace levels of tritium that we found in Los Alamos and the Pueblo of San Ildefonso water supply wells. Regarding the now discredited tritium measurement of 20 pCi/L for the Pajarito No. 3 Well (see Section VII.E.1.c), the ATSDR said, "It should be emphasized that 20 pCi/L is only 1/1000 of the present EPA drinking water limit and 3/10,000 of EPA's proposed limit for drinking water. ATSDR considers water at these drinking water levels to be safe for human consumption. The 20 pCi/L is orders of magnitude below a level that would present a health hazard to individuals drinking this water. In addition, this concentration is one to two orders of magnitude less than the minimum detectable limit of the recommended liquid scintillation counting method used by the EPA."

The discovery of trace levels of tritium in some test wells (EARE 1995b) is a matter of concern to the Laboratory. However, most of these test wells tap the top of the main aquifer; the water supply wells draw water from deeper levels. A higher tritium level was detected in a test well (Test Well 2A) that does not reach the main aquifer, but is used to monitor conditions at a much shallower level beneath Pueblo Canyon. Water from Test Well 2A had a tritium measurement of 2,237 pCi/L. Regarding this tritium measurement, the ATSDR said "Even though this well is only a test well and apparently does not provide drinking water . . . compared to the EPA drinking water limit . . . of total radioactivity, this level is not of concern to affect health."

c. Reevaluation of Tritium in Water Supply Well PM-3 (David Rogers, Max Maes, and Alan Stoker, ESH-18)**.** Water Supply Well PM-3 was sampled for trace-level tritium analysis in August of 1992, with the analysis showing 1.2 pCi/L (Table VII-7). This is considered to represent 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 956 to 291 to 776 m (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 5,000 to 5,385 L/min (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 miles) (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.

In order to increase confidence in the tritium results, zonal sampling was carried out in Supply Well PM-3 in April 1994. This sampling was made possible because the main pump had to be removed for repairs. The well service contractor completed removing the main pump from PM-3 in January 1994. A downhole video camera inspection determined that the production casing was in good condition. Welded joints appeared sound, no broken louvers were seen, and no corrosion problems appeared. Some expected scale deposits were observed at various depths. The bottom of the well was filled with sediments to a depth of about 683 m (2,240 ft). A smaller submersible pump was temporarily installed in Well PM-3 to conduct the zonal sampling. The well was left undisturbed until the sampling was conducted on April 25 through 28, 1994. The tritium analyses were made by two independent laboratories (University of Miami and Teledyne) and the sample sets include several special Quality Assurance samples, both blanks and known-concentration internal spikes.

Samples were collected on subsequent days at depths of 610, 503, 374, and 301 m (2,000, 1,650, 1,226, and 987 ft). The analyses from the University of Miami are listed in Table VII-7. The results at all four depths show no measurable tritium at the detection limit of the University of Miami method, which is about 0.3 pCi/L for this set of samples. Results from the Teledyne analyses were below that laboratory's detection limit (3 to 5 pCi/L) for the

Table VII-7. Trace-Level Tritium Measurements in Water Supply Well PM-3

	Sample	Tritium Units[a]		pCi/L	
	Date	Tritium	±[b]	Tritium	±
PM-3 First Analysis					
	8/18/92	0.37	0.09	1.20	0.29
PM-3 Suspect Result and Followup Reanalyses					
Original Analysis	5/19/93	6.67	0.22	21.61	0.71
Renalysis 1, 11/93	5/19/93	0.12	0.09	0.39	0.29
Renalysis 2, 11/93	5/19/93	-0.06	0.09	-0.19	0.29
PM-3 Zonal Sampling					
PM-3 @ 987'	4/28/94	0.13	0.09	0.42	0.29
PM-3 @ 1226'	4/27/94	0.08	0.10	0.26	0.32
PM-3 @ 1650'	4/26/94	0.01	0.09	0.03	0.29
PM-3 @ 2000'	4/25/94	0.03	0.09	0.10	0.29

[a]The University of Miami detection limit for this set of samples was 0.3 pCi/L (0.1 TU); 1 TU = 3.24 pCi/L.
[b]The ± values represent one standard deviation of the uncertainty of measurement.

503 and 301 m (1,650 and 987 ft) samples, showed 4.4 pCi/L in the 610 m (2,000 ft) sample, and 9.8 pCi/L in the 374 m (1,226 ft) sample. Both laboratories performed adequately on the QA samples, with the University of Miami performance in terms of detection limit being at least ten times lower than Teledyne. The Laboratory's interpretation is that the University of Miami results are better technically, and that there is no measurable tritium at any depth in the PM-3 supply well. However, the conflicting results from the second laboratory, even though judged to be less reliable, cast a small measure of doubt on the confidence in the tritium results.

The carbon-14 analyses on the four zonal depth samples from Supply Well PM-3 contribute to the interpretation of no recent recharge (Table VII-6). All four carbon-14 measurements were identical within the analytic uncertainty, and indicate an age range for the water of about 6,400 years to about 12,200 years. These results are almost the same as the carbon-14 measurement made on the May 1993 sample, which showed an age range of about 5,000 years to about 11,800 years.

d. Results for Wells Showing Recent Tritium. The information in this section supplements a previous report on the detection of trace levels of tritium in wells in the Los Alamos area (EARE 1995b). As previously reported, trace levels of tritium were detected at four household wells at the Pueblo of San Ildefonso (EARE 1995b). Recent recharge to intermediate-depth perched groundwater beneath the Pajarito Plateau has also been indicated at three wells and one spring. Many other samples of well and spring water show no apparent recent recharge to the main aquifer.

Measurements of tritium by trace-level analytical methods suggest 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 (EARE 1995b). In three of the locations involving the main aquifer, the results are unambiguous. The levels measured range from less than 2% to less than 0.01% of current drinking water standards, and all are less than levels that could be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations.

The locations where tritium measurements clearly indicate the presence of recent surface recharge to the main aquifer are (1) Test Well 1, situated in Pueblo Canyon near the confluence with Los Alamos Canyon; (2) in old observation and water supply wells LA-1A and LA-2, located in Los Alamos Canyon near its confluence with the Rio Grande; and (3) at Test Well 8, in Mortandad Canyon, located about a mile downstream from the outfall of TA-50, the radioactive liquid waste treatment plant for the Laboratory.

In two other main aquifer locations, the trace-level tritium results were questionable and required further investigation, starting with resampling incorporating meticulous quality assurance, to determine whether the results are real or an artifact of sampling or analysis error. The first of the ambiguous locations is at Supply Well PM-3, discussed in the previous section. The second of the questionable measurements is at Test Well 4, on the mesa east of Acid Canyon in the Los Alamos townsite.

The four intermediate-depth perched groundwater locations having trace-level tritium results demonstrating recent recharge include Test Well 2A in the middle reach of Pueblo Canyon, Test Well 1A in lower Pueblo Canyon, Well LADP-3 in mid-Los Alamos Canyon, and Basalt Spring in lower Los Alamos Canyon. The results at Test Wells 1A and 2A and Basalt Spring are consistent with other chemical quality observations extending back into the 1960s. This work was done by the USGS when they were performing groundwater monitoring for the Laboratory. Well LADP-3 was drilled in Los Alamos Canyon in 1993 as part of the Environmental Restoration Project investigations. Well LADP-3 is down gradient from the Omega West Reactor, which was discovered in 1993 to have been leaking tritiated cooling water for some time (EARE 1995b; see Section VII.E.3).

Test Well 1, Test Well 1A, and Basalt Spring. Test Well 1 is located in Pueblo Canyon near its confluence with Los Alamos Canyon. One sample was taken in August of 1992, with a result of about 350 pCi/L; the second sample was taken in May 1993, also with a result of about 350 pCi/L. Other information and observations since 1991 had indicated a suspected communication with the adjacent shallower test well, Test Well 1A, and Basalt Spring located further east in Los Alamos Canyon. Both wells were drilled in 1949 by cable tool, Test Well 1A 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, and Test Well 1 to a depth of 196 m (642 ft) penetrating the top of the main aquifer in the Puye conglomerate.

The intermediate perched groundwater at Test Well 1A and Basalt Spring has long been known to be affected by effluents discharged into Pueblo Canyon, starting with measurements made by the USGS in the 1950s and 1960s. Starting in 1991 indications of unexpectedly high water levels in Test Well 1 and some chemical quality data suggested a downward communication of water from the intermediate perched groundwater sampled by Test Well

1A to the main aquifer penetrated by Test Well 1. Results of those initial investigations were reported in the "Environmental Surveillance at Los Alamos during 1991." The trace-level tritium samples were collected to help understand the potential problem. The two consistent results indicate the suspected problem does exist. One possible route of communication is along the ungrouted, cable-tool installed casings. The other possibility is a downward movement through the rock beneath the canyon.

Carbon-14 measurements on samples from both Test Well 1 and 1A (Table VII-6) show the definite presence of recent contamination from nonmeteoric sources because the carbon-14 levels are much higher than are found in atmospheric precipitation.

Test Well 2 and 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. Samples from those wells in October 1992 and May 1992 showed the presence of tritium in Test Well 2A, as expected from previous routine environmental monitoring. (The level in Test Well 2A was about 2,200 pCi/L, which is consistent with previously reported levels and measurements made in 1992 and 1993.) Test Well 2 showed no measurable tritium in the 1992 sample, and a result just at the detection limit for the 1993 sample.

The carbon-14 sample for Test Well 2 resulted in a meaningless (negative) minimum estimated age, which could indicate either a lack of understanding of carbonate geochemistry or a possible recharge of recent water. This is taken as an indication that the seal around Test Well 2 is adequate to prevent significant downward movement in the well bore (even though it was installed by cable tool), but there may be a very small amount of recent recharge occurring.

Test Well 4. Test Well 4 is located on a mesa east of the former radioactive liquid effluent 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). It had been capped and out of service for about 20 years until the fall of 1992 when it was refurbished and equipped with a new pump. This operation included the introduction of some surface water for cleaning and priming the pump. 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 about 11 pCi/L. In November 1993, the University of Miami reported reanalysis of previously unused portions of the May 1993 sample from Test Well 4. The result for Test Well 4 was unchanged, at about 11 pCi/L. Other data (e.g., 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.

The carbon-14 measurement of the sample from Test Well 4 indicates the possibility of recent recharge; the result is not conclusive because part of the interpretation requires an assumption to determine the amount of carbon isotope dilution that might occur as carbonates dissolve from rocks.

Pueblo of San Ildefonso Wells. Tritium was detected in two of three old water supply and observation wells, located in lower 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 through the canyon alluvium of water containing both past Laboratory releases (from Acid-Pueblo Canyon and from DP-Site and other Los Alamos Canyon sources) and precipitation containing atmospheric weapons testing fallout.

Supply Well LA-1B (Figure IV-5) 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 of 1991 and May of 1993. The carbon-14 and tritium ages for LA-1B are in agreement, indicating water ages exceeding 30,000 to 40,000 years, and showing no component of recent recharge. This is consistent with the well construction method that would be expected to seal out infiltration along the wellbore, and the greater depth of the well screen within the main aquifer Santa Fe Group formations.

Two other Los Alamos canyon wells showed trace-level tritium detections. 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 27 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 is similar to the range of recent rainfall levels in the Los Alamos area, of about 20 to 450 pCi/L

(Adams 1995) 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 trace-level tritium.

The second result is from former supply well LA-2 (Figure IV-5), 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. Screens or slotted casing start at 32 m (105 ft) depth. The tritium content of the May 1993 sample from LA-2 was 13 pCi/L. Because of the construction of these wells and their shallow depth of first screen it is not surprising to expect at least some downward movement of surface water.

The carbon-14 and tritium ages for Wells LA-1A and LA-2 are inconsistent. The radiocarbon ages range from about 6,000 to 16,000 years, while the tritium ages are about 20 to 400 years. The radiocarbon ages for Wells LA-1A and LA-2 are sharply lower than that for Well LA-1B, which is apparently unaffected by recent recharge. The presence of trace levels of tritium in Wells LA-1A and LA-2 indicates some component of recent recharge. One explanation for the different ages for carbon-14 and tritium might be that mixing of younger and older water has less of an effect on the radiocarbon age than the tritium age, as a result of the large difference in half-lives of these two isotopes. The addition of a small amount of surface water to much older main aquifer water would significantly raise the amount of the shorter-lived tritium, sharply decreasing the apparent tritium age. On the other hand, this dilution would only increase the component of the longer-lived carbon-14 a little, with a smaller effect on the carbon-14 age.

Radiocarbon and tritium ages were obtained for four other water supply wells at the Pueblo of San Ildefonso. The tritium ages for the wells are all greater than 1,500 years. The Pajarito Pump No. 2 has the smallest radiocarbon age, from 1,280 to 9,700 years. This well was found during 1994 to have a significant NO_3-N (nitrate as nitrogen) concentration, of 19 mg/L (See Section VII.E.5). Nitrate contamination is usually attributed to recharge from septic systems, feedlots, or fertilizers, and is common in wells in the Española Valley and in other agricultural areas. The presence of high NO_3-N and the lower radiocarbon age for the Pajarito Well Pump No. 2 suggest a significant component of recent surface recharge. This well is located along the Rio Grande, north of the confluence with Los Alamos Canyon (see Figure IV-5).

Three other wells had much greater radiocarbon ages: the East and West Artesian Wells and the Halladay House Well. The East and West Artesian Wells had some nitrate contamination in 1994, again suggesting that a small component of recent surface recharge has mixed with a larger quantity of much older water. These wells are also located along the Rio Grande, north of the confluence with Los Alamos Canyon.

The Halladay House Well had a very low NO_3-N concentration of 1.1 mg/L, which suggests little surface contamination. This well was sampled in February 1992 and May 1993, with both results showing no measurable 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 within Los Alamos Canyon as to be unlikely to penetrate any saturated alluvium.

Future Work. Additional sampling of groundwater for trace-level tritium analyses is being planned. Continuing discussions with the Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez and the Pueblo Office of Environmental Protection are expected to lead to a major sampling effort. This sampling will include groundwater sources on and adjacent to the pueblos that have not previously been analyzed for trace-level tritium. Most of the groundwater sources in the vicinity of Los Alamos will be resampled to add confidence to the validity of the measurements.

e. Trace-Level Tritium Results for the White Rock Canyon Springs (David Rogers and Alan Stoker, ESH-18; Fraser Goff, EES-1; and Andrew Adams, CST-7)**.** Most of the White Rock Canyon Springs and some surface waters were sampled for trace-level tritium in 1994 (Tables VII-8 and VII-9). For the most part, the 1994 results for the springs are similar to earlier measurements (EPG 1994). In general, the values are much lower than the tritium content of contemporary precipitation in the Los Alamos vicinity (from 20 to 450 pCi/L [Adams 1995]). The highest 1994 White Rock Canyon tritium value is 15.4 pCi/L for Spring 4 and could indicate mixing with rainwater; other values are generally below 5 pCi/L.

For Doe Spring in Chaquehui Canyon, the 1990 tritium value was about 18 pCi/L. This relatively high value was attributed to mixing with rainwater at the collection point. The 1994 value for Doe Spring was 2.2 pCi/L. Except for the 1990 Doe Spring sample, the 1990–91 White Rock Canyon Spring tritium values imply maximum tritium

Table VII-8. White Rock Canyon Springs Trace-Level Tritium Measurements

Location	September 90 pCi/L	± [a]	October 91 pCi/L	±	September 94 pCi/L	±
White Rock Canyon Springs Group I						
Sandia Spring					0.52	0.29
Spring 3	3.40	0.29	1.65	0.39	2.20	0.29
Spring 3A					2.75	0.32
Spring 3AA					0.29	0.32
Spring 4					15.4	0.55
Spring 4A			2.40	0.39	1.39	0.39
Spring 5					0.39	0.29
Ancho Spring	3.40	0.29	4.21	0.36	1.78	0.32
White Rock Canyon Springs Group II						
Spring 5A					4.05	0.32
Spring 5B					4.67	0.42
Spring 6			1.78	0.32	6.80	0.42
Spring 6A	0.06	0.29	0.03	0.29	0.39	0.29
Spring 7	1.46	0.29	2.10	0.29	1.30	0.29
Spring 8	5.83	0.29	7.09	0.55	4.54	0.32
Spring 8B	4.66	0.29			2.04	0.39
Spring 9					1.04	0.42
Spring 9A			1.78	0.29	2.69	0.32
Doe Spring	17.71	0.58			2.24	0.32
Chaquehui Spring					3.73	0.39
Spring 10					3.76	0.32
White Rock Canyon Springs Group III						
Spring 1					0.87	0.29
Spring 2			4.21	0.36	3.82	0.32
White Rock Canyon Springs Group IV						
Spring 3B	0.91	0.29	0.13	0.29	0.84	0.29

[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); 1 TU = 3.24 pCi/L.

ages greater than 750 years (Spring 8 in 1991). The 1990 and 1991 Ancho Spring tritium values imply maximum ages of 1,750 and 1,500 years; ages for other springs are greater (Blake 1995).

The low tritium values and large apparent ages for water from the White Rock Canyon Springs are consistent with the view that many of these springs are discharging directly from the main aquifer (Purtymun 1980b). This hypothesis is further supported by indications from stable isotope (deuterium and oxygen-18) evaluations that the White Rock Canyon Springs are recharged at significantly higher elevations than the spring locations. The mean recharge elevation for the springs is about 2,234 ± 104 m (7,330 ± 460 ft), while the average discharge elevation is about 1,649 m (5,410 ft). These recharge elevations suggest that the White Rock Canyon Springs are recharged from the Pajarito Plateau or other upland areas within the Rio Grande Rift, but not from the Jemez or Sangre de Cristo Mountains (Blake 1995).

Two streams near White Rock Canyon were also evaluated for trace-level tritium. The tritium value for Pajarito Creek (Table VII-9) was about 2 pCi/L. This might reflect a strong component of discharge from springs feeding the creek (Spring 4A), with little contribution from rainwater. The tritium concentrations for Frijoles Creek (21 to 29 pCi/L) suggest a large contribution from contemporary precipitation.

2. Main Aquifer Hydrologic Properties. (Stephen McLin, ESH-18)

a. Measurement of Main Aquifer Water Levels. In October 1992, the Laboratory began measuring and recording water level fluctuations in test wells completed into the main aquifer below Pajarito Plateau and in

Table VII-9. Trace-Level Tritium Measurements in Groundwater and Surface Water

Location	Sample Date	Tritium Units Tritium	± [a]	pCi/L Tritium	±
White Rock Canyon Surface Water					
Pajarito Creek	09/28/94	0.61	0.11	1.98	0.36
Frijoles Creek	09/29/94	6.54	0.22	21.2	0.71
Frijoles Creek	09/29/94	8.89	0.29	28.8	0.94
L***os Alamos Canyon Alluvial Groundwater***					
LAO-B	10/19/94	20.2	0.7	65.4	2.3
LAO-C	10/31/94	20.9	0.7	67.7	2.3
LAO-0.3	10/19/94	27.1	0.9	87.8	3.0
LAO-0.6	10/20/94	155	5	502	16
LAO-0.8	10/26/94	50.5	1.7	164	5.5
LAO-R1	10/25/94	444	15	1,440	49
LAO-0.91	10/25/94	144	5	467	16
LAO-1	10/24/94	158	5	512	16
L***os Alamos Canyon Surface Water***					
SW-1	10/19/94	24.2	0.8	78.4	2.6
SW-2	10/20/94	26.8	0.9	86.8	2.9
SW-3	10/20/94	29.3	1	94.9	3.2
SW-4	10/24/94	115.3	3.8	374	12
SW-5	10/26/94	132	4	428	13
L***os Alamos Canyon Intermediate-Depth Groundwater***					
LAOIA-1.1 Guaje	10/28/94	8.34	0.29	27.0	0.94
LAOIA-1.1 Puye	10/28/94	2.89	0.12	9.36	0.39
LAOIA-1.1 Guaje	11/17/94	0.24	0.11	0.78	0.36

[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); 1 TU = 3.24 pCi/L.

various other monitoring wells throughout the facility. These data are automatically recorded at hourly intervals using calibrated pressure transducers. Table VII-10 summarizes the locations, start and end dates, and final water levels recorded during 1994. These same data are also presented in greater detail in the forthcoming Laboratory report entitled, "Water Supply at Los Alamos during 1994." Previous environmental surveillance and water supply reports contain additional historical water level data that are not reported here.

b. TA-49 Barometric and Earth Tide Monitoring Station. 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 and Purtymun (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 one-half inch 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 BP data will be presented in a special report once a sufficiently long record has been collected.

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, which 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

Table VII-10. Wells Equipped with Recording Transducers in 1994

Well	Start Date	End Date	Water Depth (ft)	Elevation (ft)
Main Aquifer Test Wells				
TW-1	01/01/94	12/31/94	548.70[a]	5,819.48[b]
TW-2	01/01/94	12/31/94	798.25	5,850.51
TW-3	01/14/94	12/31/94	780.80	5,816.81
TW-4	01/01/94	12/31/94	1,176.89	6,069.44
TW-8	01/11/94	12/31/94	993.11	5,884.92
DT-5A	01/01/94	09/11/94	1,183.65	5,960.98
DT-9	01/01/94	11/28/94	1,116.31	5,920.40
DT-10	01/01/94	09/20/94	1,097.21	5,922.71
Pueblo of San Ildefonso Main Aquifer Test Well				
LA-1B	01/01/94	12/31/94	artesian	5,634.72[c]
LA-1A	12/22/94	12/31/94	artesian	TOC[d]
Municipal Water Supply Well				
PM-1	04/30/94	12/31/94	755.48	5,766.02
PM-3	12/22/94	12/31/94	769.44	5,871.81
Otowi-1	12/22/94	12/31/94	677.23	5,721.52
Intermediate Perched Zone Wells				
TW-1A	01/01/94	12/31/94	194.39	6,176.83
TW-2A	01/12/94	12/31/94	113.50	6,539.86
LADP-3	05/06/94	10/28/94	323.21	6,434.79
Alluvial Canyon Wells				
LAO-C	07/10/94	10/28/94	3.82	7,047.66
LAO-3	07/10/94	10/28/94	8.92	6,571.43
LAO-4	07/10/94	10/28/94	12.86	6,508.75
LAO-6A	07/10/94	10/28/94	15.66	6,382.74
APCO-1	01/12/94	11/10/94	6.62	6,361.57
MCO-6B	01/01/94	11/28/94	33.34	6,817.62
MCO-5	01/01/93	12/01/93	20.67	6,856.75
PCO-1	07/13/93	10/26/93	12.19	6,675.58
PCO-2	07/13/93	10/26/93	10.14	6,608.95
PCO-3	07/13/93	09/04/93	7.17	6,539.99
Other Wells:				
SHB-3	12/22/94	12/31/94	664.46	6,943.79
CH-2	01/01/94	12/31/94	493.33	6,651.12

[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 5,616 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.
[d]TOC = Top of Casing reference point.

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.

c. Water Production Records. Monthly water production records are provided to the State Engineer's Office under the water rights permit held by DOE for the Los Alamos water system. During 1994, total production from 10 water supply wells and the Water Canyon Gallery for potable and nonpotable use was 5.44 x 10^6 m^3 (1.438 billion gal. or 4,412 ac ft). This production amounts to 80% of the total diversion right of 6.8 x 10^6 m^3

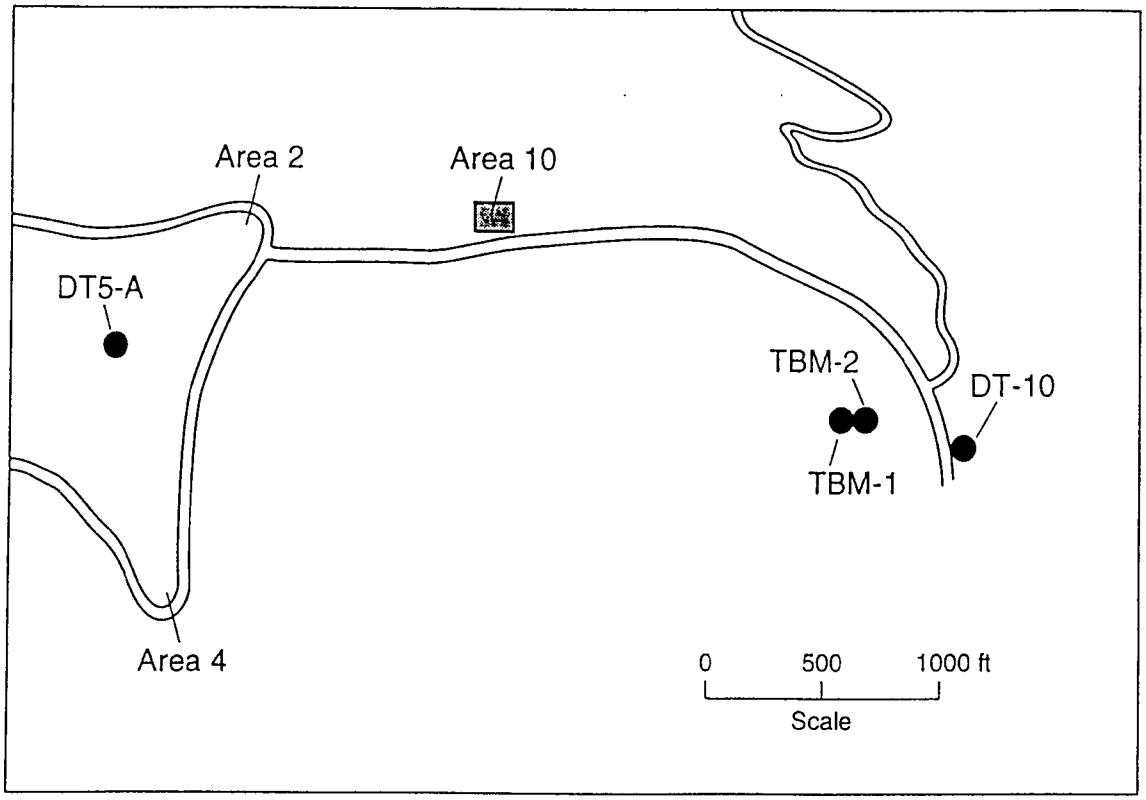


Figure VII-5. Locations of test holes TBM-1 and TBM-2 at TA-49.

(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 entitled "Water Supply at Los Alamos during 1993" (Purtymun 1995b).

3. Omega West Reactor Leak. (David Rogers, ESH-18; Patrick Longmire and Andrew Adams, CST-7)

In "Environmental Surveillance at Los Alamos during 1993" (EARE 1995b) we reported the discovery of a leak in the cooling system at the Omega West Reactor, TA-2 (location in Figure VII-8), during early January 1993. The reactor coolant water contained high tritium levels because it absorbs neutrons during its passage through the reactor core. At that time, the reactor operators determined that the cooling system was losing water at a rate of approximately 288 L/day (75 gal./day). Preliminary screening indicated that tritium was the primary contaminant of concern, and that other radionuclides were not released to the environment in significant levels. Data from water samples indicated that water containing higher levels of tritium remained within the Laboratory boundary. Following removal of the fuel elements from the reactor and draining of the cooling system, the leak ceased on March 18, 1993. The tritium leak was isolated in the cooling system delay line, located immediately west of the Omega West Reactor building.

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 groundwater tritium concentration in the reactor building basement was between 100,000 and 120,000 pCi/L (OWR 1993). 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 18, 1993: from 69,200 to 400 pCi/L for the wells, and from 21,700 to 200 pCi/L for the surface water stations (EARE 1995b).

An analysis of historical tritium levels in Los Alamos Canyon surface water and groundwater (EARE 1995b) showed that tritium concentrations since 1970 for alluvial Observation Well LAO-1 (Figure VII-8) had remained

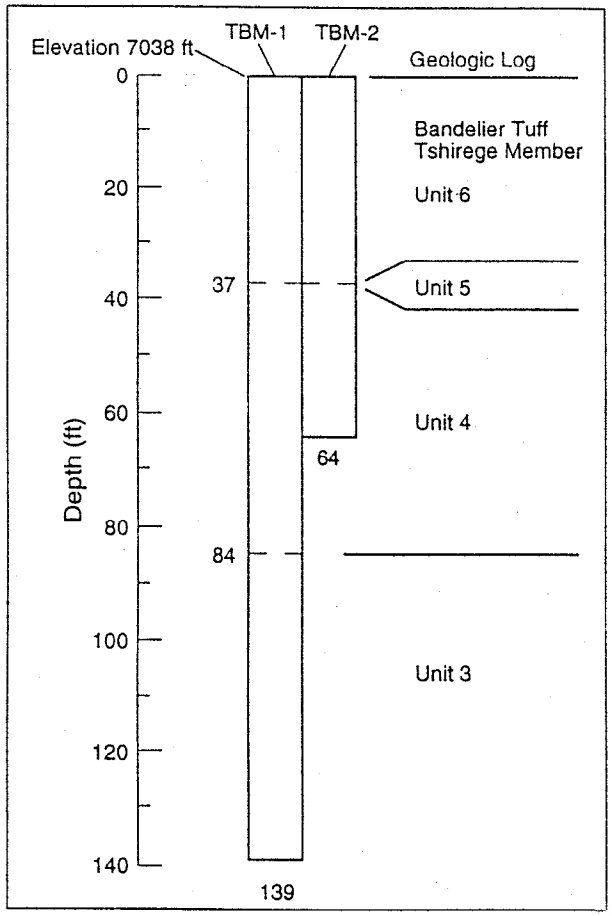


Figure VII-6a. Geologic logs of test holes TBM-1 and TBM-2 at TA-49.

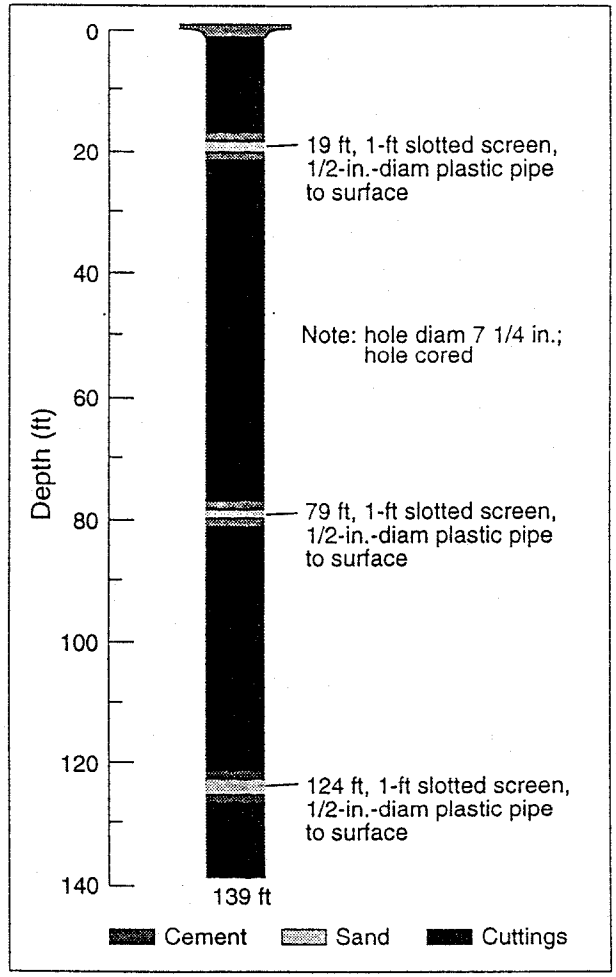


Figure VII-6b. Test hole TBM-1 constructed with three zones to measure barometric pressures in the tuff at depths of 19, 79, and 124 ft.

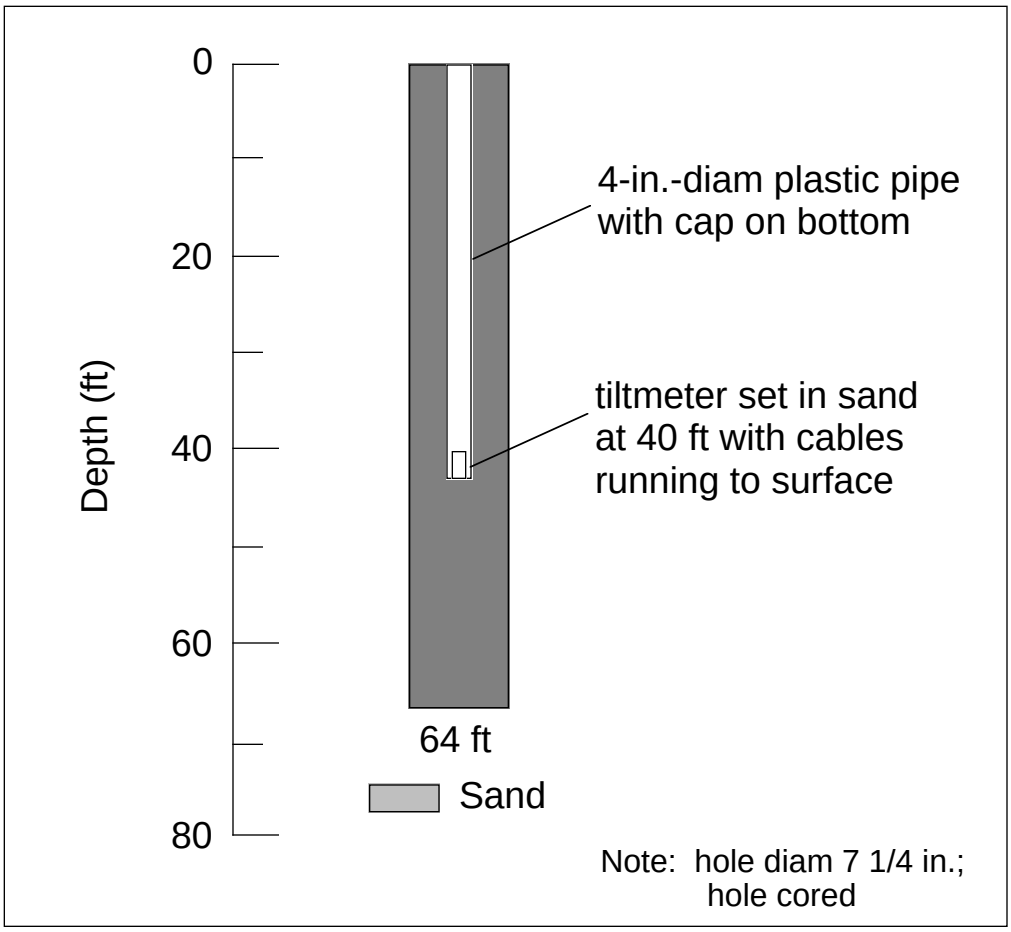


Figure VII-7. Test hole TBM-2 equipped with a biaxial tiltmeter to measure deformation of the tuff at 40 ft.

approximately constant, at about 10,000 pCi/L. Well LAO-1 is located just downstream from the reactor. This tritium concentration is a factor of 10 higher than both the tritium concentrations at the upstream Well LAO-C, and the tritium concentrations observed in downstream alluvial observation Wells LAO-2, -3, -4, and -4.5 in the early 1990s. In the early 1990s, the tritium concentrations in upstream Well LAO-C remained slightly above the detection limit, of about 300 to 700 pCi/L, for the EPA-specified liquid scintillation counting method. The steady tritium concentrations at Well LAO-1 suggest the pressure of a constant source of tritium immediately upstream, which is consistent with a steady leakage of cooling water from the Omega West Reactor since it began operation in 1956. The tritium concentration in Well LAO-1 had declined to 1,300 pCi/L on June 23, 1993, suggesting that the Omega West Reactor was no longer leaking tritiated water into Los Alamos Canyon.

Table VII-9 and Figure VII-8 show recent trace-level tritium measurements on Los Alamos Canyon groundwater and the Los Alamos Canyon stream, carried out as part of the Laboratory's Environmental Restoration Project. The trace-level tritium measurements employed by this study were performed at the University of Miami and have a detection limit of about 1 pCi/L (see Section VII.E.1 for a discussion of other trace-level tritium measurements).

The 1994 groundwater data show that upstream of TA-41, tritium concentrations found in Wells LAO-B, LAO-C, and LAO-0.3 are consistent with contemporary rainfall tritium levels (from 20 to 450 pCi/L [Adams 1995]) in the Los Alamos vicinity. The tritium concentration in Well LAO-C was 68 pCi/L. This is consistent with previously reported values, which were slightly above the standard scintillation technique detection limit, of about 300-700 pCi/L.

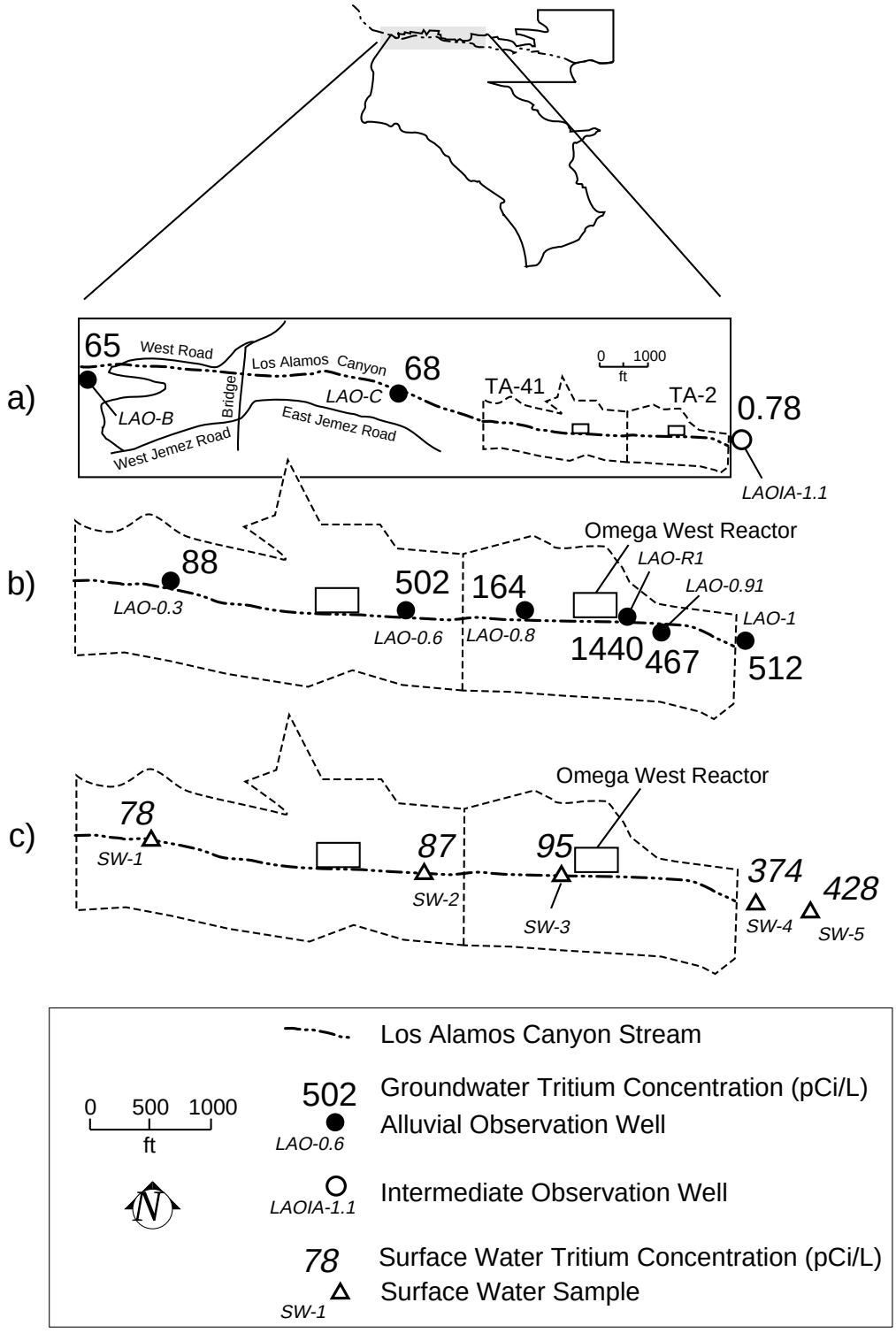


Figure VII-8. Map of Los Alamos Canyon showing locations of TA-2 and TA-41, the Omega West Reactor, alluvial and intermediate-depth observation wells, surface water stations, and trace-level tritium concentrations: (a) background groundwater tritium levels; (b) groundwater tritium levels near TA-2 and TA-41; (c) surface water tritium levels near TA-2 and TA-41.

A tritium concentration of 502 pCi/L at LAO-0.6 suggests that the main building at TA-41 could be a recent or present tritium source. This building is used for the development and testing of weapons systems. The facility has used major amounts of tritium in the past, and tritium releases have included major stack discharges and leaks of tritium into the septic system. Proceeding downstream from the main building at TA-41, Well LAO-0.8 shows a lower tritium concentration of 164 pCi/L.

Tritium concentrations in Well LAO-R1, just downstream from the Omega West Reactor, were about 70,000 pCi/L after discovery of the reactor leak in January 1993, and declined to about 1,400 pCi/L by July 1993. In October 1994, Wells LAO-R1 and LAO-0.91 had tritium values of 1,440 and 467 pCi/L. The tritium concentration for alluvial observation Well LAO-1, downstream of the Omega West Reactor has sharply decreased from about 10,000 pCi/L prior to 1993, to 1,300 pCi/L on June 23, 1993, and to a 1994 value of 512 pCi/L. The results for Wells LAO-R1, LAO-0.91, and LAO-1 suggest that, even though the reactor leak has ceased, tritium previously leaked in the area of the reactor building is continuing to disperse as a result of mixing and dilution by groundwater flowing down the canyon.

Surface water tritium values from five locations (Figure VII-8) confirm the picture of tritium derived from the alluvial well data. Tritium levels in the Los Alamos Canyon stream above the Omega West Reactor range from 78 to 95 pCi/L, and are in the range of contemporary rainfall tritium levels in the Los Alamos area. No increase of tritium occurs in the stream in the TA-41 area. For two surface water stations downstream from the Omega West Reactor, tritium values are 374 and 428 pCi/L. These tritium levels are similar to values in nearby alluvial Wells LAO-0.91, and LAO-1. This similarity in tritium levels between the groundwater and surface water suggests that there is rapid communication and mixing between the two water bodies, and that tritium is being rapidly diluted and carried away from the area of the Omega West Reactor.

The 1994 environmental surveillance data (discussed in Section VII.C.1.b) have a much higher detection limit (of about 300 to 700 pCi/L, for the EPA-specified liquid scintillation counting method) than the trace-level detection limit data. Nonetheless, with the larger analytical uncertainty taken into consideration, the surveillance data are in general agreement with the trace-level detection limit data described in this section.

The intermediate-depth Well LAO-IA-1.1 (depth about 98 m [323 ft]) was drilled within the Guaje Mountain fault zone about 305 m (1,000 ft) downstream from the Omega West Reactor during 1994. This borehole found 7 m (22 ft) of perched water in the Guaje Pumice Bed below 89.6 m (294 ft), but the tritium concentration was at background levels. The water initially pumped from the well had a tritium concentration of 27 pCi/L in the Guaje Pumice Bed, and 9 pCi/L in the underlying Puye Formation. This tritium could have been the result of downward leakage of stream water or rainwater during well construction. A second sample from the Guaje Pumice Bed, taken November 17, 1994, after well construction was finished, found no detectable tritium at that level. This lack of tritium suggests that tritium has not infiltrated much beneath the canyon bottom at this point, although tritium has been found within the Guaje Pumice Bed at Well LADP-3, about 1,067 m (3,500 ft) farther downstream. Borehole LADP-3 penetrated 20 m (65 ft) of alluvium and 74 m (243 ft) of the Otowi Member (Broxton 1995). Tritium (5,500 pCi/L) was found in perched groundwater at 99 m (325 ft) in the underlying Guaje Pumice Bed.

4. Trace-Level Mass Spectroscopic Analysis of Plutonium and Uranium. (David Rogers, Alan Stoker, and Bruce Gallaher, ESH-18)

Another extremely sensitive analytical chemistry technique is being evaluated for applicability to samples from groundwater and sediment sources. The method is trace-level mass spectroscopy for isotopes of uranium and plutonium. The isotopic uranium analyses of groundwater should provide much higher confidence levels in determining whether the observed uranium in groundwater is from entirely natural sources or contains some anthropogenic components. The trace-level mass spectrometry analyses for plutonium should provide both lower detection limits (better by several orders of magnitude) as well as isotopic ratio information that can distinguish between various sources such as worldwide fallout or specific effluent sources. A large number of groundwater and sediment samples have been collected and submitted to the ultra-clean mass spectroscopy facility at the Chemical Sciences and Technology Division for analysis. At the present time the analysis of these samples is incomplete.

5. Nitrate Levels at the Pueblo of San Ildefonso and Los Alamos-Pueblo Canyons. (David Rogers, ESH-18)

High nitrate values were found in analyses of water samples collected at several water supply wells at the Pueblo of San Ildefonso during 1994 (Table VII-11). (Nitrate values are reported here in terms of nitrate as nitrogen; the concentration of nitrate is 4.427 times the concentration of nitrogen.) Once the laboratory results

were verified, the Water Quality and Hydrology Group (ESH-18) notified the DOE of this discovery on March 27, 1995, and the DOE notified at the Pueblo of San Ildefonso immediately.

Nitrate levels exceeding the EPA primary drinking water MCL of 10 mg/L (nitrate as nitrogen) are a public health concern because of the potential for methemoglobinemia in small children. The hemoglobin of small children is not sufficiently developed, so nitrate can interfere with their oxygen supply resulting in suffocation, or blue-baby syndrome. High concentrations of nitrate are common in groundwater in rural areas, as a result of runoff and infiltration from feedlots, fertilizer use, and from septic systems (Hem 1989), and are a common problem in the Española Valley.

Several other high nitrate values were found in wells and a spring in Los Alamos and Pueblo Canyons (Table VII-11). The high nitrate values at several of these locations could arise from the Los Alamos County Bayo sew-

Table VII-11. Groundwater and Surface Water Nitrate Values (Nitrate as Nitrogen [mg/L])

Location	1988	1989	1990	1991	1992	1993	1994
San Ildefonso Wells							
Don Juan Playhouse				1.8		2.07	2.9
Eastside Artesian	2		1.8	<0.04		<0.04	8.6
Westside Artesian	<1	<0.1		<0.1		0.04	5.7
Halladay House	<1	0.5	1.4	0.5	0.54	0.61	1.1
Martinez House		0.2			8.36	9.54	15.8
Old Community			0.7				2.0
New Community	2				1.25	1.28	
Otowi House		0.6			0.26	0.33	10.8
Pajarito Pump No. 1	<1		0.4	0.1	0.17		7.7
Pajarito Pump No. 2		0.3	1.6		1.73	1.49	19.0
Sanchez House					0.85	1.07	9.5
San Ildefonso Springs							
La Mesita Spring	<0.2	2.2	4.4	1.4	2.65	2.91	5.8
Sacred Spring	<0.2	0.1	8.2	1.5	4.25	0.28	1.8
Indian Spring	0.7	0.7	0.8	0.5	0.42	0.88	0.83
Pueblo Canyon Surface Water							
Acid Weir	0.8	0.7	1.3	0.7	0.38	1.0	<0.04
Pueblo 1	<0.2	2.5	1.2	0.3	16.60	<0.04	<0.04
Pueblo 2	4.2	1.8	dry	dry	7.10	dry	dry
Pueblo 3	5.7	3.7	1.06	13.4	6.85	4.53	dry
Hamilton Bend Spring	dry	1.5	dry	dry	dry	dry	dry
Los Alamos/Pueblo Canyon Intermediate and Main Aquifer Groundwater							
TW-1	6			5.3	6.45	5.88	23.0
TW-1A	<0.2	2.7	0.0	2.9	1.82	5.78	19.4
TW-2A	<0.2	<0.1	1.4	<0.04	3.21	3.62	13.7
Basalt Spring	1.7	3.0	2.2	10.9	5.02	2.27	15
APCO-1					0.34	<0.04	1.8
Upper Los Alamos Canyon Groundwater							
LAO-3	1.5	0.4	0.6	0.4	0.30	0.15	0.22
LAO-4		<0.1	0.3	0.0	0.10	<0.04	<0.04
LAO-4.5		0.2	0.1	0.1		<0.04	<0.04
Lower Los Alamos Canyon Main Aquifer Groundwater							
LA1A						0.54	1.5
LA1B		0.5	0.5	0.5		0.69	6.3
Other							
TW-8	<0.2	0.3	0.2	<0.04		0.17	5.10

age treatment plant outfall. Infiltration to the intermediate perched and main aquifer groundwater has been shown to be relatively rapid beneath parts of Pueblo Canyon (see Section VII.E.1). This could explain nitrate levels at Test Wells 1, 1A, and 2A and Basalt Spring in Pueblo and Los Alamos Canyons. Further, Test Well 8 in Mortandad Canyon showed a large increase in nitrate. Nitrate is a common contaminant found in Mortandad Canyon alluvial groundwater, resulting from the treatment process at the TA-50 Radioactive Liquid Waste Treatment Plant.

Trace levels of tritium found in Test Well 8 in Mortandad Canyon and Test Wells 1, 1A, and 2A in Pueblo and Los Alamos Canyons also indicate the presence of recent recharge at these locations (see Section VII.E.1). Therefore, the presence of elevated nitrate levels is not surprising but tends to confirm the initial interpretation of the trace-level tritium discoveries in these wells.

The sudden increase in nitrate levels at several stations does suggest the possibility of laboratory or sampling error. The Inorganic Trace Analysis Group (CST-9) was asked to recheck all of their analytical procedures for these samples, and reported that the analyses all met quality control criteria. The possibility of field contamination of several samples cannot be ruled out.

The NMED/AIP collected duplicate samples at two stations, La Mesita and Basalt Spring on the same day as the ESH-18 samples (Table VII-12). The NMED/AIP value for La Mesita Spring (2.0 mg/L) is lower than the ESH–18 value (5.8 mg/L), but the disagreement is not great. For Basalt Spring, the NMED/AIP value (13.2 mg/L) compares well with the ESH-18 value (15 mg/L).

Table VII-12. 1994–95 Groundwater Nitrate Values (Nitrate as Nitrogen [mg/L])

	1994 Surveillance 7/27–7/28	1994 NMED/AIP 7/27–7/28	1995 Special Sampling 4/95	1995 Surveillance 5/24–5/25[a]
San Ildefonso Wells				
Don Juan Playhouse	2.9			
Eastside Artesian	8.6		2.00	
Westside Artesian	5.7			1.46
Halladay House	1.1			0.57
Martinez House	15.8		9.00	8.63
Old Community	2.0			
New Community				1.45
Otowi House	10.8			0.58
Pajarito Pump No. 1	7.7		0.20	0.21
Pajarito Pump No. 2	19.0			1.33
Sanchez House	9.5		0.90	0.95
San Ildefonso Springs				
La Mesita Spring	5.8	2.0		
Sacred Spring	1.8			1.29
Indian Spring	0.83			0.78
Los Alamos/Pueblo Canyon Intermediate and Main Aquifer Groundwater				
Basalt Spring	15	13.2	9.91[b]	2.27
			15.1[b]	
			9.7[b]	
Lower Los Alamos Canyon Main Aquifer Groundwater				
LA1A	1.5[c]			0.01
LA1B	6.3[c]			0.00

[a]Preliminary 1995 data subject to verification.
[b]Collected by EES-1 from three springs in the area of Basalt Spring.
[c]Samples collected August 2, 1994.

Preliminary 1995 ESH-18 special sampling data (Table VII-12) have shown lower nitrate values for four water supply wells at the Pueblo of San Ildefonso. Preliminary 1995 Surveillance data (Table VII-12) also give nitrate levels in line with those prior to 1994 (Table VII-11).

The possibility that nitrate and tritium are reaching the main aquifer at Test Well 8 beneath Mortandad Canyon is of great concern. Future testing of several of the test wells is planned, including time-series sampling of water drawn from the wells, to evaluate the possibility of well-bore leakage as a contamination source. This has also been suspected to be the cause of tritium contamination found in some wells (see Section VII.E.1.d).

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) Environment, Safety, and Health (ESH) Division has its own quality assurance program (QAP) with documented sampling procedures. Each environmental chemistry and analysis activity of the Chemical Sciences and Technology (CST) Division also has documented QAPs 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 1994, the Quality Assurance Support Group (ESH-14) provided support for QA functions at the Laboratory. ESH-14 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 requested. The Laboratory's Internal Assessment Group (AA-2) manages an independent environmental appraisal and auditing program that verifies appropriate implementation of environmental requirements. The Quality and Planning Program Office provides management and coordination of the effort to become a customer-focused unified Laboratory. This office launched a number of initiatives in continuous improvement, including a Quality Council, quality awareness training, staff-level continuous quality improvement (CQI) teams, and management-initiated "re-engineering" teams aimed at the Laboratory's core processes.

Each monitoring activity sponsored by the ESH Division 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 US Department of Energy (DOE) Orders 5400.1 (DOE 1988a) and 5700.6C (DOE 1991b). Each QAP must address the following criteria.

- Management
  program
  personnel training and qualification
  quality improvement
  documents and records
- Performance
  work processes
  design
  procurement
  inspection and acceptance training
- Assessment
  management assessment
  independent assessment

QAPs for each environmental monitoring program performed by groups in ESH Division have been included in the current Environmental Monitoring Plan (EMP) (EARE 1995a). The EMP is reviewed every year and revised every three years. The QAPs will be revised under DOE Order 5700.6C within two years. (ESH-14 distributed the QA Guidebook and Reference Manuals to Laboratory managers in 1993.)

B. Sampling Procedures

1. Thermoluminescent Dosimeters.

Thermoluminescent dosimeters (TLDs) used at the Laboratory are composed of lithium fluoride (LiF) crystals 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 included in the exposure determined with LANL TLDs.

The chips are annealed at 400°C (752°F) for 1 hour and then cooled rapidly to room temperature. This is followed by annealing at 100°C (212°F) for 1 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 placed in a borosilicate glass rack so that all vials in a batch can be simultaneously placed in the annealing ovens.

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 of TLDs is prepared each time chips are annealed. The calibration set is read at the start of the dosimetry cycle. The calibration set and exposure levels are established to coincide with 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).

Exposure in air is converted to dose using the conversion factor 1.05 mR = 1 mrem tissue dose. This factor is derived as the reciprocal of the product of the roentgen-to-rad conversion factor (0.958) for muscle tissue of the 661-KeV decay photon of ^{137}Cs, and 0.994, which is the attenuation factor at the electronic equilibrium thickness. A rad-to-rem conversion factor of l.0 for gamma rays is used, as recommended by the International Commission on Radiation Protection (Johns 1983, ICRP 1970). A weighted least-squares linear regression is used to determine the relationship between TLD reader response and dose, the weighting factor being the variance of the sample set (Bevington 1969).

The TLD chips are 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. Ambient Air Monitoring. For ambient air monitoring, the Air Quality Group (ESH-17) operated 52 air sampler stations at 50 locations (Table IV-1). All samples are collected twice each month.

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 particulates are collected on 60-mm-diameter polystyrene filters (Microsorban). A portion of the total airflow (200 mL/min) is passed through a cartridge containing silica gel (135 g) to collect atmospheric water vapor. The flow rates are multiplied by the total run time to determine the volume of air sampled.

The particulate filters are analyzed twice each month for gross alpha and gross beta activity. Particulate filters are also analyzed twice each month using gamma spectrometry. Particulate filters are combined and analyzed quarterly for plutonium, americium, and uranium. The silica gel collected twice each month is heated to drive off the moisture, which is then analyzed for tritium using liquid scintillation counting.

A rotameter, calibrated twice a year using a factory-calibrated flow meter, is used to determine air flow in both sampling trains. The total time of operation is multiplied by the average flow rate to determine the volume of air sampled.

A specific radioiodine (^{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 sent to the analytical laboratory for quantitative analysis.

b. Radioactive Air Emissions Monitoring. Samples are generally collected at weekly intervals from approximately 90 release points. Sample collection and analyses are performed by personnel from health physics groups (ESH-1 and ESH-4) and the Inorganic Trace Analysis Group (CST-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. Samples are extracted by an air sampling pump, which passes the sample through a filter that traps the particles. The pumps typically sample at a rate of 2 cfm. The activity on the filter 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) present at the facility. To determine the total activity released, the radioactivity on the sample filter is multiplied by the ratio of the stack flow to the sample flow during the sampling period. This total activity is expressed in Ci. The radioisotopes of plutonium are not listed separately because the gross alpha analysis does not distinguish between the individual isotopes. Likewise, the gross beta 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 a remotely located instrument, which measures the concentration of tritium. This concentration, in conjunction with the effluent exhaust rate, is used to determine the tritium activity (in Ci) released to the environment. 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 where tritium water vapor is captured on silica gel. Each month, the gel is replaced, and the activity of the vapor is determined.

The 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 World Services, Inc. (JCI) in accordance with the Environmental Protection Agency (EPA) reference methods that use calibrated Pitot tubes.

c. Nonradioactive Air Emissions Monitoring. The nonradiological monitoring network consists of 1 criteria pollutant station, 1 visibility monitoring station, 1 acid precipitation monitoring station, and 12 samplers where beryllium is monitored. Results of nonradiological monitoring are presented in Chapter VI.A.2.

Stack monitoring systems are not compliant with Subpart H; however, all stacks that require monitoring are monitored with adequate monitoring systems. Upgrades of the monitoring systems are in progress.

The criteria pollutant monitoring station owned by the Laboratory is located south of TA-49, adjacent to Bandelier National Monument. This station began operation in the second quarter of 1990 and operated until September 30, 1994. It continuously monitored air concentrations of nitrogen dioxide (NO2), ozone (O3), and sulfur dioxide (SO_2). A PM-10 high-volume air sampler was run every six days to collect small particulate matter (less than 10 microns in diameter). Once each month, the New Mexico Environment Department (NMED) audited the flow rate of the instrument.

Atmospheric visibility is monitored and analyzed with a transmissometer. A 10-min measurement is taken every hour, 24 h/day. The site path is 4.58 km (2.84 mi) long and runs between TA-49 and TA-33. Air Resource Specialists, Inc., of Fort Collins, Colorado, is responsible for data quality and analysis.

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 the University of Illinois for further analysis. Colorado State University coordinates the program. Blind samples are audited twice per year by the US Geological Survey.

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 4 cfm. The equipment operates continuously, and samples are collected monthly. A composite of the monthly samples is generated quarterly for chemical analysis. A rotameter, calibrated twice a year with a factory-calibrated flow meter, is used to determine air flow.

3. Water Sampling.

a. Surface Water and Groundwater. The Laboratory maintains three separate programs for monitoring water quality: the surface and groundwater monitoring program, 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 Water Quality & Hydrology (ESH-18) personnel and are analyzed by CST-9 or a contracted analytical laboratory. 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 water 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 after each monitoring period for each outfall category to EPA and NMED. Samples collected from the Laboratory's industrial outfalls are collected by ESH-18 personnel and analyzed by CST-9 and contract laboratories. Samples collected from the sanitary outfalls are collected by JCI Environmental (JENV) staff and analysis is performed by JENV Laboratory. 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 JENV Laboratory also collects samples from the Laboratory and county water distribution systems and tests them for microbiological contamination, as required by SDWA. The JENV Laboratory is certified by SLD for microbiological testing of drinking water. See Section VIII.B.3.c for more information on the sampling program.

b. National Pollutant Discharge Elimination System. Personnel from ESH-18 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, "Guidelines Establishing Test Procedures for Analysis of Pollutants under the Clean Water Act; Final Rule and Technical Amendments" (EPA 1991) or otherwise specified NPDES Permit Nos. NM0028355 and NM0028576. Chain-of-custody (COC) procedures for sample collection and analysis are conducted during sampling for NPDES industrial compliance.

CST-9 analyzes industrial discharges for pollutants listed in the NPDES permits. A contract laboratory analyzes treated effluent from the TA-50 wastewater treatment plant for total toxic organics and ^{226}Ra plus ^{228}Ra. NPDES samples that are analyzed by contract laboratories are handled, shipped, and tracked by CST-3. Samples are tested according to EPA-approved methods documented in 40 CFR Part 136.

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 18th 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 CST-9 laboratories participate in the National Discharge Monitoring Report Quality Assurance Program. CST-3 and CST-9 also participate 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.

Microbiological sampling and analysis are performed by the JENV Laboratory. Laboratory staff are certified by the NMED to perform drinking water compliance sampling, and the Laboratory is certified by the NMED for microbiological compliance analysis. Certification requirements include proficiency samples, maintenance of an approved QA/QC program, and periodic audits by the NMED. Chemical and radiological sampling is performed by LANL staff certified by NMED to perform drinking water compliance sampling. These samples are sent to laboratories certified by the EPA and the NMED.

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.

All samples are collected and handled in accordance with the guidelines recommended by the American Society for Testing and Materials (ASTM 1990). The procedure for taking soil samples involves taking five subsamples (plugs), 100 mm (4 in.) in diameter and 50 mm (2 in.) deep, with a stainless steel ring at the centers and corners of a 10-m (33-ft) square area. The five plugs are combined and mixed thoroughly in a gallon resealable plastic bag to form a single composite sample and then placed in pre-labeled 500-mL poly bottles for radionuclide analysis and 125 mL poly bottles for heavy metal analysis. They are fitted with COC tape, placed into individual resealable plastic bags, and then into a locked ice chest for transportation to the Laboratory. Most samples are submitted to CST-9 for the analysis of radiological constituents (gross alpha, gross beta and gamma activity, ^{90}Sr, uranium, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, and ^{241}Am) and trace and heavy metal elements (silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, antimony, selenium, and thallium). These are the only EPA regulated heavy and trace metals. In addition, moisture distilled from soil samples is analyzed for tritium.

6. Foodstuffs Sampling.

Produce samples are collected from local gardens in the summer and fall of each year (Salazar 1984). Each produce sample is collected with plastic gloves and sealed in a labeled plastic bag. Samples are transported in a locked ice chest and refrigerated until prepared for chemical analyses. Produce samples are washed, as if prepared for consumption, and quantitative wet, dry, and ash weights determined. All results are reported on an oven-dry-weight basis (dry g). A complete sample bank is kept frozen until all radiochemical analyses have been completed. Water is distilled from samples and submitted for tritium analysis. Heavy and trace metals in produce are sampled every three years. Samples are dried at 75°C for 48 h, ground in a Wiley Mill using a 20-mm stainless steel screen, and collected in 20-mL poly bottles. All samples are submitted under full COC for the analysis of silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, antimony, selenium, and thallium.

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 labeled 500-mL poly bottles by a heat lamp. The bees and honey samples are submitted under COC for radiochemical analyses. Heavy and trace metals in honey are sampled every three years.

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.

Elk (*Cervus elaphus*) meat and bone tissue are collected from fresh road kills around the Laboratory. Background samples are collected from the NM Department of Game and Fish during this same period of time. Tissue samples from each elk are collected: >1000 g each of leg bone and muscle. Samples are submitted to CST-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 are tested using a Student's t-test at the 0.05 probability level (Gilbert 1987).

Milk is collected directly from the dairies in the Pojoaque Valley and Albuquerque, NM and submitted to CST-9 in the original containers for the analysis of tritium, uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{131}I, and ^{137}Cs.

7. Meteorological Monitoring.

Because the Laboratory site is topographically complex, it is difficult to design a meteorological monitoring network capable of capturing the full spatial variability of all measured variables. Quantifying the representativeness of wind measurements is especially difficult. For most applications, however, data from the current network has been adequate for characterizing important features of the meteorological environment.

For the most part, it has been possible to locate meteorological monitoring stations in areas that provide good exposure to the processes being monitored. Wind and temperature measurements are made from towers of open lattice construction with instruments mounted on booms that project out from the towers toward the west a distance at least two tower cross sections; thus flow distortion effects for the prevailing wind directions are minimized. All temperature sensors are aspirated to minimize radiative effects. Towers are located in open areas where anemometers and rain gages are outside the wake effects of trees and buildings, and upward-looking radiometers have an unrestricted view of the sky.

Each tower is equipped with its own programmable datalogger that handles signal conditioning, sampling, simple statistical operations, and interim data storage. Most signals are sampled every 3 s and averaged over 15 min. After acquisition by the main computers, the data are processed to generate tables and plots for characterizing conditions and for quality control.

The calibration of all instrumentation is checked twice annually, once during an internal audit and once during an independent, external audit. Calibration and maintenance procedures are documented in LANL-ESH-17-402,RO (1995). In 1994, TRC Environmental Corporation performed the external audit. In the summary of their report, they state that "The overall operation, knowledge and attentiveness to this monitoring program is excellent and meets the requirements and goals stated in the Quality Assurance Project Plan" (TRC 1994).

By the time meteorological data have been permanently archived, they have been checked in a number of ways. Daily, statistical summaries of the data are evaluated and problems noted in a logbook. Weekly, when the data are transferred to the archive, all signals are checked against the expected range of values for each signal type. Detailed time series of all variables are checked by a meteorologist for reasonableness and internal consistency. Remaining problems are entered into the logbook. The logbook is then used by a data analyst to accomplish the final editing of the data. Recovery of good data from the network exceeded 95% in 1994.

Further details related to quality assurance and sampling procedures used in the meteorological monitoring program are given in Section 13 of the current Los Alamos Environmental Monitoring Plan (EARE 1995a).

8. Sewage Sludge Sampling.

Representative samples of sewage sludge are collected three times per year from the sludge beds at the TA-46 SWSC plant. Samples are collected in accordance with the procedures set forth in LANL-ESH-18-602 Administrative Procedures: Handling, Disposal and Reuse of Sanitary Treatment Solids (September 8, 1994). Samples are submitted for analysis to an EPA-approved contract laboratory for chemical constituents and CST-9 for radiochemistry.

C. Analytical Chemistry.

1. Methodology.

a. Introduction. Most analytical chemistry services are provided by the Laboratory's CST-3, -9, and -12 Groups which provide analytical services to the Laboratory's environmental, waste management, radiation

protection, and industrial hygiene operations. CST-3 is responsible for QA for the health and environmental analytical work. CST-9 and -12 participate in the following interlaboratory performance evaluation studies:

- 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, Radiochemistry Performance Evaluation Studies;
- DOE Environmental Measurements Laboratory, Quality Assessment program for Radiochemistry;
- NPDES; and
- DOE Beryllium Intercomparison Study.

CST-3 Sample Management functions as an interface between the groups CST-9 and -12 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, Sample Management 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;
- DOE Mixed Analyte Performance Evaluation Program;
- DOE In Vitro Performance Evaluation Study;
- 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 CST-3 Sample Management, where the pertinent information is entered into the CST Laboratory Information Management System, and the request is given an analytical service agreement. Sample numbers, each representing a single sample, are assigned to a particular station and are 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 analytical service agreement number is entered in the collector's log book opposite sample numbers submitted, along with the date the sample was delivered to CST-3. CST-3 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 collector's 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; (5) total number of samples; (6) priority of sample or samples; and (7) remarks. 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; and (5) analyst, i.e., chemist to perform analyses. One copy of the form goes to the collector for filing, one is kept by Sample Management, 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 by CST-9 for the following radioactive constituents: gross alpha, gross beta, and ^{90}Sr by proportional counting; isotopic americium, plutonium, thorium, and uranium by radiometric alpha spectroscopy; elemental uranium by kinetic phosphorescence analysis; tritium by liquid scintillation; gross gamma, gamma scans, and isotope specific analysis for ^{137}Cs, ^{144}Ce; ^{57}Co; ^{60}Co; ^{152}Eu; ^{129}I; ^{40}K; ^{22}Na; ^{237}Np; ^{106}Ru; ^{241}Am; ^{106}Ru; ^{226}Ra; and ^{228}Ra by gamma-ray spectrometry.

During 1994, an improved procedure for separation of americium for radiometric alpha spectroscopy of air and water samples was implemented. This method increased analytical throughput by at least a factor of 2, decreased environmental/safety hazards from acid and alcohol/acid waste generation, and improved analytical accuracy, reproducibility, and reliability over the complex and laborious method previously used.

In addition, development of a new microwave-based method for dissolving 10-g soil samples for radiometric alpha spectroscopy was initiated. In the past, only 1-g samples were used for microwave dissolution. This method should increase throughput, improve data quality, and reduce workspace and environmental hazards for soil digestion.

CST-9 also enhanced throughput capabilities for gamma spectroscopy by having six working HPGe detectors available for counting and increasing utilization of the robotics system for automated sample counting. The alpha spectroscopy count room was updated by replacing 32 of the 144 detectors with state-of-the-art commercial instrumentation.

New gamma spectroscopy procedures were developed for ^{241}Am and ^{226}Ra in soil samples. The ^{241}Am procedure by gamma spectroscopy provided more rapid throughput for customers requiring less measurement sensitivity than obtained by radiometric alpha spectroscopy.

For biological environmental samples, productivity was increased due to reorganization of work responsibilities within this task area and adaptation of procedures used for human tissues samples. Finally, a new sample preparation, tracking, and disposal system was implemented for environmental samples which has improved CST-9's ability to provide results to customers in a timely manner.

c. Stable Constituents. A number of analytical methods are used by CST-9 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. 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 by CST-9 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. Volatile organic compounds (VOCs) are analyzed using Method 8260, SW-846. Tables D-20 and D-21 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-22 is the target list for SVOCs in water. Soil-gas (poregas) monitoring is performed by collecting organic vapors on charcoal adsorbent traps or thermal desorption traps. Charcoal traps are chemically desorbed while thermal desorption traps are thermally desorbed. Both desorption methods are followed by gas chromatography/mass spectrometry (GC/MS) analysis. Chemical and thermal desorption result in different analyte lists as shown in Tables D-23 and D-24. Polychlorinated biphenyls (PCBs) in soil, water, and oil samples are analyzed using GC with electron capture detection using a modified version of Method 8080.

Instruments available for organic analysis include GC/flame ionization detector, GC/electron capture detector, GC/MS, high performance liquid with 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, separatory funnel extraction, Kuderna Danish concentration, evaporative blowdown, and gel permeation chromatography cleanup of sample extracts.

Table VIII-1. Method Summary (Organic Compounds)

Analyte	Matrix	Method	Technique[a]
VOCs	Air	E0700	GC/MS
	Soil	E0720 (8260)	PAT/GC/MS
	Water	E0730 (8260)	PAT/GC/MS
PCBs[b]	Water	E0430 (modified 8080)	GC/ECD
	Oil	E0400 (modified 8080)	GC/ECD
	Soil	E0410 (modified 8080)	GC/ECD
	Swipes	E0420(modified 8080)	GC/ECD
SVOCs	Soil, waste	E0500 (8270)	GC/MS
	and water	E0530;	GC/MS

[a]Gas chromatography (GC), purge and trap (PAT), electron capture detection (ECD), and mass spectrometry (MS).
[b]Polychlorinated biphenyl (PCBs)

Organic mixed waste analyses are performed for samples containing up to the following limits of radioactivity:

Alpha 300 nCi/g or 300 nCi/L
Beta 1 mCi/g or 1 mCu.K
Gamma 500 nCi/g or 500 nCi/L
Tritium 50 mCi/g or 50 mCi/L

Higher level samples are analyzed on a case-by-case basis. New methods are being developed for routine analysis of mixed waste greater than the levels listed above.

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 permits 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 CST's QA Plan 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) and from NIST are used for QA of uranium and thorium determinations in silicate matrices. CST-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 CST-9's Quality Assurance Team.

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 (i.e., continuing calibration standards and blanks).

d. Organic Constituents. Soil samples are analyzed for VOCs, SVOCs, pesticides, and herbicides for compliance work done under Resource Conservation and Recovery Act. 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 Team. 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 1994 were environmental compliance samples analyzed for pesticides, VOCs, SVOCs, and 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. For routine PCB analysis, daily calibration is only performed for Aroclors 1242, 1254, and 1260. These aroclors represent the bulk of the target analytes found at the Laboratory. Other aroclors are included in the calibration mixture run on the GC system each time a full calibration curve is run. QC samples for PCBs are prepared by diluting EPA standards or by preparing standards in hexane from the neat analyte. Aroclors 1242, 1254, and 1260 are used to spike the QC samples which are prepared using a vacuum pump oil base as the blank matrix.

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 estimated from the propagated sources of analytical error.

Standard deviations for the station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the following equation:

$$s = \sqrt{\frac{\sum_{i=1}^{N} \left(\bar{c} - c_i\right)^2}{(N-1)}},$$

where

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):

$$s = \sqrt{\frac{\sum_i \left(R - r_i\right)^2}{\left(N - 1\right)}}.$$

These calculated values are presented as the CST-3 "Ratio ± Std Dev" in Table D-28. 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:

$$\left|\overline{X}_{\mathrm{E}} - \overline{X}_{\mathrm{C}}\right|,$$

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 $X_{\mathrm{E}} - X_{\mathrm{C}}$ is given by

$$Sr = \sqrt{\left(U_{\mathrm{E}}^2 / N\right) + S_{\mathrm{C}}^2},$$

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:

$$z = \frac{\left|\overline{X}_{\mathrm{E}} - \overline{X}_{\mathrm{C}}\right|}{\sqrt{\left(U_{\mathrm{E}}^2 / N\right) + S_{\mathrm{C}}^2}}$$

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 ST (under control), between $2S_T$ and $3S_T$ (warning level), or outside >$3S_T$ (out of control).

With the exception of bulk materials, more than 90% of the organic analyses are within <2 propagated 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 1993. 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-8.

IX. Publications

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R. Aguilar and P.R. Fresquez, "Restoration of Degraded Rangeland with Municipal Sewage Sludge: Effects on Soils, Vegetation and Surface Hydrology," in *Symposium Proceedings of the 15th Internation Congress of Soil Science*, pp. 440-401, (Acapulco, Mexico, July 10–16, 1994).

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S. Cross, "Biological Evaluation for the Environmental Restoration Program, Operable Unit 1114; Technical Areas 3, 30, 59, 60, 61, 64," Los Alamos National Laboratory report LA-UR-94-21 (January 1994).

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S. Cross, "Assessment for the Mixed Waste Storage and Disposal Facility, Technical Areas 67 and 15," Los Alamos National Laboratory report LA-UR-94-1400 (April 1994).

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D.F. Raymer and J.R. Biggs, "Comparison of Small Mammal Species Diversity near Outfalls, Natural Streams, and Dry Canyons," LA-12725-MS (March 1994).

IX. Publications

D.M. VanEtten and W.D. Purtymun, “Depleted Uranium Investigation at Missile Impact Sites in White Sands Missile Range,” Los Alamos National Laboratory report LA-12675-MS (January 1994).

R.J. Wechsler, T.M. Sandoval, D.E. Bryant, L. Hupke, and L. Esquibel, “1993 Annual PCB Document,” Los Alamos National Laboratory report LA-UR-94-2839, (July 1994).

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STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

Throughout this report, concentrations of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, and foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 5400.1, "General Environmental Program;" 5400.5, "Radiation Protection of the Public and the Environment;" 5480.1, "Environmental Protection, Safety, and Health Protection Standards;" 5480.11, "Requirements for Radiation Protection for Occupational Workers;" and 5484.1, "Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements," Chap. III, "Effluent and Environmental Monitoring Program Requirements."

Radiation Standards. DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using the 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 EDE.[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 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.

Appendix A

Table A-1. DOE Public Dose Limits 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 for Water and Derived Air Concentrations[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.

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 (5 pCi/L). Gross alpha activity (including ^{226}Ra, but excluding radon and uranium) may not exceed 15×10^{-9} μCi/mL (15 pCi/L).

A screening level of 5×10^{-9} μCi/mL (5 pCi/L) for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water (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.

Toxicity Characteristic Leaching Procedure 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.

Wildlife Water Standards. The purpose of these standards is to designate the uses for which the surface waters of the State of New Mexico shall be protected and to describe the water quality standards necessary to sustain the designated uses. In this report, the Wildlife Watering Standards (Table A-6)[A11] are used to compare with the quality of surface water at the Laboratory.

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	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours[a]	$\mu g/m^3$	150		
PM_{10} [b]	Annual arithmetic mean	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
Carbon monoxide	8 hours[a]	ppm	8.7	9	
	1 hour[a]	ppm	13.1	35	
Ozone	1 hour[c]	ppm	0.06	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	$\mu g/m^3$		1.5	1.5
Beryllium	30 days	$\mu g/m^3$	0.01		
Asbestos	30 days	$\mu g/m^3$	0.01		
Heavy metals (total combined)	30 days	$\mu g/m^3$	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		Radiochemical Contaminants	
Primary Standards	**MCL (mg/L)**		**MCL**
Asbestos	7 million fibers/L (longer than 10 μm)		
As	0.05	Gross alpha[b]	15 pCi/L
Ba	2.0	Gross beta & photon	4 mrem/yr
Be	0.004	^{3}H	20,000 pCi/L
Cd	0.005	^{90}Sr	8 pCi/L
CN	0.2	^{226}Ra & ^{228}Ra	5 pCi/L
Cr	0.1		
F	4.0		
Hg	0.002		
Ni	0.1		**Screening Limits**
NO_3 (as N)	10.0	Gross alpha[b]	5×10^{-9} μCi/mL
NO_2 (as N)	1.0		(5 pCi/L)
Se	0.05		
Sb	0.006	Gross beta	50×10^{-9} μCi/mL
Tl	0.002		(50 pCi/L)
	Action Levels (mg/L)		
Pb	0.015		
Cu	1.3		

Secondary Standards	**(mg/L)**
Cl	250
Cu	1.0
Fe	0.3
Mn	0.05
SO_4	250
Zn	5.0
TDS[c]	500
pH	6.5–8.5 standard unit

Table A-4. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Inorganic Chemicals, Organic Chemicals, and Radiochemicals[a] (Cont.)

Organic Chemical Contaminants	MCL (μg/L)
Alachlor	2
Atrazine	3
Carbofuran	40
Chlordane	2
Dibromochloropropane	0.2
2,4-D	70
Ethylene dibromide	0.05
Heptachlor	0.4
Heptachlor epoxide	0.2
Lindane	0.2
Methoxychlor	40
Polychlorinated biphenyls	0.5
Pentachlorophenol	1
Toxaphene	3
2,4,5-TP	50
Benzo[a]pyrene	0.2
Dalaphon	200
Di(2-ethylhexyl)adipate	400
Di(2-ethylhexyl)phthalate	6
Dinoseb	7
Diquat	20
Endothall	100
Endrin	2
Glyphosate	700
Hexachlorobenzene	1
Hexachlorocyclopentadiene	50
Oxamyl (Vydate)	200
Picloram	500
Simazine	4
2,3,7,8-TCDD (Dioxin)	0.00003
Total trihalomethanes	100
Vinyl chloride	2
Benzene	5
Carbon tetrachloride	5
1,2-dichloroethane	5
Trichloroethylene	5
para-Dichlorobenzene	75
1,1-Dichloroethylene	7
1,1,1-Trichloroethane	200
cis-1,2-Dichloroethylene	70
1,2-Dichloropropane	5
Ethylbenzene	700
Monochlorobenzene	100

Table A-4. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Inorganic Chemicals, Organic Chemicals, and Radiochemicals[a] (Cont.)

Organic Chemical Contaminants (Cont.)	MCL (μg/L)
o-Dichlorobenzene	600
Stryene	100
Tetrachloroethylene	5
Toluene	1000
trans-1,2-Dichloroethylene	100
Xylenes (total)	10000
Dichloromethane	5
1,2,4-Trichlorobenzene	70
1,1,2-Trichloroethane	5

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. A10.

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
Dissolved Hg	0.01
Dissolved Se	0.05
Dissolved V	0.1
Dissolved Zn	25.0
$^{226}Ra + {}^{228}Ra$	30 pCi/L

Appendix A

REFERENCES

A1. US Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public," US Department of Energy report DOE/EH-0071 (July 1988).

A2. US Department of Energy, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," US Department of Energy report DOE/EH-0070 (July 1988).

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).

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)	35.3	Cubic feet (ft^3)
Hectares (ha)	2.47	Acres
Grams (g)	0.035	Ounces (oz)
Kilograms (kg)	2.2	Pounds (lb)
Kilometers (km)	0.62	Miles (mi)
Liters (L)	0.26	Gallons (gal.)
Meters (m)	3.28	Feet (ft)
Micrograms per gram (µg/g)	1	Parts per million (ppm)
Milligrams per liter (mg/L)	1	Parts per million (ppm)
Square kilometers (km^2)	0.386	Square miles (mi^2)

Table B-3. Common Measurement Abbreviations and Measurement Symbols

aCi	attocurie
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
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

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: The Laboratory has about 180,000 sq ft of leased space for training, support, architectural engineering design, unclassified research and development in theLos Alamos townsite and White Rock. The publicly accessible Community Reading Room, the Bradbury Science Museum, and DOE's Los Alamos Area Office are also located in 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 in 1993.

TA-3, Core Area: The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in this main TA of the Laboratory. Other buildings house central computing facilities, chemistry and materials science laboratories, and earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA-3 contains about 50% of the Laboratory's employees and floor space. A Van de Graaff accelerator was put on shutdown status in 1994.

TA-5, Beta Site: This site contains some physical support facilities such as an electrical substation, test wells, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, Two-Mile Mesa Site: The site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending disposal.

TA-8, GT Site (or Anchor Site West): This is a dynamic testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (x-ray machines with potentials up to 1,000,000 V and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East: At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site: Facilities are located here for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q Site: This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.

TA-15, R Site: This is the home of PHERMEX (the pulsed high-energy radiographic machine emitting x-rays) a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for weapons development testing. It is also the proposed site 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, pulsed-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. The eastern portion is designated for a future sanitary landfill.

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, this site 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	Included in RCRA Permit or Interim Status[a]
3-29[b]	Container (3 Units)	Interim S[c]
3-102-118A	Container	Closed
14-35	OB/OD[d] (2 Units)	Interim T[c]
15-184[b]	OD	Interim T[c]
16, Area P	Landfill	Closure in Progress
16	OB (6 Units)	Interim T[c]
16	Surface Impoundment	Closure in Progress
16-88[b]	Container	Interim S[c]
16-1150	Incinerator	Permitted T[e]
21-61[b]	Container	Interim S[c]
22-24	Container	Closed
35-85	Surface Impoundment	Closure in Progress
35-125	Surface Impoundment	Closed
36-8[b]	OD	Interim T[c]
39-6	OD	Interim T[c]
39-57	OD	Interim T[c]
40, SDS	OB/OD	Closure in Progress
40-2	Container	Closed
50-1-60A[b]	Container	Interim TS[c]
50-1-60D[b]	Container	Interim S[c]
50-1-BWTP	Aboveground Tank	Closed
50-37-115[b]	Aboveground Tank (2 Units)	Interim S[c]
50-37-115[b]	Container	Interim S[c]
50-37-117	Container	Permitted S[e]
50-37-117[b]	Container	Interim S[c]
50-37-118[b]	Container	Interim S[c]
50-37-CAI[b]	Incinerator	Interim T[c]
50-37-CAI	Incinerator	Permitted T[e]
50-69[b]	Container	Interim S[c]
50-69[b]	Container	Interim S[c]
50-114	Container	Permitted S[e]
50-114[b]	Container	Interim S[c]
50-137[f]	Container	Permitted S[e]
50-138[f]	Container	Permitted S[e]
50-139[f]	Container	Permitted S[e]
50-140[f]	Container	Permitted S[e]
53-166[b]	Surface Impoundment	Interim S[g]
53-166[b]	Surface Impoundment	Interim S[g]
53-166[b]	Surface Impoundment	Interim S[g]
54, Area G Over Pit 33[b]	Container	Interim S[c]
54, Area G	Landfill	Closure in Progress

Table D-1. Hazardous Waste Management Facilities at Los Alamos National Laboratory (Cont.)

Technical Area/Building	Facility Type	Included in RCRA Permit or Interim Status[a]
54, Area G Pad 1[b]	Container	Interim S[c]
54, Area G Pad 2[b]	Container	Interim S[c]
54, Area G Pad 4[b]	Container	Interim S[c]
54, Area G Over Pit 30[b]	Container	Interim S[c]
54, Area G Shaft 145[b]	Container	Interim S[c]
54, Area G Shaft 146[b]	Container	Interim S[c]
54, Area G Shaft 148[b]	Container	Interim S[c]
54, Area G Shaft 147[b]	Container	Interim S[c]
54, Area G Shaft 149[b]	Container	Interim S[c]
54, Area H	Landfill	Closure in Progress
54, Area L	Aboveground Tank (2 Tanks)	Closure in Progress
54, Area L Shaft 36[b]	Container	Interim S[c]
54, Area L Shaft 37[b]	Container	Interim S[c]
54, Area L Gas Cyl[b]	Container	Interim S[c]
54, Area L Gas Cyl	Container	Permitted S[e]
54-8[b]	Container	Interim S[c]
54-31	Container	Permitted S[e]
54-32	Container	Permitted S[e]
54-33[b]	Container	Interim S[c]
54-48[b]	Container	Interim S[c]
54-49[b]	Container	Interim S[c]
54-68	Container	Permitted S[e]
54-69	Container	Permitted S[e]
55, Near Bldg 4[b]	Container	Interim S[c]
55-4[b]	Container (3 Units)	Interim S[c]
55-4[b]	Tank (13 Tanks)	Interim TS[c]
55-4[b]	Container	Interim S[c]
55-4[b]	Container	Interim S[c]
55-4[b]	Container	Interim TS[c]
55-4[b]	Container	Interim S[c]
55-4[b]	Misc. Unit	Closure in Progress

[a]S = Storage; T = Treatment.
[b]Designates mixed waste units.
[c]Part A, January 1991.
[d]OB/OD = open burning/open detonation.
[e]November 1989.
[f]These units have not yet been constructed.
[g]Revised Part A, October 1993.

Table D-2. Types of Discharges and Parameters Monitored at the Laboratory under National Pollutant Discharge Elimination System Permit NM0028355 (Effective August 1, 1994)

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	Once per month
02A	Boiler blowdown	2	pH, total suspended solids, flow, total copper, total iron, total phosphorus, sulfite (as SO3), total chromium	Once per three months
03A	Treated cooling water	40	Total suspended solids, free available chlorine, flow, total phosphorus, total arsenic, pH	Once per three months
04A	Noncontact cooling water	44	pH, flow, total residual chlorine	Once per three months
051	Radioactive waste treatment plant (TA-21 and TA-50)	1	Ammonia (as N), chemical oxygen demand, total suspended solids, total cadmium, total chromium, total copper, total iron, total lead, total mercury, total nitrogen, total nickel, nitrate-nitrite (as N), total zinc, total toxic organics, radium-226, radium-228, pH, flow	Once per week
05A	High explosives wastewater	18	Chemical oxygen demand, pH, flow, total suspended solids	Once per three months
06A	Photo waste water	14	Total silver, pH, flow	Once per three months
07A	Asphalt plant	1	pH, total suspended solids, chemical oxygen demand, oil & grease, flow	Once per three months
128	Printed circuit board	1	pH, chemical oxygen demand, total suspended solids, total iron, total copper, total silver, flow	Once per week
S	Sanitary wastewater (05S & 13S)	2	Biochemical oxygen demand, flow, pH, total suspended solids, fecal coliform bacteria	Variable frequency, from three per month to once per three months

Table D-2. Types of Discharges and Parameters Monitored at the Laboratory under National Pollutant Discharge Elimination System Permit NM0028355 (effective August 1, 1994) (Cont.)

EPA Identification No.	Type of Discharge	Number of Outfalls	Monitoring Required	Sampling Frequency
01A, 02A 03A, 04A 051, 05A 06A, 07A 128, 05S 13S	All discharge categories	124	Total aluminum, total arsenic, total boron total cadium, total chromium, total cobalt, total copper, total lead, total mercury, total, selenium, total vanadium, total zinc, radium-226 + radium-228, tritium[a]	Once per year

[a]When accelerator produced.

Note: See "Environmental Surveillance in Los Alamos during 1993" for NPDES permit limits for January 30, 1990 through July 31, 1994.

Table D-3. Limits Established by National Pollutant Discharge Elimination System Permit NM0028355 for Sanitary Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
13S TA-46 SWSC	BOD[a]	30.0	45.0	mg/L
		100.0	N/A	lb/day
	TSS[b]	30.0	45.0	mg/L
		100.0	N/A	lb/day
	Fecal coliform bacteria	500.0	500.0	org/100 mL
	pH	6-9	6-9	standard unit
05S TA-21 Package Plant	BOD[a]	30.0	45.0	mg/L
		0.5	N/A	lb/day
	TSS[b]	30.0	45.0	mg/L
		0.5	N/A	lb/day
	COD[c]	125.0	125.0	mg/L
		2.1	N/A	lb/day
	pH	6-9	6-9	standard unit

[a]Biochemical oxygen demand.
[b]Total suspended solids.
[c]Chemical oxygen demand
NOTE: Sanitary Outfalls 02S, 03S, 04S, 07S, 09S, 10S, and 12S were eliminated from the Laboratory's NPDES permit on July 9, 1993.

Table D-4. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality at Sanitary Sewage Treatment Outfalls

Discharge Location (Outfall)	Permit Parameters	Number of Deviations
*TA-21 (05S)	Fecal coliform bacteria	0
	COD[a]	0
	BOD[b]	0
	TSS[c]	0
	pH	0
TA-46 (13S)	Fecal coliform bacteria	0
	BOD[b]	0
	TSS[c]	0
	pH	0

[a]Chemical oxygen demand.
[b]Biochemical oxygen demand.
[c]Total suspended solids.
*No discharge from outfall 05S during 1994.

Table D-5. Limits Established by National Pollutant Discharge Elimination System Permit NM0028355 for Industrial Outfall Discharges August 1, 1994

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	30.0	100.0	mg/L
	Total Fe	10.0	40.0	mg/L
	Total Cu	1.0	1.0	mg/L
	Total P	20.0	40.0	mg/L
	Sulfite	35.0	70.0	mg/L
	Total Cr	1.0	1.0	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	20.0	40.0	mg/L
	Total As	0.04	0.04	mg/L
	pH	6-9	6-9	standard unit
04A Noncontact cooling	pH	6-9	6-9	standard unit
	Total Cl	Report[b]	Report[b]	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	0.3	lb/day
	Total Cr	0.19	0.38	lb/day
	Total Cu	0.63	0.63	lb/day
	Total Fe	1.0	2.0	lb/day
	Total Pb	0.06	0.15	lb/day
	Total Hg	0.003	0.09	lb/day
	Total Zn	0.62	1.83	lb/day
	TTO[c]	1	1	mg/L
	Ni	Report[b]	Report[b]	mg/L
	N	Report[b]	Report[b]	mg/L
	NO_3-NO_2	Report[b]	Report[b]	mg/L
	Ammonia (as N)	Report[b]	Report[b]	mg/L
	pH	6-9	6-9	standard unit
05A High explosive	Oil & Grease	15.0	15.0	mg/L
	COD[d]	125.0	125.0	mg/L
	TSS	30.0	45.0	mg/L
	pH	6-9	6-9	standard unit

Table D-5. Limits Established by National Pollutant Discharge Elimination System Permit NM0028355 for Industrial Outfall Discharges August 1, 1994 (Cont.)

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
06A Photo waste	Ag	0.5	1.0	mg/L
	pH	6-9	6-9	standard unit
07A Asphalt Plant	COD	125.0	125.0	mg/L
	TSS	100.0	100.0	mg/L
	Oil & Grease	15.0	15.0	mg/L
	pH	6-9	6-9	standard unit
128 Printed circuit board	COD	125.0	125.0	mg/L
	TSS	1.25	2.5	lb/day
	Total Fe	0.05	0.1	lb/day
	Total Cu	0.05	0.1	lb/day
		1.0	1.0	mg/L
	Total Ag	0.02	0.02	mg/L
	pH	6-9	6-9	standard unit
All Outfall Categories:	Total Aluminum	5.0	5.0	mg/L
Annual Water Quality	Total Arsenic	0.04	0.04	mg/L
Parameters	Total Boron	5.0	5.0	mg/L
	Total Cadmium	0.2	0.2	mg/L
	Total Chromium	5.1	5.1	mg/L
	Total Cobalt	1.0	1.0	mg/L
	Total Copper	1.6	1.6	mg/L
	Total Lead	0.4	0.4	mg/L
	Total Mercury	0.01	0.01	mg/L
	Total Selenium	0.05	0.05	mg/L
	Total Vanadium	0.1	0.1	mg/L
	Total Zinc	95.4	95.4	mg/L
	Radium 226+228	30.0	—	pCi/L
	Tritium	3,000,000	—	pCi/L

[a]Total suspended solids.
[b]Effluents are reported to EPA but are not subject to limits.
[c]Total Toxic Organics.
[d]Chemical Oxygen Demand.

Table D-6. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality at Industrial Outfalls: Deviation 1994

EPA ID	Technical Area	Date	Parameter		Results/Limits	Units
January						
03A037	TA-21-314	01/06/94	pH	(daily max)	9.3/9.0	su
03A037	TA-21-314	01/06/94	TSS	(daily max)	362/100	mg/L
February						
128128	TA-22-91	02/07/94	Cu	(daily max)	0.116/0.10	lbs/day
128128	TA-22-91	02/07/94	Fe	(daily max)	0.143/0.10	lbs/day
March						
06A123	TA-15-183	03/15/94	CN	(daily max)	0.37/0.20	mg/L
April						
03A049	TA-53-64	04/20/94	TSS	(daily max)	133,130/100	mg/L
03A049	TA-53-64	04/20/94	P	(daily max)	40/5	mg/L
03A049	TA-53-64	04/20/94	TSS	(daily avg)	29,584/30	mg/L
03A049	TA-53-64	04/20/94	P	(daily avg)	9.02/5	mg/L
May - - No exceedances during monitoring period.						
June						
05A066	TA-9A	06/07/94	TSS	(daily max)	80/45	mg/L
July - - No exceedances during monitoring period.						
August						
128	TA-22-91	08/24/94	pH	(daily max)	9.2/9.0	su
128	TA-22-91	08/04 94	Fe	(daily max)	1.64/0.10	lbs/day
128	TA-22-91	08/04/94	Fe	(daily avg)	0.33/0.05	lbs/day
September						
05A066	TA-09-A	09/07/94	TSS	(daily max)	92.0/45.0	mg/L
05A066	TA-09-A	09/07/94	TSS	(daily avg)	47.5/30.0	mg/L
05A053	TA-16-410	09/21/94	O & G	(daily max)	204.2/15.0	mg/L
05A053	TA-16-410	09/21/94	O & G	(daily avg)	103.0/15.0	mg/L
October						
03A045	TA-48-1	10/18/94	pH	(daily max)	9.3/9.0	su
November						
03A028	TA-15-202	11/29/94	As(T)	(daily max)	0.28/0.04	mg/L
03A045	TA-48-1	11/08/94	pH	(daily max)	9.5/9.0	su
03A045	TA-48-1	11/15/94	pH	(daily max)	9.1/9.0	su
03A047	TA-53-60	11/09/94	Cl_2	(daily max	0.60/0.50	mg/L
03A047	TA-53-60	11/29/94	Cl_2	(daily avg)	0.30/0.20	mg/L
December						
03A028	TA-15-202	12/15/94	As(T)	(daily max)	0.068/0.04	mg/L
03A028	TA-15-202	12/15/94	As(T)	(daily avg)	0.12/0.04	mg/L
05A056	TA-16-260	12/13/94	O & G	(daily max)	47/15	mg/L
05A056	TA-16-260	12/13/94	O & G	(daily avg)	26.2/15	mg/L
128	TA-22-91	12/05/94	pH	(daily max)	9.8/9.0	su

Table D-7. Federal Facilities Compliance Agreement and Administrative Order: Compliance Schedule for Waste Stream Characterization Program and High Explosives Wastewater Treatment Plant

Outfalls	Date	Status or Target Date
Outfall 05A (HE Wastewater Treatment)		
Complete conceptual design report	July 1992	Completed
Complete design criteria	June 1993	Completed
Begin line item project	January 1994	Completed
Complete Title I design	July 1994	Completed
Complete Title II design	July 1996	July 31, 1996
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	Completed
Complete 25% corrective actions	September 1994	Completed
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. 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-9. 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**
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,G
	Nemouridae	*Amphinemura*	*banksi*	F,G,L,P,SG
	Nemouridae	*Malenka*	*coloradensis*	F
	Nemouridae	*Malenka*		G,L
	Nemouridae	*Nemoura*		F
	Nemouridae	*Podmosta*	*delicatula*	G
	Nemouridae	*Zapada*	*cinctipes*	F,L
	Nemouridae	*Zapada*	*frigida*	L
	Perlidae	*Acroneuria*	*abnormis*	F
	Perlidae	*Hesperoperla*	*pacifica*	F,L,SG
	Perlodidae	*Cultus*	*aestivalis*	GL
	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
	Pteronarcyidae	*Pteronarcys*		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 grandis*	F,G
	Ephemerellidae	*Ephemerella*	*inermis*	F,G,L
	Ephemerellidae	*Ephemerella*	*infrequens*	F,G
	Ephemerellidae	*Ephemerella*		F
	Heptageniidae	*Cinygmula*		F,G,L

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Heptageniidae	*Epeorus*	*longimanus*	F,G,L
	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,L
	Tricorythidae	*Tricorythodes*	*minutus*	G,S
	Tricorythidae	*Tricorythodes*		A,F
Odonata				
suborder Anisoptera				
(Dragonflies)	Aeshnidae	*Aeshna*		A,C,F,I,S
	Aeshnidae	*Anax*		H,P,S,48
	Aeshnidae	*Boyeria*		L,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,S
	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,S
	Naucoridae	*Ambrysus*	*mormon*	A,C,PS
	Notonectidae	*Notonecta*	*undulata*	F
	Notonectidae	*Notonecta*		C,S

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Veliidae	*Microvelia*		F,G,L
	Veliidae	*Rhagovelia*		S
	Veliidae			A,PS
Trichoptera				
(Caddisflies)	Brachycentridae	*Amiocentrus*		F
	Brachycentridae	*Brachycentrus*	*americanus*	F
	Brachycentridae	*Brachycentrus*		F
	Brachycentridae	*Micrasema*		F,G,L
	Brachycentridae pupae	*Micrasema*		G
	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,G,L,S
	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*?		G,L,P,S
	Limnephilidae	*Dicosmoecus*		F
	Limnephilidae	*Hesperophylax*		G,L,P,S,SG
	Limnephilidae pupae	*Hesperophylax*		G
	Limnephilidae	*Limnephilus*		F,G,L,PW,S
	Limnephilidae	*Oligophlebodes*		F,G,L,P,S
	Limnephilidae pupae	*Oligophlebodes*		G
	Limnephilidae	*Psychoronia*		F,G
	Limnephilidae			G,L,PW
	Odontoceridae	*Namamyia*		G
	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,L
	Rhyacophilidae pupae	*Rhyacophila*	*brunnea* complex	G,L
	Rhyacophilidae	*Rhyacophila*	*hyalinata*	F,G
	Rhyacophilidae	*Rhyacophila*	*valuma*	F,G

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Rhyacophilidae	*Rhyacophila*		F
	Rhyacophilidae	*Rhyacophila*	Type A	A
Megaloptera (Nerve-wings)	Corydalidae	*Neohermes*?		G,L
Lepidoptera (Butterflies and moths)	Noctuidae			G,L,PS
	Pyralidae			G,S
	Pyralidae	*Paraponyx*		PS
	Pyralidae	*Parargyractis*	*kearfottalis*	F,PS
	Pyralidae	*Petrophyla*		PS
Coleoptera (Beetles)	Amphizoidae	*Amphizoa*		G
	Curculionidae	*Phytonomus*		G,L,S
	Curculionidae			D,F
	Curculionidae adult			G
	Dryopidae	*Helichus*	*suturalis**	F
	Dryopidae	*Helichus*	*striatus**	F
	Dryopidae (adults)	*Helichus*		F,G,L,P,PS,S
	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	*Hydroporus*		S
	Dytiscidae	*Hygrotus*		S
	Dytiscidae			L,S
	Dytiscidae (adults)			G,L,PS,S
	Dytiscidae (adults)		Type A	M,S
	Dytiscidae (adults)		Type B	M,S
	Dytiscidae (adults)		Type C	S
	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

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Elmidae (adults)	*Zaitzevia*		C,G,L,S
	Elmidae			G,L,S
	Elmidae (adults)			C,S,PS
	Gyrinidae (adults)	*Gyrinus*		A,F,S,PS
	Haliplidae	*Haliplus*		IC
	Haliplidae	*Peltodytes*		G
	Haliplidae (adults)			S
	Helodidae			P
	Helodidae	*Prionocyphon*		G
	Hydrophilidae	*Ametor*	*scabrosus**	F
	Hydrophilidae	*Ametor*		A,C,G,L,S
	Hydrophilidae (adults)	*Ametor*		G
	Hydrophilidae	*Berosus*	*styliferous*	F
	Hydrophilidae	*Crenitis**		F
	Hydrophilidae	*Cymbiodyta*	*dorsalis**	F
	Hydrophilidae (adults)	*Enochrus?*		G
	Hydrophilidae (adults)	*Helphorus*		L
	Hydrophilidae (adults)	*Hydrobius*		L
	Hydrophilidae	*Hydrochus*		G
	Hydrophilidae (adults)	*Hydrochus*		G
	Hydrophilidae			G,L,P
	Hydrophilidae (adults)			G
	Psephenidae	*Psphenus*?		C,P,48
	Psephenidae			G
Diptera (Flies)	Blephariceridae			F
	Ceratopogonidae (Heleidae)	*Bezzia*		G,L,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	*Parametriocnemus*		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	*Tvetnia*		L,PS,S

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Chironomidae	*Zavrelia*		F
	Chironomidae	Type A		C,G,H,L,P, PS,S, SG,128
	Chironomidae	Type B		G,L,P,S,PS
	Chironomidae	Type C		G,H,L,P,S,128
	Chironomidae	Type D		G,L,P,PS,S
	Chironomidae	Type E		G,L,PS
	Chironomidae	Type F		G,L,S
	Chironomidae	Type G		A,C,G,H,L,P, PS,S
	Chironomidae pupae	Type G		G
	Chironomidae	Type H		L,S
	Chironomidae	Type I		SG
	Chironomidae (pupae)			C,G,I,L,S
	Chironomidae pupae	Type PA		G,L
	Chironomidae (pupae)	Type PB		S
	Chironomidae (pupae)	Type PC		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,L,P,S
	Empididae			H
	Empididae (pupae)	*Hemerodromia*		G,S
	Ephydridae	*Brachydeutera*		S
	Ephydridae (pupae)			S
	Muscidae	*Limnophora*	*aequifrons*	F
	Muscidae	*Limnophora*		A,D,L,S,SG
	Psychodidae	*Maruina*		G,L,S
	Psychodidae	*Pericoma*		F,G,L
	Psychodidae (pupae)			S
	Ptychopteridae	*Bittacomorpha*		A,G,L,S
	Ptychopteridae	*Ptychoptera*		G
	Ptychopteridae			F
	Simuliidae	*Prosimilium*		A,F,G,L,S
	Simuliidae	*Simulium*		A,F,L,PS,S
	Simuliidae			D,F,G,L,S,SG
	Simuliidae (pupae)			G,L,S
	Simuliidae pupae	Type PA		G
	Stratiomyidae	*Eulalia*		F
	Stratiomyidae	*Odontomyia*		G,PS,S
	Stratiomyidae			A,F,G
	Syrphidae	*Tubifera*	*bastardii*	F

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Tabanidae	*Chrysops*		H,M
	Tabanidae	*Tabanus*		128,PW,S
	Tabanidae			F,G,L,S
	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	G,L,S

****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 firestation pond
PW = Pajarito Wetlands
PS = Pajarito Springs
S = Sandia Canyon
M = Mortandad
SG = Starmer's Gulch
48 = TA-48 pond
128 = outfall 128

Appendix D

Table D-10. Noninsect Aquatic Invertebrates Collected in Los Alamos County and Adjacent Watersheds

Phylum or Subphylum	Class, etc.	Common Name	Location[a]
Annelida (Segmented worms)	Naididae	Coil worms	F,G,L,S
	Oligochaeta, 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)	family Hydracarina	Water mites	C,F,G,L,PS,SG
Aschelminthes (Round worms and hairworms)	Nematomorpha	Horsehair worm	C,F,G,L,P,S,SG
	Nematomorpha, Gordioidea,Gordiidae, *Gordius*	Horsehair worm	F,G
Crustacea (Crustaceans)	Amphipoda, *Hyatella azteca*	Scuds	A,C,PS
	Cladocera	Water fleas	O
	Copepoda	Copepods	S
	Ostracoda, Candoniidae	Seed shrimp	S
	Ostracoda, Cyprididae	Seed shrimp	C,S,SG
	Amphipoda, Palaemonidae	Scuds	A,C
	Amphipoda, *Hyalella azteca*	Scuds	PS
Mollusca (Mollusks)	Planorbidae, *Gyralus 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
	Gastropoda Type A	Snails	G,L
	Sphaeriidae, *Pisidium casertanum*	Clams	F,G,L
	Pelecypoda, *Pisidium compressa*	Clams	H
	Sphaeriidae	Clams	F
Nematoda (Round worms)		Free-living roundworm	F,G,S
Platyhelminthes (Flatworms)	Turbellaria	Planaria	A,C,F,G,PS,S,SG

[a]**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
PW = Pajarito Wetlands
PS = Pajarito Springs
S = Sandia Canyon
SG = Starmer's Gulch
48 = TA-48 pond
128 = Outfall 128

Table D-11. 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 in Section V.B.1.

Table D-12. Locations of Air Sampling Stations[a]

Location	Northing Coordinate[b]	Easting Coordinate[b]
Regional (28-44 km)		
1. Española	1819247.9	544369.5
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-12. Locations of Air Sampling Stations[a] (Cont.)

Location	Northing Coordinate[b]	Easting Coordinate[b]
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-8 for station locations.
[b]New Mexico State Plane Coordinates.

Table D-13. Locations of Surface Water Sampling Stations[a]

Location[a]	Northing Coordinate[b]	Easting Coordinate[b]
OFF-SITE STATIONS		
REGIONAL STATIONS		
Rio Chama at Chamita	30°05″	106°07″
Rio Grande at Embudo	36°12″	105°58″
Rio Grande at Otowi	1 773 000	532 300
Rio Grande at Cochiti	35°37″	106°19″
Rio Grande at Bernalillo	35°17″	106°36″
Jemez River	35°40″	106°44″
PERIMETER STATIONS		
Radioactive Effluent Release Areas		
Acid-Pueblo Canyons		
Acid Weir	1 778 741	484 214[b1]
Pueblo 1	1 778 817	484 165 [b1]
Pueblo 2	1 776 803	495 013[b1]
Los Alamos Canyon		
Los Alamos at Rio Grande	1 773 000	532 300[b2]
Other Areas		
Guaje Canyon	1 794 000	471 600[b2]
Los Alamos Reservoir	1 777 200	468 600[b2]
Mortandad at Rio Grande	1 756 595	523 638[b3]
Pajarito at Rio Grande	1 747 532	516 715[b3]
Frijoles at Park Headquarters	1 737 929	494 140[b3]
Frijoles at Rio Grande	1 729 494	499 198[b3]
ON-SITE STATIONS		
Radioactive Effluent Release Areas		
Acid-Pueblo Canyons		
Pueblo 3	1 774 826	506 429[b1]
Pueblo at SR 502	1 771 862	512 695[b1]
DP–Los Alamos Canyons		
DPS-1	1 774 796	493 081[b1]
DPS-4	1 773 228	497 258[b1]
Mortandad Canyon		
GS-1	1 770 230	486 502[b1]
Other Areas		
Cañada del Buey	1 766 666	491 631[b1]
Pajarito Canyon	1 759 676	497 730
Water Canyon at Beta	1 757 513	485 058
Sandia Canyon		
SCS-1	1 773 872	480 978[b1]
SCS-2	1 771 081	492 581[b1]
SCS-3	1 770 207	495 655[b1]
Ancho at Rio Grande	1 735 497	509 307[b3]

[a]Off-site regional surface water sampling locations are shown in Figure V-11; off-site perimeter and on-site sampling locations are given in Figure V-I2.

[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-14. Locations of Sediment Sampling Stations[a]

Location	Northing Coordinate[b]	Easting Coordinate[b]
OFF-SITE STATIONS		
REGIONAL STATIONS		
Chamita[c]	36°05″	106°07″
Embudo[c]	36°12″	106°58″
Rio Grande at Otowi[c]	35°52≤	106°08″
Rio Grande at Sandia[d]	1758925	525014
Rio Grande at Pajarito[d]	1747532	516715
Rio Grande at Water[d]	1741139	514154
Rio Grande at Ancho[d]	1735497	509307
Rio Grande at Frijoles[d]	1729494	499198
Rio Grande at Cochiti[c]	35°37″	106°19″
Rio Grande at Bernalillo[c]	35°17″	106°36″
Jemez River[b]	35°40″	106°44″
PERIMETER STATIONS		
Radioactive Effluent Release Areas		
Acid-Pueblo Canyon		
Acid Weir[e]	1778741.5	484213.6
Pueblo 1[e]	1778817.4	484165.4
Pueblo 2[e]	1776802.8	495013.5
DP-Los Alamos Canyon		
Los Alamos at Totavi	1772357.9	519683.8
Los Alamos at LA-2[e]	1777157.0	526680.137
Los Alamos at Otowi	1774114.9	531709.9
Other Canyons		
Guaje at SR 502	1777366.5	525674.0
Bayo at SR 502	1774361.7	522361.8
Sandia at Rio Grande[d]	1758925	525014
Cañada Ancha at Rio Grande	N/A[f]	N/A
Pajarito at Rio Grande[d]	1747532	516715
Frijoles at National Monument Headquarters	1737929.3	494139.8
Frijoles at Rio Grande[d]	1729494	499198
Mortandad Canyon on San Ildefonso Pueblo Land		
Mortandad A-6	N/A	N/A
Mortandad A-7	N/A	N/A
Mortandad A-8	N/A	N/A
Mortandad at SR 4 (A-9)[e]	1763782.7	509436.7
Mortandad A-10	N/A	N/A
Mortandad at Rio Grande (A-11)[c]	1756595	523638

Table D-14. Locations of Sediment Sampling Stations[a] (Cont.)

Location	Northing Coordinate[b]	Easting Coordinate[b]
ON-SITE STATIONS		
Radioactive Effluent Release Areas		
Acid-Pueblo Canyon		
Hamilton Bend Spring[e]	1775857.4	502232.8
Pueblo 3[e]	1774826.4	506425.0
Pueblo at SR 502[e]	1771862.0	512694.7
DP-Los Alamos Canyon		
DPS-1[e]	1774796.3	493080.9
DPS-4[e]	1773227.8	497258.4
Los Alamos at Bridge[e]	1775550.8	478015.5
Los Alamos at LAO-1[e]	1773884.4	489162.8
Los Alamos at GS-1[e]	1770827.3	507906.9
Los Alamos at LAO-3[e]	1773012.4	497803.4
Los Alamos at LAO-4.5[e]	1772073.7	503410.1
Los Alamos at SR 4[d]	1771473.8	511651.0
Mortandad Canyon		
Mortandad near CMR Building[e]	1772092.7	479491.8
Mortandad west of GS-1	N/A	N/A
Mortandad at GS-1[e]	1770229.5	486502.2
Mortandad at MCO-5[e]	1769482.7	492212.1
Mortandad at MCO-7[e]	1768419.6	494306.2
Mortandad at MCO-9[e]	1768309.1	497813.6
Mortandad at MCO-13 (A-5)[e]	1767168.7	501051.6
Other Canyons		
Sandia at SR 4[e]	1767568.8	507558.5
Cañada del Buey at SR 4[e]	1756281.4	511459.2
Pajarito at SR 4[e]	1754333.2	508284.8
Potrillo at SR 4[e]	1751097.4	505375.0
Fence at SR 4	1751220.5	505153.7
Water at SR 4[e]	1749965.7	500428.6
Indio at SR 4	1747798.3	501075.1
Ancho at SR 4	1741156.4	500015.5
Water at Rio Grande[d]	1741139	514154
Ancho at Rio Grande[d]	1735497	509307
Chaquehiu at Rio Grande[d]	1733012	502768
Solid Radioactive Waste Management Areas		
Area G, TA-54[e]		
G-1	1757654.9	501645.5
G-2	1757160.7	502094.9
G-3	1756706.5	503162.6
G-4	1756643.1	503955.1
G-5	1756592.8	504153.1
G-6	1756494.6	504786.9

Table D-14. Locations of Sediment Sampling Stations[a] (Cont.)

Location	Northing Coordinate[b]	Easting Coordinate[b]
Area G, TA-54[e] (Cont.)		
G-7	1757361.2	505155.7
G-8	1757539.2	506507.4
G-9	1758521.8	505236.2
Area AB, TA-49[e]		
AB-1	1775633.2	484290.4
AB-2	1755169.0	485200.5
AB-3	1755569.9	485238.6
AB-4	1755640.2	486640.9
AB-4A	1755773.2	486638.4
AB-5	1754799.9	485631.3
AB-6	1754684.8	485643.4
AB-7	1754417.4	485583.5
AB-8	1754383.4	484698.5
AB-9	1756396.7	488195.0
AB-10	1754547.5	488279.6
AB-11	1752019.9	488479.1

[a]Sediment sampling locations in Figures V-14 and V-15.

[b]New Mexico State Plane Coordinates.

[c]Latitude/Longitude data from US Geological Survey (USGS).

[d]Coordinate data from GPS, estimated accuracy ± 2 to 5 m.

[e]Coordinate data from standard land survey.

[f]Not available.

Table D-15. Locations of Soil Sampling Stations[a]

Location	Northing Coordinate[b]	Easting Coordinate[b]
Regional Soil		
Rio Chama	1844693.096	1677875.228
Embudo	1816440.315	1744693.086
Otowi 1777182.637	1668721.670	
Near Santa Cruz	1816438.561	1744700.759
Cochiti 1644216.892	1647114.194	
Bernalillo	1572864.707	1549601.021
Jemez 1719495.437	1502276.101	
Perimeter Soils		
L.A. Sportsman Club	1788136.211	1636493.387
North Mesa	1780072.446	1630330.015
Near TA-8 (GT Site)	1768805.627	1609433.446
Near TA-49	1755456.289	1620318.345
White Rock (east)	1758301.447	1655116.466
Tsankawi	1768110.302	1647985.099
On-Site Soil		
TA-21 (DP Site)	1774989.218	1631266.389
East of TA-53	1772914.010	1629196.631
TA-50 1769548.575	1626390.047	
Two-Mile Mesa	1769494.453	1615386.422
East of TA-54	1757882.733	1645162.755
R-Site Road East	1761923.229	1625863.108
Potrillo Drive	1759475.770	1635153.829
S-Site (TA-16)	1759328.803	1618868.688
Near Test Well DT-9	1752337.978	1629594.961
Near TA-33	1740806.015	1638487.987

[a]Soil sampling locations are given in Figures V-14 and V-18.
[b]New Mexico State Planar Coordinates, NAD 1983

Table D-16. Locations of Groundwater Sampling Stations

Location[a]	Northing Coordinate	Easting Coordinate
MAIN AQUIFER ON SITE		
Test Wells		
Test Well 1	1772014.8	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-1	1783547.0	515946.4
Well G-1A	1784291.0	514996.6
Well G-2	1785061.0	513966.2
Well G-3	1786156.0	511432.1
Well G-4	1786390.0	508704.8
Well G-5	1787845.0	506705.3
Well G-6	1786789.0	504580.1
MAIN AQUIFER SPRINGS		
White Rock Canyon Springs		
Group I		
Sandia Spring[b]	1761428	522938
Spring 3[b]	1753500	521243
Spring 3A[b]	1753236	521276
Spring 3AA[b]	1750988	521047
Spring 4[b]	1747825	515784
Spring 4A[c]	1747800	515900
Spring 5[b]	1742479	515812
Spring 5AA[c]	1742500	510900
Ancho Spring[c]	1739900	505400
Group II		
Spring 5A[b]	1741943	515121
Spring 5B[c]	1738100	510800
Spring 6[b]	1735455	508638
Spring 6A[b]	1734210	506318
Spring 7[c]	1733500	504800
Spring 8[c]	1733400	504200
Spring 8A[b]	1733446	503574
Spring 8B[c]	1733500	503000
Spring 9[b]	1733255	503191

Table D-16. Locations of Groundwater Sampling Stations (Cont.)

Location[a]	Northing Coordinate	Easting Coordinate
MAIN AQUIFER SPRINGS		
White Rock Canyon Springs		
Group II (Cont.)		
Spring 9A[b]	1733085	502498
Doe Spring[b]	1733536	502081
Spring 10[b]	1728100	497779
Group III		
Spring 1[b]	1767795	527684
Spring 2[b]	1766286	527068
Group IV		
La Mesita Spring[c]	1770700	516300
Spring 2A[c]	1754800	522400
Spring 3B[b]	1749752	521110
Other Springs		
Sacred Spring[c]	1780300	529800
Indian Spring[c]	1777200	525700
ALLUVIAL CANYON GROUNDWATER		
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[c]	1770700	516300
PERCHED AQUIFER IN VOLCANICS		
Water Canyon Gallery[c]	1762500	463900

Table D-16. Locations of Groundwater Sampling Stations (Cont.)

Location[a]	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, Figure IV-5 for the location of Pueblo of San Ildefonso wells. Coordinates are surveyed unless noted.
[b]Coordinate data from GPS, estimated accuracy ± 2 to 5 m.
[c]Coordinates estimated from USGS quadrangle map.
[d]Not available.

Table D-17. Locations of Beehives

Location	Northing Coordinate[b]	Easting Coordinate[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. White Rock/ Pajarito Acres (TA-36)	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-19; on-site beehives are presented in Figure V-20.
[b]New Mexico State Plane Coordinates.

Table D-18. 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-19. 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-20. Volatile Organic Compounds in Water Determined by PAT[a] Analyses

Compound	CAS[b] #	Limit of Quantification (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
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
Ethylbenzene	100-41-4	5
o,m,p-Xylene (mixed)	1330-20-7	5
Styrene	100-42-5	5
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

Table D-20. Volatile Organic Compounds in Water Determined by PAT[a] Analyses (Cont.)

Compound	CAS[b] #	Limit of Quantification (μg/L)
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
Dichlorodifluoromethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5

[a]Purge-and-trap gas chromatography/mass spectrometry.
[b]Chemical abstract service.

Table D-21. Volatile Organic Compounds in Solids Determined by SW-846 Method 8260

Compound	CAS[a] #	Limit of Quantification (μg/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
2-Butanone (MEK)	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5

Table D-21. Volatile Organic Compounds in Solids Determined by SW-846 Method 8260 (Cont.)

Compound	CAS[a] #	Limit of Quantification (μg/kg)
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
Ethylbenzene	100-41-4	5
o,*m*,*p*-Xylene (mixed)	1330-20-7	5
Styrene	100-42-5	5
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	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
Dichlorodifluonomethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5

[a]Chemical abstract service.

Table D-22. Semivolatile Organic Compounds 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	50
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	50
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	20
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	50
Dibenzofuran	132-64-9	50
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	20
4,6-Dinitro-2-methylphenol	534-52-1	50
N-Nitrosodiphenylamine	86-30-6	10

Table D-22. Semivolatile Organic Compounds in Water (Cont.)

Compound	CAS[a] #	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	50
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	50
Butylbenzylphthalate	85-68-7	10
3,3'-Dichlorobenzidine	91-94-1	10
Benzo(*a*)anthracene	56-55-3	20
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-23. Volatiles Determined in Air (Pore Gas) - Thermal Desorption

Compound	CAS[a] #	Limit of Quantification (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-24. Volatiles Determined in Air (Pore Gas) - Charcoal Desorption

Compound	CAS[a] #	Limit of Quantification (μg/L)
Benzene	71432	10.0
Bromobenzene	108861	10.0
Carbon tetachloride	56235	10.0
Chlorobenzene	108907	10.0
Chloroform	67663	10.0
Ethylbenzene	100414	10.0
m-Xylene	108383	10.0
o-Xylene	95476	10.0
Tetachloroethylene	127184	10.0
Toluene	108883	10.0
Trichloroethylene	79016	10.0
1,1,1-Trichloroethane	71556	10.0
1,2,4-Trimethylbenzene	95636	10.0

[a]Chemical abstract service.

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 Administrat-ion (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.)
- ***EDE*** Effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100 mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to $100 \times 0.12 = 12$ mrem.
- ***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 compliance	The documentation, through environmental surveillance, that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection.
environmental monitoring	The collection and analysis of samples, or measurements, of liquid and gaseous liquid effluents and gaseous emissions for the purpose of characterizing and quantifying contaminants.
environmental surveillance	The collection and analysis of samples or direct measurements of air, water, sediments, soils, foodstuffs, and plants and animals for the purpose of determining compliance with applicable standards and permit requirements, assessing radiation exposures of members of the public and assessing the impacts on the environment.
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 ($1/2 \times 1/2$), after three half-lives, one-eighth ($1/2 \times 1/2 \times 1/2$), and so on.
hazardous waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) and the NM Hazardous Waste Act (NMHWA) 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. 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.

NMHWA The NM Hazardous Waste Act authorizes and governs the hazardous waste program in New Mexico.

nonpoint source Any nonconfined area from which pollutants are discharged into a body of water (e.g., agricultural runoff, construction runoff, 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 mg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or mg/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 mg/g or mg/kg.

QA Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.

QC Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

R Roentgen. The roentgen is a unit for measuring exposure. It is defined only for the effect on air and applies only to gamma and x-rays in air. It does not relate biological effects of radiation to the human body.

1 roentgen = 1,000 milliroentgen (mR)

rad Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the

radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body.

1 rad = 1,000 millirad (mrad)

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 Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains to only people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) due to the different types of radiation.

rem = rad x quality factor
1 rem = 1000 millirem (mrem)

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.

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
ANOI	Advanced Notice of Intent
ANSI	American National Standards Institute
AO	Administrative Order
AQCR	Air Quality Control Regulation (New Mexico)
BEIR	biological effects of ionizing radiation
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOD	biochemical/biological oxygen demand
BP	barometric pressure
Btu	British thermal unit
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAI	controlled-air incinerator
CAS	Condition Assessment Survey
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
COPC	contaminants of potential concern
CSU	Colorado State University
CWA	Clean Water Act
CY	calendar year
CYRSL	current years 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
DREF	dose rate effectiveness factors
EA	Environmental Assessment

EARE	Environmentall Assessments & Resource Evaluations
ECD	electron capture detection
EDE	effective dose equivalent
EES	Earth and Environmental Sciences (LANL Division)
EES-1	Geology and Geochemistry Group
EIS	Environmental Impact Statement
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
ESAL	Ecotoxicological Screening Action Level
ESH	Environment, Safety, & Health (LANL Division)
ESH-13	ESH Training Group
ESH-14	Quality Assurance Group
ESH-17	Air Quality Group
ESH-18	Water Quality & Hydrology Group
ESH-19	Hazardous & Solid Waste Group
ESH-20	Environmental Assessments & Resource Evaluations Group
EST	Ecological Studies Team (ESH-20)
FDA	Food and Drug Administration
FFCA	Federal Facilities Compliance Agreement
FFCAct	Federal Facilities Compliance Act
FONSI	Finding of No Significant Impact
FY	fiscal year
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GMP	Groundwater Monitoring Plan
GMPMPP	Groundwater Protection Management Program Plan
HAP	Hazardous Air Pollutant
HAZWOPER	hazardous waste operations
HE	high-explosive
HEPA	high-efficiency particulate air (filter)
HPGe	high purity germanium detector
HPIC	high pressure ion chamber
HPTL	High Pressure Tritium Laboratory
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
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)
LAMPFNET	Los Alamos Meson Physics Facility network
LANL	Los Alamos National Laboratory (or the Laboratory)
LDR	land disposal restrictions
LET	linear energy transfer
LLW	low-level radioactive waste
LLMW	low-level mixed waste
LTRSL	long-term regional statistical reference level
MCL	maximum contaminant level
MDA	minimum detectable amount (activity)
MDA	material disposal area
MDL	minimum detection limit
MEI	maximum exposed individual
MIDAS	Meteorological Information Dispersion Assessment System
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
NFA	no further action
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
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
NOV	Notice of Violation
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)

ORSRL	overstory regional statistical reference level
OSHA	Occupational Safety and Health Act/Administration
OU	operable unit
PA	performance assessment
PAT	purge-and-trap gas chromatography/mass spectrometry
PCB	polychlorinated biphenyl
PDL	public dose limit
PHERMEX	Pulsed High-Energy Machine
ppb	parts per billion
ppm	parts per million
P^3O	Pollution Prevention Program Office
PP	pollution prevention
PPOA	Pollution Prevention Opportunity Assessment
PRP	peer review panel
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 Spectometry
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RD&D	desearch, development, and demonstration
RFA	RCRA facility assessment
RFI	RCRA facility investigation
ROD	Record of Decision
RPS	Radiation Protection Standard (now PDL)
RSRL	regional statistical reference level
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)
SOC	synthetic organic compound
SODAR	sound, distance, and ranging
SOP	standard operating procedure
SOP	stratospheric ozone protection
SPCC	Spill Prevention Control and Countermeasures
SR	state road
SRM	standard reference material
SVOC	semivolatile organic compound

SW	solid waste
SWAT	soil, water, and air testing
SWEIS	Site-Wide Environmental Impact Statement
SWPP	Storm Water Prevention Plan
SWDA	Solid Waste Disposal Act
SWMR	solid waste management regulations
SWMU	solid waste management unit
SWSC	Sanitary Wastewater Systems Consolidation
TA	Technical Area
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
THM	trihalomethane
TLD	thermoluminescent dosimeter
TLDNET	thermoluminescent dosimeter network
TRI	toxic chemical release inventory
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSS	total suspended solids
TU	tritium unit
TWISP	Transuranic Waste Inspectable Storge Project
UC	University of California
ULB	upper limit background
URSRL	understory regional statistical reference level
USGS	United States Geological Survey
UST	underground storage tank
UV	ultraviolet
VAC	Voluntary Corrective Action
VOC	volatile organic compound
WCTF	Weapons Component Testing Facility
WETF	Weapons Engineering Tritium Facility
WIPP	Waste Isolation Pilot Project
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
Aluminum	Al
Americium	Am
Argon	Ar
Antimony	Sb
Arsenic	As
Astatine	At
Barium	Ba
Berkelium	Bk
Beryllium	Be
Bicarbonate	HCO_3
Bismuth	Bi
Boron	B
Bromine	Br
Cadmium	Cd
Calcium	Ca
Californium	Cf
Carbon	C
Cerium	Ce
Cesium	Cs
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Curium	Cm
Cyanide	CN
Carbonate	CO_3
Dysprosium	Dy
Einsteinium	Es
Erbium	Er
Europium	Eu
Fermium	Fm
Fluorine	F
Francium	Fr
Gadolinium	Gd
Gallium	Ga
Germanium	Ge
Gold	Au
Hafnium	Hf
Helium	He
Holmium	Ho
Hydrogen	H
Hydrogen oxide	H_2O
Indium	In
Iodine	I
Iridium	Ir
Iron	Fe
Krypton	Kr
Lanthanum	La
Lawrencium	Lr (Lw)
Lead	Pb
Lithium	Li
Lithium fluoride	LiF
Lutetium	Lu
Magnesium	Mg
Manganese	Mn
Mendelevium	Md
Mercury	Hg
Molybdenum	Mo
Neodymium	Nd
Neon	Ne
Neptunium	Np
Nickel	Ni
Niobium	Nb
Nitrate (as Nitrogen)	NO_3-N
Nitrite (as Nitrogen)	NO_2-N
Nitrogen	N
Nitrogen dioxide	NO_2
Nobelium	No
Osmium	Os
Oxygen	O
Palladium	Pd
Phosphaeus	P
Phosphate (as Phosphous)	PO_4-P
Platinum	Pt
Plutonium	Pu
Polonium	Po
Potassium	K
Praseodymium	Pr
Promethium	Pm
Protactinium	Pa
Radium	Ra
Radon	Rn
Rhenium	Re
Rhodium	Rh
Rubidium	Rb
Ruthenium	Ru
Samarium	Sm
Scandium	Sc
Selenium	Se
Silicon	Si
Silver	Ag
Sodium	Na
Stronium	Sr
Sulfate	SO_4
Sulfite	SO_3
Sulfur	S
Tantalum	Ta
Technetium	Tc
Tellurium	Te
Terbium	Tb
Thallium	Tl
Thorium	Th
Thulium	Tm
Tin	Sn
Titanium	Ti
Tritiated water	HTO
Tritium	^3H
Tungsten	W
Uranium	U
Vanadium	V
Xenon	Xe
Ytterbium	Yb
Yttrium	Y
Zinc	Zn
Zirconium	Zr

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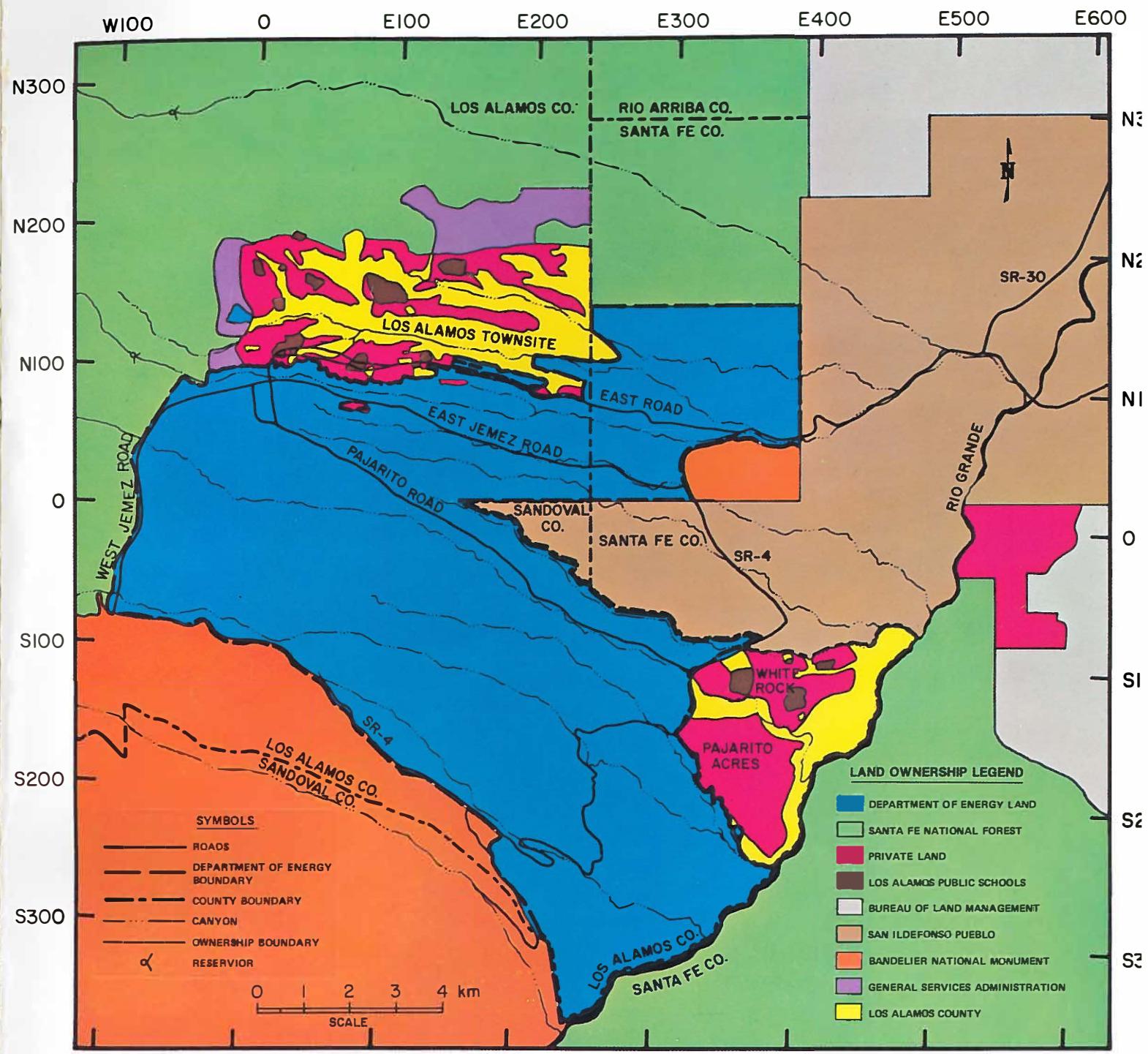

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