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Environmental Surveillance at Los Alamos during 1992

Los Alamos
NATIONAL LABORATORY

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FOREWORD

Suggestions on How to Use This Report

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

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

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

3. Scientists with Limited Interest. Read Section I, the Executive Summary, to determine the parts of the Laboratory's environmental program that interest you. Then read the summaries and technical details of these sections in the body of the report. Sections IX and X contain lists of publications issued in 1992 and references, respectively.

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

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

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F. Cultural Resources	B. Larson
G. Population Distribution	K. Jacobson
III. Compliance Summary	
A. Introduction	K. Kohen
B. Compliance Status	J. White, S. Rae, N. Williams, A. Pendergrass, P. Powers, J. Dewart, D. Stavert, M. Alexander, B. Larson, T. Foxx, R. Morales, J. McInnis
C. Current Issues and Actions	S. Rae, J. McInnis, D. Stavert, K. Hargis, J. White, K. Jacobson, K. Kohen
IV. Environmental Program Information	
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B. Measurement of External Penetrating Radiation	K. Jacobson
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ENVIRONMENTAL SURVEILLANCE AT

LOS ALAMOS DURING 1992

ENVIRONMENTAL PROTECTION GROUP

ABSTRACT

This report describes the environmental surveillance program at Los Alamos National Laboratory during 1992. 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 1992 to assess external penetrating radiation; quantities of airborne emissions and liquid effluents; concentrations of chemicals and radionuclides in ambient air, surface waters and groundwaters, municipal water supply, soils and sediments, and foodstuffs; and environmental compliance. Using comparisons with standards, regulations, and background levels, this report concludes that environmental effects from Laboratory operations are small and do not pose a demonstrable threat to the public, Laboratory employees, or the environment.

I. EXECUTIVE SUMMARY

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

The Laboratory supports an ongoing environmental surveillance program as required by DOE Orders 5400.1, "General Environmental Protection Program," and 5484.1, "Effluent and Environmental Monitoring Program Requirements." The principal focus of the surveillance program is routine monitoring for radioactive and nonradioactive pollutants on Laboratory sites and in the surrounding region. These activities document compliance with appropriate standards, identify trends, provide information for the public, document the environmental impact of Laboratory operations, and contribute to general environmental knowledge. Detailed supplemental environmental studies also are carried out to determine the extent of potential problems, to provide a basis for any remedial action, and to gather further information on the surrounding environment. The Laboratory utilizes more than 450 sampling stations for routine monitoring of the environment. Table I-1 presents the number of each type of environmental monitoring station in use in 1992. During 1992, more than 8,200 environmental samples were the subject of approximately 127,000 analyses for radioactive and nonradioactive constituents.

Estimated Doses and Risks from Radiation Exposure

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

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

Type of Monitoring	Off Site	On Site	Total
External radiation	27	139	166
Air	19	21	40[a]
Surface waters[b,c]	16	12	28
Groundwaters[b]	48	29	77
Soils	13	10	23
Sediments	30	50	80
Foodstuffs	24	22	46
Meteorology	1	6	7

[a]Includes four stations that monitor nonradioactive air only.
[b]Samples from 17 additional special surface water and groundwater stations related to the Fenton Hill Geothermal Program were also collected and analyzed as part of the monitoring program.
[c]Does not include National Pollutant Discharge Elimination System (NPDES) outfalls sampled to demonstrate regulatory compliance.

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

In CY92, the estimated maximum EDE due to Laboratory operations was 6.1 mrem, taking into account shielding by buildings (30% reduction) and occupancy (100% for residences, 25% for businesses). It is 6.1% of DOE's 100 mrem/yr PDL for all pathways. This dose resulted mostly from external radiation from short-lived, airborne emissions from a linear particle accelerator at Los Alamos Meson Physics Facility (LAMPF), as shown in Table I-2. 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 12 years. Table I-3 presents a summary of the annual EDEs attributable to 1992 Laboratory operations. The estimated maximum EDE from Laboratory operations is about 2% of the 346 mrem received from background radiation and radioactivity in Los Alamos during 1992 (Figure I-2).

The EPA-approved method of calculating EDE, which is used to demonstrate compliance with National Emissions Standards for Hazardous Air Pollutants (NESHAP) requirements, does not allow the Laboratory to take into account shielding or occupancy factors. In 1992, that EDE was 7.9 mrem, which is in compliance with EPA standards of 10 mrem/yr from the air pathway.

Risk Estimates. Estimates of the added risk of cancer were calculated to provide a perspective for comparing the significance of radiation exposures. Based on the average effective dose, incremental cancer risk to residents of Los Alamos townsite and White Rock caused by 1992 Laboratory operations was estimated to be less than 1 chance in 1,000,000 (Table I-4). This risk is compared with the 1 chance in 8,000 for cancer from natural background radiation and the 1 chance in 43,000 for cancer from medical radiation. The overall lifetime risk in the United States of contracting some form of cancer is 1 chance in 4. The lifetime risk of cancer mortality is 1 chance in 5.

Environmental Monitoring and Compliance Activities

External Penetrating Radiation Monitoring. LANL measures external penetrating radiation at 166 thermoluminescent dosimeters (TLDs) located both off and on site. Annual averages for the TLDs were generally the same in 1992 as in 1991, consistent with the variability in natural background radiation observed at the monitoring stations. No radiation measurements above background were recorded at LAMPF in CY92. The current detection limit of the TLD system is 3.0 mrem.

Table I-2. Estimate of Radiation Doses (in mrem)

Dose Source	Measured	Estimated[a]
External Penetrating Radiation from Airborne Emissions	<3[b]	5.31
Direct Penetrating Radiation	<3[b]	+
Inhalation of Airborne Emissions	0.075	0.34
Treated Effluents	0	0
Ingestion of Foodstuff	0.430	0.43
TOTAL	<3	6.08

[a]Includes building shielding and occupancy factor credits.
[b]Measured simultaneously.

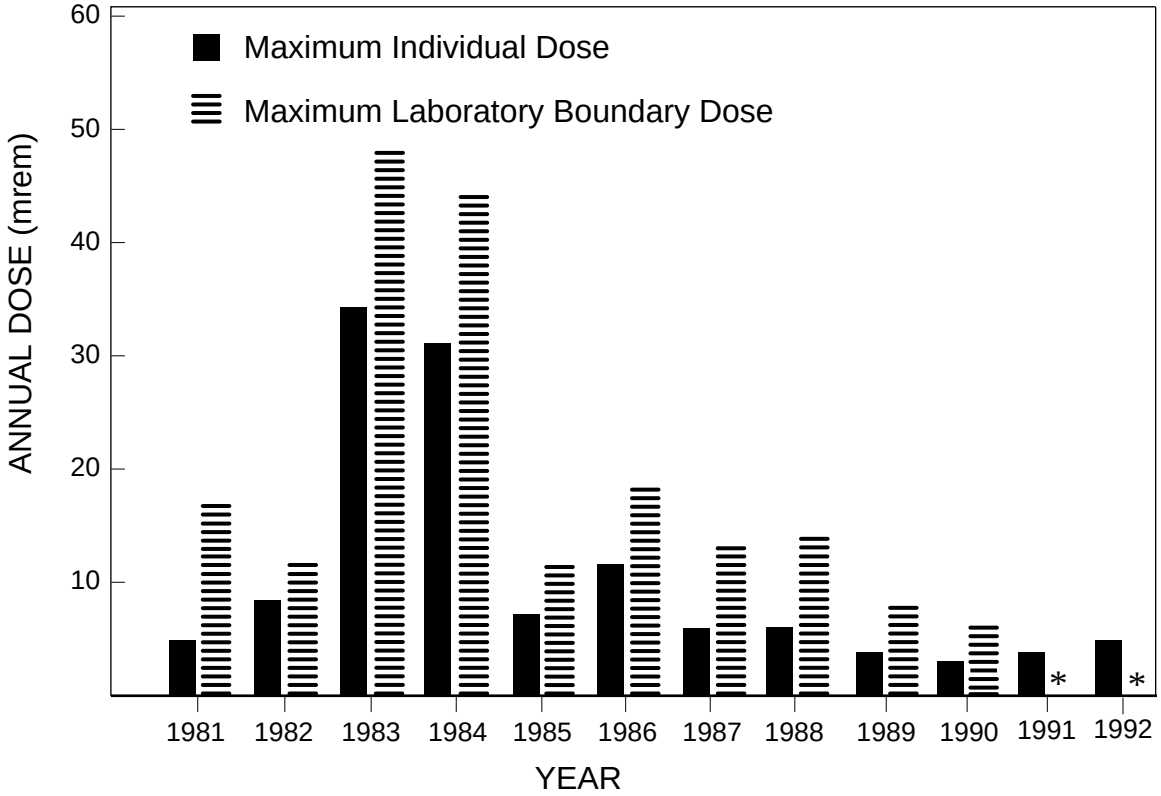


Figure I-1. Summary of estimated maximum individual and maximum Laboratory boundary doses from external penetrating radiation generated by Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources).

* No above-background Laboratory boundary doses, as measured by TLDs, were recorded during 1991 or 1992. See Section IV.B.2 for discussion.

Table I-3. Summary of Annual Effective Dose Equivalents Attributable to 1992 Laboratory Operations, Using DOE-Approved Dose Calculation Method

	Maximum Individual Dose[a]	Average Dose to Nearby Residents: Los Alamos	Average Dose to Nearby Residents: White Rock	Collective Dose to Population within 80 km of the Laboratory
Dose	6.1 mrem	0.12 mrem	0.11 mrem	1.4 person-rem
Location	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
Background	340 mrem	340 mrem	327 mrem	72,000 person-rem
DOE Public Dose Limit	100 mrem	+	+	+
Percentage of Public Dose Limit	6.1%	0.12%	0.11%	+
Percentage of Background	2%	0.04%	0.03%	0.002%

[a]Maximum individual dose is the dose to any individual at or outside the Laboratory at sites where the highest dose rate occurs (the location of the maximum exposed individual [MEI]). Calculations take into account occupancy (the fraction of time a person is actually at that location) and shielding by buildings, as allowed by the DOE- approved method for calculating PDLs.

Figure I-2. Components of the 1992 dose at LANL's maximum exposed individual location.

Table I-4. Added Individual Lifetime Cancer Mortality Risks Attributable to 1992 Radiation Exposure

Exposure Source	EDE Used in Risk Estimate (mrem)	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.12	less than 1 in 1,000,000
White Rock area	0.11	less than 1 in 1,000,000
Natural Radiation		
Cosmic, terrestrial, self-irradiation, and radon exposure[a]		
Los Alamos	340	1 in 8,000[b]
White Rock	327	1 in 8,000
Medical X Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in 43,000

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

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

Radioactive Air Monitoring. The sampling network for ambient airborne radioactivity consisted of 36 continuously operating air sampling stations in 1992. Ambient air is routinely sampled for tritium, plutonium, americium, uranium, iodine, and gross alpha and beta activity. Total radioactive airborne emissions during 1992 increased slightly from those in 1991. Tritium was the only radionuclide whose air concentrations indicated any measurable impact from radionuclide releases from Laboratory operations. Annual average concentrations of tritium continued to be much less than 0.1% of DOE's guides at all stations and posed no environmental or health problems in 1992. Annual average concentrations of all other radionuclides in air during 1992 were also much less than 0.1% of the guides. Table I-5 presents both the 1991 and 1992 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 1992, the maximum dose to a member of the public of 7.9 mrem from airborne releases was calculated using the EPA-approved computer program CAP-88. More than 95% of the modeled 1992 EDE was due to gaseous activation products released from LAMPF. Air submersion was the primary pathway of exposure (versus inhalation or ground deposition).

Table I-5. Comparison of 1991 and 1992 Releases of Radionuclides from Laboratory Operations[a]

Airborne Emissions

Radionuclide	Units	Activity Released 1991	Activity Released 1992	Ratio 1992:1991
^{3}H	Ci	4,716	1,298	0.3
^{32}P	µCi	17	9	0.5
Uranium	µCi	336[b]	242[b]	0.7
Plutonium	µCi	37	12	0.3
Gaseous mixed activation products	Ci	57,431	71,950	1.3
Mixed fission products	µCi	1,096	275	0.3
Particulate/vapor activation products	Ci	0.21	0.73	4.2
Spallation products	Ci	<0.1	<0.1	1.0
Total	Ci	62,147[c]	73,249	1.1

Liquid Effluents

Radionuclide	Activity Released (mCi) 1991	Activity Released (mCi) 1992	Ratio 1992:1991
^{3}H	10,600	10,630	1.0
$^{82,85,89,90}Sr$	124	17	0.1
^{137}Cs	67	0.5	0.01
^{234}U	0.07	0.05	0.7
$^{238,239,240}Pu$	1.3	0.7	0.5
^{241}Am	1.1	0.3	0.3
Rounded Total	10,800	10,650	0.99

[a] Detailed data are presented in Tables V-1 and V-2 for airborne emissions and Table IV-26 for liquid effluents.
[b] Does not include dynamic testing.
[c] Number presented in "Environmental Surveillance at Los Alamos during 1991" has been corrected. The activity released in 1991 due to airborne emissions (63,633 Ci) was incorrect because of an error in the addition of Ci and µCi.

EPA audited LANL's NESHAP program in August 1992. Data gathered during the audit is being used to develop a Federal Facilities Compliance Agreement (FFCA) between EPA and DOE, including a schedule for upgrading the stack monitoring program (necessitated by the Notice of Noncompliance [NON] issued in November 1991). During the audit, credit for building shielding and occupancy factors that had been used in estimating the dose to the maximum exposed individual were disallowed. A second NON was issued to DOE on November 23, 1992 because Laboratory emissions exceeded the 10 mrem/yr standard during the 1990 reporting period when this credit was removed. As a result of this second NON, DOE is required to submit monthly emissions and dose assessment reports, as specified in 40 CFR 61.94 (c).

Unplanned Airborne Releases. There were several unplanned airborne radiological releases reported during 1992, as summarized in Table I-6. 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.

Table I-6. Summary of Unplanned Radioactive Airborne Releases

Date	Location	Released Material	Amount Released	Maximum EDE [a]
March 25, 1992	TA-55	^{242}Pu	0.045 µCi	0.0001 mrem
July 31 to August 7, 1992	TA-3	^{232}Th	9.9 µCi	0.0034 mrem
September 18, 1992	TA-53	^{3}H	20 Ci	0.08 mrem
September 24, 1992	TA-53	^{3}H	20 Ci	0.04 mrem
October 29 to November 20, 1992	TA-48	G/MAP[b]	5.5 mCi	0.000087 mrem
October 30 to November 6, 1992	TA-3	^{238}U	0.6 µCi	0.000065 mrem

[a]Maximum effective dose a equivalent to a member of the public at the nearest off-site location.

[b]G/MAP = gaseous/mixed activation products.

^{72}As (0.6 mCi)
^{73}As (1.4 mCi)
^{74}As (1.1 mCi)
^{75}Se (1.8 mCi)
^{68}Ge/^{68}Ga (0.6 mCi)

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

Compliance with the Federal Clean Air Act and the New Mexico Air Quality Control Act. These acts establish ambient air quality standards, require the permits for new sources, and set acceptable emission limits. During 1992, all of the Laboratory's existing operations remained in compliance with air quality regulations for nonradioactive emissions. No unplanned airborne nonradiological releases were reported during 1992.

Surface Water and Groundwater Monitoring. The Laboratory monitors surface waters and groundwaters to detect potential or known transport of contaminants from the Laboratory. Measurable concentrations of radionuclides from Laboratory operations (primarily historical) are transported by surface water off site to Pueblo and Los Alamos canyons. The perched alluvial groundwater in off-site reaches of Pueblo and Los Alamos canyons also shows the influence of both industrial and sanitary effluents. The intermediate depth perched groundwater beneath Pueblo Canyon at two locations (Test Well 2A on county land and Test Well 1A near the eastern Laboratory boundary) shows both radioactive and chemical quality influences from historical releases. The main aquifer shows the presence of recent recharge (less than 30 to 50 yr) at one location beneath Pueblo Canyon (Test Well 1). The questions raised in past years about the potential presence of ^{137}Cs contamination in some areas were resolved in 1992. A new method of analysis was implemented during 1992 that has a much lower detection limit; all ^{137}Cs measurements from the main aquifer were less than 5% of the Derived Concentration Guides applicable to DOE Drinking Water Systems.

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

The Laboratory submitted an application for a new NPDES permit in September 1990. The Conditions of Certification for the NPDES permit required effluent limits based on water quality standards applicable to the Rio Grande rather than on water quality standards applicable to LANL's ephemeral streams. Subsequently, in October 1992, UC and DOE petitioned the New Mexico Water Quality Control Commission (NMWQCC) to review the New Mexico Environment Department's (NMED's) conditional certification of the NPDES permit limits. Settlement negotiations took place during the first quarter of 1993 that resulted in an agreement with NMED for the Laboratory to fund a study of the Laboratory's discharge receiving channels to determine their correct use designations. NPDES permit effluent limits are based on the water quality standards for each use designation. The NMED has certified the EPA's draft permit; final approval from EPA is expected by fall 1993. In CY92, the Laboratory was in compliance with the NPDES permit in 99.6% of the analyses sampled at sanitary waste discharges and 99.0% at the industrial waste discharges.

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

Compliance with the Safe Drinking Water Act. Samples are collected and analyzed from the Laboratory and Los Alamos County water distribution systems on a routine basis in order to determine the levels of microbiological organisms, organic and inorganic chemical constituents, and radioactivity in the local drinking water. During 1992, all parameters regulated under the Safe Drinking Water Act were in compliance with contaminant levels established by regulation.

Unplanned Liquid Releases. There were three unplanned radioactive liquid releases reported during 1992 that were minor in extent and were cleaned up to meet applicable standards. There were 41 unplanned nonradioactive liquid releases reported during 1992. Each of these releases was minor and was contained on Laboratory property; none was found to be of any threat to health or the environment.

Soils and Sediments Monitoring. Measurements of radioactivity and chemicals in samples of soils and sediments provide data on indirect pathways of exposure. Areas within Pueblo, Los Alamos, and Mortandad canyons all had concentrations of radioactivity in sediments at levels higher than those attributable to natural terrestrial sources or worldwide fallout. Cesium, plutonium, and strontium in Mortandad Canyon result from effluents from a liquid waste treatment plant. No run-off 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 run-off has transported some low-level contamination from the active waste disposal area and several of the inactive areas into canyons within the Laboratory boundary. Analyses of toxic metals in surface sediments in these canyons indicate that no constituents exceed EPA threshold criteria for determining hazardous waste.

Compliance with the Resource Conservation and Recovery Act *(RCRA).* This act regulates hazardous wastes from generation through disposal. The EPA has given full authority for administering the RCRA, with the exception of the ***Hazardous and Solid Waste Amendments (HSWA) of 1984***, to NMED. LANL had frequent interactions with federal and state RCRA personnel during 1992. The Laboratory is currently out of compliance with RCRA requirements related to storage of certain hazardous and mixed wastes subject to the land disposal restrictions (LDRs) because of a lack of adequate or available treatment capacity. The DOE and LANL are negotiating an FFCA on mixed waste storage and treatment subject to LDRs. NMED conducted its annual waste compliance inspection the week of May 4, 1992; this inspection resulted in the Laboratory receiving two Compliance Orders in January 1993 involving, among other matters, the management of mixed waste. Proposed fines totaled $1.6 million.

Six underground storage tanks were removed during 1992. By June 1992, the Laboratory's Environmental Restoration program submitted 9 of the required total of 24 RCRA facility investigation (RFI) work plans.

Other legislation concerning hazardous waste disposal, storage, and treatment include

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

No deficiencies or violations were found in the Laboratory's compliance with these acts.

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

In 1991, elevated levels of ^{3}H and $^{239,240}Pu$ were detected in fruit samples collected from a tree growing in the Laboratory's original site, TA-1. In 1992, the fruit from this tree was completely removed to prevent ingestion by the public; samples were collected for analysis. Although the levels were still higher than radionuclides in samples collected from other nearby fruit trees, the total EDE was less than 0.2% of the DOE's PDL of 100 mrem/yr for all pathways.

Resource Assessments. In accordance with the ***National Environmental Policy Act (NEPA) of 1969***, federal agencies must consider the environmental impacts of proposed activities. In 1992, the Laboratory's Environmental Protection group reviewed 1,067 actions proposed to be undertaken at the Laboratory. More than 75% of the proposed actions had no significant environmental, safety, or health issues and were excluded from further NEPA documentation because they were covered by categorical exclusions approved by DOE. The remaining 315 projects had possible effects on the environment and were reviewed though the ES&H Questionnaire system, which provides detailed descriptions of proposed activities.

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***

No deficiencies or violations were found in the Laboratory's compliance with these requirements.

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 to be completed by a hundred scientists, by 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory. In 1947 Los Alamos Laboratory became Los Alamos Scientific Laboratory, which in turn became Los Alamos National Laboratory (LANL or the Laboratory) in 1981.

Today, the Laboratory is a research and development (R&D) institution operated by the University of California (UC) for the Department of Energy (DOE). Managing the Laboratory since its inception in 1943, UC has maintained the tradition of free inquiry and debate that is essential to excellence in all scientific undertakings. The Laboratory's mission, which has evolved over the years in response to changes in national policy, is to apply science and technology to the nation's security and well being. The Laboratory is responsible for ensuring the feasibility, safety, and security of nuclear weapons from their early development through their retirement; the Laboratory works with production plants to ensure that designs can be manufactured and with the armed services to ensure that the weapons are safe, secure, and reliable throughout their life cycle.

The Nuclear weapons program has contributed to the Laboratory's expertise in many areas of science and technology, which in turn has enabled the Laboratory to solve complex problems of national importance where science makes a difference. Although LANL's special role in defense+particularly in nuclear weapons technology+will continue, the Laboratory is increasingly using its core technical competencies+such as nuclear technology, high-performance computing and modeling, dynamic experimentation and sensors, systems engineering and prototyping, advanced materials and processing, and beam technologies+to solve problems in the defense, civilian, and commercial sectors.

The operating cost of the Laboratory for fiscal year (FY) 92 was $1,028 million, with an additional $31 million for construction and $43 million for capital equipment. In FY92, 61% of the operating budget supported defense related activities; 13% Department of Defense projects; 23% civilian R&D, predominantly research and technology development and programs supported by the nondefense programs within DOE; and 3% was classified as Work for Others, which includes work conducted for the Nuclear Regulatory Commission, National Institutes for Health, and the National Aeronautics and Space Administration (Figure II-1). Approximately $129 million was spent on Environmental Restoration (ER), Corrective Activities (CA), and Waste Management (WM); this money represents 15% of the operating budget supported by DOE/Defense Activities.

With about 7,450 full-time-equivalent employees, the Laboratory is the largest employer in northern New Mexico. More than 3,000 of these employees are technical staff members, more than 2,000 are technicians, and the remainder are administrative and general support personnel. The Laboratory also employees more than 2,300 people in special programs and as limited term employees. In addition, more than 2,500 people are employed by contractors providing support services, protective force services, and specialized scientific and technical services.

B. Geographic Setting

The Laboratory and the associated residential areas of Los Alamos and White Rock are located in Los Alamos County, in north central New Mexico, approximately 100 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe (Figure II-2). The 111 km^2 (43 mi^2) Laboratory site and adjacent communities are situated on Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west oriented canyons cut by intermittent streams (Figure II-3). Mesa tops range in elevation from approximately 2,400 m

Figure II-1. FY92 actual operating costs by percentage of allocation to programs.

(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 Valley.

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

The Laboratory is divided into Technical Areas (TAs), which are used for building sites, experimental areas, waste disposal locations, roads, and utility rights-of-way (see Figure II-4 and Appendix C). However, these uses account for only a small part of the total land area. Most land provides isolation 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-5) 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, Otowi Tract northwest of State Road 502 near the White Rock Y and in Mortandad Canyon, are open to the public subject to restrictions protecting cultural resources.

In August 1977, the Laboratory site was dedicated as a National Environmental Research Park. 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. Park resources are available to individuals and organizations outside of the Laboratory to facilitate self-supported research on these subjects deemed compatible with the Laboratory programmatic mission (DOE 1979).

A final Environmental Impact Statement (EIS) that assessed potential cumulative environmental impacts associated with then, known future, and continuing activities at the Laboratory was completed in 1979 (DOE 1979).

Figure II-3. Topography of the Los Alamos area.

The report provided environmental input for decisions regarding continuing activities at the Laboratory. It also provided more detailed information on the environment in and around Los Alamos. DOE is planning to prepare a new site-wide EIS for the Laboratory within the next several years.

C. Geology and Hydrology

Most of the finger-like mesas in the Los Alamos area are Bandelier Tuff, ash fall, ash fall pumice, and rhyolite tuff (Figure II-6). The tuff, ranging from nonwelded to welded, is over 300 m (1,000 ft) thick in the western part of the plateau and thins to about 80 m (260 ft) eastward above the Rio Grande. It was deposited as a result of a major eruption of a volcano in the Jemez Mountains about 1.1 to 1.4 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-6) 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 extends across the Rio Grande Valley and is more than 1,000 m (3,300 ft) thick. The Laboratory is bordered on the east by the Rio Grande, within the Rio Grande Rift. Because the rift is slowly widening, the area experiences frequent but minor seismic disturbances.

Surface water in the Los Alamos area occurs primarily as ephemeral or intermittent reaches of streams. Perennial springs on the flanks of the Jemez Mountains supply base flow into upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the Laboratory site before they are depleted by evaporation, transpiration, and infiltration. Run-off from heavy thunderstorms or heavy snowmelt reaches the Rio Grande several times a year in some drainages. Effluents from sanitary sewage, industrial waste treatment plants, and cooling-tower blowdown enter some canyons at rates sufficient to maintain surface flows for varying distances.

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) perched water (a body of groundwater above an impermeable layer that separates it from the underlying main body of groundwater), and (3) the main aquifer of the Los Alamos area.

Figure II-5. Major canyons and mesas.

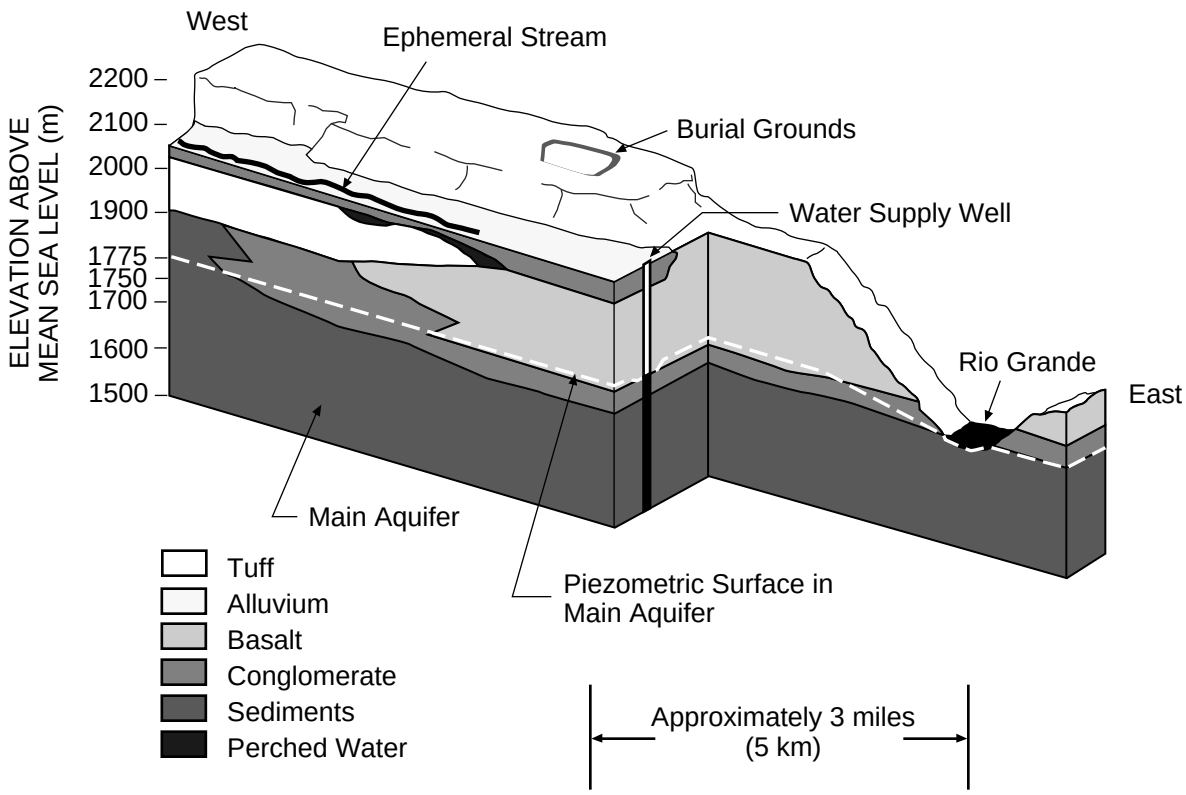


Figure II-6. Conceptual illustration of geologic and hydrologic relationship in Los Alamos area.

Ephemeral and interrupted streams have deposited alluvium that ranges from less than 1 m (3 ft) to as much as 30 m (100 ft) in thickness. Run-off 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 gradient, it is depleted by evapotranspiration and movement into underlying volcanics (Purtymun 1977). 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-6), 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 in the eastern part and along 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 throughout the Plateau. Major recharge to the main aquifer is probably from the west because the piezometric surface slopes downward to the east. The main aquifer discharges into the Rio Grande through springs in White Rock Canyon. The 18.5 km (11.5 mi) reach of the river in White Rock Canyon between Otowi Bridge and the mouth of Rito de Frijoles receives an estimated 5.3 to 6.8 + 10^6 m^3 (4,300 to 5,500 ac-ft) annually from the aquifer.

D. Climatology

Climatological averages for atmospheric state variables (temperature, pressure, and moisture) and precipitation are based on observations made at the official Los Alamos weather station from 1961 to 1991. Extremes are based on the 1911 to 1991 period. Although the location of the official weather 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 meteorological conditions described here are representative of conditions on the Pajarito Plateau at an elevation of approximately 2,250 m (7,400 ft) above sea level.

Statistics on wind do not vary significantly from year to year; it may be helpful to refer to the wind roses for 1992 (Figures II-7 and II-8) along with the following text. In these diagrams, the length of each spoke is proportional to the amount of time that the wind blew from the indicated direction; circles of a probability of 6% and 12% are shown for reference. The spoke representing each wind direction sector is partitioned into segments, and the length of each segment is proportional to percentage of time the wind speed fell within the indicated range. Unless otherwise noted, the following discussion is based on winds observed at 11 m (36 ft) above the ground. The average time for wind gusts is approximately 1 s.

Los Alamos winds are generally light, averaging 2.8 m/s (6.3 mi/h). Strong winds are most frequent during the spring when sustained winds exceeding 11 m/s (25 mi/h) with peak gusts exceeding 22 m/s (50 mi/h) are common. The highest wind gust in the record is 34.4 m/s (77 mi/h).

Winds over the plateau show considerable spatial structure and temporal variability. The semiarid climate promotes strong surface heating by day and strong radiative cooling by night. Because the terrain is very complex, heating and cooling rates are uneven over the Los Alamos area, and this results in diurnal thermally generated local flows. However, it is often difficult to explain observed winds completely in terms of the simple conceptual models of slope and valley flows.

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 1650 ft) deep. By noon, southerly flow usually prevails over the entire plateau.

At measurement sites closer to the eastern edge of the plateau, wind roses show a weak secondary peak in the daytime wind direction in the northeast sector. These northeasterlies also show up in the wind roses for observations made at 92 m (300 ft) and 510 m (1,670 ft) above the ground. They are thought to result from cold air drainage down the Rio Grande Valley that persists into the early morning hours.

The prevailing nighttime flow along the western edge of the plateau 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-3. At sites 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, with minor peaks in the distribution around northwest and northeast. At 510 m (1,673 ft) above the ground, the wind direction distribution exhibits a broad, flat peak covering the whole western half of the compass.

Atmospheric flow in the canyons is quite different than over the plateau. Data collected from Los Alamos Canyon suggest that at night a cold air drainage fills the lower portion of the canyon. The flow is steady and continues for about an hour after sunrise when it ceases abruptly and is followed by an unsteady up-canyon flow for a couple of hours. This up-canyon flow often gives way to the development of 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.

Figure II-7. Wind roses for daytime winds observed at 11 m (36 ft) above the ground at the four towers. Roses at the top of the figure are for winds at 92 m (302 ft) above the ground (from tower measurements) and 510 m (1,673 ft) above the ground (from SODAR measurements).

Figure II-8. Wind roses for nighttime winds observed at 11 m (36 ft) above the ground at the four towers. Roses at the top of the figure are for winds at 92 m (302 ft) above the ground (from tower measurements) and 510 m (1,673 ft) above the ground (from SODAR measurements).

Turbulence intensity+expressed as the standard deviation of the horizontal wind direction angle+averages 20| during the day. Other things being equal, this is a larger value than would be observed over flatter, smoother sites. Even at night, when the drainage flow is stable, the turbulence intensity generally exceeds 12|. Because the drainage layer often has a shear zone both above and below, its turbulence levels remain quite high in spite of the static stability.

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

Although the dry atmosphere promotes rapid nighttime cooling near the ground, this cooling is somewhat counterbalanced by the flow of sensible heat from above, generated by turbulence in the drainage flow. Therefore, the strong surface-based temperature inversions often observed in the valleys are not observed on the plateau. Inversions of 3|C (37|F) over 100 m (328 ft) are typical, and these are generally destroyed less than two hours after sunrise. Average atmospheric pressure at the weather station is 776 mbar (22.91 in. of mercury), which is about 76% of the standard pressure at sea level.

Monthly average values of the dew point temperature range from -9.4|C (15.0|F) in January to 8.9|C (48|F) in August, when moist subtropical air invades the region during the "monsoon" season. Fog is rare in Los Alamos, occurring on fewer than five days a year.

The average annual precipitation (rainfall plus the water-equivalent of frozen precipitation) is 47.6 cm (18.7 in.). However, the annual total is variable from year to year; the standard deviation of these fluctuations is 12.2 cm (4.8 in.), which is 25% of the mean precipitation. 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.). 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 in.) less annual precipitation than the official weather station, and the eastern flanks of the Jemez often receive 13 cm more.

About 36% of the annual precipitation falls from convective storms during July and August that are often accompanied by hail. This summertime precipitation is often referred to as the "monsoon" season. However, the signature of true monsoon circulation, namely large and persistent changes in wind and pressure patterns, is not observed in the southwest United States (Lyons 1992). Although there is a definite period of maximum summertime precipitation, a precipitation maximum is not part of the widely accepted definitions of a monsoon. Thus, "rainy season" is probably a more apt term for the months of July and August.

Winter precipitation occurs mostly as snow; freezing rain is rare. Annual snowfall averages 150 cm (59 in.). The highest recorded snowfall for one season is record 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, snowfall equal to or exceeding 2.6 cm (1 in.) will occur on 14 days, and snowfall equal to or exceeding 10.2 cm (4 in.) will occur on 4 days. The snow is generally dry; on average 20 units of snow is equivalent to 1 unit of water.

Los Alamos receives sunshine for approximately 75% of daylight hours. During the warm half of the year about 20% of this incoming solar radiation is reflected at the surface. The remaining 80%, the net short-wave energy, is the radiant energy at the land surface. Roughly half of this net short-wave energy is counterbalanced by a net loss of radiation to space. The remainder, referred to as the net all-wave energy, is dissipated by energy transfer to the ground and the lower atmosphere.

On clear days, approximately 20% of the net all-wave energy is deposited as heat in the ground, and the remainder is transferred to the atmosphere by the eddy flux of sensible and latent heat. The ratio of the sensible heat flux to latent heat flux, the Bowen ratio, is sometimes used to characterize climate; values range from 0.1 over tropical oceans to 10.0 over deserts. During the warm half of the year this ratio ranges from 0.5 to 3.0 at the TA-6 weather station. Low values occur in the early spring, when the ground is wet from snow melt and during the rainy season. High values occur when the surface is dry, usually in June | before the rains begin | and in early fall. An analysis of one year of latent heat flux data suggests that the water flux equivalent of this evapotranspiration amounts to 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 to the Jemez Mountains 20 km (12 mi) 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 on to 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 the variations in elevation and are thus confined to generally smaller habitats.

As a result of human's 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 the Laboratory's establishment created open, grassy areas on the mesas that have not yet returned to climax plant communities. These areas provide feeding areas for herbivores, especially deer and elk, and the adjacent timbered canyon slopes provide cover.

F. Cultural Resources

Approximately 60% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and close to 1,000 sites have been recorded. Over 95% 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 the preferred locations for development at the Laboratory today.

G. Population Distribution

In 1992 the estimated population of Los Alamos County was approximately 18,200 (based on the 1990 US Census, adjusted to July 1, 1992) (USBC 1991). Two residential and related commercial areas exist in the County (Figure II-2). 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 11,400. The White Rock area (including the residential areas of White Rock, La Senda, and Pajarito Acres) has about 6,800 residents. About 40% of the people employed in Los Alamos County commute from other counties. It is estimated that approximately 224,000 persons lived within an 80 km (50 mi) radius of the Laboratory in 1992 (Table II-1).

Table II-1. 1992 Population within 80 km of Los Alamos National Laboratory[a,b]

Direction	Distance from TA-53[c] (km) 1|2	2|4	4|8	8|15	15|20	20|30	30|40	40|60	60|80
N	1	0	0	0	0	0	1,169	0	378
NNE	0	0	0	582	0	558	1,781	1,850	227
NE	1	0	0	0	326	15,860	1,039	1,170	3,965
ENE	0	0	0	2,031	1,609	2,843	2,827	1,222	2,267
E	0	0	87	26	582	1,199	728	0	1,422
ESE	0	0	0	0	0	306	24,239	1,091	1,511
SE	0	0	6,796	0	0	0	56,036	2,558	8
SSE	0	0	0	0	0	0	446	4,551	99
S	0	0	0	50	0	347	670	7,363	0
SSW	0	0	0	20	0	891	219	8,981	36,507
SW	0	0	0	0	0	0	343	4,532	0
WSW	0	0	0	0	0	343	341	2,775	225
W	0	0	0	0	0	0	0	179	144
WNW	0	1,443	6,572	0	0	0	0	0	3,359
NW	0	526	1,731	0	0	0	0	1,481	0
NNW	0	581	582	0	0	0	0	65	64
1992 Pop. Distribution	2	2,550	15,768	2,709	2,517	22,347	89,838	37,818	50,176

[a]Total population within 80 km of Los Alamos National Laboratory is 223,725.
[b]Please see Figure II-2 for more information on the location of the population.
[c]Please see Figure II-4 for the location of TA-53.

III. COMPLIANCE SUMMARY

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

LANL had frequent interactions with federal and state Resource Conservation and Recovery Act (RCRA) personnel during 1992. The Laboratory cannot comply with RCRA requirements related to storage of mixed waste and certain hazardous wastes subject to land disposal restrictions (LDRs) because of the lack of adequate or available treatment capacity. A National Capacity Variance that allowed the Laboratory to store some of these wastes expired May 7, 1992. The Department of Energy (DOE) and the Environmental Protection Agency (EPA) initiated negotiations on a Federal Facilities Compliance Agreement (FFCA) on the storage and treatment of mixed waste subject to LDRs. In January 1993, the New Mexico Environment Department (NMED) proposed fines totaling $1.6 million for alleged various violations of the state's Hazardous Waste Act (NMHWA).

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

In 1992, the Laboratory was in compliance with its on-site liquid discharge requirements in 99.6% of the samples from its sanitary effluent outfalls and in 99.0% of the samples from its industrial effluent outfalls. Under an Administrative Order (AO) and an FFCA with EPA, new sanitary waste treatment facilities were under construction in 1992. Concentrations of constituents in the drinking water distribution system remained within federal and state water supply standards.

The Laboratory was in compliance with all federal nonradiological ambient air quality standards. As a result of the review of nonradiological emissions from new and modified operations, an application for a permit for beryllium machining operations at Technical Area (TA)-55-4 was submitted to and approved by NMED in 1992. In addition, three beryllium machining source registrations were submitted to NMED.

EPA standards limit the effective dose equivalent (EDE) to members of the public from Laboratory airborne radioactive emissions to less than 10 mrem/yr. The Laboratory's 1990 emissions exceeded this limit and thus were not in compliance with the standards. Consequently, the DOE received a Notice of Noncompliance (NON), and DOE and LANL began negotiating an FFCA on stack monitoring protocols. The Laboratory's 1992 emissions, however, were in compliance with the standards; the EDE was 7.9 mrem calculated using EPA-approved methods that do not take into account building shielding or occupancy.

During 1992, 1,067 actions proposed to be undertaken at the Laboratory were reviewed for National Environmental Policy Act (NEPA) applicability, and 56 DOE Environmental Checklists (DECs) were submitted to DOE. In addition, Laboratory archaeologists evaluated 987 proposed actions, which required 49 intensive field surveys, for possible effects on cultural resources. Laboratory biologists reviewed 615 proposed actions for potential impacts on threatened and endangered species; 70 actions required additional study. And finally, 615 proposed actions were reviewed for their effect on floodplains and wetlands. Seven projects may be inside floodplain or wetland boundaries; floodplain/wetland assessments are being prepared for these projects.

A. Introduction

Many of the activities and operations at the Laboratory involve or produce liquids, solids, and gases that contain radioactive and/or hazardous materials. It is the policy of the Laboratory that operations shall be performed in a manner that protects the environment and addresses compliance with applicable federal and state environmental

protection regulations. This policy is in accordance with DOE requirements to protect the public, environment, and worker health and to comply with applicable environmental laws, regulations, and orders.

Federal and state environmental requirements address handling, transport, release, and disposal of contaminants and pollutants, as well as protection of ecological, archaeological, historic, atmospheric, and aquatic resources. Regulations specify generic requirements and standards to ensure maintenance of environmental qualities.

Table III-1 presents a list of the major environmental requirements that affect the activities of the Laboratory and the principal authorities administering these requirements. Table III-2 lists the environmental permits and approvals issued and the specific operations and/or sites affected.

B. Compliance Status

1. Resource Conservation and Recovery Act.

a. Introduction. The Laboratory produces a wide variety of hazardous wastes. RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, mandates a comprehensive program to regulate hazardous wastes, from generation through disposal. A major emphasis of the amendments is to reduce hazardous waste volume and toxicity and to require treatment of hazardous waste prior to land disposal.

EPA or an authorized state agency grants RCRA permits to specifically regulate the treatment, storage, and disposal of hazardous waste and the hazardous component of radioactive mixed waste. A RCRA Part A permit application identifies (1) facility location, (2) owner and operator, (3) hazardous or mixed wastes to be managed, and (4) hazardous waste management methods. A facility that has submitted a RCRA Part A permit application is allowed to manage hazardous or mixed wastes under transitional regulations known as the Interim Status Requirements pending issuance of a RCRA Operating Permit. The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous or mixed waste management. DOE was granted a hazardous waste facility permit on November 8, 1989.

EPA granted base RCRA authorization to New Mexico on January 25, 1985, transferring regulatory control of hazardous wastes under RCRA to NMED. Implementation of state authority for hazardous waste regulation is found in the NMHWA and Hazardous Waste Management Regulations (HWMR). Although NMED has not yet obtained authorization for implementing the majority of the 1984 HSWA, HWMR follows the federal codification for regulations in effect on July 1, 1992 concerning the generation and management of hazardous waste. The State of New Mexico's Hazardous Waste Program was authorized to regulate mixed waste by the EPA on July 25, 1990. 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. A schedule for submittal of the Part B application has been transmitted to NMED. Part B permit applications were submitted for three surface impoundments in July 1991. Negotiations continue on the submittal of modifications for the interim status units.

The Laboratory is currently out of compliance with RCRA requirements related to storage of certain hazardous and mixed waste subject to the LDRs. Such wastes include solvents; dioxins/furans; California list; and the first, second, and third groups of scheduled wastes. No treatment alternative has been available for these wastes. The National Capacity Variance on storage of scheduled mixed waste expired on May 8, 1992. DOE has continued negotiations with EPA Region 6 on an FFCA to develop a schedule to bring all waste subject to LDRs into compliance.

b. Solid Waste Disposal. The TA-54, Area J landfill received 307 cu yd of solid waste in 1992. The landfill is used as a staging area for nonradioactive asbestos (approximately 595 cu yd) that is shipped off site to an approved commercial disposal site. Radioactive asbestos and asbestos suspected of being contaminated with radioactive material continue to be disposed into a monofill constructed at TA-54, Area G.

In January 1992, LANL submitted a Notice of Intent (NOI) to continue to operate LANL's industrial solid waste landfill, located at TA-54, Area J to the NMED's Solid Waste Bureau. In addition, in February 1992, LANL submitted an annual solid waste management report to NMED for LANL's TA-54, Area J landfill. LANL also disposes of sanitary solid waste and rubble at the Los Alamos County landfill on East Jemez Road, DOE property that is operated under a special use permit with the county. Los Alamos County has day-to-day operating responsibility for

Table III-1. Major Environmental Requirements under which the Laboratory Operated in 1992

Requirement	Regulatory Citation	Responsible Agency	Related Requirements
Resource Conservation and Recovery Act	RCRA, 40 CFR 260268, 270272, 280, and 281	EPA/NMED	Hazardous and Solid Waste Amendments address releases of hazardous constituents. 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 300311	EPA	Superfund Amendments and Reauthorization Act (SARA), NM Emergency Management Act
Emergency Planning and Community Right-to-Know Act	EPCRA 40 CFR 350-373	EPA	Executive Order 12856
Toxic Substances Control Act	TSCA 40 CFR 700766	EPA	
Federal Insecticide, Fungicide, and Rodenticide Act	FIFRA 40 CFR 150189	NMDA/EPA	NM Pest Control Act
Clean Water Act	CWA 40 CFR 121136 40 CFR 400424	EPA/NMED	National Pollutant Discharge Elimination System (NPDES) (40CFR122): two permits mandate specific monitoring and reporting conditions along with setting standards for effluent quality for Laboratory discharges to the environment. NM Water Quality Control Commission Regulations NM Liquid Waste Disposal Regulations NM Oil Conservation Division - Groundwater discharge plan, Fenton Hill Water Quality Standards for Interstate and Intrastate Streams in NM
Safe Drinking Water Act	SDWA 40 CFR 141148	EPA/NMED	NM Water Supply Regulations

Table III-1 (Cont.)

Legislation	Regulatory Citation	Responsible Agency	Related Legislation and Regulations
Federal Clean Air Act	CAA 40 CFR 5099	EPA/NMED	National Emission Standards for Hazardous Air Pollutants (NESHAP) for **Radionuclides** (40 CFR61, Subpart H) requires that no member of the public receive more than 10 mrem/yr (effective dose equivalent), **Asbestos** (40 CFR 61, Subpart M) requires no visible asbestos emissions to the environment, and **Beryllium** (40 CFR 61, Subpart C) requires notification, emission limits, and stack performance testing. Ambient Air Quality Standards NM Air Quality Control Regulations
National Environmental Policy Act	NEPA, 40 CFR 15001508, 10 CFR 1021	Council on Environmental Quality/DOE	
National Historic Preservation Act	NHPA 36 CFR 800	State Historic Preservation Officer	NM Cultural Properties Act Archaeological Resources Protection Act Native American Graves Preservation and Repatriation Act American Indian Religious Freedom Act (AIRFA) Antiquities Act of 1906
Endangered Species Act	50 CFR 402	U.S. Fish and Wildlife NM Game and Fish	Fish and Wildlife Coordination Act NM Wildlife Conservation Act NM Endangered Plant Species Act
Floodplain Management	Executive Order 11988	DOE	10 CFR 1022
Protection of Wetlands	Executive Order 11990	DOE	10 CFR 1022 CWA 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 1992

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA hazardous waste facility	Hazardous waste storage, treatment, and disposal	November 1989	November 1999	NMED
	Postclosure care	Application submitted September 1988		NMED
	RCRA Mixed Waste	Part A application submitted January 1991		NMED
HSWA	RCRA Corrective Activities	March 1990	December 1999	EPA
PCBs[a]	Disposal of PCBs at TA-54, Area G	June 5, 1980	–	EPA
PCB oil	Incineration of PCB oils[b]	May 21, 1979	–	EPA
NPDES[c], Los Alamos	Discharge of industrial and sanitary liquid effluents	Modified permit January 30, 1990	March 1, 1991[d]	EPA
NPDES, Fenton Hill	Discharge of industrial liquid effluents	October 15, 1979	June 30, 1983[d]	EPA
NMLWD Regulations[e]	Discharge of sanitary effluents from septic tank systems into soil	f	–	NMED
Groundwater discharge plan, Fenton Hill	Discharge to groundwater	July 9, 1990	June 5, 1995	NMOCD-g
Groundwater discharge plan, TA_46 Sanitary Wastewater Treatment Plant	Discharge to groundwater	July 20, 1992	July 20, 1997	NMED
Air Quality (NESHAP)[h]	Construction and operation of five beryllium facilities	December 26, 1985; March 19, 1986; September 8, 1987; April 26, 1989 November 25, 1992	–	NMED
Open Burning (AQCR 301)	Burning of jet fuel for ordnance testing, TA-11	August 30, 1991	After four tests	NMED
Open Burning (AQCR 301)	Burning of scrap wood from experiments, TA-36	October 10, 1991	October 10, 1992	NMED

[a]Polychlorinated biphenyls.
[b]No incineration occurred during 1992 even though the activity was permitted.
[c]National Pollutant Discharge Elimination System.
[d]Permit administratively extended while new permit is pending.
[e]New Mexico Liquid Waste Disposal Regulations.
[f]Dates vary depending on individual permits.
[g]New Mexico Oil Conservation Division.
[h]National Emission Standards for Hazardous Air Pollutants.

the landfill and is responsible for permitting this activity with the state. LANL contributed approximately 33% of the total volume disposed at this site during 1992 with the remainder contributed by Los Alamos County residents.

In 1992, Johnson Controls Inc. (JCI), the Laboratory's support services subcontractor, salvaged 151 kg (331 lb) of silver; 330,605 kg (727,330 lb) of scrap metal; 33,643 kg (74,014 lb) of lead; 12,950 kg (28,490 lb) of lead acid batteries; 8,236 gal. of waste oil; 342 tons of paper; 2,228 kg (4,902 lb) of scrap nonhazardous photographic film; and 11,982 kg (26,360 lb) of truck and automobile tires from the GSA motor pool. This effective waste minimization program conforms to RCRA Subtitle D and continues to be expanded.

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 verbal approval to proceed with closure activities was subsequently received from NMED. 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. When preliminary results of the sampling effort revealed that the criteria for clean closure had been met, the impoundments were backfilled and revegetated. However, when the final analytical results were received, it was found that the allowed sample holding times had been exceeded and that the data could not be defended as correct. The closure plan was modified to reflect the events of the field work that occurred and to include bore sampling to verify that all hazardous constituents from the area had been removed. It was determined that there were minimal amounts of contaminants left in place, but the levels of contamination did not exceed the EPA's health-based risk 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 by July 31, 1991, and were submitted to NMED in August 1991. The closure report and closure certification letters for TA-35-85 were submitted December 20, 1991. 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 for two reasons: (1) the Laboratory had failed to delineate the vertical extent of the contamination, and (2) the Laboratory had failed to demonstrate that releases from the unit to the surrounding soil or surface waters were below health-based risk levels. An amended closure plan was submitted to the state on September 4, 1992, to address these concerns. In accordance with this plan, the Laboratory and NMED split samples from Ten-Site Canyon for analysis. 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.

TA-40, Scrap Detonation Site. On September 13, 1991, NMED notified the Laboratory that the closure plan for the TA-40 Scrap Detonation Site had been approved. The plan received no comments from the public. The start date of the closure plan was September 30, 1991. This closure is proceeding behind schedule because the original closure plan did not take into account possible contamination, which was detected above action levels at several different site locations during the sampling phase. The closure plan is being amended to include risk assessments for the areas where contamination was detected above action levels.

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 before receiving an approved closure plan. After the tanks had been cleaned several times, the final decontamination was completed in August. A final closure plan report that reflected the actual closure process of these units was submitted in June 1991. An addendum to the final closure plan was submitted in July 1992. NMED approved the plan in August 1992. Soil sampling at Area L will be conducted in 1999 to demonstrate clean closure, in conjunction with the HSWA permit corrective action investigations at Area L.

TA-16, Landfill at 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 include standards to which this unit would be

subject once the Laboratory received its RCRA permit. Since that time, the Environmental Restoration (ER) Program Office has come into existence and is providing oversight of closures. The Laboratory requested an extension of the closure deadlines for this and other units that appear within the HSWA Module of the RCRA permit. An extension of the closure window would allow the ER program to incorporate the results of the RCRA facility investigation (RFI)/Corrective Measures Study into the closure process. NMED rejected this approach and indicated that it would allow an extension for evaluation of the outstanding issues, identified in the closure plan; the schedule for any investigations would have to be approved by NMED.

TA-53, Surface Impoundments. A closure plan for the 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. Sampling activities associated with this closure are scheduled to take place in late fiscal year (FY) 93.

d. Underground Storage Tanks. Six underground storage tanks (USTs) were removed in calendar year (CY) 92. Two 560 gal. USTs (TA-3-MP 3 & 4) that contained reclaimed oil and were located at TA-60 (formerly part of TA-3) were removed. These USTs were replaced with three aboveground vaulted tanks. A 3,000 gal. diesel UST (TA-59-6) was removed and replaced with a vaulted below grade tank. A 1,000 gal. diesel UST TA-50-37 was removed and replaced with a vaulted below grade tank. UST TA-35-159, with a capacity of 6,000 gal. and containing dielectric oil, was removed. This UST was not replaced. The final UST (TA-15-287) to be removed was a 15,000 gal. dielectric oil tank. It was replaced with an aboveground tank.

e. Other RCRA Activities. Areas L and G, located at TA-54 on Mesita del Buey, have been used for storage of hazardous wastes and are subject to RCRA regulation. Information on a groundwater monitoring waiver for both Areas L and G has been submitted to NMED. Vadose zone (the subsurface above the main aquifer) monitoring is being conducted quarterly throughout Areas L and G to identify any releases from the storage units. This type of monitoring is used to detect the presence of organic vapor in the vadose zone. A total of 27 monitoring systems have been installed.

Table D-1 in Appendix D, lists hazardous waste management facilities at the Laboratory. In FY89, the TA-40 scrap detonation pit used for destroying high explosive (HE) scrap was closed to waste detonation. All HE scrap is now handled at other detonation and open burning sites included in the Part A permit application. A closure plan for the TA-40 facility was submitted to NMED, approved in 1991, and implemented in 1992.

A RCRA-permitted controlled air incinerator (CAI) for treating hazardous waste is located at TA-50-37. A trial burn was conducted in October 1986. The raw data were submitted to NMED in December 1986, and a final report for the test burn was submitted on March 5, 1987. These data and the report were used to support the Laboratory's application for a hazardous waste permit for this facility. The permit was issued in November 1989. The CAI is currently closed for upgrades to improve control, reliability, and construction materials so that waste can be routinely burned. Before operations can be resumed, the Laboratory must submit a modification of the RCRA Part B permit for approval by NMED and complete NEPA documentation for the CAI.

f. RCRA Compliance Inspection. NMED conducted the annual hazardous waste compliance inspection the week of May 4, 1992 (see Table III-3). EPA officials from Region 6 and the National Enforcement Investigations Center accompanied the state during the first three days of the inspection. On January 28, 1993 LANL received two Compliance Orders (COs) from NMED. The first CO (93-03) addressed violations involving the management of mixed waste in TA-54, Area G transuranic waste (TRU) pads 1, 2, and 4 and identified four violations. CO 93-03 proposed fines of $1.28 million. Three findings of CO 93-03 alleged deficiencies that could, according to the findings, adversely affect human health and the environment if not addressed in a timely manner. DOE and LANL began negotiations with NMED in February 1993 to address the proposed fines and to develop a plan to bring the TRU pads into compliance with current RCRA storage requirements. Negotiations were ongoing during the first quarter of 1993 to reach agreement, embodied in a proposed Consent Agreement for remediation of TRU pads 1, 2, and 4.

The second CO (93-04) addressed deficiencies related to the Laboratory's general waste management requirements (e.g., satellite/less than 90 day accumulation area requirements and operating records). Twenty counts were identified in this CO; CO 93-04 proposed fines of $0.35 million. All deficiencies in this CO were corrected within 30 days, and negotiations continued on the proposed fines.

Table III-3. Environmental Inspections and Audits Conducted at the Laboratory in 1992 and the First Quarter of 1993

Date	Purpose	Performing Agency
January 29|30, 1992	Inspection of permitted beryllium machining operations	NMED
January 30, 1992	Inspection of Otowi Well #4 construction project	NMED
February 7, 1992	TA-53 waste stream characterization inspection	NMED
March 17, 1992	Spill cleanup inspection	DOE/LAAO
March 17, 1992	TSCA inspection	EPA
May 1, 1992	Annual certification inspection of pesticide applications	NMDA
May 4|8, 1992	RCRA compliance inspection of hazardous waste management activities	NMED
May 5|7, 1992	LANL canyons/water quality survey	NMED/AO
August 5, 1992	LANL canyon survey/evaluation	NMED
August 24|28, 1992	NESHAP compliance evaluation on radioactive air emissions	EPA
September 29, 1992	LANL canyon survey/evaluation	EPA
December 1992| January 1993	NPDES permit program evaluation	DOE/LAAO
February 16|26, 1993	Agreement In Principle (AIP) evaluation	NMED-AIP
April 13, 1993	Spill cleanup evaluation	NMED-AIP

g. RCRA Personnel Training. Hazardous Waste Generator Training, part of the extended General Employee Training curriculum, is required by Laboratory policy for anyone generating solid, hazardous, or radioactive waste. In 1992, 1,011 persons received training in the course. An additional course, Waste Generator for Temporary Storage, provided training to generators of hazardous waste and to workers assigned to support the hazardous waste management facilities. This training is based on the general requirements of RCRA (40 CFR Parts 262.34 and 265.16) and Appendix C of the Hazardous Waste Operating Permit. These same workers are required to attend various facility-specific training events as applicable for their job duties. In 1992, 140 Waste Management Coordinators received training in Waste Management Coordinator Fundamentals in.

h. Waste Minimization. Subtitle A of the Solid Waste Disposal Act, of which RCRA is a part, states that the generation of hazardous waste is to be reduced or eliminated as soon as possible. All hazardous waste must be handled so as to 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. Every two years the Laboratory

submits a report on waste minimization by waste streams to NMED. In 1991, minimized waste was reported for 13 streams; no report was required in 1992.

i. HSWA Compliance Activities. In 1992, its third year of operation, the ER program made significant strides. The first stage of the ER program's cleanup effort consisted primarily of meeting the planning requirements of the Laboratory's permit to operate under RCRA. These requirements include the program's Installation Work Plan, which is updated and submitted annually to EPA and RFI work plans. On November 20, 1992, LANL submitted a request for permit modification to add SWMUs identified in Module VIII of the LANL hazardous waste permit from 603 to 1,088. These additional units are being incorporated into the RFI work plans. Of a required total of 24 RFI work plans, 9 had been completed by June 1992, 10 will be submitted to EPA in 1993, and the remainder will be submitted in 1994 and 1995. In June 1992, the ER program released the first edition of its Technical Scope Baseline Summary. This 3-volume document provides basic information on the 24 operable units (OUs) to be cleaned up and on other tasks performed by the ER program.

On March 19, 1992, the first field sampling began at OU 1102 (TA-21) under the first RFI work plan approved by EPA. During the summer, additional sampling occurred at OUs 1071 (TA-0), 1078 (TA-1), 1079 (TAs-10 and 45), and 1144 (TA-49).

The ER program proposes to participate in the construction of a Mixed Waste Storage and Disposal Facility to dispose of mixed wastes generated by the remediation process. In 1992, the conceptual design report for this facility was completed and submitted to DOE. LANL met with NMED several times during 1992 to discuss development of a permit for this project. A permit application to initiate this project will be developed during the next two years.

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

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

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

Section 313 of the Emergency Planning and Community-Right-to-Know Act (EPCRA) exempts facilities not meeting certain Standard Industrial Classification (SIC) code criteria from reporting requirements. It is Laboratory policy to not exercise this exemption and to report its releases under the remaining provisions of Section 313. (Executive Order [EO] 12856 requires federal agencies to disregard the SIC code exemption when reporting under Section 313 beginning in CY94.) However, all research operations at the Laboratory are also exempt under other provisions of the regulation, and only pilot plants and specialty chemical production facilities at the Laboratory must report their releases. As a result, the Plutonium Processing Facility (TA-55) is the only operation at the Laboratory that is covered by Section 313. Nitric acid is the only regulated chemical that is used at the Plutonium Processing Facility in amounts greater than the Section 313 reporting thresholds.

A report describing the use of Section 313 chemicals must be submitted to EPA in July for the preceding CY. The Laboratory submitted the required Section 313 report to EPA in August 1992. The delay in reporting was caused by EPA's delay releasing new reporting forms. However, EPA extended the deadline for reporting to September 1, 1992 in recognition of this delay. This report covered the releases of nitric acid during 1991.

About 19,051 kg (41,912 lb) of nitric acid were used for plutonium processing with releases to the air of approximately 146 kg (320 lb). The amount of nitric acid released to the atmosphere was calculated using data obtained from a study that measured the air emissions from the facility and approved engineering techniques. The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in the wastewater treatment operations. Only the air releases in 1991 were required to be reported. Data on releases for CY92 will be reported under Section 313 in July 1993.

4. Toxic Substances Control Act.

The Toxic Substances Control Act (TSCA 15 U.S.C. 2601|2692.) is administered by the EPA, which has authority to conduct premanufacture reviews of new chemicals prior to their introduction into the marketplace. This act requires testing of chemicals that may present a significant risk to humans and the environment; establishes record keeping and reporting requirements for new information regarding adverse health and environmental effects associated with chemicals; governs the manufacture, use, storage, handling, and disposal of polychlorinated biphenyl (PCB) equipment; and sets standards for PCB spill cleanups. Because the Laboratory's activities are in the realm of research and development, the PCB regulations (40 CFR 761) have been the Laboratory's main concern under TSCA. Substances that are governed by the PCB regulations include, but are not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, paints, slurries, dredge spoils, soils, and

materials contaminated as a result of spills. Most of the provisions of the regulations apply to transformers, capacitors, and other items with PCB concentrations above a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to items whose concentrations are 50 ppm and above. At the Laboratory, equipment and materials containing greater than 500 ppm PCBs are transported off site to EPA-approved facilities for treatment and disposal and those containing 50 to 499 ppm PCBs are incinerated off site at EPA-approved facilities or disposed of at TA-54, Area G. Area G is approved by the EPA for disposal of PCB-contaminated materials.

Table III-4 summarizes the type of waste that was disposed of during 1992. Most of the waste sent off site was associated with the retrofilling or replacement of PCB transformers. The Laboratory has been retrofilling, replacing, and dechlorinating PCB-containing transformers in order to reduce environmental contamination and regulatory risks. In 1992, retrofilling activities continued for 22 transformers (expected to be reclassified to non-PCB status in FY93), 17 PCB transformers were dechlorinated, and 289 PCB capacitors, previously loaned to universities were recalled and disposed of. Also, as part of the Laboratory's PCB risk reduction program, another comprehensive survey of all potential PCB equipment at the Laboratory was initiated. Two similar surveys were conducted during the 1980s.

EPA Region 6 submitted requests for information on the Laboratory's CAI and the Area G landfill in order to continue use as PCB disposal activities. The requested information was provided to EPA. Also during 1992, DOE and EPA had several communications regarding storage of PCB waste contaminated with radioactive constituents, which cannot be disposed of within the one year storage limit required by PCB regulations. It was agreed to initiate negotiations on an FFCA to address this storage.

EPA Region 6 conducted a one day TSCA PCB inspection on March 17, 1992. No deficiencies in the program were noted at the inspection outbriefing. No audits or inspections were conducted by outside agencies during the first quarter of 1993.

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 for workers who apply pesticides. The Laboratory is also regulated by the NM Pest Control Act, administered by NMDA, which regulates pesticide use, storage, and certifications. NMDA conducts annual inspections of JCI's compliance with the act. The application, storage, disposal, and certification of these chemicals is conducted in compliance with these regulations. JCI applies pesticides under the direction of the Laboratory's Pest Control Administrator. A Laboratory Pest Control Policy, 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 application equipment. In 1992, approximately 218 kg (479 lb) of herbicides, 23 kg (51 lb) of insecticides, and 1 kg (2.7 lb) of rodenticide were applied at the Laboratory. The herbicide and insecticide usage for 1992 is summarized in Table III-5.

Table III-4. Disposal of PCBs in 1992

Off-Site Disposal in kg (lb)

Medium	50-499 ppm		>500 ppm	
Water	+		4,674.00	(10,282.80)
Oil	6,013.00	(13,228.60)	27,043.00	(59,494.60)
Soil	+		64.00	(140.80)
Debris	4,209.00	(9,259.80)	1,755.00	(3,861.00)
Retrofill fluids	+		7,523.00	(16,550.60)
Transformers	(4) 0.51	(1.12)	(17) 25,928.74	(57,043.22)
Switchgears	+		(2) 2,200.00	(4,840.00)
Capacitors	+		(80) 2,236.78	(4,920.91)
Total	10,222.51	(22,489.52)*	71,424.52	(157,133.94)*
Total off-site disposal			81,647.03	(179,623.46)*

On-Site Disposal at TA-54, Area G in kg (lb)

Medium	50-499 ppm		>500 ppm	
Soil	2,886.36	(6,349.99)	44,854.50	(98,679.90)
Debris	27.27	(59.99)	24,568.08	(54,049.77)
Miscellaneous	13.66	(30.05)	4,086.33	(8,989.92)
Total	2,927.29	(6,440.03)*	73,508.91	(161,719.60)*
Total on-site disposal			76,436.20	(168,159.64)*
PCBs disposed of in 1992:			158,083.23	(347,783.10)*

*Totals may not add due to rounding.

6. Clean Water Act.

a. National Pollutant Discharge Elimination System. The primary goal of the Clean Water Act (CWA) (33 U.S.C. 446 *et seq.*) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the National Pollutant Discharge Elimination System (NPDES) that requires permitting of all point-source effluent discharges to the nation's waters. 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.

The DOE and the University of California (UC) have two NPDES permits, one covering the effluent discharges at Los Alamos and one covering the hot dry rock geothermal facility located 50 km (30 mi) west of Los Alamos at Fenton Hill (Table III-2). Both permits are issued and enforced by EPA Region 6 in Dallas, Texas. However, NMED performs some compliance evaluation inspections and monitoring for EPA through a Section 106 water quality grant.

An application for a new NPDES permit was submitted to EPA by the Laboratory on September 4, 1990, in order to meet the 180 day submittal requirement before the old permit expired. The Laboratory's NPDES Permit No. NM0028355 expired on March 1, 1991, and is being continued under 40 CFR 122.6. On May 11, 1991, EPA issued a public notice, fact sheet, and draft NPDES permit to LANL. On August 8, 1991, the Laboratory submitted comments on the draft permit to EPA. On August 9, 1991, NMED denied certification of the draft permit. On September 4, 1991, NMED sent a letter to EPA Region 6 requesting that LANL be allowed to continue its discharge under administrative continuance of the expired permit.

Table III-5. Herbicide, Insecticide, and Rodenticide Usage during 1992

Type	Use in Kg	(lb)
Herbicide		
Velpar L	181.300	(398.860)
A-4-D	+36.350	+(79.970)
Subtotal	217.650	(478.830)*
Insecticide		
Tempo	0.179	(0.393)
Ficam W	0.045	(0.099)
Diazinon G	3.400	(7.480)
Resmitherin	1.020	(2.244)
Search-Out	0.085	(0.187)
Scotts #4	18.160	(39.952)
P.O.W.	+0.368	+(0.809)
Subtotal	23.257	(51.165*
Rodenticide		
Maki	+1.220	+(2.684)
Subtotal	1.220	(2.684)*
Total	242.127	(532.679)*

*Totals may not add due to rounding.

Between March and September 1992, EPA issued two different draft NPDES permits for public comment. During the comment periods for the draft permits, NMED informed EPA and LANL that the conditions for certification would require more stringent effluent limitations. Initially, the state applied standards based on the designated uses of stream segments No. 2-111 and No. 2-118 of the Water Quality Standards for Interstate and Intrastate Streams in New Mexico. Later, the state decided to apply the general standard that applies to existing or attainable uses of these same stream segments. As a result, NMED ultimately issued two separate conditions of certification. Table III-6 details the chronology of the steps involved in obtaining the Laboratory's permit.

The final conditions of certification of the NPDES permit required effluent limits based on water quality standards applicable to the Rio Grande, rather than on water quality standards applicable to LANL's ephemeral receiving streams. Subsequently, in October 1992, UC and DOE petitioned the New Mexico Water Quality Control Commission (NMWQCC) to review NMED's conditional certification of the NPDES permit limits. A hearing date, for presenting arguments to the NMWQCC, was set for March 1993. In January 1993, NMED and LANL requested a delay of the hearing until April 20, 1993. Settlement negotiations took place during the first quarter of 1993 and resulted in a settlement agreement with NMED for the Laboratory to fund a study of the channels that receive the Laboratory's discharges in order to determine their correct use designations. NPDES permit effluent limits are based on the water quality standards for each use designation. The NMED has certified the EPA's draft permit; final approval from EPA is expected by fall 1993.

During 1992, the Laboratory's NPDES permit for Los Alamos included 9 sanitary wastewater treatment facilities and 130 industrial outfalls. A summary of these outfalls is included in Table D-2. The NPDES permit for the geothermal facility at Fenton Hill includes only one industrial outfall. Under the Laboratory's existing NPDES permit for Los Alamos, samples are collected for analysis on a weekly basis, and results are reported each month to the EPA and NMED. During 1992, effluent limits were exceeded in one of the 266 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded in 20 of the 2,028 samples collected from the industrial outfalls. As shown in Figure III-1, overall compliance for the sanitary and industrial discharges during 1992 was 99.6% and 99.0%, respectively. Tables D-3 through D-6 present monitoring standards. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1992.

Table III-6. New NPDES Permit Chronology of Events

September 1990	LANL submits application for new permit.
October 1990	EPA issues preliminary draft permit.
March 1991	Current NPDES permit expires.
May 1991	EPA issues draft permit.
August 1991	LANL comments on draft permit.
August 1991	NMED denies certification of permit.
September 1991	NMED proposes to address standards issues.
November 1991	EPA visits Laboratory and NMED.
March 1992	EPA issues draft permit.
April 1992	NMED comments on preliminary draft permit.
May 1992	EPA issues draft permit.
July 1992	LANL comments on draft permit.
July 1992	NMED issues conditional certification.
August 1992	EPA reopens certification period.
September 1992	NMED issues new conditional certification.
October 1992	LANL appeals certification to NMWQCC.
December 1992	Hearing date set for March 2, 1993.
December 1992	NMED reply to LANL Petition for Review.
January 1993	NMED and LANL request delay until April.
January 1993	New hearing date set for April 20, 1993.
April 1993	Settlement agreement reached: NMED recertified the NPDES permit conforming to Livestock & Wildlife Watering standards and LANL withdraws its appeal.

During the first quarter of 1993, there were no violations in the 39 sanitary waste samples analyzed; effluent limits were exceeded 6 times in the 529 samples of industrial discharges. As shown in Figure III-2, overall compliance for the sanitary and industrial discharges during the first quarter of 1993 was 100% and 98.9%, respectively. There was no discharge for the industrial outfall at the geothermal facility at Fenton Hill during the first quarter of 1993.

b. Waste Stream Characterization. The Environmental Protection Group (EM-8) continued the waste stream identification and characterization (WSC) program during 1992 in order to verify that each waste stream is properly monitored under the outfall category for which it is permitted. These studies consist of dye testing, interviews with user groups, and coordinating with other Laboratory organizations so that sources, concentrations, and volumes of pollutants that enter waste streams, receive treatment, and are discharged to the environment can be determined.

Field surveys for waste stream identification and characterization have been completed for 70% of the facilities at the Laboratory. These include facilities at TAs-3, 8, 9, 11, 15, 16, 18, 22, 35, 36, 39, 40, 43, 53, 59, 61, and the TA-21 Steam Plant. Surveys are ongoing at TA-46. Action plans for implementing corrective actions for TA-16 facilities were submitted to EM-8 on March 11, 1993. These action plans include milestone dates to bring the facilities into compliance with the NPDES permit program. EM-8 has developed a WSC corrective action tracking database for tracking corrective actions and NOIs.

Figure III-2. Summary of Clean Water Act compliance in the first quarter of 1993, NPDES Permit NM0028355

c. 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, chemical storage, and equipment containing oil. Training is provided for the user group's designated Spill Coordinator on the requirements of the SPCC Plan and emergency response. The Spill Coordinator plays the major role in implementation of the SPCC Plan at the group level. During 1992, funding was allocated to various user groups for the purchase of chemical storage lockers for drum and container storage; 16 chemical lockers were purchased. In 1992 the last of 40 major secondary containment structures were completed, as discussed in Section III.C.2, Corrective Activities. The SPCC Plan began its third revision in fall 1992 and is ongoing.

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

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

As a condition of the General Permit, the facility manager for each Laboratory facility covered by the permit must prepare a Storm Water Pollution Prevention Plan (SWPPP) by April 1, 1993. EM-8 identified 76 facilities that must prepare a site-specific SWPPP. The Water Quality and Toxics section of EM-8 developed "Guidelines for Preparing a Storm Water Pollution Prevention Plan" to assist LANL facility managers in preparing these plans, which are due in 1993.

Each plan must identify potential sources of pollution that may reasonably be expected to affect the quality of storm water discharges. In addition, the plan must describe and ensure implementation of practices used to reduce the pollutants in storm water discharges at the facility and to ensure compliance with the terms and conditions of the General Permit. Discharges from SWMUs located on the facility site must be addressed. Facilities must implement the provisions in the SWPPP by October 1993.

Tables III-7 and III-8 summarize the results of the 1992 storm water sampling program and present the sampling parameters. The results of these analyses will be submitted to EPA as part of the Laboratory's NPDES permit application for storm water associated with industrial activity.

Sampling of Snowmelt Run-off in LANL Canyons. Snowmelt run-off samples and analyses establish whether or not the LANL watershed is impacted by storm water discharges associated with industrial activities. On May 5, 6, and 7, 1992, NMED and EM-8 collected water samples from spring run-off at LANL. The samples were taken from ephemeral streams within canyons that discharge from the Pajarito Plateau. The results of these analyses will be used to determine baseline concentrations of contaminants for comparison with future annual samples. Results of analyses are available from the Water Quality and Toxics section of EM-8.

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

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

Compliance samples are analyzed for organic and inorganic constituents and for radioactivity at the NM Health Department's Scientific Laboratory Division (SLD) in Albuquerque. SLD reports the analytical results directly to NMED. The JCI Environmental (JENV) laboratory also collects samples throughout the Laboratory and county

Table III-7. Storm Water Investigations, 1992

	Sites Completed	Date	Time	Rainfall (in)	Flow (L)	Storm Water Outfall
TA-9	Anchor Site East	7/17	1310-1345	0.40	+6,526	SWO-9-B[a]
TA-15	Phermex	9/15	1335-1410	0.40	+2,379	SWO-15-184-C
TA-16	Burn Grounds	7/17	1310-1338	0.35	+2,384	SWO-16-BG-A
TA-16-260	HE Machining 16-260	7/29	1305-1430	0.15	23,704-+52,361	SWO-16-260-D
TA-50 North	Liquid Waste Treatment	5/20	1245-1400	0.11	49,399-+54,393	SWO-50-IN-A
TA-54 Area G-1	Radioactive Waste Storage	6/25	1409-1453	0.40	28,547-+29,444	SWO-54-AG-1A
TA-54 Area G-1	Re-sample (Grab)	8/29				SWO-54-AG-1A
TA-55 West	Plutonium Facility West	8/04	1405-1548	0.70	27,833-152,656	SWO-55-4W-C

[a]SWO = storm water outfall

Table III-8. Parameters for Analysis, Storm Water Investigation, May|September 1992

GRAB SAMPLE PARAMETERS

Form 2F-VII Part A (Permit Application)
Oil and Grease, BOD, COD, TSS, Total Kjeldahl Nitrogen, Nitrate plus Nitrite Nitrogen, Total Phosphorus, pH

Form 2F-VII Part B (Permit Application)

Effluent Guidelines/Existing NPDES Permits
Available Free Chlorine

Form 2F-VII Part C (Permit Application)

Pollutants from Tables 2F-2, 2F-3, and 2F-4
Metals
Total Cyanide
Organics
VOA, SVOA, Pesticides, Herbicides, PCB
Radioactivity
Alpha, Beta, Total Radium, Total Radium-226

COMPOSITE SAMPLE PARAMETERS

Form 2F-VII Part A (Permit Application)
BOD, COD, TSS, Total Kjeldahl Nitrogen, Nitrate plus Nitrite Nitrogen, Total Phosphorus

Form 2F-VII Part B (Permit Application)

Effluent Guidelines/Existing NPDES Permits
Available Free Chlorine

Form 2F-VII Part C (Permit Application)

Pollutants from Tables 2F-2, 2F-3, and 2F-4
Metals
Organics
VOA, SVOA, Pesticides, Herbicides, PCB
Radioactivity
Alpha, Beta, Total Radium, Total Radium-226

distribution systems and tests them for microbiological contamination, as required under the SDWA. The JENV laboratory is certified by SLD for microbiological testing of drinking water.

During 1992, all parameters regulated under the SDWA were in compliance with the MCLs established by regulation. Summaries of the results are presented in Tables III-9 through III-15.

Each month during 1992 an average of 47 samples was collected throughout the Laboratory and county water distribution systems to determine the amount of residual free chlorine available for disinfection and the microbiological quality of the distribution systems. These samples were collected by JENV personnel and analyzed in the JENV-certified laboratory for the presence of coliform bacteria, an indicator used to determine if harmful bacteria could be present. During 1992, of the 563 samples analyzed, 3 indicated the presence of coliforms. Fifty-three of the microbiological samples (approximately 9%) collected were found to have some noncoliform bacteria present. Although the presence of noncoliform bacteria is not a violation of the SDWA, it does indicate biofilm growth in the distribution lines. Biofilm accumulation is controlled with a flushing and disinfection program. A summary of the microbiological analytical results is found in Table III-15.

Data on the parameters regulated under the SDWA are not complete for the first quarter of 1993. Data on the microbiological quality of the distribution system indicated that during the first quarter of 1993, none of the 142 samples analyzed indicated the presence of coliforms. Nine of the samples (approximately 6%) were found to have some noncoliform bacteria present.

Table III-9. Radioactivity in the Water Distribution System (pCi/L)

Location Standard for Calibration	Gross Alpha		Gross Beta	
North Community Fire Station				
^{241}Am	0.4	(0.3)[a]		
Natural uranium	0.5	(0.4)		
^{137}Cs			3.4	(0.7)
^{90}Sr, ^{90}Y			3.6	(0.7)
Los Alamos Airport				
^{241}Am	1.2	(0.5)		
Natural uranium	1.5	(0.7)		
^{137}Cs			5.1	(1.2)
^{90}Sr, ^{90}Y			5.2	(1.2)
S-Site Fire Station				
^{241}Am	0.3	(0.4)		
Natural uranium	0.4	(0.5)		
^{137}Cs			2.4	(0.8)
^{90}Sr, ^{90}Y			2.5	(0.8)
Barranca School				
^{241}Am	0.5	(0.4)		
Natural uranium	0.7	(0.5)		
^{137}Cs			2.6	(0.8)
^{90}Sr, ^{90}Y			2.7	(0.8)
White Rock Fire Station				
^{241}Am	0.7	(0.9)		
Natural uranium	0.9	(1.2)		
^{137}Cs			4.7	(1.5)
^{90}Sr, ^{90}Y			4.7	(1.5)
EPA Screening Level[b]	5.0		50.0	
EPA MCL	15.0		[c]	

[a] Uncertainties are in parentheses.
[b] See Appendix A for additional information on drinking water standards.
[c] MCL for gross beta is a dose limit of 4 mrem/yr.

Table III-10. Radon at Wellheads in 1992 (pCi/L)

Sampling Location	Radon-222 Value	
PM-1	420	(110)[a]
PM-2	1,260	(120)
PM-3	470	(110)
PM-5	730	(120)
G-1	570	(110)
G-1A	440	(110)
G-2	650	(110)
G-4	580	(110)
G-5	630	(110)
G-6	470	(110)
Proposed Maximum Contaminant Level (PMCL)	300	

[a]Uncertainties are in parentheses.

Table III-11. Total Trihalomethane Concentrations in the Water Distribution System (μg/L)

	1992 Quarters				1993 Quarters
Sampling Location	**First**	**Second**	**Third**	**Fourth**	**First**
Los Alamos Airport	0.0	[a]	4.8	1.4	1.9
White Rock Fire Station	0.0	0.0	0.6	0.6	0.0
North Community Fire Station	0.0	1.7	1.6	0.1	0.0
S-Site Fire Station	0.0	0.9	1.8	0.0	0.0
Barranca School	0.0	1.6	0.0	2.3	0.0
TA-33, Bldg. 114	2.7	7.8	10.9	13.6	5.2
MCL[b]	100.0	100.0	100.0	100.0	

[a]Insufficient sample for analysis due to laboratory error.
[b]MCL under both the SDWA and the NM Water Supply Regulations.

Table III-12. Volatile Organic Compounds at Wellheads in 1992 (µg/L)

Containment	Composite Samples A*	B*	C*	
VOC Group I				
63 Compounds	0.00 N	0.00 N	0.00 N	
VOC Group II				
1,2-Dibromoethane (EDB)	0.00 N	0.00 N	0.00 N	
1,2-Dibromo-3-chloropropane (DBCP)		0.00 N	0.00 N	0.00 N

Minimal detection limit (MDL) = 1.00 µg/L for VOC Group I.
MDL = 0.04 µg/L for VOC Group II.
++N = None detected above detection limit.

*Composite Samples A = Pajarito Mesa wells #1, 2, 3, 5
B = Guaje wells #1, 1A, 2
C = Guaje wells #4, 5, 6

Table III-13. Lead and Copper at Residential Taps in 1992

Statistic Group	Lead	Copper
Below Detection Limit	54 samples	32 samples
Above Detection Limit and Below Action Level	8 samples	32 samples
At or Above Action Level	2 samples	0 samples
Totals	64 samples	64 samples
MDL (µg/L)	5	50
90th Percentile Value (µg/L)	6	130
EPA Action Level (µg/L)	15	1,300

Table III-14. Inorganic Constituents in the Water Distribution System in 1992 (mg/L)

Sampling Location	As	Ba	Cd	Cr	F	Pb	Hg	Nitrate (as N)	Se	Ag
Los Alamos Airport	<0.005	<0.1	<0.001	<0.005	0.63	<0.005	<0.0005	0.47	<0.005	<0.001
North Community Fire Station	0.010	<0.1	<0.001	0.010	0.55	<0.005	<0.0005	0.53	<0.005	<0.001
Barranca School	0.010	<0.1	<0.001	0.010	0.55	<0.005	<0.0005	0.54	<0.005	<0.001
S-Site Fire Station	0.010	<0.1	<0.001	<0.005	0.25	<0.005	<0.0005	0.32	<0.005	<0.001
White Rock Fire Station	0.010	<0.1	<0.001	<0.005	0.29	<0.005	<0.0005	0.51	<0.005	<0.001
TA-33, Bldg. 4	<0.005	<0.1	<0.001	0.010	0.25	<0.005	<0.0005	0.37	<0.005	<0.001
MCL[a]	0.050	1.0	0.010	0.050	4.00	0.050	0.0020	10.00	0.010	0.050

[a]MCL under both the SDWA and the NM Water Supply Regulations.

Table III-15. Microbiological Sampling of the Water Distribution System

Month	No. of Samples Conducted	No. of Samples with Presence of Bacteria: Coliform[a]	No. of Samples with Presence of Bacteria: Noncoliform
1992			
January	49	1	3
February	47	0	3
March	47	0	6
April	46	0	8
May	45	0	7
June	59	2	7
July	47	0	4
August	45	0	4
September	46	0	3
October	46	0	2
November	44	0	6
December	42	0	3
1993			
January	49	0	2
February	45	0	1
March	48	0	6
MCL (5% of samples collected)		2	N/A[b]

[a]For a system that collects at least 40 samples per month, if no more than 5% of the samples collected during a month are coliform-positive, the system is in compliance with the MCL for total coliforms.
[b]N/A means analysis not performed, lost in analysis, or not completed.

8. Federal Clean Air Act and the New Mexico Air Quality Control Act.

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

+ National Emission Standards for Hazardous Air Pollutants (NESHAP);
+ National Ambient Air Quality Standards;
+ New Source Performance Standards (NSPS); and
+ Stratospheric Ozone Protection (SOP).

All of the above requirements that are applicable to LANL, except the NESHAP for radionuclides and provisions relating to SOP, have been adopted by the State of New Mexico as part of its State Implementation Plan. Therefore, all of these regulations, except the radionuclide NESHAP and SOP, are discussed in Subsection b, State Regulations.

Radionuclide NESHAP. Under 40 CFR 61, Subpart H, EPA limits the EDE to any member of the public from radioactive airborne releases from DOE facilities, including LANL, to 10 mrem/yr. For 1992, the maximum dose to a member of the public from airborne releases was calculated using the EPA-approved computer program CAP-88 to be 7.9 mrem. More than 95% of the modeled 1992 EDE was due to gaseous activation products released from the Los Alamos Meson Physics Facility (LAMPF). Air submersion was the primary pathway of exposure (versus inhalation or ground deposition).

In 1991, EPA determined that LANL did not meet the requirements of 40 CFR 61, Subpart H, and issued LANL an NON. Specific findings of the NON included deficiencies in LANL's identification and evaluation of release sources, lack of stack monitoring equipment on all point release sources, inadequate quality assurance programs, and lack of a highest effective dose calculation. All these findings have been or are being addressed; corrective actions include preparing a comprehensive inventory of point release sources, upgrading stack monitoring equipment throughout the Laboratory, establishing and implementing a quality assurance program, and submitting complete monthly and annual reports on schedule. (Additional details are available in quarterly progress reports prepared by

the Radioactive Air Emissions Management group [HS-9]). In addition, any construction or modifications undertaken at LANL that will increase airborne radioactive emissions require preconstruction approval from EPA. In 1992, 117 such projects were reviewed; only 2 of these were determined to require preconstruction approval.

EPA audited LANL's NESHAP program in August 1992. Data gathered during the audit are being used to support development of an FFCA between EPA and DOE. Building shielding factors previously used in estimating the dose to the maximum exposed individual without prior EPA approval were disallowed. These shielding factors account for the portion of time an individual spent indoors and wearing clothes. A second NON was issued to DOE on November 23, 1992, because the shielding factors were used and because Laboratory emissions exceeded the 10 mrem/yr standard during the 1990 reporting period when these factors were not used in the calculations.
As a result of the second NON, DOE is required to submit a monthly emissions and dose assessment report, as specified in 40 CFR 61.94(c). To correct the findings in the NON, LANL stated that it would no longer use shielding factors to calculate the EDE value to demonstrate compliance with the radionuclide NESHAP without prior EPA approval and instituted an emissions management plan for LAMPF to assure compliance with the standard.

Stratospheric Ozone Protection. Effective July 1, 1992, Section 608 (National Emission Reduction Program) of the Clean Air Act Amendments (CAAA) of 1990 prohibited individuals from knowingly venting ozone depleting substances (ODS) used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of air conditioning or refrigeration equipment. JCI services and maintains all refrigeration and air conditioning systems at the Laboratory in full compliance with these provisions. Final regulations have yet to be adopted with regard to the certification requirements for personnel, the type of recovery/recycling equipment, and the procedures used for recovery/recycling. However, 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.

Section 609 (Servicing of Motor Vehicle Air Conditioners) of the CAAA established standards and requirements related to recycling equipment used in 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. Letters of certification were sent to EPA from JCI on October 15, 1992 certifying that JCI uses EPA-approved recovery/recycling equipment and that only properly trained and certified technicians operate the equipment.

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

AQCR 301 - Regulation to Control Open Burning. AQCR 301 regulates the open burning of materials. Under this regulation, open burning of explosive materials is permitted when transport of these materials to other facilities may be dangerous. Provisions of this regulation allow DOE and the Laboratory to burn waste explosives and explosive-contaminated wastes. Civil defense-related research projects require open burning permits. In 1992, the Laboratory had two open burning permits: one for the open burning of jet fuel for ordnance testing at TA-11, Site K; and the other for burning explosive-contaminated wood at TA-36 (Table III-2). The Laboratory has applied for an extension of the permit issued by NMED for the burning of explosive-contaminated wood at TA-36 but has not yet received formal approval from the state.

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. Excess opacity was recorded three times in 1992 during training exercises for the operation of the backup oil fired combustion system. These incidents are discussed under the heading of AQCR 801, which allows excess emissions in the event of malfunction, start up, shutdown, or scheduled maintenance provided NMED is given proper notification.

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 68,182 kg/h (75 ton/h) capacity, is required to meet an emission limit of 16 kg (35 lb) of particulate matter per hour. A stack test of the asphalt plant in August 1992 indicated an average emission rate of 4.1 kg/h (9.1 lb/h) and a maximum rate of 4.5 kg/h (10.0 lb/h) over three tests (Kramer 1992). Although the plant is old and is not required to, it meets NSPS stack emission limits for asphalt plants (Kramer 1992).

AQCR 507 - Oil Burning Equipment - Particulate Matter. This regulation applies to an oil burning unit having a rated heat capacity greater than 250 million British Thermal Units (Btu) per hour. Oil burning equipment of this capacity must emit less than 0.03 lb/10^6 Btu of particulate. Although the Laboratory boilers utilize oil as a backup fuel, all have maximum rated heat capacities below this level; consequently, this regulation does not apply. The TA-3 Cogeneration Facility operates the three highest heat capacity boilers, each having a maximum rated heat capacity of 188 million Btu per hour.

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 for NO_2 of 0.3 lb/10^6 Btu when natural gas consumption exceeds 10^{12} Btu/yr/unit. The TA-3 power plant's boilers have the potential to operate at heat inputs that exceed the 10^{12} Btu/yr/unit, but they have not been operated beyond this limit. Therefore, these boilers have not been subject to this regulation. However, the TA-3 power plant meets the emission standard. The emission standard is equivalent to a flue gas concentration range of 146 to 253 ppm NO_2 dependent on the air to fuel burning ratio; the measured flue gas concentration of the TA-3 boilers ranged from 2 to 4 ppm NO_2 during 1992.

AQCR 605 - Oil Burning Equipment - Sulfur Dioxide. This regulation applies to oil burning equipment having a heat input greater than 10^{12} Btu/yr. Although the Laboratory utilizes oil as a backup fuel for its boilers, none utilize it at this high a rate. Therefore, this regulation did not apply during 1992 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/10^6 Btu.

AQCR 606 - Oil Burning Equipment - Nitrogen Dioxide. This regulation applies to oil burning equipment having a heat input greater than 10^{12} Btu/yr. None of the Laboratory boilers utilize oil (their backup fuel) at this rate. Therefore this regulation did not apply during 1992 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/10^6 Btu.

AQCR 702 - Permits. Provisions of AQCR 702 require permitting of 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 emission 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 1992, over 120 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 affects Bandelier National Monument's Wilderness Area. Each new or modified source at the Laboratory is reviewed to determine whether this regulation applies. However, due to the small amount of air pollution emitted by the Laboratory, DOE and the Laboratory have not yet been required to submit a permit under this regulation.

AQCR 751 - Emission Standards for Hazardous Air Pollutants. In this regulation, NMED adopts by reference all of the federal NESHAPs, except those for radionuclides and new 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 1992, 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 160 sq ft or 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 for 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. Radioactive 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 1992, JCI removed approximately 2,450 lin ft of friable pipe insulation from individual small jobs. A total of 1,680 lin ft was removed during large jobs. Small job activity accounted for 401 sq ft of friable material removed, and 596 sq ft was removed during large jobs. A total of 6,634 sq ft of unregulated material, such as vinyl

asbestos tile, transite board, siding and pipe; and asphaltic roofing materials were removed through both large and small jobs, resulting in approximately 7,556 cu ft of material for disposal. Not included is 9,851 cu ft of dirt suspected of being contaminated with asbestos removed from an area along East Jemez Road in the second quarter of 1992.

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 prior to the adoption of the federal NESHAP. NMED inspected all five permitted beryllium operations in January 1992. All operations were found to be in compliance. One permitted beryllium processing operation, TA-3-35, has not been constructed, so the permit is not active. The Laboratory received a permit for an additional beryllium processing operation at TA-55-4 on November 25, 1992. The beryllium operation was started in January 1993. Exhaust air from each of these operations passes through air pollution control equipment before it exits through a stack. A fabric filter controls emissions from TA-3-39. The other operations use high-efficiency particle-attenuation filters with efficiencies greater than 99.95% to control emissions. Source tests for the existing operations have demonstrated that all beryllium operations meet the emissions limits established by the NESHAP. The source test for the new TA-55-4 beryllium machining operation was conducted in February 1993. Emissions from this source were found to be negligible.

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 NMED either prior to or within 24 hours of the occurrence, followed by written notification within 10 days of the occurrence. Excess particulate emissions were recorded three times during 1992 by a Laboratory smoke reader. These excess emissions were recorded on November 18, 23, and 24 during testing of the oil fired boiler backup systems at the TA-3 Power Plant and steam plants at TA-16 and TA-21. The excess emissions lasted only briefly (0.5 to 4.0 hours), and NMED was notified in all instances, as per AQCR 801. New training procedures initiated in 1993 should reduce the chances of excess emissions from the testing of the oil fired backup system.

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

9. National Environmental Policy Act.

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

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

NEPA provides specific protection to areas defined as unique resources (sensitive areas). Under NEPA review, proposed projects are evaluated for possible effects on cultural resources (archaeological sites or historic buildings), in accordance with the National Historic Preservation Act of 1966 (NHPA). 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 (EOs). A proposed pro-

ject otherwise eligible for a categorical exclusion cannot be approved if it is determined these sensitive areas would be adversely affected.

b. Compliance Actions. LANL project personnel initiate NEPA reviews by completing ES&H Questionnaires, which forms the basis of DOE Environmental Checklists (DECs) that EM-8 then submits to the Los Alamos Area Office of DOE (DOE/LAAO). DOE/LAAO uses DECs for DOE/AL's requirement to prepare Environmental Checklists/Action Description Memoranda (ECL/ADMs) to assist DOE in determining the appropriate levels of NEPA documentation (categorical exclusions, EAs, or EISs) for LANL projects. During 1992, EM-8 reviewed 1,067 proposed Laboratory actions for NEPA applicability. More than 75% of them (design studies, computer installation, office modifications, road signs, etc.) had no significant environmental, safety, or health issues and were covered by umbrella categorical exclusions approved by DOE/AL. The remainder (315) had possible effects on the environment and were reviewed through the Environment, Safety, and Health (ES&H) Questionnaire system, which provides detailed descriptions of proposed activities. In 1992, EM-8 prepared 56 DECs (40 covering 1992 projects and 16 covering 1991 projects). Several related questionnaires were combined in DECs. Sixty-five 1992 projects were canceled, were determined to be covered by prior NEPA documentation, or were later determined not to require NEPA documentation for other reasons. Umbrella categorical exclusions approved by DOE covered 140 projects. Sixteen projects are on hold pending resolution of funding, scope of activities, or other issues. The remaining projects from 1992 will be documented at a later date, as appropriate.

DOE decisions were still pending on six DECs submitted during 1992 and five submitted in the first quarter of 1993. Of the DECs submitted to DOE for decisions in 1992, 40 were categorically excluded from additional NEPA documentation; EAs were required for five actions. Of the six EAs pending DOE decisions at the end of 1991, FONSIs were signed for three, and two were still in review or revision at the end of 1992. In addition, the requirement for an EA for one project was withdrawn. This information is summarized in Table III-16. Copies of the final EAs and FONSIs are available to the public through DOE/LAAO.

In the first quarter of 1993, EM-8 reviewed an additional 217 projects of which 73% were covered by umbrella categorical exclusions. Sixty of these projects were reviewed through ES&H questionnaires (27 of these questionnaires were covered by umbrella categorical exclusions; 10 were canceled or were found to have prior NEPA documentation). Four DECs were submitted to DOE (one received a categorical exclusion; three are pending NEPA determinations). The other 19 are in preparation or on hold pending further information. One EA that had been in preparation at the end of 1992 was submitted to DOE for review in the first quarter of 1993.

Also in the first quarter of 1993, nine DECs for project reviews from prior years were submitted for DOE review. One proposed action was categorically excluded; DOE determinations on the others are still pending. Of the DEC determinations pending at the end of 1992, three projects received categorical exclusions during the first quarter of 1993, and DOE determined that one required preparation of an EA.

c. Types of Activities Reviewed. Determinations by DOE for umbrella categorical exclusions covered ES&H Questionnaires for the following actions in 1992 and the first quarter of 1993

+ routine maintenance (75/7);
+ relocations of portable buildings (3/0);
+ environmental and safety improvements (37/13);

Table III-16. Status of Environmental Assessments in 1992 and First Quarter 1993

Environmental Assessments that Received Findings of No Significant Impact (FONSI) during 1992	Sorbent Reactivity Study[a] Advanced Free Electron Laser Scintillation Vial Crusher Relocation of Superconducting Ceramics, Mechanical Characterization, and Filament-Winding Operations
Environmental Assessments Submitted to DOE or in Revision during 1992	TRU Waste Compactor and Drum Storage Facility[b] Expansion of TA-54, Area G Decommission of TA-33, Building 86 LLW Drum Staging Facility Hazardous Waste Treatment Facility New Production Reactor Safety Center[c] High Explosive Material Test Facility[d]
Environmental Assessments in Preparation	Controlled Air Incinerator LA/NTS Explosive Pulsed Power Experiment (SCYLLA) Uranium Oxide Reduction Environmental Analytical Chemistry Facility New Sanitary Landfill Isotope Separator Building Weapons Component Testing Facility[b] Accelerator Prototype Lab[b] CMR Upgrades - Phase II[b] C-H TRU Waste - Source Term Test Program[b] Medical Radioisotope Production[e] Restart of Plutonium-Beryllium Recovery Process[e]

[a] Requirement for EA withdrawn; categorical exclusion issued.
[b] EAs required by DOE in 1992.
[c] EA completed but project canceled.
[d] EA in preparation at the end of 1992; submitted to DOE in first quarter of 1993.
[e] EAs required by DOE in first quarter of 1993.

+ construction and modification of support structures (13/4);
+ asbestos removals (5/0);
+ PCB removal (1/0);
+ installations of instrumentation (3/1); and
+ improvements in work place habitability (3/1).

DECs submitted during 1992 and the first quarter of 1993 can be categorized according to type of proposed action as follows

+ decontamination and decommissioning projects (6/0);
+ bench-scale, pilot-scale, and outdoor research (24/7);
+ waste management and environmental restoration (8/0);
+ environmental and safety improvements (4/2);
+ construction and facility modification projects (12/3);
+ new or modified processes (2/0); and
+ emergency actions and repairs (0/1).

10. National Historic Preservation Act.

As required by Section 106 of the NHPA, Laboratory activities are evaluated in consultation with the State Historic Preservation Officer (SHPO) for possible effects on cultural resources. During 1992, Laboratory archaeologists evaluated 987 actions, which resulted in 49 intensive field surveys.

Although only 12 of the 49 field surveys were conducted for the ER program, these 12 surveys covered approximately 6,000 acres of land managed by the DOE, Forest Service, GSA, and local Indian pueblos. A total of 218 new archaeological sites were recorded, and the site records were updated for 123 previously recorded sites. Nine cultural resource surveys were submitted to SHPO for review and concurrence. Two archaeological sites were tested in advance of a proposed pipeline construction project. The excavation of an Anasazi pueblo ruin at TA-54 was completed.

In the first quarter of 1993, EM-8 reviewed 174 Laboratory actions for possible effects to cultural resources and continued ongoing field surveys. One revised cultural resource survey report was submitted to the SHPO for review and concurrence.

11. Endangered, Threatened, and Protected Species.

DOE and the Laboratory must comply with the Endangered Species Act, the Fish and Wildlife Coordination Act, NM Wildlife Conservation Act, and the NM Endangered Plant Species Act. During 1992, EM-8 reviewed 615 proposed Laboratory actions for their potential impact on threatened and endangered species. Of these, 315 proposed actions were identified through the ES&H Questionnaire system. The Biological Resource Evaluations Team (BRET) of EM-8 determined that 45 projects required reconnaissance surveys (Level I surveys). These surveys evaluate the degree of previous development or disturbance at the site and ascertain if there are any surface waters or floodplains in the area. BRET also determined that 16 projects required quantitative surveys (Level II surveys) to look for habitat types that may support threatened or endangered species. In addition, BRET concluded that nine projects (Table III-17) required intensive surveys designed to determine the presence or absence of threatened or endangered species (Level III survey). The Laboratory adhered to protocols and permit requirements of the NM State Game and Fish Department.

To identify projects requiring a survey, BRET first reviewed a database of habitat requirements for endangered, threatened, and candidate species. After the surveys were completed, BRET compared the habitat characteristics of sites to the habitat requirements of the species in question. BRET is preparing biological evaluations for projects requiring a Level II or Level III survey, and will consult with the US Fish and Wildlife for written concurrence of findings, as required under the Endangered Species Act.

BRET did not find any species protected at the state or federal level within any project sites surveyed in 1992. However, highly suitable habitat exists for many of these species (e.g., goshawk, Jemez Mountains salamander, meadow jumping mouse) within some project sites.

During the first quarter of 1993, EM-8 reviewed 112 proposed Laboratory actions for potential impact on threatened or endangered species. Of these, 15 projects were identified that required Level I surveys, 3 projects needed Level II surveys, and 1 project required a Level III survey.

12. Floodplain/Wetland Protection.

Los Alamos National Laboratory must comply with EO 11988, Floodplain Management, and EO 11990, Protection of Wetlands (EPA 1989a). During 1992, 615 proposed Laboratory actions were reviewed for impact to floodplains and wetlands. Seven projects reviewed in 1992 may be located within floodplain or wetland boundaries. Floodplain/Wetland Assessments are being prepared for these projects. None of the seven proposed projects will affect a wetland area greater than one acre, and all affected wetlands were artificially created from Laboratory effluents. In compliance with 10 CFR 1022, a Floodplain/Wetland Notice of Involvement and Statement of Findings for these projects will be submitted to the DOE for publication in the Federal Register.

During the first quarter of 1993, 112 proposed actions were reviewed for impact to floodplains and wetlands. All projects reviewed during this quarter were to be located outside floodplain or wetland boundaries.

Table III-17. Projects Identified in 1992 which Require a Species-Specific Survey

Project Name	Species Surveyed
RCRA Mixed Waste Disposal Facility, TA-67	Goshawk[a]
ISF Gas line Replacement, Townsite Portion Western Area and extends 3.0 miles east of county	Jemez Mountains salamander
Site Characterization, OU 1182, TA-11, 13, 16, 24, 25, 28, & 37	Goshawk[a]
Site Characterization, OU 1086, TA-15	Goshawk[a]
Site Characterization, OU 1093, TA-18, 27, and 65	Meadow jumping mouse Spotted bat
Site Characterization, OU 1098, TA-2, 41	Meadow jumping mouse Jemez Mountains salamander
Site Characterization, OU 1111, TA-6, 7, 22, 40, 58, and 62	Meadow jumping mouse Jemez Mountains salamander
Site Characterization, OU 1114, TA-3, 30, 59, 60, 61, and 64	Goshawk[a]
Site Characterization, OU 1157, TA-8, 9, 23, and 69	Goshawk[a] Spotted bat

[a]Goshawk surveys will be conducted in June 1993.

C. Current Issues and Actions

1. Compliance Agreements.

a. Mixed Waste FFCA. On May 13, 1992, DOE notified EPA that it was storing certain mixed waste that was not in compliance with the storage prohibition of the land disposal restrictions under RCRA. An FFCA is being negotiated by DOE, with input from the Laboratory, with the EPA. With a few very specific exceptions, operations at the Laboratory which generate mixed waste have been suspended since May 1992 pending execution of this FFCA. The Laboratory's then Associate Director for Operations established a procedure for granting waivers from the suspension of operations that generate mixed waste if an operation is related to ES&H or if appropriate waste treatment can be demonstrated.

b. NMED COs for Hazardous Waste Operations. In January 1993, NMED issued two COs against the Laboratory alleging various violations of the NMHWA. The COs proposed fines totaling $1.6 million. In addition to other requirements, the COs seek to require the Laboratory to develop a plan and schedule to store wastes from TA-54, Area G, pads 1, 2, and 4 in compliance with RCRA and the NMHWA. DOE and the Laboratory negotiated a compliance agreement with NMED to resolve these matters.

c. NPDES FFCA and Administrative Order. On July 23, 1992, EPA Region 6 served an Administrative Order (AO), Docket No. VI-92-1306 on UC that listed 20 violations of the Laboratory's NPDES permit between April 1991 to March 1992. The AO also stated that LANL had failed to comply with the specified compliance schedule and/or for AO, Docket No. VI-91-1329 outfalls 02A-007, 04S, 05S, 09S, 10S, and 12S. The AO included a revised compliance schedule and interim effluent limits for outfalls 02A-007, 04S, 05S, 09S, 10S, and 12S. All sanitary discharges are scheduled to be in compliance with the NPDES permit limits by January 1993. The AO also established interim limits and incorporated the requested changes to the schedules for the WSC surveys by specifying that they must be completed for each TA rather than on an outfall-by-outfall basis. Final completion dates for the WSC surveys remain the same.

In March 1993, EPA sent a draft FFCA, Docket No. VI-92-1305, to DOE that eliminated the discrepancies between UC's current AO and the previous FFCA (Docket No. VI-91-1328). The FFCA is currently being reviewed by DOE and UC. The FFCA contains the compliance schedule for outfalls 09S and 05A and interim effluent discharge limits for outfall 09S reflecting design and construction milestone dates. Completion of outfall 05A's design, construction, and compliance with final permit limits is expected by October 1996. Outfall 09S was in compliance with final limits by January 1993. The current and proposed schedules for completing projects required under the AO and FFCA are presented in Table D-7.

d. NESHAP FFCA. The radioactive air emissions at the Laboratory have been evaluated against DOE/EH-0173T, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance, and 40 CFR Part 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities. Based on off-site environmental monitoring results and on doses calculated from measured stack emissions, the off-site doses for 1992 were less than 10 mrem/yr which is the standard given in 40 CFR 61.92.

DOE is currently negotiating an FFCA with EPA Region 6 that will include schedules for the Laboratory to follow to come into compliance with radioactive stack monitoring requirements. A draft FFCA was initially submitted by DOE/LAAO to EPA on March 12, 1992; the FFCA has not yet been finalized.

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

The Agreement provides for access by NMED personnel to the four DOE facilities and for office space for NMED personnel on site at the Laboratory. During 1992, three to four NMED personnel were on site, and it is expected that this will increase to six or seven during the next year.

During 1992, NMED reviewed the routine environmental monitoring programs conducted at the Laboratory and also participated in some types of sampling. This included collecting splits of both surface water and groundwater samples from some locations on site and groundwater from springs along the Rio Grande in White Rock Canyon. NMED personnel also initiated reviews of work plans developed for submittal to the EPA under the Laboratory's ER program. A report on the reviews of the routine environmental monitoring program are expected during 1993.

2. Corrective Activities.

The Corrective Activities (CA) Program is managed by EM-8 personnel under guidance from DOE/EM-30. Funding is provided through the Five-Year Plan, a planning process in which waste management activities are identified and budgeted for. The CA Program includes those activities designed to bring active or standby facilities into compliance with ambient air, water, and solid waste regulations and/or agreements.

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

+ *High Explosive Wastewater Treatment System.* This project consists of two HE wastewater treatment facilities and a collection piping system to transfer HE-contaminated fluids from existing building sumps to treatment facilities. Conceptual design for the facility was completed in 1992; construction is planned for FY96. Upgrading the HE wastewater facilities is required under the Laboratory's NPDES FFCA and AO. An EA was started in 1992 and is expected to be completed in 1993. EM-7 provides project management.
+ *Sanitary Wastewater System Consolidation (SWSC) Project.* The SWSC Project was completed in 1992 and eliminated eight of the Laboratory's nine sanitary treatment facilities that had deteriorated and were in need of upgrades. The start up of the SWSC Plant began in August 1992. All collection lines and lift stations were completed in November 1992. Also, the Laboratory met all FFCA and AO requirements by November.
+ *Water Supply and Cross Connection Controls (CCC) Survey.* A survey of approximately 220 Laboratory buildings for cross connections was completed in 1992. The survey identified and corrected 40 absent or improper water supply controls and corrected approximately 60 potential cross connections. The CCC Survey will continue in 1993.

+ *TA-53 Sanitary Lagoons Elimination Project.* In 1992, approximately 60% of the TA-53 Sanitary Lagoons Elimination Project was completed, as required by the current AO. The project involves closing out the sanitary lagoons at TA-53, in part by rerouting the sanitary waste to the new SWSC Plant. The project is expected to be completed in 1993.
+ *PCB Transformers and Capacitors.* This project consists of replacing and retrofilling PCB-contaminated transformers and disposal of PCB-contaminated capacitors and other equipment. This is an ongoing activity and is required to ensure compliance with the TSCA.
+ *Waste Stream Characterization (WSC) Survey.* This survey of all Laboratory buildings is being conducted in order to identify and eliminate noncomplying wastewater discharges and to comply with NPDES permitting requirements. At the end of 1992, approximately 75% of all Laboratory facilities had been surveyed. WSC work will continue into 1993.

Several other Corrective Activities projects are designed to achieve compliance with the CWA NPDES permit and the FFCA and AO requirements for effluent discharges. This work includes improvements to prevent wastewater overflows and releases, upgrades to septic tank systems, and implementation of SPCC Plan requirements. In 1992, the last of 40 major secondary containment structures was completed. ("Major structures" are greater than 660 gal. aboveground storage tanks.) All known major outdoor storage tanks are now equipped with secondary containment to prevent spills.

3. Emergency Planning

In accordance with DOE Orders in the 5500 series, the Laboratory's policy is to develop and maintain an emergency management system that, through emergency planning, emergency preparedness, and effective response capabilities, is capable of responding to and mitigating the potential consequences of emergencies. The Laboratory's Emergency Management Plan incorporates in one document a description of the entire process designed to plan for, respond to, and mitigate the potential consequences of an emergency.

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 TAs-16, 35, 53, and 54. All but the demonstration at TA-53 have been provided to the state's Hazardous Waste Program for review.

5. Significant Accomplishments.

In 1992, its third year of operation, the ER program made significant strides toward becoming a cohesive organization whose many parts interacted more smoothly to improve product quality. The organizational infrastructure has been improved with the result that several operations whose accomplishments were previously described as poor to average are now considered outstanding by DOE and Laboratory management. Continuous quality improvement in the ER program is well under way.

In 1992, several significant achievements were made by EM-8 personnel in the PCB program, including

+ applications to obtain PCB disposal approvals for the TA-54, Area G landfill and the CAI were submitted to EPA for approval;
+ the necessary submittals were prepared and coordinated to obtain a liner exemption for burial of solid PCB waste to TA-54, Area G;
+ a new survey of PCB-contaminated equipment at the Laboratory was initiated;
+ 17 PCB-contaminated transformers and substations were replaced;
+ 2 PCB-contaminated transformers (>500 ppm PCB-oil) were dechlorinated;
+ 18 high-risk PCB-contaminated transformers were dechlorinated;
+ 289 PCB-contaminated capacitors previously loaned to universities were recalled and disposed of;

+ 93 buildings and transportables at 5 Laboratory sites were surveyed. From the survey, 149 PCB-contaminated capacitors were found and added to the inventory. In addition, over 270 oil and swipe samples were submitted for PCB analysis, and retrofilling or maintenance activities on 22 PCB-contaminated transformers were continued so they could be reclassified to non-PCB status in FY93.

The Water Quality and Toxics section of EM-8 continued its program 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 an opportunity to achieve compliance with its NPDES permit under the current AO.

In May 1992, the Laboratory established the Radioactive Air Emissions Management (RAEM) Program (HS-9) to ensure that reliable data are collected from Laboratory stacks and to take a proactive approach in controlling the Laboratory's radioactive air emissions. The RAEM Program manages and coordinates efforts to control radioactive air emissions. The functions of the program are to:

+ establish criteria to assess data reliability;
+ provide technical guidance and support to Laboratory operations that emit radionuclides;
+ coordinate Laboratory activities to ensure that all Laboratory operations are in full compliance with EPA regulations for radioactive air emissions;
+ develop and implement new methods and systems to reduce radioactive air emissions to as low as reasonably achievable; and
+ serve as the Laboratory's point of contact with EPA and DOE for issues concerning radioactive air emissions.

During 1992, DECs were prepared to cover many routine activities at LANL, including routine maintenance; environmental and safety improvements; construction, modification, and operation of support structures; PCB removals; asbestos removals; improvements in work place habitability; installation of instrumentation; and relocation of portable structures. DOE categorically excluded these actions from the need for further NEPA documentation in 1992. The Laboratory was able to apply the categorical exclusion to 844 proposed activities without preparing detailed documentation on each project. EM-8 also prepared three DECs that described bench-scale and pilot-scale research for CLS-1, CLS-6, and INC-11. DOE's categorical exclusions allow experiments to proceed and be modified as long as they remain within the boundary conditions described in the DECs without preparing additional NEPA documents.

6. Significant Problems.

a. Lawsuits. In 1991, a lawsuit, Lujan v. Regents of the University of California, was filed against the Laboratory. Plaintiffs claim that they were injured by exposure to discharges and emissions of radioactive and hazardous materials from past operations of the Laboratory. Plaintiffs are seeking compensatory and punitive damages, as well as injunctive relief against certain ongoing operations of the Laboratory.

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

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

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

The case of United States of America and Regents of the University of California v. State of New Mexico involved three conditions the NMED placed on the Laboratory's RCRA permit for the CAI. The Laboratory and DOE believed these conditions improperly regulated radioactive emissions and therefore fell outside NMED jurisdiction. In August 1992, a federal District Court ruled in favor of NMED. The US Department of Justice has appealed the ruling on behalf of DOE. The Laboratory did not join in the appeal.

b. Other Legal Actions. On March 31, 1992, DOE and UC were notified that Concerned Citizens for Nuclear Safety intend to file a citizen suit pursuant to Section 7604 of the Clean Air Act (CAA). According to the notice letter, the suit will allege, among other things, that the Laboratory is not in compliance with the monitoring requirements for radionuclides found in 40 CFR, Part 61, Subpart H and will ask for an injunction against continued operation of all sources. Nothing further happened on this notice during CY92 or the first quarter of 1993.

The Laboratory is negotiating three FFCAs, one for noncompliance with the mixed waste storage provisions of RCRA, one for the NPDES permit, and one for the radioactive NESHAP. The second two FFCAs will be modeled on the mixed waste FFCA and will be delayed until that agreement has been finalized.

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

+ LANL, by using a shielding factor that reduces its calculated emission level by approximately 30%, is using "other procedures" without prior approval of EPA and is in violation of 40 CFR 61.93 (a).
+ In 1990, LANL used this shielding factor to calculate emissions of radionuclides to the ambient air. As calculated using the specified methodology (without the shielding factor), an EDE of 11.5 mrem/yr may have been received by a member of the public, thereby violating 40 CFR 61.92.
+ Because LANL violated the emission limits for CY90, it must immediately comply with the 40 CFR 61.94 and
  (1) report on a monthly basis all the information required by 40 CFR 61.94 (b);
  (2) continue this monthly reporting until the requirement is either modified or ended by the Director of the Air, Pesticides, and Toxics Division, EPA Region 6; and
  (3) include in each monthly report the additional information described in 40 CFR 61.94 (c)(1) and (2).

The Laboratory identified a beryllium cutting operation at TA-55-4 in August 1991 for which a permit may be required under AQCR 702 - Permits. Beryllium cutting operations were suspended at this site by the Laboratory. NMED issued an Notice of Violation (NOV) for the beryllium cutting operation on October 16, 1991. The Laboratory submitted a permit and received NMED approval for beryllium operations at TA-55-4 on November 25, 1991. The Laboratory and DOE are negotiating the specific provisions of the NOV settlement with NMED. The last official correspondence on the subject of the NOV, which reviewed the regulatory history of the beryllium NESHAP, was sent to NMED on September 11, 1992.

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 as well as to assess conformance with applicable regulations and 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 environmental program deficiencies.

+ inadequate site-wide programs for the management of wastes;
+ inadequate identification, monitoring, and control of effluent releases;
+ inadequate regulatory permit strategy and management; and
+ lack of oversight of 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 has prepared action plans to address all of the environmental deficiencies identified by the Tiger Team. These plans were submitted to DOE for review and approval on March 31, 1992. The Tiger Team Corrective Action Plan was signed by the Secretary of Energy on October 28, 1992.

Of the 49 action plans for which the Laboratory's EM Division is responsible, 29 are in the high priority group, and 20 are of low priority. These 49 action plans address 90 individual Tiger Team findings for which the Division has primary responsibility. In the EM Division, detailed Work Breakdown Structures are being applied in a project-managed approach to this effort. As of March 31, 1993, completion reports had been filed for 14 of the 90 findings. Work is well underway on many of the remaining findings, the last of which is expected to be resolved in the year 2002.

8. DOE/HQ Audits and Assessments.

The DOE Albuquerque Field Office prepares an Annual Management Performance Appraisal Report of Los Alamos at the end of each fiscal year. The FY92 report was generally complimentary about the Laboratory's significant improvement over the past years, and specifically mentioned the excellence of the ER program. The report identified deficiencies in the Laboratory's waste management program, which was determined to need significant improvement in senior management support, line management leadership, and effective management and technical 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.

During 1992, the average levels of external penetrating radiation (including x and gamma rays and charged-particle contributions from cosmic, terrestrial, and manmade sources) were generally the same as in 1991, showing no statistically discernible increase in radiation levels attributable to Laboratory operations.

Air is sampled for tritium, plutonium, americium, uranium, and iodine; the highest measured annual average concentrations all corresponded to less than 0.3% of the Department of Energy's (DOE's) public dose limits (PDLs).

Surface water, soils, and sediments were sampled and analyzed so that the impact of Laboratory operations could be monitored. Surface waters and shallow alluvial groundwaters in present and former radioactive liquid effluent areas contain radioactivity in concentrations greater than natural terrestrial and worldwide fallout levels; nonradioactive constituents are also present in greater concentrations in the effluent areas than in natural waters. Radionuclides and chemical concentrations in waters from areas where there has been no direct release of treated effluents showed no observable effects of Laboratory operations. Most regional and perimeter soil and sediment stations contained radioactivity at or near background levels; concentrations of plutonium in sediments from regional reservoirs on the Rio Chama and Rio Grande reflected worldwide fallout. During 1992, all drinking water samples were in compliance with the maximum contaminant levels established by regulation.

Concentrations of radionuclides in foodstuffs (produce, honey, and fish) collected from on-site Laboratory areas were compared with levels in samples collected from off-site (perimeter and regional [background]) locations to determine the impact of Laboratory operations. With the exception of tritium, radionuclides in produce collected on site were within background concentrations. Fish from Cochiti Reservoir (downstream from the Laboratory) had slightly higher levels of uranium than fish from Abiquiu Reservoir (upstream of Laboratory operations).

In addition to environmental surveillance activities, the Laboratory carried out a number of special studies during 1992, which provide valuable supplementary environmental information.

A. Introduction

The Laboratory supports an ongoing environmental surveillance program as required by Department of Energy (DOE) Orders 5400.1 (DOE 1988a) and 5484.1 (DOE 1990a). The surveillance program includes routine monitoring of radioactive and nonradioactive pollutants in environmental media (air, water, soil, etc.) on the Laboratory site and in the surrounding region. These activities document compliance with appropriate standards, identify trends, provide information for the public, and contribute to general environmental knowledge. Detailed, supplemental environmental studies also are carried out to determine the extent of potential problems, to provide a basis for any remedial actions, and to gather additional information on the surrounding environment.

The monitoring program supports the Laboratory's policy to protect the public, employees, and the environment from harm that could be caused by Laboratory activities and to reduce environmental impact as much as practicable.

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

+ **Off-site** locations include
  Regional stations are located within the five counties surrounding Los Alamos County (Figure II-2) at distances up to 80 km (50 mi) from the Laboratory. They provide a basis for determining conditions beyond the range of potential influence from normal Laboratory operations.

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

The general location of all monitoring stations is presented in maps in the text. For off-site perimeter and on-site stations, specific location coordinates are presented in Appendix D. The specific location of most of these stations is also available on the Facility for Information Management, Analysis, and Display (FIMAD) computer system at the LANL Community Reading Room, 1350 Central Avenue, Los Alamos, New Mexico.

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

Additional samples are collected and analyzed to obtain information about particular events, such as major surface run-off events, nonroutine releases, or special studies. Approximately 127,000 analyses for chemical and radiochemical constituents were carried out on more than 8,200 environmental samples during 1992. 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.

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

	Off Site				On Site
Type of Monitoring	**Regional**	**Perimeter**	**Laboratory**	**Waste Disposal Area**	**Total**
External radiation	4	23	51	88	166
Air	3	16	16	5	40[a]
Surface waters[b,c]	6	10	12	0	28
Groundwaters[b]	0	48	29	0	77
Soils	7	6	9	1	23
Sediments	11	19	29	21	80
Foodstuffs	13	11	21	1	46
Meteorology	0	1	5	1	7

[a]Includes four stations that monitor only nonradioactive air emissions.

[b]Samples from an additional 17 special surface water and groundwater stations related to the Fenton Hill Geothermal Program were also collected and analyzed as part of the monitoring program.

[c]Does not include National Pollutant Discharge Elimination System (NPDES) outfalls sampled to demonstrate regulatory compliance.

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

B. Measurement of External Penetrating Radiation

1. Introduction.

Natural external penetrating radiation comes from terrestrial and cosmic sources. The natural terrestrial component results primarily from the decay of potassium-40 and from radionuclides in the decay chains of thorium and uranium. Natural terrestrial radiation in the Los Alamos area is highly variable with time and location. During any year, external radiation levels can vary from 15% to 25% at any location because of changes in soil moisture and snow cover (NCRP 1975b). There is also spatial variation because of different topographies, soils, and rock types in different areas (ESG 1978).

Natural ionizing radiation from cosmic sources increases with elevation because of reduced shielding by the atmosphere. At sea level, cosmic sources yield between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km (1.4 mi), receives about 75 mrem/yr (unshielded) from cosmic sources. However, different locations in the region range in elevation from about 1.7 km (1.1 mi) at Española to 2.7 km (1.7 mi) at Fenton Hill, resulting in a corresponding range between 45 and 90 mrem/yr from cosmic sources. This component can vary |10% because of solar modulations (NCRP 1987a).

Fluctuations in natural background ionizing radiation make it difficult to detect an increase in radiation levels from manmade sources, especially when the size of the increase is small relative to the magnitude of natural fluctuations.

2. Monitoring Network and Results.

Levels of external penetrating radiation (including x and gamma rays and charged-particle contributions from cosmic, terrestrial, and manmade sources) in the Los Alamos area are measured with thermoluminescent dosimeters (TLDs) in three independent networks. These networks are used to measure radiation levels (1) on site at the Laboratory and off site (perimeter, and regional), (2) at the Laboratory boundary north of the Los Alamos Meson Physics Facility (LAMPF), and (3) at low-level radioactive waste management areas. The current detection limit of the TLD system is 3 mrem.

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

a. Laboratory and Regional Areas. The environmental network consists of 51 stations divided into 3 groups. The off-site regional group consists of 4 locations, 28 to 44 km (17 to 27 mi) from the Laboratory boundary, at Fenton Hill and in the neighboring communities of Española, Pojoaque, and Santa Fe. 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 IV-1). Table IV-2 contains the TLD measurements obtained at off-site regional, off-site perimeter, and on-site monitoring stations. Details of the sampling methodology for the TLD network are found in Section VIII.C.1.

Annual averages for the groups were generally the same in 1992 as in 1991 (Figure IV-2), close to the averages observed in 1990, and consistent with the variability in natural background observed at these stations. Off-site stations, both regional and perimeter, showed no statistically significant increase in radiation levels attributable to Laboratory operations (Table IV-2). The annual dose averages at off-site regional stations ranged from 92 to 124 mrem. Annual measurements at off-site perimeter stations ranged from 82 to 151 mrem. Some comparisons provide a useful perspective for evaluating these measurements. For instance, the average person in the United States receives about 53 mrem/yr of radiation from medical diagnostic procedures (NCRP 1987a). Effective dose equivalents (EDEs) from external penetrating radiation are presented in Section V.C.3.b.

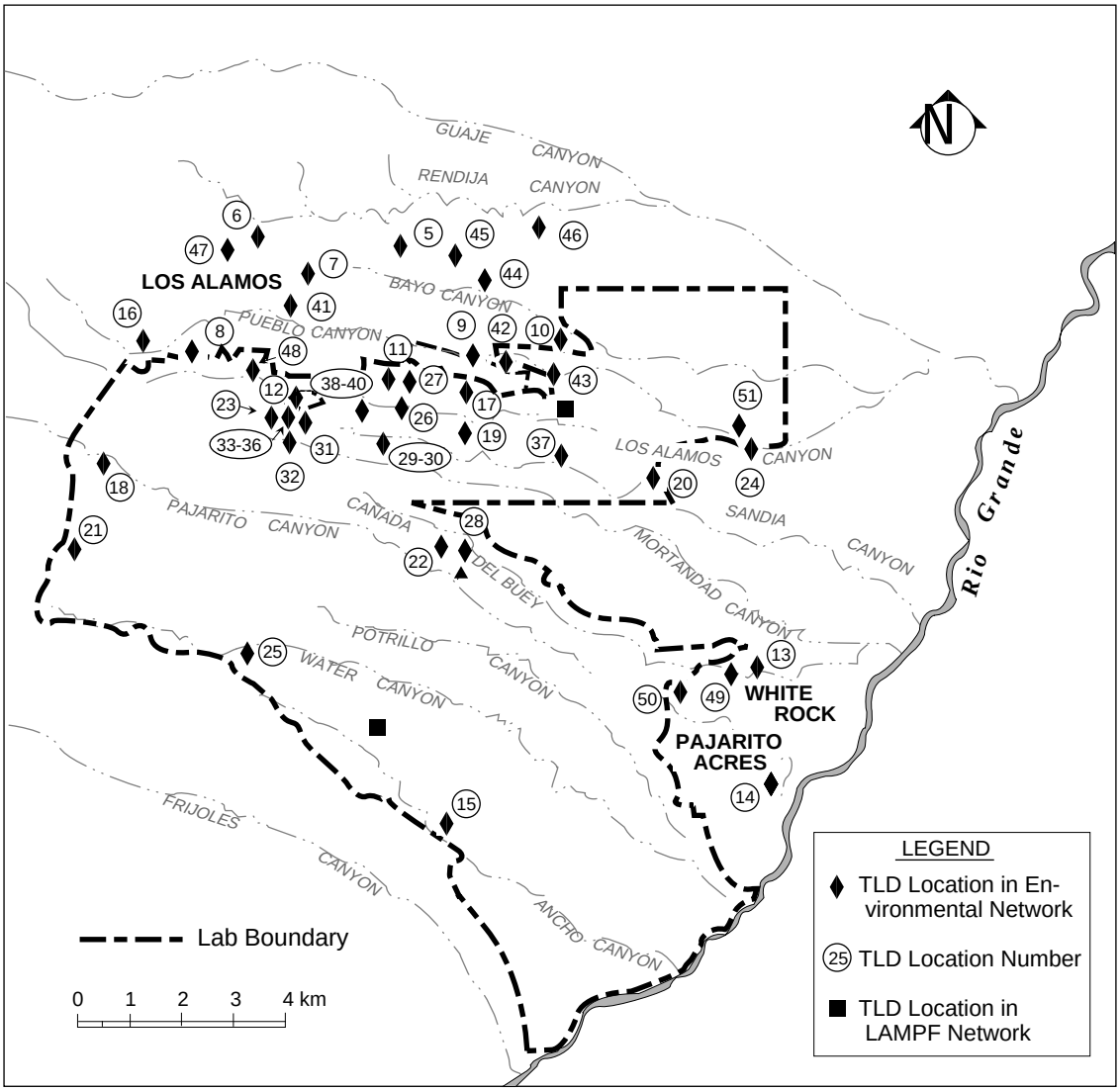


Figure IV-1. Off-site perimeter and on-site Laboratory TLD locations. (Does not show Regional Stations. Specific locations are presented on the FIMAD system at the Community Reading Room.)

b. Technical Area (TA) 53 Network. This network monitors external radiation from airborne activation products (gases, particles, and vapors) released by LAMPF, TA-53. Air emissions from LAMPF constitute the largest Laboratory source of off-site external penetrating radiation. Due to prevailing southerly winds, the TA-53 TLD network is located at the Laboratory boundary 800 m (0.5 mi) north of LAMPF. The network consists of 12 TLD sites. Twelve background TLD sites are located about 9 km (5.5 mi) from TA-53, near the southern boundary of the Laboratory (Figure IV-1).

The TLDs are changed each quarter of the calendar year (CY) or more often if LAMPF's operating schedule indicates the need (e.g., during start up or shutdown of the accelerator for extended periods midway through a calendar quarter). The difference between the annual measurement at the Laboratory boundary north of LAMPF from the background site was less than three mrem.

Table IV-2. TLD Measurements

Station Location	1992 Dose Average[a] (mrem)	
Uncontrolled Areas (Off Site)		
Regional Stations (28–44 km)		
1. Española	95	(8)
2. Pojoaque	92	(7)
3. Santa Fe	97	(12)
4. Fenton Hill	124	(18)
Perimeter Stations (0–4 km)[b]		
5. Barranca School	112	(3)
6. Arkansas Avenue	103	(7)
7. Cumbres School	90	(12)
8. 48th Street	105	(17)
9. Los Alamos Airport	100	(13)
10. Bayo Canyon	138	(5)
11. Shell Station	129	(6)
12. Royal Crest Trailer Court	109	(21)
13. White Rock	107	(15)
14. Pajarito Acres	105	(7)
15. Bandelier Lookout Station	113	(14)
16. Pajarito Ski Area	141	(2)
20. Well PM-1 (SR 4 and Truck Rt.)	150	(6)
41. McDonald's	111	(12)
42. Airport-South	121	(9)
43. East Gate Business Park	121	(13)
44. Big Rock Loop	151	(10)
45. Cheyenne Street	150	(9)
46. Los Pueblos Street	140	(20)
47. Urban Park	143	(17)
48. County Landfill	116	(18)
49. Piñon School	105	(10)
50. White Rock Church of the Nazarene	103	(11)
51. Bayo Canyon Well	82	(4)
Controlled Areas (On Site)		
On-Site Stations[b]		
17. TA-21 (DP West)	129	(17)
18. TA-6 (Two Mile Mesa)	118	(6)
19. TA-53 (LAMPF)	135	(12)
21. TA-16 (S Site)	120	(15)
22. Booster P-2	130	(12)
23. Mesita del Buey	123	(6)
24. State Highway 4	152	(8)
25. Frijoles Mesa	119	(5)
26. TA-2 (Omega Stack)	118	(13)
27. TA-2 (Omega Canyon)	159	(14)
28. TA-18 (Pajarito Site)	123	(8)
29. TA-35 (Ten Site A)	109	(18)
30. TA-35 (Ten Site B)	118	(9)
31. TA-59 (Occupational Health Lab)	122	(13)
32. TA-3 (Van de Graaff)	118	(10)
33. TA-3 (Guard Station)	136	(13)
34. TA-3 (Alarm Building)	121	(6)
35. TA-3 (Guard Building)	113	(7)
36. TA-3 (Shop)	120	(4)
37. TA-72 (Pistol Range)	142	(14)
38. TA-55 (Plutonium Facility South)	150	(22)
39. TA-55 (Plutonium Facility West)	146	(8)
40. TA-55 (Plutonium Facility North)	120	(10)

[a]Uncertainties (|2 standard deviations) are in parentheses.
[b]See Figure IV-1.

Figure IV-3 presents summary data on the contribution of external penetrating radiation to the maximum individual dose and the maximum Laboratory boundary dose. Doses significantly decreased beginning in 1987. No above-background increase in external radiation from Laboratory operations was measured above TLD-detection limits in off-site areas by the TLD monitoring network during 1992.

c. Low-Level Radioactive Waste Management Areas Network. This network of 88 locations monitors radiation levels at 1 active and 10 inactive low-level radioactive waste management areas. These waste management areas are controlled-access areas and are not accessible to the general public. Active and inactive waste areas are monitored for external penetrating radiation with arrays of TLDs (Table IV-3). Annual averages at all sites ranged from 85 to 236 mrem and compare well with the annual averages for the perimeter locations (Tables IV-2 and IV-3). The extremes at Area G (the active radioactive waste area) and Area T (an inactive waste area) have been noted in previous years. Values for Area T compare to previous years. The maximum recorded value for Area G is a location near the aboveground storage area for mixed wastes. The increase in the maximum value from previous years reflects an increased amount of radioactive waste in the temporary storage area.

C. Air Monitoring

1. Airborne Radioactivity.

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

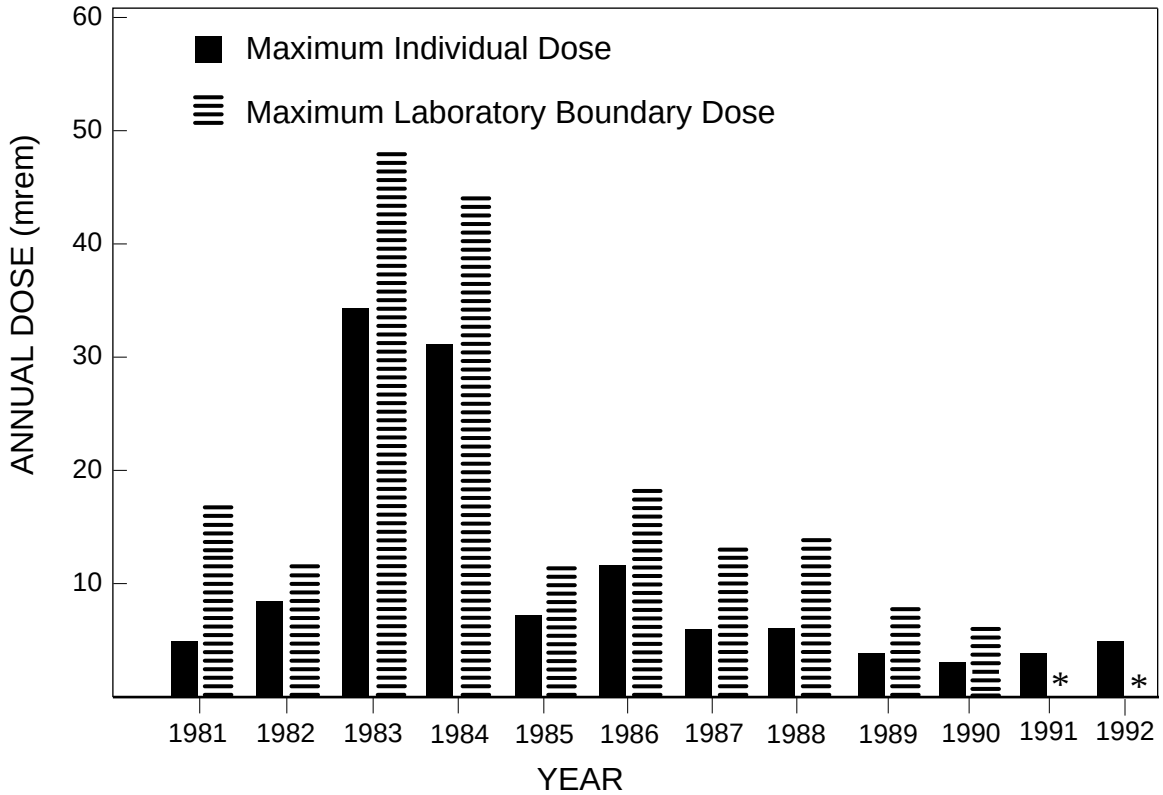


Figure IV-3. Summary of estimated maximum individual and maximum Laboratory boundary doses from external penetrating radiation generated by Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources). Maximum individual dose calculated with DOE-approved methods that take building shielding and occupancy into account.

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

cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic radiation and stable water). Levels of background radioactivity in the atmosphere, and which are useful in interpreting air sampling data, are summarized in Table IV-4. 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 guides for uncontrolled areas.

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 IV-4) are less than 1% of the Derived Air Concentrations (DAC) guide for uncontrolled areas. The DAC guide represents a concentration that would result in an annual dose of 100 mrem.

b. Monitoring Network. The sampling network for ambient airborne radioactivity consists of 36 continuously operating air sampling stations including off-site locations (3 regional and 14 perimeter), 14 on-site stations, and 5 on-site waste site stations. One station at TA-18 is inactive. The 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 levels of atmospheric radioactivity. The

Table IV-3. Doses Measured by TLDs at On-Site Waste Disposal Areas during 1992

Waste Disposal Area	Number of TLD Locations	Annual Doses (mrem) Mean	Minimum	Maximum
TA-21, Area A[a]	5	107 (6)[b]	84	133
TA-21, Area B	14	115 (11)	101	139
TA-50, Area C	10	122 (13)	107	135
TA-33, Area E	4	100 (7)	96	105
TA- 6, Area F	4	100 (16)	94	105
TA-54, Area G	26	236 (58)	113	2,020
TA-21, Area T	7	142 (19)	110	242
TA-21, Area U	4	119 (16)	112	124
TA-21, Area V	4	106 (13)	97	109
TA-35, Area W	1	111 (22)	111	111
TA-49, Area AB	10	85 (6)	83	91

[a]See Figure II-4 for location of Technical Areas (TAs).

[b]Uncertainties (| 2 standard deviations) are in parentheses.

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

Radioactive Constituent[a]	Units	Santa Fe[b] 1988|1991	New Mexico[c] 1992	DOE Guide for Uncontrolled Area[d]
Gross beta	10^{-15} µCi/mL	10.0+(+0.0)[e]	9.6+(+1.9)	++9,000
^{3}H	10^{-12} µCi/mL	+	0.3+(+0.8)	200,000
Uranium (natural)	$++^{+++}$+pg/m^{3}	58.2+(19.5)	92.0+(15.0)	100,000
^{234}U	10^{-18} µCi/mL	22.5+(+7.5)	30.6+(+9.0)	+90,000
^{235}U	10^{-18} µCi/mL	0.8+(+0.4)	2.6+(+0.7)	100,000
^{238}U	10^{-18} µCi/mL	22.5+(+7.5)	28.8+(+8.0)	100,000
^{238}Pu	10^{-18} µCi/mL	0.3+(+0.2)	0.6+(+3.8)	+30,000
$^{239,240}Pu$	10^{-18} µCi/mL	0.2+(+0.1)	1.5+(+2.2)	+20,000
^{241}Am	10^{-18} µCi/mL	+	1.3+(+4.1)	+20,000
^{131}I	10^{-12} µCi/mL	+	+	++++400

[a]See Appendix D, Table D-35 for detection limits.

[b]EPA (1989|1993), Reports 53 through 68. Data are from the EPA Santa Fe, New Mexico, sampling location and were taken from January 1988 through December 1991. Data for 1992 were not available at time of publication.

[c]Data are annual averages from the regional stations (Española, Pojoaque, Santa Fe) and were taken by the Laboratory during CY92.

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

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

14 perimeter stations are within 4 km (2.5 mi) of the Laboratory boundary. Fourteen on-site stations are within the Laboratory boundary (Figure IV-4, Table D-8). Samples are collected from one of the on-site stations (located at TA-59) on a weekly basis for gross alpha, beta, and gamma screening purposes.

In addition to Station 27 at TA-54, which is part of the routine air sampling network, four additional stations are located at the active radioactive waste disposal site, TA-54, Area G, and one station at an inactive waste disposal site, TA-49, Area AB. In the past these additional stations were not identified as part of the airnet system.

In August 1992 five stations for monitoring iodine-131 in air were added to the air monitoring network. These are colocated with existing stations.

Beginning in the third quarter of 1992, all air monitoring stations were replaced with a new type of sampling system to increase reliability in sampling and monitoring data. The sample period was also decreased from monthly to twice a month. The airnet monitoring network experienced approximately 5% station downtime during 1992.

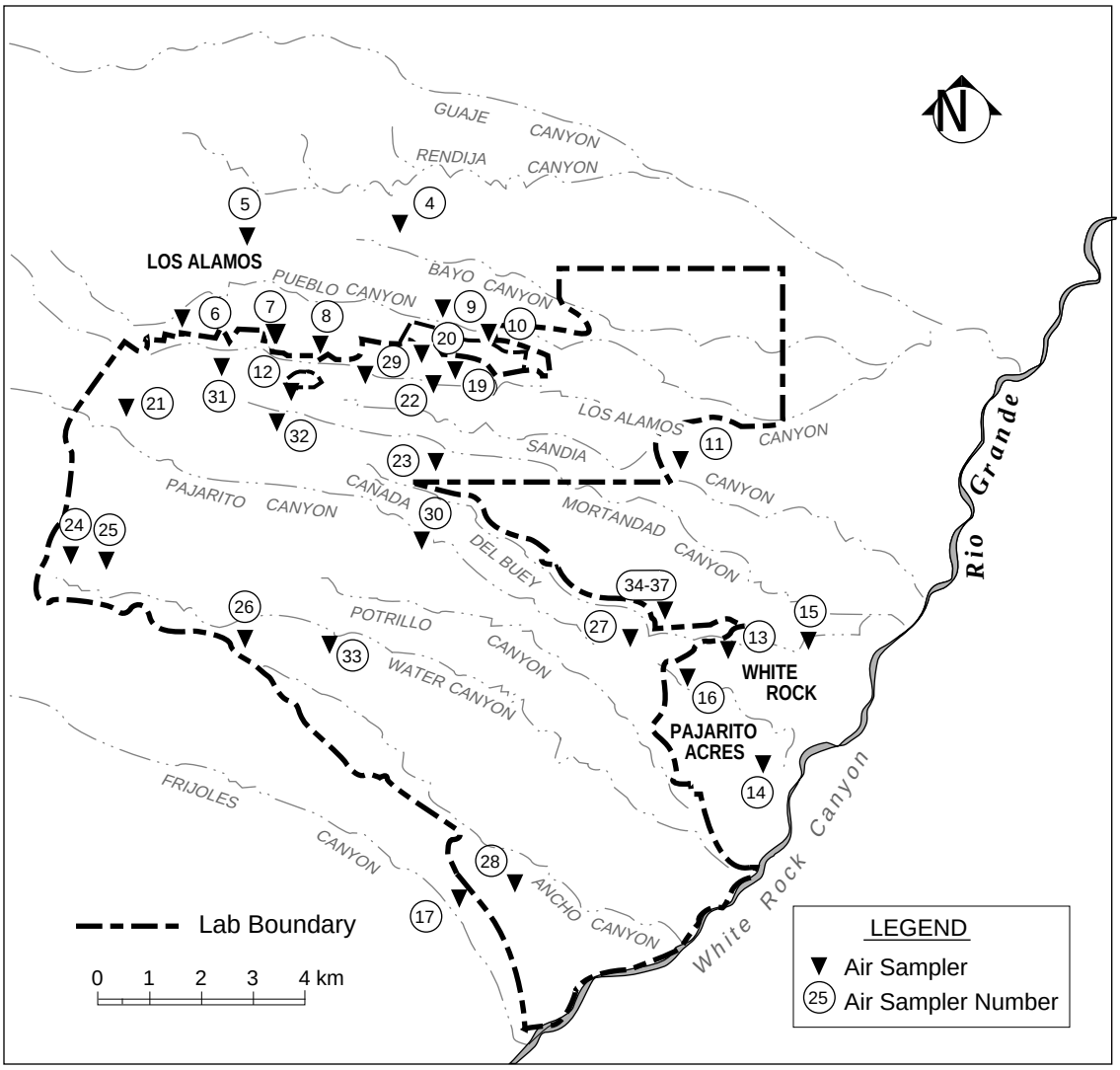


Figure IV-4. Approximate locations for off-site perimeter and on-site Laboratory stations for sampling airborne radionuclides. (Does not show Regional Stations. Specific locations are presented in Table D-8 and on the FIMAD system at the Community Reading Room.)

c. Analytical Results.

Gross Alpha and Beta Radioactivity. Gross alpha and beta analyses help in evaluating general radiological air quality. Alpha or beta activity for any single radionuclide cannot be present in greater quantity than the total gross concentration. 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.

The National Council on Radiation Protection and Measurements (NCRP) estimates concentration of long-lived gross alpha activity in air to be 2,030 aCi/m^3. The primary alpha activity is due to ^{210}Po (a decay product of radon gas) and other naturally occurring radionuclides (NCRP, 1987a). There were more than 500 air samples collected and analyzed for gross alpha activity in 1992; none were above background.

The NCRP estimated concentration levels of long lived gross beta activity in air to be 20,000 aCi/m^3. This activity is primarily due to the presence of ^{210}Pb and ^{210}Bi (decay products of radon gas), and other naturally occurring radionuclides (NCRP 1987a). There were more than 500 air samples collected and analyzed for gross beta activity in 1992; none were above background.

Tritium. In 1992, the off-site regional mean concentration of tritium as tritiated water in air (0.3[|6.4] + 10^{-12} μCi/mL) was lower than the off-site perimeter annual mean (2.7 [|17.3] + 10^{-12} μCi/mL) and the on-site annual mean (6.1[|26.4] + 10^{-12} μCi/mL). The waste sites' annual mean (42.8 [|34.7] + 10^{-12} μCi/mL) was 7 times the on-site annual mean. The elevated concentrations observed in the waste sites are at TA-54, Area G, near shafts where tritium contaminated waste is disposed of. The highest concentration observed in any month was also at TA-54, Area G, Station 35 (685 [|205] + 10^{-12} μCi/mL). These tritium concentrations are <0.1% of the concentration guide in air, based on DOE's DACs for uncontrolled areas. Table IV-5 presents complete monitoring data.

Tritium in rainwater was also analyzed by the Geology and Geochemistry Group (EES-1) of the Laboratory's Earth and Environmental Sciences Division, as reported in Section IV.I.2. Elevated levels of tritium in rainwater were found in samples from the Los Alamos area, which contained >20 tritium units (TUs), compared to the expected worldwide average concentration of 10 to 20 TUs. One tritium unit is equal to 3.2 pCi/L of water.

Table IV-5. Airborne Tritium as Tritiated Water Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (pCi/m^3 [10^{-12} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas (Off Site)							
+1. Española	125	15	15	2.2 (0.8)	|2.4[e] (1.5)	0.4 (3.2)	<0.1
+2. Pojoaque	105	15	15	2.1 (0.9)	|0.9 (1.3)	0.4 (3.3)	<0.1
+3. Santa Fe	126	15	14	3.6 (1.0)	|3.0 (2.3)	0.3 (4.5)	<0.1
Group Summary		45	44	3.6 (1.0)	|3.0 (2.3)	0.3 (6.4)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas (Off Site)							
+4. Barranca School	108	15	8	10.0 (1.0)	|1.9 (0.8)	2.6 (3.5)	<0.1
+5. Urban Park	92	12	7	8.4 (2.5)	|1.8 (0.9)	2.6 (5.1)	<0.1
+6. 48th Street	107	11	13	5.7 (1.3)	0.5 (0.5)	2.6 (3.6)	<0.1
+7. Shell Station	78	14	4	9.0 (1.8)	0.3 (0.2)	4.1 (4.5)	<0.1
+8. McDonald's	93	15	5	11.8 (2.0)	1.0 (0.4)	5.8 (5.0)	<0.1
+9. Los Alamos Airport	94	14	9	8.9 (1.8)	0.0 (0.9)	3.5 (4.6)	<0.1
10. East Gate	104	14	4	10.5 (2.4)	|1.4 (0.8)	3.8 (4.5)	<0.1
11. Well PM|1	112	15	11	4.9 (1.6)	|0.3 (0.2)	2.0 (4.5)	<0.1
12. Royal Crest Trailer Park	76	13	6	10.7 (1.9)	|0.0 (0.6)	3.9 (4.6)	<0.1

Table IV-5. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (pCi/m^3 [10^{-12} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Perimeter Stations (0–4 km), Uncontrolled Areas (Off Site) (Cont.)							
13. White Rock, Piñon School	84	12	7	6.0 (2.0)	0.1 (0.3)	2.6 (4.3)	<0.1
14. Pajarito Acres	94	15	14	4.6 (1.2)	|11.5 (6.9)	0.1 (7.7)	<0.1
15. White Rock Fire Station	78	14	11	5.7 (2.1)	|0.8 (0.5)	1.6 (3.5)	<0.1
16. White Rock Church of the Nazarene	70	14	10	10.6 (3.2)	0.0 (0.6)	2.3 (4.8)	<0.1
17. Bandelier	83	15	15	2.6 (0.6)	|1.0 (0.5)	0.8 (2.2)	<0.1
Group Summary		193	124	11.8 (2.0)	|11.5 (6.9)	2.7(17.3)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	79	13	1	38.8 (4.9)	0.7 (0.4)	13.1 (8.1)	<0.1
20. TA-21, Area B	86	14	6	17.6 (3.5)	|3.7 (1.9)	5.6 (6.4)	<0.1
21. TA-6	119	14	11	12.8 (3.4)	|0.9 (0.7)	2.7(11.7)	<0.1
22. TA-53, LAMPF	74	14	7	14.6 (3.1)	|0.4 (|0.4)	4.9 (7.1)	<0.1
23. TA-52, Beta Site	76	14	6	8.9 (2.2)	|1.2 (0.6)	4.4 (5.1)	<0.1
24. TA-16, S-Site	61	8	7	4.7 (2.0)	|0.2 (1.3)	1.5 (3.9)	<0.1
25. TA-16-450	68	12	9	7.2 (3.6)	|1.4 (0.7)	1.6 (6.1)	<0.1
26. TA-49	85	15	15	2.7 (0.6)	|0.1 (0.6)	1.2 (3.0)	<0.1
27. TA-54	111	14	4	25.5 (3.0)	|0.7 (2.1)	10.0 (6.7)	<0.1
28. TA-33	68	12	7	10.1 (2.5)	|0.8 (0.5)	3.7 (6.2)	<0.1
29. TA-2, Omega Site	76	13	8	15.4 (2.5)	|3.6 (2.2)	4.3 (5.1)	<0.1
30. Booster P-2	109	15	13	6.3 (0.8)	|0.3 (0.5)	2.0 (3.6)	<0.1
31. TA-3	71	12	0	68.2 (4.5)	5.0 (0.7)	26.9(12.4)	<0.1
32. TA-48	75	14	10	8.1 (3.1)	|2.7 (3.0)	2.7 (5.9)	<0.1
Group Summary		184	104	68.2 (4.5)	|3.7 (1.9)	6.1(26.4)	<0.1
Waste Site Stations, Controlled Areas							
33. Area AB	75	9	7	6.9 (1.7)	|1.1 (0.5)	2.0 (4.7)	<0.1
34. Area G-1 NE Corner	98	13	2	46.7 (6.0)	2.3 (1.1)	18.1 (8.9)	<0.1
35. Area G-2 South Fence	105	14	1	685.0 (205.0)	2.5 (0.7)	164.1(30.4)	<0.1
36. Area G-3 Gate	82	12	8	185.6 (11.5)	1.0 (0.5)	24.2(12.4)	<0.1
37. Area G-4 Water Tank	74	13	5	14.2 (2.8)	1.0 (0.5)	5.6 (5.2)	<0.1
Group Summary		61	23	685.0 (205.0)	|1.1 (0.5)	42.8(34.7)	

[a]See Figure IV-4 for map of local stations.
[b]Minimum detection limit (MDL) = $2 + 10^{-12}$ μCi/mL.
[c]Uncertainties (|2 σ) are in parentheses.
[d]Controlled area DOE Derived Air Concentration (DAC) = $2 + 10^{-5}$ μCi/mL; uncontrolled area DAC guide = $1 + 10^{-7}$ μCi/mL.
[e]See Section VIII, D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negatives values.

Plutonium. Of the 123 air sample analyses performed in 1992 for ^{238}Pu from locations outside of the waste sites, only 4 samples were above the minimum detection limit of $4 + 10^{-18}$ µCi/mL. All mean air concentrations of ^{238}Pu were less than 0.1% of the DOE's DAC guide for uncontrolled areas, $3 + 10^{-14}$ µCi/mL. The highest concentration was observed during the second quarter of 1992 at an off-site perimeter station located near McDonald's, 8.4 [|4.3] + 10^{-18} µCi/mL. Other sampling locations near this station did not indicate any elevated sample results. Twenty samples from the waste sites were analyzed for ^{238}Pu. The highest observation was 9.7 [|3.8] + 10^{-18} µCi/mL, which is less than 0.1% of the DOE's DAC guide.

The 1992 annual means for ^{239,240}Pu air concentrations for the regional (1.5 [|8.1] + 10^{-18} µCi/mL), perimeter (5.9 [|21.8] + 10^{-18} µCi/mL), on-site (4.2 [|20.4] + 10^{-18} µCi/mL) and waste site stations (1.1 [|16.0] + 10^{-18} µCi/mL) were all less than 0.1% of the DOE DAC guide for controlled and uncontrolled areas. The maximum concentration observed was (92 [|28] + 10^{-18} µCi/mL) at the on-site TA-49 sampler. Tables IV-6 and IV-7 present complete monitoring data on plutonium concentrations.

Six perimeter stations (Los Alamos Shell, East Gate, Well PM-1, White Rock Piñon School, Pajarito Acres, and White Rock Fire Station) were found to have mean ^{239,240}Pu activity concentrations statistically greater than the regional (background) activity of 1.5 [8.1] aCi/m^3. Background activity from plutonium is due to resuspension of fallout from atmospheric testing. These elevated readings were recorded in the first quarter of 1992. If these elevated readings are omitted, the mean ^{239,240}Pu concentrations for the quarterly perimeter results equal the value recorded for the regional locations.

Table IV-6. Airborne ^{238}Pu Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} µCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
+1. Española	62,679	4	4	1.9 (4.5)	0.0 (3.9)	0.9 (3.9)	<0.1
+2. Pojoaque	68,874	4	4	2.4 (3.3)	0.4 (3.0)	1.0 (3.5)	<0.1
+3. Santa Fe	58,333	4	4	0.6 (4.4)	|1.1[e] (4.1)	|0.2 (4.1)	<0.1
Group Summary		12	12	2.4 (3.3)	|1.1 (4.1)	0.6 (3.8)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
+4. Barranca School	63,526	4	4	1.3 (3.4)	|0.1 (3.8)	0.5 (3.8)	<0.1
+5. Urban Park	73,921	4	3	4.1 (3.4)	0.2 (2.7)	1.9 (3.3)	<0.1
+6. 48th Street	66,282	4	4	2.7 (4.7)	|0.6 (3.2)	1.0 (3.7)	<0.1
+7. Shell Station	60,763	4	4	2.7 (3.5)	0.0 (3.7)	1.1 (4.0)	<0.1
+8. McDonald's	56,508	4	3	8.4 (4.3)	0.4 (5.3)	2.7 (4.4)	<0.1
+9. Los Alamos Airport	77,457	4	4	2.0 (3.2)	0.0 (3.5)	0.9 (3.1)	<0.1
10. East Gate	69,905	4	4	3.1 (3.6)	0.3 (3.1)	1.2 (3.5)	<0.1
11. Well PM-1	65,152	4	4	0.0 (0.0)	|1.0 (3.2)	|0.4 (3.7)	<0.1
12. Royal Crest Trailer Park	63,157	4	4	2.4 (4.3)	0.0 (3.5)	1.1 (3.9)	<0.1
13. White Rock, Piñon School	77,415	4	4	1.9 (2.9)	0.0 (3.2)	1.2 (3.1)	<0.1
14. Pajarito Acres	58,919	4	4	2.6 (6.5)	|2.7 (3.8)	0.6 (4.3)	<0.1
15. White Rock Fire Station	62,575	4	4	1.6 (3.5)	|0.4 (3.3)	0.5 (3.9)	<0.1
16. White Rock Church of the Nazarene	60,712	4	4	2.4 (7.3)	0.8 (4.0)	1.5 (4.4)	<0.1
17. Bandelier	55,826	4	4	1.6 (4.2)	|0.4 (5.8)	0.2 (4.4)	<0.1
Group Summary		56	54	8.4 (4.3)	|2.7 (3.8)	1.0 (3.8)	<0.1

Table IV-6. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	63,977	4	4	1.0 (3.5)	|0.3 (3.8)	0.4 (3.9)	<0.1
20 TA-21, Area B	51,625	4	4	1.1 (4.6)	0.0 (4.6)	0.6 (4.7)	<0.1
21. TA-6	68,196	4	4	1.0 (3.9)	0.2 (3.2)	0.7 (3.5)	<0.1
22. TA-53 (LAMPF)	74,341	4	4	2.1 (3.4)	0.0 (3.5)	1.0 (3.2)	<0.1
23. TA-52, Beta Site	63,758	4	4	0.9 (5.4)	|0.2 (3.2)	0.5 (3.9)	<0.1
24. TA-16, S-Site	47,643	3	3	0.0 (0.0)	|0.3 (4.7)	|0.2 (3.9)	<0.1
25. TA-16-450	60,313	4	4	0.2 (3.7)	|1.7 (7.4)	|0.4 (4.4)	<0.1
26. TA-49	72,353	4	3	3.8 (3.4)	0.0 (3.1)	1.0 (3.3)	<0.1
27. TA-54	67,833	4	4	1.7 (3.0)	|0.3 (5.2)	0.7 (3.7)	<0.1
28. TA-33	69,164	4	4	1.0 (3.0)	0.5 (3.4)	0.7 (3.6)	<0.1
29. TA-2 (Omega)	42,788	4	4	1.0 (4.8)	|0.5 (7.1)	0.0 (6.2)	<0.1
30. Booster P-2	61,466	4	4	1.3 (3.8)	|0.1 (4.2)	0.5 (3.9)	<0.1
31. TA-3	59,199	4	4	1.9 (4.1)	0.4 (6.4)	1.1 (4.3)	<0.1
32. TA-48	52,864	4	4	2.8 (8.5)	|0.5 (0.9)	1.0 (4.3)	<0.1
Group Summary		55	54	3.8 (3.4)	|1.7 (7.4)	0.6 (4.1)	<0.1
Waste Site Stations, Controlled Areas							
33. Area AB	54,677	4	4	1.2 (2.9)	|5.2 (17.3)	|0.7 (7.0)	<0.1
34. Area G-1 NE Corner	66,917	4	1	6.8 (3.5)	1.3 (6.6)	3.8 (4.0)	<0.1
35. Area G-2 South Fence	67,509	4	4	0.3 (3.0)	0.0 (6.7)	0.2 (4.0)	<0.1
36. Area G-3 Gate	61,381	4	3	9.7 (3.8)	|0.3 (4.8)	2.4 (4.0)	<0.1
37. Area G-4 Water Tank	63,368	4	3	3.4 (3.1)	0.0 (3.4)	1.1 (3.9)	<0.1
Group Summary		20	15	9.7 (3.8)	|5.2 (17.3)	1.4 (4.6)	<0.1

[a]See Figure IV-4 for map of on-site and perimeter stations.

[b]MDL = $4 + 10^{-18}$ μCi/mL.

[c]Uncertainties (|2 σ) are in parentheses.

[d]Controlled area DOE DAC = $2 + 10^{-12}$ μCi/mL;
+uncontrolled area DAC guide = $3 + 10^{-14}$ μCi/mL.

[e]See Section VIII.D.3, Data Handling of Radiochemical Samples,
+for an explanation of the presence of negatives values.

Table IV-7. Airborne ^{239,240}Pu Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
+1. Española	62,679	4	4	1.3 (2.4)	0.4 (2.6)	0.8 (4.7)	<0.1
+2. Pojoaque	68,874	4	4	1.7 (2.5)	1.2 (2.7)	1.4 (4.4)	<0.1
+3. Santa Fe	58,333	4	3	4.3 (2.9)	1.1 (0.9)	2.1 (5.0)	<0.1
Group Summary		12	11	4.3 (2.9)	0.4 (2.6)	1.5 (8.1)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
+4. Barranca School	63,526	4	4	2.7 (0.8)	0.3 (2.5)	1.3 (4.6)	<0.1
+5. Urban Park	73,921	4	4	1.7 (2.6)	0.0 (2.2)	0.7 (4.0)	<0.1
+6. 48th Street	66,282	4	3	3.1 (1.0)	0.0 (2.4)	1.1 (4.6)	<0.1
+7. Shell Station	60,763	4	3	43.2 (4.5)	0.5 (3.1)	11.5 (6.6)	<0.1
+8. McDonald's	56,508	4	4	2.0 (2.8)	0.3 (3.0)	1.5 (5.5)	<0.1
+9. Los Alamos Airport	77,457	4	4	1.7 (1.0)	0.6 (1.8)	1.3 (3.7)	<0.1
10. East Gate	69,905	4	3	30.4 (3.1)	0.3 (2.3)	8.1 (5.2)	<0.1
11. Well PM-1	65,152	4	3	28.0 (3.2)	|0.5[e] (2.3)	7.1 (5.5)	<0.1
12. Royal Crest Trailer Park	63,157	4	2	6.0 (2.9)	0.3 (2.9)	3.0 (4.8)	<0.1
13. White Rock, Piñon School	77,415	4	3	43.3 (4.4)	0.0 (2.2)	11.1 (5.7)	<0.1
14. Pajarito Acres	58,919	4	3	79.5 (8.3)	0.8 (2.3)	20.7 (10.0)	<0.1
15. White Rock Fire Station	62,575	4	3	45.2 (4.9)	0.5 (2.3)	12.3 (6.9)	<0.1
16. White Rock Church of the Nazarene	60,712	4	3	4.2 (4.9)	0.8 (2.7)	2.0 (6.1)	<0.1
17. Bandelier	55,826	4	4	1.1 (0.8)	|0.3 (2.8)	0.5 (5.5)	<0.1
Group Summary		56	46	79.5 (8.3)	|0.5 (2.3)	5.9 (21.8)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	63,977	4	4	2.9 (1.2)	0.0 (3.6)	1.3 (5.1)	<0.1
20. TA-21, Area B	51,625	4	3	3.6 (1.5)	2.3 (3.0)	2.7 (5.4)	<0.1
21. TA-6	68,196	4	4	1.8 (2.1)	|0.8 (2.2)	1.0 (4.1)	<0.1
22. TA-53 (LAMPF)	74,341	4	4	2.1 (2.3)	1.0 (2.0)	1.5 (3.9)	<0.1
23. TA-52, Beta Site	63,758	4	4	1.0 (2.6)	|0.9 (3.6)	0.3 (5.0)	<0.1
24. TA-16, S Site	47,643	3	0	18.2 (2.3)	5.3 (3.1)	12.5 (4.7)	<0.1
25. TA-16-450	60,313	4	4	0.2 (2.2)	|2.7 (1.7)	|0.6 (4.4)	<0.1
26. TA-49	72,353	4	3	92.0(28.0)	0.5 (2.1)	24.0 (6.8)	<0.1
27. TA-54	67,833	4	2	37.1 (3.4)	0.8 (0.6)	11.7 (5.3)	<0.1
28. TA-33	69,164	4	4	0.4 (0.4)	0.0 (3.0)	0.2 (4.4)	<0.1
29. TA-2 (Omega)	42,788	4	4	2.6 (4.7)	|0.1 (2.7)	1.5 (8.1)	<0.1
30. Booster P-2	61,466	4	4	2.4 (0.8)	0.6 (2.5)	1.2 (4.8)	<0.1
31. TA-3	59,199	4	4	2.3 (4.2)	0.6 (2.3)	1.4 (5.6)	<0.1
32. TA-48	52,864	4	4	0.4 (0.6)	|0.6 (5.7)	|0.1 (6.9)	<0.1
Group Summary		55	48	92.0(28.0)	|2.7 (1.7)	4.2 (20.4)	<0.1

Table IV-7. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Waste Site Stations, Controlled Areas							
33. Area AB	54,677	4	4	1.6 (0.7)	0.0 (2.5)	0.8 (12.2)	<0.1
34. Area G-1 NE Corner	66,917	4	3	3.4 (2.3)	0.8 (0.6)	1.9 (5.4)	<0.1
35. Area G-2 South Fence	67,509	4	4	1.4 (1.9)	0.0 (2.3)	0.8 (5.4)	<0.1
36. Area G-3 Gate	61,381	4	4	1.6 (3.0)	|0.3 (3.2)	0.8 (5.0)	<0.1
37. Area G-4 Water Tank	63,368	4	4	2.0 (0.7)	0.6 (2.3)	1.3 (4.9)	<0.1
Group Summary		20	19	3.4 (2.3)	|0.3 (3.2)	1.1 (16.0)	

[a]See Figure IV-4 for map of local stations.
[b]Minimum detectable limit = 3 + 10^{-18} μCi/mL.
[c]Uncertainties (|2 σ) are in parentheses.
[d]Controlled area DOE DAC = 2 + 10^{-12} μCi/mL; uncontrolled area DAC = 2 + 10^{-14} μCi/mL.
[e]See Section VIII, D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negatives values.

The above background readings recorded in the first quarter of 1992 at the six off-site perimeter air sampling stations has not yet been explained. No elevated readings were recorded for these stations in the fourth quarter of 1991 (EPG 1993) or the second quarter of 1992, and no elevated readings were recorded by adjacent off-site stations. One elevated plutonium concentration was recorded at an on-site station, TA-6, but this station is not near these six perimeter stations. There were no unplanned releases involving ^{239,240}Pu from LANL during the first quarter of 1992 (Section V.B.3.a). The sampling results for other radioisotopes that are normally detected along with ^{239}Pu were not found to be elevated for the same stations. Gross alpha screening performed prior to radioisotopic analysis did not indicate elevated alpha activity in the samples.

These elevated results appeared to be an artifact of the sampling and/or radiochemical analysis procedure; however, they were included for estimating the total off-site dose from LANL operations (Section V.C). There is no associated health risk for these elevated readings. The incremental dose associated with the station with the highest quarterly concentration (79.5 [|8.3] + 10^{-18} μCi/mL at Pajarito Acres) is less than 0.01 mrem.

Americium. Measured concentrations of ^{241}Am were all less than 0.1% of the DOE's DAC guides for controlled and uncontrolled areas. The off-site perimeter mean (1.8 [|17.9] + 10^{-18} μCi/mL) and the on-site mean (2.3 [|20.0] + 10^{-18} μCi/mL) were within the regional mean (1.2 [|9.1] + 10^{-18} μCi/mL). The station with the highest observed concentration (12.6 [|4.6] + 10^{-18} μCi/mL) was the on-site station at TA-6. Table IV-8 presents complete monitoring data for americium.

Uranium. Because uranium is a naturally occurring radionuclide in soil, it is found in airborne soil particles that have been resuspended by wind or mechanical forces (for example, vehicles or construction activity). As a result, uranium concentrations in air are heavily dependent on the immediate environment of the air sampling station. Stations with relatively high annual averages or maximums are in dusty areas such as Santa Fe, Pojoaque, and Española, where heavier accumulations of dust on filters result in increased amounts of natural uranium in the samples. This accounts for the larger uranium concentrations at regional stations. The measured mean concentrations of ^{238}U and ^{234}U from off-site regional stations are approximately the same, which suggests that the measured uranium is naturally occurring uranium from soils and not from Laboratory operations.

Total uranium concentrations were calculated from the isotopic composition analysis for each station. The 1992 annual means for uranium concentrations in air for off-site regional and off-site perimeter, on-site, and waste site stations were 87.2 (| 54.5) pg/m^3, 55.1 (| 123.3) pg/m^3, 63.3 (| 130.7) pg/m^3, and 68.0 (| 87.5) pg/m^3, respectively. All measured annual means were less than 0.1% of the DOE's DAC guides for uranium in air for controlled and uncontrolled areas. No effects attributable to Laboratory operations were observed. Isotopic uranium analysis of the air samples was initiated in 1992, which allows for a more accurate dose assessments from potential exposures to uranium. Total uranium concentrations in terms of mass is also given in Table IV-9 for comparison with uranium data from previous Environmental Surveillance reports. Activity concentrations for three isotopes of uranium are presented in Tables IV-10 through IV-12.

Iodine. Data from five new iodine-131 air monitoring stations are presented in Table IV-13. All concentrations were below the minimum detection limit (MDL) ($1 + 10^{-11}$ µCi/mL) and well below the DOE DAC. The highest observed concentration ($5[|3] + 10^{-12}$ µCi/mL) was at TA-48. Note that there were no results recorded above the MDL, thus the relative large uncertainty associated with each concentration.

Table IV-8. Airborne ^{241}Am Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} µCi/mL]) Max[c]	Min[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Station (44 km), Uncontrolled Area							
+2. Pojoaque	15,716	1	1	1.1 (3.8)	1.1 (3.8)	1.1 (3.8)	<0.1
+3. Santa Fe	58,333	4	2	3.7 (4.1)	|1.6[e] (4.4)	1.3 (8.3)	<0.1
Group Summary		5	3	3.7 (4.1)	|1.6 (4.4)	1.2 (9.1)	<0.1
Perimeter Stations (0|4 km), Uncontrolled Areas							
+6. 48th Street	34,955	2	2	1.4 (3.6)	1.2 (3.3)	1.3 (4.9)	<0.1
+8. McDonald's	31,933	2	2	1.8 (4.3)	0.9 (3.4)	1.4 (5.4)	<0.1
+9. Los Alamos Airport	41,338	2	1	2.0 (2.7)	1.0 (3.1)	1.5 (4.1)	<0.1
10. East Gate	32,656	2	0	2.4 (3.6)	2.1 (3.8)	2.3 (5.2)	<0.1
12. Royal Crest Trailer Park	49,266	3	0	2.8 (4.4)	2.2 (3.5)	2.5 (6.5)	<0.1
13. White Rock, Piñon School	38,451	2	1	4.1 (3.1)	2.0 (3.1)	3.0 (4.4)	<0.1
15. White Rock Fire Station	26,843	2	1	2.2 (4.7)	2.0 (4.2)	2.1 (6.3)	<0.1
16. White Rock Church of the Nazarene	60,712	4	2	2.5 (3.0)	0.9 (4.0)	1.8 (9.5)	<0.1
17. Bandelier	29,973	2	2	0.9 (3.8)	0.6 (4.2)	0.7 (5.7)	<0.1
Group Summary		21	11	4.1 (3.1)	0.6 (4.2)	1.8 (17.9)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21 DP Site	15,631	1	0	2.7 (3.8)	2.7 (3.8)	2.7 (3.8)	<0.1
20. TA-21, Area B	51,625	4	3	6.7 (5.1)	0.9 (4.4)	2.7 (9.3)	<0.1
21. TA-6	68,196	4	2	12.6 (4.6)	1.3 (3.2)	4.5 (7.6)	<0.1
22. TA-53 (LAMPF)	74,341	4	3	2.7 (3.4)	1.4 (2.9)	1.8 (6.5)	<0.1
23. TA-52 Beta Site	37,049	2	2	1.7 (3.3)	1.0 (3.2)	1.4 (4.6)	<0.1
24. TA-16, S Site	12,793	1	1	1.1 (4.7)	1.1 (4.7)	1.1 (4.7)	<0.1
26. TA-49	35,544	2	2	1.1 (3.2)	0.0 (3.6)	0.5 (4.8)	<0.1
27. TA-54, Area G	30,527	2	1	4.1 (3.2)	1.4 (5.2)	2.7 (6.1)	<0.1
30. Booster P-2	27,968	2	1	4.9 (4.2)	0.6 (4.4)	2.8 (6.1)	<0.1
31. TA 3	24,200	2	0	4.5 (6.4)	2.0 (4.1)	3.2 (7.6)	<0.1
Group Summary		24	15	12.6 (4.6)	0.0 (3.6)	2.3 (20.0)	<0.1

Table IV-8. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Max[c]	Min[c]	Mean[c]	Mean as a Percentage of Guide[d]
Waste Site Stations, Controlled Areas							
34. Area G-1 NE Corner	66,917	4	2	3.7 (6.6)	1.3 (2.9)	2.4 (8.5)	<0.1
35. Area G-2 South Fence	67,509	4	3	2.0 (7.6)	0.4 (2.9)	1.2 (9.3)	<0.1
36. Area G-3 Office	26,129	2	2	1.3 (4.4)	0.0 (4.8)	0.7 (6.5)	<0.1
37. Area G-4 Water Tank	26,396	2	1	2.8 (4.9)	1.8 (4.2)	2.3 (6.5)	<0.1
Group Summary		12	8	3.7 (6.6)	0.0 (4.8)	1.7 (15.6)	

[a]See Figure IV-4 for map of station locations.
[b]MDL = $2 + 10^{-18}$ μCi/mL.
[c]Uncertainties (|2 σ) are in parentheses.
[d]Controlled area DOE DAC = $2 + 10^{-12}$ μCi/mL; uncontrolled area DAC guide = $2 + 10^{-14}$ μCi/mL.
[e]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negatives values.
NOTE: Only those Airnet stations listed in this table are sampled for ^{241}Am.

Table IV-9. Airborne Uranium Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (pg/m^3) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28|44 km), Uncontrolled Areas							
+1. Española	62,679	4	0	93.6 (13.4)	29.9 (15.8)	53.2 (36.2)	<0.1
+2. Pojoaque	68,874	4	0	158.4 (12.7)	27.0 (14.5)	95.8 (27.2)	<0.1
+3. Santa Fe	58,333	4	0	244.0 (19.9)	22.0 (15.4)	112.4 (30.4)	<0.1
Group Summary		12	0	244.0 (19.9)	22.0 (15.4)	87.2 (54.5)	<0.1
Perimeter Stations (0|4 km), Uncontrolled Areas							
+4. Barranca School	63,526	4	0	187.6 (18.1)	42.1 (7.4)	92.8 (26.8)	<0.1
+5. Urban Park	73,921	4	0	125.8 (14.0)	11.8 (9.4)	54.1 (31.9)	<0.1
+6. 48th Street	66,282	4	0	138.4 (16.7)	19.9 (11.4)	57.1 (25.0)	<0.1
+7. Shell Station	60,763	4	0	75.1 (9.3)	36.1 (15.0)	62.8 (41.7)	<0.1
+8. McDonald's	56,508	4	0	48.7 (11.1)	29.9 (37.0)	39.1 (42.5)	<0.1
+9. Los Alamos Airport	77,457	4	0	158.3 (13.6)	39.2 (9.6)	91.4 (24.4)	<0.1
10. East Gate	69,905	4	0	325.5 (22.1)	44.5 (6.8)	122.8 (28.4)	<0.1
11. Well PM-1	65,152	4	0	45.5 (7.8)	20.6 (14.6)	29.7 (34.3)	<0.1
12. Royal Crest Trailer Park	63,157	4	0	65.7 (8.4)	39.4 (15.3)	55.4 (36.4)	<0.1
13. White Rock Piñon School	77,415	4	0	50.9 (6.6)	12.1 (11.1)	29.0 (15.0)	<0.1

Table IV-9. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (pg/m^3) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Perimeter Stations (0|4 km), Uncontrolled Areas (Cont.)							
14. Pajarito Acres	58,919	4	0	29.7 (45.8)	4.6 (6.5)	20.7 (48.5)	<0.1
15. White Rock Fire Station	62,575	4	0	72.3 (9.4)	26.2 (15.0)	51.5 (21.0)	<0.1
16. White Rock Church of the Nazarene	60,712	4	0	59.0 (12.6)	14.0 (14.1)	30.2 (21.0)	<0.1
17. Bandelier	55,826	4	0	79.9 (40.8)	12.2 (13.6)	35.0 (44.2)	<0.1
Group Summary		56	0	325.5 (22.1)	4.6 (6.5)	55.1 (123.3)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	63,977	4	0	143.9 (37.9)	7.2 (5.2)	65.5 (41.3)	<0.1
20. TA-21, Area B	51,625	4	0	114.4 (16.1)	20.3 (15.4)	61.8 (27.7)	<0.1
21. TA-6	68,196	4	0	74.0 (15.5)	14.0 (13.6)	46.0 (24.1)	<0.1
22. TA-53 (LAMPF)	74,341	4	0	544.1 (39.6)	31.4 (6.6)	178.4 (41.9)	<0.1
23. TA-52, Beta Site	63,758	4	0	138.2 (38.1)	18.6 (5.8)	63.6 (41.4)	<0.1
24. TA-16, S Site	47,643	3	0	73.6 (17.0)	39.2 (8.5)	55.4 (20.8)	<0.1
25. TA-16-450	60,313	4	0	51.0 (23.0)	15.3 (13.4)	35.5 (30.4)	<0.1
26. TA-49	72,353	4	0	126.4 (14.4)	11.3 (17.5)	68.6 (28.3)	<0.1
27. TA-54	67,833	4	0	129.2 (12.7)	8.2 (18.2)	50.0 (29.1)	<0.1
28. TA-33	69,164	4	0	30.9 (24.1)	15.9 (4.6)	22.9 (31.4)	<0.1
29. TA-2 (Omega)	42,788	4	0	107.2 (15.7)	46.9 (3.1)	63.2 (25.7)	<0.1
30. Booster P-2	61,466	4	0	57.3 (11.0)	28.2 (14.9)	41.6 (22.5)	<0.1
31. TA-3	59,199	4	0	94.5 (15.5)	11.1 (14.3)	51.3 (25.6)	<0.1
32. TA-48	52,864	4	0	162.0 (15.3)	23.1 (60.0)	82.0 (68.8)	<0.1
Group Summary		55	0	544.1 (39.6)	7.2 (5.2)	63.3 (130.7)	<0.1
Waste Site Stations, Controlled Areas							
33. Area AB	54,677	4	0	316.5 (61.1)	21.3 (7.7)	161.2 (67.9)	<0.1
34. Area G-1 NE Corner	66,917	4	0	128.0 (16.8)	23.5 (7.4)	56.0 (35.8)	<0.1
35. Area G-2 South Fence	47,212	3	0	47.4 (7.6)	21.2 (23.7)	34.1 (25.7)	<0.1
36. Area G-3 Gate	61,381	4	0	101.9 (10.1)	22.7 (16.8)	60.5 (24.7)	<0.1
37. Area G-4 Water Tank	63,368	4	0	44.9 (11.1)	12.3 (14.9)	28.0 (21.9)	<0.1
Group Summary		19	0	316.5 (61.1)	12.3 (14.9)	68.0 (87.5)	<0.1

[a]See Figure IV-4 for map of local stations.
[b]MDL = 1 pg/m^3.
[c]Uncertainties (|2 σ) are in parentheses.
[d]Controlled area DOE DAC = 2 + 10^8 pg/m^3;
+uncontrolled area DAC guide = 1 + 10^5 pg/m^3.

Table IV-10. Airborne ^{234}U Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
+1. Española	62,679	4	0	29.5 (4.1)	10.8 (6.0)	18.8 (13.2)	<0.1
+2. Pojoaque	68,874	4	0	50.5 (5.2)	10.8 (3.1)	29.6 (9.0)	<0.1
+3. Santa Fe	58,333	4	0	82.8 (6.5)	11.5 (5.8)	43.3 (10.6)	<0.1
Group Summary		12	0	82.8 (6.5)	10.8 (6.0)	30.6 (19.2)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
+4. Barranca School	63,526	4	0	43.1 (4.7)	11.0 (2.1)	21.6 (8.0)	<0.1
+5. Urban Park	73,921	4	1	15.2 (2.5)	2.8 (3.6)	8.4 (10.5)	<0.1
+6. 48th Street	66,282	4	0	25.5 (3.7)	4.7 (4.3)	14.7 (8.2)	<0.1
+7. Shell Station	60,763	4	0	26.9 (6.9)	9.6 (5.7)	18.3 (15.5)	<0.1
+8. McDonald's	56,508	4	0	11.5 (2.1)	5.5 (6.1)	9.3 (15.8)	<0.1
+9. Los Alamos Airport	77,457	4	0	24.6 (3.9)	6.7 (3.6)	18.2 (6.6)	<0.1
10. East Gate	69,905	4	0	27.0 (2.9)	8.0 (5.1)	20.2 (7.0)	<0.1
11. Well PM-1	65,152	4	0	12.2 (2.1)	5.5 (5.5)	9.0 (12.8)	<0.1
12. Royal Crest Trailer Park	63,157	4	0	16.8 (2.3)	8.4 (5.8)	12.6 (13.3)	<0.1
13. White Rock, Piñon School	77,415	4	1	12.1 (1.9)	2.6 (4.2)	7.6 (5.2)	<0.1
14. Pajarito Acres	58,919	4	0	11.9 (3.1)	4.3 (2.0)	8.4 (18.4)	<0.1
15. White Rock Fire Station	62,575	4	0	19.6 (2.5)	4.2 (5.7)	15.1 (7.1)	<0.1
16. White Rock Church of the Nazarene	60,712	4	0	12.5 (3.7)	4.0 (5.3)	8.6 (7.1)	<0.1
17. Bandelier	55,826	4	1	10.6 (15.5)	3.1 (5.2)	7.0 (16.5)	<0.1
Group Summary		56	3	43.1 (4.7)	2.6 (4.2)	12.8 (43.6)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	63,977	4	0	27.6 (14.3)	6.0 (1.8)	14.2 (15.4)	<0.1
20 TA-21, Area B	51,625	4	0	26.8 (5.5)	4.7 (5.8)	15.5 (8.9)	<0.1
21. TA-6	68,196	4	1	16.9 (4.5)	1.0 (5.1)	11.1 (7.8)	<0.1
22. TA-53 (LAMPF)	74,341	4	0	38.6 (4.6)	8.3 (3.9)	17.1 (6.6)	<0.1
23. TA-52, Beta Site	63,758	4	1	15.9 (2.3)	3.2 (5.1)	11.3 (15.7)	<0.1
24. TA-16, S-Site	47,643	3	0	23.4 (5.8)	8.7 (1.7)	17.8 (7.0)	<0.1
25. TA-16-450	60,313	4	1	8.7 (1.7)	3.4 (3.9)	6.0 (10.9)	<0.1
26. TA-49	72,353	4	1	12.7 (3.0)	2.1 (6.2)	8.2 (8.7)	<0.1
27. TA-54	67,833	4	1	40.3 (3.9)	0.0 (6.9)	16.6 (10.9)	<0.1
28. TA-33	69,164	4	0	8.2 (3.3)	4.8 (6.1)	6.9 (11.6)	<0.1
29. TA-2 (Omega)	42,788	4	0	30.0 (5.7)	5.6 (3.8)	15.1 (8.7)	<0.1
30. Booster P-2	61,466	4	0	15.9 (3.0)	5.8 (5.6)	13.1 (7.9)	<0.1
31. TA-3	59,199	4	1	35.2 (5.9)	3.2 (5.4)	17.6 (9.3)	<0.1
32. TA-48	52,864	4	0	52.2 (4.7)	5.1 (22.7)	23.5 (25.1)	<0.1
Group Summary		55	6	52.2 (4.7)	0.0 (6.9)	13.9 (44.9)	<0.1

Table IV-10. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Waste Site Stations, Controlled Areas							
33. Area AB	54,677	4	0	23.7 (23.1)	5.1 (2.0)	15.0 (25.5)	<0.1
34. Area G-1 NE Corner	66,917	4	0	30.3 (4.4)	9.0 (7.6)	16.0 (12.7)	<0.1
35. Area G-2 South Fence	47,212	3	0	13.2 (2.3)	7.2 (9.0)	10.4 (9.5)	<0.1
36. Area G-3 Gate	61,381	4	0	29.1 (3.0)	11.0 (6.4)	22.6 (8.9)	<0.1
37. Area G-4 Water Tank	63,368	4	1	32.4 (5.3)	2.1 (5.6)	12.8 (8.4)	<0.1
Group Summary		19	1	32.4 (5.3)	2.1 (5.6)	15.4 (32.4)	<0.1

[a]See Figure IV-4 for map of on-site and perimeter stations.
[b]MDL = 4 + 10^{-18} μCi/mL.
[c]Uncertainties (|2 σ) are in parentheses.
[d]Controlled area DOE DAC = 2 + 10^{-12} μCi/mL;
+uncontrolled area DAC guide = 3 + 10^{-14} μCi/mL.

Table IV-11. Airborne ^{235}U Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [$10^{|18}$ μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28|44 km), Uncontrolled Areas							
+1. Española	62,679	4	4	2.7 (1.8)	0.0 (5.2)	0.9 (10.8)	<0.1
+2. Pojoaque	68,874	4	3	3.6 (1.6)	0.0 (1.5)	1.6 (5.6)	<0.1
+3. Santa Fe	58,333	4	2	14.2 (2.7)	0.0 (2.2)	5.3 (6.5)	<0.1
Group Summary		12	9	14.2 (2.7)	0.0 (5.2)	0.2 (13.8)	<0.1
Perimeter Stations (0|4 km), Uncontrolled Areas							
+4. Barranca School	63,526	4	4	2.1 (1.9)	0.6 (2.1)	1.4 (5.5)	<0.1
+5. Urban Park	73,921	4	4	1.3 (7.8)	|0.8[e] (1.9)	0.4 (8.8)	<0.1
+6. 48th Street	66,282	4	3	4.3 (2.2)	|1.1 (2.3)	1.0 (5.3)	<0.1
+7. Shell Station	60,763	4	4	2.5 (1.7)	0.3 (10.8)	1.2 (12.1)	<0.1
+8. McDonald's	56,508	4	4	0.8 (1.7)	0.0 (2.1)	0.4 (13.6)	<0.1
+9. Los Alamos Airport	77,457	4	4	2.3 (1.6)	0.2 (3.2)	1.2 (4.3)	<0.1
10. East Gate	69,905	4	4	2.7 (1.5)	0.5 (4.4)	1.5 (5.3)	<0.1
11. Well PM-1	65,152	4	4	2.2 (1.8)	0.0 (4.8)	0.7 (11.0)	<0.1
12. Royal Crest Trailer Park	63,157	4	3	4.9 (1.6)	0.0 (5.1)	1.8 (11.5)	<0.1
13. White Rock, Piñon School	77,415	4	4	1.4 (1.5)	|0.2 (3.7)	0.3 (4.5)	<0.1
14. Pajarito Acres	58,919	4	4	2.2 (1.9)	0.0 (15.2)	0.9 (16.0)	<0.1
15. White Rock Fire Station	62,575	4	4	1.4 (2.4)	0.0 (5.0)	0.6 (6.0)	<0.1

Table IV-11. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [$10^{|18}$ μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Perimeter Stations (0|4 km), Uncontrolled Area (Cont.)							
16. White Rock Church of the Nazarene	60,712	4	3	3.2 (3.7)	0.3 (4.7)	1.4 (6.4)	<0.1
17. Bandelier	55,826	4	4	1.0 (13.5)	0.0 (1.9)	0.4 (14.5)	<0.1
Group Summary		56	53	4.9 (1.6)	|1.1 (2.3)	0.3 (36.5)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	63,977	4	3	5.0 (12.6)	0.0 (1.5)	1.9 (13.5)	<0.1
20 TA-21, Area B	51,625	4	4	2.6 (2.1)	|0.3 (5.1)	1.2 (6.4)	<0.1
21. TA-6	68,196	4	4	1.7 (1.7)	0.0 (1.9)	0.5 (5.4)	<0.1
22. TA-53 (LAMPF)	74,341	4	4	1.8 (1.7)	|0.3 (1.6)	0.6 (4.5)	<0.1
23. TA-52, Beta Site	63,758	4	4	1.8 (4.5)	0.8 (1.6)	1.4 (13.6)	<0.1
24. TA-16, S|Site	47,643	3	3	2.0 (2.5)	0.9 (2.0)	1.3 (3.5)	<0.1
25. TA-16|450	60,313	4	4	0.5 (4.3)	0.0 (3.7)	0.2 (9.6)	<0.1
26. TA-49	72,353	4	4	2.0 (1.6)	|2.3 (3.0)	0.3 (5.7)	<0.1
27. TA-54	67,833	4	2	5.6 (3.2)	0.0 (1.5)	2.4 (7.2)	<0.1
28. TA-33	69,164	4	4	1.0 (1.6)	|1.5 (5.3)	|0.3 (9.9)	<0.1
29. TA-2 (Omega)	42,788	4	4	1.7 (3.5)	|0.5 (4.7)	0.7 (6.4)	<0.1
30. Booster P|2	61,466	4	4	1.9 (1.7)	0.3 (4.9)	1.0 (6.0)	<0.1
31. TA-3	59,199	4	4	2.7 (1.8)	0.0 (3.2)	1.1 (6.0)	<0.1
32. TA-48	52,864	4	2	6.0 (4.3)	0.0 (5.1)	2.6 (21.1)	<0.1
Group Summary		55	50	6.0 (4.3)	|2.3 (3.0)	0.4 (36.1)	<0.1
Waste Site Stations, Controlled Areas							
33. Area AB	54,677	4	4	1.5 (8.9)	|1.2 (20.2)	0.6 (22.2)	<0.1
34. Area G-1 NE Corner	66,917	4	4	2.4 (7.7)	1.2 (1.8)	1.7 (10.4)	<0.1
35. Area G-2 South Fence	47,212	3	3	0.9 (7.9)	0.6 (1.5)	0.7 (8.2)	<0.1
36. Area G-3 Gate	61,381	4	3	4.1 (2.2)	0.0 (5.6)	1.7 (6.2)	<0.1
37. Area G-4 Water Tank	63,368	4	4	2.8 (2.8)	0.0 (1.7)	1.3 (6.1)	<0.1
Group Summary		19	18	4.1 (2.2)	|1.2 (20.2)	0.5 (27.3)	

[a]See Figure IV-4 for map of on|site and perimeter stations.
[b]MDL = 2 + $10^{|18}$ μCi/mL.
[c]Uncertainties (|2 σ) are in parentheses.
[d]Controlled area DOE DAC = 2 + $10^{|12}$ μCi/mL; uncontrolled area DAC guide = 3 + $10^{|14}$ μCi/mL.
[e]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of
+the presence of negatives values.

Table IV-12. Airborne ^{238}U Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
+1. Española	62,679	4	0	31.0 (4.2)	10.0 (4.5)	17.7 (10.5)	<0.1
+2. Pojoaque	68,874	4	0	52.6 (4.0)	9.1 (4.1)	31.9 (8.4)	<0.1
+3. Santa Fe	58,333	4	0	80.9 (6.4)	7.3 (4.4)	36.9 (9.3)	<0.1
Group Summary		12	0	80.9 (6.4)	7.3 (4.4)	28.8 (16.4)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
+4. Barranca School	63,526	4	0	62.6 (5.8)	14.0 (2.1)	30.9 (8.2)	<0.1
+5. Urban Park	73,921	4	0	42.1 (4.4)	3.9 (2.7)	18.1 (9.4)	<0.1
+6. 48th Street	66,282	4	0	45.8 (5.3)	6.6 (3.2)	19.0 (7.6)	<0.1
+7. Shell Station	60,763	4	0	25.0 (2.8)	12.0 (4.2)	20.9 (12.3)	<0.1
+8. McDonald's	56,508	4	0	16.3 (3.4)	10.0 (10.5)	13.1 (12.2)	<0.1
+9. Los Alamos Airport	77,457	4	0	52.9 (4.3)	13.1 (2.7)	30.5 (7.6)	<0.1
10. East Gate	69,905	4	0	109.0 (7.1)	14.7 (2.0)	41.0 (8.8)	<0.1
11. Well PM-1	65,152	4	0	15.2 (2.4)	6.9 (4.1)	9.8 (9.8)	<0.1
12. Royal Crest Trailer Park	63,157	4	0	22.0 (2.6)	13.2 (4.4)	18.3 (10.5)	<0.1
13. White Rock, Piñon School	77,415	4	0	17.1 (2.0)	4.1 (3.1)	9.7 (4.3)	<0.1
14. Pajarito Acres	58,919	4	1	10.0 (13.0)	1.4 (1.9)	6.8 (13.8)	<0.1
15. White Rock Fire Station	62,575	4	0	24.2 (2.9)	8.8 (4.2)	17.2 (6.1)	<0.1
16. White Rock Church of the Nazarene	60,712	4	0	19.3 (3.7)	4.7 (4.0)	9.9 (6.1)	<0.1
17. Bandelier	55,826	4	0	26.7 (11.6)	4.0 (3.9)	11.7 (12.6)	<0.1
Group Summary		56	1	109.0 (7.1)	1.4 (1.9)	18.4 (36.0)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	63,977	4	1	47.5 (10.8)	2.4 (1.5)	21.7 (11.8)	<0.1
20 TA-21, Area B	51,625	4	0	38.0 (5.0)	6.9 (4.4)	20.6 (8.4)	<0.1
21. TA-6	68,196	4	0	24.8 (4.9)	4.6 (3.9)	15.3 (7.3)	<0.1
22. TA-53 (LAMPF)	74,341	4	0	182.3 (13.0)	10.6 (2.0)	59.8 (13.6)	<0.1
23. TA-52, Beta Site	63,758	4	0	46.1 (10.8)	6.0 (1.7)	21.1 (11.8)	<0.1
24. TA-16, S-Site	47,643	3	0	24.4 (5.3)	13.0 (2.6)	18.4 (6.4)	<0.1
25. TA-16-450	60,313	4	0	17.1 (6.5)	5.1 (3.9)	11.9 (8.7)	<0.1
26. TA-49	72,353	4	0	42.1 (4.6)	4.2 (5.4)	23.0 (8.7)	<0.1
27. TA-54	67,833	4	1	42.8 (4.0)	2.8 (5.2)	16.4 (8.7)	<0.1
28. TA-33	69,164	4	0	10.3 (6.8)	5.2 (1.3)	7.7 (9.0)	<0.1
29. TA-2 (Omega)	42,788	4	0	35.7 (4.7)	15.7 (0.9)	21.1 (7.7)	<0.1
30. Booster P-2	61,466	4	0	19.0 (3.3)	9.4 (4.2)	13.8 (6.6)	<0.1
31. TA-3	59,199	4	0	31.3 (4.9)	3.7 (4.1)	17.0 (7.8)	<0.1
32. TA-48	52,864	4	0	53.8 (4.8)	7.7 (17.0)	27.1 (19.9)	<0.1
Group Summary		55	2	182.3 (13.0)	2.4 (1.5)	21.1 (38.7)	<0.1

Table IV-12. (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Waste Site Stations, Controlled Areas							
33. Area AB	54,677	4	0	106.4 (17.3)	7.0 (2.3)	54.0 (19.4)	<0.1
34. Area G-1 NE Corner	66,917	4	0	42.8 (5.4)	7.6 (2.2)	18.5 (10.5)	<0.1
35. Area G-2 South Fence	47,212	3	0	15.8 (2.3)	7.0 (6.7)	11.3 (7.4)	<0.1
36. Area G-3 Gate	61,381	4	0	33.9 (3.3)	7.6 (4.8)	20.1 (7.4)	<0.1
37. Area G-4 Water Tank	63,368	4	0	14.6 (3.3)	4.1 (4.2)	9.2 (6.4)	<0.1
Group Summary		19	0	106.4(17.3)	4.1 (4.2)	22.6 (25.2)	<0.1

[a]See Figure IV-4 for map of on-site and perimeter stations.
[b]MDL = 3 + 10^{-18} μCi/mL (Table D-38).
[c]Uncertainties (|2 σ) are in parentheses.
[d]Controlled area DOE DAC = 2 + 10^{-12} μCi/mL;
+uncontrolled area DAC guide = 3 + 10^{-14} μCi/mL.

Table IV-13. Airborne ^{131}I Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL[b]	Concentrations (pCi/m^3 [10^{-12} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Perimeter Stations (0–4 km), Uncontrolled Areas							
+8. McDonald's	69	13	13	3 (5)	|3[e] (+2)	1 (+20)	<0.2
16. White Rock Church of the Nazarene	69	14	14	4 (4)	|1 (+6)	1 (+20)	<0.3
On-Site Stations, Controlled Areas							
20. TA-21, Area B	56	11	11	2 (4)	|1 (+5)	1 (+10)	<0.2
21. TA-6	65	14	14	4 (6)	|40 (70)	-2 (100)	<0.4
32. TA-48	67	14	14	5 (3)	2 (+3)	2 (+40)	<0.5
		66	66	5 (3)	|40 (70)	1 (+50)	<0.2

[a]See Figure IV-4 for map of stations. These are the only stations monitored for ^{131}I.
[b]MDL = 1 + 10^{-11} μCi/mL.
[c]Uncertainties (|2 σ) are in parentheses.
[d]Uncontrolled area DOE DAC = 4 + 10^{-10} μCi/mL.
[e]See Section VIII.D.3, Data Handling of Radiochemical Samples,
+for an explanation of the presence of negatives values.

d. Air Monitoring at Area G and Area AB.

In addition to the routine air monitoring performed for the environmental surveillance program, four additional air samplers are operated within the controlled area at TA-54, Area G and a fifth air sampler is operated at Area AB at TA-49 as part of a program monitoring on-site conditions at radioactive waste management areas.

These samplers measure air concentrations of ^{3}H, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am. The Area G samplers are located near active waste disposal operations areas, and the measured air concentrations reflect these operations. The air sampling results for 1992 are given in Tables IV-5 through IV-12. All measured air concentrations are slightly above background but are less than 0.1% of the DOE's radioactivity DAC guides for on-site areas. Although the radioactivity DACs for off-site areas do not apply to these on-site areas, the annual average air concentrations measured during 1992 also are less than 0.1% of these more restrictive DAC guides.

The air concentration of ^{238}Pu at sampler G-1 was measured during 1992 to be 3.8 aCi/m^3 (3.8 [|18.3] + 10^{-18} µCi/mL), which is less than 0.1% of the DOE DAC guide for on-site areas. In the past, ^{238}Pu concentrations at Station G-1 have been elevated due to a spill near the air sampler (EPG 1993).

Air concentrations of ^{3}H at air sampler G-2 were observed to be higher than readings from other samplers in the area. The 1992 average air concentration was measured to be 164.0 pCi/m^3 (164.0 [|38.4] + 10^{-12} µCi/mL), which is less than 0.1% of the on-site DAC guide. All other air samplers at Area G measured ^{3}H concentrations within the range of those observed elsewhere. The G-2 air sampler is located south of shafts used to dispose of higher level waste containing tritium and reflects the air concentrations close to these shafts.

Air concentrations of other radionuclides were also small percentages of the DAC guides and reflect ongoing operations at Area G during 1992. These estimates are confirmed by routine environmental monitoring in off-site areas. All measured air concentrations in off-site areas were less than 0.1% of the DOE concentration guides.

The measured air concentrations at the TA-49, Area AB, air sampler showed no increase above background levels. TA-49, Area AB is located along the southern boundary of the Laboratory where below ground experiments were performed with fissionable material (plutonium and enriched uranium) between 1959 and 1961.

2. Nonradioactive Air Quality.

a. Introduction. In addition to the radiological monitoring network, the Laboratory operates a network of nonradiological ambient air monitors. Because the Los Alamos area lies in a remote area far from large metropolitan areas and major sources of air pollution, extensive monitoring has not been conducted. The Laboratory operates monitors to routinely measure primary (or "criteria") pollutants, beryllium, acid precipitation, and visibility.

b. Monitoring Network. The nonradiological monitoring network consists of a variety of monitoring stations: on-site criteria pollutant monitor, 17 beryllium monitors, 1 perimeter acid rain monitor, and 1 perimeter visibility monitoring station.

c. Primary Pollutants. The New Mexico Environment Department (NMED) operates the Laboratory-owned criteria pollutant monitoring station at TA-49, adjacent to Bandelier National Monument. This station, which began operation in the second quarter of 1990, continuously monitors air concentrations of nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Filters to trap small particulate matter (less than 10 microns in diameter | PM_{10}) are collected every 6 days and weighed. The NMED analyzes all results and provides the results to the Laboratory. The data collected during 1992 are shown in Table IV-14. Measured ozone concentrations do not exceed the federal primary or secondary standard. However, the maximum hourly concentration exceeded the New Mexico ambient standard.

The ozone levels in many areas of the state exceeded state standards, although the causes are unknown; the ozone levels may result from transport from urban areas or may be generated by local sources. Because the New Mexico Air Quality Act does not specifically require compliance with state standards, there are no enforcement actions associated with these levels. Instead, the state uses these standards as guidelines for setting allowable emission limits for regulated sources based on modeling results. At present, LANL is not affected by these emission limits.

d. Beryllium. The Laboratory conducts beryllium monitoring at 17 monitoring stations: 1 regional station (28-44 km), 8 perimeter stations (0-4 km), and 8 on-site stations. Biweekly samples are taken, composited

Table IV-14. Nonradiological Ambient Air Monitoring Results for 1992

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary	Measured Concentrations
Sulfur dioxide[a]	Annual arithmetic mean	ppm	0.02	0.03		0.0005
	24 hours	ppm	0.10	0.14		
	+3 hours	ppm			0.05	
	+1 hour+	ppm				0.009
PM_{10}[a]	Annual arithmetic mean	$\mu g/m^3$		50	50	8
	24 hours	$\mu g/m^3$		150	150	21
Ozone[a]	+1 hour+	ppm		0.12	0.12	0.076
Nitrogen dioxide[a]	Annual arithmetic mean	ppm	0.05	0.053	0.053	0.002
	24 hours	ppm	0.10			
	+1 hour+	ppm				0.02
Beryllium[b]	Calendar quarter	ng/m^3				0.02
	30 day	ng/m^3	10			

[a]Measurements made at Bandelier Monitoring Compound.
[b]Measurement made at TA-52.

quarterly, and analyzed. Table IV-15 presents the results for 1992. All concentrations were well below the New Mexico ambient air standards.

e. Acid Precipitation. The Environmental Protection Group (EM-8) 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. The 1992 annual and quarterly deposition rates are presented in Table IV-16. The mean field pH is reported as a logarithmic mean. Previous Environmental Surveillance at Los Alamos reports have incorrectly reported field pH as a linear mean; corrected logarithmic field pH means for 1990 and 1991 are presented in Table D-9.

Deposition rates for the various ionic species vary widely and are somewhat dependent on precipitation. The highest deposition rates usually coincide with high precipitation. The lowest rates normally occur in the winter, probably reflecting the decrease in wind-blown dust. The ions in the rainwater are from both nearby and distant anthropogenic and natural sources. High nitrate and sulfate deposition may be caused by anthropogenic sources, such as motor vehicles, copper smelters, and power plants.

The natural pH of rainfall, without anthropogenic contributions, is unknown. Because of the contribution from entrained alkaline soil particles in the southwest, natural pH may be higher than 5.6, the pH of rainwater in equilibrium with atmospheric carbon dioxide. Some studies indicate that there may be an inverse relationship between elevation and pH.

f. Visibility. Since October 1988, LANL has operated a visibility monitoring station on site (TA-49, TA-33) adjacent to Bandelier National Monument. Measurements are performed using protocols established for the National Park Service, Forest Service, EPA, and other government agencies under the auspices of the IMPROVE (Interagency Monitoring of Protected Visual Environments) Network. Data collected to date indicate that the visibility near the monitoring site is generally very good, with the visual range exceeding 110 km (68 miles) or more most of the time (Table IV-17). On the clearest days, visibility exceeds 144 km (90 miles).

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

Table IV-15. Airborne Beryllium Concentrations for 1992

Station Location[a]	Total Air Volume (m^3)	No. of Samples	Concentrations (ng/m^3) Maximum[b]	Minimum[b]	Mean[b]
OFF-SITE STATIONS, UNCONTROLLED AREAS					
Regional (28|44 km)					
Pojoaque	68,874	4	0.03 (0.01)	0.01 (0.00)	0.02 (0.02)
Group Summary		4	0.03 (0.01)	0.01 (0.00)	0.02 (0.02)
Perimeter (0|4 km)					
Barranca School	63,526	4	0.05 (0.01)	0.01 (0.01)	0.03 (0.02)
Los Alamos, 48th Street	31,327	2	0.02 (0.00)	0.01 (0.00)	0.01 (0.00)
Shell Station	60,763	4	0.03 (0.02)	0.02 (0.00)	0.02 (0.02)
East Gate	17,777	1	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)
Royal Crest	13,782	1	0.02 (0.00)	0.02 (0.00)	0.02 (0.00)
White Rock - Piñon School	38,965	2	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)
Pajarito Acres	25,893	2	0.02 (0.00)	0.01 (0.00)	0.02 (0.00)
Bandelier	25,853	2	0.02 (0.00)	0.01 (0.00)	0.02 (0.00)
Group Summary		18	0.05 (0.01)	0.01 (0.00)	0.02 (0.03)
ON-SITE STATIONS, CONTROLLED AREAS					
TA-21 DP Site	37,193	2	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)
TA-21 Area B	24,837	2	0.03 (0.02)	0.02 (0.02)	0.02 (0.02)
TA-53 LAMPF	36,459	2	0.02 (0.01)	0.02 (0.01)	0.02 (0.02)
TA-52 Beta Site	26,710	2	0.02 (0.00)	0.01 (0.00)	0.02 (0.00)
TA-16 S-Site	12,793	1	0.02 (0.00)	0.02 (0.00)	0.02 (0.00)
TA-16-450	34,601	2	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)
TA-49	36,809	2	0.02 (0.01)	0.01 (0.00)	0.02 (0.01)
TA-3	24,200	2	0.02 (0.00)	0.01 (0.00)	0.01 (0.00)
Group Summary		15	0.03 (0.02)	0.01 (0.00)	0.02 (0.03)

[a]See Figure IV-4 for map of off-site perimeter and on-site stations.
[b]Uncertainties (|2 σ) are in parentheses.

meteorological factors like relative humidity and precipitation. At Bandelier, the visibility typically ranges from 64 to 144 km (40 to 90 miles). Most of the periods at the low end of this range typically have relatively high humidity or in other ways are adversely affected by weather conditions. Excluding periods of adverse weather, visibility at Bandelier is rarely (less than 10% of the time) less than about 88 km (55 miles).
During mid-October 1992, while a forest fire burned near the monitoring site, the average visibility was typically between 64 and 80 km (40 and 50 miles) even though the humidity was relatively low (between 20% and 60%). While these visibility ranges would be considered good in many urban areas and even in some remote areas of the eastern US, only a few episodes of lower visibility have been observed at Bandelier since monitoring began.

D. Surface Water Monitoring

1. Introduction.

Surface waters from off-site (regional and perimeter) and on-site (Laboratory and DOE lands) stations are monitored to routinely survey the environmental effects of Laboratory operations. As described in Section II.C, there are no perennial surface water flows that extend completely across the Laboratory in any of the canyons. Spring-fed flow originating on the flanks of the Jemez Mountains in Los Alamos Canyon maintains a flow into the Los Alamos

Table IV-16. Annual and Quarterly Wet Deposition Statistics for 1992

1992	Quarter				
	First	Second	Third	Fourth	Annual
Field pH (Log.)					
Mean	5.0	5.0	4.8	4.8	4.9
Minimum	4.8	4.8	4.7	4.7	4.7
Maximum	5.2	5.0	5.0	4.9	5.2
Precipitation (m)	3.9	9.4	12.2	10.1	35.6
Deposition (microequivalents per square meter)					
Ca	150	1,397	1,248	449	3,244
Mg	25	173	197	49	444
K	5	72	107	8	192
Na	52	365	265	144	826
NH_4	277	1,275	1,109	333	2,994
NO_3	484	1,484	1,791	629	4,388
Cl	85	226	254	85	650
SO_4	562	1,770	2,103	833	5,268
PO_4	NR	NR	NR	NR	NR
H	524	555	1,150	532	2,761

NR = Not reported.

Table IV-17. Median Visibility Measured at Bandelier National Monument in 1992

Season	Median Visibility km (mi)	
Winter (12/91|2/92)	124	(77)
Spring (3/92|5/92)	117	(73)
Summer (6/92|8/92)	104	(64)
Fall (9/92|11/92)	110	(68)

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 run-off occurs in two modes: (1) spring snowmelt run-off that occurs over highly variable periods of time (days to weeks) at a low discharge rate and sediment load, and (2) summer run-off from thunderstorms that occurs over a short period of time (hours) at a high discharge rate and sediment load. None of the surface waters within the Laboratory are a source of municipal, industrial, or irrigation water. The waters are used by wildlife.

Most canyons receive discharges from some of the approximately 140 NPDES permitted industrial and sanitary effluent outfalls, which support flows for varying distances in some of the canyons. The largest effluent-supported flow is in Sandia Canyon from the TA-3 Sanitary Sewage Plant. In 1992, 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. 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. (See Section V.C.2 for further explanation.) Routine chemical analyses of water samples have been carried out for many constituents over a number of years to monitor general water quality. For the stream channels that cross the DOE lands, nonradioactive chemical quality analyses of surface water samples from the on-site and downstream off-site locations are compared with NMED Livestock and Wildlife Watering Standards (NMWQCC 1991).

2. Monitoring Network.

The locations of surface water monitoring stations are shown in Figures IV-5 and IV-6 and are listed in Table D-10.

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

The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 37,037 km^2 (14,300 mi^2) in southern Colorado and northern New Mexico. Discharge for the periods of record (1895 to 1905 and 1909 to 1992) has ranged from a minimum of 1.7 m^3/s (60 ft^3/s) in 1902 to 683 m^3/s (24,400 ft^3/s) in 1920. The discharge for water year 1992 (October 1991 through September 1992) ranged from 13.4 m^3/s (479 ft^3/s) in October to 164 m^3/s (5,840 ft^3/s) in April (USGS 1993).

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 1992 ranged from 2.5 m^3/s (88 ft^3/s) in October to 73 m^3/s (2,610 ft^3/s) in June.

The station at Jemez on the Jemez River drains an area of the Jemez Mountains west of Los Alamos. The Fenton Hill Hot Dry Rock Geothermal Facility (TA-57) is located within this drainage. The drainage area is small, about 1,220 km^2 (471 mi^2). During water year 1992, discharge (as measured at the gage 3.5 mi north of Jemez) ranged from 0.6 m^3/s (22 ft^3/s) in September to 29 m^3/s (1,050 ft^3/s) in April. 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.

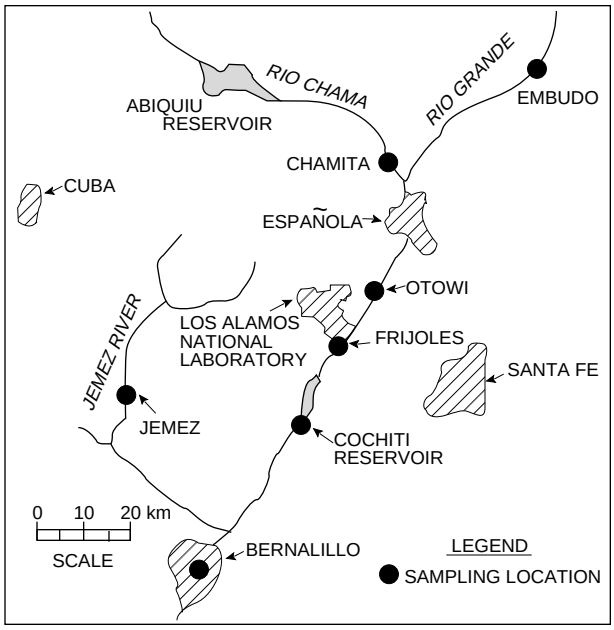


Figure IV-5. Off-site regional surface water sampling locations. (Map denotes general locations only; see Table D-10 for specific coordinates.)

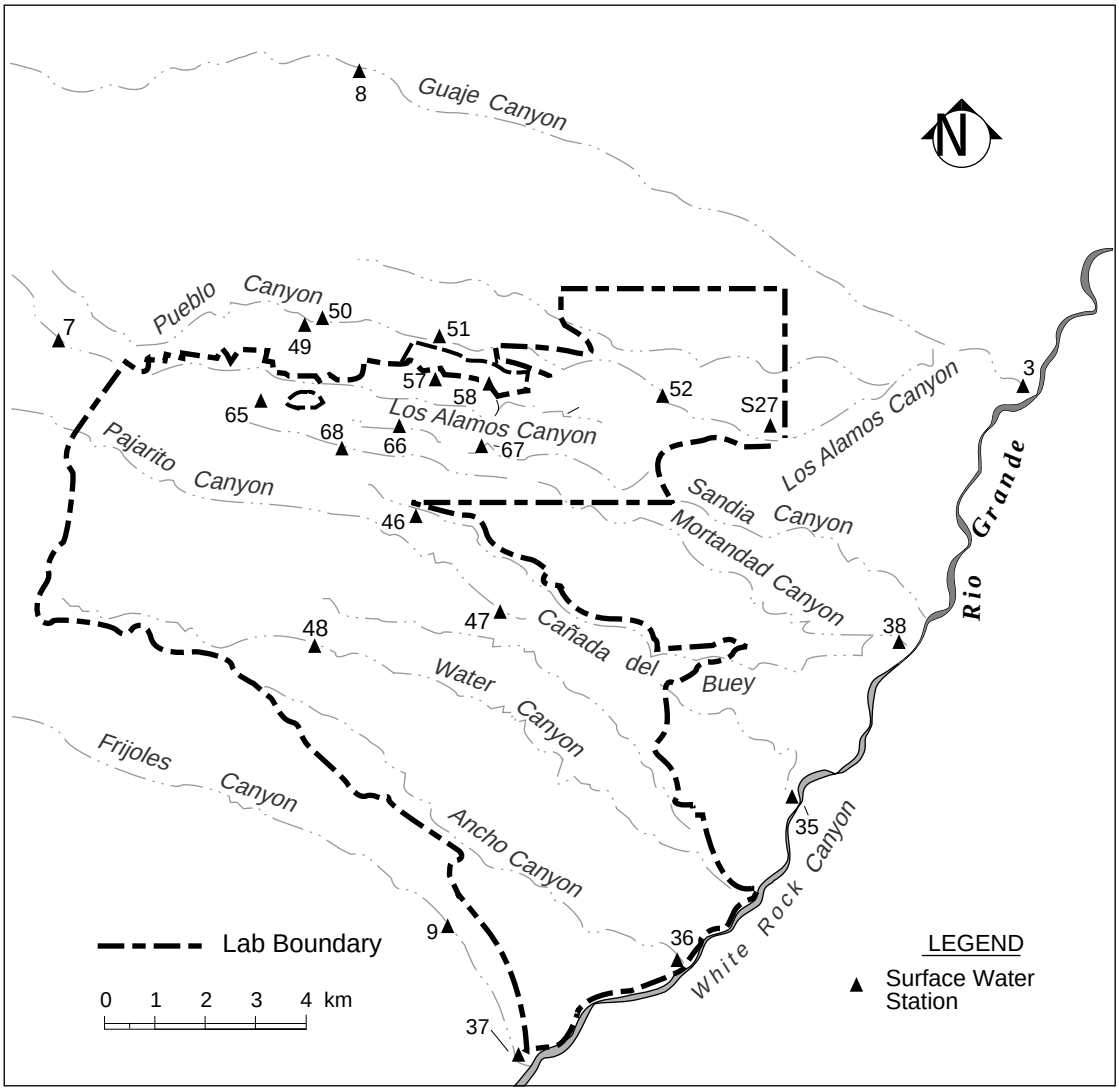


Figure IV-6. Surface water sampling locations for off-site perimeter and on-site Laboratory sites. (Map denotes general locations only. See Table D-10 for specific locations. The FIMAD system at the Community Reading Room also presents specific locations in a computer format.)

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

This effluent flow from Pueblo Canyon into Los Alamos Canyon generally extends to somewhere between Totavi (just east of the DOE-San Ildefonso Pueblo 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 run-off and on return flow from the shallow alluvium. In the past, discharges from the Los Alamos County Pueblo Canyon sanitary sewage plant upstream from the confluence with Acid Canyon maintained more regular flow; however, discharges to the stream from this plant were permanently discontinued in 1991. In lower Los Alamos Canyon, off-site surface water samples are collected at its confluence with the Rio Grande.

Other Areas. Off-site perimeter stations within about 4 km (2.5 mi) of the Laboratory boundary include surface water stations at Los Alamos Reservoir, Guaje Canyon, and Frijoles Canyon. Los Alamos Reservoir, in upper Los Alamos Canyon on the flanks of the mountains west of Los Alamos, has a capacity of 51,000 m^3 (41 ac ft) and a drainage area of 16.6 km^2 (6.4 mi^2) above the intake. The reservoir is used for recreation and limited storage of water for irrigation of landscaping in the townsite.

The station in Guaje Canyon is below Guaje Reservoir, which is located in upper Guaje Canyon and has a capacity of 871 m^3 (0.7 ac-ft) and a drainage area above the intake of about 14.5 km^2 (5.6 mi^2). Flow into the reservoir is maintained by perennial springs. The stream and reservoir are used for recreation and for storing water used for landscape irrigation in the townsite.

Surface water flow in Frijoles Canyon is sampled at Bandelier National Monument Headquarters. Flow in the canyon is from spring discharge in the upper reach of the canyon. The drainage area above the monument head-quarters 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.

c. 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.

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 IV.E 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 county-DOE boundary. Some of this effluent flow infiltrates the tuff and maintains a shallow body of perched allu-vial 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 IV-6).

DP Canyon, a small tributary of Los Alamos Canyon, received treated radioactive liquid waste effluents between 1952 and 1984. Some residuals remain, primarily associated with sediments that are subject to resuspension and redissolution in surface flow. DP Canyon presently receives some sanitary effluent from the treatment plant at TA-21. Sampling stations consist of two surface water stations in DP Canyon, DPS-1 and DPS-4.

In the upper reach of Los Alamos Canyon (above Station LAO-1), there were releases of treated and untreated radioactive effluents during the earliest years of operations at TA-1 (late 1940s) and some release of water from the

research reactor at TA-2. The Los Alamos Canyon drainage also received discharge containing some radioactivity in previous years from the sanitary sewage lagoon system at LAMPF (TA-53). (In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon.) There is normally some surface flow in the westernmost portion of Los Alamos Canyon within Laboratory boundaries that is maintained by discharge from the Los Alamos Reservoir. This flow generally infiltrates the shallow alluvium in the canyon and is depleted before it reaches the eastern margin of the Laboratory at State Road 4. Water quality in this portion of Los Alamos Canyon is monitored through samples taken of the alluvial water. (See Section VII for further information.) Snowmelt will often saturate the alluvium sufficiently to result in some surface flow beyond State Road 4 for varying periods in the spring. In the fall of 1991, the USGS, under contract to the Laboratory, resumed continuous operation of a stream flow gaging station a short distance upstream from State Road 4.

Mortandad Canyon has a small drainage area that heads at TA-3. Industrial liquid wastes containing radionuclides are collected and processed at the industrial waste treatment plant at TA-50, which began operating in 1963. After treatment the effluents are released into Mortandad Canyon. Most of the residual contamination is now associated with the sediments in the canyon. The inventory of transuranic contaminants (about 400 mCi) is entirely contained on site (Stoker 1991). Hydrologic studies in the canyon were initiated by the USGS in 1960. Since that time, there has been no continuous surface water flow from the upper and middle reaches of the canyon down to or beyond the Laboratory's boundary; the small drainage area in the upper part of the canyon results in limited run-off and a thick section of unsaturated alluvium in the lower canyon allows rapid infiltration and storage of run-off 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 run-off events and settle out transported sediments. It is approximately another 1.5 km (1 mi) downstream to the Laboratory boundary with San Ildefonso Pueblo.

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.

3. Analytical Results.

a. Radiochemical Analyses. The results of radiochemical analyses of surface water samples for 1992 are listed in Table IV-18. 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 ^{239,240}Pu analyses for Ancho and Chaquehui canyons at the Rio Grande and the ^{238}Pu analyses for Frijoles at Rio Grande and Rio Grande at Embudo were slightly above detection limits. They did not have ratios expected for worldwide fallout (^{239,240}Pu about 20 times ^{238}Pu) and did not have detectable levels in 1991 samples. Similarly, the measurements taken last year that were slightly above detection limits were not detected this year. The tritium level in this year's sample from Frijoles Stream at Bandelier National Monument

Table IV-18. Radiochemical Analyses of Surface Waters

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
OFF-SITE STATIONS										
REGIONAL STATIONS										
Rio Chama at Chamita	0.6_(0.3)[b]	N/A[c]	20.7_(64.3)	0.7_(0.1)	_0.008_(0.011)[d]	0.000_(0.020)	N/A	2_(1)	3_(1)	548_(190)
Rio Chama at Embudo	0.3_(0.3)	N/A	115.0_(91.9)	0.7_(0.1)	0.040_(0.030)	0.000_(0.020)	N/A	2_(1)	3_(1)	548_(190)
Rio Grande at Otowi	0.6_(0.3)	N/A	54.4_(63.8)	1.0_(0.1)	0.009_(0.011)	0.004_(0.004)	N/A	3_(1)	3_(1)	452_(190)
Rio Grande at Frijoles	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Cochiti	0.3_(0.3)	N/A	126.0_(72.0)	1.2_(0.1)	0.000_(0.010)	_0.004_(0.004)	N/A	2_(1)	6_(1)	452_(190)
Rio Grande at Bernalillo	0.3_(0.3)	N/A	175.0_(102.0)	1.2_(0.1)	0.013_(0.016)	0.009_(0.009)	N/A	3_(1)	4_(1)	405_(190)
Jemez River	0.5_(0.3)	N/A	231.0_(105.0)	0.5_(0.1)	0.004_(0.012)	0.008_(0.008)	N/A	4_(1)	3_(1)	24_(167)
PERIMETER STATIONS										
Radioactive Effluent Release Areas										
Acid-Pueblo Canyon										
Acid Weir	0.5_(0.3)	N/A	1.9_(1.4)	0.6_(0.2)	0.041_(0.028)	3.010_(0.290)	0.137_(0.024)	3_(1)	12_(1)	500_(100)
Pueblo 1	1.5_(0.4)	N/A	3.5_(1.3)	< 0.2_(0.0)	_0.008_(0.012)	0.029_(0.031)	0.021_(0.012)	0_(1)	15_(2)	10_(90)
Pueblo 2	0.3_(0.3)	N/A	1.9_(1.1)	< 0.2_(0.0)	0.004_(0.014)	0.045_(0.027)	0.042_(0.014)	0_(1)	13_(1)	120_(90)
DP-Los Alamos Canyon										
Los Alamos Canyon Reservoir	0.3_(0.3)	N/A	2.9_(1.1)	< 0.6_(0.0)	0.004_(0.016)	0.018_(0.014)	N/A	1_(0)	4_(1)	110_(90)
Los Alamos at Otowi	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas										
Guaje at SR 4	0.6_(0.3)	N/A	0.9_(0.5)	< 0.6_(0.0)	0.000_(0.010)	0.021_(0.011)	N/A	1_(0)	4_(1)	0_(90)
Mortandad at Rio Grande	0.6_(0.3)	_0.4_(1.5)	_0.3_(1.3)	2.7_(0.3)	0.007_(0.018)	0.007_(0.020)	_0.005_(0.030)	4_(2)	14_(2)	20_(90)
Pajarito at Rio Grande	0.3_(0.3)	_0.2_(1.5)	2.3_(1.2)	1.0_(0.2)	_0.007_(0.016)	0.014_(0.014)	0.008_(0.030)	2_(1)	4_(1)	80_(90)
Frijoles at National Monument Headquarters	0.5_(0.3)	N/A	0.9_(1.2)	< 0.6_(0.0)	0.017_(0.018)	0.011_(0.016)	N/A	1_(0)	5_(1)	170_(90)
Frijoles at Rio Grande	0.1_(0.3)	0.1_(1.5)	0.4_(0.4)	1.3_(0.2)	0.031_(0.015)	0.016_(0.012)	0.024_(0.030)	0_(1)	8_(1)	700_(100)
ON-SITE STATIONS										
Radioactive Effluent Release Areas										
Acid-Pueblo Canyon										
Pueblo 3	0.6_(0.3)	N/A	3.1_(1.2)	< 0.2_(0.0)	_0.004_(0.008)	0.064_(0.032)	0.028_(0.014)	0_(1)	13_(1)	220_(100)
Pueblo at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table IV-18. (Cont.)

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
Radioactive Effluent Release Areas (Cont.)										
Mortandad Canyon										
Mortandad at GS-1	11.9_(1.0)	134.4_(8.6)	3.9_(1.5)	0.6_(0.2)	0.224_(0.034)	0.505_(0.050)	0.875_(0.068)	1_(1)	66_(7)	120_(100)
DP-Los Alamos Canyon										
DPS-1	0.8_(0.3)	19.6_(1.4)	44.8_(7.1)	2.2_(0.3)	_0.010_(0.030)	0.182_(0.033)	0.300_(0.300)	1_(1)	40_(4)	400_(100)
DPS-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas										
Cañada del Buey at SR-4	0.6_(0.3)	N/A	2.5_(1.2)	1.3_(0.2)	0.000_(0.010)	0.016_(0.014)	N/A	3_(1)	10_(1)	60_(90)
Pajarito Canyon	0.4_(0.3)	N/A	1.8_(1.2)	< 0.2_(0.0)	_0.013_(0.013)	0.018_(0.011)	N/A	0_(1)	5_(1)	0_(90)
Water Canyon at Beta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	0.4_(0.3)	0.0_(1.5)	3.3_(1.3)	0.4_(0.2)	_0.004_(0.004)	0.022_(0.012)	0.032_(0.030)	1_(1)	5_(1)	_30_(90)
Sandia Canyon										
SCS-1	1.1_(0.3)	N/A	0.8_(1.5)	< 0.2_(0.0)	0.000_(0.010)	0.000_(0.010)	N/A	1_(1)	12_(1)	_40_(90)
SCS-2	1.0_(0.3)	N/A	2.0_(1.2)	0.3_(0.2)	_0.004_(0.012)	0.004_(0.008)	N/A	1_(1)	9_(1)	0_(90)
SCS-3	0.8_(0.3)	N/A	0.9_(1.0)	0.3_(0.2)	0.004_(0.013)	0.009_(0.009)	N/A	2_(1)	14_(2)	0_(90)
Background Statistical Limit+	_	0.87	0.44	4.4	0.006	0.023	_	_	_	7.9

[a]Tritium as tritiated water in moisture distilled from sample.

[b]Radioactivity counting uncertainties _(_1 standard deviation) are shown in parentheses.

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

[d]See Section VIII.D.3 for an explanation of the presence of negative values.

+Average plus 2 standard deviations of measurements in regional samples 1974_1986 _(Purtymun 1987a).

Headquarters is back down to essentially detection limit levels. Cesium measurements in past years have raised some questions about the potential presence of ^{137}Cs contamination in areas where it would not be expected. These questions were raised because the detection limit of the analytical method was relatively high in comparison with the relevant guidelines or standards and also higher than typical environmental levels. A new method was implemented during 1992 by the Environmental Chemistry Group (See Section VIII.D.1.b). This method has a much lower detection limit, about 2 pCi/L. Some 1992 samples were analyzed by both methods; in such cases only the result generated by the newer method is shown in the table. Those from locations where only worldwide fallout levels of cesium would be expected had results very near the detection limits of the new method, much lower than measured by the older method, and much lower than reported in previous years' reports. The samples analyzed only by the older method are still inconclusive because of the large individual measurement uncertainties; however, none are more than 10% of the DOE guide. All samples in 1993 will be analyzed by the new method.

Multiple measurements of radioactivity in samples of run-off in Pueblo and Los Alamos canyons, as well as several additional locations, are presented and discussed in Section IV.E.5.a, Sediment and Soil Monitoring.

One additional type of measurement was made on some water samples in 1992 to enhance understanding of transport mechanisms. These analyses were made for plutonium on the suspended solids filtered from the water samples (see Section VII.3.a). This was done in order to estimate the fraction of activity associated with the liquid and suspended solid fractions. Because many results included measurements below detection limits, the calculated percentages for individual samples had very large uncertainties. However, the results fell into two basic groups, confirming expectations on the transport of materials in the different watercourses. Samples from the Rio Grande (grab samples taken at the surface) and from natural flowing streams (Guaje Canyon, Los Alamos Canyon west of the Laboratory, Frijoles Stream, and Ancho and Chaquehui streams at the Rio Grande) contained about 5% to 15% of the total plutonium associated with filterable solids. Samples taken from watercourses within the Laboratory (Pueblo, Sandia, and Pajarito canyons and Canada del Buey) contained about 50% to 80% of the total plutonium associated with the filterable solids. Even when the activity contained in the suspended solids is taken into account, the total radioactivity measured in each sample was less than 20% of the DOE guide for plutonium in ingested water.

b. Nonradioactive Analyses. The results of major chemical constituents in surface water samples for 1992 are listed in Table IV-19. The results are 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. None of the measurements exceed any standards for livestock and wildlife watering.

The results of metal analyses on surface water samples for 1992 are listed in Table IV-20. Trace metals were not analyzed for regional stations in 1992. The levels are generally consistent with previous observations. None of the measurements exceed any limits for livestock and wildlife watering (see Appendix A).

Very few analyses for organics in surface water were performed during 1992 because of a ban on generating potential mixed wastes (see Section III.B.1.a). The surface waters sampled were from some of the regional stations taken late in the year, such as Embudo, Otowi, Cochiti, and Bernalillo on the Rio Grande; Chamita on the Chama River; the Los Alamos Reservoir; and Guaje Canyon. The parameters analyzed included the volatile and semivolatile organics and PCBs (see Section VIII.D for detailed listings of parameters). Possible traces of acetone were found in two samples from Chamita and Embudo (22 and 28 ng/mL compared with the quantification limit of 20 ng/mL) and 1,2-dichloroethane (7 ng/mL compared with the quantification limit of 5 ng/mL). However, there were some irregularities in the analytical laboratory's quality assurance program, and the validity of the results may be questionable. Furthermore, both Chamita and Embudo are a considerable distance upstream from the Laboratory.

4. 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 IV-7. 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 San Ildefonso Pueblo. In general, there has been a

Table IV-19. Chemical Quality of Surface Waters (mg/L)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Total Hardness	pH[b]	Conductivity (µmhos/cm)
OFF-SITE STATIONS																	
REGIONAL STATIONS																	
Rio Chama at Chamita	16	39	8.3	2	15	3	0.2	<5	74	<0.0	62	0.23	N/A[c]	140	131	8.3	317
Rio Grande at Embudo	17	31	5.5	2	15	6	0.3	<5	79	<0.0	31	0.26	N/A	182	99	8.3	242
Rio Grande at Otowi	21	37	7.0	2	16	7	0.3	<5	89	<0.0	44	0.23	N/A	238	122	8.1	307
Rio Grande at Frijoles	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Cochiti	18	37	6.6	2	21	10	0.3	<5	75	<0.0	47	0.25	N/A	256	120	8.2	226
Rio Grande at Bernalillo	18	37	6.4	2	20	10	0.3	<5	76	<0.0	49	0.23	N/A	244	117	8.2	268
Jemez River	18	27	2.9	2	12	11	0.3	<5	71	<0.0	6	0.22	N/A	156	80	7.9	160
PERIMETER STATIONS																	
Radioactive Effluent Release Areas																	
Acid-Pueblo Canyons																	
Acid Weir	24	11	1.7	4	44	28	0.4	<5	82	N/A	8	0.38	N/A	322	33	7.1	247
Pueblo 1	86	15	4.0	15	68	36	0.6	<5	86	N/A	27	16.60	N/A	470	55	7.1	473
Pueblo 2	86	15	3.8	15	70	35	0.6	<5	101	N/A	27	7.10	N/A	474	52	7.3	471
Los Alamos Canyon																	
Los Alamos Canyon Reservoir	39	8	2.6	3	6	6	0.2	<5	29	0.0	5	<0.04	<0.01	118	30	8.1	84
Los Alamos at Rio Grande	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas																	
Guaje Canyon	56	8	2.6	3	7	2	0.2	<5	37	0.1	5	<0.04	<0.01	128	31	7.7	90
Mortandad at Rio Grande	99	31	8.8	17	85	48	0.5	<1	150	9.0	32	7.05	N/A	1102	113	8.0	614
Pajarito at Rio Grande	73	23	4.6	3	14	32	0.5	<1	82	<0.0	32	0.65	N/A	752	76	8.3	172
Frijoles at Park Headquarters	65	9	3.0	2	10	4	0.3	<5	47	0.1	4	<0.04	<0.01	140	36	7.8	83
Frijoles at Rio Grande	62	11	3.1	2	10	32	0.2	4	51	0.0	32	<0.04	N/A	992	40	8.0	75
ON-SITE STATIONS																	
Radioactive Effluent Release Areas																	
Acid-Pueblo Canyons																	
Pueblo 3	86	15	3.8	15	70	35	0.6	<5	97	N/A	27	6.85	N/A	422	53	7.3	450
Pueblo at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad Canyon																	
GS-1	61	31	2.2	3	30	8	0.7	2	133	N/A	7	3.57	N/A	206	85	8.3	270

Table IV-19. (Cont.)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Total Hardness	pH[b]	Conductivity (µmho/cm)
Radioactive Effluent Release Areas (Cont.)																	
DP-Los Alamos Canyons																	
DPS-1	26	23	1.6	3	45	12	0.6	<1	100	N/A	7	0.36	N/A	148	63	7.4	247
DPS-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas																	
Cañada del Buey	37	10	2.5	3	22	10	0.5	<5	12	0.1	28	0.08	<0.01	454	35	5.7	94
Pajarito Canyon	38	25	6.3	4	21	17	0.3	<5	95	0.0	4	0.12	<0.01	196	88	7.2	173
Water Canyon at Beta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	81	14	3.2	2	12	3	0.4	16	55	<0.0	4	0.91	N/A	90	48	8.9	100
Sandia Canyon																	
SCS-1	24	22	5.5	12	48	27	0.5	<5	88	3.1	28	6.87	0.11	762	77	7.7	380
SCS-2	74	21	4.0	9	67	31	0.5	<5	100	1.8	60	1.88	0.02	358	69	8.0	430
SCS-3	75	21	4.0	8	67	32	0.5	<5	104	1.9	60	1.87	0.02	362	69	8.1	324
Drinking Water System Limit					250[d]		4[e]					250[d]	10[e]		500[d]		6.8-8.5[d]
Livestock and Wildlife Watering								None in this table[f]									

[a]Total dissolved solids.
[b]Standard Units.
[c]N/A means analysis not performed, lost in analysis, or not completed.
[d]Maximum contaminent level (MCL) for secondary constituents, applicable to drinking water system, given here for comparison only, see Appendix A.
[e]MCL for primary constituents, applicable to drinking water system, given here for comparison only, see Appendix A.
[f]NM Water Quality Standards applicable to streams for designated uses, given here for comparison only, see Appendix A.

Table IV-20. Trace Metals in Surface Waters (mg/L)

Stations	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg*
OFF-SITE STATIONS												
REGIONAL STATIONS (Data was not analyzed in CY92)												
PERIMETER STATIONS												
Radioactive Effluent Release Areas												
Acid-Pueblo Canyons												
Weir	0.0012	1.00	0.0043	0.030	0.0224	0.0020	0.0003	0.0101	<0.020[a]	0.007	0.83	<0.0001
Pueblo 1	0.0010	0.19	0.0076	0.210	0.0091	0.0010	0.0003	0.0052	<0.020	0.017	0.28	<0.0001
Pueblo 2	0.0004	0.16	0.0078	0.200	0.0068	<0.0010	0.0003	0.0066	<0.020	0.012	0.30	<0.0001
Los Alamos Canyon												
Los Alamos Canyon Reservoir	<0.0006	0.14	<0.0020	<0.020	0.0158	<0.0010	<0.0020	<0.0050	<0.020	<0.002	0.14	<0.0001
Los Alamos at Rio Grande	N/A[b]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas												
Guaje Canyon	<0.0006	0.11	<0.0020	<0.020	0.0181	<0.0010	<0.0020	<0.0050	<0.020	<0.002	0.11	<0.0001
Mortandad at Rio Grande	<0.0050	0.09	<0.0020	0.340	0.0487	0.0005	0.0004	0.0040	<0.010	0.026	0.07	<0.0001
Pajarito at Rio Grande	<0.0050	0.01	<0.0020	0.021	0.0415	0.0005	0.0003	0.0070	<0.010	0.012	0.02	<0.0001
Frijoles at Park Headquarters	<0.0006	0.12	<0.0020	<0.020	0.0156	<0.0010	<0.0020	<0.0050	<0.020	<0.002	0.16	<0.0001
Frijoles at Rio Grande	<0.0050	0.14	<0.0020	<0.005	0.0161	0.0005	0.0002	0.0020	<0.010	0.002	0.17	<0.0001
ON-SITE STATIONS												
Radioactive Effluent Release Areas												
Acid-Pueblo Canyons												
Pueblo 3	0.0005	0.33	0.0081	0.200	0.0073	0.0010	0.0003	0.0292	<0.020	0.013	0.45	<0.0001
Pueblo at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad Canyon												
GS-1	<0.0300	0.11	<0.0020	0.040	0.0300	<0.0020	<0.0100	<0.0200	<0.004	0.040	0.23	0.0003
DP-Los Alamos Canyons												
DPS-1	<0.0300	1.38	0.0035	0.058	0.1000	<0.0020	<0.0100	<0.0200	<0.004	<0.030	1.10	0.0010
DPS-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas												
Cañada del Buey	0.0012	3.50	0.0058	0.070	0.1450	0.0029	<0.0005	0.0170	N/A	0.021	3.40	0.0003
Pajarito Canyon	<0.0005	0.09	<0.0020	0.020	0.0719	0.0026	<0.0005	0.0080	N/A	<0.005	1.30	<0.0001
Water Canyon at Beta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	<0.0050	0.05	<0.0020	0.018	0.0266	<0.0005	<0.0005	0.0010	<0.010	0.007	0.06	<0.0001
Sandia Canyon												
SCS-1	0.0011	0.21	0.0051	0.060	0.0382	<0.0005	0.0010	0.0180	N/A	0.009	0.44	0.0003
SCS-2	0.0011	0.62	0.0050	0.050	0.0348	0.0005	0.0006	0.0180	N/A	0.009	0.74	0.0001
SCS-3	0.0005	0.55	0.0051	0.050	0.0336	0.0010	0.0022	0.0210	N/A	0.008	0.67	0.0001
Drinking Water System Limit	0.05[c]		0.05[c]				0.01[c]	0.05[c]		1.0[d]	0.3[d]	0.002[c]
Livestock and Wildlife Watering Limit[e]		5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01

*Data on additional trace metals in surface water is continued on page IV-38.

Table IV-20. (Cont.)

Station	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
OFF-SITE STATIONS											
REGIONAL STATIONS (Data was not analyzed in CY92)											
PERIMETER STATIONS											
Radioactive Effluent Release Areas											
Acid-Pueblo Canyons											
Weir	0.005	0.002	<0.02	0.0056	0.0003	<0.002	N/A	0.0542	0.0003	0.01	0.020
Pueblo 1	0.008	0.002	<0.02	0.0015	<0.0002	<0.002	N/A	0.0819	<0.0002	0.02	0.019
Pueblo 2	0.002	0.002	<0.02	0.0017	<0.0002	<0.002	N/A	0.0780	<0.0002	0.02	0.016
Los Alamos Canyon											
Los Alamos Canyon Reservoir	<0.005	<0.001	<0.02	<0.0006	<0.0006	<0.002	N/A	0.0560	<0.0006	0.01	0.010
Los Alamos at Rio Grande	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas											
Guaje Canyon	<0.005	<0.001	<0.02	<0.0006	<0.0006	<0.002	N/A	0.0420	<0.0006	0.00	<0.003
Mortandad at Rio Grande	0.017	0.011	<0.01	0.0005	0.0012	<0.002	N/A	0.1320	<0.0002	0.01	0.029
Pajarito at Rio Grande	0.003	0.001	<0.01	0.0005	0.0006	<0.002	N/A	0.1200	<0.0002	0.01	<0.001
Frijoles at Park Headquarters	<0.005	<0.001	<0.02	<0.0006	<0.0006	<0.002	N/A	0.0540	<0.0006	0.01	<0.003
Frijoles at Rio Grande	0.004	0.001	<0.01	<0.0002	0.0004	<0.002	N/A	0.0550	<0.0002	<0.01	0.016
ON-SITE STATIONS											
Radioactive Effluent Release Areas											
Acid-Pueblo Canyons											
Pueblo 3	0.008	0.003	<0.02	0.0022	<0.0002	<0.002	N/A	0.0759	0.0002	0.02	0.023
Pueblo at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad Canyon											
GS-1	<0.002	1.200	<0.01	0.0430	<0.0010	<0.002	N/A	0.0600	<0.0010	<0.03	0.010
DP-Los Alamos Canyons											
DPS-1	0.160	<0.030	<0.01	0.0050	<0.0020	<0.002	N/A	0.0900	0.0008	<0.03	0.040
DPS-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other Areas											
Cañada del Buey	0.081	0.139	<0.02	0.0114	<0.0003	<0.002	<0.010	0.0735	<0.0003	0.03	0.116
Pajarito Canyon	0.191	0.003	<0.02	<0.0003	<0.0003	<0.002	0.017	0.1630	<0.0003	0.02	0.028
Water Canyon at Beta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	<0.001	<0.001	<0.01	0.0002	<0.0005	<0.002	N/A	0.0580	<0.0002	0.01	<0.001
Sandia Canyon											
SCS-1	0.037	0.380	<0.02	<0.0003	0.0005	<0.002	0.024	0.0965	<0.0003	0.05	0.010
SCS-2	0.022	0.223	<0.02	0.0020	0.0017	<0.002	<0.0100	0.0969	<0.0003	0.04	0.038
SCS-3	0.017	0.213	<0.02	<0.0003	0.0007	<0.002	<0.0100	0.1010	<0.0003	0.05	0.033
Drinking Water System Limit	0.05[d]			0.05[c]		0.01[c]					5.0[d]
Livestock and Wildlife Watering Limit[e]				0.1		0.05				0.1	25

[a]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[b]N/A means analysis not performed, lost in analysis, or not completed.
[c]Maximum contaminent level for primary constituents, applicable to drinking water system, given here for comparison only, see Appendix A.
[d]Maximum contaminent level for secondary constituents, applicable to drinking water system, given here for comparison only, see Appendix A.
[e]New Mexico Water Quality Standards applicable to streams for designated uses, given here for comparison only, see Appendix A.

decrease in the combined levels of ^{238}Pu and $^{239,240}Pu$ (in solution) over three and a half decades. With continual improvements in detection limits, it is still possible for some residuals to be detected. In the 1992 sample, the plutonium activity in the liquid portion of the sample (0.06 pCi/L) represents about 25% of the total activity. 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, Sediment and Soil Monitoring.

Figure IV-7. Tritum and plutonium concentrations at the Pueblo-3 sampling station.

E. Sediment and Soil Monitoring

1. Introduction.

Sediments and soils from off-site (regional and perimeter) and on-site (Laboratory and DOE land) locations are monitored to provide routine surveillance of environmental effects of Laboratory operations. One major mechanism of transport of contaminants is the hydrologic cycle, principally in surface water; sheet erosion of soil and the movement of suspended sediment or the bed load in surface run-off in canyons 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 Laboratory.

There are no standards directly applicable to radioactive contamination of soils or sediments; rather, the levels of contaminants in soils or sediments must be interpreted by means of pathway analyses that determine the consequences in terms of dose to humans if the contaminated particles are either ingested or inhaled. (See Section V.C.2 for further information.) As an indication of environmental contamination levels attributable to Los Alamos 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 limits for worldwide fallout levels of ^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$ and natural background levels of total uranium in northern New Mexico soils and sediments (Purtymun 1987a). The average concentration level in these samples plus twice the standard deviation of the mean was adopted as an indicator of an approximate upper limit for worldwide fallout or natural background concentrations.

2. Monitoring Network.

The sediment sampling locations are shown in Figure IV-8 (off-site regional), Figure IV-9 (off-site perimeter and on site), and Figure IV-10 (solid waste management areas) and are listed in Table D-11. The locations of the soil sampling locations are shown in Figure IV-8 (off-site regional) and Figure IV-11 (off-site perimeter and on site), and listed in Table D-12. The sediment stations are organized in the same groupings as the surface water sampling locations discussed in the previous section, Surface Water Monitoring, which provides the basic rationale for the groupings and related historic information.

a. Off-Site Regional Stations. The regional stations for both soils and stream sediments are located in the three major drainages in northern New Mexico surrounding the Laboratory. One additional soil station is located near Santa Cruz Lake, across the Rio Grande valley to the northeast of the Laboratory.

Special samples of lake sediments are also collected from three locations each in Abiquiu Reservoir and Lake Heron on the Rio Chama upstream from Los Alamos and three locations in Cochiti Reservoir on the Rio Grande downstream of Los Alamos. The three lakes are the nearest upstream and downstream lakes. One kg samples of these sediments (100 times the mass usually used) are used to obtain lower detection limits for ^{238}Pu and $^{239,240}Pu$ analysis. Large samples increase the sensitivity of the analyses and are necessary so that plutonium concentrations due to worldwide fallout from atmospheric tests can be effectively evaluated.

b. Off-Site Perimeter Stations. The radioactive effluent release area sediment stations are located to represent the off-site drainages affected by transport of residuals from past releases, as discussed in the previous section. The off-site areas in Acid and Pueblo canyons contain an estimated 150 mCi of plutonium from effluent releases into Acid Canyon from 1944 through 1964 (ESG 1981). The three sampling stations include one in Acid Canyon at Acid Weir just above the confluence with Pueblo Canyon and two downstream in Pueblo Canyon at Pueblo 1 and Pueblo 2.

The off-site portion of Los Alamos Canyon contains an estimated 30 mCi of plutonium. Table D-10 lists the three stations that are sampled routinely. Transport of contaminated sediments off site is discussed in Section IV.E.5. 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 San Ildefonso Pueblo land so that conditions down gradient from the on-site residual contamination can be documented, as discussed in the previous section. Also, sediment samples have been taken from the Rio Grande at confluences with major canyons that cross the Laboratory and adjacent public or San Ildefonso Pueblo lands.

Six soil sampling stations within 4 km (2.5 mi) of the Laboratory perimeter are located to reflect the soil conditions of the inhabited areas to the north and east of the Laboratory.

c. 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 (see Section IV.D.2 for historic information). 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 IV.E.5. No off-site transport of contaminated sediments from Mortandad Canyon has been measured.

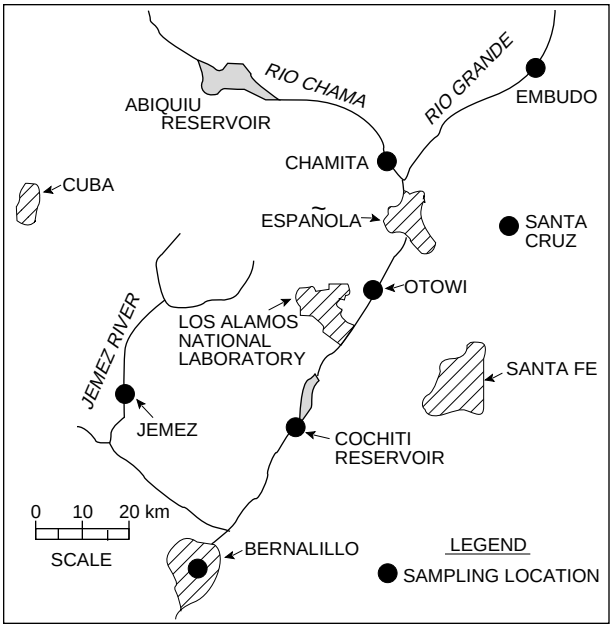


Figure IV-8. Off-site regional sampling locations for sediments and soil. (Additional sediment samples are taken from the Rio Grande between Otowi and Cochiti, see Table D-11 and Figure IV-9.)

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 IV-10a), 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 Area G in suspended or bed 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 in the land surface that occurred during earlier handling of the wastes.

From 1959 to 1961, hydronuclear experiments were conducted in underground shafts that ranged in depth from 15 to 36 m (49 to 118 ft) beneath the surface of the mesa at TA-49 (Purtymun 1987b, ESG 1988). The experiments involved a combination of conventional (chemical) high explosives usually in a nuclear weapons configuration. The quantity of fissile material was kept far below the amount required for a nuclear explosion (Purtymun 1987b). The residuals of the experiments were confined in the shafts and left in place. The site is designated Solid Waste Management Area AB. A surface contamination incident occurred in 1960 during excavation of a shaft, and some erosional transport of radioactivity occurred (Purtymun 1987b, ESG 1988). Eleven sediment stations were established in 1972 to monitor surface sediments in natural drainage from the experimental area. Another station (AB-4A) was added in 1981 as the drainage changed (Figure IV-10b). These sediment monitoring stations are sampled annually.

The other areas group contains eight sediment sampling stations, which are located where the canyons intersect State Road 4 (all Laboratory facilities in or adjacent to those canyons are located upgradient of this highway).

The on-site soil sampling stations (Table D-11 and Figure IV-11) are located near Laboratory facilities that are the principal sources of airborne emissions or that could be potential contaminant sources.

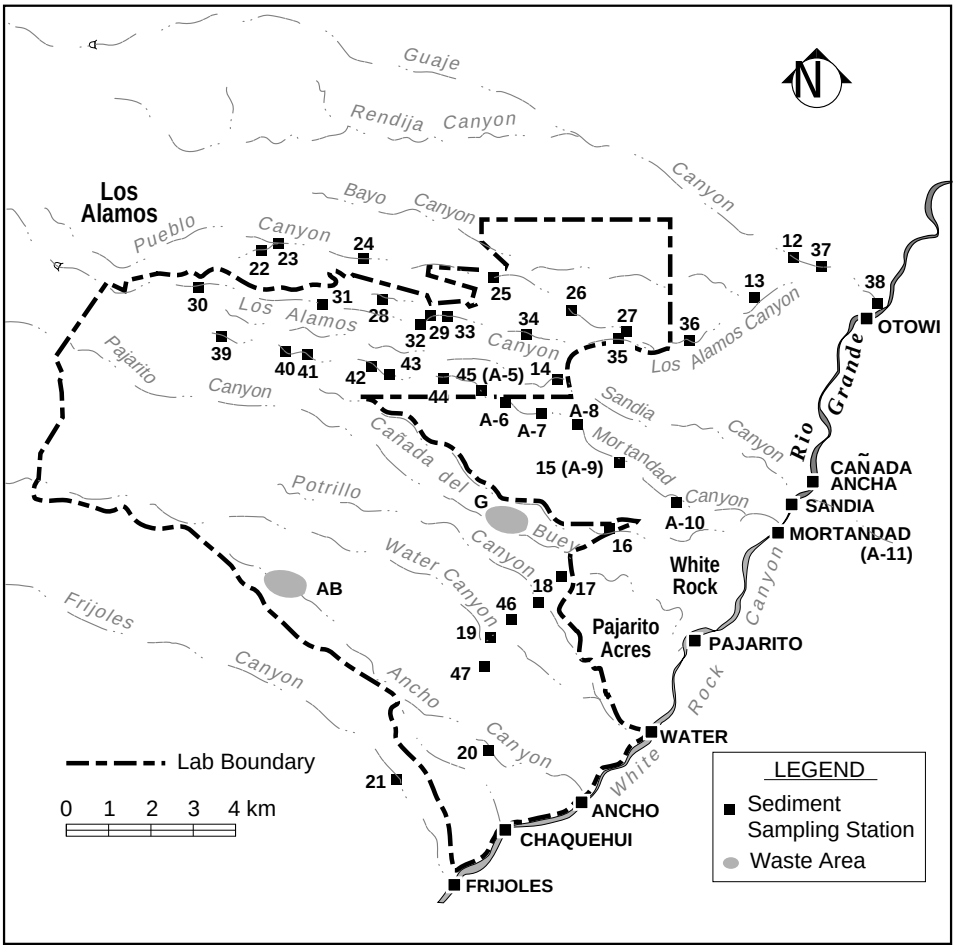


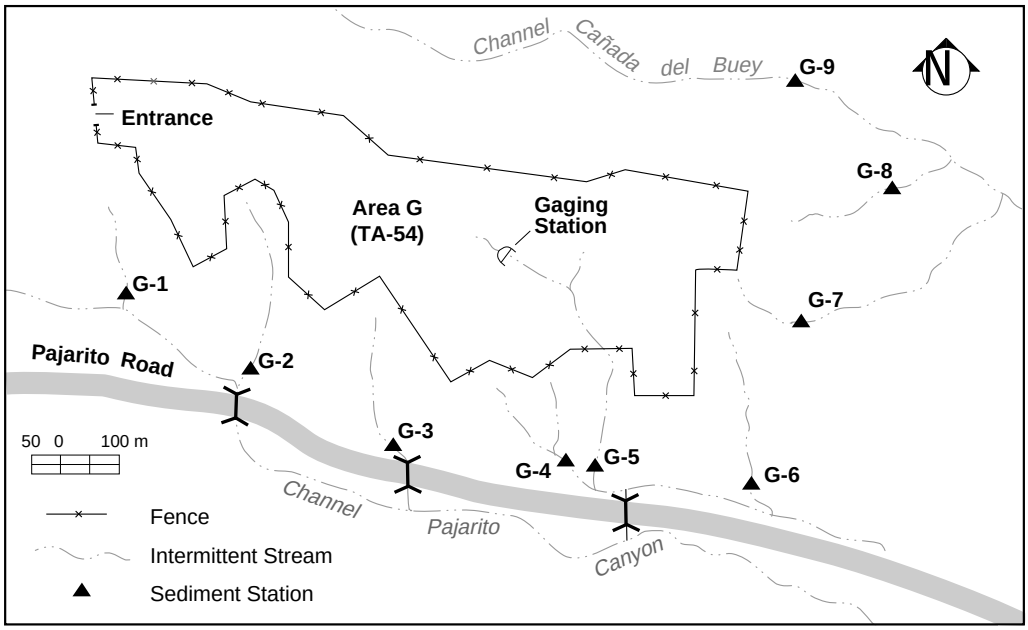
Figure IV-9. Sediment sampling locations for off-site perimeter and on-site Laboratory stations. Solid waste management areas with multiple sampling locations are shown in Figure IV-10. (Map denotes general locations only. See Table D-11 for specific coordinates; specific locations are available on the FIMAD system at the Community Reading Room.

Nineteen special sediment samples were collected from Cañada del Buey in early 1992 as part of the effort to document existing conditions prior to the possible discharge of treated effluent from the new Sanitary Wastewater Systems Consolidation (SWSC) Project (see Section VII.E.2 for a more detailed discussion).

3. Analytical Results.

a. Radiochemical Analyses. The results of radiochemical analyses of sediment samples collected from off-site (regional and perimeter) and on-site locations, including solid waste management areas, in 1992 are listed in Table IV-21.

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.



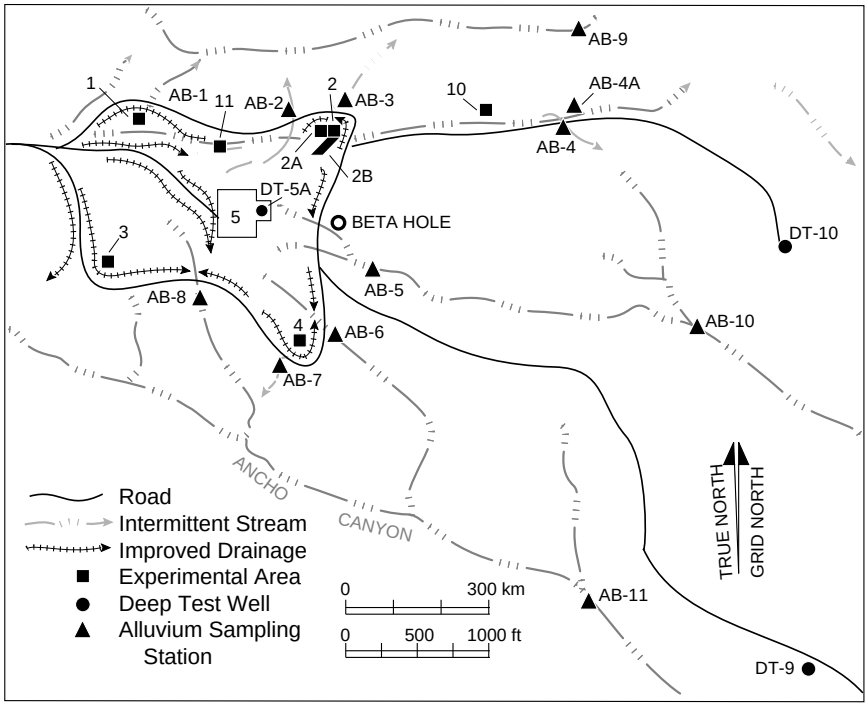


Figure IV-10. Off-site perimeter and on-site sediment sampling locations on and near solid waste management areas.
a. Upper map shows the locations of alluvium sampling stations at TA-54, Area G.
b. Bottom map shows the location of experimental areas and sediment stations at TA-49, Area AB.

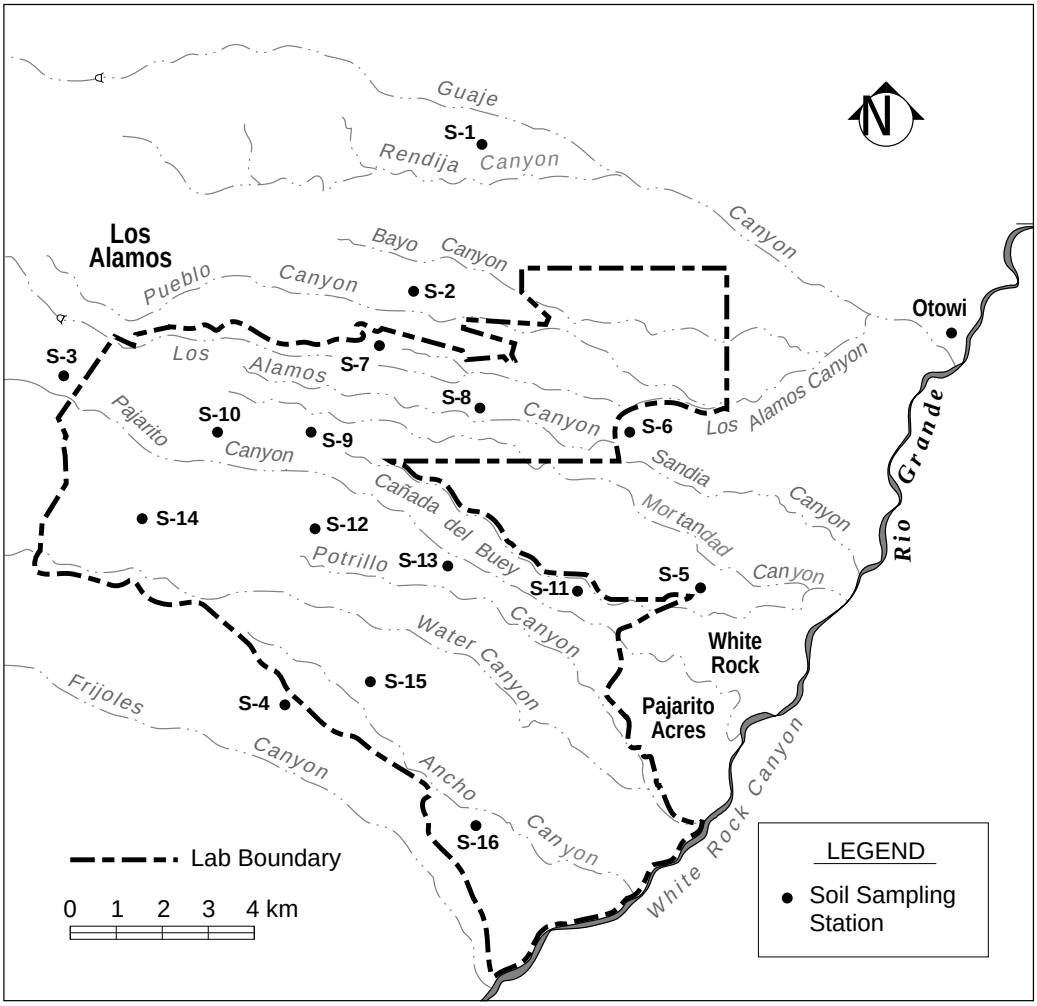


Figure IV-11. Off-site perimeter and on-site Laboratory soil sampling locations. (Map denotes generalized locations only. Refer to Table D-12 for specific coordinates; specific locations are presented on the FIMAD system at the Community Reading Room.)

Samples taken on San Ildefonso Pueblo land in Mortandad Canyon are discussed in detail Section IV.I.5. Only the sample from location A-6, showed levels of ^{137}Cs and ^{239,240}Pu slightly above the statistical regional reference level for fallout.

The majority of the sediment samples collected outside known radioactive effluent release areas were within the statistically derived reference level that reflects activity attributable to worldwide fallout (Purtymun 1987a). These statistical limits based on regional samples collected between 1974 and 1986 give a level expected to be exceeded by about 1 in 40 samples taken from the same population.

In the samples from the Jemez River and from the Rio Grande (from the regional and White Rock Canyon groups), only the samples from Chamita and Otowi contained ^{238}Pu values that exceeded the reference level. Since

Table IV-21. Radiochemical Analyses of Sediments

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
OFF-SITE STATIONS										
REGIONAL STATIONS										
Chamita	0.3[b] (0.3)[c]	0.2 (0.2)	0.0 (0.1)	2.9 (0.3)	0.009 (0.008)	0.003 (0.006)	0.139 (0.077)	6 (1)	3 (0)	9 (1)
Embudo	0.3 (0.3)	0.1 (0.2)	0.1 (0.1)	2.9 (0.3)	0.005 (0.003)	0.004 (0.002)	0.086 (0.074)	6 (1)	2 (0)	8 (1)
Rio Grande at Otowi	0.2 (0.3)	0.1 (0.2)	0.3 (0.2)	1.1 (0.1)	0.005 (0.003)	0.003 (0.002)	0.052 (0.069)	1 (0)	1 (0)	5 (1)
Rio Grande at Frijoles	0.2 (0.3)	0.0 (0.2)	0.2 (0.1)	1.7 (0.0)	0.003 (0.003)	0.009 (0.002)	0.002 (0.003)	3 (1)	4 (0)	3 (1)
Rio Grande at Cochiti	N/A[d]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Bernalillo	0.2 (0.3)	0.1 (0.2)	0.0 (0.1)	1.8 (0.2)	0.001 (0.003)	0.002 (0.002)	0.131 (0.074)	5 (1)	2 (0)	7 (1)
Jemez River	0.3 (0.3)	0.3 (0.2)	0.1 (0.1)	2.6 (0.3)	0.009 (0.003)	0.004 (0.002)	0.160 (0.084)	14 (3)	3 (0)	11 (1)
Rio Grande in White Rock Canyon										
Rio Grande at Sandia	0.3 (0.3)	0.2 (0.2)	0.1 (0.1)	2.1 (0.1)	0.000 (0.003)	0.003 (0.002)	0.001 (0.003)	2 (1)	3 (0)	3 (1)
Rio Grande at Mortandad	0.2 (0.3)	0.2 (0.2)	0.0 (0.1)	1.8 (0.0)	0.003 (0.003)	0.004 (0.002)	0.005 (0.003)	2 (1)	3 (0)	2 (1)
Rio Grande at Pajarito	0.2 (0.3)	0.0 (0.2)	0.1 (0.1)	1.6 (0.0)	0.005 (0.003)	0.004 (0.002)	0.001 (0.003)	2 (1)	4 (1)	3 (1)
Rio Grande at Water Canyon	0.2 (0.3)	0.0 (0.2)	0.0 (0.1)	1.6 (0.0)	0.000 (0.003)	0.003 (0.002)	0.001 (0.003)	3 (1)	4 (0)	2 (1)
Rio Grande at Ancho	0.6 (0.3)	0.0 (0.2)	0.1 (0.1)	1.2 (0.0)	0.002 (0.003)	0.002 (0.002)	0.002 (0.003)	2 (1)	2 (0)	0 (1)
Rio Grande at Chaquehui	0.4 (0.3)	0.0 (0.2)	0.1 (0.1)	1.7 (0.0)	0.001 (0.003)	0.002 (0.002)	0.003 (0.003)	3 (1)	3 (0)	3 (1)
PERIMETER STATIONS										
Radioactive Effluent Release Areas										
Acid-Pueblo Canyon										
Acid Weir	0.1 (0.3)	0.1 (0.2)	0.3 (0.1)	1.9 (0.2)	0.040 (0.003)	6.750 (0.240)	0.466 (0.104)	13 (3)	1 (0)	8 (1)
Pueblo 1	0.1 (0.3)	0.0 (0.2)	0.1 (0.1)	2.0 (0.2)	0.008 (0.003)	0.005 (0.002)	0.071 (0.076)	4 (1)	2 (0)	10 (1)
Pueblo 2	3.6 (0.7)	0.9 (0.2)	0.1 (0.1)	5.9 (0.6)	0.017 (0.003)	1.020 (0.040)	0.207 (0.096)	6 (1)	2 (0)	15 (2)
DP-Los Alamos Canyon										
Los Alamos at Totavi	1.4 (0.4)	0.1 (0.2)	0.0 (0.1)	4.4 (0.4)	0.004 (0.003)	0.019 (0.002)	0.126 (0.043)	5 (1)	2 (0)	13 (1)
Los Alamos at LA-2	0.2 (0.3)	0.1 (0.2)	0.4 (0.1)	1.5 (0.2)	0.006 (0.003)	0.227 (0.012)	0.102 (0.077)	3 (1)	1 (0)	8 (1)
Los Alamos at Otowi	0.3 (0.3)	0.0 (0.2)	0.2 (0.1)	1.7 (0.2)	0.010 (0.003)	0.178 (0.009)	0.019 (0.030)	2 (1)	1 (0)	6 (1)
Other Areas										
Guaje at SR 4	1.0 (0.6)	2.9 (0.2)	0.1 (0.1)	1.9 (0.2)	0.005 (0.003)	0.188 (0.016)	0.038 (0.075)	3 (1)	2 (0)	9 (1)
Bayo at SR 4	0.7 (0.3)	0.1 (0.2)	0.0 (0.1)	2.1 (0.2)	0.011 (0.003)	0.007 (0.002)	0.106 (0.077)	2 (1)	2 (0)	7 (1)
Sandia at Rio Grande	1.9 (1.0)	0.0 (0.2)	0.0 (0.1)	1.0 (0.0)	0.003 (0.003)	0.001 (0.002)	0.001 (0.003)	2 (1)	1 (0)	1 (1)
Cañada Ancha at Rio Grande	1.7 (0.9)	0.0 (0.2)	0.1 (0.1)	0.7 (0.0)	0.004 (0.003)	0.001 (0.002)	0.002 (0.003)	2 (0)	1 (0)	1 (1)

Table IV-21. (Cont.)

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
Other Areas (Cont.)										
Pajarito at Rio Grande	0.3 (0.3)	0.0 (0.2)	0.1 (0.1)	0.7 (0.0)	0.000 (0.003)	0.003 (0.002)	0.001 (0.003)	1 (0)	1 (0)	1 (1)
Water Canyon at Rio Grande	14.7 (8.4)	0.1 (0.2)	0.1 (0.1)	0.7 (0.0)	0.000 (0.003)	0.002 (0.002)	0.001 (0.003)	2 (0)	1 (0)	2 (1)
Ancho at Rio Grande	0.3 (0.3)	0.0 (0.2)	0.1 (0.1)	0.5 (0.0)	0.004 (0.003)	0.002 (0.002)	0.002 (0.003)	1 (0)	1 (0)	0 (1)
Chaquehui at Rio Grande	0.0 (0.3)	0.1 (0.2)	0.1 (0.1)	1.7 (0.0)	0.001 (0.003)	0.005 (0.002)	0.003 (0.003)	3 (1)	4 (0)	3 (1)
Frijoles at National Monument Headquarters	0.3 (0.3)	0.2 (0.2)	0.0 (0.1)	1.8 (0.2)	0.001 (0.003)	0.005 (0.002)	0.138 (0.076)	2 (1)	1 (0)	7 (1)
Frijoles at Rio Grande	0.3 (0.3)	0.0 (0.2)	0.1 (0.1)	1.2 (0.0)	0.001 (0.003)	0.005 (0.002)	0.000 (0.003)	1 (0)	1 (0)	3 (1)
Mortandad Canyon on San Ildefonso Lands										
Mortandad A-6	0.3 (0.3)	0.6 (0.2)	2.1 (0.3)	N/A	0.003 (0.001)	0.064 (0.005)	0.023 (0.003)	5 (1)	9 (1)	9 (1)
Mortandad A-7	2.2 (0.6)	0.2 (0.2)	0.3 (0.1)	N/A	0.001 (0.001)	0.009 (0.002)	0.005 (0.003)	3 (1)	3 (0)	6 (1)
Mortandad A-8	0.8 (0.3)	0.2 (0.2)	0.3 (0.1)	N/A	0.005 (0.001)	0.008 (0.002)	0.005 (0.003)	4 (1)	3 (0)	8 (1)
Mortandad at SR 4 (A-9)	0.9 (0.3)	0.2 (0.2)	0.1 (0.1)	2.6 (0.3)	0.004 (0.003)	0.007 (0.002)	0.130 (0.081)	3 (1)	2 (0)	11 (1)
Mortandad A-10	1.3 (0.3)	0.0 (0.2)	0.0 (0.1)	N/A	0.001 (0.001)	0.003 (0.001)	0.003 (0.003)	4 (1)	3 (0)	5 (1)
Mortandad at Rio Grande	0.0 (0.3)	0.4 (0.2)	0.0 (0.1)	1.1 (0.0)	0.001 (0.003)	0.001 (0.002)	0.002 (0.003)	2 (1)	2 (0)	0 (1)
ON-SITE STATIONS										
Radioactive Effluent Release Areas										
Acid-Pueblo Canyon										
Hamilton Bend Spring	0.5 (0.3)	0.1 (0.2)	0.2 (0.1)	4.3 (0.4)	0.008 (0.003)	0.416 (0.020)	0.017 (0.084)	3 (1)	1 (0)	12 (1)
Pueblo 3	0.1 (0.3)	0.0 (0.2)	0.2 (0.1)	2.7 (0.3)	0.004 (0.003)	0.007 (0.002)	0.017 (0.076)	6 (1)	2 (0)	10 (1)
Pueblo at SR 4	0.2 (0.3)	0.0 (0.2)	0.1 (0.1)	3.8 (0.4)	0.013 (0.003)	1.070 (0.040)	0.198 (0.083)	6 (1)	3 (0)	11 (1)
DP-Los Alamos Canyon										
DPS-1	0.8 (0.3)	0.2 (0.2)	0.1 (0.1)	2.2 (0.2)	0.008 (0.003)	0.007 (0.002)	0.217 (0.081)	3 (1)	2 (0)	8 (1)
DPS-4	1.3 (0.3)	0.9 (0.2)	4.0 (0.6)	2.8 (0.3)	0.037 (0.003)	0.144 (0.008)	0.411 (0.100)	3 (1)	5 (1)	13 (1)
Los Alamos at Bridge	0.3 (0.3)	0.1 (0.2)	0.1 (0.1)	2.9 (0.3)	0.003 (0.003)	0.003 (0.002)	0.147 (0.080)	6 (1)	3 (0)	12 (1)
Los Alamos at LAO-1	5.4 (0.7)	0.1 (0.2)	0.2 (0.1)	2.2 (0.2)	0.004 (0.003)	0.129 (0.008)	0.175 (0.081)	3 (1)	1 (0)	9 (1)
Los Alamos at GS-1	1.6 (0.4)	0.2 (0.2)	0.0 (0.1)	1.9 (0.2)	0.006 (0.003)	0.329 (0.015)	0.136 (0.078)	3 (1)	1 (0)	7 (1)
Los Alamos at LAO-3	2.0 (0.4)	0.5 (0.2)	2.8 (0.4)	2.9 (0.3)	0.036 (0.003)	0.165 (0.008)	0.493 (0.109)	3 (1)	5 (1)	11 (1)
Los Alamos at LAO-4.5	1.9 (0.4)	0.5 (0.2)	2.1 (0.3)	4.3 (0.4)	0.033 (0.003)	0.268 (0.013)	0.410 (0.097)	5 (1)	4 (1)	14 (1)
Los Alamos at SR 4	0.3 (0.3)	0.2 (0.2)	1.4 (0.2)	2.3 (0.2)	0.006 (0.003)	0.053 (0.004)	0.109 (0.077)	3 (1)	2 (0)	8 (1)

Table IV-21. (Cont.)

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
Mortandad Canyon										
Mortandad near CMR	9.9 (1.5)	0.2 (0.2)	0.0 (0.1)	1.6 (0.2)	0.022 (0.003)	0.010 (0.002)	0.122 (0.074)	2 (1)	1 (0)	5 (1)
Mortandad west of GS-1	4.1 (0.6)	0.1 (0.2)	0.1 (0.1)	2.2 (0.2)	0.008 (0.003)	0.005 (0.002)	0.019 (0.046)	5 (1)	2 (0)	8 (1)
Mortandad at GS-1	80.3 (0.2)	1.1 (0.2)	28.1 (4.2)	2.6 (0.3)	1.330 (0.030)	3.400 (0.120)	4.670 (0.710)	13 (3)	27 (3)	34 (3)
Mortandad at MCO-5	93.7 (9.3)	1.7 (0.2)	22.8 (3.4)	1.6 (0.2)	2.900 (0.110)	8.310 (0.310)	11.000 (1.660)	32 (6)	29 (3)	29 (3)
Mortandad at MCO-7	19.8 (3.0)	0.5 (0.2)	3.2 (0.5)	2.9 (0.3)	0.377 (0.018)	1.200 (0.050)	2.160 (0.340)	9 (2)	6 (1)	12 (1)
Mortandad at MCO-9	2.6 (0.6)	0.3 (0.2)	0.2 (0.0)	4.5 (0.5)	0.013 (0.003)	0.030 (0.004)	0.282 (0.093)	7 (2)	4 (0)	14 (2)
Mortandad at MCO-13 (A-5)	1.6 (1.2)	0.2 (0.2)	2.8 (0.4)	2.5 (0.3)	0.002 (0.003)	0.021 (0.002)	0.099 (0.078)	5 (1)	3 (0)	10 (1)
Other Areas										
Sandia at SR 4	0.1 (0.3)	0.0 (0.2)	0.0 (0.1)	3.4 (0.3)	0.005 (0.003)	0.002 (0.002)	0.240 (0.086)	4 (1)	1 (0)	10 (1)
Cañada del Buey at SR 4	0.9 (0.4)	0.0 (0.2)	0.3 (0.1)	2.8 (0.3)	0.013 (0.005)	0.006 (0.003)	0.148 (0.080)	3 (1)	2 (0)	10 (1)
Pajarito at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potrillo at SR 4	1.3 (0.5)	0.1 (0.2)	0.1 (0.1)	1.9 (0.2)	0.001 (0.003)	0.008 (0.002)	0.034 (0.075)	5 (1)	2 (0)	10 (1)
Fence at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water at SR 4	3.4 (1.4)	0.1 (0.2)	0.4 (0.1)	2.1 (0.2)	0.000 (0.003)	0.008 (0.002)	0.106 (0.076)	3 (1)	2 (0)	9 (1)
Indio at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at SR 4	1.4 (1.0)	0.1 (0.2)	1.0 (0.2)	1.6 (0.2)	0.001 (0.003)	0.002 (0.002)	0.181 (0.084)	2 (1)	1 (0)	9 (1)
TA-54, Area G										
G-1	0.4 (0.3)	N/A	0.1 (0.1)	2.3 (0.2)	0.004 (0.001)	0.003 (0.001)	N/A	6 (1)	3 (0)	2 (1)
G-2	0.1 (0.3)	N/A	0.1 (0.1)	2.7 (0.3)	0.002 (0.001)	0.005 (0.001)	N/A	6 (1)	3 (0)	4 (1)
G-3	1.5 (0.4)	N/A	0.0 (0.1)	1.9 (0.2)	0.002 (0.001)	0.006 (0.001)	N/A	4 (1)	2 (0)	3 (1)
G-4	0.5 (0.3)	N/A	1.2 (0.2)	4.5 (0.5)	0.009 (0.002)	0.039 (0.004)	N/A	6 (1)	4 (1)	7 (1)
G-5	0.8 (0.3)	N/A	0.0 (0.1)	3.7 (0.4)	0.013 (0.002)	0.057 (0.004)	N/A	7 (1)	3 (0)	6 (1)
G-6	0.7 (0.3)	N/A	0.4 (0.2)	3.7 (0.4)	0.036 (0.003)	0.153 (0.008)	N/A	9 (2)	4 (1)	5 (1)
G-7	0.8 (0.3)	N/A	0.2 (0.1)	4.4 (0.4)	0.016 (0.002)	0.043 (0.003)	N/A	6 (1)	5 (1)	6 (1)
G-8	2.4 (0.5)	N/A	0.1 (0.1)	3.0 (0.3)	0.189 (0.010)	0.219 (0.011)	N/A	5 (1)	2 (0)	5 (1)
G-9	0.3 (0.3)	N/A	0.1 (0.1)	2.6 (0.3)	0.039 (0.003)	0.026 (0.003)	N/A	4 (1)	2 (0)	4 (1)

Table IV-21. (Cont.)

Location	^{3}H (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
Other Areas (Cont.)										
TA-49, Area AB										
AB-1	0.7 ± (0.3)	0.4 ± (0.2)	0.2 ± (0.1)	N/A	0.002 ± (0.001)	0.018 ± (0.002)	± 0.075 ± (0.070)	7 ± (2)	7 ± (1)	± 2 ± (1)
AB-2	1.3 ± (0.3)	0.2 ± (0.2)	0.3 ± (0.1)	N/A	0.030 ± (0.003)	0.094 ± (0.006)	± 0.059 ± (0.069)	7 ± (2)	7 ± (1)	± 3 ± (1)
AB-3	0.5 ± (0.3)	0.3 ± (0.2)	0.6 ± (0.1)	N/A	0.048 ± (0.004)	0.102 ± (0.006)	± 0.143 ± (0.073)	9 ± (2)	6 ± (1)	± 1 ± (1)
AB-4	0.8 ± (0.3)	0.2 ± (0.2)	0.3 ± (0.1)	N/A	0.005 ± (0.001)	0.020 ± (0.002)	± 0.175 ± (0.079)	9 ± (2)	8 ± (1)	± 1 ± (1)
AB-4A	0.7 ± (0.3)	0.3 ± (0.2)	0.3 ± (0.1)	N/A	0.005 ± (0.001)	0.026 ± (0.003)	± 0.116 ± (0.077)	9 ± (2)	8 ± (1)	± 2 ± (1)
AB-5	0.9 ± (0.3)	0.6 ± (0.7)	0.4 ± (0.1)	N/A	0.002 ± (0.001)	0.014 ± (0.002)	± 0.144 ± (0.073)	8 ± (2)	6 ± (1)	± 3 ± (1)
AB-6	0.9 ± (0.3)	0.0 ± (0.2)	0.1 ± (0.1)	N/A	0.001 ± (0.001)	0.006 ± (0.001)	± 0.157 ± (0.077)	7 ± (1)	6 ± (1)	± 3 ± (1)
AB-7	3.9 ± (0.9)	0.3 ± (0.2)	0.3 ± (0.1)	N/A	0.011 ± (0.002)	0.010 ± (0.002)	± 0.147 ± (0.078)	4 ± (1)	4 ± (1)	± 5 ± (1)
AB-8	0.5 ± (0.3)	0.2 ± (0.2)	0.3 ± (0.1)	N/A	0.002 ± (0.001)	0.006 ± (0.001)	± 0.085 ± (0.074)	6 ± (1)	4 ± (0)	± 5 ± (1)
AB-9	2.5 ± (0.6)	0.3 ± (0.2)	± 0.0 ± (0.1)	N/A	0.000 ± (0.001)	0.008 ± (0.002)	± 0.176 ± (0.072)	4 ± (1)	5 ± (1)	± 4 ± (1)
AB-10	0.9 ± (0.5)	0.2 ± (0.2)	0.1 ± (0.1)	N/A	0.000 ± (0.001)	0.005 ± (0.001)	± 0.102 ± (0.076)	6 ± (1)	5 ± (1)	± 4 ± (1)
AB-11	1.3 ± (0.3)	0.2 ± (0.2)	0.1 ± (0.1)	N/A	0.000 ± (0.001)	0.004 ± (0.001)	0.069 ± (0.064)	5 ± (1)	5 ± (1)	± 3 ± (1)
Background Statistical Limit+	±	0.87	0.44	4.4	0.006	0.025	±	±	±	7.9

[a]Tritium as tritiated water in moisture distilled from sample.

[b]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

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

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

+Average plus 2 standard deviations of measurements in regional samples 1974 ± 1986 (Purtymun 1987a).

they were not in the expected ratio with ^{239,240}Pu values for those stations, which themselves were below the statistical fallout reference level, it is likely that the ^{238}Pu measurements were analytical anomalies rather than real values. (Neither of the stations showed detectable amounts last year.) None of the stations with detectable amounts in 1991 had detectable amounts in 1992.

In the off-site perimeter other areas group, the samples from Bayo Canyon contained about twice the ^{238}Pu as the statistical fallout reference level. Since the ^{238}Pu measurements were not in the expected ratio with ^{239,240}Pu values for worldwide fallout, and were below the statistical fallout reference level, it is likely that the measured ^{238}Pu level was an analytical anomaly rather than a real value. The sample from Bayo Canyon in 1991 was below the reference level; none of the samples from locations showing slightly elevated levels in 1991 were elevated in 1992. The sample collected from Guaje Canyon in 1992 showed an elevated ^{90}Sr level of 2.9 pCi/g, about three times the statistical reference level for fallout, and a ^{239,240}Pu value of 0.188 pCi/g, about eight times the statistical reference level for fallout. The 1991 sample from that location showed nothing above the reference levels. There is no known source of contaminants in Guaje Canyon; the only unusual activity has been a substantial amount of earth moving activity due to road construction in Guaje Canyon near where it crosses State Road 4. The sediment sample collected from Water Canyon at the Rio Grande (Table IV-21, Perimeter Stations, Other Areas) showed an unexpected and unexplainable level of tritium (14.7 nCi/L). No known source occurs upstream. Further analyses will be conducted in 1993.

Additional special sediment samples were again collected from Chaquehui Canyon near its confluence with the Rio Grande during the White Rock Canyon sampling trip in October 1992. The sample from the routine sampling location closest to the Rio Grande showed no detectable activity. However, the moisture distilled from four samples collected further up the canyon contained measurable tritium that was comparable to the levels originally seen in the fall of 1991 and from a special resampling in February 1992. The October 1992 results included 3.0 nCi/L in the sample collected immediately upstream of the location where flow from Spring 9A joins the Chaquehui channel, 1.5 nCi/L in the sample collected several hundred feet further upgradient (where the channel first reaches the cliff face), 1.1 nCi/L in the sample collected just below Doe Spring, and 7.5 nCi/L in the sample collected just above Doe Spring.

For comparison, the 1991 routine sediment sample collected from Chaquehui Canyon at its confluence with the Rio Grande in White Rock Canyon contained 28 nCi/L tritium in moisture distilled from the sediment. Because of this unexpected anomaly, the location was resampled in February 1992 as soon as weather had warmed sufficiently to melt snow and permit hiking into White Rock Canyon. That second sample also showed above background tritium levels, about 5.4 nCi/L. Four additional samples were collected further upstream in Chaquehui Canyon. These four sediment samples had tritium contents ranging from about 0.5 to about 1.1 nCi/L, which, while lower, were still above levels that could be attributed to worldwide fallout. No obvious source could be identified. Water samples collected from Doe Spring and Spring 9A from October 1991 and 1992 showed no tritium levels above the normal detection limits. A potential source could be a known area of tritium-contaminated soil in TA-33, which is located about 3.2 km (2 mi) upgradient in a side drainage to Chaquehui Canyon. However, there is no obvious mechanism to move contaminated soil that far by a run-off event that would not also significantly dilute the tritium in moisture. This area will be investigated in detail under the Environmental Restoration (ER) Program Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) that includes TA-33 (see Section III.B.1.h). The RFI Workplan encompassing TA-33, submitted to EPA in May 1992, includes field sampling tasks to help determine whether TA-33 could be the source.

The results for routine annual sediment samples from two solid radioactive waste areas (Table IV-21) were within the range of previous observations. Around Area G at TA-54, the statistical fallout levels for ^{238}Pu and/or ^{239,240}Pu were exceeded at Stations G-4, G-5, G-6, G-7, G-8, and G-9. The levels are generally in the same range as observed in previous years. Samples from Station G-5 was lower than observed in 1991, while the others were higher with those from G-6 and G-8 being seven to ten times the statistical reference level for regional fallout. The ^{137}Cs concentration in the sample from location G-4 was about three times the statistical reference level for regional sediments.

Tritium levels in the sediment samples around Area G were within the general range observed in soils and sediments, with the exception of the sample from G-8 that showed 2.4 nCi/L. However, even that sample did not repeat the anomalously high levels seen in 1990 (EPG 1992).

Around Area AB at TA-49, worldwide fallout levels of ^{238}Pu and/or ^{239,240}Pu were exceeded at stations AB-2, AB-3, AB-4, and AB-4A. These areas have shown elevated levels in previous years and are believed to be associated with known surface contamination incidents related to hydronuclear experiments conducted at the site between 1959 and 1961 (Purtymun, 1987b).

Three off-site perimeter soil samples and eight on-site samples contained ^{238}Pu or ^{239,240}Pu levels that ranged from slightly above to up to three times the statistical worldwide fallout reference level. While the levels were generally within the ranges of values seen previously, the number of samples is higher than seen in either 1990 or 1991 for no apparent reason. These samples with seemingly high levels are presumed to reflect normal variability as there were no known atmospheric releases; alternatively, they may reflect the deposition of plutonium from historical airborne releases in the earlier years of the Laboratory's operation. Two regional samples (collected at Cochiti and near Santa Cruz) contained elevated levels of ^{238}Pu, and one (from Otowi) showed an elevated level of ^{239,240}Pu up to twice the regional statistical reference level. Since the samples from Cochiti and Santa Cruz contained rations of ^{238}Pu and ^{239,240}Pu that do not reflect worldwide fallout levels and because their ^{239,240}Pu levels were below the statistical reference level, it is likely that the ^{238}Pu measurements were analytical anomalies rather than real values. The levels in the sample from Otowi were almost identical to those seen in 1991 and were in the proportion expected for worldwide fallout.

Uranium levels in the perimeter and on-site locations contain higher concentrations of natural uranium than other regional stations in northern New Mexico because the soils are derived from the Pajarito Plateau's volcanic rocks whose natural uranium contents are higher than average. The uranium levels are in the same range as those previously measured.

b. Nonradioactive Constituents. Soils and sediments from the known radioactive effluent release areas were analyzed for trace metals. These analyses, made to begin establishing a data base of results comparable to those reported by other agencies such as the USGS, are meaningful for accounting for geochemical processes. Results for the sediment samples collected in 1992 are presented in Table IV-22. None of the results show any indication of any significant accumulations of metals above what can be attributed to natural concentrations. The results of the 1992 soil sampling program are included in Table IV-23. Samples from previous years were analyzed using the EPA's Toxicity Characteristic Leaching Procedure (TCLP) to determine whether any sediments or soils exceeded the criteria for hazardous waste. None of the samples exceeded or even approached these criteria.

Sediments from the other locations were also analyzed in 1992 for the full suite of trace metals in 1992 (Table IV-22). (Sediments from the perimeter locations in White Rock Canyon were first analyzed for specific metals in 1991.) None of the results indicate significant accumulations of metals above what can be attributed to natural concentrations. The measurements repeated in 1992 generally yielded results comparable to those obtained in 1991.

4. Long-Term Trends.

The concentrations of radioactivity in sediments from the Acid, Pueblo, and Los Alamos canyons that are or may be transported off-site were studied extensively about 10 years ago as part of the Formerly Utilized Sites Remedial Action Program and are fully documented (ESG 1981). Data gathered from selected locations as part of a routine monitoring program indicate that the concentrations of radionuclides in drainage sediment have been relatively constant at each location since 1980. The total plutonium concentrations (^{238}Pu and ^{239,240}Pu) observed since 1980 in sediments at four indicator locations are shown in Figure IV-12. The first location is Acid Weir, the location in Acid Canyon near its confluence with Pueblo Canyon where the highest concentrations are typically observed. This location is on Los Alamos County property and effectively integrates the mobile sediments from all of Acid Canyon. The second location is Pueblo Canyon at State Road 502, just upstream of the confluence with Los Alamos Canyon. This location is on DOE land and reflects levels just prior to off-site transport of sediments. The third location is Los Alamos Canyon at Totavi, located on San Ildefonso Pueblo, which represents the first off-site point. The fourth location is Los Alamos Canyon at Otowi, also located on San Ildefonso Pueblo, which reflects sediment concentrations at the point where they enter the Rio Grande.

Table IV-22. Total Recoverable Trace Metals from Sediments (μg/g)[a]

Stations	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg*
OFF-SITE STATIONS												
REGIONAL STATIONS												
Rio Chama at Chamita	<1.0[b]	4,350.0	2.08	30.2	255.0	0.65	<0.6	10.0	5.63	4.8	2,100.0	<0.01
Rio Grande at Embudo	<1.0	4,400.0	2.60	102.0	417.0	0.59	<0.6	12.0	13.00	7.4	2,500.0	<0.01
Rio Grande at Otowi	<1.0	2,930.0	0.88	<20.0	158.0	0.21	<0.6	3.3	5.47	<2.0	380.0	<0.01
Rio Grande at Frijoles	<1.0	11,300.0	1.84	7.0	215.0	0.67	<1.0	12.0	6.00	12.0	12,600.0	0.03
Rio Grande at Cochiti	N/A[c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Bernalillo	<1.0	3,560.0	1.27	21.1	141.0	0.27	<0.6	4.2	3.82	<2.0	1,500.0	<0.01
Jemez River	<1.0	4,780.0	4.26	<20.0	260.0	0.60	<0.6	6.5	4.50	4.6	1,500.0	<0.01
Rio Grande in White Rock Canyon												
Rio Grande at Sandia	<1.0	7,800.0	1.90	6.3	175.0	0.53	0.3	26.0	4.50	6.2	10,000.0	0.03
Rio Grande at Mortandad	<1.0	6,100.0	1.75	5.0	152.0	0.49	<1.0	8.5	4.20	6.2	10,000.0	0.02
Rio Grande at Pajarito	<1.0	8,600.0	1.66	8.5	175.0	0.56	<1.0	9.0	5.00	8.0	10,300.0	0.02
Rio Grande at Water Canyon	<1.0	8,500.0	2.23	6.8	185.0	0.67	<1.0	9.5	4.70	9.5	11,000.0	0.03
Rio Grande at Ancho	<1.0	3,800.0	1.39	3.8	87.0	0.36	<1.0	4.3	2.50	<5.0	5,600.0	0.02
Rio Grande at Chaquehui	<1.0	4,000.0	1.31	3.1	139.0	0.41	<1.0	5.7	3.20	<5.0	6,900.0	<0.02
PERIMETER STATIONS												
Radioactive Effluent Release Areas												
Acid-Pueblo Canyon												
Acid Weir	<1.0	5,720.0	0.94	<20.0	34.0	0.33	<0.6	2.6	4.05	<2.0	1,200.0	0.02
Pueblo 1	<1.0	5,940.0	1.02	<20.0	34.0	0.41	<0.6	2.2	2.83	3.6	1,100.0	0.01
Pueblo 2	<1.0	5,920.0	0.35	<20.0	33.0	0.32	<0.6	1.6	3.00	2.1	750.0	<0.01
DP-Los Alamos Canyon												
Los Alamos at Totavi	<1.0	7,140.0	0.63	30.7	56.0	0.57	<0.6	6.1	13.10	4.3	2,880.0	<0.01
Los Alamos at LA 2	<1.0	5,730.0	0.36	<20.0	37.0	0.32	<0.6	3.0	6.55	6.8	1,720.0	<0.01
Los Alamos at Otowi	<1.0	5,470.0	0.32	33.2	13.0	0.17	<0.6	1.1	4.69	<2.0	530.0	<0.01
Other Areas												
Guaje at SR 4	<1.0	5,470.0	0.47	<20.0	45.0	0.34	<0.6	2.7	2.99	2.4	620.0	<0.01
Bayo at SR 4	<1.0	5,920.0	0.73	<20.0	87.0	0.38	<0.6	6.6	4.30	5.5	1,400.0	<0.01
Sandia at Rio Grande	<1.0	2,300.0	0.57	3.7	27.0	0.43	<1.0	12.0	6.00	<5.0	18,300.0	0.02
Cañada Ancha at Rio Grande	<1.0	3,500.0	1.88	2.8	69.0	0.34	<1.0	3.6	2.70	<5.0	5,500.0	<0.02
Pajarito at Rio Grande	<1.0	1,300.0	0.32	1.6	11.0	0.16	<1.0	2.3	1.30	1.0	3,100.0	0.03
Water Canyon at Rio Grande	<1.0	2,000.0	0.61	3.1	31.0	0.29	<1.0	2.0	1.90	<5.0	5,300.0	0.02
Ancho at Rio Grande	<1.0	840.0	0.28	1.5	9.2	0.11	<1.0	<0.5	<0.50	<5.0	1,700.0	<0.02
Chaquehui at Rio Grande	<1.0	4,700.0	2.11	4.4	150.0	0.49	<1.0	6.5	4.00	8.0	7,900.0	<0.02
Frijoles at Park Headquarters	<1.0	6,200.0	0.21	<20.0	20.0	0.25	<0.6	0.9	2.17	<2.0	850.0	<0.01
Frijoles at Rio Grande	<1.0	2,500.0	0.30	1.9	21.0	0.30	<1.0	2.8	1.50	<5.0	5,600.0	0.02
Mortandad Canyon on San Ildefonso Pueblo												
Mortandad A-6	<0.6	9,200.0	2.04	5.7	71.0	0.81	<0.8	6.5	3.50	6.0	8,900.0	0.04
Mortandad A-7	<0.6	3,200.0	1.02	5.0	24.0	0.40	<0.8	2.3	2.00	2.2	7,200.0	<0.02
Mortandad A-8	<0.6	6,200.0	1.48	3.4	57.0	0.60	<0.8	4.3	2.80	3.9	7,700.0	<0.02
Mortandad at SR 4 (A-9)	<1.0	7,100.0	0.78	<20.0	69.0	0.51	<0.6	4.5	6.14	2.2	2,740.0	<0.01
Mortandad at A-10	<0.6	8,900.0	1.56	5.0	88.0	0.70	<0.8	7.5	5.00	3.2	10,500.0	<0.02
Mortandad at Rio Grande (A-11)	<1.0	3,600.0	0.75	3.5	48.0	0.38	<1.0	7.7	3.90	12.0	11,000.0	0.04

*Data on additional trace metals from sediments are presented beginning on page IV-53.

Table IV-22. (Cont.)

Stations	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg*
ON-SITE STATIONS												
Radioactive Effluent Release Areas												
Acid-Pueblo Canyon												
Hamilton Bend Spring	<1.0	6,250.0	0.38	<20.0	34.0	0.43	<0.6	2.4	2.09	3.6	1,180.0	<0.01
Pueblo 3	<1.0	5,590.0	0.78	20.7	49.0	0.51	<0.6	2.4	6.83	3.4	1,220.0	<0.01
Pueblo at SR 4	<1.0	6,340.0	1.07	23.4	92.0	0.67	<0.6	13.0	7.11	4.4	2,300.0	<0.01
DP-Los Alamos Canyon												
DPS-1	<1.0	6,480.0	0.96	<20.0	28.0	0.45	<0.6	2.3	3.21	<2.0	1,100.0	<0.01
DPS-4	<1.0	6,000.0	0.82	<20.0	32.0	0.46	<0.6	2.4	2.73	<2.0	700.0	<0.01
Los Alamos at Bridge	<1.0	5,740.0	1.18	<20.0	84.0	0.53	<0.6	6.6	7.11	7.0	2,500.0	0.01
Los Alamos at LAO-1	<1.0	5,220.0	0.70	37.0	43.0	0.34	<0.6	3.4	3.33	2.8	1,200.0	<0.01
Los Alamos at GS-1	<1.0	6,030.0	0.54	<20.0	38.0	0.30	<0.6	2.8	2.57	6.4	810.0	<0.01
Los Alamos at LAO-3	<1.0	6,280.0	1.33	<20.0	33.0	0.42	<0.6	2.6	6.10	3.5	1,300.0	<0.01
Los Alamos at LAO-4.5	<1.0	5,930.0	0.68	20.0	39.0	0.52	<0.6	2.7	5.16	5.0	1,130.0	<0.01
Los Alamos at SR 4	<1.0	5,740.0	0.45	<20.0	24.0	0.34	<0.6	1.8	5.11	4.3	1,100.0	<0.01
Mortandad Canyon												
Mortandad near CMR	<1.0	4,800.0	0.88	<20.0	85.3	0.34	<0.6	7.0	3.28	4.7	970.0	<0.01
Mortandad W GS-1	<1.0	5,560.0	1.32	23.4	62.0	0.50	<0.6	3.6	5.55	3.4	760.0	<0.01
Mortandad at GS-1	<1.0	6,300.0	0.75	<20.0	24.0	0.40	<0.6	3.1	4.95	<2.0	1,100.0	0.05
Mortandad at MCO-5	<1.0	5,620.0	0.42	<20.0	14.0	0.34	<0.6	1.5	1.34	<2.0	740.0	<0.01
Mortandad at MCO-7	<1.0	6,570.0	0.66	<20.0	12.0	0.24	<0.6	1.2	2.88	4.5	920.0	<0.01
Mortandad at MCO-9	<1.0	5,800.0	1.18	34.7	60.0	0.70	<0.6	3.1	7.14	6.4	1,080.0	<0.01
Mortandad at MCO-13 (A-5)	<1.0	5,900.0	0.99	118.0	44.0	0.67	<0.6	3.1	1.70	18.0	500.0	<0.01
Other Areas												
Sandia at SR 4	<1.0	5,730.0	0.47	<20.0	29.0	0.43	<0.6	6.6	2.27	2.2	1,800.0	<0.01
Cañada Del Buey at SR 4	<1.0	6,550.0	0.69	<20.0	53.0	0.42	<0.6	2.8	4.91	<1.0	2,400.0	<0.01
Pajarito at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potrillo at SR 4	<1.0	6,350.0	1.06	22.1	60.0	0.62	<0.6	5.0	7.74	4.2	2,610.0	<0.01
Fence at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water at SR 4	<1.0	5,770.0	0.50	25.1	35.0	0.48	<0.6	2.4	2.29	<2.0	1,500.0	<0.01
Indio at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at SR 4	<1.0	6,300.0	0.49	63.0	28.0	0.48	<0.6	3.6	2.60	<2.0	600.0	<0.01
TA-54, Area G (Data was not analyzed in CY92)												
TA-49, Area AB												
AB-1	<1.0	6,160.0	3.36	14.9	550.0	2.20	<0.8	25.0	8.35	9.0	1,870.0	0.02
AB-2	<1.0	6,260.0	3.31	15.9	520.0	2.40	<0.8	28.0	12.40	8.0	2,050.0	0.02
AB-3	<1.0	6,260.0	1.15	11.5	344.0	2.00	<0.8	12.5	9.00	<6.0	1,720.0	<0.01
AB-4	<1.0	6,080.0	3.07	21.7	489.0	2.60	<0.8	29.0	8.50	<6.0	2,050.0	0.02
AB-4A	<1.0	6,540.0	2.69	20.6	426.0	2.30	<0.8	23.0	8.70	<6.0	1,930.0	0.02
AB-5	<1.0	6,370.0	2.19	19.2	293.0	1.90	<0.8	18.0	7.70	<6.0	2,000.0	0.01
AB-6	<1.0	6,290.0	2.94	25.2	517.0	2.00	<0.8	22.0	10.60	<6.0	2,030.0	0.01
AB-7	<1.0	5,870.0	1.43	28.9	494.0	1.80	<0.8	23.0	9.20	<6.0	2,040.0	<0.01
AB-8	<1.0	6,550.0	3.04	18.5	339.0	2.00	<0.8	12.0	5.80	<6.0	1,650.0	0.01
AB-9	<1.0	7,300.0	1.42	20.5	423.0	2.30	<0.8	37.0	9.20	<6.0	3,100.0	<0.01
AB-10	<1.0	7,160.0	1.71	30.7	380.0	2.30	<0.8	25.0	10.20	<6.0	3,600.0	0.01
AB-11	<1.0	6,160.0	2.32	6.2	462.0	2.40	<0.8	40.0	10.30	<6.0	3,810.0	0.02

*Data on additional trace metals from sediments are presented beginning on page IV-54.

Table IV-22. (Cont.)

Station	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
OFF-SITE STATIONS											
REGIONAL STATIONS											
Rio Chama at Chamita	214.0	<0.30	9.89	7.0	<3.00	0.28	20.0	85.0	<6.00	25.0	26.0
Rio Grande at Embudo	249.0	<0.30	10.00	9.0	<3.00	<0.20	17.0	47.0	<6.00	28.0	40.0
Rio Grande at Otowi	76.0	<0.30	2.66	4.0	<2.00	<0.20	8.0	19.0	<6.00	11.0	10.0
Rio Grande at Frijoles	270.0	<1.00	9.10	6.0	<0.05	0.37	12.0	99.0	0.08	27.0	32.0
Rio Grande at Cochiti	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rio Grande at Bernalillo	155.0	<0.30	5.70	4.6	<2.00	<0.20	10.0	64.0	<6.00	11.0	14.0
Jemez River	360.0	<0.30	8.23	7.6	<2.00	0.23	21.0	48.0	<6.00	14.0	28.0
Rio Grande in White Rock Canyon											
Rio Grande at Sandia	230.0	<1.00	22.00	7.0	<0.05	0.25	12.0	75.0	0.10	21.0	26.0
Rio Grande at Mortandad	160.0	<1.00	6.00	32.0	<0.05	0.20	11.0	63.0	<0.04	22.0	23.0
Rio Grande at Pajarito	220.0	<1.00	9.00	6.0	<0.05	0.23	11.0	82.0	0.08	22.0	27.0
Rio Grande at Water Canyon	250.0	<1.00	6.70	5.0	<0.05	<0.20	13.0	83.0	0.09	24.0	29.0
Rio Grande at Ancho	150.0	<1.00	4.00	4.0	<0.05	<0.20	9.0	37.0	0.05	12.0	15.0
Rio Grande at Chaquehui	152.0	<1.00	4.00	5.0	<0.05	0.26	9.0	39.0	0.07	16.0	18.0
PERIMETER STATIONS											
Radioactive Effluent Release Areas											
Acid-Pueblo Canyon											
Acid Weir	156.0	<0.30	2.70	29.0	<2.00	<0.20	7.0	11.0	<6.00	5.8	35.0
Pueblo 1	317.0	0.40	1.50	17.0	<3.00	<0.20	8.3	9.0	<6.00	7.0	47.0
Pueblo 2	193.0	0.50	1.70	7.0	<2.00	<0.20	8.0	15.0	<6.00	4.7	38.0
DP-Los Alamos Canyon											
Los Alamos at Totavi	159.0	<0.30	14.90	23.0	<3.00	<0.20	13.0	41.0	<6.00	12.0	47.0
Los Alamos at LA 2	278.0	0.40	12.00	5.0	<3.00	<0.20	9.0	20.0	<6.00	4.4	24.0
Los Alamos at Otowi	56.0	<0.30	5.96	3.3	<3.00	<0.20	3.4	3.3	<6.00	2.7	8.0
Other Areas											
Guaje at SR 4	164.0	<0.30	3.07	6.0	<2.00	<0.20	8.2	25.0	<6.00	5.5	21.0
Bayo at SR 4	170.0	<0.30	9.80	8.0	<2.00	<0.20	13.0	39.0	<6.00	15.0	22.0
Sandia at Rio Grande	320.0	<1.00	8.00	3.0	<0.05	<0.20	10.0	13.0	<0.04	43.0	44.0
Cañada Ancha at Rio Grande	130.0	<1.00	5.30	2.0	<0.05	0.26	7.0	22.0	<0.04	12.0	13.0
Pajarito at Rio Grande	50.0	<1.00	<2.00	2.0	<0.05	<0.20	6.0	3.7	<0.04	5.0	13.0
Water Canyon at Rio Grande	179.0	<1.00	2.00	4.0	<0.05	<0.20	6.0	5.0	0.04	6.0	23.0
Ancho at Rio Grande	47.0	<1.00	<2.00	1.0	<0.05	<0.20	7.0	3.4	<0.04	2.7	6.0
Chaquehui at Rio Grande	228.0	4.00	6.00	5.0	<0.05	0.38	9.6	65.0	0.07	16.0	25.0
Frijoles at Park Headquarters	94.0	<0.30	1.50	4.0	<2.00	<0.20	6.0	15.0	<6.00	2.0	9.0
Frijoles at Rio Grande	128.0	<1.00	<2.00	3.0	<0.05	<0.20	7.1	7.0	<0.04	6.7	25.0
Mortandad Canyon on San Ildefonso Pueblo											
Mortandad A-6	348.0	<1.20	4.30	16.5	<6.00	<0.20	16.0	14.0	<2.00	11.6	43.0
Mortandad A-7	309.0	<1.30	1.60	5.9	<6.00	<0.20	14.0	3.9	5.00	4.0	45.0
Mortandad A-8	292.0	<1.20	3.30	10.0	<6.00	<0.20	15.0	9.6	2.60	8.9	35.0
Mortandad at SR 4 (A-9)	373.0	<0.30	8.84	9.0	<2.00	<0.20	10.0	16.0	<6.00	12.0	35.0
Mortandad at A-10	382.0	<1.20	5.90	8.0	<6.00	<0.25	15.0	16.0	<12.00	17.0	36.0
Mortandad at Rio Grande (A-11)	187.0	<1.00	7.00	1.5	<0.05	0.28	12.0	16.0	<0.04	21.0	32.0

Table IV-22. (Cont.)

Station	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
ON-SITE STATIONS											
Radioactive Effluent Release Areas											
Acid-Pueblo Canyon											
Hamilton Bend Spring	170.0	<0.30	3.12	6.0	<2.00	<0.20	8.2	13.0	<6.00	4.5	28.0
Pueblo 3	240.0	<0.30	9.21	8.0	<3.00	<0.20	10.0	14.0	<6.00	5.8	17.0
Pueblo at SR 4	646.0	0.30	9.35	60.0	<3.00	<0.20	14.0	38.0	<6.00	12.0	100.0
DP-Los Alamos Canyon											
DPS-1	164.0	<0.30	3.25	15.0	<2.00	<0.20	8.4	9.3	<6.00	4.5	32.0
DPS-4	154.0	<0.30	2.50	11.0	<2.00	<0.20	6.0	8.0	<6.00	4.2	25.0
Los Alamos at Bridge	312.0	0.33	7.61	28.0	<2.00	<0.20	10.0	23.0	<6.00	13.0	45.0
Los Alamos at LAO-1	209.0	0.50	4.40	11.0	<2.00	<0.20	7.2	18.0	<6.00	6.2	29.0
Los Alamos at GS-1	120.0	<0.30	2.98	7.0	<3.00	<0.20	7.0	18.0	<6.00	5.2	20.0
Los Alamos at LAO-3	143.0	0.50	3.80	12.0	<2.00	<0.20	8.0	11.0	<6.00	5.8	41.0
Los Alamos at LAO-4.5	189.0	0.50	6.30	14.0	<3.00	<0.20	9.0	16.0	<6.00	5.3	38.0
Los Alamos at SR 4	76.0	0.35	6.39	5.0	<3.00	<0.20	8.0	13.0	<6.00	2.9	15.0
Mortandad Canyon											
Mortandad near CMR	132.0	<0.30	4.95	24.0	<3.00	<0.20	8.4	25.6	<6.00	7.4	64.7
Mortandad W GS-1	233.0	0.60	5.67	15.0	<3.00	<0.20	12.0	23.0	<6.00	8.0	31.0
Mortandad at GS-1	285.0	0.90	6.96	5.0	<3.00	<0.20	9.0	4.6	<6.00	3.7	23.0
Mortandad at MCO-5	107.0	<0.30	2.12	5.0	<2.00	<0.20	7.0	4.1	<6.00	2.2	16.0
Mortandad at MCO-7	158.0	0.45	1.85	<3.0	<2.00	<0.20	5.0	2.6	<6.00	2.0	12.0
Mortandad at MCO-9	320.0	0.50	6.87	11.0	<2.00	<0.20	9.0	10.0	<6.00	7.0	39.0
Mortandad at MCO-13 (A-5)	275.0	0.70	<2.00	12.0	<3.00	<0.20	11.0	8.0	<6.00	6.1	31.0
Other Areas											
Sandia at SR 4	347.0	0.60	2.84	12.0	<2.00	<0.20	8.0	8.4	<6.00	8.0	69.0
Cañada Del Buey at SR 4	268.0	<0.30	7.56	7.0	<2.00	<0.20	8.0	16.0	<6.00	7.0	22.0
Pajarito at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potrillo at SR 4	304.0	0.50	9.89	9.0	<3.00	<0.20	12.0	13.0	<6.00	13.0	45.0
Fence at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water at SR 4	115.0	<0.30	4.27	11.0	<3.00	<0.20	10.0	30.0	<6.00	4.6	22.0
Indio at SR 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at SR 4	262.0	0.60	<2.00	11.0	<3.00	<0.20	16.0	16.0	<6.00	11.0	51.0
TA-54, Area G (Data was not analyzed in CY92)											
TA-49, Area AB											
AB-1	493.0	<7.0	10.10	30.0	3.00	0.28	<3.0	145.0	<5.00	50.0	42.0
AB-2	540.0	<7.0	13.70	30.0	8.00	0.28	<3.0	140.0	<5.00	56.0	78.0
AB-3	396.0	<7.0	8.40	<24.0	<2.30	<0.20	63.0	101.0	<4.00	32.0	96.0
AB-4	444.0	<7.0	11.20	34.0	<2.00	0.24	78.0	135.0	<4.00	57.0	48.0
AB-4A	491.0	<7.0	10.20	28.0	<2.30	<0.20	64.0	103.0	<4.00	47.0	50.0
AB-5	444.0	<7.0	9.40	<24.0	<2.30	0.22	53.0	47.0	<4.00	40.0	55.0
AB-6	524.0	<7.0	11.50	31.0	<2.30	0.23	67.0	119.0	<4.00	47.0	45.0
AB-7	412.0	<7.0	11.30	<24.0	4.00	<0.20	67.0	204.0	<4.00	47.0	37.0
AB-8	355.0	<7.0	9.00	27.0	<2.30	<0.20	69.0	78.0	<4.00	26.0	60.0
AB-9	565.0	<7.0	13.60	<24.0	<2.30	0.20	86.0	230.0	<4.00	79.0	66.0
AB-10	504.0	<7.0	14.30	<24.0	<2.30	<0.20	76.0	152.0	<4.00	63.0	66.0
AB-11	661.0	<7.0	16.20	26.0	<2.30	<0.20	90.0	161.0	<4.00	112.0	90.0

[a] Analysis by EPA Method 3051 for trace metals.
[b] Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[c] N/A means analysis not performed, lost in analysis, or not completed.

Table IV-23. Total Recoverable Trace Metals in Soils (μg/g)[a]

Stations	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg*
OFF-SITE STATIONS												
REGIONAL STATIONS												
Rio Chama	<0.01[b]	4,940	2.07	19	103	0.55	<0.5	9.0	4.0	5.5	1,650	<0.01
Embudo	<0.01	5,090	1.50	23	102	0.70	<0.5	8.0	5.0	7.0	1,560	<0.01
Otowi	<0.01	6,190	0.69	11	91	0.67	<0.5	6.6	4.0	7.0	1,520	<0.01
Santa-Cruz	<0.01	5,160	4.70	16	184	1.00	<0.5	16.0	6.0	10.0	2,100	0.01
Cochiti	<0.01	4,910	2.28	15	161	0.70	<0.5	11.0	6.0	9.0	1,840	<0.01
Bernalillo	<0.01	3,930	7.50	20	233	0.70	<0.5	10.0	4.0	8.0	1,450	<0.01
Jemez	<0.01	4,580	2.37	22	180	0.80	<0.5	10.0	4.0	9.0	1,350	0.02
PERIMETER STATIONS												
Sportsman Club	<0.01	5,740	1.36	9	70	0.72	<0.5	6.0	5.0	5.0	1,360	<0.01
North Mesa	<0.10	5,420	3.23	13	133	1.00	<0.5	11.0	7.0	9.0	1,710	0.01
TA-8	0.30	5,810	2.34	7	83	0.50	<0.5	3.6	4.0	6.5	1,190	0.01
TA-49	<0.01	5,640	3.95	17	193	1.20	<0.5	12.0	8.0	8.0	1,810	0.02
White-Rock	<0.01	6,030	2.48	21	170	1.30	<0.5	11.0	6.0	8.0	1,980	<0.01
Tsankawi	<0.01	6,000	1.01	22	62	1.10	<0.5	3.1	2.4	3.5	1,350	<0.01
ON-SITE STATIONS												
TA-21	N/A[c]	5,130	0.00	22	N/A	N/A	N/A	N/A	8.0	N/A	1,570	N/A
East of TA-53	<0.01	5,880	2.70	21	82	1.00	<0.5	9.0	2.8	7.0	1,490	0.02
TA-50	0.23	6,290	2.28	24	166	1.20	<0.5	12.0	7.0	7.0	1,930	0.03
2-Mile Mesa	<0.01	4,790	3.31	23	112	1.00	<0.5	10.0	4.0	3.4	1,300	0.01
East of TA-54	<0.01	6,070	1.34	26	88	0.90	<0.5	6.9	4.0	4.9	1,500	<0.01
R-Site-RD-E	<0.01	4,960	2.18	48	96	0.80	<0.5	9.0	6.0	3.1	1,450	<0.01
Potrillo-DR	<0.10	5,480	2.23	39	116	0.97	<0.5	11.0	7.0	5.8	1,680	<0.01
S-Site	<0.01	4,750	2.86	26	114	1.00	<0.5	11.0	4.0	2.9	1,310	<0.01
Near Well DT-9	<0.01	6,320	2.83	32	178	1.40	<0.5	13.0	6.0	7.0	1,870	0.02
Near TA-33	<0.01	5,780	2.00	30	97	1.40	<0.5	12.0	5.0	7.4	1,800	0.01
Limit for EPA Toxicity Criteria	5		5		100		1	5				0.2

*Data on additional trace metals in soil is presented on page IV-56.

Table IV-23. (Cont.)

Stations	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
OFF-SITE STATIONS											
REGIONAL STATIONS											
Rio Chama	171	<0.4	10	8	<2.00	0.45	14	44	<2.0	20.0	23
Embudo	257	<0.4	10	12	<2.00	0.39	15	29	<2.0	16.0	27
Otowi	254	0.7	9	10	2.00	2.10	13	44	4.0	16.0	33
Santa-Cruz	328	<0.4	14	11	2.60	0.68	21	103	<2.0	32.0	43
Cochiti	316	<0.4	12	17	3.00	0.43	17	94	1.3	26.0	37
Bernalillo	211	0.6	9	11	2.40	0.72	20	265	<2.0	26.0	30
Jemez	412	<0.4	8	21	1.50	0.42	26	41	2.0	21.0	50
PERIMETER STATIONS											
Sportsman Club	292	<0.5	7	33	2.00	<2.00	10	19	<2.0	11.0	32
North Mesa	522	<0.4	10	15	2.00	0.30	13	27	4.0	29.0	34
TA-8	445	0.4	5	21	<2.00	0.26	10	19	<2.0	9.4	36
TA-49	621	0.4	12	19	1.90	0.41	14	36	<2.0	28.0	35
White-Rock	392	<0.4	11	84	1.90	0.33	13	36	<2.0	21.0	47
Tsankawi	258	0.4	5	22	<2.00	0.20	8	15	<2.0	6.4	23
ON-SITE STATIONS											
TA-21	N/A	N/A	10	N/A	N/A	0.00	N/A	N/A	N/A	N/A	N/A
East of TA-53	183	<0.4	7	24	<2.00	0.31	13	19	<2.0	16.0	45
TA-50	376	<0.4	11	16	<0.07	0.40	16	33	<2.0	28.0	37
2-Mile Mesa	516	<0.4	7	17	<2.00	0.35	15	29	<2.0	34.0	22
East of TA-54	324	<0.4	7	18	<2.00	0.22	12	19	<2.0	13.0	41
R-Site-RD-E	278	<0.4	8	12	<2.00	0.31	13	26	<2.0	24.0	20
Potrillo-DR	370	<0.4	10	14	<2.00	0.26	14	23	<2.0	23.0	29
S-Site	482	<0.4	7	14	<2.00	0.27	15	30	<2.0	30.0	23
Near Well DT-9	348	<0.4	11	16	<2.00	0.38	16	32	<2.0	27.0	40
Near TA-33	287	0.6	10	19	<2.00	0.38	15	28	<2.0	20.0	41
Limit for EPA Toxicity Criteria				5		1					

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

Figure IV-12. Total plutonium concentrations in sediments.

5. Transport of Radionuclides in Sediments from Surface Run-Off.
The major transport of radionuclides from canyons that have received radioactive effluents (Acid-Pueblo, DP-Los Alamos, and Mortandad canyons) is by surface run-off. Residual radionuclides in the effluents may become adsorbed or attached to sediment particles in the stream channels. Concentrations of radioactivity in the alluvium are generally highest near the effluent outfall and decrease downhill in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and surface run-off.

a. 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 IV.D.2 for additional historic information.) Over the years some of that radioactivity has been transported off site into lower Los Alamos Canyon largely by snowmelt and thunderstorm run-off.

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 1992 (except between mid-June and early August) and typically extended to a location between Totavi (just east of the DOE-San Ildefonso Pueblo boundary) and the confluence of Guaje and Los Alamos canyons. Periodic grab samples of effluent and run-off 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-mm-pore-size filter; radioactivity on suspended sediments refers to the residue retained by the filter.) The samples collected from run-off 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 IV-24, and the levels for other radioactive constituents are shown in Table IV-25. These tables also show results of grab samples of snowmelt run-off from other canyons; results for these other canyons are discussed in Section IV.E.5.b.

Concentrations of plutonium in the suspended sediments from Pueblo and Los Alamos canyons were above background though the levels were comparable to those seen in previous years. The increased transport of contaminated sediments from Pueblo Canyon is not having any significant effect on the concentrations of plutonium in sediments from lower Los Alamos Canyon (ESG 1981). Current measurements from throughout the region are given in Table IV-21; measurements from locations in lower Los Alamos Canyon are shown in Figure IV-12. Run-off from summer thunderstorms and long periods of snowmelt periodically move accumulated sediments from lower Los Alamos Canyon into the Rio Grande (ESG 1981, Lane 1985).

The effluent-induced flow will slightly increase the rate at which contaminated sediments from historical discharges in Acid and Pueblo canyons are moved through Los Alamos Canyon to the Rio Grande. Theoretical estimates (ESG 1981), confirmed by field measurements (see Special Reservoir Sediment Studies and Special Rio Grande Sediment Study below), predict that the incremental contributions to radioactivity on sediments in Cochiti Reservoir resulting from Laboratory operations are small (approximately 10%) relative to the contributions from worldwide fallout. The incremental doses accumulated through food pathways (see Section IV.G.3) are well below DOE's applicable PDLs.

b. Radionuclides in Water and Sediment from Snowmelt Run-Off. During the spring snowmelt season, grab samples of run-off were collected from several other canyons. The analytical results are shown in Tables IV-24 and IV-25. These results are for unfiltered samples and represent total concentrations, both dissolved and suspended solids.

c. 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 IV-26). 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 IV.D.2 and Section VII.B 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 run-off enters the channel. The canyon's small drainage area and the capacity of the thick unsaturated alluvium to store run-off have prevented transport to the Laboratory boundaries. To further ensure containment of sediment transport by major run-off 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 run-off 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. Run-off 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.

No significant thunderstorm run-off events occurred in Mortandad Canyon during 1992, and only routine samples were collected.

d. Radionuclides in Sediment from Cañada del Buey. Results of radiochemical analyses of 19 extra samples collected from the stream channel of Cañada del Buey are shown in Table IV-27. The samples were collected to document conditions prior to the release of treated effluents from the Sanitary Wastewater Systems Consolidation (SWSC) project. The sampling locations in Cañada del Buey extend along the reach parallel to the Laboratory-San Ildefonso Pueblo boundary (see Figure IV-9). Sample locations CDB-J1 and CDB-K are in Cañada del Buey north of routine sampling location G-1 and the westernmost portion of Area G. Special sampling locations CDB-A

Table IV-24. Plutonium in Surface Waters in 1992

Location Sediment (pCi/L) and Date	Concentration in Solution ^{239}Pu (pCi/L)	Concentration in Solution ^{238}Pu (pCi/L)	Concentration in Suspended Sediment ^{239}Pu (pCi/g)	Concentration in Suspended Sediment ^{238}Pu (pCi/g)	Suspended Sediment (g/L)	Total in Solution and Suspended ^{239}Pu	Total in Solution and Suspended ^{238}Pu	Total in Solution and Suspended % dissolved
OFF-SITE PERIMETER STATIONS								
Los Alamos Canyon								
Los Alamos at Rio Grande								
03/27	|0.005[a]	0.005	0.010	0.012	0.45875	0.010	0.017	18.2
04/03	0.050	0.000	2.986	0.040	3.35100	3.036	0.040	1.6
04/16	0.008	0.008	3.045	0.040	1.06825	3.053	0.048	0.5
04/24	0.036	|0.008	0.000	0.000	0.17650	0.036	0.000	100.0
DP-Los Alamos Canyons								
Los Alamos at Totavi								
04/03	|0.010	|0.010	0.069	0.002	0.02925	0.069	0.002	0.0
Other Areas								
Water Canyon at SR 502								
04/24	0.005	0.005	0.000	0.000	0.04775	0.005	0.005	100.0
ON-SITE STATIONS								
Acid-Pueblo Canyons								
Pueblo at SR 502								
03/27	0.000	0.000	0.005	0.000	0.14775	0.005	0.000	0.0
04/24	0.004	|0.008	1.813	0.017	0.72500	1.817	0.017	0.2
07/26	0.026	0.004	0.120	0.008	0.01275	0.146	0.012	19.0
08/03	0.052	|0.009	0.092	0.000	0.01625	0.144	0.000	36.1
09/03	0.011	0.005	0.001	0.000	0.01750	0.012	0.005	93.6
10/07	0.000	0.009	0.003	0.000	0.02300	0.002	0.009	77.9
11/18	0.000	0.005	0.001	0.000	0.01750	0.001	0.005	79.0
12/09	0.006	0.005	0.002	0.000	0.02125	0.008	0.005	87.9
Los Alamos Canyon at Omega Bridge								
04/03	0.020	|0.020	0.001	0.000	0.02475	0.021	0.000	93.1
Pueblo Canyon at Gaging Station								
04/03	0.020	0.040	0.014	0.000	0.00725	0.034	0.040	81.0
04/28	0.005	0.013	0.000	0.000	0.04500	0.005	0.013	100.0
04/28	0.019	0.011	0.000	0.000	0.06800	0.019	0.011	100.0
05/01	0.004	|0.002	0.000	0.000	0.02400	0.004	0.000	100.0
05/05	|0.004	0.004	0.013	0.003	0.00500	0.013	0.007	21.1
05/05	0.013	0.010	0.002	|0.001	0.00475	0.015	0.010	93.8
05/06	|0.004	0.011	0.007	0.001	0.00450	0.007	0.012	57.3
05/06	0.011	0.017	0.000	|0.001	0.00100	0.011	0.017	100.0
05/07	0.009	|0.003	|0.003	|0.003	0.00275	0.009	0.000	100.0
DP-Los Alamos Canyons								
Los Alamos at Gaging Station 1								
04/03	0.020	0.000	0.028	|0.000	0.01850	0.048	0.000	42.0
04/28	0.005	|0.002	0.000	0.000	0.00625	0.005	0.000	100.0
04/28	0.014	|0.019	0.000	0.000	0.00900	0.014	0.000	100.0
04/28	0.005	|0.005	0.000	0.000	0.00475	0.005	0.000	100.0
04/29	0.000	|0.005	0.000	0.000	0.00625	0.000	0.000	100.0
04/29	0.004	0.004	0.000	0.000	0.00450	0.004	0.004	100.0
04/30	0.004	|0.002	0.000	0.000	0.00575	0.004	0.000	100.0
04/30	0.010	|0.005	0.000	0.000	0.00400	0.010	0.000	100.0
05/01	0.032	0.012	0.079	0.158	0.00225	0.111	0.170	15.7
05/02	0.019	0.027	0.012	0.003	0.00825	0.031	0.030	75.7
05/02	0.010	0.008	0.009	0.002	0.00775	0.019	0.010	61.4
05/03	0.003	|0.003	0.009	0.000	0.00825	0.012	0.000	24.0

Table IV-24. (Cont.)

Location and Date	Concentration in Solution ^{239}Pu (pCi/L)	Concentration in Solution ^{238}Pu (pCi/L)	Concentration in Suspended Sediment ^{239}Pu (pCi/g)	Concentration in Suspended Sediment ^{238}Pu (pCi/g)	Suspended Sediment (g/L)	Total in Solution and Suspended Sediment (pCi/L) ^{239}Pu	Total in Solution and Suspended Sediment (pCi/L) ^{238}Pu	Total in Solution and Suspended Sediment (pCi/L) % dissolved
Los Alamos at Gaging Station 1 (Cont.)								
05/03	0.002	0.000	0.008	0.002	0.00750	0.010	0.002	16.9
05/04	0.017	0.000	0.008	0.000	0.00900	0.025	0.000	67.0
05/05	|0.002	0.008	0.009	0.001	0.00575	0.009	0.009	45.2
05/05	0.011	0.002	0.009	|0.001	0.00575	0.020	0.002	58.6
05/06	0.009	0.000	0.010	|0.001	0.00575	0.019	0.000	47.9
05/06	|0.002	0.000	0.012	0.002	0.00525	0.012	0.002	0.0
05/07	0.002	0.005	0.011	0.000	0.00625	0.013	0.005	38.4
05/07	0.000	0.000	0.014	0.001	0.00550	0.014	0.001	0.0
Los Alamos at SR 4								
04/16	0.004	|0.013	0.221	0.014	0.12800	0.225	0.014	1.7
04/24	0.005	|0.010	0.000	0.000	0.03575	0.005	0.000	100.0
Other Areas								
Pajarito Canyon								
04/16	|0.004	0.000	0.000	0.000	0.00925	0.000	0.000	100.0
04/24	0.004	0.009	0.000	0.000	0.00200	0.004	0.009	100.0

[a]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

Table IV-25. Radioactivity in Spring Run-off Surface Waters in 1992

Location	(nCi/L)	^{3}H (pCi/L)	^{137}Cs (µg/L)	Uranium (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma
PERIMETER STATIONS OFF-SITE							
Los Alamos Canyon							
Los Alamos at Rio Grande	1.1 (0.7)[a]	57.4(150.4)	0.6 (0.1)	1 (2)	8 (2)	-185[b]	(371)
DP-Los Alamos Canyons							
Los Alamos at Totavi	1.7 (0.4)	164.0 (86.2)	< 1.0 (0.0)	1 (1)	12 (1)	|214	(167)
Other Areas							
Water Canyon at SR 502	0.8 (0.3)	174.0 (95.0)	0.1 (0.1)	1 (1)	4 (1)	|238	(167)
ON-SITE STATIONS							
Acid-Pueblo Canyons							
Pueblo at SR 502	0.3 (0.6)	+28.5 (86.6)	0.1 (0.1)	1 (2)	15 (3)	+198	(283)
Los Alamos Canyon at Omega Bridge	0.1 (0.3)	|55.7 (68.9)	< 1.0 (0.0)	|0 (1)	4 (1)	|262	(167)
Pueblo Canyon at Gaging Station	|0.1 (0.3)	+68.7 (85.0)	< 1.0 (0.0)	|1 (1)	17 (2)	|262	(167)
DP-Los Alamos Canyons							
Los Alamos at Gaging Station 1	2.2 (0.4)	|43.1 (61.2)	< 1.0 (0.0)	3 (1)	11 (1)	|381	(167)
Los Alamos at SR 4	1.4 (0.6)	+35.7 (94.0)	< 1.0 (0.0)	0 (1)	4 (1)	+|95	(271)
Other Areas							
Pajarito Canyon	0.6 (0.4)	+91.4(125.7)	0.2 (0.1)	1 (1)	5 (1)	|214	(253)

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

[b]See Section VIII.D.3, Data Handling of Radioactive Samples, for an explanation of the presence of negative values.

Table IV-26. Quality of Effluent Released from the TA-50 Radioactive Liquid Waste Treatment Plant to Mortandad Canyon in 1992

Radionuclide	Activity Released[a] (mCi)	Mean Concentration (µCi/mL)
^{3}H	10,630	$5.3 + 10^{-4}$
$^{82,85,89,90}Sr$	17	$8.5 + 10^{-7}$
^{137}Cs	0.5	$2.5 + 10^{-8}$
$^{234}U+$	0.05	$2.5 + 10^{-9}$
^{238}Pu	0.32	$1.6 + 10^{-8}$
$^{239,240}Pu$	0.39	$2.0 + 10^{-8}$
^{241}Am	0.27	$1.3 + 10^{-8}$
Total[b]	10,650	

[a]As reported on DOE Form F-5821.1.
[b]Total effluent volume $1.99 + 10^{7}$ liters.

Table IV-27. Radiochemical Analyses of Specially Collected Sediment Samples from Cañada del Buey

Location	^{3}H (nCi/L)[a]	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
CDB-A	0.5+(0.3)[b]	0.0+(0.1)	2.4+(0.2)	|0.001[c] +(0.002)	0.000+(0.001)	4+(1)	3+(0.3)	5+(1)
CDB-B	1.1+(0.3)+	0.2+(0.1)	2.0+(0.2)	0.001++(0.001)	0.002+(0.001)	5+(1)	2+(0.3)	6+(1)
CDB-C	0.6+(0.3)+	|0.1+(0.1)	2.1+(0.2)	0.006++(0.002)	0.002+(0.001)	6+(1)	3+(0.4)	5+(1)
CDB-D	2.5+(0.3)+	0.7+(0.2)	3.2+(0.3)	0.001++(0.002)	0.013+(0.003)	7+(1)	3+(0.4)	7+(1)
CDB-E	1.0+(0.3)+	0.5+(0.1)	2.5+(0.2)	0.004++(0.002)	0.020+(0.004)	2+(1)	2+(0.3)	6+(1)
CDB-F	0.4+(0.3)+	0.9+(0.2)	3.3+(0.3)	0.002++(0.002)	0.030+(0.005)	4+(1)	3+(0.3)	8+(1)
CDB-G	0.7+(0.3)+	0.1+(0.1)	3.2+(0.3)	0.006++(0.003)	0.007+(0.003)	7+(2)	4+(0.5)	7+(1)
CDB-H	0.6+(0.3)+	0.2+(0.1)	2.7+(0.3)	0.001++(0.003)	0.000+(0.001)	3+(1)	2+(0.3)	6+(1)
CDB-I	0.5+(0.3)+	0.0+(0.1)	2.3+(0.2)	0.002++(0.003)	0.005+(0.003)	4+(1)	2+(0.3)	5+(1)
CDB-J	0.6+(0.3)+	0.4+(0.2)	2.7+(0.3)	0.003++(0.002)	0.013+(0.003)	5+(1)	3+(0.4)	3+(1)
CDB-J1	0.6+(0.3)+	0.2+(0.2)	3.3+(0.3)	0.002++(0.001)	0.005+(0.001)	4+(1)	2+(0.3)	5+(1)
CDB-K	0.2+(0.3)+	0.3+(0.1)	5.8+(0.6)	0.001++(0.001)	0.010+(0.002)	10+(2)	5+(0.6)	7+(1)
CDB-L	0.2+(0.3)+	0.4+(0.2)	2.9+(0.3)	0.005++(0.002)	0.018+(0.002)	6+(1)	3+(0.4)	|2+(1)
CDB-M	0.1+(0.3)+	0.2+(0.1)	3.7+(0.4)	0.029++(0.003)	0.058+(0.004)	5+(1)	3+(0.4)	|1+(1)
CDB-N	0.5+(0.3)+	0.3+(0.1)	3.1+(0.3)	0.006++(0.002)	0.017+(0.003)	5+(1)	3+(0.3)	3+(1)
CDB-O	0.2+(0.3)+	0.1+(0.1)	2.6+(0.3)	0.006++(0.001)	0.006+(0.001)	4+(1)	2+(0.3)	2+(1)
CDB-P	0.2+(0.3)+	0.1+(0.1)	3.2+(0.3)	0.001++(0.001)	0.003+(0.001)	5+(1)	3+(0.3)	3+(1)
CDB-Q	0.2+(0.3)+	|0.1+(0.1)	1.9+(0.2)	0.003++(0.001)	0.003+(0.001)	5+(1)	2+(0.3)	1+(1)
CDB-R	0.1+(0.3)+	0.1+(0.1)	1.9+(0.2)	0.003++(0.001)	0.004+(0.001)	2+(1)	1+(0.2)	2+(1)
Statistical Limit of Regional Background		0.87	4.4	0.006	0.023			7.9

[a]Tritium as tritiated water in moisture distilled from samples.
[b]Radioactivity counting uncertainties (|1 standard deviation) are shown in parentheses.
[c]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

through CDB-J are located further upstream. Special sampling locations CDB-L through CDB-R extend downstream, with CDB-M coincident with routine sampling location G-1 and CDB-R located at State Road 4.

Of the samples collected upstream of potential run-off from Area G, samples from CDB-F showed levels slightly exceeding the statistical reference level for worldwide fallout for ^{137}Cs and ^{239,240}Pu. Of the samples collected downstream, only the sample from CDB-M contained levels exceeding the reference levels for both ^{238}Pu and ^{239,240}Pu. The values are similar to those seen previously at routine sampling location G-9.

6. Special Reservoir Sediment Studies.

Results of the analyses of the large samples specially collected in 1992 from Abiquiu and Cochiti reservoirs are presented in Tables IV-28 and IV-29. The results are similar to those from past years.

Levels of plutonium and cesium in the sample from the middle station in Cochiti Reservoir slightly exceeded the statistically established regional fallout reference levels (Purtymun 1987a). The ^{239,240}Pu level of 0.0377 | 0.0011 pCi/g was slightly above the reference level of 0.023 pCi/g. The cesium concentration of 0.5 | 0.1 pCi/g was slightly above the reference level of 0.44 pCi/g. The measurements of the other constituents were lower than regional statistical reference levels.

The results of these analyses are best interpreted in conjunction with information from a special study, "Plutonium Deposition and Distribution from Worldwide Fallout in Northern New Mexico and Southern Colorado," which provides a broader regional context for analyses of reservoir sediments (Purtymun 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 plutonium concentrations in Cochiti Reservoir are almost identical to the concentrations found in the Rio Grande Reservoir in Colorado; (2) reservoirs on the Rio Chama exhibit slightly lower concentrations than those found in the Rio Grande Reservoir; and (3) the isotopic ratios of ^{239,240}Pu to ^{238}Pu are essentially the same, with nearly complete overlap of the statistical uncertainties, for all of the soil and sediment samples analyzed. These findings are consistent with the interpretation that the source of the plutonium at all locations studied is predominantly from worldwide fallout.

Table IV-28. Radiochemical Analyses of Sediments from Reservoirs on the Rio Chama and Rio Grande[a]

Location	^{3}H (nCi/L)[b]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
Abiquiu Reservoir (Rio Chama)								
Upper	0.3+(0.3)[c]	0.2+(0.2)	0.2+(0.1)	2.2+(0.2)	|0.064[d]+(0.088)	10 (2)	4 (0)	1,238 (214)
Middle	0.6+(0.3)	0.1+(0.2)	0.1+(0.1)	1.6+(0.2)	|0.038++(0.068)	3 (1)	2 (0)	357 (167)
Lower	0.2+(0.3)	0.0+(0.2)	0.0+(0.1)	2.3+(0.2)	|0.090++(0.076)	5 (2)	4 (0)	714 (190)
Cochiti Reservoir (Rio Grande)								
Upper	|0.4+(0.3)	0.2+(0.2)	0.1+(0.1)	1.2+(0.1)	|0.069++(0.081)	3 (1)	2 (0)	333 (167)
Middle	0.0+(0.3)	0.3+(0.2)	0.5+(0.1)	4.6+(0.5)	|0.228++(0.088)	16 (4)	7 (1)	1,905 (238)
Lower	|0.3+(0.3)	0.0+(0.2)	0.1+(0.1)	1.7+(0.2)	|0.204++(0.082)	4 (1)	2 (0)	476 (167)
Background (1974|1986)[e]	+	0.87	0.44	4.4	0.006	0.023	+	+

[a]Samples were collected in June 1992 at Abiquiu and July 1992 at Cochiti.
[b]Tritium as tritiated water in moisture distilled from sample.
[c]Radioactivity counting uncertainties(|1 standard deviation) are shown in parentheses.
[d]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[e]Purtymun (1987a).

Table IV-29. 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	∞x+	(s)	0.7	(0.4)[b]	12.7	(6.3)	18
1985	∞x+	(s)	0.7	(0.5)	8.8	(0.9)	12
1986	∞x+	(s)	0.3	(0.1)	7.5	(1.7)	25
1987	∞x+	(s)	0.2	(0.1)	3.8	(3.1)	19
1988	∞x+	(s)	0.3	(0.2)	7.5	(2.6)	25
1989	∞x+	(s)	0.2	(0.6)	3.7	(0.4)	18
1990	∞x+	(s)	0.14	(0.1)	2.6	(1.6)	19
1991	∞x+	(s)	0.33	(0.1)	7.2	(2.6)	22
1992	Upper	0.1	(0.03)	1.84	(0.14)	18	
	Middle	0.106	(0.02)	0.23	(0.03)	2	
	Lower	0.044	(0.012)	0.326	(0.036)	7	
	∞x+	(s)	0.08	(0.03)	0.8	(0.9)	10
Cochiti Reservoir (Rio Chama)							
1984	∞x+	(s)	0.7	(1.1)	19.7	(14.0)	28
1985	∞x+	(s)	1.6	(0.6)	24.1	(7.3)	15
1986	∞x+	(s)	1.2	(0.5)	21.2	(6.1)	18
1987	∞x+	(s)	0.8	(0.7)	17.5	(13.8)	22
1988	∞x+	(s)	1.7	(2.3)	21.1	(2.9)	7
1989	∞x+	(s)	2.5	(2.3)	49.3	(7.3)	20
1990	∞x+	(s)	1.1	(0.5)	20.9	(10.7)	19
1991	∞x+	(s)	0.2	(0.1)	4.1	(3.4)	21
1992	Upper	0.054	(0.13)	1.23	(0.07)	23	
	Middle	5.5	(0.4)	37.7	(1.07)	7	
	Lower	0.2	(0.03)	1.37	(0.09)	7	
	∞x+	(s)	1.9	(3.1)	13.4	(21.0)	7
Background							
(1974|1986)[c]		6.0		23.0			

[a]Samples were collected in June 1992 at Abiquiu Reservoir and July 1992 at Cochiti Reservoir.

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

[c]Purtymun (1987a).

The data from the 1992 plutonium analyses are shown in a long term context in Table IV-29. 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 1992 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 ^{239,234}Pu to ^{238}Pu that is much larger than values typical of worldwide fallout.) This is

consistent with the long term observation that the contributions of radionuclides from Los Alamos Canyon are a relatively small proportion of the total carried in the Rio Grande.

The contribution of total plutonium carried by run-off from Los Alamos Canyon into the Rio Grande is estimated to be about 10% of the contribution from worldwide fallout (ESG 1981, Graf 1993). The range of plutonium levels in sediments in the Rio Grande in the vicinity of Los Alamos 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.

7. Special Rio Grande Sediment Study.

A geomorphologic study completed in 1991, "Geomorphology of Plutonium in the Northern Rio Grande System," (Graf 1993) uses a historical perspective to evaluate the contributions of plutonium from Los Alamos to the Rio Grande. This study uses historical aerial photography and hydrologic data to study the movement and deposition of sediments over time. Among the study's conclusions regarding a regional plutonium budget for the 1948 to 1985 period accounting for both worldwide fallout and input from Los Alamos Canyon for the northern Rio Grande, three are particularly relevant to interpreting the surveillance data:

- Fallout accounts for more than 90% of the plutonium in the system; slightly less than 10% is from activity at the Laboratory.
- About half of the total plutonium (from fallout and the Laboratory) is estimated to be stored along the river, and the remainder has been carried to Elephant Butte Reservoir.
- Most of the contributions from the Laboratory are found along the river between Otowi and Peña Blanca (just downstream from Cochiti Dam); since 1973 the downstream transport of the contributions from the Laboratory has terminated in Cochiti Reservoir.

The study identified locations where sediments had been deposited during specific periods. A special sediment sample deposited between 1941 to 1968 was collected from a floodplain near Buckman (just south of Cañada Ancha on Figure IV-9). This sample was subjected to a very sensitive analysis (detection limits as little as 0.0001 pCi/gm) of plutonium isotopes by the Isotope Geochemistry Group at the Laboratory, which found that the plutonium at Buckman contained a ratio of ^{239}Pu to ^{240}Pu consistent with approximately an equal amount of plutonium from worldwide fallout and from the Acid-Pueblo-Los Alamos canyon system. The total level of ^{239}Pu to ^{240}Pu in the sample (0.017 pCi/g) was near the statistically derived fallout level (0.023 pCi/g). The precise analysis found that the deposit contained a substantial contribution from historical flows out of Los Alamos Canyon. Such techniques may be useful for research into other sediment transport processes.

F. Monitoring of the Water Distribution Systems

1. Introduction.

EPA established maximum contaminant levels (MCLs) for organic and inorganic constituents, microbiological contaminants, and radioactivity in drinking water in the Safe Drinking Water Act (SDWA). These standards have been adopted by the State of New Mexico and are included in the New Mexico Water Supply Regulations (NMEIB 1991). NMED has been authorized by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

Compliance samples are analyzed for organic and inorganic constituents and for radioactivity at the State Scientific Laboratory Division (SLD) in Albuquerque. SLD reports the analytical results directly to NMED. The Johnson Controls Inc. Environmental (JENV) laboratory also collects samples from the Laboratory's and county's distribution systems and tests the samples for microbiological contamination, as required under the SDWA. The JENV laboratory is certified by SLD for microbiological testing of drinking water.

During 1992, all water samples collected at Los Alamos and tested by SLD in Albuquerque and by the JENV laboratory were found to be in compliance with the maximum contaminant levels established by SDWA regulation.

2. Sampling and Analytical Results.

a. Radiological Analyses of Drinking Water. Sampling locations were increased from three sites in 1991 to five sites in 1992. The SDWA specifies a sequential analysis protocol for radioactivity measurements. When gross activity measurements are below the screening limits, the Laboratory does not need to perform further isotopic analyses or perform dose calculations. The concentrations of gross alpha activity concentrations were less than the screening level of 5 pCi/L. For gross beta, the activity measurements were less than the screening limit of 50 pCi/L. These results are summarized in Table III-9.

In 1992 all operating water supply wells were sampled for radon. Radon is a naturally occurring radionuclide produced during the decay of geological sources of uranium. This testing was not required under the SDWA but was conducted because EPA has issued a proposed MCL for radon of 300 pCi/L. The MCL for radon will become effective 18 months after its final promulgation by EPA. (Promulgation of the final rule is not expected for at least two years.) As shown in Table III-10, the radon concentrations in the sampled wells ranged from 420 to 1,260 pCi/L. In 1993 additional sampling will be conducted at points of entry into the water distribution system. Radon has a half life of about 12 days, residence time in storage tanks will reduce radon concentrations somewhat before the water reaches consumers. If the MCL is finalized at the 300 pCi/L level and further testing shows that entry point concentrations are higher than 300 pCi/L, drinking water will need to be treated to remove the naturally occurring radon.

b. Chemical Analyses of Drinking Water. In the fourth quarter of 1991 and through 1992, quarterly trihalomethane quarterly sampling locations were increased from five to six sites. The added site was at TA-33 which is near the end of a long, dead end water main. Since trihalomethanes are formed as chlorine reacts with organic material in the distribution system, this site was added because of water's long residence time in the main. As expected, the TA-33 sampling location did contain higher concentrations of trihalomethane than the other sites. However, all trihalomethane measurements were well below the MCLs, as shown in Table III-11.

Samples analyzed for volatile organic compounds (VOCs) were drawn from each of the 10 operating wells and combined into 3 composite samples by the analyst at SLD. All chemical results were in compliance with MCLs. These results are summarized in Table III-12.

A new sampling program for lead and copper measured at residential taps was initiated in 1992 in accordance with the SDWA. The object of this program is to measure lead and copper in the tap water under circumstances that maximize the potential for the water to leach lead and copper from plumbing materials inside the home. The Laboratory cooperated with officials of Los Alamos County to identify and contact residents of single family homes with copper piping built between 1982 and 1987. The residents were given sample containers and instructions for collecting first draw samples. Residents returned the filled sample containers to the JENV laboratory, where the samples were acidified and packaged for transport to the SLD for analysis.

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, water suppliers must take prescribed actions to monitor and control the corrosivity of the water supplied to the customers. Another way of saying this is if the 90th percentile values for lead and copper are less than the action levels, the system is in compliance without the need to implement corrosion control. As shown in Table III-13, the 90th percentile values for lead and copper were well below the EPA action levels.

For 1992, sampling locations for inorganic chemicals were increased from three to six sites throughout the distribution system so that the well fields and major service areas are well represented. Taps are flushed for several minutes so that samples represent water that is freshly drawn from the water main. As shown in Table III-14, all locations and all parameters were below MCLs.

c. Microbiological Analyses of the Water Distribution System. Each month during 1992 an average of 47 samples were collected at sampling sites throughout the distribution system and analyzed for microbiological contaminants. Under the SDWA, samples are tested for total coliform and noncoliform bacteria. If a sample is found to contain of coliform bacteria, it is also tested for the presence of fecal coliforms, and samples are collected for repeat analysis. Each sampling site was also tested in the field for its

residual concentration of free chlorine. Chlorine gas is added to the water to provide a residual disinfectant capability in the distribution system.

The MCL for total coliforms is no more than 5% of the total number of samples collected each month showing the presence of total coliforms. Because Los Alamos collected over 40 samples each month in 1992, the MCL was 2 samples showing the presence of total coliforms (Table III-15). During the month of June, two samples contained coliforms, but the MCL was not exceeded. No fecal coliforms were detected in any of the samples collected in 1992.

3. Other Environmental Activities for Protection of the Water Supply Systems.

Other programs conducted to protect the water supply system include the following:

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

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

c. Cross Connection Survey Program. In 1992 the Laboratory began a comprehensive building by building survey of interior plumbing systems to identify and correct cross connections. Personnel from the Engineering Division Maintenance Group (ENG-6) visually surveyed buildings looking for actual or potential cross connections between potable water systems and industrial, fire, cooling, or other nonpotable water supplies. The surveyors checked for the presence of adequate backflow prevention devices and labeled the piping and outlets where necessary.

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

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

Physical piping alterations were made in some cases and in other cases low hazard potential cross connections that presented little hazard were scheduled for piping modifications. Due to the labor intensive and detailed nature of these surveys, fewer than 10% of the Laboratory's approximately 2,400 buildings were surveyed in 1992. The survey and corrective action program will continue at least through 1994.

G. Foodstuffs Monitoring

1. Introduction.

Samples of foods (produce, fish, and honey) are collected and analyzed for radioactivity in an effort to monitor potential contamination in the food chain resulting from Laboratory operations. The two main objectives of the Foodstuffs Monitoring Program are (1) to compare levels of radionuclides in foodstuffs collected from off-site regional (background) areas to levels in foods collected from Laboratory and perimeter areas, and (2) to calculate any additional radiation dose to Laboratory and area residents (Los Alamos and

White Rock) based on the data collected and compare it to radiation protection standards recommended by the International Commission on Radiological Protection (ICRP 1979) and the National Council on Radiation Protection and Measurements (NCRP 1987a). Radiation doses to individuals from the ingestion of foodstuffs are presented in Section V.C.3.f.

2. Monitoring Network.

Fruits, vegetables, grains, bees, and honey are collected each year from Laboratory, perimeter (Los Alamos and White Rock), and regional (Española and Santa Fe) locations. Samples of produce are also collected from several Indian lands (San Ildefonso, Cochiti, and Santo Domingo) located in the general vicinity of LANL. Regional or background samples are collected upstream from the confluence of the Rio Grande and intermittent streams that cross Laboratory lands. The regional sampling locations are also sufficiently distant from the Laboratory as to be unaffected by airborne emissions.

Fish are collected upstream and downstream of the Laboratory. Cochiti Reservoir, a 9,361 ac flood-and-sedimentation-control project, is located on the Rio Grande approximately 8 km (5 mi) downstream from the Laboratory. Surface-feeding (trout, salmon, crappie, bass, and walleye) and bottom-feeding fish (catfish, suckers, and carp) collected from Cochiti Reservoir are compared with fish collected from Abiquiu, Heron, and/or El Vado reservoirs. Abiquiu, Heron, and El Vado reservoirs are located on the Rio Chama, a tributary of the Rio Grande, upstream of the Laboratory. These reservoirs are used as control (background) points for the fish sampling program.

All foodstuffs samples are analyzed by the Environmental Chemistry Group (EM-9) for concentrations of ^{3}H, uranium, ^{90}Sr, ^{238}Pu, ^{239,240}Pu, and ^{137}Cs. Bee and honey samples are also analyzed for ^{7}Be, ^{22}Na, ^{54}Mn, ^{57}Co, and ^{83}Rb, as well as for arsenic, beryllium, boron, cadmium, chromium, lead, mercury, and selenium.

Locations of produce, fish, and beehives sampling stations are shown in Figures IV-13 and IV-14 and Table D-13.

3. Analytical Results.

a. Produce. Concentrations of radionuclides in produce collected from off-site (regional and perimeter) and on-site (Laboratory) locations during the 1992 growing season are presented in Table IV-30. In general, most radionuclides in produce collected from off-site and on-site locations were within values reported for these areas in past years. With the exception of ^{3}H, all radionuclides in produce collected from Laboratory and perimeter areas were within regional background concentrations. Tritium concentrations in produce collected from Laboratory and perimeter areas were statistically hiegher than in produce collected from regional background areas. The range in ^{3}H levels in produce samples collected from Laboratory and perimeter areas ranged in concentration from -0.10 to 4.70 pCi/mL and from -0.10 to 9.40 pCi/mL, respectively. (See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.)

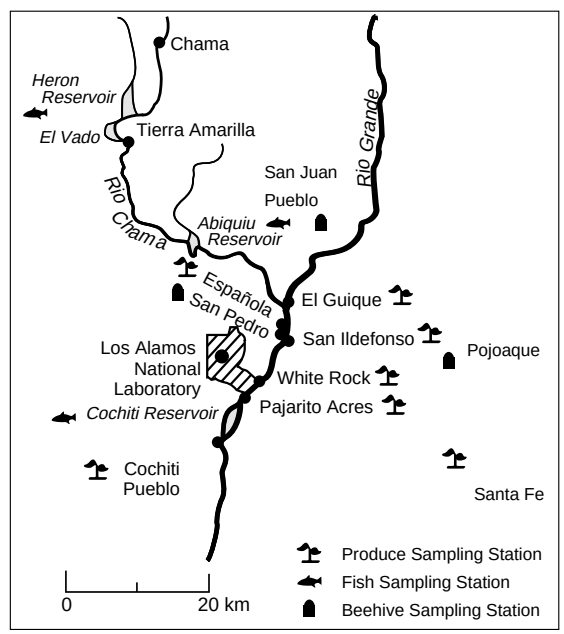


Figure IV-13. Produce, fish, and beehive off-site (regional and perimeter) sampling locations. (Map denotes general locations only.)

Figure IV-14. Locations of beehives in on-site Laboratory areas. Regional stations are shown on Figure IV-13. (Map denotes general locations. Specific locations are presented in Table D-13 and are presented on the FIMAD system in the Community Reading Room.)

Elevated levels of ^{3}H (16 pCi/mL) and $^{239,240}Pu$ (0.02 pCi/dry g) were detected in fruit samples collected in 1991 from a tree growing on grounds previously occupied by the original Laboratory site (TA-1) (EPG 1993). The source of ^{3}H and $^{239,240}Pu$ was traced to soil surface and subsurface contamination around the subject tree (Fresquez 1992a). Samples of fruit were collected from the tree during the 1992 growing season. Air sampling around the fruit tree was also conducted to address concerns of potential airborne release of $^{239,240}Pu$. Concentrations of ^{3}H and $^{239,240}Pu$ in fruit samples collected during the 1992 growing season were slightly lower than in 1991: 11.8 pCi/mL and 0.008 pCi/dry g, respectively (Fresquez 1992b). Moreover, no airborne plutonium was detected in any of 10 samples collected over a 6 month time period.

b. Fish. Radionuclides in surface- and bottom-feeding fish collected upstream (Abiquiu, Heron, and/or El Vado reservoirs) and downstream (Cochiti Reservoir) of the Laboratory are presented in Table IV-31. Concentrations of ^{137}Cs, total U, ^{238}Pu, and $^{239,240}Pu$ in surface-feeding fish collected from Cochiti Reservoir were not statistically different from concentrations in fish collected from reservoirs upstream of the Laboratory.

Table IV-30. Radionuclides in Produce Collected from Off-Site and On-Site Areas during the 1992 Growing Season[a]

	^{3}H (pCi/mL)	^{90}Sr (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)
OFF-SITE STATIONS						
Regional						
Española/Santa Fe						
N	16.00	16.0	16.0	16.0	16.0	16.0
Mean	0.15	29.0	17.0	6.7	8.9	–46.0[b]
Std dev (2σ)	0.42	46.0	42.0	26.8	24.0	200.0
Minimum	0.20 (0.6)[c]	3.5 (7.0)	0.0 (0.0)	–3.8 (22.0)	0.0 (56.0)	–324.0 (276)
Maximum	0.70 (0.6)	79.2 (40.0)	83.0 (12.0)	50.0 (60.0)	39.9 (54.0)	87.0 (54)
Cochiti/Santo Domingo						
N	10.00	10.0	10.0	10.0	10.0	10.0
Mean	0.05	14.0	3.6	6.9	3.2	–83.0
Std dev (2σ)	0.24	32.0	4.8	22.0	9.6	302.0
Minimum	–0.10 (0.6)	0.0 (6.0)	0.6 (0.1)	0.0 (72.0)	0.0 (48.0)	–454.0 (364)
Maximum	0.20 (0.6)	48.4 (24.0)	8.4 (1.2)	33.4 (100.0)	15.4 (31.0)	62.0 (110)
San Ildefonso						
N	6.00	6.0	6.0	6.0	6.0	6.0
Mean	0.10	15.0	4.4	5.3	7.4	67.0
Std dev (2σ)	0.24	44.0	8.4	9.2	12.8	172.0
Minimum	–1.00 (0.6)	2.6 (5.2)	0.7 (0.0)	0.0 (92.0)	0.0 (10.4)	-53.0 (196)
Maximum	0.20 (0.6)	61.6 (30.0)	11.2 (1.4)	12.0 (18.0)	15.4 (62.0)	159.0 (168)
Perimeter						
Los Alamos/White Rock						
N	16.00	16.0	16.0	15.0	15.0	16.0
Mean	1.64	50.0	14.0	3.7	26.3	–3.4
Std dev (2σ)	5.62	94.0	44.0	11.2	67.6	186.0
Minimum	–0.10 (0.6)	5.3 (11.0)	0.0 (0.0)	0.0 (28.0)	0.0 (73.0)	–213.0 (216)
Maximum	9.40 (1.8)	164.7 (36.0)	83.0 (12.0)	14.0 (84.0)	129.6 (32.0)	244.0 (548)
ON-SITE STATIONS						
N	10.00	10.0	10.0	10.0	10.0	10.0
Mean	1.84	57.0	19.0	2.6	11.4	–32.0
Std dev (2σ)	3.24	78.0	30.0	11.6	17.2	130.0
Minimum	–0.10 (0.6)	9.2 (10.0)	3.1 (0.6)	0.0 (109.0)	0.0 (73.0)	–162.0 (224)
Maximum	4.70 (1.4)	134.4 (32.0)	39.4 (5.7)	16.8 (100.0)	23.0 (74.0)	65.0 (240)

[a]There are no concentration guides for produce.
[b]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[c]Counting uncertainties (|2 standard deviations) are in parentheses.

Table IV-31. Radionuclides in Fish in 1992

	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
SURFACE FEEDERS (Crappie, Trout, Bass, and Walleye)					
Abiquiu, Heron, and El Vado					
N	18	18	18.0	18.0	18
Mean	11	96	1.2	4.5	14
Std dev (2σ)	20	168	1.5	14.0	50
Minimum	2 (4)[a]	–68[b] (216)	0.2 (0.0)	0.0 (18)	0 (16)
Maximum	45 (30)	290 (230)	3.6 (0.2)	22.0 (66)	112 (50)
Cochiti					
N	12	12	12.0	12.0	12
Mean	41	132	5.4	3.3	9
Std dev (2σ)	18	126	18.6	12.0	34
Minimum	26 (26)	46 (126)	2.2 (0.2)	0.0 (72)	0 (51)
Maximum	56 (28)	279 (142)	35.0 (0.4)	14.0 (84)	60 (50)
BOTTOM FEEDERS (Catfish, Sucker, and Carp)					
Abiquiu, Heron, and El Vado					
N	20	20	20.0	20.0	20
Mean	32	110	5.2	4.0	18
Std dev (2σ)	396	144	8.0	14.0	56
Minimum	5 (4)	0 (0)	0.8 (0.0)	0.0 (30)	0 (40)
Maximum	56 (28)	294 (254)	17.0 (1.0)	24.0 (72)	99 (44)
Cochiti					
N	12	12	12.0	12.0	12
Mean	15	105	8.8	7.6	6
Std dev (2σ)	12	126	6.4	16.0	14
Minimum	5 (10)	16 (234)	5.1 (0.2)	0.0 (36)	0 (16)
Maximum	24 (16)	242 (144)	16.0 (0.8)	27.0 (54)	24 (31)

[a]Counting uncertainties (|2 standard deviations) are in parentheses.
[b]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

^{90}Sr in surface-feeding fish collected from Cochiti Reservoir was statistically different from that in fish collected from Abiquiu, Heron, and El Vado reservoirs. Although the levels of ^{90}Sr in fish from Cochiti Reservoir were statistically higher than background levels, they were within the range found in these fish in previous years and were even lower than ^{90}Sr levels observed in 1991. Also, the difference between ^{90}Sr levels found in surface-feeding fish collected from Cochiti and levels in fish collected from Abiquiu, Heron, and/or El Vado reservoirs was small (0.030 pCi/dry g).

The concentrations of most radionuclides in bottom-feeding fish collected from Cochiti were not statistically different than concentrations in fish collected from Abiquiu, Heron, and/or El Vado reservoirs. Again, as in previous years, levels of total uranium were statistically higher in bottom-feeding fish collected from Cochiti Reservoir than in to fish collected upstream of the Laboratory.

Heavy and trace metals in fish are sampled every three years; the results of the next sampling session will be presented in the environmental surveillance report for CY94.

c. Bees and Honey. Data collected over two years (1991 and 1992) are presented. Data collected in 1991 are presented in Tables IV-32 through IV-35, and the data collected in 1992 are presented in Tables IV-36 through IV-39.

Table IV-32. Radionuclides in Bees Collected from Off-Site and On-Site Areas during 1991

Station	^{3}H (pCi/L)	^{7}Be (pCi/g)	^{22}Na (pCi/g)	^{54}Mn (pCi/g)	^{57}Co (pCi/g)	^{83}Rb (pCi/g)	^{137}Cs (pCi/g)	U (ng/g)
OFF-SITE STATIONS								
Regional								
San Pedro	688	0.70	0.06	0.10	–0.01[a]	–0.97	0.08	16
	(600)[b]	(1.80)	(0.14)	(0.14)	(0.21)	(1.37)	(0.21)	(4)
Pojoaque	605	0.52	0.15	0.17	0.01	0.04	–0.10	20
	(600)	(1.80)	(0.15)	(0.16)	(0.20)	(1.33)	(1.98)	(4)
San Juan	400	0.33	0.08	0.01	0.04	–0.20	–0.11	20
	(600)	(1.41)	(0.12)	(0.12)	(0.12)	(0.80)	(0.13)	(4)
$\bar{X}$[c]	564	0.51	0.10	0.09	0.01	–0.38	–0.04	19
	(|296)	(|0.38)	(|0.10)	(|0.16)	(|0.06)	(|1.06)	(|0.22)	(|4)
ON-SITE STATIONS								
TA-5	994	1.36	–0.04	0.02	0.07	–0.09	0.02	33
	(600)	(1.80)	(0.12)	(0.12)	(1.20)	(0.92)	(0.12)	(6)
TA-8	530	–0.55	0.00	0.14	0.04	–0.73	0.15	16
	(600)	(1.82)	(0.13)	(0.15)	(0.21)	(1.37)	(0.11)	(4)
TA-9	658	0.52	0.03	0.05	0.05	0.02	–0.04	18
	(600)	(1.56)	(0.12)	(0.12)	(0.12)	(0.87)	(0.13)	(4)
TA-15	5,262	1.89	0.11	0.16	0.03	0.56	–0.08	67
	(1,052)	(1.64)	(0.12)	(0.13)	(0.12)	(0.94)	(0.28)	(14)
TA-16	374	0.86	–0.01	0.06	0.28	–0.21	–0.02	16
	(600)	(1.55)	(0.12)	(0.12)	(0.12)	(0.80)	(0.13)	(4)
TA-21	8,146	1.26	0.03	0.08	–0.00	–0.03	–0.03	24
	(1,630)	(1.59)	(0.13)	(0.14)	(0.11)	(0.79)	(0.14)	(4)
TA-33	14,091	1.26	0.16	0.10	0.07	–0.88	0.18	16
	(2,818)	(1.81)	(0.17)	(0.17)	(0.21)	(1.34)	(0.21)	(4)
TA-49	918	1.29	0.01	0.01	0.24	–0.55	–0.04	19
	(600)	(1.81)	(0.14)	(0.16)	(0.22)	(1.00)	(0.20)	(4)
TA-50	1,753	0.12	–0.02	0.10	0.23	–0.67	–0.11	54
	(600)	(1.83)	(0.13)	(0.16)	(0.22)	(1.36)	(0.21)	(10)
TA-53	4,912	1.00	0.10	0.05	0.08	–0.14	-0.08	54
	(982)	(1.70)	(0.12)	(0.12)	(0.12)	(0.90)	(0.12)	(10)
TA-54	24,111	1.24	–0.04	–0.01	0.11	0.66	–0.01	26
	(4,822)	(2.00)	(0.13)	(0.20)	(0.21)	(1.33)	(0.21)	(6)

[a]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[b]Counting uncertainties (|2 standard deviations) are in parentheses.
[c] $\bar{X}$ = average.

Table IV-33. Trace Metals in Bees Collected from Off-Site and On-Site Areas during 1991

Station	Arsenic (µg/g)	Beryllium (µg/g)	Boron (µg/g)	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)	Mercury (ng/g)	Selenium (µg/g)
OFF-SITE STATIONS								
Regional								
San Pedro	<0.3[a]	<0.01	3.5	0.14	0.10	<0.4	<5	<0.3
Pojoaque	<0.3	<0.01	3.2	0.11	0.09	<0.4	<5	<0.3
San Juan	<0.3	<0.01	4.9	0.08	0.08	<0.4	<5	<0.3
_X_ [b]	<0.3	<0.01	3.9	0.11	0.09	<0.4	<5	<0.30
	(_0.0)[c]	(_0.00)	(_1.8)	(_0.06)	(_0.02)	(_0.0)	(_0)	(_0.00)
ON-SITE STATIONS								
TA-5	<0.3	<0.01	4.4	0.12	0.13	<0.4	<5	<0.3
TA-8	<0.3	<0.01	2.6	0.05	0.07	35.4	<5	<0.3
TA-9	<0.3	<0.01	3.7	0.09	0.08	29.8	<5	<0.3
TA-15	<0.3	<0.01	4.4	0.11	0.08	10.7	<5	<0.3
TA-16	<0.3	<0.01	3.7	0.07	0.14	19.0	<5	<0.3
TA-21	<0.3	<0.01	7.1	0.08	0.08	5.8	<5	<0.3
TA-33	<0.3	<0.01	4.4	0.08	0.08	16.7	<5	<0.3
TA-49	<0.3	<0.01	6.2	0.12	0.10	33.3	<5	<0.3
TA-50	<0.3	<0.01	3.7	0.06	0.12	<0.4	<5	<0.3
TA-53	<0.3	<0.01	4.8	0.10	0.11	<0.4	<5	<0.3
TA-54	<0.3	<0.01	4.6	0.10	0.12	<0.4	<5	<0.3

[a] Uncertainty of the results is _10%.
[b] _X_ = average.
[c] _ 2 standard deviations.

Table IV-34. Radionuclides in Honey Collected from Off-Site and On-Site Areas during 1991

Station	^{3}H (pCi/L)	^{7}Be (pCi/L)	^{22}Na (pCi/L)	^{54}Mn (pCi/L)	^{57}Co (pCi/L)	^{83}Rb (pCi/L)	^{137}Cs (pCi/L)	U (ng/g)
OFF-SITE STATIONS								
Regional								
San Pedro	0 (600)[b]	–501[a] (1,084)	4 (56)	43 (76)	–18 (60)	53 (214)	58 (84)	<0.01
Pojoaque	300 (600)	713 (850)	–45 (61)	1 (72)	–70 (60)	75 (146)	17 (62)	<0.01
San Juan	–100 (600)	491 (750)	–57 (64)	–19 (64)	–18 (60)	106 (161)	–2 (60)	<0.01
_X+[c]	67 (|416)	234 (|1,293)	–32 (|64)	8 (|64)	–35 (|60)	78 (|53)	24 (|61)	<0.01 (|0.00)
ON-SITE STATIONS								
TA-5	100 (600)	228 (736)	87 (62)	27 (68)	–117 (110)	–1 (142)	31 (60)	<0.01
TA-8	400 (600)	815 (864)	–12 (61)	–15 (74)	–10 (64)	49 (160)	14 (60)	<0.01
TA-9	200 (600)	–75 (822)	–61 (64)	49 (74)	–51 (60)	–37 (140)	–9 (60)	<0.01
TA-15	5,400 (600)	590 (824)	–12 (80)	43 (76)	–28 (60)	93 (148)	–22 (60)	<0.01
TA-16	700 (600)	108 (824)	–15 (60)	–50 (76)	24 (60)	–15 (60)	–26 (60)	<0.01
TA-21	9,100 (1,800)	272 (806)	–60 (62)	18 (50)	31 (60)	–51 (142)	73 (70)	<0.01
TA-33	12,400 (660)	–898 (1,126)	33 (82)	24 (92)	–113 (116)	39 (220)	31 (60)	<0.01
TA-49	100 (600)	–560 (1,226)	47 (80)	20 (92)	–12 (110)	–3 (196)	10 (94)	<0.01
TA-50	1,800 (600)	19 (804)	–40 (62)	26 (74)	–67 (61)	–95 (130)	40 (82)	<0.01
TA-53	6,400 (1,200)	58 (734)	79 (51)	52 (88)	–30 (121)	85 (146)	32 (68)	<0.01
TA-54	95,300 (16,000)	231 (1,188)	14 (80)	30 (94)	–44 (112)	–62 (188)	41 (96)	<0.01

[a]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[b]Counting uncertainties (| 2 standard deviations) are in parentheses.
[c] _X+ = average.

Table IV-35. Trace Metals in Honey Collected from Off-Site and On-Site Areas during 1991

Station	Arsenic (µg/g)	Beryllium (µg/g)	Boron (µg/g)	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)	Mercury (ng/g)	Selenium (µg/g)
OFF-SITE STATIONS								
Regional								
San Pedro	<0.3[a]	<0.01	7.8	<0.02	<0.09	<0.04	<10	<0.3
Pojoaque	<0.3	<0.01	7.8	<0.02	<0.09	<0.04	<10	<0.3
San Juan	<0.3	<0.01	8.1	<0.02	<0.09	<0.04	<10	<0.3
_X_[b]	<0.3 (_0.0)[c]	<0.01 (_0.00)	7.9 (_0.4)	<0.02 (_0.0)	<0.09 (_0.00)	<0.04 (_0.0)	<10 (_0)	<0.3 (_0.0)
ON-SITE STATIONS								
TA-5	0.3	<0.01	10.1	0.02	<0.09	<0.04	<10	<0.3
TA-8	<0.3	<0.01	6.2	0.04	<0.09	<0.40	<10	<0.3
TA-9	<0.3	<0.01	5.8	<0.02	<0.09	<0.40	<10	<0.3
TA-15	<0.3	<0.01	9.3	0.02	<0.09	<0.40	<10	<0.3
TA-16	0.3	<0.01	6.6	<0.02	<0.09	<0.40	<10	<0.3
TA-21	0.5	<0.01	7.7	<0.02	<0.09	<0.40	<10	<0.3
TA-33	<0.3	<0.01	6.9	0.02	<0.09	<0.40	<10	<0.3
TA-49	0.3	<0.01	6.8	0.02	<0.09	<0.40	<10	<0.3
TA-50	<0.3	<0.01	7.5	<0.02	<0.09	<0.40	<10	<0.3
TA-53	0.3	<0.01	7.5	0.04	<0.09	<0.40	<10	<0.3
TA-54	0.3	<0.01	7.7	0.03	<0.09	<0.40	<10	<0.3

[a]Uncertainty of the results is _10%. The density of honey is about 1,860 g/L.
[b] _X_ = average.
[c]_ 2 standard deviations.

Table IV-36. Radionuclides in Bees Collected from Off-Site and On-Site Areas during 1992

Station	^{3}H (pCi/L)	^{7}Be (pCi/g)	^{22}Na (pCi/g)	^{54}Mn (pCi/g)	^{57}Co (pCi/g)	^{83}Rb (pCi/g)	^{137}Cs (pCi/g)	U (ng/g)
OFF-SITE STATIONS								
Regional								
San Pedro	200	6	0.13	0.10	0.13	0.69	0.09	6.83
	(600)[a]	(10)	(0.20)	(0.14)	(0.12)	(0.95)	(0.17)	(0.96)
Pojoaque	200	48	0.09	0.01	0.03	2.56	–0.05[b]	4.48
	(600)	(121)	(0.17)	(0.20)	(0.20)	(3.42)	(0.16)	(0.66)
San Juan	100	89	0.20	0.12	0.22	1.96	–0.17	5.85
	(600)	(137)	(0.19)	(0.23)	(0.22)	(3.24)	(0.18)	(0.82)
_*X*+[c]	167	48	0.14	0.08	0.13	1.74	–0.04	5.72
	(|116)	(|84)	(|0.12)	(|0.12)	(|0.20)	(|1.90)	(|0.26)	(|2.36)
ON-SITE STATIONS								
TA-5	20,900	114	0.43	0.55	0.45	0.23	0.21	4.37
	(2,800)	(134)	(0.40)	(0.46)	(0.42)	(7.46)	(0.32)	(0.64)
TA-8	14,600	–72	–0.04	0.06	–0.02	3.71	0.05	4.18
	(2,400)	(134)	(0.16)	(0.20)	(0.18)	(3.50)	(0.16)	(0.62)
TA-9	1,100	96	0.28	0.10	0.25	2.99	–0.07	4.67
	(600)	(152)	(0.20)	(0.21)	(0.22)	(3.60)	(0.16)	(0.66)
TA-15	13,100	98	0.08	–0.02	–0.03	0.08	–0.06	11.21
	(2,200)	(136)	(0.16)	(0.23)	(0.19)	(0.16)	(0.14)	(1.56)
TA-16	300	10	0.01	0.13	0.16	1.61	0.06	32.84
	(600)	(120)	(0.17)	(0.21)	(0.20)	(3.06)	(0.16)	(4.60)
TA-21	16,100	52	–0.01	0.08	0.11	2.32	–0.06	7.82
	(2,400)	(134)	(0.20)	(0.23)	(0.20)	(3.08)	(0.16)	(1.10)
TA-33	13,500	55	0.28	0.27	0.16	1.65	0.03	5.21
	(2,200)	(128)	(0.11)	(0.22)	(0.22)	(3.06)	(0.16)	(0.72)
TA-49	1,600	98	0.17	0.09	0.03	3.13	–0.01	7.30
	(800)	(137)	(0.18)	(0.20)	(0.20)	(3.48)	(0.16)	(1.02)
TA-50	1,700	31	0.09	0.19	0.12	0.52	0.16	10.76
	(800)	(128)	(0.18)	(0.22)	(0.20)	(3.32)	(0.16)	(1.52)
TA-53	21,700	37	7.63	0.33	0.34	–2.07	0.05	5.76
	(2,800)	(133)	(2.32)	(0.24)	(0.22)	(3.54)	(0.16)	(0.80)
TA-54	411,800	42	0.00	0.32	0.34	2.08	0.08	0.00
	(16,200)	(128)	(0.16)	(0.24)	(0.22)	(3.76)	(0.16)	(0.00)

[a]Counting uncertainties (|2 standard deviations) are in parentheses.

[b]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

[c] _*X*+ = average.

Table IV-37. Trace Metals in Bees Collected from Off-Site and On-Site Areas during 1992

Station	Arsenic (µg/g)	Beryllium (µg/g)	Boron (µg/g)	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)	Mercury (ng/g)	Selenium (µg/g)
OFF-SITE STATIONS								
Regional								
San Pedro	<0.2[a]	<0.01	4.60	0.08	0.13	<0.40	<10	0.66
Pojoaque	<0.2	<0.01	3.46	0.07	0.07	<0.40	<10	0.62
San Juan	<0.2	<0.01	5.24	0.07	0.11	<0.40	<10	0.57
_X_[b]	<0.2	<0.01	4.43	0.07	0.10	<0.40	<10	0.62
	(_0.0)[c]	(_0.00)	(_1.80)	(_0.02)	(_0.06)	(_0.00)	(_0)	(_0.10)
ON-SITE STATIONS								
TA-5	<0.2	<0.01	3.38	0.06	0.09	<0.40	<10	<0.20
TA-8	<0.2	<0.01	2.97	0.05	0.10	<0.40	<10	0.39
TA-9	<0.2	<0.01	2.90	0.07	0.10	<0.40	<10	0.32
TA-15	<0.2	<0.01	2.83	0.05	0.09	<0.40	<10	<0.20
TA-16	<0.2	<0.01	3.94	0.06	0.09	<0.40	<10	0.24
TA-21	<0.2	<0.01	5.46	0.07	0.09	<0.40	<10	<0.20
TA-33	<0.2	<0.01	6.97	0.07	0.09	<0.40	<10	<0.20
TA-49	<0.2	<0.01	3.74	0.08	0.11	<0.40	<10	<0.20
TA-50	<0.2	<0.01	3.70	0.06	0.10	<0.40	<10	<0.20
TA-53	<0.2	<0.01	4.06	0.05	0.16	0.76	<10	<0.20
TA-54	<0.2	<0.01	7.50	0.06	0.10	<0.40	<10	<0.20

[a]Uncertainty of the results is _10%.
[b] _X_ = average.
[c]_ 2 standard deviations.

Table IV-38. Radionuclides in Honey Collected from Off-Site and On-Site Areas during 1992

Station	^{3}H (pCi/L)	^{7}Be (pCi/L)	^{22}Na (pCi/L)	^{54}Mn (pCi/L)	^{57}Co (pCi/L)	^{83}Rb (pCi/L)	^{137}Cs (pCi/L)	U (ng/g)
OFF-SITE STATIONS								
Regional								
San Pedro	200	0.21	0.02	0.09	–0.04[a]	–1.03	0.00	0.65
	(600)[b]	(5.40)	(0.07)	(0.10)	(0.08)	(1.38)	(0.07)	(0.08)
Pojoaque	300	2.59	0.05	0.12	–0.01	0.14	–0.01	0.23
	(600)	(5.40)	(0.07)	(0.10)	(0.08)	(1.34)	(0.06)	(0.10)
San Juan	700	2.00	0.03	0.05	–0.06	0.78	–0.10	0.41
	(600)	(5.50)	(0.07)	(0.10)	(0.09)	(1.36)	(0.08)	(0.06)
_X+[c]	400	1.60	0.03	0.09	–0.04	–0.04	–0.04	0.43
	(|530)	(|2.46)	(|0.04)	(|0.08)	(|0.06)	(|1.84)	(|0.12)	(|0.42)
ON-SITE STATIONS								
TA-5	800	5.27	0.05	0.06	0.03	–0.36	0.03	0.19
	(600)	(6.06)	(0.07)	(0.09)	(0.10)	(1.36)	(0.08)	(0.06)
TA-8	500	–0.60	0.02	–0.01	–0.02	–0.16	–0.05	0.42
	(600)	(5.40)	(0.07)	(0.08)	(0.10)	(1.34)	(0.06)	(0.32)
TA-9	29,100	1.61	0.03	0.04	–0.10	–0.94	–0.03	0.30
	(3,400)	(5.40)	(0.08)	(0.10)	(0.10)	(1.47)	(0.04)	(0.06)
TA-15	1,200	0.38	0.07	–0.05	–0.13	–0.22	–0.03	4.05
	(800)	(5.40)	(0.08)	(0.06)	(0.09)	(1.48)	(0.07)	(0.44)
TA-16	1,500	4.29	0.02	0.06	–0.02	0.26	–0.04	0.25
	(800)	(5.60)	(0.07)	(0.10)	(0.09)	(1.48)	(0.03)	(0.06)
TA-21	49,900	0.23	0.04	0.03	0.01	–0.69	–0.03	0.80
	(5,000)	(5.40)	(0.07)	(0.08)	(0.10)	(1.48)	(0.07)	(0.12)
TA-33	25,100	3.44	–0.01	0.09	–0.03	0.29	–0.02	0.35
	(3,000)	(5.40)	(0.07)	(0.08)	(0.09)	(1.60)	(0.07)	(0.06)
TA-49	2,500	2.40	0.01	0.02	–0.02	0.65	–0.11	0.98
	(1,000)	(5.40)	(0.08)	(0.09)	(0.10)	(1.50)	(0.04)	(0.54)
TA-50	4,300	4.42	0.07	0.08	0.06	–0.39	0.02	0.66
	(600)	(5.60)	(0.07)	(0.09)	(0.11)	(1.46)	(0.07)	(0.08)
TA-53	32,700	1.84	0.62	0.12	–0.06	0.33	0.04	1.57
	(3,600)	(5.50)	(0.20)	(0.10)	(0.09)	(1.74)	(0.07)	(0.18)
TA-54	94,700	2.28	0.02	0.09	0.02	–0.48	0.01	0.27
	(6,400)	(5.40)	(0.06)	(0.10)	(0.10)	(1.60)	(0.06)	(0.07)

[a]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[b]Counting uncertainties (| 2 standard deviations) are in parentheses.
[c] _X+ = average.

Table IV-39. Trace Metals in Honey Collected from Off-Site and On-Site Areas during 1992

Station	Arsenic (µg/g)	Beryllium (µg/g)	Boron (µg/g)	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)	Mercury (ng/g)	Selenium (µg/g)
OFF-SITE STATIONS								
Regional								
San Pedro	<0.2[a]	<0.01	5.57	<0.05	<0.2	<0.4	<20	0.26
Pojoaque	<0.2	<0.01	8.04	<0.05	<0.2	<0.4	<20	0.30
San Juan	<0.2	<0.01	8.42	<0.05	<0.2	<0.4	<20	0.24
_X_[b]	<0.2	<0.01	7.34	<0.05	<0.2	<0.4	<20	0.27
	(_0.0)[c]	(_0.00)	(_3.10)	(_0.0)	(_0.00)	(_0.0)	(_0)	(_0.06)
ON-SITE STATIONS								
TA-5	<0.2	<0.01	7.21	<0.05	<0.2	<0.4	<20	<0.20
TA-8	<0.2	<0.01	5.75	<0.05	<0.2	<0.4	<20	<0.20
TA-9	<0.2	<0.01	8.21	<0.05	<0.2	<0.4	<20	<0.20
TA-15	<0.2	<0.01	5.51	<0.05	<0.2	<0.4	<20	<0.20
TA-16	<0.2	<0.01	5.49	<0.05	<0.2	<0.4	<20	0.32
TA-21	<0.2	<0.01	6.90	<0.05	<0.2	<0.4	<20	<0.20
TA-33	<0.2	<0.01	6.82	<0.05	<0.2	<0.4	<20	<0.20
TA-49	<0.2	<0.01	8.31	<0.05	<0.2	<0.4	<20	0.21
TA-50	<0.2	<0.01	6.32	<0.05	<0.2	<0.4	<20	<0.20
TA-53	<0.2	<0.01	13.40	<0.05	<0.2	<0.4	<20	<0.20
TA-54	<0.2	<0.01	8.80	<0.05	<0.2	<0.4	<20	<0.20

[a] Uncertainty of the results is _20%. The density of honey is about 1,860 g/L.
[b] _X_ = average.
[c] _2 standard deviations.

1991. With the exception of ^{3}H and lead, most radionuclide and trace metal elements in bee and honey samples collected from on-site sampling areas during 1991 were within the statistical range observed in samples collected from off-site hives.

Levels of ^{3}H in bees collected from Laboratory areas ranged in concentration from 374 (|600) to 24,111 (|4,822) pCi/L (Table IV-32). The highest ^{3}H contents in bees collected from the Laboratory were from TA-54, Area G. The average concentration of ^{3}H in bees collected from off-site areas was 564 (|296) pCi/L.

Most trace metals in bees collected from Laboratory areas were similar to metal contents in bees collected from off-site regional background areas (Table IV-33). However, levels of lead were higher in seven TAs (TA-8, TA-9, TA-15, TA-16, TA-21, TA-33 and TA-49) than in bees from off-site (regional background) locations (<0.40 µg/g).

Levels of ^{3}H in honey collected from Laboratory beehives ranged from 100 (|600) to 95,300 (|16,000) pCi/L (Table IV-34). Regional background levels of ^{3}H in honey averaged 67 (|416) pCi/L. Honey produced by the hives on Laboratory lands is not available for public consumption.

Levels of trace metal elements, including lead, in honey collected from Laboratory areas were not statistically higher than levels in honey collected from off-site regional background hives (Table IV-35). Although bees collected from seven TAs contained above background levels of lead, the concentration of lead in all honey samples collected from Laboratory lands was similar to lead concentrations in honey collected from regional areas. In other words, there was no transfer of lead from bees to the honey they produced.

1992. Except for ^{3}H, the levels of radionuclide and trace metals in bee and honey samples collected from on-site hives during 1992 were within the statistical range observed in samples collected from off-site hives.

Levels of ^{3}H in bees collected from Laboratory areas ranged in concentration from 300 (|600) to 411,800 (|16,200) pCi/L (Table IV-36). Bees collected from TA-54, Area G contained the highest ^{3}H levels at the Laboratory. The average concentration of ^{3}H in bees collected from off-site (regional background) areas was 167 (|116) pCi/L.

The levels of all trace metals, including lead, in bees collected from Laboratory areas were similar to the levels in bees collected from background areas (Table IV-37).

The levels of ^{3}H in honey collected from Laboratory lands ranged from 500 (|600) to 94,700 (|6,400) pCi/L (Table IV-38). Background concentrations averaged 400 (|530) pCi/L. The highest ^{3}H levels in honey at the Laboratory stations were from the hive located at TA-54.

Levels of trace metals in honey collected from Laboratory lands were similar to levels in honey collected from off-site regional background locations (Table IV-39).

H. Environmental Assessments

The National Environmental Policy Act (NEPA) mandates that federal agencies consider the environmental impacts of their actions prior to final decision making. NEPA establishes the national policy of creating and maintaining conditions under which man and nature can exist in productive and enjoyable harmony and fulfill the social, economic, and other requirements of present and future generations. The sponsoring agency, DOE for LANL activities, is responsible for preparation of NEPA documentations, which include the following:

- a categorical exclusion, applied to specific types of activities that have been determined to have no adverse environmental impacts;
- an Environmental Assessment (EA), evaluating environmental impacts, leading to either a Finding of No Significant Impact (FONSI) if the impacts are found to be not significant or preparation of an Environmental Impact Statement (EIS) if the impacts could be significant; and
- an EIS, in which impacts of proposed and alternative actions are evaluated and mitigation measures proposed, leading to a Record of Decision (ROD) in which the agency discusses the decision to proceed with an action.

The proposed activities documented in EAs submitted to DOE for review in 1992 and in EAs being revised during that period are summarized below. DOE reviews the analysis of environmental impacts for the actions

presented in each EA and submits draft EAs to the NMED and to potentially affected Indian tribes for review before taking final action, which is to issue a FONSI or prepare an EIS. After the decision whether to issue a FONSI or an EIS has been made, the DOE places copies of the EAs in public reading rooms in Los Alamos and Albuquerque.

The EAs described below are drafts, currently either at DOE for review or being revised according to DOE comments. Table IV-40 summarizes the proposed construction and operation dates for these activities.

Table IV-40. Proposed Schedule for Activities with Environmental Assessments under Review or Revision as of March 31, 1993.

Activity	Proposed Construction	Proposed Operation
High Explosive Materials Test Facility	FY94	FY95
Deactivate, Disassemble, and Decontaminate High Pressure Tritium Laboratory	N/A	FY94
Low-Level Waste Drum Staging Facility	FY94	FY94
Transuranic (TRU) Waste Compactor and Drum Storage	FY96	FY97
Expansion of TA-54, Area G	FY94	FY94
Hazardous Waste Treatment Facility	FY96	FY98

High Explosive Materials Test Facility. The proposed action is to consolidate mechanical testing of high explosive materials in a new facility to enhance process efficiency, increase operational safety, and decrease maintenance costs. Tests of high explosive components include measurement of mechanical properties (such as tensile strength) and 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.

Deactivate, Disassemble, and Decontaminate the High Pressure Tritium Laboratory, TA-33, Building 86. The proposed action is to remove and dispose of all materials and equipment from the High Pressure Tritium Laboratory (HPTL), decontaminate the HPTL, 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 (WETF). Since that time, the HPTL has been steadily emitting a small amount of tritiated water vapor to the air. Implementing the proposed action would eliminate one source of airborne contamination and the costs required to maintain and monitor the empty building. Alternative actions include leaving the building as is but continuing the maintenance and monitoring activities, delaying one or more steps for an indefinite period, and reusing the building after the equipment has been removed. Environmental issues include radiation doses and risk to individuals from the emissions of tritiated water vapor and the volume of solid low-level waste (LLW) that would be produced.

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

Transuranic (TRU) Waste Compactor and Drum Storage Building. The proposed action is designed to increase safety and minimize the volume of waste generated at the Laboratory's Plutonium Processing Facility at TA-55; this action consists of two activities: (1) installing a 20-ton hydraulic press in an existing laboratory area to compact approximately 500 lb of TRU waste per week; and (2) using a prefabricated, concrete-floored, metal building for temporary storage of drums of solid TRU waste pending certification and transport to a longer term storage area. At DOE's request, LANL combined separate EAs for the TRU Waste Compactor and the Drum Storage Building into a single EA. Alternatives to the proposed actions include installing the waste compactor but not the drum storage building, constructing the drum storage building but not the waste compactor, or continuing operations under current conditions. Some of the potential environmental, safety, and health issues include air emissions, worker safety, on-site TRU waste management, and TRU waste transportation.

Expansion of TA-54, Area G. Routine activities at the Laboratory generate solid LLW which is 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 area is limited by the space suitable for pit construction. The proposed action is to expand Area G, TA-54 onto adjacent acreage on Mesita del Buey in order to provide adequate facilities for disposing solid LLW after the currently active part of Area G has been filled. Alternatives to expanding Area G include installing specialized aboveground storage structures at the existing 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.

Hazardous Waste Treatment Facility. The proposed action is to construct a new Hazardous Waste Treatment Facility (HWTF) within the Laboratory complex at TA-63. The proposed HWTF would provide a central location for existing hazardous and mixed waste treatment processes and a location for developing alternative treatment processes for existing and future wastes that would otherwise be stored. The HWTF would allow the Laboratory to comply with the terms of a Federal Facilities Compliance Agreement (FFCA) for treatment, storage, and disposal of mixed wastes. Alternatives to building the HWTF and centralizing waste treatment processes include transporting untreated wastes off site, developing and utilizing alternative waste treatment processes at various sites throughout the Laboratory, or 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.

I. Other Significant Environmental Activities at Los Alamos

1. Studies to Measure External Radiation. (Keith Jacobson)

In addition to the Laboratory's routine TLD monitoring of external penetrating radiation, which is described in Section IV.B, other special studies were conducted during 1992. The first study, which was continued from previous years, evaluated TLD measurements as part of a continuing study to compare Laboratory TLDs with TLDs obtained from a commercial contractor.

The study, which began in August 1990 and continued through 1992, involves placing environmental dosimeters obtained from the contractor next to Laboratory dosimeters at 22 locations that are part of the routine environmental monitoring network. Two contractor TLDs were placed at five of these locations. The comparison was a blind study as far as the contractor was concerned; the contractor's TLDs were set out and collected following the contractor's instructions. No information was given to the contractor concerning the nature of study, and the TLDs provided to LANL were processed by the contractor as would those used for any other purpose.

The measured levels of average annual external radiation for 11 perimeter and 11 on-site stations measured with TLDs supplied by LANL and a contractor are shown in Figure IV-15. These figures also show the two standard deviations above and below the contractor's measurements. The LANL TLD measurements were +0.3% and +7.7%

Figure IV-15. Average annual levels of external radiation in 1992 measured using TLDs supplied by LANL and a contractor at (a) on-site stations and (b) perimeter stations.

of the contractor's measurements for the perimeter and on-site groups, respectively. As in 1991, measurements from LANL's TLDs appear slightly higher than those from the contractor's. In general, there was good agreement between the contractor's and LANL's measurements.

In addition, two special studies with TLDs were conducted during the LAMPF run cycle in an attempt to monitor the LAMPF plume. Seventy-two extra dosimeters were deployed in three sectors downwind from LAMPF (the north, north-northeast, and the northeast sectors). LANL began testing a new type of highly sensitive dosimeters which were located next to the regular TLDs at the Laboratory boundary north of LAMPF (Figure IV-1). Preliminary results indicate that these new dosimeters, constructed of Al_2O_3, are nearly 30 times more sensitive than the presently used LiF type. Results from these special studies will be presented in the environmental surveillance report for CY93.

2. Tritium in Precipitation near Los Alamos, New Mexico. (Andrew Adams and Fraser Goff [EES-1])
In February 1990 EES-1 commenced a study to determine the background levels of tritium in precipitation near Los Alamos (Adams 1991). This study is one of the framework studies that support the ER program at Los Alamos. Results were first presented in this report last year (EPG 1993).
In Figures IV-16 through IV-18, all the collection locations and their elevations are plotted. The results of the tritium analyses shown in small boxes. The wind roses in the upper corners represent the average wind directions for that time period (EPG 1990). The wind rose on the left represents the daytime winds, and that on the right represents the night winds. Results are presented in Tritium Units (TU), about 3.2 pCi/L of water. The data on tritium in precipitation, together with data on cold springs and creeks from other studies in the Jemez Mountains, suggests that rainwater with greater than 20 TUs must be contaminated to some degree by Laboratory activities (Vuataz 1986, Meeker 1990). Assuming that the maximum value of background tritium in precipitation is 20 TU, a 20-TU contour was drawn through the data points for each sampling period. The position of the contour is approximate. Over the 3- to 4-month time periods represented by these samples, the average concentration is almost 2 orders of magnitude below EPA limits set for tritium in drinking water (20,000 pCi/L, which is about 6,200 TU).
Figure IV-16 shows the results of the 13 samples collected from December 1991 to April 1992. The tritium values inside the 20-TU contour range from 34.0 TU at the intersection of State Roads 4 and 502 to 95.5 at the old Philomena's near East Gate Industrial Park. Outside the background contour, the tritium values range from 7.43 TU at VC-2B (Sulphur Springs) to 16.5 TU at Pajarito Mountain.
Figure IV-17 shows the results of the 13 samples collected from April 1992 to August 1992. Within the 20-TU contour, the tritium values range from 23.0 TU at Boundary Peak to 63.4 TU at East Gate. Outside the contour, tritium ranges from 12.2 TU at the Santa Fe Airport to 18.8 TU at Pajarito Mountain.
Figure IV-18 shows the results of the August 1992 to December 1992 collection period. Inside the 20-TU background contour, the tritium values range from 25.6 TU at TA-49 to 115.9 TU at a private residence (KM) in the western area of the Los Alamos townsite. Outside the contour, tritium ranges from 7.42 TU at VC-2B to 14.3 TU at Pajarito Mountain.
There are three mechanisms that produce tritium in the rain observed in the Los Alamos region. First, there is a natural background level of tritium that is produced by cosmic rays bombarding water vapor in the atmosphere. This background level depends on several factors including latitude, season, and distance from the ocean. For the intercontinental US, this natural background, which was present before the era of nuclear weapons testing, is about 6 TU.
Second, there is an anthropogenic tritium input to the atmosphere from aboveground nuclear testing, which ceased in 1963. The maximum mean tritium level in rain in the southwestern US was about 2,800 TU in 1963 (Vuataz 1986) but has decreased to about 11 TU in 1991 (Shevenell, in press).
Third, there is an additional anthropogenic tritium input to rain within the Los Alamos region caused by activities at LANL. It is the third mechanism that is believed to produce the tritium anomalies centered over Los Alamos, which is depicted in Figures IV-16 through IV-18. The low-level tritium analyses performed on rain can detect very small amounts of released tritium. The magnitude of these concentrations are generally two orders of magnitude (or 0.01%) below EPA limits for tritium in drinking water.

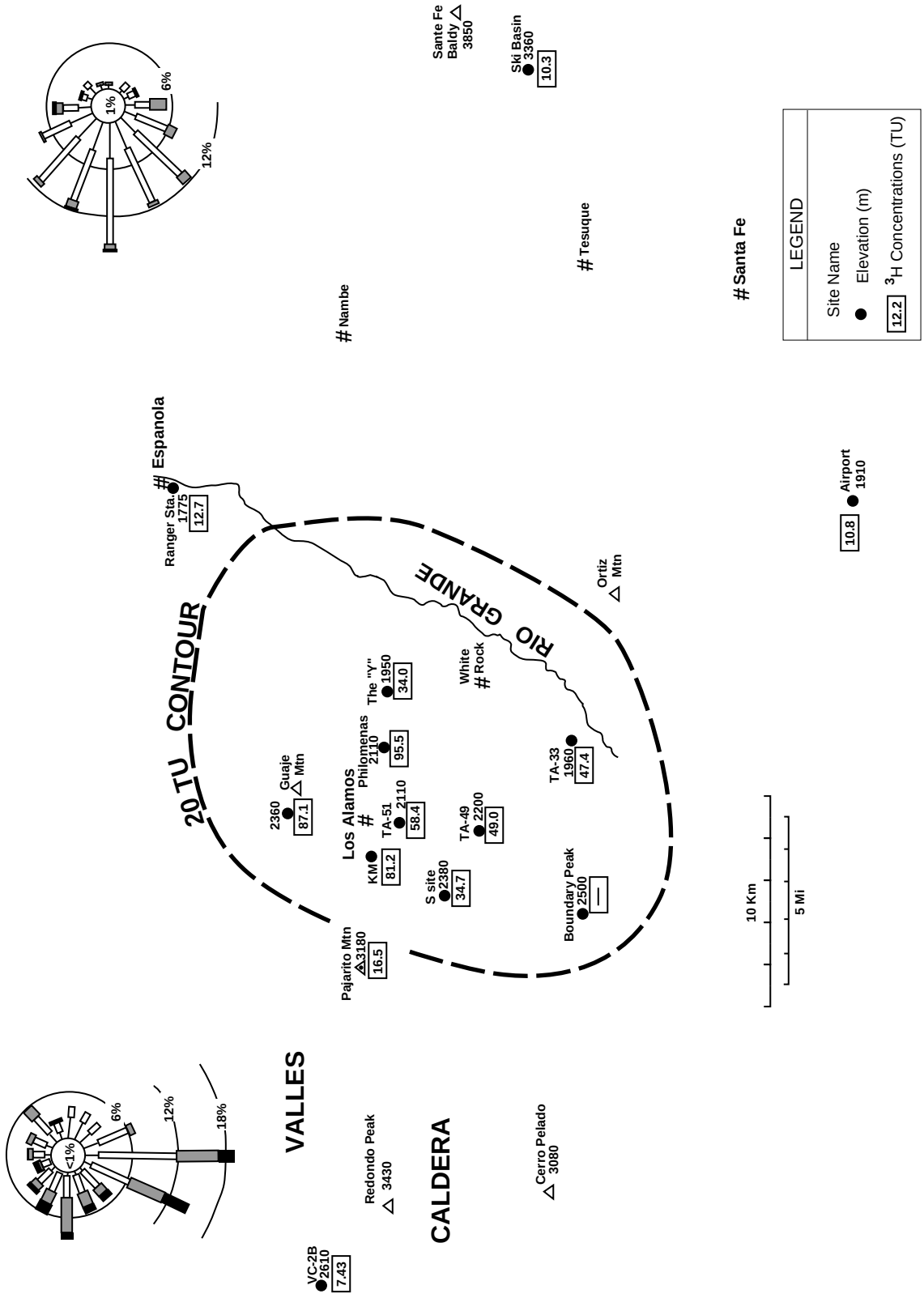


Figure IV-16. Tritium in rainwater (collected from December 1991 to April 1992).

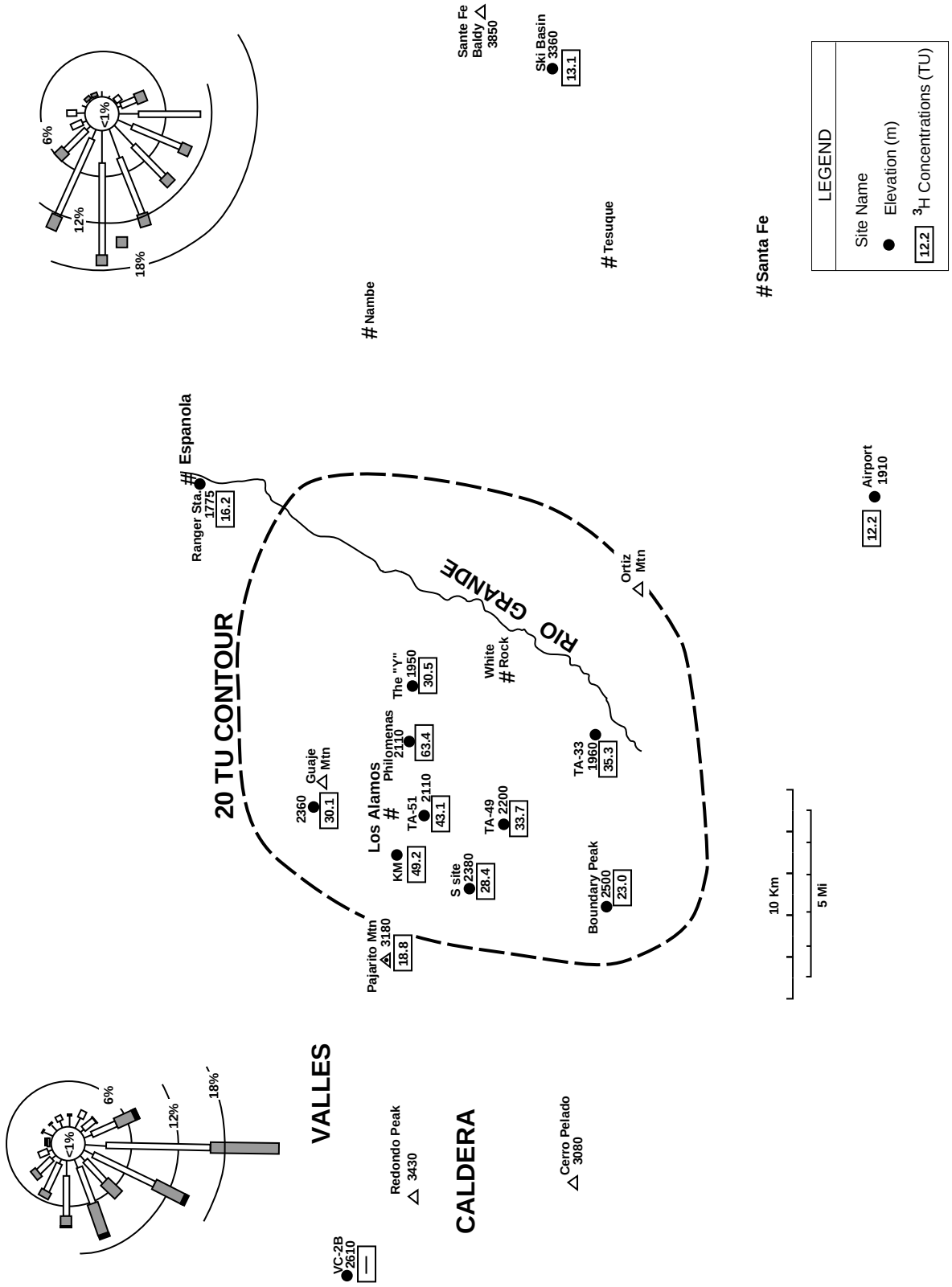


Figure IV-17. Tritium in rainwater (collected from April 1992 to August 1992).

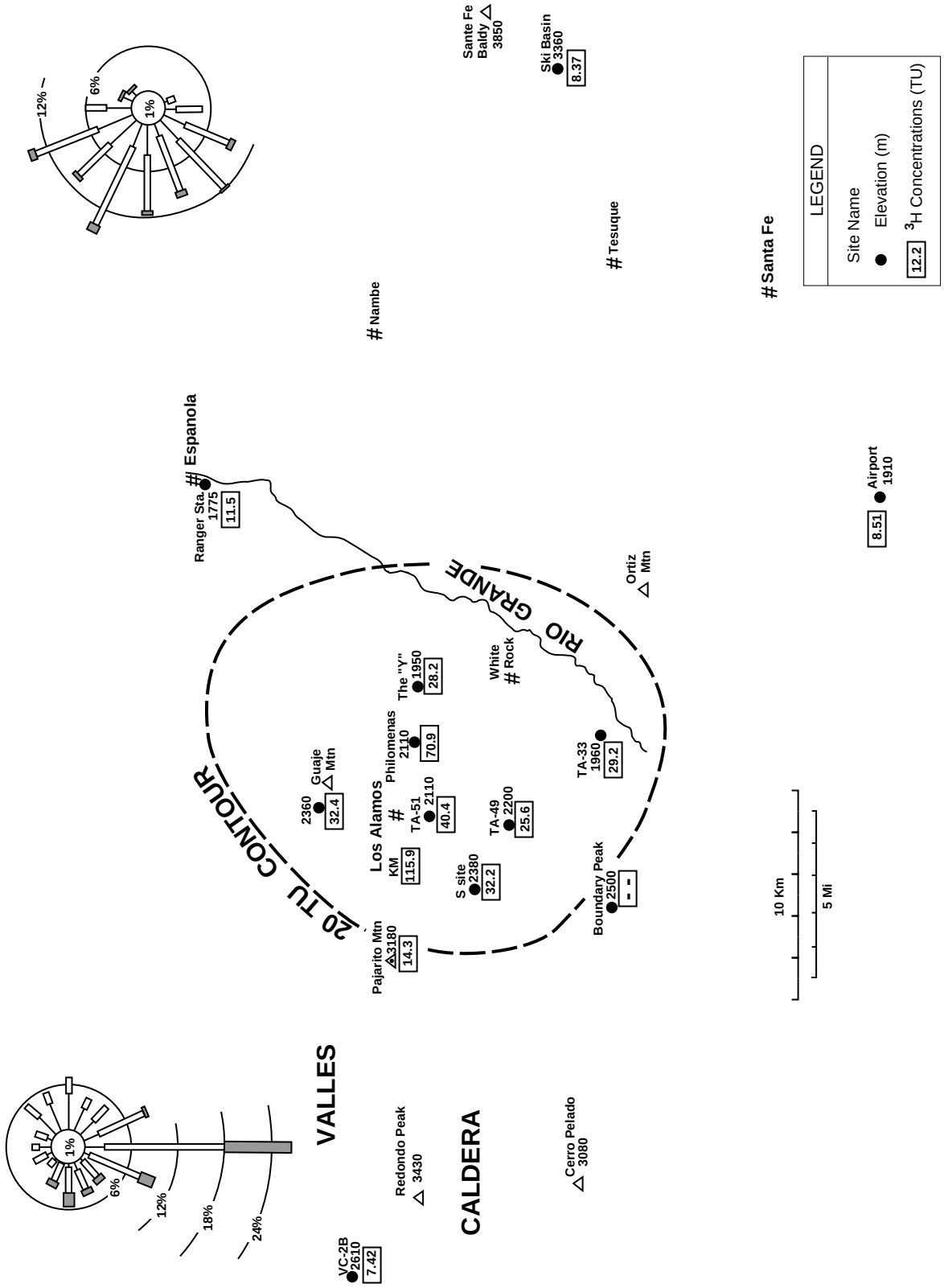


Figure IV-18. Tritium in rainwater (collected from August 1992 to December 1992).

3. Meteorological Monitoring. (Greg Stone)

The meteorological database supports and guides a range of weather-sensitive activities. Observations of wind speed, wind direction, and atmospheric stability provide essential input to regulatory modeling of atmospheric dispersion; meteorological modeling is used to demonstrate regulatory compliance for routine activities at the Laboratory, and it supports safety analysis and environmental assessment studies. A key activity of the program is to provide modeling support to the Laboratory's Emergency Management and Response (EM&R) Office during incidents that may involve releases of hazardous substances to the atmosphere. In the event of a release, real-time wind data and source term estimates are used in computer models to locate the plume and estimate concentration or dose. The database also supports other monitoring and surveillance programs related to air quality, hydrology, and biology.

Weather forecasts are provided to a variety of groups, from those responsible for snow removal to those conducting experiments and measurement programs that are weather sensitive. Daily observations are also provided to the Cooperative Observer Network program of the National Weather Service, which maintains a national climate database.

a. Monitoring Network. Routine meteorological monitoring is conducted continually across a network consisting of four towers, one monostatic Doppler SODAR (for sonic detection and ranging), and three supplementary rain gage stations (Figure IV-19).

The TA-6 tower has been designated as the official meteorological station for Los Alamos and the Laboratory; climatic statistics for the area are based on measurements at this natural meadow site. The TA-49 tower is also located in a natural meadow, and it provides observations in the vicinity of an air quality monitoring station just north of Bandelier National Monument. This tower is also close to the old tritium facility at TA-33. The TA-53 tower is used for monitoring wind conditions near LAMPF, which is the Laboratory's principal source of radioactive emissions. The TA-54 tower, located just east of the active radioactive and chemical waste disposal facilities, is used to characterize conditions in the White Rock area.

The full set of measured variables is described in Table D-14, and variables measured at each of the towers are shown in Table D-15.

b. Monitoring Results for 1992.

Wind. Statistics for the near-surface winds during 1992 are summarized in the wind roses shown in Figures II-7 and II-8. Although the probability distribution of wind direction during 1992 was similar to other years, the frequency of high winds in the spring was significantly less than normal.

Atmospheric State Variables and Precipitation. Figure IV-20 summarizes the temperature and precipitation patterns for 1992, as observed at the official Los Alamos weather station at TA-6. Notable departures from normal include warm temperatures in April and cold temperatures in November and December. The year finished with 50.2 cm (19.77 in.) total precipitation, which is 2.6 cm (1.02 in.) more than normal. Notable departures from the normal precipitation pattern include an unusually wet May and dry June. Table IV-41 compares monthly precipitation values for all seven rain gage stations in the network. The annual totals show the normal west-to-east gradient in precipitation; the eastern edge of the area received less than 60% of the precipitation received along the western edge.

Snowfall for the calendar year totaled 87.6 cm (34.5 in.), which was 60% of the normal amount; most of the deficit occurred between January and March.

4. Environmental Monitoring at the Fenton Hill Site. (Alan Stoker, Steve McLin, Max Maes, and William Purtymun).

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.

Figure IV-19. Off-site perimeter and on-site Laboratory meteorological monitoring locations.

The chemical quality of surface water and groundwaters in the vicinity of TA-57 (Figure IV-21) 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 1992 the samples were collected on November 20, 1992. The results of the general chemical analyses are presented in Table IV-42, and the results of trace metal analyses are presented in Table IV-43.

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). Tritium levels were also measured in the water samples; all levels were at or below the

Figure IV-20. Temperature and precipitation for 1992.

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

5. Environmental Studies at San Ildefonso Pueblo. (Alan Stoker, Max Maes, and John Sorrell [Bureau of Indian Affairs])

To document the potential impact of Laboratory operations on lands belonging to San Ildefonso Pueblo, 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 for Radioactive and Chemical Contamination of Lands and Natural Resources Belonging to the Pueblo of San Ildefonso," No. DE-GM32-87AL37160, was concluded in June 1987. The agreement calls for both hydrologic pathway sampling (including water, soils, and sediments) and foodstuff sampling. This section

Table IV-41. Monthly and Total Precipitation at the Seven Rain Gage Stations (in.)

	North Community	S-Site	TA-6	TA-49	TA-53	TA-54	White Rock Y
January	0.48	0.67	0.61	0.48	0.50	0.45	0.42
February	0.41	0.42	0.34	0.33	0.24	0.38	0.36
March	1.38	1.40	1.21	1.25	1.21	1.25	1.03
April	0.33	1.22	0.59	0.43	0.43	0.23	0.34
May	3.54	4.03	3.46	3.11	3.49	3.41	2.97
June	2.17	1.45	1.29	0.85	1.09	0.80	0.99
July	3.16	2.49	1.41	1.87	1.45	1.17	1.17
August	4.26	4.92	5.05	3.31	3.08	1.66	1.95
September	0.85	0.68	2.26	1.18	1.36	1.03	0.73
October	1.23	0.83	0.59	0.36	0.34	0.22	0.27
November	1.25	1.34	1.28	1.39	0.07	0.96	0.98
December	1.62	1.72	1.68	1.62	0.48	1.65	1.28
Annual	20.68	21.17	19.77	16.18	13.74	13.21	12.49

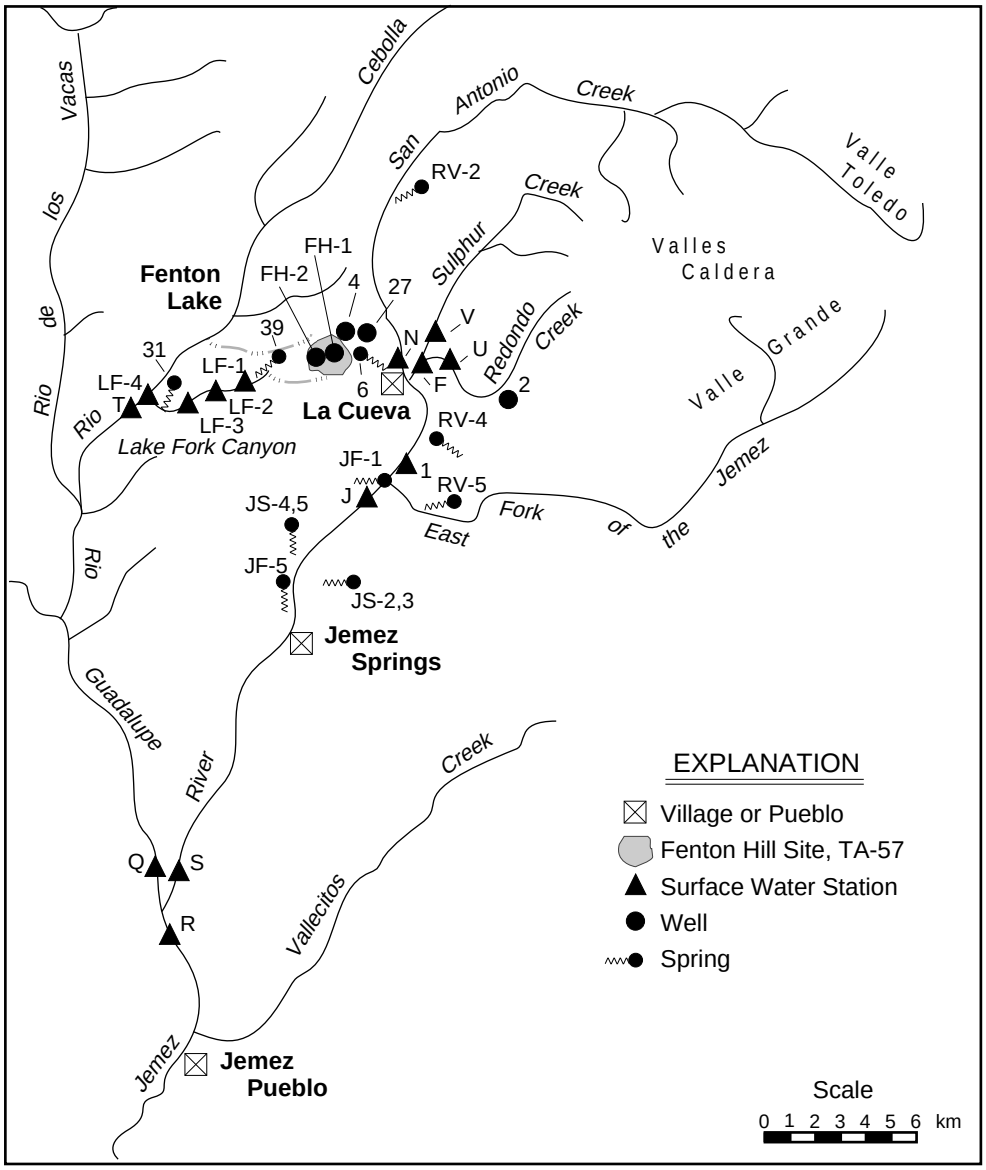
deals with the hydrologic pathway. The foodstuff sampling results are presented in Section IV.G of this report. During 1987, 1988, 1989, 1990, and 1991, water, soil, and sediment samples were collected in accord with the agreement (Purtymun 1988b, ESG 1989, EPG 1990, EPG 1992, EPG 1993).

In 1992, special water samples were collected from eight groundwater wells. Samples were collected by Laboratory personnel in the company of personnel from the San Ildefonso Pueblo Governor's Office and the BIA, on September 1 and October 30. Water samples taken from the New Community Well, Pajarito Pump 1, Pajarito Pump 2, the Halladay House well, and the Otowi House well on September 1, and two locations not previously sampled, the Sanchez House well and Martinez House well, on October 29. An alluvial groundwater monitoring well, installed by the BIA to investigate leaks in an underground storage tank at the site of an old gasoline station at Totavi, was also sampled on September 1. The BIA collected duplicate samples at the New Community Well, Pajarito Pump 2, Halladay House, Otowi House, and the Totavi alluvial monitoring well. These duplicate samples were analyzed by the BIA's own laboratory for inorganic chemicals and by a contracted laboratory for radioactivity.

On September 2, special sediment samples were collected from four previously sampled locations on San Ildefonso Pueblo lands in Mortandad Canyon, designated A-6, A-7, A-8, and A-10. Sediment samples were also collected across a transect of the Mortandad stream channel at the San Ildefonso Pueblo-Laboratory boundary. The transect located near A-6 in Figure IV-22, included 10 locations centered at the fence posts along the boundary; the samples were identified as MT-1 through MT-10. At each location a shallow sample was scooped along a line about 1 m long. Two new locations in Sandia Canyon were also sampled for sediments. These locations were in the Sandia Canyon stream channel at the San Ildefonso Pueblo-Bandelier National Monument boundary and a few hundred yards further east, identified as SSI-1 and SSI-2.

The MOU also specifies collection and analysis of 9 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 run-off in Los Alamos Canyon. These locations are identified in Table IV-44 to permit cross-referencing with other sections of this report. Sampling in 1992 also included sampling snowmelt run-off and flow fed by treated effluent from the Los Alamos County sewage treatment plant. Results and interpretation of this sampling are described in Section IV.E of this report.

a. Groundwater. Radiochemical analyses of the 1992 groundwater samples are shown in Table IV-45. The major difference from previous results are the ^{137}Cs measurements, which are all much lower than previously reported. The ^{137}Cs measurements for 1992 were all made using an improved method with a lower



detection limit (See Section VIII.D 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. None of the values measured in 1992 exceed the DOE

DCG for water supply systems or the proposed EPA maximum contaminant level; all were less than 20% of the DCG.

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 1, Pajarito Pump 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 are suspected of inaccuracies for two principal reasons: (1) none of the previously sampled locations had shown the presence of these isotopes, (2) results of BIA duplicate samples for 1992 sent to an independent laboratory did not confirm the results, and (3) preliminary results from the

Table IV-42. Chemical Quality of Surface Water and Groundwater near Fenton Hill (mg/L)

Station		SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Total Hardness	pH[b]	Specific Conductance (µmho/cm)
Surface Water																		
J	Jemez River	60	10	2.2	2	16	100	1.0	<5	52	N/A[c]	13	0.09	N/A	162	35	8.1	123
N	San Antonio	62	11	1.6	2	14	3	1.3	<5	47	N/A	9	0.05	N/A	158	34	7.9	112
Q	Rio Guadalupe	31	51	5.7	2	15	8	0.6	14	167	N/A	8	<0.04	N/A	228	151	8.4	366
S	Jemez River	58	42	4.6	11	83	2	1.4	11	169	N/A	9	0.05	N/A	418	124	8.5	733
LF-1	Lake Fork-1	43	12	2.1	1	11	4	1.0	<5	42	N/A	4	9.32	N/A	148	40	6.1	107
LF-2	Lake Fork-2	74	23	2.4	2	12	3	0.9	<5	58	N/A	4	0.46	N/A	134	67	7.0	112
LF-3	Lake Fork-3	63	12	1.9	2	13	3	1.2	<5	50	N/A	10	6.78	N/A	152	38	7.1	112
LF-4	Lake Fork-4	54	16	2.5	3	13	3	1.2	<5	58	N/A	6	0.54	N/A	140	49	7.3	127
Groundwater																		
JS-4,5	Jemez Village (spring)	92	27	4.4	3	47	4	1.2	<5	187	N/A	8	0.24	N/A	302	85	7.9	396
FH-1	Fenton Hill (well)	75	89	9.7	6	28	82	2.0	10	214	N/A	12	0.23	N/A	460	262	7.9	75
JF-1	Jemez Canyon (hot spring)	50	179	18.1	48	470	3	2.5	<5	592	N/A	5	0.21	N/A	1,900	522	7.7	3,304
JF-5	Soda Dam (hot spring)	52	312	22.6	145	961	7	3.6	<5	1,170	N/A	14	<0.04	N/A	3,860	872	6.9	6,954
Loc. 4	Hofheins (well)	90	8	2.2	2	16	4	0.4	<5	59	N/A	4	0.34	N/A	124	30	7.6	117
Loc. 27	La Cueva (well)	80	15	4.4	3	17	4	0.5	<5	88	N/A	5	0.28	N/A	190	55	7.2	173
RV-4	Spence Spring	77	5	1.4	2	51	20	0.7	<5	111	N/A	10	<0.04	N/A	206	18	8.3	259
Loc.31	Cold Springs	55	21	3.0	4	12	3	1.1	<5	59	N/A	5	0.62	N/A	142	65	7.5	121
Loc. 39	LF Tank	28	15	2.9	2	6	5	0.8	<5	48	N/A	14	0.16	N/A	112	48	6.7	121

[a] Total Dissolved Solids.
[b] Standard Units.
[c] N/A means analysis not performed, lost in analysis, or not completed.

1993 samples do not show levels above detection limits for the same analyses from samples taken at the same locations (all the same wells were sampled in May 1993 except Pajarito Pump 1, which was not operable). In particular, the BIA results showed no detectable plutonium in the New Community Well, Pajarito Pump 2, or the Halladay House or Otowi House wells.

In 1992 the filterable solids removed from water samples during the normal laboratory filtering process (see Section VII.C.3) were also analyzed for the presence of plutonium and americium. These results showed that less than 30% of the reported activity was removed by the filtering process. However, confidence in this percentage is not high because the radioactivity measured in the filtered solids was at or below the detection limit of the analytical method and because of uncertainties in the measurements of the liquid portion.

The uranium concentration observed for Pajarito Pump 1 was twice that in the sample taken in 1991. The observed value of 41.9 µg/L slightly exceeds the DOE Guide for Drinking Water Systems (30 µg/L). Gross alpha levels in the samples from the New Community Well, Pajarito Pump 1, and the Sanchez House well 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. These measurements are consistent with the levels in previous samples from the New Community and Pajarito wells and with relatively high levels of natural uranium in other wells in the area (EPG 1993).

The analyses of samples from the alluvial monitor well shows the low but not surprising presence of americium, plutonium, and tritium. This well samples water in the alluvium that is probably maintained by surface flow in Los Alamos Canyon.

The chemical quality of the groundwater, shown in Table IV-46, is consistent with previous observations. The sample from Pajarito Pump 1 exceeded the drinking water standard for TDS but contained a level similar to that previously measured. Pajarito Pump 1 also exceeded the secondary standard for iron. The Totavi alluvial monitoring well contained elevated levels of nitrate, iron, and manganese; these results are consistent with the expectation that the alluvial water is maintained by surface flow from Los Alamos Canyon that carries treated sanitary effluents. Trace metal analyses are shown in Table IV-47.

Table IV-43. Trace Metals in Surface Water and Groundwater near Fenton Hill (mg/L)

Stations		Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg
Surface Water													
J	Jemez River	<0.001[a]	0.11	0.0064	0.03	0.009	<0.001	<0.001	0.0025	<0.01	0.003	0.18	<0.0001
N	San Antonio	<0.001	0.11	0.0029	0.02	0.035	<0.001	<0.001	<0.0020	<0.01		<0.003	0.20 <0.0001
Q	Rio Guadalupe	<0.001	0.03	0.0025	0.07	0.047	<0.001	<0.001	<0.0020	<0.01		<0.003	0.08 <0.0001
S	Jemez River	<0.001	0.07	0.0817	0.89	0.028	<0.001	<0.001	0.0020	<0.01	0.013	0.14	<0.0001
LF-1	Lake Fork-1	<0.001	0.24	<0.0020	0.01	0.013	<0.001	<0.001	<0.0020	<0.01		0.005	3.19 <0.0001
LF-2	Lake Fork-2	<0.001	1.85	0.0024	0.04	0.043	<0.001	<0.001	0.0020	0.01	<0.003	71.50	
	<0.0001												
LF-3	Lake Fork-3	<0.001	<0.03	<0.0020	0.02	0.012	<0.001	<0.001	0.0030	<0.01	<0.003	0.06	
	<0.0001												
LF-4	Lake Fork-4	<0.001	0.22	<0.0020	0.02	0.023	<0.001	<0.001	<0.0030	<0.01		<0.003	0.84 <0.0001

Stations		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Surface Water												
J	Jemez River	N/A[b]	0.010	<0.01	<0.001	<0.0005	<0.002	N/A	0.065	<0.002	<0.01	<0.009
N	San Antonio	0.001	0.006	<0.01	0.002	<0.0010	<0.002	N/A	0.060	<0.002	<0.01	<0.009
Q	Rio Guadalupe	<0.001	0.003	<0.01	<0.001	<0.0005	<0.002	N/A	0.259	<0.002	<0.01	<0.009
S	Jemez River	N/A	0.010	<0.01	0.001	<0.0005	<0.002	N/A	0.199	<0.002	<0.01	<0.009
LF-1	Lake Fork-1	0.008	<0.001	<0.01	<0.002	<0.0010	<0.002	N/A	0.073	<0.002	<0.01	0.020
LF-2	Lake Fork-2	0.691	0.001	<0.01	<0.002	<0.0010	<0.002	N/A	0.128	<0.002	<0.01	0.031
LF-3	Lake Fork-3	<0.001	0.001	<0.01	<0.002	<0.0010	<0.002	N/A	0.073	<0.002	<0.01	<0.009
LF-4	Lake Fork-4	<0.006	<0.009	<0.01	<0.002	<0.0010	<0.002	N/A	0.077	<0.002	<0.01	<0.010

Stations		Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg
Groundwater													
JS-4,5	Jemez Village												
	(spring)	<0.001	<0.03	0.0228	0.20	0.034	<0.001	<0.001	0.018	<0.01	0.029	<0.01	<0.0001
FH-1	Fenton Hill (well)	<0.001	<0.03	<0.0020	1.22	0.098	<0.001	<0.001	0.003	<0.01	0.012	0.22	<0.0001
JF-1	Jemez Canyon												
	(hot spring)	<0.001	<0.03	<0.0020	5.43	0.200	<0.001	<0.001	<0.002	<0.01	<0.003	0.02	<0.0001
JF-5	Soda Dam												
	(hot spring)	<0.001	<0.03	1.5700	12.80	0.171	<0.001	<0.001	<0.002	<0.01	<0.003	0.04	<0.0001
Loc.4	Hofheins (well)	<0.001	<0.03	<0.0020	<0.01	0.031	<0.001	<0.001	0.002	<0.01	0.011	<0.01	<0.0001
Loc. 27	La Cueva (well)	<0.001	<0.03	0.0040		0.01	0.060	<0.001	<0.001		0.003	<0.01	<0.003
RV-4	Spence Spring	<0.001	0.05	0.0476	0.10	0.001	<0.001	<0.001	0.002	<0.01	0.003	<0.01	<0.0001
Loc.31	Cold Springs	<0.001	2.85	<0.0020	0.03	0.018	<0.001	0.004	<0.002	<0.01	0.004	4.93	<0.0001
Loc. 39	LF Tank	<0.001	<0.03	<0.0020		0.01	0.025	<0.001	<0.001		<0.002	<0.01	<0.003

Stations		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Groundwater												
JS-4,5	Jemez Village											
	(spring)	0.002	0.029	<0.01	<0.002	0.0020	<0.002	N/A	0.200	<0.002	<0.01	0.297
FH-1	Fenton Hill (well)	0.004	<0.001	0.03	0.002	<0.0010	<0.002	N/A	0.382	<0.002	<0.01	3.650
JF-1	Jemez Canyon											
	(hot spring)	<0.001	0.005	<0.01	<0.002	<0.0010	<0.002	N/A	1.560	<0.002	<0.01	<0.009
JF-5	Soda Dam											
	(hot spring)	<0.001	<0.001	<0.01	<0.001	<0.0005	<0.002	N/A	1.650	<0.002	<0.01	<0.009
Loc.4	Hofheins (well)	<0.001	0.004	<0.01	<0.002	<0.0010	<0.002	N/A	0.063	<0.002	<0.01	0.070
Loc. 27	La Cueva (well)	<0.001	0.001	<0.01	<0.002	<0.0010	<0.002	N/A	0.113	<0.002	<0.01	<0.009
RV-4	Spence Spring	<0.002	0.065	<0.01	<0.001	<0.0005	<0.002	N/A	0.031	<0.002	<0.01	<0.009
Loc.31	Cold Springs	<0.001	<0.001	<0.01	<0.002	<0.0010	<0.002	N/A	0.081	<0.002	<0.01	<0.009
Loc. 39	LF Tank	<0.001	<0.001	<0.01	<0.002	<0.0010	<0.002	N/A	0.102	<0.002	<0.01	<0.009

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

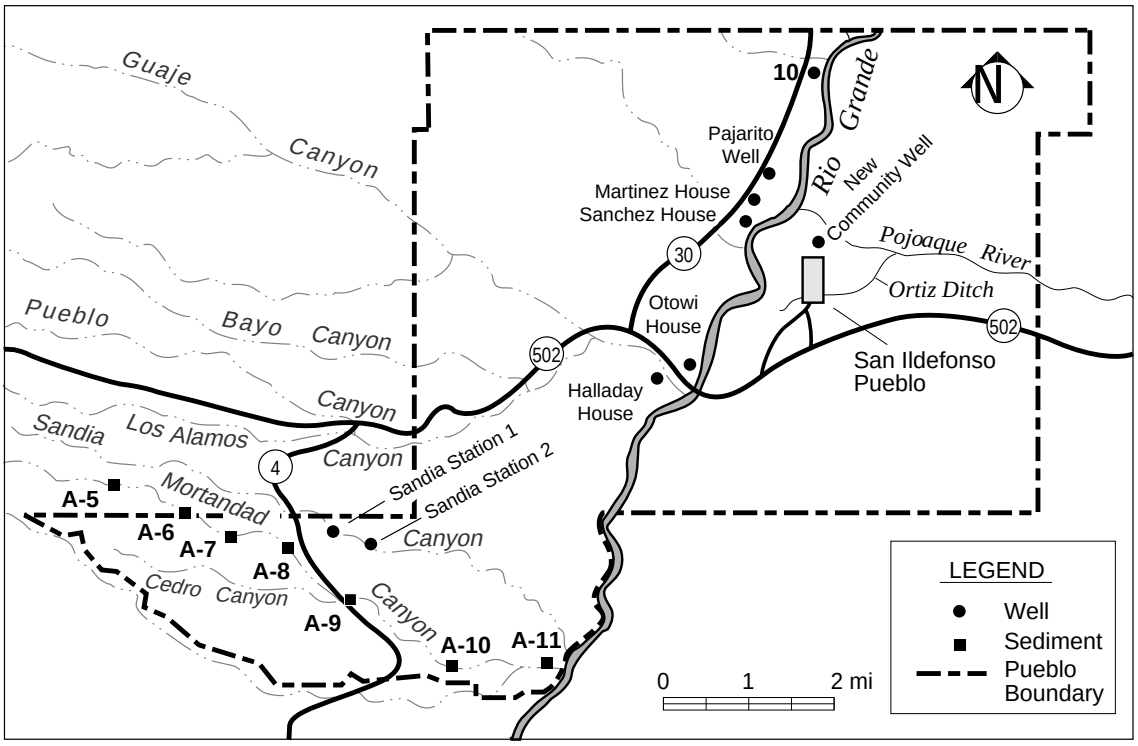


Figure IV-22. Groundwater and sediment stations on San Ildefonso Pueblo land. (Map denotes general locations only; see Table IV-44 for cross-referencing to specific locations.)

The results of LANL's analyses were generally in good agreement with results of chemical analyses of the duplicate samples collected by the BIA. In most of the analyses for which direct comparisons were possible (that is, for actual values rather than detection limits), most of the results agreed within 20%. Measurements with less consistently good agreement included those in arsenic, nitrate, calcium, potassium, and chloride. However, no pattern was apparent; neither laboratory consistently measured higher levels than the other.

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

In accordance with the MOU, on September 2, 1992, sediments from Mortandad Canyon were collected from seven previous sampling locations, one slightly west of the San Ildefonso Pueblo-Laboratory boundary and six within the Pueblo (Figure IV-22). Samples were also collected at 10 new locations. The results of analyses for radiochemicals and trace metals in these samples are shown in Table IV-48 and Table IV-49.

The highest level of ^{239}Pu from previously sampled locations in 1992 was obtained at Station A-6 (on San Ildefonso Pueblo property adjacent to the boundary with the Laboratory). The sample contained about 2 1/2 times the statistically derived comparison value for fallout in northern New Mexico; however, this value is within the

Table IV-44. Locations on San Ildefonso Pueblo Lands for Water and Sediment Sampling that are Included in the Routine Monitoring Program

Station Identification	Map Designation	See this Table for Results
Water Sampling Locations		
Rio Grande		
Otowi	Figure IV-6, No. 3	IV--18, -19, -20
Springs in Los Alamos Canyon		
Basalt Spring	Figure VII-1, No. 56	VII-1, -2, -3
Indian Spring	Figure VII-1, No. 12	VII-1, -2, -3
Spring in Canyon North of Los Alamos Canyon		
Sacred Spring	Figure VII-1, No. 11	VII-1, -2, -3
Spring in Sandia Canyon		
Sandia Spring	Figure VII-1, No. 13	VII-1, -2, -3
Springs in White Rock Canyon		
La Mesita Spring	Figure VII-1, No. 10	VII-1, -2, -3
Spring 1	Figure VII-1, No. 32	VII-1, -2, -3
Spring 2	Figure VII-1, No. 33	VII-1, -2, -3
Sanitary Effluent Flow in Mortandad Canyon		
Mortandad at Rio Grande	Figure IV-6, No. 38	IV-18, -19, -20
Sediment Sampling Locations		
Guaje at SR 502	Figure IV-9, No. 12	IV-21, -22
Bayo at SR 502	Figure IV-9, No. 13	IV-21, -22
Los Alamos Canyon		
Los Alamos at SR 4	Figure IV-9, No. 35	IV-21, -22
Los Alamos at Totavi[a]	Figure IV-9, No. 36	IV-21, -22
Los Alamos at LA-2[a]	Figure IV-9, No. 37	IV-21, -22
Los Alamos at Otowi	Figure IV-9, No. 38	IV-21, -22
Sandia Canyon		
Sandia at SR 4	Figure IV-9, No. 38	IV-21, -22
Sandia at Rio Grande	Figure IV-9, SANDIA	IV-21, -22
Mortandad Canyon		
Mortandad at MCO-13	Figure IV-9, No. 45 and Figure IV-22, A-5	IV-21, -22
Mortandad at SR 4	Figure IV-9, No. 15 and Figure IV-22, A-9	IV-21, -22
Mortandad at Rio Grande	Figure IV-9, MORTANDAD	IV-21, -22

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

Table IV-45. Radiochemical Analysis of Groundwater from Wells on San Ildefonso Pueblo Land

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)
MAIN AQUIFER (OFF SITE)										
San Ildefonso Wells										
Halladay Well	0.2 (0.3)[a]	0.1 (0.7)	1.6 (1.1)	1.3 (0.2)	0.000 (0.010)	0.337 (0.053)	0.018 (0.018)	0 (1)	2 (0)	500 (100)
Martinez Well	0.4 (0.3)	0.7 (0.8)	28.0 (11.0)	8.3 (0.8)	0.008 (0.030)	0.016 (0.020)	0.047 (0.030)	1 (1)	7 (1)	200 (100)
New Community Well	0.5 (0.3)	-0.1[b] (0.7)	2.5 (1.1)	23.0 (2.3)	0.110 (0.031)	0.131 (0.033)	0.030 (0.014)	14 (3)	10 (1)	80 (90)
Otowi House Well	0.5 (0.3)	0.0 (0.7)	1.6 (1.0)	1.9 (0.2)	-0.005 (0.008)	0.041 (0.014)	0.018 (0.021)	3 (1)	7 (1)	500 (100)
Pajarito Well Pump 1	0.3 (0.3)	0.2 (0.8)	1.9 (1.0)	11.4 (1.1)	-0.006 (0.006)	0.052 (0.019)	0.041 (0.019)	6 (3)	6 (1)	220 (90)
Pajarito Well Pump 2	0.5 (0.3)	-0.4 (0.7)	2.3 (1.2)	7.2 (0.7)	0.014 (0.010)	0.028 (0.013)	0.030 (0.022)	2 (1)	4 (1)	350 (100)
Sanchez House Well	0.2 (0.3)	0.5 (0.7)	10.5 (9.8)	18.8 (1.9)	0.004 (0.030)	0.009 (0.020)	0.067 (0.060)	6 (2)	8 (1)	40 (100)
MAIN AQUIFER SPRINGS										
White Rock Canyon Springs Group IV										
La Mesita Spring	0.2 (0.3)	0.3 (0.7)	15.0 (9.6)	11.9 (1.2)	-0.004 (0.030)	0.008 (0.020)	0.043 (0.030)	2 (1)	5 (1)	200 (100)
CANYON ALLUVIUM GROUNDWATERS										
Other Canyons										
Totavi BIA Observation Well 1	0.8 (0.3)	0.7 (0.7)	0.4 (1.1)	7.0 (0.7)	0.028 (0.013)	0.046 (0.016)	0.021 (0.050)	7 (3)	10 (1)	100 (90)
PERCHED SYSTEM IN CONGLOMERATES & BASALT										
Pueblo/Los Alamos/Sandia Canyon Area										
Basalt Spring	0.8 (0.3)	0.7 (0.7)	13.2 (10.6)	1.3 (0.5)	0.014 (0.030)	0.023 (0.020)	0.030 (0.030)	1 (1)	5 (1)	30 (100)

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

[b]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

Table IV-46. Chemical Analysis of Groundwater on San Ildefonso Pueblo Land (mg/L)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Total Hardness	pH[b]	Specific Conductance (µmho/cm)
MAIN AQUIFER (OFF SITE)																	
San Ildefonso Wells																	
Halladay Well	31	6	0.0	1	68	6	0.6	8	85	N/A[c]	13	0.54	N/A	158	16	9.0	195
Martinez Well	46	46	2.6	3	55	16	0.6	1	157	N/A	32	8.36	N/A	200	126	8.0	486
New Community Well	29	17	1.0	1	93	14	0.3	<5	182	N/A	33	1.25	N/A	276	47	8.3	466
Otowi House Well	62	62	4.6	3	42	50	0.4	<5	183	N/A	21	0.26	N/A	362	172	7.1	603
Pajarito Well Pump 1	32	78	7.8	6	520	21	0.4	<5	513	N/A	39	0.17	N/A	994	228	7.4	1468
Pajarito Well Pump 2	42	27	1.4	2	91	32	0.9	<5	179	N/A	21	1.73	N/A	316	73	7.8	515
Sanchez House Well	43	39	2.6	2	122	61	1.6	3	251	N/A	54	0.85	N/A	224	109	8.0	746
MAIN AQUIFER SPRINGS																	
White Rock Canyon Springs Group IV																	
La Mesita Spring	32	39	1.5	3	30	7	0.2	<1	122	N/A	14	2.65	N/A	232	104	8.2	297
CANYON ALLUVIUM GROUNDWATERS																	
Other Canyons																	
Totavi BIA Observation Well 1	63	115	20.0	10	135	160	0.4	<5	119	N/A	34	14.30	N/A	598	371	6.7	953
PERCHED SYSTEM IN CONGLOMERATES & BASALT																	
Pueblo/Los Alamos/Sandia Canyon Area																	
Basalt Spring	50	29	7.5	4	29	21	0.5	<1	97	N/A	21	5.02	N/A	298	85	7.6	334

[a]Total Dissolved Solids.
[b]Standard Units.
[c]N/A means analysis not performed, lost in analysis, or not completed.

range measured previously in the vicinity, and its ratio with ^{238}Pu is what would be expected for plutonium from worldwide fallout. The level of ^{137}Cs measured in samples from that location also exceeded by a factor of about 2 to 4 the statistically derived comparison value for fallout in soils and sediments in northern New Mexico.

Five of the samples from the new 10-location transect located several hundred feet from the A-6 location contained ^{239,240}Pu levels exceeding the statistically derived levels from fallout in northern New Mexico, and 5 contained levels lower than that value. Only one ^{238}Pu sample contained a level that exceeded the fallout reference level. The highest value at transect location 2 matched the level observed at Station A-6. In all but one transect sample, the ratio of the plutonium isotopes (^{239,240}Pu/^{238}Pu) was consistent with the expected ratio (about 20) for northern New Mexico. If the plutonium had been transported in run-off from the contaminated portion of Mortandad Canyon further upstream on Laboratory property, the ratio would have been much smaller. In the contaminated portion of Mortandad Canyon, the ratio is more typically observed to be in the range of 2 to 4. Thus the new measurements are consistent with previous observations and interpretations that no plutonium run-off has been transported through the San Ildefonso Pueblo-Laboratory boundary.

For samples dominated by worldwide fallout at these low 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 no run-off to separate silt from the clay-size particles that typically show higher concentrations of plutonium.

Results of samples from the two new sediment sampling locations in Sandia Canyon are all within the range of values expected from worldwide fallout. The results do not indicate any presence of contaminants from Laboratory operations, findings consistent with current and previous measurements of sediments from Sandia Canyon where it crosses the Laboratory boundary at State Road 502.

Table IV-47. Trace Metals in Groundwater on San Ildefonso Pueblo Land (mg/L)

Stations	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg
MAIN AQUIFER (OFF SITE)												
San Ildefonso Wells												
Halladay Well	<0.0002	<0.03	0.0103	0.070	0.0383	<0.0002	0.0002	0.014	<0.020	0.002	0.08	<0.0001
Martinez Well	<0.0010	<0.02	0.0097	0.110	0.1820	<0.0010	<0.0010	0.005	<0.004	0.019	<0.00	0.0010
New Community Well	<0.0002	<0.03	0.0033	0.030	0.0170	<0.0002	<0.0002	<0.001	<0.020	0.002	<0.01	<0.0001
Otowi House Well	<0.0002	<0.03	0.0030	0.020	0.2770	<0.0002	0.0002	<0.001	<0.020	0.008	0.02	<0.0001
Pajarito Well Pump 1	<0.0002	<0.03	0.0186	2.200	0.0989	<0.0002	0.0003	<0.001	<0.020	0.002	4.40	0.0003
Pajarito Well Pump 2	<0.0002	<0.03	0.0160	0.250	0.1130	<0.0002	0.0002	0.004	<0.020	0.003	<0.01	<0.0001
Sanchez House Well	0.0010	<0.02	0.0105	0.324	0.1340	<0.0010	0.0010	0.004	<0.004	0.010	<0.00	0.0009
MAIN AQUIFER SPRINGS												
White Rock Canyon Springs Group IV												
La Mesita Spring	<0.0010	0.64	<0.0020	0.056	0.1090	<0.0010	<0.0010	0.004	<0.004	0.003	1.47	0.0006
CANYON ALLUVIUM GROUNDWATERS												
Other Canyons												
Totavi BIA Observation Well 1	<0.0002	1.97	0.0084	0.200	0.3390	0.0006	0.0004	0.007	<0.020	0.008	3.30	<0.0001
PERCHED SYSTEM IN CONGLOMERATES & BASALT												
Pueblo/Los Alamos/Sandia Canyon Area												
Basalt Spring	<0.0010	0.060	0.0041	0.082	0.0480	<0.0010	<0.0010	0.003	<0.004	0.003	0.03	0.0008

Stations	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
MAIN AQUIFER OFF SITE											
San Ildefonso Wells											
Halladay Well	0.003	0.003	<0.02	0.0007	<0.0004	<0.002	N/A[a]	0.1340	<0.0002	0.02	0.006
Martinez Well	<0.001	0.004	<0.01	0.0060	0.0010	<0.002	N/A	0.6630	0.0004	0.03	0.059
New Community Well	0.004	0.002	<0.02	0.0005	<0.0004	0.002	N/A	0.2000	<0.0002	0.01	0.007
Otowi House Well	0.003	<0.001	<0.02	0.0022	<0.0004	<0.002	N/A	0.7290	<0.0002	0.01	0.317
Pajarito Well Pump 1	0.005	0.002	<0.02	0.0011	<0.0004	<0.002	N/A	1.3100	<0.0002	0.01	0.118
Pajarito Well Pump 2	0.002	0.007	<0.02	0.0015	<0.0004	<0.002	N/A	0.4480	<0.0002	0.03	0.011
Sanchez House Well	0.001	0.014	<0.01	<0.0010	0.0020	<0.002	N/A	0.4480	0.0005	0.02	0.011
MAIN AQUIFER SPRINGS											
White Rock Canyon Springs Group IV											
La Mesita Spring	<0.001	0.002	0.01	<0.0010	0.0010	<0.0020	N/A	0.906	0.0004	0.00	<0.009
CANYON ALLUVIUM GROUNDWATERS											
Other Canyons											
Totavi BIA Observation Well 1	0.760	0.003	<0.02	0.0112	<0.0004	<0.0020	N/A	0.389	<0.0002	0.02	0.027
PERCHED SYSTEM IN CONGLOMERATES & BASALT											
Pueblo/Los Alamos/Sandia Canyon Area											
Basalt Spring	<0.001	0.003	<0.01	<0.0010	0.0010	<0.0020	N/A	0.165	0.0004	0.01	<0.009

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

Table IV-48. Radiochemical Analyses of Sediments on San Ildefonso Pueblo Land

	^{3}H (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
PERIMETER STATIONS (OFF SITE)										
DP-Los Alamos Canyons										
Los Alamos at Totavi	0.4 (0.3)[a]	0.0 (0.2)	-0.0 (0.1)	N/A[b]	0.001 (0.001)	0.014 (0.002)	0.004(0.003)	2 (0)	1 (0)	1 (1)
Los Alamos at LA-2	0.5 (0.3)	0.0 (0.2)	0.4 (0.1)	N/A	0.003 (0.001)	0.198 (0.010)	0.022(0.003)	3 (1)	1 (0)	1 (1)
Other Areas										
Sandia Canyon										
Station 1	0.3 (0.3)	0.0 (0.2)	0.0 (0.1)	N/A	0.002 (0.001)	0.005 (0.001)	0.002(0.003)	3 (1)	2 (0)	2 (1)
Station 2	0.8 (0.3)	0.2 (0.2)	0.1 (0.1)	N/A	0.000 (0.001)	0.001 (0.001)	0.001(0.003)	2 (1)	1 (0)	5 (1)
Mortandad Canyon										
Mortandad A-6	0.3 (0.3)	0.6 (0.2)	2.1 (0.3)	N/A	0.003 (0.001)	0.064 (0.005)	0.023(0.003)	5 (1)	9 (1)	9 (1)
Mortandad A-7	2.2 (0.6)	0.2 (0.2)	0.3 (0.1)	N/A	0.001 (0.001)	0.009 (0.002)	0.005(0.003)	3 (1)	3 (0)	6 (1)
Mortandad A-8	0.8 (0.3)	0.2 (0.2)	0.3 (0.1)	N/A	0.005 (0.001)	0.008 (0.002)	0.005(0.003)	4 (1)	3 (0)	8 (1)
Mortandad A-10	1.3 (0.5)	0.0 (0.2)	-0.0 (0.1)	N/A	0.001 (0.001)	0.003 (0.001)	0.003(0.003)	4 (1)	3 (0)	5 (1)
Transects										
Station 1	0.5 (0.3)	0.2 (0.2)	1.3 (0.2)	N/A	0.001 (0.001)	0.027 (0.003)	0.009(0.003)	3 (1)	6 (1)	8 (1)
Station 2	0.4 (0.3)	0.3 (0.2)	1.0 (0.2)	N/A	0.002 (0.001)	0.064 (0.004)	0.010(0.003)	6 (1)	6 (1)	8 (1)
Station 3	0.5 (0.3)	0.2 (0.2)	1.1 (0.2)	N/A	0.003 (0.001)	0.042 (0.003)	0.008(0.003)	6 (1)	8 (1)	9 (1)
Station 4	0.9 (0.3)	0.3 (0.2)	0.2 (0.1)	N/A	0.010 (0.001)	0.008 (0.001)	0.003(0.003)	5 (1)	5 (1)	8 (1)
Station 5	0.6 (0.3)	0.3 (0.2)	0.2 (0.1)	N/A	0.000 (0.001)	0.007 (0.001)	0.002(0.003)	4 (1)	5 (1)	8 (1)
Station 6	0.4 (0.3)	0.1 (0.2)	0.3 (0.1)	N/A	0.000 (0.001)	0.013 (0.002)	0.002(0.003)	4 (1)	5 (1)	8 (1)
Station 7	0.4 (0.3)	0.8 (0.2)	1.3 (0.2)	N/A	0.004 (0.001)	0.044 (0.004)	0.011(0.003)	7 (2)	9 (1)	9 (1)
Station 8	0.3 (0.3)	0.2 (0.2)	1.2 (0.2)	N/A	0.002 (0.001)	0.039 (0.003)	0.008(0.003)	5 (1)	6 (1)	8 (1)
Station 9	0.8 (0.3)	0.2 (0.2)	0.6 (0.1)	N/A	0.001 (0.001)	0.015 (0.002)	0.005(0.003)	5 (1)	5 (1)	9 (1)
Station 10	0.8 (0.3)	0.2 (0.2)	0.1 (0.1)	N/A	0.001 (0.001)	0.010 (0.002)	0.008(0.003)	6 (1)	5 (1)	11 (1)
ON-SITE STATIONS										
Acid-Pueblo Canyons										
Pueblo at SR 4	0.0 (0.3)	0.1 (0.2)	3.1 (0.5)	N/A	0.006 (0.001)	1.010 (0.041)	0.030(0.003)	3 (1)	2 (0)	6 (1)

[a] Counting uncertainties (|1 standard deviation) are in parentheses.
[b] N/A means analysis not performed, lost in analysis, or not completed.

Table IV-49. Trace Metals in Sediments on San Ildefonso Pueblo Land (+µg/g)

Stations	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg
PERIMETER STATIONS (OFF SITE)												
DP-Los Alamos Canyons												
Los Alamos at Totavi	<0.6[a]	2,500.0	0.41	6.0	21.0	0.24	<0.8	2.3	2.1	<5.00	4,400.0	<0.02
Los Alamos at LA-2	<0.6	2,100.0	0.45	2.8	25.0	0.30	<0.8	3.0	2.0	1.70	4,900.0	<0.02
Other Areas												
Sandia Canyon												
Station 1	<0.6	4,400.0	0.66	3.0	37.0	0.50	<0.8	12.0	3.0	4.00	7,800.0	0.02
Station 2	<0.6	4,700.0	0.62	3.2	41.0	0.60	<0.8	9.3	2.9	3.50	8,900.0	<0.02
Mortandad Canyon												
Mortandad A-6	<0.6	9,200.0	2.04	5.7	71.0	0.81	<0.8	6.5	3.5	6.00	8,900.0	0.04
Mortandad A-7	<0.6	3,200.0	1.02	5.0	24.0	0.40	<0.8	2.3	2.0	2.20	7,200.0	<0.02
Mortandad A-8	<0.6	6,200.0	1.48	3.4	57.0	0.60	<0.8	4.3	2.8	3.90	7,700.0	<0.02
Mortandad A-10	<0.6	8,900.0	1.56	5.0	88.0	0.70	<0.8	7.5	5.0	3.20	10,500.0	<0.02
Transects												
Station 1	<0.6	5,200.0	1.92	3.7	58.0	0.50	<0.8	3.7	13.0	44.00	6,900.0	0.03
Station 2	<0.6	7,900.0	1.59	6.0	66.0	0.70	0.8	5.0	4.9	40.00	7,900.0	0.02
Station 3	<0.6	12,900.0	2.50	8.3	108.0	1.00	<0.8	8.5	5.3	13.00	12,500.0	0.03
Station 4	<0.6	9,900.0	3.11	4.5	103.0	1.00	<0.8	6.5	4.7	8.00	10,400.0	0.03
Station 5	<0.6	6,700.0	1.92	5.9	66.0	0.70	<0.8	4.5	3.4	4.60	7,700.0	0.02
Station 6	<0.6	9,200.0	1.86	4.5	93.0	0.96	<0.8	6.0	4.3	7.00	10,200.0	0.03
Station 7	<0.3	12,000.0	3.29	7.4	111.0	1.00	<0.8	8.0	18.0	8.00	12,000.0	0.04
Station 8	<6.0	7,700.0	2.04	6.0	66.9	0.70	<0.8	5.0	3.3	5.00	8,100.0	0.02
Station 9	<0.6	8,000.0	1.57	5.0	68.0	1.00	<0.8	5.0	4.0	4.50	9,490.0	0.02
Station 10	<0.6	11,400.0	2.45	6.7	94.0	1.00	<0.8	8.0	5.0	5.60	12,000.0	0.03
ON-SITE STATIONS												
Acid-Pueblo Canyons												
Pueblo at SR 4	<0.6	4,400.0	0.91	5.0	32.0	0.7	0.8	7.0	7.0	33.0	20,800.0	0.02

Stations	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
PERIMETER STATIONS (OFF SITE)											
DP-Los Alamos Canyons											
Los Alamos at Totavi	181.0	<1.2	3.0	<6.0	<6.00	<0.20	13.0	5.0	<12.0	4.4	21.0
Los Alamos at LA-2	174.0	1.2	4.8	6.0	<6.00	0.29	<10.0	5.8	<2.0	6.0	22.0
Other Areas											
Sandia Canyon											
Station 1	293.0	1.3	3.6	13.0	<6.00	<0.20	14.0	6.8	6.4	7.8	47.0
Station 2	347.0	1.3	4.3	13.0	0.78	<0.20	17.8	7.2	3.2	9.7	49.0
Mortandad Canyon											
Mortandad A-6	348.0	<1.2	4.3	16.5	<6.00	<0.20	16.0	14.0	<2.0	11.6	43.0
Mortandad A-7	309.0	1.3	1.6	5.9	<6.00	<0.20	14.0	3.9	5.0	4.0	45.0
Mortandad A-8	292.0	<1.2	3.3	10.0	<6.00	<0.20	15.0	9.6	2.6	8.9	35.0
Mortandad A-10	382.0	<1.2	5.9	8.0	<6.00	0.25	15.0	16.0	<12.0	17.0	36.0
Transects											
Station 1	283.0	<1.2	3.1	13.0	<6.00	0.33	15.0	16.7	<12.0	7.6	54.0
Station 2	300.0	<1.2	6.0	12.5	<6.00	0.32	18.0	11.4	<12.0	9.9	177.0
Station 3	436.0	<1.2	7.0	18.0	<6.00	<0.20	18.0	19.0	<12.0	16.0	92.0
Station 4	404.0	<1.2	6.0	13.0	<6.00	0.30	20.0	20.0	<12.0	13.0	74.0
Station 5	317.0	<1.2	4.6	10.0	<6.00	<0.20	12.0	12.0	<12.0	9.3	57.0
Station 6	406.0	<1.2	5.5	14.0	<6.00	<0.20	13.0	18.0	<12.0	12.6	74.0
Station 7	448.0	1.2	6.0	18.0	<6.00	<0.20	18.0	22.0	<12.0	15.0	74.0
Station 8	335.0	0.8	4.0	13.0	<6.00	<0.20	16.0	11.0	<12.0	10.0	80.0
Station 9	374.0	<1.2	4.0	13.0	<6.00	<0.20	15.0	11.0	<12.0	11.0	61.0
Station 10	427.0	<1.2	5.0	14.0	<6.00	<0.20	17.0	17.0	<12.0	15.0	60.0
ON-SITE STATIONS											
Acid-Pueblo Canyons											
Pueblo at SR 4	434.0	3.7	6.0	12.0	<6.00	<0.20	15.0	8.0	17.70	17.0	111.0

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

The samples of sediments collected from San Ildefonso Pueblo in 1992 were analyzed for trace metals. The results, which are within the general ranges expected for geologic materials, will provide a basis for future comparisons.

c. Monitoring Well. A monitoring well (SIMO-1) was installed in 1990 in Mortandad Canyon just east of sediment sampling station A-6 on San Ildefonso Pueblo land by BIA and Laboratory personnel under the general terms of the MOU (EPG 1992). The purpose of the monitoring well was to confirm the absence of any perched water in the alluvium of Mortandad Canyon.

No evidence of perched water was found, confirming previous inferences that no water could be moving from the Laboratory onto San Ildefonso Pueblo lands beneath the surface. Even though the hole from the monitoring well did not penetrate saturated zones, a polyvinyl chloride casing with screened sections was installed across two intervals that were geologically likely locations for water to accumulate. When inspected in February 1992, the well was found to be dry.

The radiochemical analyses of the cores showed no evidence of any contaminants from the Laboratory (EPG 1992). The plutonium measurements were all at or below detection limits. Tritium levels in water vapor extracted from the cores from the surface down to 4.27 m (14 ft) were within the range attributable to background expected in northern New Mexico soils (Purtymun 1987a); below 4.27 m (14 ft) the tritium measurements were below the limits of detection. Gross gamma activity and levels of ^{137}Cs in all cores were within the expected range for background in northern New Mexico soils (Purtymun 1987a). The levels of uranium measured were well within the ranges for naturally occurring uranium expected for the Tshirege, Tsankawi, and Otowi formations that were penetrated by the hole (Becker 1985, Crowe 1978).

6. Environmental Restoration Program at Los Alamos National Laboratory. (Lars Soholt, EM-13)

In 1989, DOE created the Office of Environmental Restoration and Waste Management (DOE/EM) whose goal is to implement the DOE's policy to ensure that its past, present, and future operations do not threaten human or environmental health and safety (DOE 1990b). Two primary laws govern ER activities within the DOE complex: RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA [Superfund]). At the Laboratory only RCRA currently governs ER activities.

Section 3004(u) of RCRA as amended by the Hazardous and Solid Waste Amendments (HSWA) mandates that permits for treatment, storage, and disposal facilities include provisions for corrective actions to mitigate releases from facilities currently in operation and to clean up contamination in areas designated as solid waste management units (SWMUs). The DOE/University of California (UC) RCRA permit includes a section called the HSWA Module, which prescribes a specific corrective action program for the Laboratory. The HSWA Module specifies a three-step corrective action process.

The RCRA Facility Investigation. The goal of this step is to identify the extent of contamination at source points and environmental pathways for the exposure of potential 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.

Corrective Measures Study. If characterization indicates that corrective measures are needed, a corrective measures study (CMS) will evaluate alternatives that might reasonably be implemented. These measures are evaluated based on their projected efficacy in reducing risks to human and environmental health and safety in a cost-effective manner.

Corrective Measures Implementation. This step implements the chosen action, verifies its effectiveness, and establishes ongoing control and monitoring requirements.

An ER program plan has been prepared in accordance with the HWSA Module and with proposed Subpart S, Corrective Action for Solid Waste Management Units, of 40 CFR 264 (EPA 1990a) in the regulations promulgated by EPA to implement HSWA. EPA proposed Subpart S in July 1990 to implement the cleanup program mandated in Section 3004(u) of RCRA. The plan describes how each of the three corrective action steps described above will be implemented at the Laboratory. DOE and UC use the operable unit approach defined in CERCLA for organizing and managing the various SWMUs. Operable units are aggregates of SWMUs that will be addressed together. The details of each step required as part of the corrective action process are presented individually for each of the 24 operable units at the Laboratory.

Major components of the program that address the requirements of the HSWA Module are

- a technical decision making approach that identifies appropriate corrective actions and meets the requirements of the EPA;
- a strategy for conducting interim remedial measures;
- a program management system for organizing and managing the Laboratory's ER efforts that includes projecting schedules and costs;
- a quality assurance program that ensures a technically defensible and valid program;
- a health and safety program that ensures adequate health and safety protection during implementation of the Laboratory's ER program;
- a records management program that tracks and stores information and data throughout the ER program; and
- a community relations program that provides information to and receives recommendations from the public throughout the life of the ER program.

The HSWA Module of the RCRA permit defines the principal requirements with which DOE/UC must comply in implementing the ER program at the Laboratory. However, RCRA does not address several issues of concern at Los Alamos. For example, source material, by-product, and special nuclear materials are exempt from the RCRA definition of solid waste and are not subject to the provisions of the HSWA Module. DOE and UC recognize that these radioactive constituents are of major concern and cannot be separated from concerns about hazardous wastes. Thus, the DOE/UC ER program addresses radioactive as well as other hazardous substances not regulated by RCRA. This approach is intended to maintain a technically comprehensive program that covers potential liabilities associated with other environmental laws, such as CERCLA. Section III.B.1.i, HSWA Compliance Activities, presents information on the accomplishments of the ER program in 1992.

7. Performance Assessments. (Dennis Armstrong)
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. This order applies only to wastes disposed of after the order became effective. The order requires a performance assessment (PA) of the disposal site to demonstrate compliance with specific performance objectives including

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

Performance Assessment for TA-54, Area G. Preparation of a draft PA document for TA-54, Area G continued in 1992. EES-5, the Geoanalysis group, began developing modeling techniques to establish the source term for the groundwater pathway, which included some preliminary work using TRACER 3D to examine the potential for contaminant flow along fractures. Limits for waste acceptance were assessed using the criteria established by the Nuclear Regulatory Commission (NRC) for Class A and Class C wastes. These limits are being incorporated into the waste acceptance criteria currently used at Area G. The document is expected to be completed in FY94.

Performance Assessment for the Mixed Waste Disposal Facility. In order to facilitate timely remediation of contaminated waste generated from the ER program, the design and eventual construction of a Mixed Waste Disposal Facility (MWDF) was initiated. 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 facility will accommodate activities required for waste management and environmental monitoring.

A PA for the MWDF, proposed to be located at TA-67, was initiated in late 1992. Work accomplished so far includes developing the scope of activities required and ensuring that adequate resources were available. This PA is a multi-year project that is expected to be completed during FY95.

8. Preoperational Studies. (Philip Fresquez)

Preoperational studies are required under DOE Order 5400.1 for areas where a new facility or process may significantly impact the environment (DOE 1988a). This order requires that chemical, physical, and biological characteristics be assessed before the site is disturbed. Two preoperational studies were conducted during 1992. Detailed results may be obtained by referring to individual preoperational reports available through EM-8.

The Dual Axis Radiographic Hydrotest Facility at TA-15. The potential ecological impact of this project was the potential release of depleted uranium and toxic metals such as beryllium. Consequently, soils and plant materials were collected from around the proposed facility and analyzed to provide baseline information on total uranium and beryllium.

The Hazardous Waste Treatment Facility and the Radioactive Liquid Waste Treatment Facility at TA-52. These proposed facilities are within 100 yards of each other. Therefore, soil and plant samples were collected over both sites. The potential ecological impact of these projects were the potential release of radioactive materials and toxic metals. Consequently, samples were analyzed for uranium, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, ^{241}Am, ^{3}H, and silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, antimony, and selenium.

9. Biological Resource Evaluations. (Terralene Foxx)

a. Biological Surveys/Monitoring. In 1990, the Biological Resources Evaluation Team (BRET) began monitoring selected biota and sensitive habitats to provide long-term data in accordance with the Endangered Species Act, Floodplain/Wetland Executive Order, NEPA, and DOE Order 5400.1 (DOE 1988a) began in 1990. Monitoring studies on raptors, reptiles and amphibians, small mammals, and birds continued through 1992. Additionally, BRET monitored wetland and adjacent upland habitats within Pajarito and Sandia canyons and initiated several new surveys to obtain inventory data on groups of organisms not previously studied.

Aquatic Invertebrates. For the past three years, BRET conducted field studies of stream macroinvertebrate communities associated with outfalls of organic and industrial waste in Sandia Canyon. Biologists sampled aquatic macroinvertebrates and water samples were collected at three permanent stations within Sandia Canyon (Figure IV-23). The purpose of the study was to develop baseline information and to determine if aquatic macroinvertebrate communities in Sandia Canyon could be correlated to water quality. Results of the study indicate that the composition of aquatic macroinvertebrate communities at each station appeared to be a function of water quality and physical characteristics of the stream. Two of the three sampling stations were characterized by low diversity of macroinvertebrates and measures of water quality that differed slightly from those from natural areas. These two areas directly received industrial and sanitary waste effluents. The last sampling station appeared to be in the "zone of recovery." At that station, water quality parameters became more stable and resembled the parameters of natural areas. A list of the macroinvertebrates collected at the three sampling stations within Sandia is in Table IV-50. As anticipated, no fish were collected from sampling stations on Laboratory land.

Terrestrial Invertebrates. BRET conducted studies of terrestrial insects in both Cañada del Buey and Pajarito Canyon during 1991. Pit traps for terrestrial insects yielded large numbers of insect orders, genera, and species. Many specimens were sent to experts for identification; specimen identification was completed in 1992. The two most common groups of insects captured in both Cañada del Buey and Pajarito Canyon were ants and beetles. Data analysis indicate a higher species composition of insects within the Pajarito wetlands than in Cañada del Buey, which is a dry canyon. Nine families of beetles have been identified from the Pajarito Canyon study area, while only three families have been identified within Cañada del Buey (Figure IV-24).

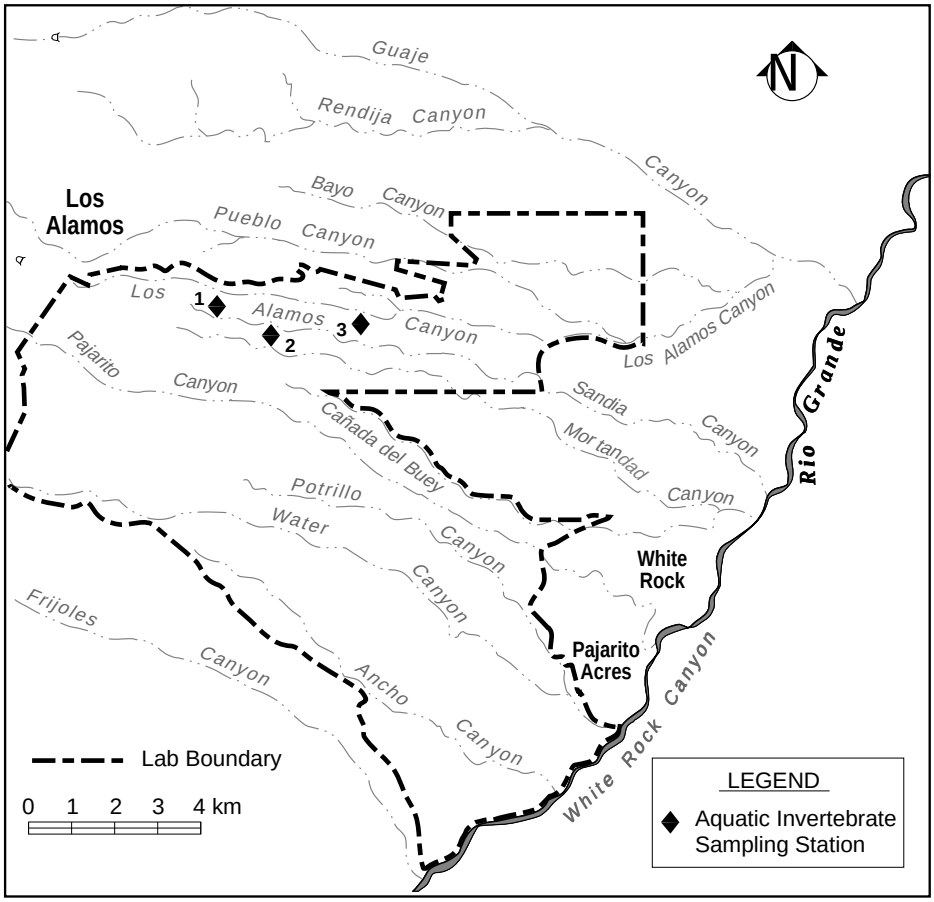


Figure IV-23. Locations of on-site aquatic invertebrate sampling stations in Sandia Canyon. (Map denotes general location only.)

Reptiles and Amphibians. Populations of reptiles and amphibians within Cañada del Buey and Pajarito Canyon were monitored during 1991. The monitoring activities continued in Pajarito Canyon throughout 1992. Because water resources are limited in Cañada del Buey, no amphibians were found. Table IV-51 identifies the reptile and amphibian species found within these two canyon ecosystems.

Birds/Raptors. Evaluation of raptor populations and raptor nest sites within Laboratory boundaries continued during 1992. Birds of concern included the zone-tail hawk (*Buteo albonotautus*), Cooper's hawk (*Accipiter cooperii*), and the Northern goshawk (*Accipiter gentilis*). Habitation for wintering Bald Eagle was identified within the areas adjacent to the Laboratory.

Additionally, point-count surveys were continued in Cañada del Buey during 1992. The compilation by the Pajarito Ornithological Survey was published in the Atlas of the Breeding Birds of Los Alamos County, New Mexico (POS 1992).

Large mammals. BRET has not evaluated elk and deer populations since the late 1970s. Aerial game counts are precluded by altitude limitations mandated by DOE for security reasons. To estimate the relative use of Pajarito Canyon and Cañada del Buey by large and medium size mammals, BRET established pellet transects in 1991, which were continued in 1992. Biologists read transects on a monthly basis. Surveys show a significantly higher number of elk pellet groups in Pajarito Canyon than in Cañada del Buey and a slightly higher number of deer pellet groups in Pajarito Canyon than in Cañada del Buey. This indicates that both species use the wetland more than the dry canyon.

Table IV-50. Aquatic Invertebrates Found at Three Sampling Stations in Sandia Canyon

Aquatic Invertebrate	Present at Station 1[a]	Present at Station 2[b]	Present at Station 3[c]
Order Diptera (Flies, Midges, and Mosquitoes)	Yes	Yes	Yes
Order Coleoptera (Beetles)	No	Yes	Yes
Order Ephemeroptera (Mayflies)	No	No	Yes
Order Trichoptera (Caddis Flies)	No	No	Yes
Order Hemiptera (True Bugs)	No	No	Yes
Order Plecoptera (Stoneflies)	No	No	Yes
Class Odonata (Damselfiles and Dragonflies)	No	No	Yes
Class Oligocheata (Aquatic Earthworms)	No	No	Yes
Class Gordiacea (Hairworms)	No	No	Yes
Class Nematoda (Roundworms)	Yes	Yes	No

[a]Station 1 = Immediately below steam plant effluent discharge point.
[b]Station 2 = Immediately below the sanitary waste discharge point.
[c]Station 3 = Half mile down from any discharge point.

Small mammals. BRET initiated a study of the diversity and habitat requirements of small nocturnal mammal species as related to NPDES wastewater outfalls. This investigation was designed to determine which small mammal species are using habitats created by various hydrological conditions: (1) artificially watered sites (NPDES outfalls), (2) natural streams, and (3) dry areas at elevations of 2,073 m (6,800 ft) to 2,287 m (7,500 ft) with ponderosa pine overstory. An additional concern was whether the artificially created (outfall) wet areas were similar to naturally created wet areas with respect to numbers and types of nocturnal mammals.

BRET selected 13 sites: 3 dry natural sites, 7 outfalls (artificially watered sites), and 3 natural stream sites. Within these sites, BRET conducted a small mammal mark-recapture study from June 1992 through August 1992. Ten species of small mammals were captured during the study.

No significant differences were found in mean numbers of unique species, percent capture rate, and species diversity between dry natural, artificially watered, and natural stream site types. The study showed that natural stream areas were significantly higher in daily mean numbers of species, percent capture rates, and species diversity than dry natural areas. The similarity in species diversity at outfalls with natural stream areas depended on the quantity of water entering the environment; those outfalls with historically high water input (>2 gal./day) were most like natural areas. Outfalls with lower water input resembled dry sites with respect to mean numbers of species, percent capture rates, and species diversity.

Figure IV-24. Comparison of numbers of beetles collected in a wet (Pajarito) and a dry (Cañada del Buey) canyon.

Table IV-51. Reptile and Amphibian Species Captured in Pajarito Canyon and Cañada del Buey, 1992

Pajarito Canyon	Cañada del Buey
Amphibians	**Amphibians**
Tiger Salamander	None
Chorus Frog	
Red Spotted Toad	
Spadefoot Toad	
Woodhouse Toad	
Reptiles	**Reptiles**
Eastern Fence Lizard	Eastern Fence Lizard
Manylined Skink	Manylined Skink
Great Plains Skink	
Whiptail	
Short-horned Lizard	

Bats. BRET directed a quantitative survey of bat species inhabiting or foraging on Laboratory lands was conducted between June 30 and July 5, 1992. The purpose of the study (1) to identify species of bats inhabiting Laboratory lands, and (2) to determine if the spotted bat (*Euderma maculatum*), listed as endangered by the NM Department of Game and Fish, was using Laboratory lands for foraging or roosting. *Euderma* has been found in the adjacent Jemez Mountains.

During 1992, BRET set up nets at three study sites within the Laboratory boundary, including sites in Los Alamos Canyon, Pajarito Canyon, and a permanent site at TA-16. Bats were also netted at a site in Frijoles Canyon along Frijoles Creek in Bandelier National Monument. Researchers monitored from dusk to 0200 h or from midnight until dawn. Data recorded included species, sex, age, reproductive status, forearm length, height, direction of flight, and time of capture. A total of 94 bats were captured; species captured during the study and capture rates are recorded in Table IV-52. At Los Alamos Canyon, 15 bats from 6 species were captured. At Pajarito Canyon, 22 bats from 10 species were caught. Forty-four bats from nine species were captured over the pond at TA-16. Thirteen bats from five species were captured in Bandelier.

Table IV-52. Bat Species Captured and Capture Rates during the Net Survey, by Study Site Location, 1992

Common Name	Species	Los Alamos Canyon	Pajarito Canyon	TA-16	Bandelier	Capture Rate[a]
Pallid bat	*Antrozous pallidus*	x	x		x	10.6
Big brown bat	*Eptesicus fuscus*	x	x	x		10.6
Silver-haired bat	*Lasionycteris noctivagans*	x		x		16.0
Hoary bat	*Lasiurus cinereus*	x	x	x		11.7
California myotis	*Myotis californicus*				x	4.3
Long-eared myotis	*Myotis evotis*		x	x		7.4
Small-footed myotis	*Myotis leibii*		x	x	x	5.3
Fringed myotis	*Myotis thysanodes*	x	x	x	x	13.8
Long-legged myotis	*Myotis volans*	x	x	x		7.4
Yuma myotis	*Myotis yumanensis*			x	x	5.3
Western pipistrelle	*Pipistrellus hesperus*		x			1.1
Townsend's big-eared bat	*Plecotus townsendii*		x			1.1
Brazilian free-tailed bat	*Tadarida braziliensis*		x	x		5.3

[a]Capture rate is the percent of the total catch at all sites.

10. Community Relations Program (Patricia Trujillo-Oviedo, PA-3).

In 1992, the Laboratory's ER community relations program played an increasingly important role in communicating with the public regarding environmental issues at the Laboratory. As part of the ER program, several community relations activities were accomplished, including

- holding a series of public information meeting in Los Alamos, Santa Fe, and Espanola in May and September;
- developing and distributing a quarterly publication providing updates on ER activities;
+ expanding the ER mailing list to 1,400 names, including names on official EPA and NMED mailing lists;
- developing and presenting exhibits at community events in Los Alamos and Espanola and at environmental conferences;
- increasing the Speakers' Bureau's emphasis on environmental topics;
- meeting with several local neighborhood associations, the Los Alamos County Council, and the Los Alamos County Administrator to address specific ER issues; and
- mailing out and collating responses to a DOE survey about ER and Waste Management issues.

The Laboratory's Community Relations group (PA-3) was involved in several events in which the public interacted with Laboratory staff. Among these events were

- a round table discussion with the Los Alamos Study Group on Nuclear Nonproliferation, an event cosponsored by Our Common Ground, a group initiated by Laboratory employees interested in promoting respect for the environment and fostering open and honest discussion of environmental issues;
- a LANL-hosted public seminar with Daniel Ellsberg of "The Pentagon Papers" fame, also co-sponsored by Our Common Ground; and
- a public forum sponsored by the Los Alamos Committee on Arms Control and International Security to discuss nuclear nonproliferation.

11. Working Group to Address Community Health Concerns.

The Working Group to Address Community Health Concerns (the Working Group) is a joint Laboratory and community group formed in June 1991 to address concerns about a possible increased incidence of brain cancer in Los Alamos. The Working Group is composed of seven members from the Los Alamos community and seven members from the Laboratory. There are two cochairs, one representing the community and the other, the Laboratory.

Thirteen meetings of the Working Group were held during 1992. Topics of discussion included LANL TLD monitoring and the incidence of thyroid cancer. At the May 20, 1992, meeting the Working Group asked the Centers for Disease Control to prepare an independent study of historical radiation exposures in Los Alamos. During 1992 the Working Group agreed to expand its charter to take a more active role in advising the Laboratory on the possible health effects of new projects. The Working Group reviewed cancer rates computed as part of an epidemiological study by the NM Health Department and concluded there was no immediate cause for concern.

12. Waste Minimization and Pollution Prevention Awareness. (Pat Josey, EM-DO)

LANL's Waste Minimization and Pollution Prevention Awareness Program is a comprehensive and continual effort to systematically reduce the amount of waste generated at the Laboratory. The program is designed to eliminate or minimize releases of pollutants to the environment from all aspects of the Laboratory's operations hazardous chemical waste, TRU waste, low-level radioactive waste, radioactive liquid waste, mixed waste, and sanitary and industrial wastes.

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

13. Environmental, Safety, and Health Training. (Shirley Fillas, HS-8)

The Laboratory maintains an extensive training program comprising ES&H courses coordinated by the ES&H Training Section of the Risk Management Support Group (HS-3). In 1992, available training included Radiation Protection for Occupational Workers, Lockout/Tagout for Affected Workers, and Occupational Safety and Health Act (OSHA) Rights and Regulations. All new employees, contractors, affiliates, long-term visitors, co-op students, and current employees working at sites governed by DOE Order 5488.20 were required to take General Employee Training (GET), which consist of 17 training modules:

- Facilities
- Quality Assurance
- ES&H Policy
- OSHA Rights and Regulations
- Fire Protection
- Industrial Hygiene

- Lockout/Tagout
- Materials Control and Accountability
- Classification
- Radiation
- Policies
- Security
- Employee Participation Packet
- Industrial Safety
- Emergency Management
- Occupational Medicine
- Environment

Introduction to Hazard Communication and Hazardous Waste Generator courses were offered as part of the Extended GET Program.

The Laboratory also offers specific environment-related courses for employees who work with hazardous and toxic wastes. A variety of classes designed to meet site-, job-, and operation-specific training needs included Hazardous Waste Generator for Temporary Storage; Hazardous Waste Operations (which meets the OSHA training requirements as described in 29 CFR 1910.120); Packaging and Transportation of Hazardous Materials; Procedures to Implement the Spill Prevention, Control, and Countermeasures Plan; and Waste Management Coordination.

V. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

A major component of the Laboratory's Environmental Surveillance Program includes monitoring for potential exposures to the public from Laboratory-related radiation sources and assessing the risk associated with that exposure. Air effluents are routinely sampled at 88 release points on Laboratory property. Air sampling is conducted on Laboratory property, along the Laboratory perimeter, and in more distant areas that serve as regional background stations. Atmospheric concentrations of tritium, uranium, plutonium, americium, radioiodine, and gross alpha and beta are measured. The largest airborne release was 71,950 Ci of short-lived (8 s to 20 min half-lives) air activation products from the Los Alamos Meson Physics Facility (LAMPF). In 1992, total radioactive air emissions increased by approximately 10%, which was mainly due to slightly increased gaseous mixed activation products released from LAMPF. Water effluent from the liquid waste treatment plant is sampled to determine the release of radionuclides. Total releases continued to decline in 1992. No radioactive contribution in foodstuffs posed a threat to the health or safety of the public. The maximum effective dose to a member of the public from 1992 Laboratory operations was 6.1 mrem. The average doses to individuals in Los Alamos and White Rock because of 1992 Laboratory activities were 0.12 and 0.11 mrem, respectively. These doses are estimated to add lifetime risks of less than one chance in one million to an individual's risk of cancer mortality.

A. Introduction

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

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

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

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

B. Radioactive Emissions

1. Air.

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

Radioactive airborne emissions are monitored at 88 Laboratory discharge locations. These emissions consist primarily of filtered exhausts from glove boxes, experimental facilities, operational facilities (such as liquid waste treatment plants), a nuclear research reactor, and a linear particle accelerator at LAMPF. Some emissions receive treatment before discharge, such as filtration for particulate matter and catalytic conversion and adsorption for activation gases. The quantities of airborne radioactivity released depend on the type of research activities and can vary markedly from year to year (Figures V-1 through V-3). During 1992, the most significant releases were from LAMPF. The amount released for the entire year was 71,950 Ci (2,662,150 GBq) of air activation products (gases, particles, and vapors) from all Laboratory operations (Tables V-1 and V-2). This emission was about 25% greater than that in 1991, due to the increased operating time of LAMPF (Table V-3). The principal airborne activation products (half-lives in parentheses) were ^{10}C (19.5 s), ^{11}C (20 min), ^{13}N (10 min), ^{16}N (7.14 s), ^{14}O (71 s), ^{15}O (123 s), and ^{41}Ar (1.83 h). Most of the radioactivity was from these radioisotopes, whose radioactivity declines very rapidly, before they reached the Los Alamos townsite. A list of selected nuclides and their half-lives is given in Table D-16.

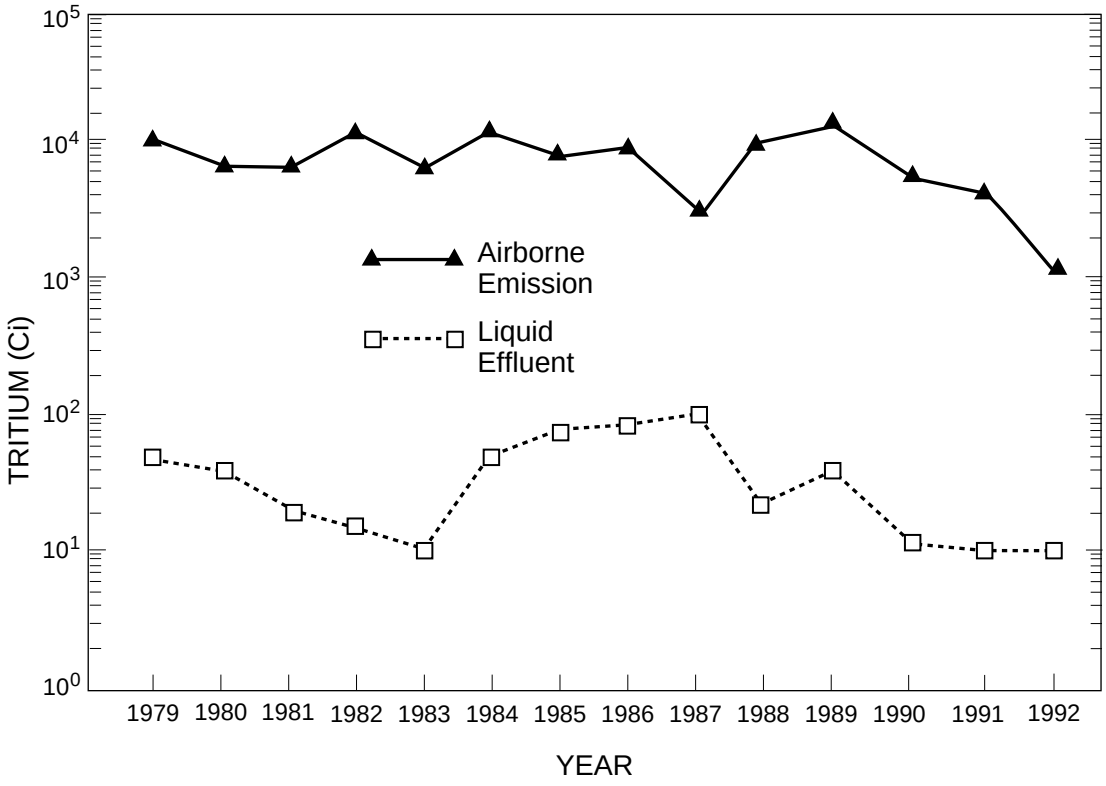


Figure V-1. Summary of tritium releases (airborne emissions and liquid effluents).

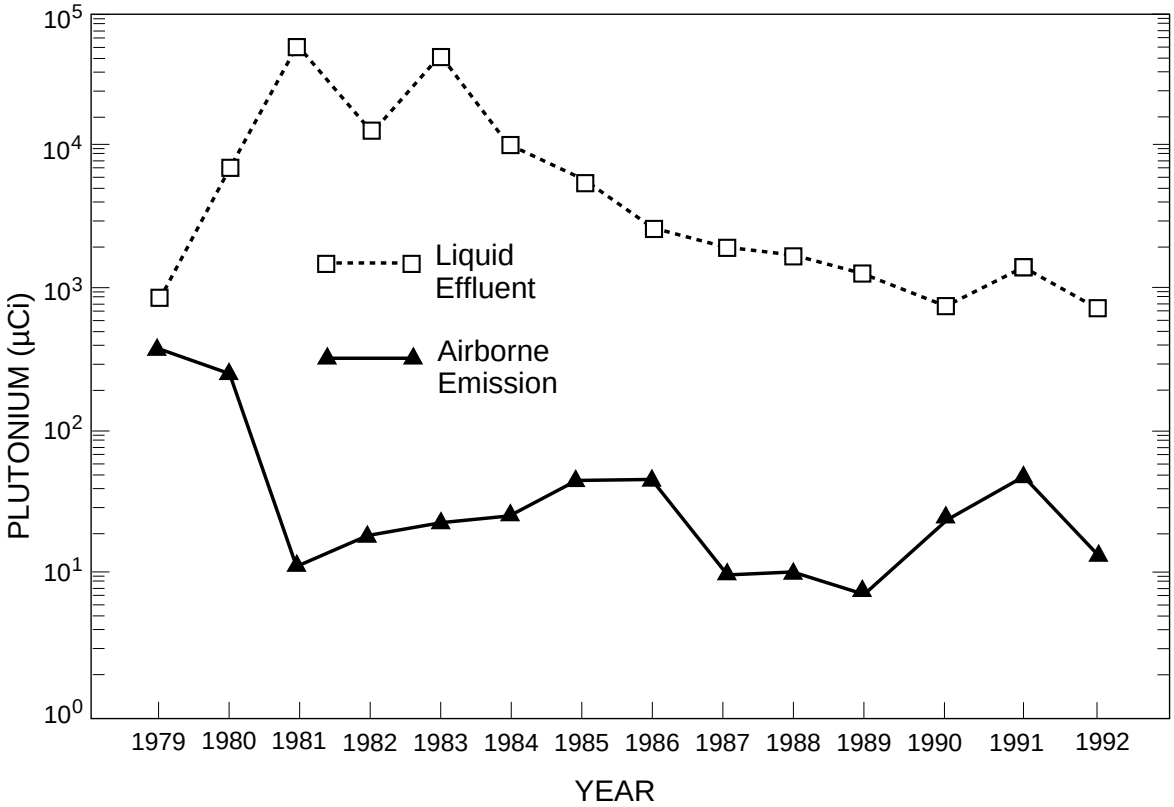


Figure V-2. Summary of plutonium releases (airborne emissions and liquid effluents).

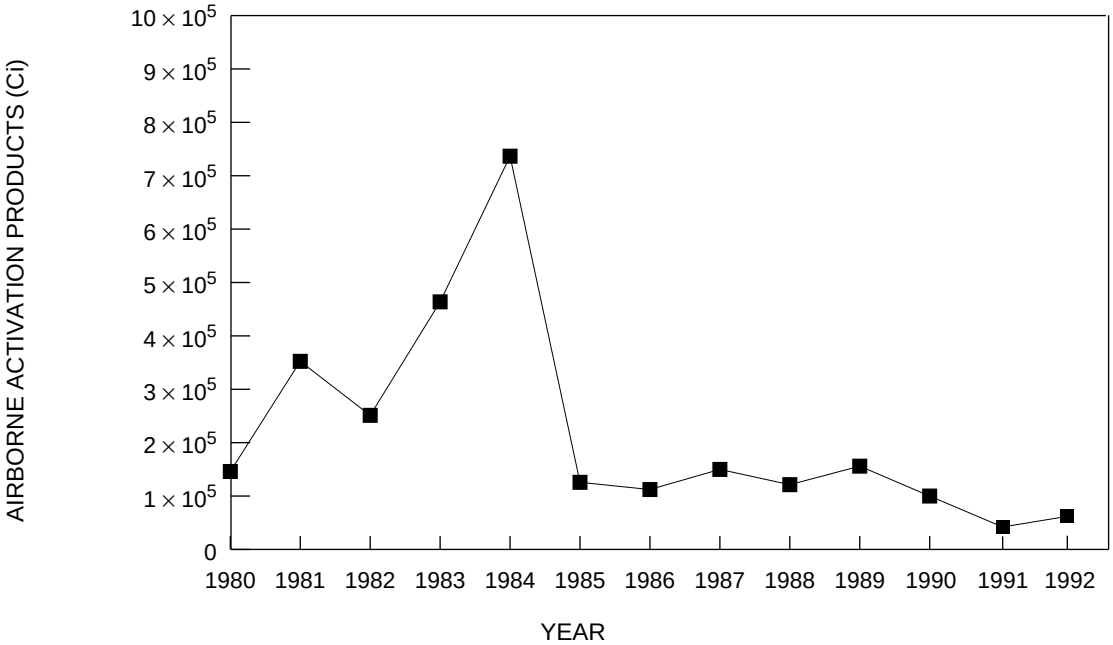


Figure V-3. Airborne activation product emissions (principally ^{10}C, ^{11}C, ^{12}N, ^{16}N, ^{14}O, ^{15}O, ^{41}Ar) from the Los Alamos Meson Physics Facility (TA-53).

Table V-1. Airborne Radioactive Emissions from Laboratory Operations in 1992[a] (in Curies)

Radio-nuclide	TA-2	TA-3	TA-15[a]	TA-16	TA-21	TA-33	TA-35
^{3}H[b]		$1.15 + 10^{+2}$		$6.28 + 10^{-2}$	$4.29 + 10^{+2}$	$3.18 + 10^{+2}$	$1.00 + 10^{-1}$
^{10}C							
^{11}C							
^{13}N							
^{16}N							
^{14}O							
^{15}O							
^{32}P							
^{41}Ar	$1.40 + 10^{+2}$						
MFP[c]		$8.42 + 10^{-6}$			$2.40 + 10^{-8}$		
^{234}U			$6.12 + 10^{-4}$				
^{235}U		$1.39 + 10^{-4}$	$3.20 + 10^{-5}$		$5.20 + 10^{-5}$		
^{238}U		$5.92 + 10^{-5}$	$1.65 + 10^{-3}$				
Pu[d]		$2.73 + 10^{-6}$			$8.70 + 10^{-7}$		$3.58 + 10^{-7}$
P/VAP[e]							

Radio-nuclide	TA-41	TA-43	TA-48	TA-50	TA-53	TA-54	TA-55	Totals
^{3}H[b]	$2.92 + 10^{+2}$				$4.21 + 10^{+1}$		$1.02 + 10^{+2}$	$1.30 + 10^{+3}$
^{10}C					$2.80 + 10^{+3}$			$2.80 + 10^{+3}$
^{11}C					$1.28 + 10^{+4}$			$1.28 + 10^{+4}$
^{13}N					$9.52 + 10^{+3}$			$9.52 + 10^{+3}$
^{16}N					$1.08 + 10^{+3}$			$1.08 + 10^{+3}$
^{14}O					$1.06 + 10^{+3}$			$1.06 + 10^{+3}$
^{15}O					$4.43 + 10^{+4}$			$4.43 + 10^{+4}$
^{32}P		$9.41 + 10^{-6}$						$9.41 + 10^{-6}$
^{41}Ar					$2.50 + 10^{+2}$			$3.90 + 10^{+2}$
MFP[c]			$2.74 + 10^{-3}$	$3.57 + 10^{-6}$				$2.75 + 10^{-3}$
^{234}U								$6.12 + 10^{-4}$
^{235}U			$4.17 + 10^{-7}$					$2.23 + 10^{-4}$
^{238}U								$1.71 + 10^{-3}$
Pu[d]			$6.72 + 10^{-6}$	$5.50 + 10^{-7}$		$1.00 + 10^{-8}$	$1.12 + 10^{-6}$	$1.24 + 10^{-5}$
P/VAP[e]			$3.79 + 10^{-2}$		$7.33 + 10^{-1}$			$7.71 + 10^{-1}$

[a]For dose calculation purposes, emissions from both TA-15 and TA-36 are conservatively considered to be released from TA-15; however, 54% of the ^{234}U, ^{235}U, and ^{238}U emissions are from TA-15 and 46% are from TA-36.

[b]1992 tritium releases from TA-16, TA-21, TA-41, and TA-53 were 81.7%, 12.75%, 0.5%, and 100% tritium oxide respectively. All remaining tritium releases were of elemental tritium.

[c]MFP = Mixed Fission Products.

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

[e]P/VAP = Particulate/vapor activation products. These include 29 radionuclides at TA-53 dominated by ^{197m}Hg, ^{7}Be, and ^{82}Br, and 20 radionuclides at TA-48 dominated by ^{75}Se, and ^{77}Br. Individual radionuclide totals for 1992 emissions are shown in Table V-2.

Table V-2. Detailed Listing of Activation Products from Laboratory Operations in 1992 (in Curies)

Mixed Activation Products	Radionuclide	Location TA-2	TA-53	TA-48
Particulate/Vapor (P/VAP)	^{72}As			$8.69 + 10^{-4}$
	^{73}As			$2.56 + 10^{-3}$
	^{74}As			$1.34 + 10^{-3}$
	^{7}Be		$2.45 + 10^{-2}$	
	^{77}Br		$2.30 + 10^{-3}$	$1.69 + 10^{-2}$
	^{82}Br		$1.16 + 10^{-2}$	
	^{109}Cd			$3.34 + 10^{-3}$
	^{56}Co		$1.03 + 10^{-5}$	$2.73 + 10^{-6}$
	^{57}Co		$3.79 + 10^{-5}$	$5.77 + 10^{-5}$
	^{58}Co		$2.62 + 10^{-5}$	$8.45 + 10^{-6}$
	^{60}Co		$4.40 + 10^{-6}$	
	^{51}Cr		$8.78 + 10^{-5}$	
	^{68}Ga			$5.72 + 10^{-4}$
	^{146}Gd		$8.16 + 10^{-7}$	
	^{153}Gd			$9.05 + 10^{-5}$
	^{68}Ge			$7.10 + 10^{-4}$
	^{197}Hg		$2.70 + 10^{-3}$	
	^{197m}Hg		$6.79 + 10^{-1}$	$5.24 + 10^{-4}$
	^{203}Hg		$1.29 + 10^{-4}$	
	^{131}I		$1.31 + 10^{-5}$	
	^{172}Lu		$5.86 + 10^{-5}$	$3.12 + 10^{-6}$
	^{173}Lu		$5.88 + 10^{-4}$	
	^{52}Mn		$2.78 + 10^{-4}$	
	^{54}Mn		$4.55 + 10^{-5}$	$1.33 + 10^{-4}$
	^{22}Na		$5.31 + 10^{-6}$	
	^{24}Na		$9.42 + 10^{-3}$	
	^{185}Os		$2.10 + 10^{-4}$	
	^{143}Pm		$4.50 + 10^{-5}$	
	^{183}Re		$1.94 + 10^{-5}$	$3.36 + 10^{-4}$
	^{46}Sc		$7.35 + 10^{-6}$	
	^{47}Sc		$1.07 + 10^{-3}$	
	^{75}Se		$7.21 + 10^{-5}$	$1.20 + 10^{-2}$
	^{182}Ta		$4.06 + 10^{-6}$	
	^{202}Tl			$1.21 + 10^{-4}$
	^{168}Tm			$3.38 + 10^{-6}$
	^{172}Tm		$5.09 + 10^{-5}$	
	^{48}V		$4.05 + 10^{-4}$	$4.77 + 10^{-6}$
	^{127}Xe		$1.88 + 10^{-5}$	
	^{169}Yb			$1.82 + 10^{-6}$
Gaseous/Mixed (G/MAP)	^{41}Ar	$1.40 + 10^{2}$	$2.50 + 10^{2}$	
	^{10}C		$2.80 + 10^{3}$	
	^{11}C		$1.28 + 10^{4}$	
	^{13}N		$9.52 + 10^{3}$	
	^{16}N		$1.08 + 10^{3}$	
	^{14}O		$1.06 + 10^{3}$	
	^{15}O		$4.43 + 10^{4}$	

Table V-3. Comparison of 1991 and 1992 Releases of Radionuclides from Laboratory Operations[a]

Airborne Emissions

Radionuclide	Units	Activity Released 1991	Activity Released 1992	Ratio 1992:1991
^{3}H	Ci	4,716	1,298	0.3
^{32}P	µCi	17	9	0.5
Uranium	µCi	336[b]	242[b]	0.7
Plutonium	µCi	37	12	0.3
Gaseous mixed activation products	Ci	57,431	71,950	1.3
Mixed fission products	µCi	1,096	275	0.3
Particulate/vapor activation products	Ci	0.21	0.73	4.2
Spallation products	Ci	<0.1	<0.1	1.0
Total	Ci	62,147[c]	73,248	1.1

Liquid Effluents

Radionuclide	Activity Released (mCi) 1991	Activity Released (mCi) 1992	Ratio 1992:1991
^{3}H	10,600	10,630	1.0
$^{82,85,89,90}Sr$	124	17	0.1
^{137}Cs	67	0.5	0.01
^{234}U	0.07	0.05	0.7
$^{238,239,240}Pu$	1.3	0.7	0.5
^{241}Am	1.1	0.3	0.3
Rounded Total	10,800	10,650	0.99

[a]Detailed data are presented in Tables V-1 and V-2 for airborne emissions and Table IV-26 for liquid effluents.
[b]Does not include dynamic testing.
[c]Number presented in Environmental Surveillance at Los Alamos during 1991 has been corrected. The activity released in 1991 due to airborne emissions (63,633 Ci) was incorrect because of an error in the addition of Ci and µCi.

Airborne tritium emissions continued to decrease from the 4,716 Ci (174,500 GBq) released in 1991 to 1,298 Ci (48,100 GBq) released in 1992 (Table V-3). Release of mixed fission products decreased from 1,096 µCi (40.4 MBq) to 275 µCi (10.1 MBq) in 1992.

In addition to releases from facilities, some depleted uranium (uranium consisting primarily of ^{238}U) is dispersed by experiments that use conventional high explosives. About 493 kg (1,085 lb) of depleted uranium was used in such experiments in 1992 (Table V-4). This mass contains about 0.183 Ci (6,790 MBq) of radioactivity. Most of the debris from these experiments was deposited on the ground in the vicinity of the firing sites. Limited experimental data show that no more than about 10% of the depleted uranium becomes airborne (Dahl 1977). Dispersion calculations indicate that resulting airborne concentrations are in the same range as that for concentrations attributable to the natural abundance of uranium that is resuspended in dust particles originating from the earth's crust.

Radioactive air emissions at the Laboratory are monitored according to DOE/EH-0173T "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991) and 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (EPA 1989c). 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.

Table V-4. Estimated Concentrations of Radioactive Elements Released by Dynamic Experiments

Element	1992 Total Usage	Fraction Released (%)	Annual Average Concentration (4 km)[a]	Annual Average Concentration (8 km)[a]	Applicable[b] Standard
Uranium	492.8 kg	10	$6 + 10^{-4}$ µg/m^3	$2 + 10^{-4}$	9 µg/m^3
^{234}U	$1.54 + 10^{-2}$ Ci	10	$2 + 10^{-17}$ µCi/mL	$6 + 10^{-18}$	$9 + 10^{-14}$ µCi/mL
^{235}U	$2.66 + 10^{-3}$ Ci	10	$3 + 10^{-18}$ µCi/mL	$1 + 10^{-18}$	$1 + 10^{-13}$ µCi/mL
^{238}U	$1.65 + 10^{-1}$ Ci	10	$2 + 10^{-16}$ µCi/mL	$7 + 10^{-17}$	$1 + 10^{-13}$ µCi/mL

[a]Distance downwind.
[b]DOE (1981).

On July 17, 1990, LANL notified the Department of Energy (DOE) that the Laboratory met the 10 mrem/yr standard but did not meet the monitoring requirements (40 CFR 61.93) with its existing sampling program. On November 27, 1991, Environmental Protection Agency (EPA) Region 6 issued the DOE a Notice of Noncompliance with 40 CFR 61, Subpart H, specifically:

1. Every release source from an operation that uses radionuclides has not been evaluated using the approved Environmental Protection Agency (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 effective dose equivalent (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 Notice of Noncompliance, the DOE is currently negotiating a Federal Facilities Compliance Agreement (FFCA) with EPA Region 6. The FFCA will include schedules that the Laboratory will follow to come into compliance with the Clean Air Act. A draft FFCA was submitted by DOE Los Alamos Area Office (LAAO) to the EPA on March 12, 1992.

2. 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 (Tables IV-26 and V-3 and Figures V-1 and V-2). 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 1992, there were no releases from the TA-21 plant or the TA-53 total retention lagoons.

Total activity released in 1992 (about 10.7 Ci) was slightly less than that released in 1991 (about 10.8 Ci) (Table V-3). The decrease resulted because of improved treatment of the radioactive liquid waste stream. 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.

3. Unplanned Releases.

a. Airborne Radionuclide Releases. On March 25, 1992, 0.045 µCi of ^{242}Pu were released at TA-55. The EDE (50 yr dose commitment) to a member of the public during passage of the puff was calculated to be 0.0001 mrem. Potential doses from this and from all other airborne releases were calculated using an atmospheric dispersion model that includes meteorological conditions and wind speed and direction characteristics during the release (EPA 1990b, LLNL 1990).

Measurements taken from July 31, 1992, to August 7, 1992, showed the release of 9.9 µCi of ^{232}Th and its daughter products from the Sigma Facility at TA-3. The maximum EDE to the nearest off-site location was calculated to be 0.0034 mrem.

On September 18, 1992, 20 Ci of elemental tritium gas were released from LAMPF at TA-53. One percent was assumed to be subsequently oxidized to tritiated water (Brown 1990). The maximum EDE to the nearest off-site location was calculated to be 0.08 mrem, which is 0.8% of the EPA's 10 mrem/yr radiation limit from the air pathway.

On September 24, 1992, 20 Ci of elemental tritium gas were released from LAMPF, TA-53. One percent was assumed to be subsequently oxidized to tritiated water (Brown 1990). The maximum EDE to the nearest off-site location was calculated to be 0.04 mrem, which is 0.4% of the EPA's 10 mrem/yr radiation limit from the air pathway.

During the period of October 29, 1992, to November 20, 1992, higher than average release rates were noted for stack FE-40 (Radiochemistry Site at TA-48). The activation products ^{72}As (0.6 mCi), ^{73}As (1.4 mCi), ^{74}As (1.1 mCi), ^{75}Se (1.8 mCi), and ^{68}Ge/^{68}Ga (0.6 mCi) were released during the three week time period. The maximum EDE to the nearest off-site location was calculated to be 0.000087 mrem.

During the period of October 30, 1992, to November 6, 1992, higher than average release rates were noted for stack FE-26 (Sigma Facility, TA-3). Approximately 0.6 µCi of ^{238}U was released during this time period. The maximum EDE to the nearest off-site location was calculated to be 0.000065 mrem.

b. Radioactive Liquid Releases. On September 18, 1992, a drum containing scintillation vials (containing xylene, tritium, and ^{14}C) stored at TA-54, Area L, was found to have pinhole leaks on its sides and top. During the overpacking process, the drum sling slipped and the drum fell on its side spilling approximately one quart of solution on the asphalt. No radioactivity was detected at the site of the spill. Site personnel covered the spill area with plastic and built a dirt berm around the perimeter of the spill to keep water away from the spillage in case it rained. Site personnel completed the cleanup on September 25, 1992, by removing the contaminated asphalt and storing the waste as low-level mixed waste.

On October 19, 1992, approximately 75 gal. cooling water from LAMPF was discharged from the radioactive liquid holding tank when the piping became plugged, which caused a backup of wastewater. The wastewater, containing low levels of radioactivity (beta and gamma emitters at approximately 12,000 dpm) was discharged into the parking lot at TA-53, near Building 3. All wastewater was contained within the parking lot and did not enter a watercourse. The area was cleaned to applicable standards.

On January 20, 1993, the operation group at TA-33, Building 93, discovered a leak in the roof of Room 12. Snowpack on the roof melted and ran down the interior wall, into a floor drain, and then into the facility's septic system. Approximately one gal. of tritiated-contaminated storm water run-off (about 2 mCi/mL) entered the septic system.

On December 23, 1992, the Laboratory decided to operate a boiler continuously at the Omega West Reactor, TA-2, to heat secondary sump water directly, and thus, to transfer heat to the primary coolant via reverse convective heat transfer in the cooling tower. A number of tests were performed with the boiler operating to determine the temperature change rates under a variety of conditions, including operation without the main pump. It was during these tests, which took place during the first few weeks of January 1993, that the reactor operators noted that the amount of system make-up water required for the system remained essentially constant (approximately 75 gal./day). The system is typically topped off twice a week. It was expected that the rate of water loss due to ordinary operations would drop while the reactor was run under lower pressure conditions. When the rate of water loss did not drop, the question arose as to whether the system was experiencing water loss through an unknown mechanism.

A systematic procedure was developed to determine whether that was the case, along with a test that isolated the flow of primary water in a circular loop that included all primary piping not associated with either

the secondary or primary piping beyond the primary pump. These procedures indicated positively that the water loss problem had been isolated to the remaining primary components. As required by DOE Order 5000.3A, DOE was notified on January 30, 1993, that a leak of tritiated water had been positively identified. The EPA and the New Mexico Environment Department (NMED) were also notified. Surface water samples were collected on January 30 and 31, 1993. Preliminary screening by the Health & Safety Division (HS) indicated that the tritium concentration of water in the primary cooling loop water was 18 to 20 million pCi/L and the concentration in the groundwater near Building 1 was 0.10 to 0.12 million pCi/L. Data collected at the Laboratory boundary indicated that the higher levels of tritiated water remained within DOE property. According to Section 207 of the NM Water Supply Regulations, the average annual tritium concentration assumed to produce a total body dose of 4 mrem/yr is 20,000 pCi/L.

During the week of February 1, 1993, experimental plans for leak isolation were developed and written, and the plan approval process was initiated. By February 12, 1993, the fuel elements were moved to the deep pool. On February 16, 1993, the reactor and surge tank levels were pumped down by removing 8,000 gal. of water to TA-50 for temporary storage. This isolated the inlet line, delay line, and the reactor tank for leak testing.

On February 17, 1993, the delay line was found to show fluid loss while the other two segments were leak-free. The outlet and inlet lines were pumped to the TA-50 storage tanks. Release of tritiated water to the environment ceased. The EPA and NMED were notified that the leak had ceased on February 18, 1993.

C. Radiological Doses

1. Introduction.

Radiological doses are calculated in order to measure the health impacts of any releases of radioactivity to the public. Radiation dose refers to the quantity of radiation energy absorbed per unit mass, multiplied by adjustment factors for type of radiation. EDE is the principal measurement used in radiation protection. This term means the hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure that may be limited to a few organs. The EDE is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100 mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to (100 + 0.12) = 12 mrem.

Standards exist which limit the maximum effective dose to the public. The DOE's public dose limit (PDL) is 100 mrem/yr EDE received from all pathways, and the dose received by air is restricted by the EPA's effective dose standard of 10 mrem/yr (Appendix A). These values are in addition to those from normal background, consumer products, and medical sources. The standards apply to locations of maximum probable exposure to an individual in an off-site, uncontrolled area.

2. Methods for Dose Calculations.

a. Introduction. Annual radiation doses are evaluated for three principal exposure pathways: external exposure (which includes exposure from immersion in air containing photon-emitting radionuclides and direct and scattered penetrating radiation), inhalation, and ingestion. Estimates are made of the following exposures:

- Maximum individual organ doses and EDE to an individual at or outside the Laboratory boundary where the highest dose rate occurs and a person actually is present. It takes into account occupancy (the fraction of time that a person actually occupies that location), shielding by buildings, and self-shielding.
- Average organ doses and EDEs to nearby residents.
- Collective EDE for the population living within an 80 km (50 mi) radius of the Laboratory.

Two evaluations of potential airborne releases are conducted: one to satisfy 40 CFR Part 61 requirements and one for all pathways. Results of environmental measurements are used as much as possible in assessing doses to individual members of the public. Calculations based on these measurements follow procedures recommended by federal agencies to determine radiation doses (DOE 1991, NRC 1977). If the impact of Laboratory operations is not detectable by environmental measurements, individual and population doses attributable to Laboratory activities are estimated through modeling of releases.

Dose conversion factors used for inhalation and ingestion calculations are given in Table D-17. These factors are taken from the DOE (1988b) and are based on factors in Publication 30 of the International Commission on Radiological Protection (ICRP 1979).

Dose conversion factors for inhalation assume a 1 µm diameter median aerodynamic activity, as well as the lung solubility category that will maximize the EDE (for comparison with DOE's 100 mrem/yr PDL) if more than one category is given. Similarly, the ingestion dose conversion factors are chosen to maximize the EDE if more than one gastrointestinal tract uptake is given (for comparison with DOE's 100 mrem/yr PDL for all pathways).

These dose conversion factors give the 50 year dose commitment for internal exposure. The 50 year dose commitment is the total dose received by an organ during the 50 year period following the intake of a radionuclide that is attributable to that intake.

External doses are calculated using the dose-rate conversion factors published by DOE (1988c) (Table D-18). These factors give the photon dose rate in millirems per year per unit radionuclide air concentration in microcuries per cubic meter. If these factors are not available in DOE 1988c, they are calculated with the computer program DOSFACTOR II (Kocher 1981).

Annual EDEs are estimated with the CAP-88 collection of computer codes published by the EPA if releases from Laboratory operations are so small that they are less than 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 thermoluminescent dosimeter (TLD) measurements are used to estimate external radiation doses.

The TLD measurements are corrected for background to determine the contribution to the external radiation field from Laboratory operations. Background estimates at each site, which are based on historical data, consideration of possible nonbackground contributions, and, if possible, values measured at locations of similar geology and topography, are subtracted from each measured value. This net dose is assumed to represent the dose from Laboratory activities that would be received by an individual who spent 100% of his or her time during an entire year at the monitoring location.

The individual dose is estimated from these measurements by taking into account occupancy and shielding. At off-site locations where residences are present, an occupancy factor of 1.0 is used. Two types of shielding are considered: (1) shielding by buildings and (2) self-shielding. Each shielding type is estimated to reduce the external radiation dose by 30%. (Note: these reductions are not used for demonstrating compliance to the EPA standard, see Section C.4.b below.)

Neutron doses from the critical assemblies at TA-18 were based on field measurements. Neutron fields were monitored principally with TLDs placed in 23 cm (9 in.) cadmium-hooded, polyethylene spheres. At on-site locations at which above background doses were measured, but at which public access is limited, dose estimates are based on a more realistic estimate of exposure time.

c. Inhalation Dose. Annual average air concentrations of ^{3}H, ^{238}Pu, ^{239,240}Pu, uranium (^{234}U, ^{235}U, ^{238}U), and ^{241}Am, determined by the Laboratory's air monitoring network, are corrected for background by subtracting the average concentrations measured at regional stations. The net concentration is reduced by 10% to account for indoor occupancy. These net concentrations are then multiplied by a standard breathing rate of 8,400 m^3/yr (ICRP 1975) to determine total adjusted intake via inhalation, in microcuries per year, for each radionuclide. Each intake is multiplied by appropriate dose conversion factors to convert radionuclide intake into 50 year dose commitments. Following ICRP methods, doses are calculated for all organs that contribute more than 10% of the total EDE for each radionuclide. The dose calculated for inhalation of ^{3}H 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 hr). This assumption is made for the boundary dose, dose to the maximum exposed individual, and dose to the population living within 80 km of the site.

Organ doses and EDEs are determined at all sampling sites for each radionuclide. A final calculation sums all radionuclides to estimate the total inhalation organ doses and EDEs.

d. Ingestion Dose. Results from foodstuffs sampling are used to calculate organ doses and EDEs from ingestion for individual members of the public. The procedure is similar to that used in the previous section. Corrections for background are made by subtracting the average concentrations plus two standard deviations

from sampling stations not affected by Laboratory operations. The radionuclide concentration in a particular foodstuff is multiplied by the annual consumption rate (NRC 1977) to obtain total adjusted intake of that radionuclide. Multiplication of the adjusted intake by the radionuclide's ingestion dose conversion factor for a particular organ gives the estimated dose to the organ. Similarly, EDE is calculated using the EDE conversion factor (Table D-17).

Doses are evaluated for ingestion of ^{3}H, ^{90}Sr, ^{137}Cs, uranium, ^{238}Pu, and ^{239,240}Pu in fruits and vegetables; ^{90}Sr, ^{137}Cs, uranium, ^{238}Pu, and ^{239,240}Pu in fish; and ^{3}H, ^{7}Be, ^{22}Na, ^{54}Mn, ^{57}Co, ^{83}Rb, ^{137}Cs, and uranium in honey.

3. Estimation of Radiation Doses.

a. Doses from Natural Background. EDEs from natural background and from medical and dental uses of radiation are estimated to provide a comparison with doses resulting from Laboratory operations. Doses from global fallout are only a small fraction of total background doses (<0.3%, NCRP 1987a) and are not considered further here. Exposure to natural background radiation results principally in whole-body doses and in localized doses to the lung and other organs. These doses are divided into those resulting from exposure to radon and its decay products that mainly affect the lung and those from nonradon sources that mainly affect the whole body.

Estimates of background radiation are based on a comprehensive report by the National Council on Radiation Protection and Measurements (NCRP 1987b). The 1987 NCRP report uses 20% shielding by structures for high-energy cosmic radiation and 30% self-shielding by the body for terrestrial radiation. The 30% protection factor is also applied to LANL sources of gamma radiation, which is less energetic than cosmic radiation.

Whole-body external dose is incurred from exposure to cosmic rays and to external terrestrial radiation from naturally occurring radioactivity in the earth's surface and from global fallout. EDEs from internal radiation are due to radionuclides deposited in the body through inhalation or ingestion.

Nonradon EDEs from background radiation vary each year depending on factors such as snow cover and the solar cycle (NCRP 1975b). Estimates of background radiation in 1992 from nonradon sources are based on measured external radiation background levels of 120 mrem (1.20 mSv) in Los Alamos and 105 mrem (1.05 mSv) in White Rock caused by irradiation from charged particles, x rays, and gamma rays. These uncorrected measured doses were adjusted for shielding by reducing the cosmic ray component (60 mrem [0.60 mSv] at Los Alamos and 53 mrem [0.53 mSv] at White Rock) by 20% to allow for shielding by structures and by reducing the terrestrial component (60 mrem [0.60 mSv] at Los Alamos and 53 mrem [0.53 mSv] at White Rock) by 30% to allow for self-shielding by the body (NCRP 1987a). To these estimates, based on measurements, were added 10 mrem (0.1 mSv) at Los Alamos and 8 mrem (0.08 mSv) at White Rock from neutron cosmic radiation (20% shielding assumed) and 40 mrem (0.4 mSv) from internal radiation (NCRP 1987a). The estimated whole body dose from background, nonradon radiation is 140 mrem (1.40 mSv) at Los Alamos and 127 mrem (1.27 mSv) at White Rock.

In addition to these nonradon doses, a second component of background radiation is dose to the lung from inhalation of ^{222}Rn and its decay products. The ^{222}Rn is produced by decay of ^{226}Ra, a member of the uranium series, which is naturally present in construction materials in buildings and in the underlying soil. The EDE from exposure to background ^{222}Rn and its decay products is taken to be equal to the national average, 200 mrem/yr (2 mSv/yr) (NCRP 1987a). This background estimate may be revised if a nationwide study of background levels of ^{222}Rn and its decay products in homes is undertaken, as recommended by the NCRP (1984, 1987a).

In 1992 the EDE to residents was 340 mrem (3.40 mSv) at Los Alamos and 327 mrem (3.27 mSv) at White Rock (Table V-5), or 140 mrem (1.40 mSv) from nonradon sources and 200 mrem (2 mSv) from radon at Los Alamos and 127 mrem (1.27 mSv) from nonradon sources and 200 mrem (2 mSv) from radon at White Rock.

Table V-5. Summary of Annual EDEs Attributable to 1992 Laboratory Operations, Using DOE-Approved Dose Calculation Method

	Maximum Dose to an Individual[a]	Average Dose to Nearby Residents		Collective Dose to Population within 80 km of the Laboratory
		Los Alamos	White Rock	
Dose	6.1 mrem	0.12 mrem	0.11 mrem	1.4 person-rem
Location of	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km Laboratory
Background	340 mrem	340 mrem	327 mrem	72,000 person-rem
DOE PDL	100 mrem	+	+	+
Percentage of PDL	6.1%	0.12%	0.11%	+
Percentage of Background	1%	0.03%	0.03%	0.002%

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

Medical and dental radiation in the United States accounts for an additional average EDE, per person, of 53 mrem/yr (0.53 mSv/yr) (NCRP 1987a). This estimate includes doses from both x rays and radiopharmaceuticals.

b. Doses to Individuals from External Penetrating Radiation from Airborne Emissions. The major source of external penetrating radiation from LANL operations has been airborne emissions from LAMPF. Nuclear reactions with air in the 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-minute, 10-minute, 71-second, and 122-second half-lives, respectively. Neutron reactions with air at the Omega West Reactor (TA-2) and LAMPF also form ^{41}Ar, which has a 1.8-hour half-life.
The radioisotopes ^{11}C, ^{13}N, ^{14}O, and ^{15}O are sources of photon radiation because of the formation of two 0.511-MeV photons through positron-electron annihilation. The ^{14}O also emits a 2.3-MeV gamma with 99% yield. The ^{41}Ar emits a 1.29-MeV gamma with 99% yield.

External penetrating radiation is routinely monitored by a special TLD network in the off-site location which receives the maximum dose from LAMPF operations. LAMPF airborne emissions in 1992 were 125% of the emissions in 1991. This increase occurred primarily because of the longer LAMPF operating schedule in 1992. However, the measured off-site dose during 1992 was less than the 3 mrem/yr (0.03 mSv/yr) detection limit of the LAMPF monitoring network. As a result, the EDE to the maximum exposed individual from 1992 Laboratory operations was not determined using environmental TLD results. The maximum off-site dose was estimated using the computer model AIRDOS (CAP-88 version), which uses measured stack emissions and meteorological data, rather than environmental measurements, to calculate off-site air concentrations and radiation doses. The computer model has been found in the past (see below) to slightly overestimate the dose at Los Alamos sites, principally because of the increased atmospheric mixing at Los Alamos, a result of uneven terrain. (The model was developed for relatively flat terrain). The maximum off-site EDE from external penetrating radiation LAMPF emissions was calculated by AIRDOS to be 5.5 mrem (0.055 mSv) during 1992. This dose is 55% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr), and 5.5% of the DOE's PDL of 100 mrem/yr (1 mSv/yr).

c. Doses to Individuals from Direct Penetrating Radiation. No direct penetrating radiation from Laboratory operations was detected by TLD monitoring in off-site areas. On-site TLD measurements of external penetrating radiation reflected Laboratory operations and did not represent any significant exposure to the public. During 1992 operations at TA-18, a potential gamma and neutron dose of 10 to 20 mrem/yr (0.10 to

0.20 mSv/yr) above background occurred to members of the public using the DOE controlled road passing by TA-18 (Figure II-4).

The on-site TLD station (Station 24, Figure IV-1) near the northeastern Laboratory boundary recorded an above-background dose of about 15 mrem (0.15 mSv). This dose reflects direct radiation from a localized accumulation of ^{137}Cs on sediments transported from TA-21 before 1964. No one resides near this location at this time.

d. Doses to Individuals from Inhalation of Airborne Emissions. The maximum individual EDEs attributable to inhalation of airborne emissions (Table V-6) are below the EPA air pathway standard of 10 mrem/yr (0.1 mSv/yr).

Exposure to airborne ^{3}H (as tritiated water vapor), ^{238}Pu, ^{239,240}Pu, ^{241}Am, uranium, ^{234}U, ^{235}U, ^{238}U, and ^{131}I was determined by measurement. Correction for background was made by assuming that natural radioactivity and worldwide fallout were represented by data from the three regional sampling stations at Española, Pojoaque, and Santa Fe. The highest EDE measured off-site for ^{238}Pu, ^{239,240}Pu, ^{241}Am, uranium, ^{234}U, ^{235}U, and ^{238}U, at the Pajarito Acres station was 0.08 mrem (0.0008 mSv), or 0.08% of the DOE's PDL of 100 mrem/yr (1 mSv/yr), and 0.8% 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 Area G operations during 1992 was estimated using the atmospheric transport model, CAP-88, to be 0.009 mrem/yr, or less than 1% of the EPA radiation limit of 10 mrem/yr for the air pathway. These doses are similar to doses estimated in previous years.

Exposure from all other atmospheric releases of radioactivity (Table V-2) was also evaluated by theoretical calculations of airborne dispersion. All inhalation potential doses from these releases were less than 0.5% of the DOE's PDL of 100 mrem/yr (1 mSv/yr).

Table V-6. Estimated Maximum Individual 50 Year Dose Commitments from 1992 Airborne Radioactivity[a]

Isotope	Location[b]	Estimated Dose (mrem)	Percentage of Public Dose Limit
^{3}H	White Rock	0.005	<0.1
^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar	East Gate	5.5	5.5
^{238}Pu, ^{239,240}Pu, ^{241}Am, uranium, ^{234}U, ^{235}U, ^{238}U	Pajarito Acres (Station 14)	0.08	<0.1

[a]Estimated maximum individual dose is the dose from Laboratory operations (excluding dose contributions from cosmic, terrestrial, medical diagnostics, and other non-Laboratory sources) to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where a person actually resides. It takes into account shielding and occupancy factors.

[b]See Figure IV-4 for station locations.

e. Doses to Individuals from Treated Effluents. At this time, discharged treated effluents do not flow beyond the Laboratory boundary but are retained in the alluvium of the receiving canyons. These treated effluents are monitored at point of discharge; their behavior in the alluvium of the canyons below outfalls has been studied and is monitored annually (Hakonson 1976a, 1976b; Purtymun 1971, 1974a).

Small quantities of radioactive contaminants transported during periods of heavy run-off have been measured in canyon sediments beyond the Laboratory boundary in Los Alamos Canyon (Figure II-5). Increased

discharge from the Bayo Canyon sanitary sewage treatment plant has resulted in additional flow in Los Alamos Canyon, typically to a location between wells LA-6 and LA-2. Calculations made with radiological data from Acid-Pueblo and Los Alamos canyons (ESG 1981) indicate a minor potential exposure pathway from these canyon sediments. Obtaining 50% annual consumption of meat from a steer that drinks water from and/or grazes in lower Los Alamos Canyon could potentially result in a maximum committed EDE of 0.8 mrem (0.008 mSv).

f. Doses to Individuals from Ingestion of Foodstuffs. Data from samples of produce, fish, and honey in 1992 were used to estimate EDEs received from ingestion of foodstuffs. The maximum EDE in 1992 from all foodstuffs analyzed are <0.4% of DOE's 100 mrem/yr (1 mSv/yr) PDL (DOE 1990a).

Produce was collected from Los Alamos and White Rock, Cochiti and San Ildefonso pueblos, and from various locations around the Laboratory. These samples were analyzed for six radionuclides (^{3}H, ^{90}Sr, ^{137}Cs, uranium, ^{238}Pu, and ^{239,240}Pu). The committed EDEs were based on the concentration of each radionuclide found in the sample and a typical annual consumption rate for produce of 160 kg (352 lb).

The maximum EDE from consuming produce from off-site locations is <0.4 mrem (<0.4% of the DOE PDL). This is based upon samples collected from Los Alamos and White Rock. This off-site maximum EDE compares well with the maximum EDE of 0.138 mrem (<0.2% of the DOE PDL) from consuming produce collected from on site. In fact, these two EDEs are statistically indistinguishable from each other. In addition, ingestion of produce collected on site is not a significant exposure pathway because of the small amount of edible material, low radionuclide concentrations, and limited access to these foodstuffs.

The maximum EDE from produce collected at San Ildefonso Pueblo during 1992 is 0.146 mrem (<0.15% of the DOE PDL). Ingestion of produce samples collected from Cochiti Pueblo in 1992 provide a maximum EDE of 0.08 mrem (0.08% of the DOE PDL). These pueblo samples are collected in an area more than 10 km (6.2 mi) beyond the Laboratory boundaries and are not believed to be impacted by Laboratory operations.

Fish samples collected in 1992 were analyzed for ^{90}Sr, ^{137}Cs, uranium, ^{238}Pu, and ^{239,240}Pu. Various types of fish are analyzed from Abiquiu Reservoir (upstream of Laboratory operations) and Cochiti Reservoir (downstream from Laboratory operations). Fish from Abiquiu Reservoir serve as a regional background. Fish collected from the two locations are divided into bottom and surface feeders. The maximum EDE to an individual eating 21 kg (46 lb) of fish from Cochiti Reservoir in 1992 (with regional background subtracted) is 0.004 mrem (0.004% of DOE PDL) for bottom feeders and 0.03 mrem (0.03% of DOE PDL) for surface feeders. Laboratory operations, therefore, do not result in significant radiation doses to the general public from consuming fish from Cochiti Reservoir.

In 1991, elevated levels of ^{3}H and ^{239,240}Pu were detected in fruit samples collected from a tree growing on the original Laboratory site (TA-1) (EPG 1993). In 1992, the fruit from this tree was completely removed to prevent ingestion by the public; samples of the fruit were retained for analysis. Although the levels were still higher than the levels of radionuclides in samples collected from other nearby fruit trees, the total EDE from the consumption of 22.7 kg (50 lb) of fruit from this tree was only 0.12 mrem/yr. This dose is less than 0.2% of the DOE's PDL of 100 mrem/yr for all pathways.

Honey samples from regional stations and locations around the Laboratory were analyzed for ^{3}H, ^{7}Be, ^{22}Na, ^{54}Mn, ^{57}Co, ^{83}Rb, ^{137}Cs, and uranium. The maximum EDE from eating 5 kg (11 lb) of this honey was <0.016 mrem (<0.02% of DOE PDL). Honey collected from Laboratory locations is not available for public consumption.

4. Total Maximum Individual Dose to a Member of the Public from 1992 Laboratory Operations.

a. Maximum Individual Dose. The maximum individual EDE to a member of the public from 1992 Laboratory operations is estimated to be 6.1 mrem/yr (0.061 mSv/yr). This is the total EDE from all pathways. This dose is 6.1% of the DOE's PDL of 100 mrem/yr (1 mSv/yr) EDE from all pathways (Table V-5) and 1.5% of the total annual dose contribution (Figure V-4).

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. As in 1991, the 1992 dose estimate is based on modeling rather than on environmental measurements for doses from external radiation from airborne radioactivity. This is because emissions from LAMPF during 1992 resulted in no measurable above-background external radiation dose in off-site areas (see Section V.C.3.b).

Figure V-4. Total contributions to 1992 dose at LANL's MEI location.

The computer model CAP-88, which is discussed in more detail in the following section, was used to make the dose estimate for external radiation from airborne radioactivity. Doses from other exposure pathways were estimated using environmental monitoring results (see Sections V.C.3.d and V.C.3.f). Doses from liquid releases and direct radiation from LANL facilities did not impact this location. The maximum EDE for external radiation from airborne emissions was estimated by CAP-88 using all measured releases from LANL facilities (Tables V-1 and V-4) and 1992 meteorological data. The dose estimate took into account shielding by buildings (30% reduction for submersion dose, 10% for inhalation dose) and occupancy (100% for residences, 25% for businesses) (Kocher 1980). The contribution to the maximum individual off-site dose via each pathway is presented in Figure V-5.

The average EDE to residents in Los Alamos townsite that is attributable to Laboratory operations in 1992 was 0.12 mrem (0.0012 mSv). The corresponding dose to White Rock residents was 0.11 mrem (0.0011 mSv). The doses are approximately 0.12% and 0.11% of DOE's PDL of 100 mrem/yr (1.0 mSv/yr).

b. Estimate of Maximum Individual Dose from Airborne Emissions for Compliance with 40 CFR Part 61, Subpart H. As required by the EPA, compliance with regulation 40 CFR 61, Subpart H must be demonstrated with the CAP-88 version of the computer codes PREPAR2, AIRDOS2, DARTAB2, and RADRISK (EPA 1990b). These codes use measured radionuclide release rates and meteorological information to calculate transport and airborne concentrations of radionuclides released to the atmosphere. The programs estimate radiation exposures from inhalation of radioactive materials; external exposure to the radionuclides present in the atmosphere and deposited on the ground; and ingestion of radionuclides in produce, meat, and dairy products.

Calculations for Laboratory airborne releases use the radionuclide emissions given in Tables V-1 and V-3. 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 that at the release point.

The maximum individual EDE, as determined by CAP-88, was 7.9 mrem (0.079 mSv). As expected, more than 98% of the maximum individual dose resulted from external exposure to air activation products from LAMPF. The 7.9 mrem (0.079 mSv) maximum dose, which would occur in the area just northeast of LAMPF, is 79% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr) EDE.

Figure V-5. LANL contributions to 1992 dose at LANL's MEI location by pathway.

5. Collective Dose Equivalents.

The collective EDE from 1992 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 1992 radioactive air emissions, their transport off site, and the resulting radiation exposures that could occur.

The 1992 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 1992 population collective EDE attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory was calculated to be 1.4 person-rem (0.014 person-Sv) to all persons. 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-7).

The collective dose from Laboratory operations was calculated from measured radionuclide emission rates (Table V-2), atmospheric modeling using measured meteorological data for 1992, and population data based on the Bureau of Census count (Table II-1). The collective dose from natural background radiation was calculated using the background radiation levels given above. For the population living within the 80 km (50 mi) radius of the Laboratory, the dose from medical and dental radiation was calculated using a mean annual dose of 53 mrem (0.53 mSv) per capita. The population distribution in Table II-1 was used in both these calculations to obtain the total collective dose.

Also shown in Table V-7 is the collective EDE in Los Alamos County from Laboratory operations, natural background radiation, and medical and dental radiation. Approximately 70% of the total collective dose from Laboratory operations is to Los Alamos County residents. This dose is <0.1% of the collective EDE from background and 0.2% of the collective dose from medical and dental radiation, respectively.

Table V-7. Estimated Collective EDEs during 1992 (person-rem [person-Sv])

Exposure Mechanism	Los Alamos County (18,200 persons)	80 km Region (224,000 persons)[a]
Total caused by Laboratory releases	1.1+(0.011)	1.4+(0.014)
Natural background		
Nonradon[b]	2,500 (25)	27,000 (270)
Radon	3,600 (36)	45,000 (450)
Totals caused by natural sources of radiation	6,100 (61)	72,000 (720)
Diagnostic medical exposures (~53 mrem/yr/person)	[c]1,000 (10)	12,000 (120)

[a]Includes doses reported for Los Alamos County.

[b]Calculations are based on TLD measurements. They include a 20% reduction in cosmic radiation from shielding by structures and a 30% reduction in terrestrial radiation from self-shielding by the body (NCRP 1987a).

[c]NCRP (1987a).

D. Risk to an Individual from Laboratory Releases

1. Estimating Risk.

Risk estimates of possible health effects from radiation doses to the public resulting from Laboratory operations have been made to provide a perspective in interpreting these radiation doses. These calculations, however, may overestimate actual risk for low-linear energy transfer (LET) radiation. The NCRP (1975a) has warned that "risk estimates for radiogenic cancers at low doses and low dose rates derived on the basis of linear (proportional) extrapolation from the rising portions of the dose incidence curve at high doses and high dose rates . . . cannot be expected to provide realistic estimates of the actual risks from low-level, low-LET radiation, and have such a high probability of overestimating the actual risk as to be of only marginal value, if any, for purposes of realistic risk-benefit evaluation."

Low-LET radiation, which includes gamma rays, is the principal type of environmental radiation resulting from Laboratory operations. Estimated doses from high-LET radiation, such as neutron or alpha particle radiation, are less than 3% of estimated low-LET radiation doses. Consequently, risk estimates in this report may overestimate the true risks.

Risk estimates used here are based on two recent reports by the National Research Council's Committee on the Biological Effects of Ionizing Radiation (BEIR IV 1988, BEIR V 1990). These reports incorporate the results of the most current research and update risk estimates in previous surveillance reports that were based on the work of the ICRP. The procedures used in this report for the risk estimates are described in more detail below.

2. Risks from Whole-Body Radiation.

Radiation exposures considered in this report are of two types: (1) whole-body exposures, and (2) individual organ exposures. The primary doses from 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 Committee's estimate (BEIR V 1990) of the risk from a single, instantaneous, high-dose rate exposure of 10 rem. The BEIR V report states that this estimate should be reduced for an exposure distributed over time that would occur at a substantially lower dose rate. The committee discussed dose rate effectiveness factors (DREFs) ranging from 2 to 10 that should be applied to the nonleukemia part of the risk estimate.

For the risk estimates presented in this report, a DREF of 2 is used for the nonleukemia risk. Following the BEIR V report, no dose rate reduction was made for the leukemia risk. The risk is then averaged over male and female populations. The total risk estimate is 440 nonleukemia cancer fatalities per 10^9 person-mrem.

3. Risks from Exposure to Radon.

Exposures to radon and radon decay products are important parts of natural background radiation. These exposures differ from the whole-body radiation discussed above in that they principally involve only the localized exposure of the lung and not other organs in any significant way. Consequently, the risks from radon exposure were calculated separately.

Exposure rates to radon (principally ^{222}Rn) and radon decay products are usually measured with a special unit, the working level (WL); 1 WL corresponds to a liter of air containing short-lived radon decay products whose total potential alpha energy is $1.3 + 10^5$ MeV. An atmosphere having a 100 pCi/L concentration of ^{222}Rn at equilibrium with its decay products corresponds to 1 WL. Cumulative exposure is measured in working level months (WLMs). A WLM is equal to exposure to 1 WL for 170 hours.

The estimated national average radon EDE that was given by the NCRP is 200 mrem/yr. The NCRP derived this dose from an estimated national average radon exposure of 0.2 WLM/yr. Because the risk factors are derived in terms of WLM, for the purposes of risk calculation it is more convenient to use the radon exposure of 0.2 WLM/yr than to use the radon dose of 200 mrem/yr. However, the 0.2 WLM/yr and the 200 mrem/yr EDE correspond to the same radiation exposure.

Risks from radon were estimated using a risk factor of $350 + 10^{-6}$/WLM. This risk factor was taken from the BEIR IV report (BEIR IV 1988).

4. Risk from Natural Background Radiation and Medical and Dental Radiation.

During 1992, persons living in Los Alamos and White Rock received an average EDE of 140 mrem (1.40 mSv) and 127 mrem (1.27 mSv), respectively, of nonradon radiation (principally to the whole body) from natural sources (including cosmic, terrestrial, and self-irradiation sources, with allowances for shielding and cosmic neutron exposure). Thus, the added risk of nonleukemia cancer mortality attributable to natural whole-body radiation in 1992 was 1 chance in 16,000 in Los Alamos and 1 chance in 18,000 in White Rock.

Natural background radiation also includes exposure to the lung from ^{222}Rn and its decay products (see above) in addition to exposure to whole-body radiation. This exposure to the lung also carries a chance of cancer mortality from natural radiation sources that were not included in the estimate for whole-body radiation. For the background EDE of 200 mrem/yr (2 mSv/yr), the added risk because of exposure to natural ^{222}Rn and its decay products is 1 chance in 14,000.

The total risk of nonleukemia cancer mortality from natural background radiation is 1 chance in 8,000 for Los Alamos and White Rock residents (Table V-8). 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 1992 Laboratory activities were 0.12 and 0.11 mrem (0.0012 and 0.0011 mSv), respectively. These doses are estimated to add lifetime risks of nonleukemia cancer mortality of one in one million (Table V-8). These risks are <0.1% of the risk attributed to exposure to natural background radiation or to medical and dental radiation.

For Americans, the average lifetime risk is a 1-in-4 chance of contracting cancer and a 1-in-5 chance of dying of cancer (EPA 1979). The Los Alamos incremental risk 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 40 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-8. Added Individual Lifetime Cancer Mortality Risks Attributable to 1992 Radiation Exposure

Exposure Source	EDE Used in Risk Estimate (mrem)	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.12	less than 1 in 1,000,000
White Rock area	0.11	less than 1 in 1,000,000
Natural Radiation		
Cosmic, terrestrial, self-irradiation, and radon exposure[a]		
Los Alamos	340	1 in++8,000[b]
White Rock	327	1 in++8,000
Medical X Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in+43,000

[a]An EDE of 200 mrem was used to estimate the risk from inhaling ^{222}Rn and its transformation products.
[b]The risks from natural radiation from nonradon sources were estimated to be 1 chance in 16,000 in Los Alamos and 1 chance in 18,000 for White Rock. The risk of lung cancer from radon exposure was estimated to be 1 chance in 14,000 for both locations. Risk estimates are derived from the NRC BEIR IV and BEIR V reports and the NCRP Report 93 (BEIR IV 1988, BEIR V 1990, NCRP 1987a).

VI. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

The Laboratory quantifies and assesses nonradioactive pollutant releases to the environment by calculating and monitoring nonradioactive emissions and effluents, evaluating unplanned releases, and conducting environmental sampling. Air emissions were determined for steam, power, and asphalt plants and from the detonation and burning of explosives, the removal of asbestos, and beryllium processing operations. All nonradioactive air emissions remained within federal limits during 1992. Surface water and groundwater are monitored to determine the Los Alamos National Laboratory's (LANL's or 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 1992.

A. Nonradioactive Emissions and Effluents Monitoring

1. Air.

a. 1990 Air Pollutant Emissions Inventory. During 1991, as part of the Environmental Oversight and Monitoring Agreement between the Department of Energy (DOE) and the New Mexico Environment Department (NMED), the Laboratory undertook an intensive effort to create a comprehensive, Laboratory-wide air pollutant emissions inventory based on 1990 chemical usages and operations. The goal of this effort was to update and expand the original emissions inventory prepared in 1987. The original inventory was performed to evaluate emissions under NMED-regulated toxic air pollutants and determine whether source registration under Air Quality Control Regulation (AQCR) 752 was required. The 1990 inventory expanded upon the 1987 work to include criteria pollutants, as well as hazardous air pollutants not currently regulated under AQCR 702 but listed in the federal Clean Air Act.

During the 1987 survey, the Laboratory identified approximately 500 sources (specific rooms within buildings) in 44 operating groups as having the potential to emit air pollutants. For the 1990 inventory, the Laboratory evaluated approximately 1,100 emissions sources, chemical usages, and air pollutant emissions. Each emission source was described using maximum 1 hr and maximum annual usages, which were based on conservative assumptions about the operation's schedule and chemical usage, disposal, and evaporation. Environmental Protection Agency (EPA)-published air pollutant emission factors (EPA 1986a) or emission factors provided on the EPA Clearinghouse Inventory of Emission Factors (CHIEF) bulletin board were used to estimate emission rates. For operations involving no emission factor, material balance equations were used. The Laboratory developed an electronic database, the Regulated Air Pollutants System (RAPS), to compile, document, and store final emission estimates. Table VI-1 lists those pollutants identified in the 1990 inventory that contribute 25 lb/yr or more to Laboratory-wide emissions. These pollutants, totaling approximately 226,636 lb, were emitted from stationary sources at the Laboratory. As a comparison, emissions contributed by the approximately 1,400 government vehicles at LANL (driven approximately 7.7 million miles in 1990) totaled 416,603 lb.

The criteria pollutants (NO_2, CO, hydrocarbons, particulates, and SO_2), make up approximately 79% of the Laboratory's stationary source emissions. The primary source of these criteria pollutants is combustion in power plants, steam plants, and asphalt plants and local space heaters. Toxic and other hazardous pollutants represent

Table VI-1. Summary of Estimated Emissions of Nonradioactive Air Pollutants[a] at Los Alamos in 1987 and 1990

Pollutant	1987 Emissions (lb/yr)	1990 Emissions (lb/yr)
Nitrogen dioxide	+[b]	118,772
Carbon monoxide	++	47,582
Nonmethane hydrocarbons	10,872	6,377
Particulate	++	5,629
Toluene	268	5,474
Methyl ethyl ketone	3,180	4,110
Heptane (*n*-heptane)	3	4,076
Xylene (*o*-,*m*-,*p*-isomers)	1,347	3,884
Methylene chloride	702	2,434
1,1,2-Trichloroethane	++	2,044
Ammonia	3,816	1,761
Sulfur dioxide	++	1,534
Nitric acid	1,674	1,457
Hydrogen chloride	1,832	1,407
V,m,&p naptha	2,162	1,351
Methyl alcohol	4,437	1,298
Isopropyl alcohol	829	1,188
Acetic acid	96	1,184
Chloroform	443	1,175
Welding fumes (not otherwise listed)	253	1,127
Wood dust (certain hard woods)	++	1,003
Nitrogen oxide	1,049	944
Stoddard solvent	941	583
Kerosene	15,265	574
Hydrogen fluoride as F	6	534
Trichloroethylene	1,229	463
Propane sultone	++	451
2-Butoxyethanol	1,014	271
Aluminum welding fumes	++	271
Heavy metals	++	251
Tungsten as W (insoluble)	++	241
Ethyl acetate	81	196
Hexane (*n*-Hexane)	435	170
Ethylene glycol	50	159
Nickel metal	++	122
Formaldehyde	9	109
Aluminum (metal and oxide)	5	89
Soft wood	525	88
Propylene oxide	++	80
Mineral oil mist	13	76
Cyclohexane	9	62
Methyl chloride	17	58
Lead	++	57
Phosgene	++	50
Sulfuric acid	121	48

Table VI-1. (Cont.)

Pollutant	1987 Emissions (lb/yr)	1990 Emissions (lb/yr)
Hydrogen peroxide	29	43
Isobutyl acetate	6	40
Ethyl ether	18	37
Tetrahydrofuran	194	37
Dichlorodifluoromethane	2	37
Lead chromate as Cr	++	36
Chlorine	++	29
Hexane, other isomers	++	26

[a]Only pollutants with 1990 emissions of 25 lb/yr or more are reported here.
[b]Data not collected for these pollutants.

approximately 21% of emissions from stationary sources at LANL. The operations contributing the majority of these emissions include surface cleaning and coating. Acid gases, metals, and miscellaneous emissions such as wood dust, hazardous gases, and plastics contribute the remaining fraction of stationary source emissions.

Continued efforts to reduce air pollutant emissions from LANL have resulted in the identification of many additional emission sources. The number of emission sources included in the 1990 air emissions inventory more than doubled the number in the 1987 inventory. As a result, pollutant emissions appear to have increased between 1987 and 1990. In reality, efforts have been made to decrease usage, and ultimately emissions, of many selected solvents, ozone depleting substances (ODS), and chlorine gas throughout the Laboratory.

The following examples highlight LANL's waste minimization efforts. In 1992, 1,1,2-trichloroethane was eliminated as a cleaning solvent within the Field Test Division at the Nevada Test Site. LANL began recovering and reusing spent refrigerants, thereby decreasing the amount of ODS emitted. The use of oil-based paints has largely been replaced with the use of water-base paints, thus reducing the usage of kerosene at LANL. Finally, carbon dioxide gas was substituted for chlorine gas as a mechanism for neutralizing wastewater generated by the steam plant.

b. Lead Pouring Operations. Lead pouring operations were discontinued at the Laboratory in April 1991.

c. Steam Plants and Power Plant. Fuel consumption and emission estimates for the steam plants located throughout the Laboratory and at the TA-3 power plant are reported in Table VI-2. The plants are sources of particulate matter, nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon monoxide (CO), and hydrocarbons. The NO_x emissions from the TA-3 power plant were estimated based on measurements of boiler exhaust gas measurements. EPA emission factors were used in making the other emission estimates (EPA 1986a). The emissions from these plants are low, posing no threat of violating ambient air quality standards. The Western Area steam plant, used as a standby plant, was not operated during 1992.

d. Asphalt Plant. In addition to the power plant and steam plants at TA-3, Johnson Controls Inc. (JCI) operates an asphalt plant at TA-3. As part of its contract with the Laboratory, JCI provides annual records summarizing operations at the plant. The records presented in Table VI-3 show 1992 production figures and estimates of emissions. Asphalt production has decreased steadily since 1986 because most of the asphalt used at the Laboratory has been purchased from an outside vendor. Although it is not required to, the plant meets the New Source Performance Standards stack emission limits for asphalt plants.

e. Detonation and Burning of Explosives. The Laboratory conducts explosive testing by detonating explosives at firing sites operated by the Dynamic Testing Division. The Laboratory maintains monthly shot records, including the type of explosive and weight fired at each mound to track emissions from this activity. Emission rates

Table VI-2. Emissions and Fuel Consumption during 1992 from the Steam Plants and TA-3 Power Plant

Pollutant	TA-3	TA-16	TA-21	Western Area	Total
Emissions (ton/yr)					
Particulate matter	2.3	2.2	0.6	0.0	5.1
Nitrogen oxides	15.3	22.4	5.7	0.0	43.4
Carbon monoxide	18.4	5.6	1.4	0.0	25.4
Hydrocarbons	0.8	0.9	0.2	0.0	1.9
Sulfur oxides	0.5	0.2	0.1	0.0	0.8
Fuel Consumption (10^9 Btu/yr)	959	333	84	0	1,376

Table VI-3. Asphalt Plant Emissions in 1992

Production (ton/yr)	Particulate Matter (lb/yr)	SO_x (lb/yr)	NO_x (lb/yr)	CO (lb/yr)	Volatile Organic Carbons (lb/yr)	Formaldehyde (lb/yr)
3,723	679	370	134	142	104	0.6

from 1990 operations were included in the 1990 air pollutant emission inventory. Table VI-4 summarizes the explosives detonation conducted at the Laboratory during 1992. The Laboratory also burns scrap and waste explosives when burning proves to be the safest disposal option. In 1992, the Laboratory burned 19,906 lb of scrap and waste explosive.

f. Asbestos. During 1992, JCI removed approximately 2,450 lin ft of friable asbestos pipe insulation from small jobs covered by the annual notification to NMED. A total of 1,680 lin ft of friable asbestos material was removed through large jobs. Small job activity accounted for 401 sq ft of friable material removed, with 596 sq ft being removed during large jobs. A large amount of unregulated material, such as vinyl asbestos tile, transite board, siding, piping, and asphaltic roofing materials, totaling 6,534 sq ft were removed. Approximately 9,851 cu ft of dirt suspected of being contaminated with asbestos was removed from an area along East Jemez Road in the second quarter of 1992.

g. Beryllium. Beryllium machining operations are located in Shop 4 at TA-3-39, in Shop 13 at TA-3-102, the beryllium shop at TA-35-213, the beryllium processing facility at TA-3-141, and at TA-55-4. Exhaust air from these operations passes through air pollution control equipment before it exits from a stack. Source tests have demonstrated that all beryllium operations meet the emission limits established by National Emission Standards for Hazardous Air Pollutants and that emissions are so low that they are unmeasurable.

2. Water.

a. Surface Water and Groundwater Monitoring. Surface waters and groundwaters are sampled and analyzed to monitor dispersion of chemicals from Laboratory operations. Chemical concentrations in water from areas where there has been no direct release of treated effluents show no observable effects from Laboratory operations. The chemical quality of surface waters from areas with no effluent release varied with seasonal

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

Element	1992 Total Usage (kg)	Fraction Released (%)	Annual Average Concentration (μg/m3) (4 km)[a]	Annual Average Concentration (μg/m3) (8 km)[a]	Applicable Standard (μg/m^3)
Beryllium	2.3	2	$3.1 + 10^{-8}$	$1.3 + 10^{-8}$	0.01[b]
Lead	48.7	100[c]	$1.0 + 10^{-4}$	$2.1 + 10^{-8}$	1.5[d]
Heavy metals[e]	1,177.5	100[c]	$1.2 + 10^{-3}$	$5.0 + 10^{-4}$	10[b]

[a]Distance downwind.
[b]Standard for 30 day average, New Mexico AQCR 201.
[c]No data are available; estimate was done assuming worst-case percentage was released into the air.
[d]Standard for 3 month average (40 CFR 50.12).
[c]Although lead is a heavy metal, it is listed separately because there is an air standard applicable to lead.

fluctuations. The quality of water off-site and downstream from the release areas reflects some impact from Laboratory operations, but these waters are not a source of municipal or industrial water supply. Water in Los Alamos Canyon is used by livestock.

Groundwater resource management and protection at Los Alamos is focused on the main aquifer underlying the region (see Section II.C, Geology and Hydrology). Groundwater resource monitoring routinely documents conditions of the water supply wells and the main aquifer. The long and comprehensive record of data indicates that DOE operations at the Laboratory have not resulted in any contamination of the main aquifer.

b. National Pollutant Discharge Elimination System. The DOE and the University of California (UC) have two National Pollutant Discharge Elimination System (NPDES) permits. One permit covers the effluent discharges for 9 sanitary wastewater treatment facilities and 130 industrial outfalls at the Laboratory. A summary of these outfalls is presented in Table D-2. The other permit covers one industrial outfall at the hot dry rock geothermal facility located 50 km (30 mi) west at Fenton Hill. Both permits are issued and enforced by EPA Region 6 in Dallas, Texas. NMED performs some compliance evaluation inspections and monitoring for EPA through a Section 106 water quality grant.

The NPDES permit for the Laboratory expired on March 1, 1991 and is being continued under 40 CFR 122.6. Between March and September 1992, the EPA issued two different draft NPDES permits for public comment. During the comment periods for the draft permits, NMED informed EPA and LANL that the conditions for certification would require more stringent effluent limitations.

The final conditions of certification of the NPDES permit required effluent limits based on water quality standards applicable to the Rio Grande, rather than on water quality standards applicable to LANL's ephemeral receiving streams. Subsequently, in October 1992, UC and DOE petitioned the New Mexico Water Quality Control Commission (NMWQCC) to review NMED's conditional certification of the NPDES permit limits. A hearing date, for presenting arguments to the NMWQCC, was set for March 1993. In January 1993, NMED and LANL requested a delay of the hearing until April 20, 1993. Settlement negotiations took place during the first quarter of 1993 and resulted in a settlement agreement with NMED for the Laboratory to fund a study of the channels that receive the Laboratory's discharges in order to determine their correct use designations. NPDES permit effluent limits are based on the water quality standards for each use designation. The NMED has certified the EPA's draft permit; final approval from EPA is expected by fall 1993.

During 1992, effluent limits were exceeded in one of the 266 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded in 20 of the 2,028 samples collected from the industrial outfalls. As shown in Figure III-1, overall compliance for the sanitary and industrial discharges during 1992 was 99.6% and 99%, respectively. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1992.

The Environmental Protection Group (EM-8) continued the waste stream identification and characterization program during 1992 in order to verify that each waste stream is properly monitored under the outfall category for which it is permitted. These studies consist of dye testing; interviews with user groups; and coordination with other Laboratory organizations to determine sources, concentrations, and volumes of pollutants that enter waste streams, receive treatment, and are discharged to the environment. Field surveys for waste stream identification and characterization have been completed for approximately 70% of the Laboratory facilities.

TA-50 Liquid Waste Treatment Plant. In recent years, treated effluents from the liquid waste treatment plant at TA-50 have been subject to NPDES permit limits. Table VI-5 presents information on the quality of effluent from the plant during 1991 and 1992. The total effluent volume decreased in 1992; the constituent levels also generally decreased (see Section V.B.2 for information on radioactive constituents released from the plant). Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon where surface flow has not passed beyond the Laboratory's boundary since the plant began operation in 1963.

Table VI-5. Quality of Nonradioactive Effluent Released from the TA-50 Radioactive Liquid Waste Treatment Plant in 1991 and 1992

Nonradioactive Constituents	Mean Concentration (mg/L)	
	1991	1992
Cd[a]	$3.3 + 10^{-4}$	$1.1 + 10^{-2}$
Ca	290	187
Cl	82	59
Total Cr[a]	$4.0 + 10^{-3}$	$3.2 + 10^{-2}$
Cu[a]	0.2	$9.5 + 10^{-2}$
F	3.3	3
Hg[a]	$1.6 + 10^{-4}$	$1.8 + 10^{-3}$
Mg	0.2	0.2
Na	397	329
Pb[a]	$7.1 + 10^{-3}$	$3.5 + 10^{-2}$
Zn[a]	0.08	0.2
CN	0.2	0.1
COD[a]	29	18
NO_3-N	164	204
PO_4	0.9	0.2
TDS[b]	1,810	1,920
pH[a]	7.16|7.7	7.05|7.54
Total Effluent Volume	$2.19 + 10^{7}$ Liters	$1.99 + 10^{7}$ Liters

[a]Regulated by NPDES permit.
[b]Total dissolved solids.

c. Safe Drinking Water Act, Municipal and Industrial Water Supplies. This program includes sampling from various points in the Laboratory and county water distribution systems to ensure compliance with the Safe Drinking Water Act (SDWA) (40 CFR 141). DOE provides drinking water to Los Alamos County. EPA has established maximum contaminant levels (MCLs) for microbiological, organic, and inorganic constituents in drinking water. These standards have been adopted by the State of New Mexico and are included in the NM Water Supply Regulations (NMEIB 1991). NMED has been authorized by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

During 1992, all water samples collected under the SDWA program at Los Alamos were in compliance with the MCLs established by regulation. Summaries of the results are presented in Tables III-11, III-12, III-13, and III-14.

Each month during 1992, an average of 47 samples was collected from the Laboratory and county water distribution systems to determine the free residual chlorine available for disinfection and the microbiological quality of the distribution systems. During 1992, of the 563 samples analyzed, 3 indicated the presence of coliforms. Fifty-three of the microbiological samples (approximately 9%) collected were found to have some noncoliform bacteria present. Although the presence of noncoliform bacteria is not a violation of the SDWA, it does indicate biofilm growth in the distribution lines. Biofilm accumulation is controlled with a flushing and disinfection program. A summary of the analytical results is found in Table III-15.

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

Section 313 of the Emergency Planning and Community Right to Know Act exempts facilities not meeting certain Standard Industrial Classification (SIC) code criteria from reporting requirements. It is Laboratory policy that this exemption not be exercised and that the Laboratory will report its releases under the remaining provisions of Section 313. Executive Order 12856 requires DOE to report, without regard to the SIC exemption, beginning in FY94. However, all research operations at the Laboratory are also exempt under other provisions of the regulation and only pilot plants and specialty chemical production facilities at the Laboratory must report their releases. As a result, the Plutonium Processing Facility (TA-55) is the only facility at the Laboratory that is covered by Section 313, and nitric acid is the only regulated chemical that is used in amounts greater than the Section 313 reporting thresholds.

Reports of Section 313 chemicals must be submitted to EPA in July for the preceding calendar year's usage. The Laboratory submitted the required Section 313 report to EPA in August 1992. The delay in reporting was caused by the delay in EPA's release of new reporting forms. However, the EPA extended the deadline for reporting to September 1, 1992, in recognition of this delay. This report covered the releases of nitric acid during 1991.

About 19,051 kg (41,912 lb) of nitric acid were used for plutonium processing with releases to the air of approximately 146 kg (320 lb). The amount of nitric acid released to the atmosphere was calculated using data obtained from a study that measured the air emissions from the facility and approved engineering techniques. The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in the wastewater treatment operations. Only the air releases required reporting for 1991. Data on releases for CY92 will be reported under Section 313 in July 1993.

4. Toxic Substances Control Act.

The Toxic Substances Control Act (TSCA 15 U.S.C. 2601-2692) is administered by the EPA, which has authority to conduct premanufacture reviews of new chemicals prior to their introduction into the marketplace. TSCA requires the testing of chemicals that may present a significant risk to humans and the environment; requires record keeping and reporting requirements for new information regarding adverse health and environmental effects associated with chemicals; governs the manufacture, use, storage, handling, and disposal of polychlorinated biphenyl (PCB) equipment; and sets standards for PCB spill cleanups. Because the Laboratory's activities are in the realm of research and development, the PCB regulations (40 CFR 761) have been the Laboratory's main concern under TSCA. Substances that are governed by the PCB regulations include but are not limited to dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, paints, slurries, dredge spoils, soils, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to transformers and capacitors and to PCB concentrations above a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to items whose PCB concentrations are 50 ppm and above. At the Laboratory,

equipment and materials with PCB levels greater than 500 ppm PCBs are transported off site for treatment and disposal, and those containing 50 to 499 ppm are incinerated off site or disposed of at TA-54, Area G. Area G is approved by the EPA for disposal of PCB-contaminated materials.

Table III-4 summarizes the types of PCB-contaminated waste that were disposed of during 1992. Most of the waste sent off site was associated with the retrofilling or replacement of PCB-containing transformers. The Laboratory has been retrofilling, replacing, and dechlorinating PCB-containing transformers in order to reduce environmental contamination and regulatory risks. In 1992, retrofilling activities continued for 22 transformers (expected to be reclassified to non-PCB status in FY93), 17 PCB-containing transformers were dechlorinated, and 289 PCB-containing capacitors, previously loaned to universities, were recalled and disposed. Also, as part of the Laboratory's PCB risk reduction program, another comprehensive survey of all potential PCB-containing equipment at the Laboratory was initiated. Two similar surveys were conducted during the 1980s.

EPA Region 6 submitted requests for information on the Laboratory's Controlled Air Incinerator and the Area G landfill so that these facilities could continue to be used for PCB disposal activities. The requested information was provided to EPA. Also during 1992, DOE and EPA discussed the storage of PCB-containing waste that was also contaminated with radioactive constituents and thus cannot be disposed of within the one year storage limit required by PCB disposal regulations. DOE and EPA agreed to initiate negotiations on a Federal Facilities Compliance Agreement (FFCA) to allow this storage. EPA Region 6 conducted a one day inspection of the TSCA PCB program on March 17, 1992. No deficiencies were reported.

B. Unplanned Releases of Nonradiological Materials

1. Airborne Releases.

No unplanned airborne nonradiological releases were reported during 1992.

2. Liquid Releases.

During 1992, 41 releases of nonradioactive liquids occurred at the Laboratory and were reported to the EPA and 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 was minor in nature and was contained on Laboratory property; none was found to be of any threat to health or the environment. Sampling and cleanup were completed, as appropriate, to confirm the presence or absence of pollutants and to prevent their further migration. The following is a summary of these unplanned releases:

- 5 releases of potable water from water line breaks and other sources in the Los Alamos water supply system;
- 3 releases of steam originating from breaks in the condensate return line and other sources in the Laboratory's steam system;
- 21 releases of sanitary sewage (less than 1,000 gal. each) from the Laboratory's wastewater treatment plant collection systems;
- a discharge of hydraulic fluid (3 to 4 quarts) from a JCI street sweeper at TA-3, Building 2001, on February 11, 1992;
- a release of 80,000 gal. of treated sanitary effluent from the TA-3, Building 336 holding tank occurred on March 3, 1992;
- a discharge of 100 gal. of water with 2% degreaser solution at TA-60, Building 1, on April 9, 1992;
- 2 unplanned releases of diesel fuel: 5 gal. at TA-53, Building 214, on April 9, 1992 and 50 gal. at TA-69, Building 1, on August 28, 1992;
- a discharge of approximately 500 gal. of emergency shower water containing less than 2.5 gal. of chemical solvents (methanol, ethanol, toluene, and nitric acid mixture) at TA-59, Building 1, on April 21, 1992;
- a release of less than one gal. of Tru-Guard roof sealant occurred at TA-55, Buildings 3 and 5, on May 29, 1992;
- a release of an unknown amount of reclaimed oil from the excavation of an underground storage tank at TA-60, Building 1, on June 1, 1992;
- an unplanned release of 150 gal. of a water and ethylene glycol mixture at Pajarito Well #4, on June 18, 1992;
- soil erosion at solid waste management unit 3-010 at TA-3, SM-30, which had exposed buried mercury with a potential to impact a nearby arroyo was reported on August 25, 1992;
- a discharge of storm water containing residual oil leaked from the valve of a secondary containment structure at TA-35, Building 85, on September 17, 1992; and

- an accidental release of less than 20 gal. of gasoline from the fuel pump of a private vehicle in the parking lot of TA-3, SM-29, on November 23, 1992;

EM-8 prepared a generalized notice of intent (NOI) to discharge 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 was submitted to NMED on October 31, 1991. The 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 under the NPDES permit. EM-8 submitted a generalized NOI for the release of steam condensate from the Laboratory's steam distribution and condensate return systems on March 24, 1992. This NOI provides coverage for steam condensate releases from leaks, pipeline repairs and replacements, and other maintenance procedures. Additionally, a generalized NOI was submitted on March 27, 1992 for releases resulting from line disinfection.

C. Environmental Sampling for the Nonradioactive Program

1. Air.

The nonradiological monitoring network consists of 1 criteria pollutant station, 17 samplers where beryllium is monitored, 1 acid precipitation monitoring station, and 1 visibility monitoring station. Results of nonradiological monitoring are presented in Section IV.C.2.

2. Water.

The Laboratory maintains three separate programs for monitoring water quality: the surface and groundwater monitoring program, and the NPDES and SDWA compliance sampling programs.

The first program involves sampling of water supply wells and special monitoring wells under the long-term environmental surveillance program. The samples are collected by EM-8 personnel and are analyzed by the Environmental Chemistry Group (EM-9). Routine chemical analyses of water samples have been carried out for many constituents over a number of years. Although surface water and shallow groundwater are not sources of municipal or industrial water supplies, results of these analyses are compared with NMED and EPA drinking water standards (maximum concentration levels). The chemical quality of surface waters is compared to NM Livestock and Wildlife Watering Standards. The results of these programs are reported for nonradioactive constituents in Sections IV.D and VII of this report. Detailed descriptions of procedures for sampling surface water and groundwater are presented in Section VIII.C.3.

Under the Laboratory's existing NPDES permit, samples are collected on a weekly basis and analyzed for the chemicals listed in the permit. Results are reported each month to EPA and NMED. See Section VIII.C.3 for more information on the NPDES compliance sampling program.

Samples collected by the Laboratory to ensure compliance with SDWA standards are analyzed for organic, inorganic, and radioactive constituents at the NM Health Department's Scientific Laboratory Division (SLD) in Albuquerque. SLD reports the analytical results directly to NMED. The JCI Environmental (JENV) laboratory also collects samples from the Laboratory and county water distribution systems and tests them for microbiological contamination, as required by the SDWA. JENV is certified by SLD for microbiological testing of drinking water. See Section VIII.C.3 for more information on the sampling program.

VII. GROUNDWATER PROTECTION MANAGEMENT PROGRAM

Efforts to monitor and protect groundwater quality in the Los Alamos area began in 1949. The long and comprehensive record of data indicates that Department of Energy (DOE) operations at Los Alamos National Laboratory (LANL or the Laboratory) have not resulted in any measurable contamination of the main aquifer. 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 days of the post-World War II Manhattan Engineer District when the Atomic Energy Commission (AEC) needed to develop a reliable water supply. The US Geological Survey (USGS) was extensively involved in overseeing and conducting various studies for development of groundwater supplies beginning in 1945 and 1946. Studies specifically aimed at protecting and monitoring groundwater quality were initiated as joint efforts between the AEC, the Los Alamos Scientific Laboratory, and the USGS in about 1949.

The long and comprehensive record of data through 1992 indicates that DOE operations at the Laboratory have not resulted in any measurable contamination of the main aquifer except at one location in Pueblo Canyon. The development and production of the water supply have not resulted in any significant depletion of the resource as there is no widespread major decline of the piezometric surface of the aquifer. 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. Several hundred reports and articles document studies and data germane to groundwater and the environmental setting of Los Alamos (Bennett 1990).

Groundwater resource monitoring routinely documents conditions of the water supply wells and the hydrologic conditions of the main aquifer as part of the overall Groundwater Protection Management Program. This information is documented in a series of annual reports providing detailed records of pumping and water level measurements. The most recent report in this series is entitled "Water Supply at Los Alamos during 1990" (Purtymun 1993).

The groundwater quality monitoring described in this report reflects the current status of the program that was initiated by the USGS for the AEC in 1949. Groundwater quality monitoring addresses the main aquifer at Los Alamos; shallow alluvial groundwaters in canyons; the intermediate depth perched systems in the basalt and the Puye conglomerate beneath parts of Pueblo, Los Alamos, and Sandia canyons; and special studies on the vadose zone. See Section II.C for a general description of hydrogeological relationships.

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 (PDLs) (see Section V.C.2). Concentrations of radioactivity in samples of water from the water supply wells completed in the Los Alamos main aquifer are also compared to New Mexico Environment Department (NMED) 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 NMED 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. Although it is not a source of municipal or industrial water, the shallow alluvial groundwaters that result in return flow to surface water and springs used by livestock and wildlife and may be compared to the Livestock and Wildlife Watering Standards established by the New Mexico Water Quality Control Commission (NMWQCC 1991).

B. Monitoring Network

There are three principal groups of groundwater sampling locations: main aquifer, alluvial perched groundwater in the canyons, and the localized intermediate depth perched groundwater systems. The sampling locations are shown in Figure VII-1 and referenced by map number in Table D-19.
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.I.4.

1. Main Aquifer.

Sampling locations for the main aquifer include test wells, supply wells, and springs. Seven deep test wells, completed into the main aquifer, are routinely sampled. One of the test wells is off site; the other six are within the Laboratory boundary. The 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 1992 was 242 m (792 ft). Test Well 1, drilled in 1950, is in the lower reach of Pueblo Canyon, near the boundary with San Ildefonso Pueblo. Depth to water in 1992 was 164 m (537 ft). 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 1992 was 237 m (778 ft).

Test Well 8, drilled in 1960, is in the middle reach of Mortandad Canyon. Depth to water in 1992 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 1992 were 361 m (1,183 ft) at DT-5A, 310 m (1,015 ft) at DT-9, and 335 m (1,097 ft) at DT-10. No perched water between the surface of the mesa and the top of the main aquifer was observed when the wells were drilled.

Samples were collected from 10 deep wells in 3 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 east of the Laboratory, and the on-site Pajarito field.

The Los Alamos Well Field, located on San Ildefonso Pueblo 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 have been turned over to San Ildefonso Pueblo: LA-1B (to be used cooperatively with the Bureau of Indian Affairs [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) will be plugged in 1993 in accordance with NM State Engineer Office regulations. Wells in the field originally ranged in depth from 265 m to 610 m (869 ft to 2,001 ft). Movement of water in the upper 411 m (1,348 ft) of the main aquifer in this area is eastward at about 6 m/yr (20 ft/yr) (Purtymun 1984).

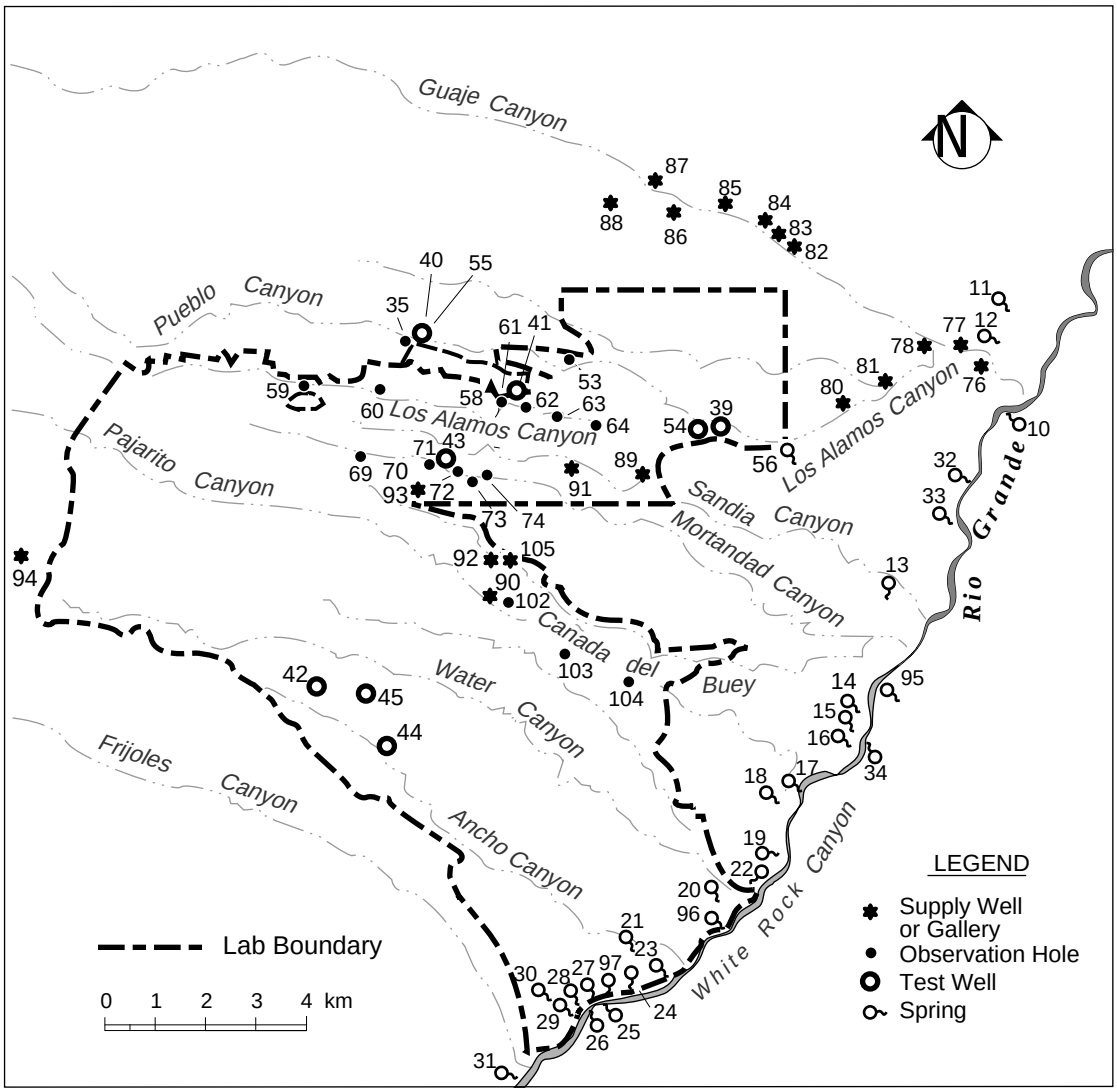


Figure VII-1. Off-site perimeter and on-site Laboratory groundwater sampling locations. (Specific locations are presented in Table D-19 and can be reviewed on the FIMAD system at the Community Reading Room.)

The Guaje Well Field is located in Guaje Canyon northeast of the Laboratory on US Forest Service lands. The Guaje Well Field contains seven wells, six of which produced during 1992. 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. No production from these wells occurred during 1992; Otowi-4 was equipped with a pump and tested in anticipation of being connected to the distribution system during 1993.

Additional samples were taken from seven other wells located in the Santa Fe Group of sedimentary deposits. These wells were sampled as part of the special sampling on San Ildefonso Pueblo. See Section IV.I.5 for information on the Memorandum of Understanding between DOE, the BIA, and San Ildefonso Pueblo.

Numerous springs near the Rio Grande were sampled because they are representative of natural discharge from the main aquifer (Purtymun 1980b). See Section II.C. for information on discharge into the Rio Grande. In White Rock Canyon four groups of springs discharge from the main aquifer. Three groups (I, II, and III) have similar, aquifer-related chemical quality. Chemical quality of springs in Group IV reflect local conditions in the aquifer, which are probably related to waters discharging through faults in volcanics. Indian and Sacred springs are west of the river in lower Los Alamos Canyon. These two springs discharge from faults in the siltstones and sandstones of the Tesuque Formation.

2. Perched Groundwater in Canyon Alluvium.

The alluvial perched groundwaters in four canyons were sampled by means of shallow observation wells as part of the routine monitoring program. Three of these canyons are radioactive effluent release areas: Pueblo, Los Alamos, and Mortandad canyons. The fourth is Pajarito Canyon, immediately south of the existing solid waste management areas at TA-54 on Mesita del Buey. All of these alluvial perched groundwater sampling locations are on site.

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 run-off, and sanitary effluents. One sampling point, Hamilton Bend Spring, which in the past discharged from alluvium in the lower reach of Pueblo Canyon, has been dry since 1990, probably because there was no discharge from the older, almost abandoned Los Alamos County Pueblo sewage treatment plant. Further east, at the location of Well APCO-1, the alluvium is continuously saturated, mainly because of infiltration of effluent from the Los Alamos County Bayo sanitary sewage treatment plant. At APCO-1, the alluvium is about 3.4 m (11 ft) thick and depth to water is about 1.8 m (6 ft).

The on-site reach of Los Alamos Canyon presently carries flow from the Los Alamos Reservoir to the west of the Laboratory, as well as National Pollutant Discharge Elimination System (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. See Section IV.D for more information on historic releases. Infiltration of NPDES-permitted effluents and natural run-off 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 run-off and in late summer from thundershowers. Water levels decline during the winter and early summer when storm run-off is at a minimum. Sampling stations consist of six 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 1.5 m to 3 m (5 to 10 ft).

Alluvial perched groundwater also occurs in the lower portion of Los Alamos Canyon on San Ildefonso Pueblo lands. This alluvium is not continuous with the alluvium within the Laboratory. During 1992 this groundwater was sampled at Totavi utilizing one of the wells installed by the BIA to investigate an underground gasoline storage tank at the site of an abandoned commercial gas station.

Mortandad Canyon has a small drainage area that also 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. See Section IV.D for more information. 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 location. The easternmost extent of saturation is on site, about 1.6 km (1 mi) west of the Laboratory boundary with San Ildefonso Pueblo. 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 depending on the amount of run-off 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). 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 run-off, 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.

One new alluvial monitoring well, installed in a limited body of perched groundwater in the upper reach of Cañada del Buey, was added to the routine monitoring locations in 1992. See Section IV.E.2 for additional details.

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 32 m (105 ft) in 1992.

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 58 m (190 ft) in 1992. Perched water in the basaltic rocks is also sampled from Basalt Spring, which is off site in lower Los Alamos Canyon on San Ildefonso Pueblo. Measurements of water levels and chemical quality over a period of time indicate that the perched groundwater is hydrologically connected to the stream in Pueblo Canyon. Perched water in similar stratigraphy was observed during the drilling of water supply wells Otowi-4 in Los Alamos Canyon (depth about 61 to 76 m [200 to 250 ft]), Otowi-1 in Pueblo Canyon (depth about 69 to 76 m [225 to 250 ft]), and PM-1 in Sandia Canyon (depth about 137 m [450 ft]).

Some recharge to the perched groundwater in the basalt occurs near Hamilton Bend Spring. The time for water from the recharge area near Hamilton Bend Spring to reach Test Well 1A is estimated to be 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 (Armistead 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 0.12 million gal. in 1992.

4. Vadose Zone.

The occurrence and movement of water in unsaturated conditions has been studied in numerous locations within the Laboratory starting with special USGS studies in the 1950s (Purtymun 1990c). Knowledge of vadose zone processes is relevant to understanding the potential for downward movement of water that could constitute recharge to the main aquifer and provide a mechanism for downward migration of contaminants.

In general, the vadose zone studies show that there is consistently low moisture content (less than 10% by volume) 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 aquifers are presumed to have a greater potential for downward water movement because there is a constant driving force. Since the mid-1980s several investigations have been performed under various Resource Conservation and Recovery Act compliance requirements that 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 1990c).

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. One of them, completed as a monitoring well, was 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. This study is summarized in Section VII.E.2.

C. Analytical Results

1. Radiochemical Constituents.

The results of radiochemical analyses of groundwater samples for 1992 are listed in Table VII-1. Discussion of the results will address first the main aquifer and second, the canyon alluvial groundwaters.

For samples from wells or springs in the main aquifer, all results for ^{3}H, ^{90}Sr, uranium, ^{238}Pu, $^{239,240}Pu$, and gross beta were below the DOE DCGs or the New Mexico standards applicable to a DOE drinking water system. 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 above (generally less than a factor of two) 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 (often 50% or more of the value) at the low levels near average detection limits, and, in the case of springs, the fact that such samples often must be collected in contact with surface rocks or channel sediments, none of the findings are interpreted to represent any indication of contamination in the main aquifer. One gross alpha analysis, for Spring 3B, is above the limit that would be applicable to a drinking water distribution system. The water from that spring has always contained a relatively high concentration of natural uranium.

Table VII-1. Radiochemical Analyses of Groundwater Samples for 1992

Location	Gross ^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	^{241}Am (pCi/L)	Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
MAIN AQUIFER ON SITE										
Test Wells										
Test Well 1	1.1(0.3)[a]	0.2(1.0)	1.1(1.3)	2.7(0.3)	0.005(0.030)	0.013(0.020)	0.000(0.030)	2(1)	6(1)	160(100)
Test Well 3	N/A[b]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Well 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Well DT-5A	0.3(0.3)	N/A	1.6(1.1)	0.2(0.1)	0.005[c](0.030)	0.005(0.020)	N/A	1(0)	2(0)	40(100)
Test Well DT-9	0.2(0.3)	N/A	1.3(1.2)	<1.0(0.0)	0.004(0.030)	0.017(0.020)	0.008(0.030)	1(1)	9(1)	160(100)
Test Well DT-10	0.1(0.3)	N/A	1.5(1.1)	<1.0(0.0)	0.005(0.030)	0.005(0.020)	0.013(0.030)	1(1)	3(0)	170(100)
Water Supply Wells										
Pajarito Well Field										
Well PM-1	0.3(0.3)	N/A	0.6(0.9)	1.2(0.6)	0.000(0.010)	0.011(0.010)	0.040(0.013)	1(1)	6(1)	10(90)
Well PM-2	0.2(0.3)	N/A	0.6(1.0)	<0.6(0.0)	0.008(0.010)	0.008(0.010)	0.020(0.010)	0(1)	2(0)	50(90)
Well PM-3	0.4(0.3)	N/A	0.1(0.9)	0.6(0.6)	0.018(0.013)	0.009(0.009)	0.015(0.014)	1(1)	8(1)	0(90)
Well PM-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Well PM-5	0.2(0.3)	N/A	0.3(1.0)	<0.6(0.0)	0.010(0.012)	0.060(0.019)	0.028(0.015)	0(1)	3(1)	10(90)
MAIN AQUIFER OFF SITE										
Test Wells										
Test Well 2	0.3(0.3)	0.7(0.8)	0.7(1.1)	<0.2(0.0)	0.000(0.010)	0.005(0.012)	0.020(0.030)	0(0)	3(1)	40(100)
Water Supply Wells										
Guaje Well Field										
Well G-1	0.4(0.3)	N/A	0.7(1.0)	<0.6(0.0)	0.014(0.016)	0.024(0.013)	0.026(0.016)	1(1)	4(1)	90(90)
Well G-1A	0.6(0.3)	N/A	1.2(1.0)	<0.6(0.0)	0.016(0.009)	0.011(0.013)	0.035(0.014)	2(1)	4(1)	0(90)
Well G-2	0.4(0.3)	N/A	0.9(1.1)	<0.6(0.0)	0.000(0.010)	0.011(0.008)	0.021(0.013)	0(1)	4(1)	0(90)
Well G-4	0.4(0.3)	N/A	1.1(1.0)	<0.6(0.0)	0.004(0.012)	0.029(0.015)	0.019(0.014)	1(1)	9(1)	0(90)
Well G-5	0.3(0.3)	N/A	2.9(1.2)	<0.6(0.0)	0.021(0.017)	0.025(0.013)	0.049(0.018)	3(1)	3(1)	30(90)
Well G-6	0.5(0.3)	N/A	0.7(1.0)	<0.6(0.0)	0.004(0.009)	0.016(0.013)	0.030(0.016)	0(1)	4(1)	60(90)

Table VII-1. (Cont.)

Location	Gross ^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	^{241}Am (pCi/L)	Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
MAIN AQUIFER SPRINGS										
White Rock Canyon Springs (Perimeter and Off Site)										
Group I										
Sandia Spring	0.3(0.3)	0.1(1.5)	1.3(1.2)	1.1(0.2)	0.021(0.013)	0.016(0.012)	0.020(0.030)	3(1)	4(1)	40(90)
Spring 3	0.5(0.3)	0.2(1.5)	21.6(85.8)	2.7(0.3)	0.000(0.010)	0.005(0.010)	0.034(0.030)	0(1)	5(1)	60(90)
Spring 3A	0.3(0.3)	0.1(1.5)	0.8(1.2)	1.6(0.2)	0.037(0.018)	0.037(0.015)	0.039(0.030)	4(1)	4(1)	100(90)
Spring 3AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 4	0.5(0.3)	0.1(1.5)	3.5(1.3)	1.3(0.2)	0.024(0.014)	0.024(0.013)	0.039(0.030)	0(1)	3(1)	140(90)
Spring 4A	0.4(0.3)	0.1(1.5)	0.4(1.1)	0.8(0.2)	0.015(0.021)	0.023(0.017)	0.026(0.030)	1(1)	4(1)	100(90)
Spring 5	0.3(0.3)	0.1(1.5)	2.7(1.3)	0.6(0.2)	0.015(0.011)	0.015(0.015)	0.014(0.030)	0(1)	4(1)	40(90)
Spring 5AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Spring	0.4(0.3)	0.4(1.5)	0.5(1.2)	<0.2(0.0)	0.025(0.020)	0.000(0.010)	0.034(0.030)	0(1)	3(1)	70(90)
Group II										
Spring 5A	0.2(0.3)	0.7(1.5)	0.8(1.2)	2.5(0.3)	0.030(0.032)	0.054(0.040)	0.015(0.030)	1(1)	4(1)	10(90)
Spring 5B	1.1(0.3)	0.4(1.5)	2.3(1.3)	2.0(0.2)	0.006(0.010)	0.012(0.012)	0.062(0.030)	0(1)	4(1)	60(90)
Spring 6	0.5(0.3)	0.0(1.5)	3.3(1.3)	0.2(0.2)	0.015(0.018)	0.005(0.011)	0.052(0.030)	0(1)	2(0)	10(90)
Spring 6A	0.5(0.3)	0.1(1.5)	2.4(1.2)	<0.2(0.0)	0.009(0.014)	0.048(0.018)	0.024(0.030)	1(1)	3(0)	50(90)
Spring 7	0.2(0.3)	0.4(1.5)	1.4(1.2)	0.6(0.2)	0.016(0.009)	0.005(0.009)	0.034(0.030)	1(1)	4(1)	80(90)
Spring 8	0.3(0.3)	0.4(1.5)	4.2(1.3)	1.7(0.2)	0.033(0.016)	0.033(0.016)	0.019(0.030)	2(1)	5(1)	140(90)
Spring 8A	0.5(0.3)	0.5(1.5)	1.8(1.2)	1.0(0.2)	0.011(0.013)	0.038(0.016)	0.022(0.030)	0(1)	3(1)	170(90)
Spring 8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 9	0.2(0.3)	0.5(1.5)	3.8(1.4)	1.7(0.2)	0.005(0.028)	0.062(0.036)	0.048(0.030)	0(1)	5(1)	30(90)
Spring 9A	0.3(0.3)	0.4(1.5)	0.7(1.1)	0.6(0.2)	0.024(0.018)	0.019(0.010)	0.025(0.030)	1(1)	4(1)	90(90)
Doe Spring	0.3(0.3)	0.4(1.5)	2.7(1.3)	1.2(0.2)	0.006(0.006)	0.011(0.011)	0.000(0.030)	2(1)	5(1)	170(90)
Spring 10	0.0(0.3)	0.4(1.5)	3.6(1.3)	3.0(0.3)	0.005(0.016)	0.026(0.012)	0.025(0.030)	2(2)	15(2)	200(90)

Table VII-1. (Cont.)

Location	Gross ^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	^{241}Am (pCi/L)	Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
Group III										
Spring 1	0.3(0.3)	0.7(1.5)	1.6(1.2)	2.9(0.3)	0.012(0.015)	0.004(0.007)	0.070(0.030)	2(1)	4(1)	120(90)
Spring 2	0.4(0.3)	0.3(1.5)	2.3(1.3)	2.7(0.3)	0.019(0.021)	0.032(0.014)	0.020(0.030)	2(1)	6(1)	70(90)
Group IV										
La Mesita	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 3B	0.3(0.3)	0.1(1.5)	2.8(1.3)	17.4(1.7)	0.080(0.019)	0.020(0.011)	0.010(0.030)	16(4)	10(1)	10(90)
Other Off-Site Springs										
Sacred Spring	0.4(0.3)	N/A	3.3(1.3)	1.0(0.6)	0.004(0.009)	0.021(0.009)	N/A	1(1)	5(1)	120(90)
Indian Spring	0.4(0.3)	N/A	3.1(1.2)	1.1(0.6)	0.008(0.008)	0.013(0.010)	N/A	2(1)	9(1)	150(90)
ALLUVIAL CANYON AQUIFERS										
Radioactive Effluent Release Areas										
DP-Los Alamos Canyon										
LAO-C	0.4(0.3)	0.0(1.0)	3.5(1.2)	3.2(0.3)	0.009(0.030)	0.028(0.020)	0.013(0.017)	1(1)	4(1)	10(100)
LAO-1	9.3(0.9)	11.8(1.1)	2.3(1.2)	1.1(0.3)	0.009(0.030)	0.009(0.020)	0.042(0.017)	2(1)	25(3)	160(100)
LAO-2	1.2(0.3)	23.2(1.6)	3.1(1.2)	0.9(0.3)	0.013(0.030)	0.073(0.020)	0.016(0.014)	1(1)	45(5)	900(100)
LAO-3	1.0(0.3)	49.9(3.3)	2.6(1.1)	1.3(0.3)	0.013(0.030)	0.037(0.020)	0.067(0.020)	1(1)	86(9)	600(100)
LAO-4	1.6(0.4)	5.4(1.0)	0.6(0.5)	1.6(0.3)	0.006(0.030)	0.018(0.020)	0.015(0.013)	1(1)	17(2)	200(100)
LAO-4.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad Canyon										
MCO-3	54.5(2.3)	18.5(1.3)	3.9(1.5)	2.5(0.3)	0.195(0.032)	0.294(0.039)	1.620(0.097)	5(2)	300(30)	140(100)
MCO-4	103.7(3.3)	132.4(8.8)	31.6(5.1)	3.8(0.4)	1.420(0.096)	4.560(0.219)	21.700(0.775)	18(5)	260(30)	140(100)
MCO-5	85.8(3.0)	35.2(2.4)	3.3(1.4)	2.1(0.2)	0.133(0.030)	0.219(0.040)	0.559(0.050)	10(3)	110(10)	190(100)
MCO-6.0	111.2(3.5)	17.4(1.2)	1.5(1.2)	2.2(0.2)	0.036(0.030)	0.058(0.020)	0.134(0.030)	4(2)	76(8)	40(100)
MCO-7	62.7(2.5)	0.0(0.7)	1.6(1.3)	0.4(0.2)	0.026(0.030)	0.021(0.020)	0.183(0.030)	3(1)	26(3)	40(100)
MCO-7.5	62.3(2.5)	0.1(0.8)	2.5(1.2)	1.5(0.2)	0.032(0.030)	0.055(0.020)	0.260(0.035)	4(2)	24(2)	140(100)

Table VII-1. (Cont.)

Location	Gross ^{3}H (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	^{241}Am (pCi/L)	Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
Other Areas										
Pajarito Canyon										
PCO-1	0.3(0.3)	1.3(0.9)	2.0(1.1)	<0.2(0.0)	0.019(0.030)	0.010(0.020)	0.022(0.030)	1(1)	4(1)	20(100)
PCO-2	0.5(0.3)	0.6(1.1)	1.8(1.3)	<0.2(0.0)	0.016(0.030)	0.010(0.020)	0.020(0.030)	1(0)	4(1)	140(100)
PCO-3	0.2(0.3)	1.7(1.0)	3.4(1.2)	<0.2(0.0)	0.004(0.030)	0.027(0.020)	0.046(0.030)	0(0)	3(0)	40(100)
Other Areas										
APCO-1	0.2(0.3)	1.5(1.0)	2.0(0.9)	1.8(0.2)	0.000(0.030)	0.119(0.027)	0.064(0.020)	6(2)	15(2)	100(100)
CDBO-6	0.9(0.3)	N/A	2.1(1.3)	<0.4(0.0)	0.000(0.030)	0.013(0.020)	0.018(0.030)	8(2)	22(2)	400(100)
PERCHED SYSTEM CONGLOMERATES AND BASALT										
(Pueblo/Los Alamos/Sandia Canyon Area)										
Test Well 1A	0.5(0.3)	0.6(0.9)	1.2(1.2)	0.3(0.2)	0.000(0.030)	0.043(0.023)	N/A	2(1)	6(1)	110(100)
Test Well 2A	2.9(0.5)	0.0(0.9)	3.0(1.3)	0.4(0.2)	0.019(0.030)	1.280(0.091)	0.011(0.030)	2(1)	7(1)	110(100)
Basalt Spring	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PERCHED AQUIFER IN VOLCANICS										
Water Canyon										
Gallery	0.2(0.3)	N/A	0.2(1.0)	<0.6(0.0)	0.009(0.016)	0.009(0.009)	0.030(0.015)	1(1)	3(1)	100(90)
Limits of Detection[d]	0.4	3	40	1	0.02	0.02	3	3	50	
DCG for Public Dose[e]	2000	1000	3000	800	40	60				
Drinking Water System	20[f]	8[g]	120[g]	30[g]	1.6[g]	1.2[g]	15[f]	50[f]		

[a]Radioactivity counting uncertainties (1 Standard Deviation) are shown in parentheses.
[b]N/A means analysis not performed, lost in analysis, or not completed.
[c]See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[d]Limit of valid quantification based on radioactivity counting statistics for analytical method.
[e]DOE DCGs to meet the Public Dose Limit applicable to water ingested, see Appendix A.
[f]MCL, See Appendix A; (NMEIB 1991 and EPA 1989b).
[g]DOE DCG applicable to DOE Drinking Water System, see Appendix A.
NOTE: See Table IV-45 for radiochemical quality of groundwater from wells on San Ildefonso Pueblo Lands.

All ^{137}Cs measurements of samples from wells and springs from the main aquifer for 1992 are less than 5% 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. These questions were raised because the previously used analytical method had a detection limit that was relatively high in comparison with the relevant guidelines or standards and also higher than typical environmental levels. A new method was implemented during 1992 by the Environmental Chemistry Group (See Section VIII.D.2.b), which has a much lower detection limit (about 2pCi/L).

Tritium measurements of samples from main aquifer wells and springs were near or below the detection limit for the standard liquid scintillation analytical method. These results are consistent with additional special tritium measurements made as part of a special study utilizing very low detection limit measurements of tritium to estimate the age of water in the main aquifer (see Section VII.E.1). In the case of the water supply wells in the Guaje Field and the four wells in the Pajarito Field sampled in August 1992, no measurable tritium was found even with the special method. Low detection limit measurements on six of the springs also confirm that their tritium levels are far below the detection limit of the normal liquid scintillation analysis.

Test Well 1 showed a slightly above detection limit value from the liquid scintillation analysis. The special low detection limit method applied to a sample collected in October 1992 gave a result of about 360 pCi/L. This is distinctly above any of the other special low detection limit measurements of samples from the main aquifer and probably indicates the presence of relatively recent water from the surface. Tritium has been present at elevated levels in the surface and alluvial water in Pueblo Canyon for many years and is related to discharges into Acid Canyon during the early years of the Laboratory. This adds further evidence to the suspicion of some type of downward movement to the main aquifer in the vicinity of Test Well 1. This problem was discussed in the previous environmental surveillance report for CY91 (EPG 1993). That study of water level and chemical quality measurements was inconclusive in determining whether the movement might be along the wellbore. Additional work will be required to determine the pathway.

The other four main aquifer test wells that were sampled in 1992 did not show any indication of tritium in the main aquifer. One sample from Test Well 2 taken in October 1992 and one sample from DT-5A collected in 1991 showed no detectable tritium by the special low detection limit method.

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.

None of the 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 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 radioactivity measurements in samples from Test Wells 1A and 2A in the intermediate depth perched zones in Pueblo Canyon indicated 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 2.9 nCi/L; this was confirmed by the low detection limit measurement, which was about 2.3 nCi/L (see Section VII.E.1). Test Well 2A also showed a possible trace of ^{137}Cs (slightly above the detection limit) and $^{239,240}Pu$ at about 1.3 pCi/L. Test Well 1A showed about 135 pCi/L of tritium by the low detection limit method (see Section VII.E.1).

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 1992 are listed in Table VII-2. The results of metal analyses of groundwater samples for 1992 are listed in Table VII-3. The results are consistent with values observed in previous years, showing some expected variability.

Table VII-2. Chemical Quality of Groundwaters (mg/L[a])

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO^4-P	SO_4	NO_3-N	Cu	TDS[b]	Total Hardness	pH[c]	Conductivity (µmho/cm)
MAIN AQUIFER ON SITE																	
Test Wells																	
Test Well 1	56	49	9.7	4	16	30	0.4	3	97	N/A[d]	22	6.45	N/A	290	164	8.1	410
Test Well 3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Well 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Well DT-5A	73	9	2.3	2	11	2	0.4	<5[e]	51	N/A	3	0.33	N/A	128	31	7.6	81
Test Well DT-9	78	20	5.4	2	22	3	0.6	<5	51	N/A	3	0.28	N/A	114	72	7.9	76
Test Well DT-10	45	10	3.0	1	9	3	0.5	<5	66	N/A	3	0.19	N/A	92	37	8.2	97
Water Supply Wells																	
Pajarito Well Field																	
Well PM-1	87	27	6.4	4	21	6	0.2	<5	110	<0.0	5	0.47	<0.01	212	94	7.9	247
Well PM-2	88	10	2.9	2	11	2	0.2	<5	47	0.0	3	0.34	<0.01	144	36	7.9	12
Well PM-3	96	26	8.1	4	20	7	0.3	<5	152	0.0	6	0.45	<0.01	232	97	7.7	241
Well PM-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Well PM-5	92	13	4.7	2	14	3	0.3	<5	74	0.1	3	0.30	<0.01	170	51	7.5	124
MAIN AQUIFER OFF SITE																	
Test Wells																	
Test Well 2	59	12	3.0	1	13	3	0.5	<1	59	N/A	3	0.17	N/A	114	41	8.2	103
Water Supply Wells																	
Guaje Well Field																	
Well G-1	87	13	0.5	3	30	3	0.7	<5	77	0.0	5	0.45	<0.01	188	34	8.2	164
Well G-1A	78	5	0.2	1	18	4	0.7	<5	85	0.0	5	0.43	<0.01	182	13	8.4	168
Well G-2	78	11	0.5	3	39	3	0.8	<5	95	0.0	4	0.42	<0.01	204	29	8.3	186
Well G-4	67	19	3.7	2	13	3	0.3	<5	73	0.0	4	0.60	<0.01	176	62	8.2	147
Well G-5	66	18	3.9	2	13	3	0.3	<5	72	<0.0	4	0.62	<0.01	162	62	8.2	146
Well G-6	58	14	2.0	2	19	3	0.3	<5	69	0.0	4	0.42	<0.01	144	45	8.3	139
MAIN AQUIFER SPRINGS																	
White Rock Canyon Springs (Perimeter and Off Site)																	
Group I																	
Sandia Spring	50	44	3.2	3	17	4	0.5	<1	126	0.0	5	0.46	N/A	206	124	8.5	225
Spring 3	54	24	1.8	3	16	4	0.5	2	81	0.0	5	0.84	N/A	218	67	8.3	160

Table VII-2. (Cont.)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO^4-P	SO_4	NO_3-N	Cu	TDS[b]	Total Hardness	pH[c]	Conductivity (µmho/cm)
Group I (Cont.)																	
Spring 3A	54	22	1.8	3	15	4	0.4	<1	81	0.1	5	0.68	N/A	226	63	7.8	160
Spring 3AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 4	57	24	4.4	3	14	7	0.5	<1	79	<0.0	10	<0.04	N/A	200	79	7.9	193
Spring 4A	73	21	4.5	2	13	5	0.4	<1	74	<0.0	7	0.89	N/A	156	72	8.2	165
Spring 5	73	20	4.7	2	13	5	0.4	17	69	<0.0	5	1.21	N/A	76	68	8.9	154
Spring 5AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Spring	80	14	3.0	2	11	3	0.4	<1	55	0.0	3	0.62	N/A	60	46	8.1	96
Group II																	
Spring 5A	62	18	2.0	3	15	8	0.4	<1	91	0.0	8	0.58	N/A	220	52	8.2	204
Spring 5B	66	22	4.8	2	14	5	0.4	2	71	<0.0	8	7.14	N/A	712	75	8.2	160
Spring 6	77	18	3.5	2	12	3	0.4	<1	69	0.1	4	0.21	N/A	130	60	7.3	136
Spring 6A	80	11	2.7	2	11	3	0.3	<1	48	0.0	3	0.32	N/A	32	38	8.0	85
Spring 7	81	15	3.2	3	14	3	0.3	<1	64	0.1	5	0.51	N/A	178	50	7.8	85
Spring 8	78	24	4.4	3	23	4	0.4	<1	92	0.1	9	0.07	N/A	224	79	8.1	196
Spring 8A	87	14	3.4	3	13	33	0.4	<1	61	0.1	33	<0.04	N/A	200	48	8.0	91
Spring 8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 9	88	22	5.2	2	15	3	0.6	<1	95	0.0	3	0.17	N/A	204	76	7.7	157
Spring 9A	76	12	3.3	1	12	3	0.5	<1	59	0.0	3	<0.04	N/A	222	45	7.9	87
Doe Spring	77	12	3.2	2	12	3	0.5	<1	59	0.0	2	<0.04	N/A	174	44	7.7	105
Group III																	
Spring 1	34	17	1.0	2	32	4	0.6	<1	92	<2.0	7	0.45	N/A	448	47	8.0	194
Spring 2	37	21	1.2	2	55	4	1.2	<1	139	0.0	7	<0.04	N/A	236	56	8.0	240
Group IV																	
La Mesita	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 3B	50	23	2.5	5	139	4	0.7	<1	339	0.2	22	1.39	N/A	536	68	8.1	647
Other Off-Site Springs																	
Sacred Spring	25	67	1.2	8	70	3	0.6	<5	94	0.1	6	4.25	<0.01	162	173	7.1	184
Indian Spring	55	37	3.0	4	25	17	0.6	<5	93	0.1	14	0.42	<0.01	224	106	7.2	237

Table VII-2. (Cont.)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO^4-P	SO_4	NO_3-N	Cu	TDS[b]	Total Hardness	pH[c]	Conductivity (µmho/cm)
ALLUVIAL CANYON AQUIFERS																	
Radioactive Effluent Release Areas																	
DP-Los Alamos Canyon																	
LAO-C	43	12	2.7	3	27	22	0.3	<1	52	N/A	5	0.13	N/A	114	40	7.3	177
LAO-1	50	14	2.7	3	34	29	0.4	<1	62	N/A	6	0.05	N/A	170	46	7.0	235
LAO-2	67	18	4.9	7	36	24	0.8	<1	90	N/A	10	0.75	N/A	232	66	7.1	291
LAO-3	62	19	3.8	9	35	21	1.0	<1	91	N/A	8	0.30	N/A	74	66	7.0	275
LAO-4	52	15	3.9	7	30	22	0.7	<1	73	N/A	7	0.10	N/A	200	53	7.3	234
LAO-4.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad Canyon																	
MCO-3	48	63	4.1	9	82	16	1.1	<1	213	N/A	21	22.70	N/A	468	175	8.1	700
MCO-4	44	66	4.9	33	100	15	1.6	<1	179	N/A	22	58.30	N/A	614	185	7.5	386
MCO-5	41	27	3.2	26	84	13	1.9	<1	162	N/A	17	21.90	N/A	400	80	8.1	592
MCO-6	38	25	3.3	25	83	16	2.0	3	164	N/A	18	19.30	N/A	378	77	8.3	576
MCO-7	51	23	5.7	10	83	27	1.5	<1	111	N/A	38	16.10	N/A	376	81	7.6	569
MCO-7.5	39	21	5.0	7	116	24	1.5	1	165	N/A	23	27.60	N/A	492	73	8.4	681
Other Areas																	
Pajarito Canyon																	
PCO-1	40	17	4.6	3	20	18	0.2	<5	67	N/A	7	0.07	N/A	150	61	7.3	201
PCO-2	40	18	4.7	4	20	18	0.2	<5	68	N/A	7	0.06	N/A	142	63	7.4	201
PCO-3	40	6	1.4	1	6	18	0.2	<5	68	N/A	7	0.06	N/A	150	20	7.4	192
Other Canyons																	
APCO-1	63	25	4.8	11	65	36	0.6	<5	111	N/A	25	0.34	N/A	290	83	7.1	437
CBDO-6	62	38	8.8	5	20	13	0.3	<1	69	N/A	2	0.10	N/A	96	132	7.4	163
PERCHED SYSTEM IN CONGLOMERATES AND BASALT																	
(Pueblo/Los Alamos/Sandia Canyon Area)																	
Test Well 1A	35	33	8.6	7	59	49	0.9	<1	108	N/A	31	1.82	N/A	266	117	7.7	496
Test Well 2A	62	38	7.3	4	24	41	0.2	<1	86	N/A	26	3.21	N/A	196	124	7.3	393
Basalt Spring	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table VII-2. (Cont.)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO^4-P	SO_4	NO_3-N	Cu	TDS[b]	Total Hardness	pH[c]	Conductivity (µmho/cm)
PERCHED AQUIFER IN VOLCANICS																	
Water Canyon Gallery	48	7	3.4	2	6	1	<0.1	<5	38	0.0	2	0.32	<0.01	90	32	6.9	93
Drinking Water System Limit						250[f]	4[g]				250[f]	10[g]		500[f]		6.8-8.5[f]	
Livestock and Wildlife Watering[h]	None in this table																

[a]Except where noted.
[b]Total dissolved solids.
[c]Standard units.
[d]N/A means analysis not performed, lost in analysis, or not completed.
[e]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[f]MCL, secondary standard (EPA 1989b), see Appendix A.
[g]MCL, primary standard (NMEIB 1991, EPA 1989b), see Appendix A.
[h]New Mexico Stream Standards for Livestock and Wildlife Watering (NMWQCC 1991), see Appendix A.

Table VII-3. Trace Metals in Groundwaters (mg/L)

Station	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg*
MAIN AQUIFER ON SITE												
Test Wells												
Test Well 1	<0.0300[a]	<0.02	<0.0020	0.066	0.0800	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.77	0.0007
Test Well 3	N/A[b]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Well 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Well DT-5A	<0.0010	<0.02	<0.0020	0.011	0.0230	<0.0020	0.0010	<0.0100	<0.004	<0.003	0.14	<0.0001
Test Well DT-9	0.0200	0.26	0.0037	0.099	0.0400	0.0020	<0.0020	0.0080	0.003	0.800	12.00	<0.0002
Test Well DT-10	0.0190	0.16	<0.0020	0.020	0.0050	0.0016	0.0040	0.0032	<0.003	<0.100	0.40	<0.0002
Water Supply Wells												
Pajarito Well Field												
Well PM-1	<0.0006	<0.03	<0.0020	0.030	0.0657	<0.0020	<0.0006	0.0050	<0.020	0.005	0.02	<0.0001
Well PM-2	<0.0006	<0.03	<0.0020	<0.020	0.0204	<0.0020	<0.0006	0.0020	<0.020	<0.003	<0.01	<0.0001
Well PM-3	<0.0006	<0.03	<0.0020	0.030	0.0462	<0.0020	<0.0006	0.0100	<0.020	0.013	<0.01	<0.0001
Well PM-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Well PM-5	<0.0006	<0.03	<0.0020	<0.020	0.0290	0.0020	<0.0006	0.0090	<0.020	<0.003	<0.01	<0.0001
MAIN AQUIFER OFF SITE												
Test Wells												
Test Well 2	<0.0300	<0.02	<0.0020	0.023	0.0200	<0.0020	<0.0100	<0.0200	<0.004	<0.030	2.58	<0.0001
Water Supply Wells												
Guaje Well Field												
Well G-1	<0.0006	<0.03	0.0096	0.030	0.0620	0.0020	<0.0006	0.0100	<0.020	0.005	<0.01	0.0001
Well G-1A	<0.0006	<0.03	0.0130	<0.020	0.0397	<0.0020	<0.0006	0.0110	<0.020	<0.003	<0.01	<0.0001
Well G-2	<0.0006	<0.03	0.0371	0.030	0.0701	<0.0020	<0.0006	0.0130	<0.020	<0.003	<0.01	<0.0001
Well G-4	<0.0006	<0.03	0.0024	<0.020	0.0145	<0.0020	<0.0006	<0.0020	<0.020	0.007	<0.01	0.0001
Well G-5	<0.0006	<0.03	0.0021	<0.020	0.0093	<0.0020	<0.0006	<0.0020	<0.020	0.003	<0.01	<0.0001
Well G-6	N/A	<0.03	0.0025	<0.020	0.0051	<0.0020	<0.0006	0.0050	<0.020	0.018	<0.01	<0.0001
MAIN AQUIFER SPRINGS												
White Rock Canyon Springs (Perimeter and Off Site)												
Group I												
Sandia Spring	<0.0050	0.14	<0.0020	0.022	0.1430	<0.0005	<0.0005	0.0010	<0.010	<0.001	0.35	<0.0001
Spring 3	<0.0050	0.04	<0.0020	0.017	0.0400	0.0005	0.0002	0.0040	<0.010	0.002	0.07	<0.0001
Spring 3A	<0.0050	0.04	<0.0020	0.017	0.0326	0.0005	0.0002	0.0060	<0.010	0.002	0.07	<0.0001
Spring 3AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

*Data on additional trace metals in groundwaters are presented on page VII-19.

Table VII-3. (Cont.)

Station	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg*
Group I (Cont.)												
Spring 4	0.0100	<0.01	0.0036	0.018	0.0428	<0.0005	<0.0005	0.0040	<0.010	<0.001	0.01	<0.0001
Spring 4A	<0.0050	0.02	<0.0020	0.021	0.0423	<0.0005	<0.0005	0.0040	<0.010	0.003	0.02	<0.0001
Spring 5	<0.0050	0.03	<0.0020	0.018	0.0184	<0.0005	<0.0005	0.0030	<0.010	<0.001	0.04	<0.0001
Spring 5AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Spring	<0.0050	0.15	<0.0020	0.019	0.0274	<0.0005	<0.0005	0.0030	<0.010	<0.001	0.11	<0.0001
Group II												
Spring 5A	<0.0050	0.11	<0.0020	0.024	0.0273	<0.0005	0.0002	0.0050	<0.010	0.001	0.10	<0.0001
Spring 5B	<0.0050	0.17	<0.0020	0.018	0.0386	0.0005	0.0003	0.0070	<0.010	0.001	0.15	<0.0001
Spring 6	<0.0050	0.03	<0.0020	0.018	0.0329	<0.0005	<0.0005	0.0030	<0.010	<0.001	0.03	<0.0001
Spring 6A	<0.0050	0.01	<0.0020	0.016	0.0206	<0.0005	<0.0005	0.0030	<0.010	<0.001	0.01	<0.0001
Spring 7	<0.0050	0.17	<0.0020	0.014	0.0266	<0.0005	<0.0005	0.0030	<0.010	<0.001	0.16	<0.0001
Spring 8	<0.0050	0.49	<0.0020	0.032	0.0432	<0.0005	<0.0005	0.0030	<0.010	<0.001	0.47	<0.0001
Spring 8A	<0.0050	0.42	<0.0020	0.009	0.0290	0.0005	0.0002	0.0030	<0.010	0.002	0.39	<0.0001
Spring 8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 9	<0.0050	0.05	<0.0020	0.018	0.0295	0.0006	0.0003	0.0030	<0.010	0.005	0.11	<0.0001
Spring 9A	<0.0050	0.18	<0.0020	0.009	0.0139	<0.0005	<0.0005	0.0040	<0.010	<0.001	0.39	<0.0001
Doe Spring	<0.0050	0.03	<0.0020	0.014	0.0174	0.0006	0.0003	0.0050	<0.010	0.005	0.04	<0.0001
Spring 10	<0.0050	2.02	0.0023	0.013	0.1570	0.0005	0.0004	0.0040	<0.010	0.007	2.36	<0.0001
Group III												
Spring 1	<0.0050	0.04	0.0030	0.036	0.0264	0.0005	0.0003	0.0070	<0.010	0.003	0.04	<0.0001
Spring 2	<0.0050	0.97	0.0247	0.074	0.0557	0.0007	<0.0005	0.0040	<0.010	0.003	0.87	<0.0001
Group IV												
La Mesita	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 3B	<0.0050	0.03	0.0117	0.150	0.0448	0.0005	0.0002	0.0090	<0.010	0.002	0.08	<0.0001
Other Off-Site Springs												
Sacred Spring	<0.0006	0.13	0.0028	0.090	0.1270	<0.0010	<0.0020	<0.0050	<0.020	<0.002	0.48	<0.0001
Indian Spring	<0.0006	0.65	0.0029	0.020	0.1010	<0.0010	<0.0020	<0.0050	<0.020	<0.002	0.30	<0.0001
ALLUVIAL CANYON AQUIFERS												
Radioactive Effluent Release Areas												
DP-Los Alamos Canyon												
LAO-C	<0.0300	0.56	<0.0020	0.013	0.0400	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.58	0.0008
LAO-1	<0.0300	0.37	0.0026	0.021	0.0400	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.17	0.0009

*Data on additional trace metals in groundwaters are presented on page VII-20.

Table VII-3. (Cont.)

Station	Ag	Al	As	B	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg*
DP-Los Alamos Canyon (Cont.)												
LAO-2	<0.0300	0.20	0.0025	0.071	0.0600	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.09	0.0009
LAO-3	<0.0300	0.18	0.0022	0.066	0.0600	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.08	0.0009
LAO-4	<0.0300	0.11	<0.0020	0.064	0.0500	<0.0020	<0.0010	<0.0200	<0.004	<0.030	0.06	0.0009
LAO-4.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mortandad Canyon												
MCO-3	<0.0300	0.72	<0.0020	0.070	0.0400	<0.0020	<0.0100	<0.0200	<0.004	0.040	0.57	0.0002
MCO-4	<0.0300	1.07	<0.0020	0.096	0.1600	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.70	0.0003
MCO-5	<0.0300	1.08	<0.0020	0.089	0.1000	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.24	0.0003
MCO-6.0	<0.0300	0.10	<0.0020	0.083	0.1000	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.05	0.0001
MCO-7	<0.0300	0.16	0.0024	0.089	0.1800	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.09	0.0003
MCO-7.5	<0.0300	0.13	<0.0020	0.100	0.1600	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.08	0.0003
Pajarito Canyon												
PCO-1	0.0007	0.08	<0.0020	<0.020	0.0885	<0.0002	0.0003	0.0020	<0.020	0.002	0.80	0.0003
PCO-2	0.0003	0.16	<0.0020	<0.020	0.0799	<0.0002	0.0003	0.0030	<0.020	0.002	2.10	0.0004
PCO-3	<0.0002	0.05	<0.0020	<0.020	0.0809	<0.0002	0.0003	0.0020	<0.020	0.008	1.30	0.0002
Other Areas												
APCO-1	0.0020	7.02	0.0100	0.200	0.2430	0.0080	0.0010	0.0600	<0.004	0.051	5.60	<0.0001
CDBO-6	<0.0100	11.40	0.0722	0.037	0.0830	<0.0020	0.0010	<0.0100	<0.004	<0.003	8.52	0.0006
PERCHED SYSTEM IN CONGLOMERATES AND BASALT (Pueblo/Los Alamos/Sandia Canyon Area)												
Test Well 1A	<0.0300	0.23	<0.0020	0.230	0.0300	<0.0020	<0.0100	<0.0200	0.009	<0.030	57.40	0.0007
Test Well 2A	<0.0300	<0.02	<0.0020	0.127	0.0300	<0.0020	<0.0100	<0.0200	<0.004	<0.030	0.97	<0.0001
Basalt Spring	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PERCHED AQUIFER IN VOLCANICS												
Water Canyon Gallery	<0.0006	<0.03	<0.0020	<0.020	0.0119	<0.0020	<0.0006	0.0070	<0.020	<0.003	<0.01	<0.0001
Drinking Water System Limit	0.05[c]		0.05[c]				0.01[c]	0.05[c]		1.0[d]	0.3[d]	0.002[c]
Livestock and Wildlife Limit Watering[b]		5.0	0.02	5.0			0.05	1.0	1.0	0.5		0.01

*Data on additional trace metals in groundwaters are presented on page VII-21.

Table VII-3. (Cont.)

Station	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
MAIN AQUIFER ON SITE											
Test Wells											
Test Well 1	0.0200	<0.030	<0.010	0.0100	0.0080	<0.0020	N/A	0.2700	<0.0005	<0.03	0.090
Test Well 3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Well 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Well DT-5A	0.0100	<0.001	<0.010	0.2090	0.0365	<0.0020	N/A	0.0610	<0.0006	<0.01	0.433
Test Well DT-9	0.1700	0.005	0.011	0.0550	<0.0010	0.0025	0.09	0.0950	<0.0020	0.01	5.000
Test Well DT-10	0.0140	<0.003	0.004	0.0500	0.0020	0.0029	0.05	0.0400	<0.0020	0.01	3.900
Water Supply Wells											
Pajarito Well Field											
Well PM-1	<0.0020	0.004	<0.020	<0.0006	<0.0006	<0.0020	N/A	0.1610	<0.0006	0.02	0.007
Well PM-2	<0.0020	<0.002	<0.020	<0.0006	0.0011	<0.0020	N/A	0.0440	<0.0006	0.01	<0.006
Well PM-3	0.0060	0.003	<0.020	<0.0006	0.0007	<0.0020	N/A	0.1410	<0.0006	0.02	0.027
Well PM-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Well PM-5	0.0030	<0.002	<0.020	<0.0006	0.0012	<0.0020	N/A	0.0620	<0.0006	0.01	<0.006
MAIN AQUIFER OFF SITE											
Test Wells											
Test Well 2	0.0020	<0.030	<0.010	<0.0080	<0.0010	<0.0020	N/A	0.0500	<0.001	<0.03	0.120
Water Supply Wells											
Guaje Well Field											
Well G-1	<0.0020	0.004	<0.020	<0.0006	<0.0006	<0.0020	N/A	0.1100	<0.0006	0.04	<0.006
Well G-1A	0.0020	0.003	<0.020	<0.0006	0.0012	<0.0020	N/A	0.0790	<0.0006	0.05	<0.006
Well G-2	0.0020	0.002	<0.020	<0.0006	0.0010	<0.0020	N/A	0.0870	<0.0006	0.09	<0.006
Well G-4	<0.0020	0.006	<0.030	<0.0006	0.0012	<0.0020	N/A	0.1130	<0.0006	0.02	0.019
Well G-5	<0.0020	0.003	<0.020	<0.0006	0.0009	<0.0020	N/A	0.0880	<0.0006	0.02	0.008
Well G-6	<0.0020	0.009	<0.020	0.0011	0.0014	<0.0020	N/A	0.0715	<0.0006	0.02	0.019
MAIN AQUIFER SPRINGS											
White Rock Canyon Springs (Perimeter and Off Site)											
Group I											
Sandia Spring	0.0674	0.001	<0.010	0.0006	<0.0005	<0.0020	N/A	0.3990	<0.0002	<0.01	0.001
Spring 3	0.0020	<0.001	<0.010	<0.0002	0.0003	<0.0020	N/A	0.2310	<0.0002	0.01	<0.001
Spring 3A	0.0030	<0.001	<0.010	<0.0002	0.0002	<0.0020	N/A	0.2230	<0.0002	0.01	0.003
Spring 3AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table VII-3. (Cont.)

Station	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Group I (Cont.)											
Spring 4	<0.0010	0.001	<0.010	0.0002	<0.0005	<0.0020	N/A	0.1370	<0.0002	<0.01	0.003
Spring 4A	<0.0010	0.001	<0.010	0.0002	<0.0005	<0.0020	N/A	0.1040	<0.0002	0.00	0.003
Spring 5	<0.0010	<0.001	<0.010	0.0004	<0.0005	<0.0020	N/A	0.0880	<0.0002	0.01	0.007
Spring 5AA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho Spring	<0.0010	<0.001	<0.010	0.0002	<0.0005	<0.0020	N/A	0.0570	<0.0002	0.01	<0.001
Group II											
Spring 5A	0.0010	0.001	<0.010	<0.0002	0.0002	<0.0020	N/A	0.2000	<0.0002	0.01	0.001
Spring 5B	<0.0010	0.002	<0.010	0.0005	0.0002	<0.0020	N/A	0.1140	<0.0002	0.01	0.012
Spring 6	<0.0010	0.001	<0.010	0.0003	<0.0005	<0.0020	N/A	0.0800	<0.0002	0.01	0.004
Spring 6A	<0.0010	0.001	<0.010	0.0004	<0.0005	<0.0020	N/A	0.0480	<0.0002	0.01	<0.001
Spring 7	<0.0010	0.001	<0.010	0.0006	<0.0005	<0.0020	N/A	0.0680	<0.0002	0.01	0.017
Spring 8	<0.0010	0.001	<0.010	<0.0002	<0.0005	<0.0020	N/A	0.1210	<0.0002	0.01	<0.001
Spring 8A	0.0010	0.002	0.010	0.0004	0.0006	<0.0020	N/A	0.0550	<0.0002	0.01	0.002
Spring 8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 9	<0.0010	0.002	<0.010	<0.0002	0.0003	<0.0020	N/A	0.0890	<0.0002	0.01	<0.001
Spring 9A	0.0164	0.001	<0.010	0.0004	<0.0005	<0.0020	N/A	0.0550	<0.0002	0.01	0.002
Doe Spring	0.0280	0.001	<0.010	0.0005	0.0003	<0.0020	N/A	0.0580	<0.0002	0.01	0.001
Spring 10	0.0460	0.002	<0.010	0.0012	0.0006	<0.0020	N/A	0.1170	<0.0002	0.01	0.006
Group III											
Spring 1	0.0010	0.004	<0.010	0.0003	0.0004	<0.0020	N/A	0.2140	<0.0002	0.02	0.005
Spring 2	0.1130	0.004	<0.010	0.0024	<0.0005	<0.0020	N/A	0.2570	<0.0002	0.04	0.007
Group IV											
La Mesita	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 3B	0.0010	0.006	<0.010	<0.0002	0.0003	<0.0020	N/A	0.2460	<0.0002	0.03	<0.001
Other Off-Site Springs											
Sacred Spring	<0.0050	<0.001	<0.020	<0.0006	<0.0006	<0.0020	N/A	0.4680	0.0008	0.01	0.012
Indian Spring	<0.0050	<0.001	<0.020	<0.0006	<0.0006	<0.0020	N/A	0.3460	0.0037	0.02	0.161
Alluvial Canyon Aquifers											
Radioactive Effluent Release Areas											
DP-Los Alamos Canyon											
LAO-C	<0.0020	<0.030	<0.010	<0.0010	<0.0020	<0.0020	N/A	0.0800	0.0004	<0.03	0.009
LAO-1	<0.0020	0.130	<0.010	0.0090	<0.0020	<0.0020	N/A	0.1100	<0.0004	<0.03	<0.020

Table VII-3. (Cont.)

tion	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
P-Los Alamos Canyon (Cont.)											
LAO-2	<0.0020	0.170	<0.010	<0.0010	<0.0020	<0.0020	N/A	0.1400	0.0009	<0.03	<0.020
LAO-3	<0.0020	0.160	<0.010	<0.0010	<0.0020	<0.0020	N/A	0.1300	0.0005	<0.03	<0.020
LAO-4	<0.0020	0.020	<0.010	0.0020	<0.0020	<0.0020	N/A	0.1000	0.0018	<0.03	<0.020
LAO-4.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ortandad Canyon											
MCO-3	<0.0020	0.940	0.010	<0.0080	<0.0010	<0.0020	N/A	0.1600	0.0010	<0.03	<0.006
MCO-4	<0.0020	0.200	0.010	<0.0080	<0.0010	<0.0020	N/A	0.2300	<0.0010	<0.03	0.030
MCO-5	<0.0020	0.080	0.010	<0.0080	<0.0010	<0.0020	N/A	0.1300	<0.0010	<0.03	0.007
MCO-6.0	<0.0020	0.060	<0.010	<0.0080	<0.0010	<0.0020	N/A	0.1200	<0.0010	<0.03	0.009
MCO-7	<0.0020	<0.030	<0.010	<0.0080	<0.0010	<0.0020	N/A	0.1600	<0.0010	<0.03	0.006
MCO-7.5	<0.0020	<0.030	<0.010	<0.0080	<0.0010	<0.0020	N/A	0.1400	<0.0010	<0.03	<0.006
ıjarito Canyon											
PCO-1	0.2570	0.001	<0.0200	0.0036	<0.0004	<0.0020	N/A	0.1200	<0.0002	0.01	0.003
PCO-2	0.1310	<0.001	<0.0200	0.0020	<0.0004	<0.0020	N/A	0.1160	<0.0002	0.02	0.006
PCO-3	0.1770	<0.001	<0.0200	0.0014	<0.0004	<0.0020	N/A	0.1240	<0.0002	<0.01	0.008
er Areas											
APCO-1	2.6000	0.006	<0.010	0.0180	0.0016	<0.0020	N/A	0.3010	0.0006	0.03	0.161
DBO-6	0.0040	0.002	0.030	<0.0080	0.0010	0.0161	<1.00	0.1250	0.0060	<0.00	0.0860
tCHED SYSTEM IN CONGLOMERATES AND BASALT											
eble/Los Alamos/Sandia Canyon Area)											
Test Well 1A	0.1300	<0.030	0.020	<0.0060	<0.0010	<0.0020	N/A	<0.0050	<0.0010	<0.03	0.420
Test Well 2A	0.1700	<0.030	<0.010	0.0110	<0.0010	<0.0020	N/A	0.2100	<0.0010	<0.03	4.000
Basalt Spring	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
tCHED AQUIFER IN VOLCANICS											
ater Canyon Gallery	0.0030	0.002	<0.020	<0.0006	<0.0006	<0.0020	N/A	0.0570	<0.0006	0.00	<0.006
king Water System Limit	0.05[d]			0.5[c]		0.01[c]					5.0[d]
stock and Wildlife											
stering Limit[b]				0.1		0.05				0.1	25

s than symbol (<) means measurement was below the specified detection limit of the analytical method.
A means analysis not performed, lost in analysis, or not completed.
L, primary standard (NMEIB 1991, EPA 1989b), see Appendix A.
L, secondary standard (EPA 1989b), see Appendix A.

Values for all parameters measured in the water supply wells were within drinking water limits. The arsenic level in Well G-2 was about 80% of the standard and was similar to previous measurements.

The test wells in the main aquifer showed levels of several constituents that exceed standards for drinking water distribution systems. 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 Test Wells 1, DT-9, and DT-10; manganese, in DT-10; and zinc, in DT-9 and DT-10. Lead levels were just at or slightly above the lead standard in DT-9 and DT-10 and were about four times the standard in DT-5A. Other test wells have occasionally had elevated lead levels in previous years.

Samples from a few springs (Sandia Spring and Springs 2, 8, 8A, 9A, 10) in White Rock Canyon showed levels of iron and manganese that would exceed secondary standards for drinking water systems; however, naturally occurring levels can be in the same range, as has been observed previously. Selenium levels were all far below the standard this year, discounting suspect levels from 1991 samples that were measured by an method with a much higher detection limit.

Alluvial canyon groundwaters in the areas receiving effluents showed the effects of those effluents in that levels of some parameters were elevated. The effects were seen in the samples from Pueblo, Los Alamos, and Mortandad canyons. The results were in the same ranges as values observed in previous years, indicating no significant changes in conditions.

Analyses for organics were performed on only three groundwater samples in 1992 because of the ban on analyses that could generate potential mixed waste (see Section III.B.1.a). The analyses addressed the volatile and semivolatile organic compounds, and PCBs (see Table D-20 for detailed listings of parameters). None of the analyses detected the presence of any of the compounds. The sources sampled included Test Wells-1, -2 and DT-5A. The analyses indicated the presence of trace amounts of chloromethane and acetone in levels slightly above quantification limits in the samples from Test Wells-1 and -2. However, the method blank also showed acetone at a similar level, and the results are interpreted as an artifact of the analysis.

D. Long-Term Trends

1. Main Aquifer.

The long-term trends of the water quality in the main aquifer are simple to summarize for all locations except Test Well 1: no concentrations of radionuclides above detection limits have been measured on water samples from the production wells or test wells that reach the main aquifer other than an occasional analytical statistical outlier not confirmed by analysis of subsequent samples. At Test Well 1, in lower Pueblo Canyon just upstream of the confluence with Los Alamos Canyon, there have been indications of some recent recharge to the main aquifer for some time (EPG 1993). Low detection limit measurements of tritium made in 1993 appear to confirm this.

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. In the central part of the plateau, water levels in Test Wells 2, 3, and 8 have declined about 7.6 to 12 m (25 to 40 ft) in slightly more than 50 years, or less than a 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). Nonpumping levels in Supply Well PM-5 have declined about 10 m (32 ft) in 10 years and in PM-3 have declined about 8 m (26 ft) in 26 years. PM-3 is the largest producer of all the wells producing more than 200 million gal./yr in the last several years. Near the southern boundary of the Laboratory, water levels in Test Wells DT-5A, DT-9, and DT-10 have declined about 1.5 to 5 m (5 to 15 ft) in 31 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 pumpage. 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.

In the Guaje Well Field northeast of the Laboratory, the average 1992 nonpumping water levels in the well field remained about the same when compared with the 1991 water levels. Increased or decreased pumpage from individual wells during the year resulted in slight declines or increases in water levels in that particular well. 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 San Ildefonso Pueblo in July 1992.

2. Alluvial Perched Groundwaters in Mortandad Canyon.

Long-term trends of radionuclide concentrations in shallow alluvial perched groundwater in Mortandad Canyon (the current radioactive effluent release area for the waste treatment plant at TA-50) are depicted in Figure VII-2. 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 (in solution) are relatively constant, fluctuating up and down in response to variations in the treatment plant effluent and storm run-off that cause some dilution in the shallow alluvial water. The tritium concentration has fluctuated almost in direct response (with a time lag of about one year) to the average annual concentration of tritium in the TA-50 effluent.

Figure VII-2. Tritium and plutonium concentrations in samples from Observation Well MCO-6. (Graph does not include 1991 data because of analytical problems.)

E. Special Studies

1. Main Aquifer.

a. Age of the Water. In an effort to better understand the nature of recharge to the main aquifer in the Los Alamos area, a series of special measurements has been initiated on selected water samples. This cooperative effort, involving researchers in the Laboratory's Environmental Protection Group, Earth and Environmental Sciences, and Isotope and Nuclear Chemistry divisions and staff from another DOE installation, is attempting to apply a range of geochemical techniques based on measurements of both radioactive and stable isotopes to help identify specific sources and estimate the age of water in the main aquifer. Through 1992, low detection limit tritium analyses have been completed on samples from 13 springs, 11 water supply wells, and 3 test wells into the main aquifer, and 2 test wells in the intermediate depth perched zone (Goff 1991, Goff 1993). All of the data are presented in Table VII-4.

The samples collected in 1992 included 11 from water supply wells in the Guaje and Pajarito fields completed in the main aquifer. These results were all at or near the detection limit, indicating essentially no measurable tritium. Similarly, Test Well 2 in the main aquifer showed no measurable tritium. Test Well 1, which was completed in the main aquifer, showed a measurable amount of tritium.

With the exception of Test Well 1, all the values for samples from main aquifer sources are all less than values for tritium in contemporary precipitation (about 30 to 60 pCi/L) and much less than the roughly 700 pCi/L that would be present now in water precipitated in northern New Mexico during 1962 and 1963 when tritium from worldwide atmospheric nuclear weapons testing was at its maximum. The interpretation is that there is not any significant component of recharge from water precipitated during the last several decades in the water from the main aquifer.

The values for tritium in the water samples from the main aquifer springs in White Rock Canyon tend to be slightly higher, ranging from less than the detection limit (0.4 nCi/L) to about 7 pCi/L, with one value about 18 pCi/L. Several of the spring samples are collected from seeps through surface soils or gravels at the edge of the river and thus are subject to mixing with some contemporary precipitation or moisture in the soil. The highest value, for Doe Spring in Chaquehui Canyon, is from a sample that was collected in 1992 from a pool in the stream channel after it had flowed over a rock face for some distance. A sample collected from Doe Spring later in 1992 contained about 3.5 pCi/L; that sample was collected on the rock face closer to the point of discharge.

The sample from Test Well 1, in the lower reach of Pueblo Canyon, with a level of about 350 pCi/L indicates the presence of recent recharge from the surface. The level is high enough to indicate the probable influence of effluent-related levels observed in the surface water and alluvial groundwater in Pueblo Canyon over the last 20 years (see Figure IV-7). This indication of recent water tends to corroborate previous observations of water level and chemical quality changes at Test Well 1, suggesting a connection with the Pueblo Canyon alluvial water or the water in the intermediate depth perched zone (see Section VII.C.1). A special pump test study of Test Wells 1 and 1A in 1991 was unable to conclusively determine a mechanism for movement (EPG 1993). This problem will require further study to determine the pathway.

The samples from Test Wells 1A and 2A also clearly show the presence of connection with the surface and perched alluvial water in Pueblo Canyon. These results are consistent with observations of influences on chemical quality observed since the earliest USGS studies (Abrahams 1966).

Preliminary interpretation of ^{14}C data for samples from five deep wells in the main aquifer indicates that the water ranges in age from more than 1,000 years to more than 20,000 years (Spangler 1992). The samples were collected in October 1991, and the analyses were completed during 1992. For each sample a range of ages was estimated. The maximum possible age estimate assumes that radioactive decay of carbon is the only process involved. The minimum age estimate assumes that the ^{14}C concentration can also be diluted by dissolution of "dead" carbon from the rock matrix, with the amount of dissolution estimated from the ratio of ^{14}C to stable ^{13}C.

The age estimates for water in the five locations are DT-5A, 1,810 to 4,560 yr; PM-5, 1,040 to 5,140 yr; PM-1, 5,620 to 14,000 yr; G-5, 6,110 to 10,900 yr; and LA-1B, >27,000 to >39,000 yr.

b. 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 1992, total production from

Table VII-4. Low Detection Limit Measurements of Tritium, as Tritiated Water (HTO) in Groundwater

Sample Location	Date of Sample	HTO (pCi/L)
Springs in White Rock Canyon		
Spring 2	Oct. 91	4.21 ± (0.36)[a]
Spring 3	Oct. 91	1.65 ± (0.39)
	Sept. 90	3.40 ± (0.29)
Spring 3B	Oct. 91	0.13 ± (0.29)
	Sept. 90	0.91 ± (0.29)
Spring 4A	Oct. 91	2.40 ± (0.39)
Spring 6	Oct. 91	1.78 ± (0.32)
Spring 6A	Oct. 91	0.03 ± (0.29)
	Sept. 90	0.06 ± (0.29)
Spring 7	Oct. 91	2.10 ± (0.29)
	Sept. 90	1.46 ± (0.29)
Spring 8	Oct. 91	7.09 ± (0.55)
	Sept. 90	5.83 ± (0.29)
Spring 8B	Sept. 90	4.66 ± (0.29)
Spring 9A	Oct. 91	1.78 ± (0.29)
Ancho Spring	Oct. 91	4.21 ± (0.36)
	Sept. 90	3.40 ± (0.29)
Doe Spring	Sept. 90	17.71 ± (0.58)
	Sept. 92	3.47 ± (6.32)
Basalt Spring	June 91	123.00 ± (4.20)
	Dec. 92	162.00 ± (6.00)
Wells in Main Aquifer		
Well LA-1B	Oct. 91	0.26 ± (0.29)
Well G-1	Aug. 92	1.10 ± (0.29)
Well G-1A	Aug. 92	0.91 ± (0.36)
Well G-2	Aug. 92	0.91 ± (0.29)
Well G-4	Aug. 92	0.62 ± (0.32)
Well G-5	Oct. 91	0.06 ± (0.29)
	Aug. 92	1.39 ± (0.29)
Well G-6	Aug. 92	1.81 ± (0.32)
Well PM-1	Oct. 91	1.65 ± (0.32)
	Aug. 92	2.23 ± (0.29)
Well PM-2	Aug. 92	0.49 ± (0.29)
	Feb. 92	0.13 ± (0.29)
Well PM-3	Aug. 92	1.20 ± (0.29)
Well PM-5	Oct. 91	0.29 ± (0.29)
	Aug. 92	1.26 ± (0.39)
Test Well 1	Oct. 92	353.00 ±(13.00)
Test Well 2	Oct. 92	0.71 ± (0.29)
Test Well DT-5A	Oct. 91	±0.23[b] ± (0.29)
Wells in Intermediate Depth Perched Zone		
Test Well 1A	Oct. 92	133.70 ± (4.50)
Test Well 2A	Oct. 92	2,260.00 ±(74.50)

[a] Counting uncertainties (| 1 standard deviation) are in parentheses.
[b] See Section VIII.D.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

the wells and gallery for potable and nonpotable use was $5.42 + 10^6$ m^3 (1.43 billion gal. or 4,387 ac ft). This production amounts to 79% of the total diversion right of $6.8 + 10^6$ m^3 (5,541 ac ft) that is available to the DOE under its permit. Details of the performance of the water supply wells (pumpage, water levels, drawdown, and specific yield) and their operation are published in a series of separate reports, the most recent of which is "Water Supply at Los Alamos during 1990" (Purtymun 1993).

2. Vadose Zone, Studies in Cañada del Buey.

Construction of the Laboratory's new Sanitary Wastewater Systems Consolidation (SWSC) project was completed in late 1992. Because treated effluent from the SWSC 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 within the upper and middle reaches of the drainage. 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 monitoring network was installed to demonstrate that effluent discharges from SWSC meet the requirements of the NMWQCC regulations. The monitoring also satisfies requirements of DOE Order 5400.1 for preoperational studies.

Results of the drilling indicate that under predischarge conditions, there is limited shallow (alluvial) perched groundwater to be impacted in Cañada del Buey. Along the 4 km (2.5 mi) of drainage system covered by the monitoring system, saturation was found within only a 0.8 km (0.5 mi) long segment, starting at about the location of new Well CDBO-6 (see Figure VII-1 for location of Cañada del Buey and Well CDBO-6) and downstream of SWSC. 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. If effluents are eventually released into the drainage, infiltration along the stream bottom will create a narrow ribbon of saturation within the alluvium and the weathered tuff that will be perched on the underlying unweathered Bandelier Tuff. It is unknown how far down the canyon the saturation will advance.

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. The wells were drilled and constructed in accord with NMED guidelines.

The thickness of the alluvium ranged from 1.2 to 5 m (4 to 17 ft) in the new shallow wells, while the underlying weathered tuff ranged from 3.7 to 12 m (12 to 40 ft). Anticipating that saturation may develop in either unit, the design of the new wells allows for water to enter the well screen from both horizons.

All but two of the new wells were dry. Of the two wet wells, only CDBO-6 had sufficient saturated thickness (3 m [10 ft]) to warrant well development and sampling. It has been equipped with a dedicated bladder pump for sampling purposes and added to the routine surveillance program. To establish pre-SWSC water quality conditions, Well CDBO-6 was sampled and analyzed for radioactive and inorganic constituents and for target volatile organic compounds. Overall water quality is good with low concentrations of dissolved solids, trace metals, and radioactivity. Results of the radioactive, general chemical, and metal analyses are included in Tables VII-1, VII-2, and VII-3, respectively. Because of the interest in predischarge values of parameters that might be influenced by effluents from a sanitary waste treatment plant, additional nitrogen compounds were measured. These included ammonia (<0.01 mg/L), nitrite (<0.02 mg/L), and total Kjeldahl nitrogen (0.342 mg/L). No organic compounds were detected in the water sample. Saturated thickness in the other wet well (CDBO-7) in 1992 was 0.3 to 0.6 m (1 to 2 ft), insufficient to sample. All of the wells will be inspected periodically to determine whether the extent of the groundwater changes.

As a complement to the shallow groundwater monitoring network, two neutron moisture logging access tubes (CDBM-1 and -2) were installed about 1 to 2 km (0.6 to 1.2 mi) downstream from CDBO-6 within the underlying Bandelier Tuff to depths of 58 and 30 m (189 and 99 ft), respectively. Moisture levels in the tuff will be monitored via the access tubes to gauge the rate of downward movement of the effluent should the canyon bottom become saturated. As shown in Figure VII-3, predischarge moisture contents of the tuff are variable with significant local

Figure VII-3. Cañada del Buey Core Hole CDBM-1: moisture profiles in July and September 1992.

increases at or near the formational contacts. The overall pattern is consistent with those previously documented in Mortandad and Potrillo canyons.

3. Main Aquifer Hydrologic Properties.

a. Measurement of Barometric and Earth Tide Responses in Test Wells. In October 1992, the Laboratory began measuring and recording water level fluctuations at wells completed in the main aquifer. These data are automatically recorded at hourly intervals using pressure transducers. Table VII-5 summarizes the locations, start up dates, and initial water levels. The table also indicates three other wells in canyon alluvial perched groundwater and two wells in the intermediate depth perched groundwater that were equipped with recording transducers. Figure VII-4 A and B shows examples of the water level fluctuations from Test Well DT-9 at TA-49 and from Well SHB-3 at TA-16. Daily water level fluctuations typically range from about 0.15 to 0.3 m (0.5 to 1 ft) or larger. These fluctuations are unrelated to aquifer pumpage. These data are being analyzed in the frequency domain using spectral analysis techniques to determine the aquifer transmissivity and its storage coefficient.

Figure VII-4 C and D depicts the power spectrum of each time series shown in Figure VII-4 A and B. The power spectrum is a standard frequency domain technique that is used to determine which frequencies are contributing to the variance in an observed data series. Both Wells DT-9 and SHB-3 show strong peaks at 1 and 2 cycles per day (cpd) that correspond to diurnal and semidiurnal fluctuations in barometric pressure. In addition, both wells also show three strong peaks between about 0.6 and 0.8 cpd that are correlated to long-period (i.e., two or more days) atmospheric pressure changes resulting from synoptic scale cyclonic and anticyclonic weather patterns.

Table VII-5. Wells Equipped with Recording Transducers

Well	Date Started	Water Depth[a]	Elevation[b]
Main Aquifer Locations			
Test Well-1	10/23/92	537.10	5,833.11
Test Well-2	10/30/92	792.64	5,856.99
Test Well-3	10/23/92	777.80	5,819.52
Test Well-4	06/16/93	792.73	5,856.03
Test Well-8	10/23/92	992.62	5,886.05
DT-5A	04/23/93	1,183.12	5,961.51
DT-9	11/23/92	1,015.01	5,921.70
DT-10	06/14/93	1,096.95	5,922.97
SHB-3	11/24/92	664.31	6,943.94
LA-1A	11/23/92	8.29	5,618.06
LA-1B	07/26/93	Flowing	5,615.96
Intermediate Perched Zone Locations			
Test Well-1A	11/10/92	190.33	6,369.28
Test Well-1B	11/10/92	104.71	6,548.65
Canyon Alluvium Locations			
APCO-1	11/10/92	6.34	6,361.85
MCO-5	10/30/92	15.39	6,862.03
MCO-6B	10/30/92	33.01	6,817.95

[a]Depth to water in feet measured below top of casing.
[b]Water elevation in feet relative to mean sea level.

It is apparent that water level fluctuations in Well SHB-3 are also affected by lunar and solar tidal fluctuations. The lunar effects occur at 0.930 and 1.932 cpd (i.e., the O1 and M2 lunar tides, respectively), and the solar effects occur at 1.003 and 2.000 cpd (i.e., the P1 and S2 solar tides, respectively). The P1 and S2 solar tides correspond to the two barometric pressure frequencies even though these phenomena are physically distinct. Water levels in deep observation wells commonly fluctuate with variations in barometric pressure. Typically these wells have a relatively thick unsaturated zone overlying a water table aquifer or are completed in a confined aquifer. It is unusual, however, for observation wells to show fluctuations that correspond to tidal variations, as observed in Well SHB-3, unless the well is completed in a confined aquifer. While it is premature to make final conclusions, these early results may suggest that the main aquifer below Pajarito Plateau is at least partially confined over a relatively large area.

Preliminary analyses of water level fluctuations in Laboratory test wells suggest that the main aquifer adjacent to the Rio Grande responds like a confined aquifer to small barometric pressure and tidal perturbations. However, at locations farther to the west of this regional groundwater discharge area, the main aquifer apparently behaves like a phreatic aquifer in some locations and a confined to leaky-confined aquifer in other areas. The extent of this transition cannot yet be fully mapped, but it apparently extends as far west as the Otowi-4 production well in Los Alamos Canyon where leaky-confined behavior is obvious, and to Observation Well SHB-3 at TA-16 where confined conditions are apparent.

These new data collection and interpretation efforts will continue as part of the Groundwater Protection Program. As more water level data become available for the main aquifer, more definitive hydrogeological interpretations will be possible.

Figure VII-4. Hourly water levels fluctuationsin the main aquifer is recorded in test wells SHB-3 (A) and DT-9 (B) between November 25, 1992, and April 2, 1993; power spectra for SHB-3 (C) and DT-9 (D) for the same period.

b. Pump Test in Supply Well LA-2. A seven day pump test was conducted in Los Alamos Well LA-2 from March 16 to 23, 1992. The LA-1 and LA-3 wells were used as observation wells during this period. The Los Alamos Well Field ceased production in 1991 due to highway construction activities; however, Well LA-2 was sporadically used throughout summer and fall of 1991 as a water source to support these construction activities. From mid-October 1991 through March 1992, there was no water production from any of these wells; hence, water levels recovered to near-static conditions. During the pump test, water levels were recorded at 15 minute intervals in LA-1, located approximately 366 m (1,200 ft) east of LA-2, and in LA-3, located about 290 m (950 ft) northwest of LA-2. Figure VII-5 shows the recorded data during the test. The data show the periodic fluctuations from barometric and tidal influences superimposed on the more gradual drawdown trends. Water production rates in LA-2 showed an exponentially declining rate over the test duration because of declining water levels in the production casing in response to pumpage. Analysis procedures followed those for variable discharge rates (Aron 1965). These analyses indicate that the aquifer transmissivity and storage coefficient for the formation surrounding LA-1 are 78 m^2 (841 ft^2) per day and 0.00102, respectively. For LA-3, these values are 45 m^2 (484 ft^2) per day and 0.00294, respectively. These results are comparable with those previously obtained in a pump test conducted at LA-3, which use LA-2 as an observation well (Theis 1962).

Figure VII-5. Results from the pump test in Well LA-2: March 16|April 10, 1992.

VIII. QUALITY ASSURANCE AND SAMPLING PROCEDURES

Quality assurance (QA) includes all of the planned and systematic actions and activities necessary to provide adequate confidence that a system or process will perform satisfactorily. Each monitoring and compliance activity sponsored by the Los Alamos National Laboratory's (LANL or the Laboratory) Environmental Protection Group (EM-8) has its own quality assurance program (QAP) with documented sampling procedures. The Environmental Chemistry Group (EM-9) also has a documented QAP for sample analysis and data verification.

A. Organization

The Laboratory is managed by the University of California (UC) for the Department of Energy (DOE) and is obligated to report both to UC and DOE. The Laboratory contract is administered through the DOE Los Alamos Area Office (DOE/LAAO) and the Albuquerque Operations Office (DOE/AL). The Laboratory Director is ultimately responsible for all Laboratory activities. However, technical and administrative responsibility and authority have been delegated to directorates and support offices.

In 1992 the Director was supported by a Deputy Director, an Executive Staff Director, nine Associate Directors, the Controller, the Laboratory Counsel, the Director of Human Resources, and the Office of Public Affairs.

The Environmental Management (EM) Division is the primary Laboratory support program for all environmental activities. The Division initiates and promotes a comprehensive Laboratory program for environmental protection and has primary responsibility for environmental surveillance and regulatory compliance. As part of these duties, the Division manages the Laboratory's waste management, corrective action, environmental chemistry, environmental protection, and environmental restoration programs, and it maintains a record of Laboratory documents related to environmental matters. Although the Laboratory Director has primary responsibility for environment, safety, and health (ES&H) management, EM Division provides line managers with assistance in preparing and completing environmental documentation such as reports required by the National Environmental Policy Act (NEPA) of 1969 and the Resource Conservation and Recovery Act (RCRA). With assistance from the Laboratory Counsel, EM Division helps to define and recommend Laboratory policies with regard to applicable federal and state environmental regulations and laws and DOE orders and directives.

The EM Division organization and groups within the Division are shown in Figure VIII-1. EM-8 assists operating groups in complying with federal, state, local, and DOE environmental requirements. This group also bears primary responsibility for monitoring the ambient environment and evaluating past, present, and future environmental impacts of Laboratory operations. EM-8 is also responsible for obtaining permits and approvals from applicable environmental regulatory authorities and overseeing corrective actions required by compliance orders and interagency agreements with regulators.

EM-9 provides analytical services to the Laboratory's environmental, waste management, radiation protection, and industrial hygiene operations. EM-9 is responsible for QA for the health and environmental analytical work. EM-9 participates in the following Interlaboratory QAPs:

- National Institute for Occupational Safety and Health, Proficiency Analytical Testing Program;
- Environmental Monitoring and Support Laboratory, Cincinnati (EMSL-CI) Drinking Water Program;
- EMSL-CI Water Pollution Study;
- Environmental Protection Agency (EPA) Environmental Monitoring Systems Laboratory-Las Vegas;

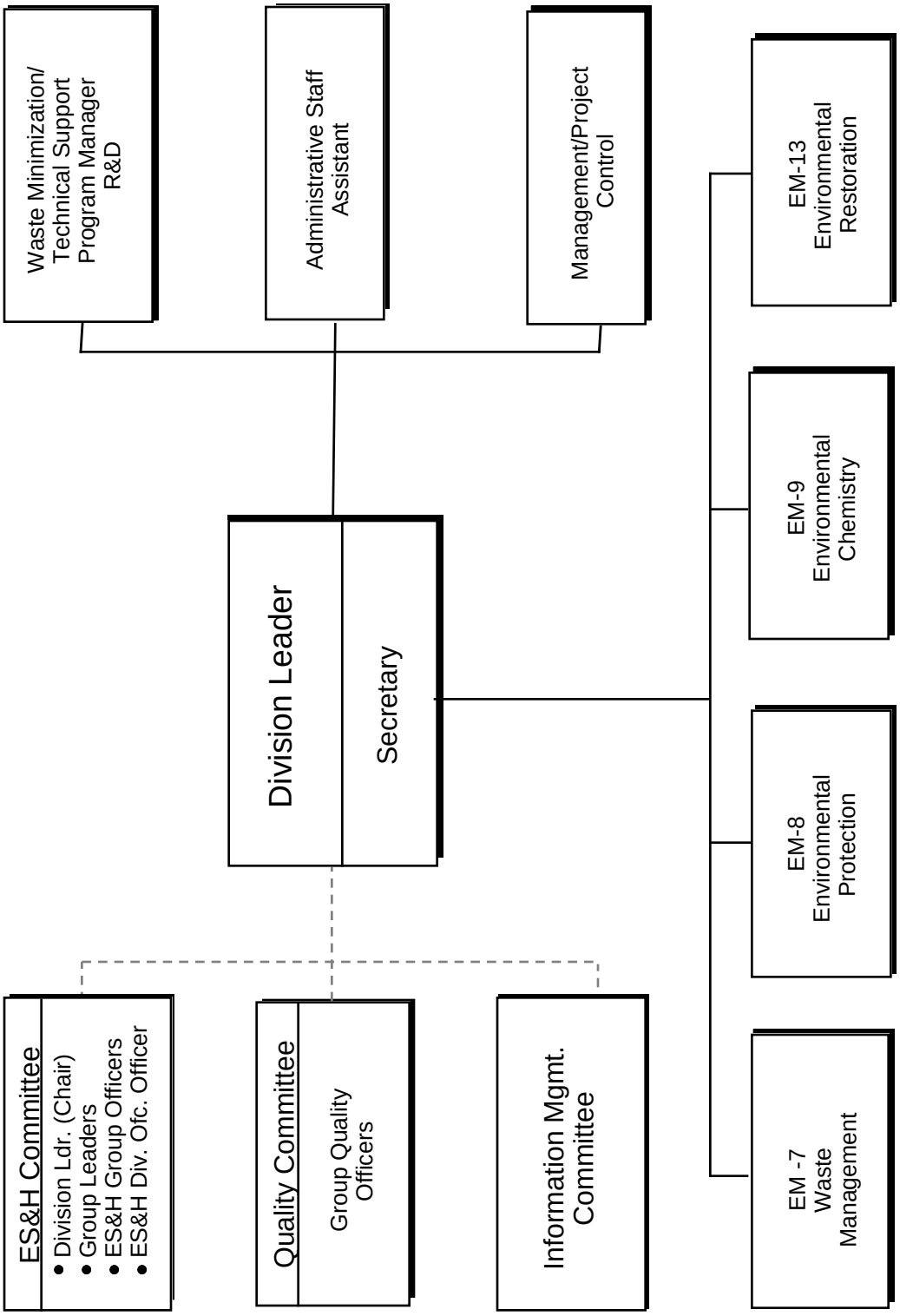


Figure VIII-1. Organizational chart for the Environmental Management Division.

- Environmental Measurements Laboratory;
- National Pollutant Discharge Elimination System (NPDES); and
- DOE Beryllium Intercomparison Study.

The Waste Management Group (EM-7) manages Laboratory-generated liquid and solid wastes to reduce the impact of the release of radioactive and hazardous materials to the environment and to ensure that requirements for regulatory compliance have been met. The Environmental Restoration Group (EM-13) is responsible for compliance with the Hazardous and Solid Waste Amendments (HSWA) and Module VIII of the RCRA Operating Permit, and it coordinates any Comprehensive Environmental Response, Compensation, and Liability Act activities at the Laboratory. The primary objective of EM-13 is to implement assessment and remediation activities as required for potential release sites and contaminated facilities at the Laboratory.

The Health and Safety Division (HS) is also key in implementing the Laboratory's environmental program. The Radiological Air Emmisions Management Group (HS-9) is responsible for tracking radiological airborne emissions from stacks around the Laboratory, for maintaining stack emission plans and QA documentation, and for preparing annual reports. HS-9 is supported in this effort by the Health Physics Operations Group (HS-1) and the Health Physics Measurement Group (HS-4). The Risk Management Support Group (HS-3) helps communicate environmental policies to Laboratory employees and ensures that appropriate environmental training programs are available, through the Policy and Guidance Section.

Several committees provide environmental reviews for Laboratory operations. The Laboratory's ES&H Questionnaire Review Committee provides reviews of proposed projects to ensure that appropriate environmental, as well as health and safety, issues are properly addressed. In 1992, the committee reviewed 308 questionnaires. The day-to-day questionnaire and review process is managed by HS-3. The Laboratory Environmental Review Committee reviews NEPA documentation for projects before submitting the documents to DOE. The ES&H Council provides senior management level oversight of environmental activities and policy development.

In 1992 the Quality Policy & Performance Directorate oversaw QA functions at the Laboratory. The Laboratory Assessment Office manages an independent environmental appraisal and auditing program that verifies appropriate implementation of environmental requirements. The Laboratory's Quality Assurance Support Office performs QA and quality control (QC) audits and surveillance of Laboratory and subcontractor activities in accordance with the QAP for the Laboratory and for specific activities, as required.

The Emergency Management Office is responsible for the Laboratory's Emergency Response 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. 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. Each monitoring activity sponsored by EM-8 has its own QAP. QAPs were unique to activities but were guided by the need to establish policies, requirements, and guidelines for the effective implementation of regulatory requirements and to meet the requirements of DOE Orders 5400.1 (DOE 1988a) and 5700.6B (DOE 1989b). Each QAP must address the following criteria:

- Organization
- Design control
- Procurement document control
- Plans, procedures, and drawings
- Document control
- Control of purchased items and services
- Identification and control of data, samples, and items
- Control of processes
- Inspection

- Test control
- Control of measuring and test equipment
- Handling, storage, and shipping
- Status of inspection, test, and operations
- Control of nonconforming items and activities
- Corrective action
- QA records
- Audits and surveillances

QAPs for each environmental monitoring program performed by EM-8 have been drafted for inclusion in the Environmental Monitoring Plan, which continues to be revised. The QAPs will be revised under DOE Order 5700.6C within two years. The Laboratory's Quality Assurance Support Office distributed the Quality Assurance Management Plan to Laboratory managers in January 1993. Training on the 10-point program will continue throughout 1993.

C. Sampling Procedures

1. Thermoluminescent Dosimeters.

Thermoluminescent dosimeters (TLDs) used at the Laboratory contain lithium fluoride (LiF) chips, 6.4 mm square by 0.9 mm thick. The TLDs, after being exposed to radiation, emit light upon being heated. The amount of light is proportional to the amount of radiation to which the TLD was exposed. The TLDs used in the Laboratory's environmental monitoring program are insensitive to neutrons, so the contribution of cosmic neutrons to natural background radiation is not measured.

The chips are annealed to 400|C (752|F) for one hour and then cooled rapidly to room temperature. This is followed by annealing at 100|C (212|F) for one hour and again cooling rapidly to room temperature. For the annealing conditions to be repeatable, chips are put into rectangular borosilicate glass vials that hold 48 LiF chips each. These vials are slipped into a borosilicate glass rack so they can be placed all at once into ovens maintained at 400|C and 100|C.

Each dosimeter contains four LiF chips, which are enclosed in a two-part threaded assembly made of an opaque yellow acetate plastic. A calibration set is prepared each time chips are annealed. The calibration set is read at the start of the dosimetry cycle. The number of dosimeters and exposure levels are determined for each calibration in order to efficiently use available TLD chips and personnel. Each calibration set contains from 20 to 50 dosimeters, which are irradiated at levels between 0 and 80 mR using an 8.5 mCi ^{137}Cs source calibrated by the National Institute of Standards (NIST) (formerly the National Bureau of Standards).

A factor of 1 mrem (tissue) = 1.050 mR is used for evaluating the dosimeter data. This factor is the reciprocal of the product of the roentgen-to-rad conversion factor of 0.958 for ^{137}Cs in muscle and of 0.994, which corrects for attenuation of the primary radiation beam at the electronic equilibrium thickness. A rad-to-rem conversion factor of l.0 for gamma rays is used, as recommended by the International Commission on Radiation Protection (John 1974, ICRP 1970). A method of weighted least-squares linear regression is used to determine the relationship between TLD reader response and dose (the weighting factor is the variance) (Bevington 1969).

The TLD chips used were all from the same production batch and were selected by the manufacturer so that the measured standard deviation in thermoluminescent sensitivity is 2.0% to 4.0% of the mean at a 10 R exposure. At the end of each field cycle, whether a calendar quarter or the Los Alamos Meson Physics Facility (LAMPF) operation 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. Samples are collected monthly at all but 1 of the 37 continuously operating stations. Samples are collected weekly from a station located on the top of the Occupational Health Laboratory (OHL) building at TA-59.

Airborne particulates are collected from the atmosphere using vacuum pumps with constant flow rates of 2 L/s (approximately 4 cu ft per minute [cfm]). The flow rates are multiplied by the total run time to determine the volume of air sampled. The particulates are collected on 60 mm diameter polystyrene filters (Microsorban), which are mounted on charcoal cartridges. The charcoal cartridge is used to quantitatively determine the presence of gaseous gamma emitters should an unplanned release occur.

The particulate filters are analyzed monthly for gross alpha and gross beta activity. Particulate filters and charcoal cartridges are also analyzed monthly using gamma ray spectrometry. The filters and cartridges collected from the OHL building at TA-59 are analyzed by the process described above on a weekly basis. Particulate filters are combined and analyzed quarterly for plutonium, americium, and uranium.

Part of the total airflow (200 cm^3/min) from the above system is passed through a cartridge containing 200 to 300 g of indicating silica gel. The silica gel absorbs atmospheric water vapor for tritium analysis. Indicating silica gel is used to determine if moisture was absorbed through the entire sample during the collection period. If the gel indicates breakthrough has occurred, the sample is discarded.

A rotameter, calibrated twice a year using a factory-calibrated flowmeter, is used to determine air flow. The total time of operation is multiplied by the average flow rate to determine the volume of air sampled. The silica gel collected monthly is heated to drive off the moisture collected from the atmosphere. The moisture is then analyzed for tritium using liquid scintillation counting.

A specific radioiodine sampling program with five 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 TEDA treated charcoal are used to collect radioiodine 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 (1 cfm) by the total time sampled. Samples are collected weekly. Filters and cartridges are qualitatively analyzed by gamma spectroscopy before they are sent to the analytical laboratory for quantitative analysis. No radioiodine was detected in 1992.

Measurements of tritium in rainwater are included in the monitoring results. This sampling program was initiated to support the Laboratory's Environmental Restoration program and was conducted by the Geology and Geochemistry Group. In the laboratory, measurement of tritium in rainwater is accomplished through ultra low-level beta counting in gas proportional counters. The tritium content of the rainwater sample is enriched through electrolysis, and then the water is reduced to hydrogen gas, which is injected into the counter and measured. The measurement is compared with background levels and standards before it is released to the investigator. Levels of tritium are given in tritium units (TU): one TU is 3.2 pCi/L of water.

b. Radioactive Air Emissions Monitoring. Samples are collected at weekly intervals from 88 monitors. Sample collection and analysis are performed by personnel from HS-1 and HS-4.

The typical system for monitoring particulate radioactivity in stack emissions consists of one or more sampling or monitoring probes that continuously extract a representative sample from the stack exhaust stream through the use of an air sampling pump that passes the sample through a filter on which the particles are trapped. The pumps typically sample at a rate of 2 cfm. The filter, with its trapped particles, is then analyzed for radioactivity. The filters are counted for either gross alpha or gross beta activity depending on the isotope(s) that are emitted from the stack. To determine the total activity released, the radioactivity on the sample filter is multiplied by the ratio of the total stack flow (during the sampling period) to the volume of air sampled by the pump during the sampling period. This total activity is expressed in microcuries or curies. The radioisotopes of plutonium are not listed separately because the gross alpha analysis count does not distinguish between the individual isotopes of plutonium. Likewise, the gross beta counts analysis does not distinguish between the individual radioisotopes in the group called mixed fission products.

The typical system for monitoring an effluent or exhaust stream for airborne tritium in the gaseous form (HT, DT, T^2) is basically an in-line system in which one or more sampling or monitoring probes continuously extract a representative sample from the stream and direct it to remotely located tritium measuring instruments through metal

tubing (or lines). The instruments measure the tritium concentration and, in conjunction with the effluent exhaust rate, the total ^3H activity (in curies) released to the environment over a period of time. At LAMPF, the tritium in the form of water (HTO) is captured on silica gel, which is changed monthly so that the ^3H activity can be counted. At other facilities such as the Tritium Systems Test Assembly (TSTA) the effluent containing ^3H activity is captured in a bubbler system so that the quantities of tritium in HT or HTO can be distinguished.

At LAMPF, the particulate/vapor activation products are captured on paper filters in the case of particulates or on charcoal filters in the case of vapor products, and total radioactivity is counted. Gaseous mixed activation products are counted in a flow-through air ionization chamber to determine total radioactivity. Isotopic ratios are measured using high purity germanium (HPGe) detectors. Stack flow rates are measured by Johnson Controls Inc. (JCI) using flowmeters that are calibrated at least quarterly using magnehelic gauges that are traceable to NIST standards.

The following procedures have been documented and approved by the Health Physics Policy and Programs Group (HS-12):

- the calibration of flowmeters used in stack effluent sampling;
- traverse flow measurements;
- Sutorbilt maintenance procedures;
- assembly and service of Sutorbilt air sampling system (air sampling pumps used to collect stack air samples);
- calibration procedures of magnehelic gauges (to calibrate the flowmeters); and
- special monitoring instructions for air sampling.

The following procedures have been documented and approved by HS-4:

- instrumentation and calibration;
- instrument issue and recall;
- calibration of fixed tritium measuring instruments at TSTA, TA-3-16, TA-21-209, TA-33-86, TA-35-213, TA-55-PF4, TA-16-205;
- calibration procedures for the TSTA stack bubbler;
- calibration and maintenance of the TA-55 CAM facility, TA-3-40-RM E28;
- gamma spectroscopy of stack filters and water samples from LAMPF;
- operation of the IMPULSE alpha analysis system (used to transfer data from HS-4 to databank on OF-VAX computer); and
- liquid scintillation analysis.

c. Nonradioactive Air. The criteria pollutant monitoring station owned by the Laboratory is located south of TA-49, adjacent to Bandelier National Monument. This station, which began operation in the second quarter of 1990, continuously monitors air concentrations of nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Filters to trap small particulate matter (less than 10 µm in diameter - PM_{10}+) are collected every 6 days and weighed. Once each month, the New Mexico Environment Department (NMED) audits the flow rate of the instrumentation.

Atmospheric visibility is also analyzed using a transmissometer. A 10 minute measurement is taken every hour, on a 24 h/day basis. The visibility is measured between TA-49 and TA-33, a distance of 4.58 km (2.84 mi). Air Resources of Fort Collins, Colorado, is responsible for data quality.

Acid deposition from precipitation is measured once per week. Water samples are examined in the field for visible contamination, pH, and electrical conductivity. Samples are sent to Colorado State University (CSU) to be further analyzed for inorganic content and pH. Blind samples are audited by CSU twice per year, and equipment checks are made once every three years.

Beryllium is monitored on the continuous ambient air monitors that are operated as part of the ambient radionuclide monitoring system. The samples are taken using a flow rate of 6 cfm. The flow rate is calibrated to a dry gas flow meter which in turn is calibrated to a NIST spirometer. The equipment operates continuously, and samples are collected monthly. A composite of the monthly samples is generated quarterly.

3. Water Sampling.

a. Surface Water and Groundwater. Surface water and groundwater sampling stations are grouped by location (off site regional, off site perimeter, and on site) and hydrologic similarity. Water samples are collected once a year. Samples from wells are collected after sufficient water has been pumped or bailed to ensure that the sample is representative of the aquifer. Spring samples (groundwater) are collected at the discharge point.

The water samples are collected in 4 L polyethylene bottles for radiochemical analyses. The 4 L bottles are acidified in the field with 5 mL of concentrated nitric acid and then are returned to the laboratory within a few hours of sample collection for filtration through a 0.45-µm membrane filter. The samples are routinely analyzed for ^{3}H, ^{137}Cs, uranium, ^{238}Pu, and $^{239,240}Pu$, as well as for gross alpha, beta, and gamma activities. Selected samples are also analyzed for ^{241}Am, ^{90}Sr, and accelerator-induced activation products. Analytical methodology and its QAP are discussed in Section VIII.D. Detailed container and preservation requirements of EM-9 are documented in a handbook (Williams 1990).

Water samples for inorganic and organic chemical analyses are collected at the same time. Most samples collected for inorganic analyses are put into three 1 L polyethylene bottles: one with no additives, one with sulfuric acid, and one with nitric acid to provide the proper range of preservatives for the analysis performed. When necessary, additional containers with appropriate preservatives are collected for mercury, cyanide, and sulfide analyses. For selected samples, additional glass containers are collected for organic analyses. Details of container and preservation requirements, and identification of EPA methodology for each analysis are contained in the EM-9 handbook (Williams 1990).

Samples of run-off are analyzed for radionuclides in solution and suspended sediments. The samples are filtered through a 0.45 µm filter. Solution is defined as the filtrate passing through the filter; suspended sediment is defined as the residue on the filter.

b. National Pollutant Discharge Elimination System. Personnel from EM-8 complete sample collection, preservation, and field analysis of the Laboratory's industrial outfall discharges that are regulated through NPDES permits. Industrial effluent samples are collected for specific parameters at the monitoring frequencies and locations specified in the NPDES permit. Monitoring is conducted according to EPA-approved methods documented in 40 CFR Part 136 and NPDES Permit Nos. NM0028355 and NM0028576. Chain-of-custody (COC) procedures for sample collection and analysis are conducted during sampling for NPDES industrial compliance.

EM-9 analyzes industrial discharges for pollutants listed in the NPDES permits. Samples are tested according to EPA-approved methods documented in 40 CFR Part 136, "Guidelines Establishing Test Procedures for Analysis of Pollutants under the Clean Water Act; Final Rule and Technical Amendments" (EPA 1991) or otherwise specified in the NPDES permits.

Treated effluent samples are collected from the sanitary treatment plants by JCI Environmental (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 for sample collection and analysis. JENV conducts the sanitary wastewater testing for pollutants listed in the NPDES permit. Testing procedures are conducted according to the seventeenth edition of "Standard Methods for the Examination of Water and Wastewater" (APHA 1989) and other conditions specified by the NPDES permit.

All instruments used for sanitary and industrial field and laboratory analyses are routinely serviced and calibrated; records are properly maintained. Measurements are made in accordance with the NPDES permit QA requirements, 40 CFR Section 122.41. QA procedures include the use of duplicate, replicate, and spike analyses; sample splits; outside reference samples; blanks; reagent blanks to check for sources of error; and method verification. Both JENV and the EM-9 laboratories participate in the National Discharge Monitoring Report Quality Assurance Program. EM-9 also participates in the EPA Water Pollution Study for blind spike analyses. The Laboratory's NPDES program is subject to compliance evaluation inspections by EPA and NMED on an annual basis.

c. Storm Water Sampling and Data Collection. Data that characterize storm water discharges are valuable to authorities issuing permits and the recipients of permits for several reasons. First, storm water sampling provides a means for evaluating the environmental risk of storm water discharge by identifying the types and amounts of pollutants present. Evaluating these data helps to determine the relative potential for the storm water discharge to

contribute to violations of water quality standards. Storm water sampling data can also be used to identify sources of pollutants. These sources can then be either eliminated or individually controlled through the permit.

With this in mind, LANL targeted specific areas from the list of identified industrial facilities within the Laboratory to monitor storm water discharges. Each site was examined to determine existing point source discharges of storm water run-off and to list potential pollutant sources exposed to rainfall.

Beginning in spring 1991, wooden flumes were installed so that storm water run-off could be manually collected. The sites were selected to obtain representative data from a variety of locations around the Laboratory. Each flume was placed in the drainage believed to be the most representative and/or "worst case" (with the highest potential for containing pollutants) for each location.

Twenty-five sites were selected for storm water monitoring, and run-off from eight of these was sampled during storm events from May through August 1992. Both grab and composite samples were taken using EPA protocols under the direction of EM-8. The samples were then shipped to an independent analytical laboratory for testing. The list of parameters tested for are from the list of 126 primary pollutants (40 CFR 423, Appendix A), selected from 2F Part VII Pollutants and Radiochemistry.

d. Safe Drinking Water Act. The sampling program for drinking water quality is designed to meet or exceed regulatory requirements under the Federal Safe Drinking Water Act (SDWA) and the New Mexico Environmental Improvement Act. Sampling locations, frequencies, preservation, handling, and analyses follow the requirements specified in federal and state regulations. Samples are drawn from the individual water supply well heads for volatile organic compounds (VOCs) and microbiological analyses. Samples for all other types of analyses for regulatory compliance are drawn from the taps in the water distribution system.

Samples are drawn at taps on the individual water supply well heads for VOCs at least once every year. Samples are collected in 40 mL glass septum vials. Travel blanks are submitted with the well head VOC samples.

Well head samples are drawn on a monthly basis for microbiological quality, which include total coliforms and noncoliforms analyses and heterotrophic plate counts. Autoclaved 100 mL polyethylene bottles are used to collect microbiological samples.

Samples for inorganic chemicals and radiochemistry are collected annually from locations in the distribution system that are representative of the well fields and major service areas. Samples are collected in 1 L polyethylene containers.

Trihalomethane (THM) samples are collected on a quarterly basis from six sampling locations spread throughout the distribution system. These are Barranca Mesa School, North Community Fire Station, Los Alamos Airport, White Rock Fire Station, S-Site Fire Station, and TA-33, Building 114. The sample containers are 40 mL glass septum vials. Travel blanks are submitted with the distribution system THM samples.

Microbiological samples are also collected throughout a network of approximately 80 locations throughout the distribution system. The sampling sites are rotated so that at least 40 samples from throughout the system are taken each month. Samples are analyzed for total coliforms, fecal coliforms, and noncoliform bacteria. Autoclaved 100 mL polyethylene bottles are used to collect microbiological samples.

Microbiological sampling and analyses are performed by personnel of the JENV, certified by the State of New Mexico for microbiological compliance analysis. Certification requirements include proficiency samples, maintenance of an approved QA/QC program, and periodic audit by the State Scientific Laboratory Division (SLD).

Chemical and radiochemical sampling is performed by LANL staff certified by NMED to do drinking water compliance sampling. These samples are sent to SLD in Albuquerque for analysis. The SLD QA/QC program is certified by the EPA.

4. Soil and Sediment Sampling.

The soil sampling procedure involves taking five plugs, 75 mm (3.0 in.) in diameter and 50 mm (2.0 in.) deep, at the center and corners of a 10 m (33 ft) square area. The five plugs are combined to form a single composite sample for radiochemical analyses.

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 soil or 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 ^{3}H.

5. Foodstuffs Sampling.

Produce from off site and on site is sampled annually. Fish from reservoirs upstream and downstream from the Laboratory are sampled annually. Bees and honey are also sampled.

Produce and soil samples are collected from local gardens in the fall of each year (Salazar 1984). Each produce or soil sample is sealed in a labeled plastic bag. Samples are refrigerated until prepared for chemical analyses. Produce samples are washed, as if prepared for consumption, and quantitative wet, dry, and ash weights are determined. Soils are split and dried at 100|C (212|F) before analysis. A complete sample bank is kept until all radiochemical analyses have been completed. Water is distilled from samples and submitted for tritium analysis. Produce ash and dry soil are submitted for analyses of ^{90}Sr, ^{137}Cs, uranium, ^{238}Pu, and ^{239,240}Pu.

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 of ^{90}Sr, ^{137}Cs, uranium, ^{238}Pu, and ^{239,240}Pu.

Bees and honey are collected by a professional (contract) bee keeper. Approximately 500 g of bees are collected. The frames of honey are enclosed in large plastic bags, marked for identification, and transported in an ice chest to the laboratory. At the laboratory, the honey is separated from the combs into 500 mL polyethylene bottles by a heat lamp. The bees and honey samples are submitted directly for radiochemical analyses.

6. Meteorological Monitoring.

For the most part, meteorological monitoring sites are located 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 caused by the tower is minimized for prevailing southerly flow during the day and westerly flow during the night. All temperature sensors are aspirated to minimize radiative effects. Towers are located in open areas where anemometers and rain gauges are outside the wake effects of trees and buildings, and upward looking radiometers have an unrestricted view of the sky. The measurements of temperature, humidity, and surface energy fluxes are thought to be representative of the measurements from natural meadows found in the transition zone between piñon and juniper woodlands and ponderosa pine forest.

Each tower has its own data logger programmed to handle all signal conditioning, computation of statistical values, and interim data storage. Data loggers are automatically called by computers every 15 minutes via standard phone lines and modems. Once in the computers, the data are processed to generate summary tables and plots for characterizing current and past conditions and for quality control.

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 the measured variables. Quantifying the representativeness of the wind measurements is an especially difficult task. Adequacy of the current network of four towers depends on meteorological conditions and on the applications of the data. When the data are used to compute statistics for periods of several days or more, results for a particular tower site are thought to be representative of an area (on the plateau) a few kilometers in radius. When the application is modeling plume transport in a stable atmosphere, this radius may shrink to a few hundred meters.

Because the atmospheric state variables (temperature, pressure, and moisture) depend mostly on elevation, interpolation between measurement sites is usually well justified.

The current rain gage network documents the east-to-west gradient in the annual precipitation well enough for most purposes; however, the seven station network is inadequate for delineating smaller scale spatial or temporal patterns.

The components of the surface radiation and energy balances are expected to show considerable spatial variability; however, most applications using these data have not required great accuracy. Recent inquiries about evapotranspiration, which is related to the latent heat flux, may make it necessary to revise measurement strategies in this area.

Most signals are sampled every 3 s and averaged over 15 min so there are 300 samples per average signal. This averaging filters out most of the fluctuations that are generally attributed to turbulence. The 15 min average for

wind is used to represent the mean wind. The standard deviations of the fluctuations in the vertical speed and horizontal wind direction are also computed every 15 min (also based on an average sample size of 300), and the results are used to characterize the turbulence in the vertical and horizontal planes, respectively.

Signals used in estimating turbulent eddy fluxes are sampled at 2 Hz and are combined in a covariance calculation every 15 min; thus the sample size for the flux variables is 1,800.

The sonic, detection, and ranging (SODAR) variables give spatial as well as temporal averages of the wind. The SODAR system is a remote sensing device that samples the wind over 30 m (98 ft), nonoverlapping layers from 60 to 720 m (197 to 2,360 ft) above the ground, depending on conditions. Each layer is sampled once every 16.7 s and averaged over 15 min. This gives a maximum sample size of 54; however, in practice the sample size is often less than 54 because conditions are often less than optimal for acoustic returns. Studies (for example, Kaimal 1984) show that the root-mean-square (RMS) difference between tower- and SODAR-derived wind directions is approximately 25|, and the RMS difference in speed is approximately 1 m/s (3.2 ft/s). Preliminary comparisons between tower- and SODAR-derived winds at the TA-6 site show that the RMS difference is close to 20|. However, much larger differences have been observed at times, especially below 120 m (394 ft), and these have been attributed to spurious echoes that occur at the TA-6 site under certain conditions. Efforts have been made to minimize this echo interference. The SODAR system also calculates RMS values of wind direction and vertical speed; however, because of the small sample size, little confidence can be placed in estimates.

All instrumentation is audited twice during the year. The winter audit is conducted by local staff and the summer audit is conducted by an external, independent contractor. No significant problems were identified by either audit in 1992 (META 1992).

Quality control of the data consists of automatic edits based on range checking, a daily review of computer-generated tables and plots, and weekly inspection of time series plots of all signals. The fraction of high-quality data recovered during the year exceeded 95%.

D. Analytical Chemistry

1. Methodology.

a. Introduction. Most analytical chemistry services are provided by the Laboratory's EM-9 Group. The EM-9 Sample Management Section functions as an interface between the group and its customers. This section provides the sample collector with presampling information about sample containers, sample volumes, and sample preservation techniques. Collection of samples for chemical and radiochemical analyses follows a set procedure to ensure proper sample collection, documentation, submittal for chemical analysis, and posting of analytical results. Before sample collection, the Sample Management Section discusses the schedule and procedures to be followed with the sample collector. The discussion includes

- number and type of samples;
- type of analyses and required limits of detection;
- proper sample containers;
- preparation of sample containers with preservative, if needed; and
- sample schedule to ensure minimum holding time so that analyses comply with EPA criteria.

After a sample is collected, it is delivered to the EM-9 Sample Management Section, where the pertinent information is entered into the EM-9 Laboratory Information Management System, and the request is given a form number. Each number, representing a single sample, is assigned to a particular station and is entered into the collector's log book. The processing of samples includes (1) validating all samples for sampling correctness and integrity, (2) scheduling and labeling all samples for analysis, (3) initiating internal COC procedures for all samples, and (4) arranging for the proper disposal of any unused portions of samples.

The request form number is entered in the collector's log book opposite sample numbers submitted, along with the date the sample was delivered to EM-9. EM-9 provides COC forms for the samples once they are received if COC did not begin in the field. The date, time, temperature (if the sample is water), and other pertinent information and remarks are entered opposite the sample number and station previously listed in the log book. The sample container is labeled with station name, sample number, date, and preservative, if added.

The analytical request form contains the following information related to ownership and the program submitted: (1) requester, i.e., sample collector; (2) program code; (3) sample owner, i.e., program manager; (4) date; and (5) total number of samples. The second part of the request form contains (1) sample number or numbers; (2) medium, e.g., water; (3) types of analyses, i.e., specific radionuclide and/or chemical constituents; (4) technique, i.e., analytical method to be used for individual constituents; (5) analyst, i.e., chemist to perform analyses; (6) priority of sample or samples; and (7) remarks. One copy of the form goes to the collector for filing, one is kept by the Sample Management Section, and the other copies accompany the sample.

The analytical results are returned to the sample collector, who posts the data according to sample and station taken from the log book. These data sheets are included in the final report.

b. Radioactive Constituents. Environmental samples are routinely analyzed for the following radioactive constituents: gross alpha, beta, and gamma; isotopic plutonium; americium; uranium; cesium; tritium; and strontium. Detailed procedures are published in the EM-9 Analytical Methods Manual (Gautier 1986). Occasionally, other radionuclides from specific sources are determined: ^{7}Be, ^{22}Na, ^{40}K, ^{51}Cr, ^{60}Co, ^{65}Zn, ^{83}Rb, ^{106}Ru, ^{134}Cs, ^{140}Ba, ^{152}Eu, ^{154}Eu, and ^{226}Ra. All but ^{226}Ra are determined by gamma-ray spectrometry on large HPGe detectors. The requirements for detection of ^{137}Cs in drinking water have been lowered to 10 pCi/L. To achieve this detection limit, a HPGe detector was reconfigured in a new shielded chamber that provides lower background. This detector appears to be able to attain the 10 pCi/L detection limit. Many of the 1992 water samples were counted in this new configuration. Depending on the concentration and matrix, ^{226}Ra is measured by emanation or by gamma-ray spectrometry of its ^{214}Bi decay product.

During 1992, the criteria for uranium analyses were changed to require lower detection limits and better estimates of the ^{238}U/^{234}U activity ratio. These requirements were achieved through measurement by alpha spectrometry. Depending on the need, uranium analyses for 1992 were performed by the following methods. An inductively coupled plasma mass spectrometer (ICPMS) was used for total uranium determination for water samples and for some high mass samples. Alpha spectrometry was used for air and water samples where the ^{234}U concentration was of interest. ICPMS and alpha spectrometry were used for the determination of ^{235}U in soil samples when the level of enrichment or depletion was of concern. Delayed neutron activation (DNA) was used for most high mass samples until the Omega West Reactor was shut down. Kinetic phosphorimetric analysis (KPA) was initiated to replace DNA.

The KPA method appears to be very useful for uranium determinations where total uranium results are adequate. The procedure has detection limits below ambient levels for all media analyzed to date and appears to be less costly than other methods. KPA will be the method of choice for total uranium determination for all media that were previously analyzed by DNA.

c. Stable Constituents. A number of analytical methods are used for various stable isotopes. The choice of method is based on many criteria, including the operational state of the instruments, time limitations, expected concentrations in samples, quantity of sample available, sample media, and EPA regulations. Instrumental techniques available include neutron activation, atomic absorption, ion chromatography, color spectrophotometry (manual and automated), potentiometry, combustion analysis, ICPMS, and inductively coupled plasma atomic emission spectrometry. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capabilities include flame, furnace, and cold vapor, as well as flame emission spectrophotometry. The methods used and references for determination of various chemical constituents are presented elsewhere (Gautier 1986).

d. Organic Constituents. Environmental soil and water samples are analyzed using EPA procedures outlined in EPA SW-846 (EPA 1989d) or modified procedures (Gautier 1986) that meet QA criteria outlined in Chapter 1 of SW-846, as shown in Table VIII-1. Methods used are supported by documented spike/recovery studies, method and field blanks, matrix spikes, surrogate spikes, and blind QC samples. VOCs are analyzed using Method 8260, SW-846. Tables D-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 (pore-gas) monitoring is performed by collecting organic vapors on charcoal, extracting the charcoal with CS_2 and analyzing the CS_2 extracts using gas chromatography/mass spectrometry (GC/MS). Soil-gas target compounds are listed in Table D-23, and the Toxicity Characteristics Leaching Procedure (TCLP) target compounds are listed in Table D-24.

Instruments available for organic analysis include GC/flame ionization detector, GC/electron capture detector, GC/MS, high performance liquid with ultraviolet (UV) and refractive index detectors, a Fourier transform infrared spectrometer, and a UV/visible spectrophotometer. Sample preparation methods include: Soxhlet extraction, ultrasonic extraction, continuous liquid/liquid extraction, Kuderna Danish concentration, evaporative blowdown, and gel permeation chromatography cleanup of sample extracts.

Table VIII-1. Method Summary (Organic Compounds)

Analyte	Matrix	Method[a]	Technique[b]
VOCs	Air	+	GC/MS
	Soil	8260	PAT/GC/MS
	Water	8260	PAT/GC/MS
TCLP	Soil	1311; 8080; 8150; 8260; 8270	GC/ECD
PCBs	Water	8080	GC/ECD
	Soil	8080	GC/ECD
	Oil	IH 320	GC/ECD
SVOCs	Soil and waste	8270	GC/MS

[a]Industrial hygiene (IH).

[b]Gas chromatograph (GC), purge and trap (PAT), electron capture detection (ECD), and mass spectrometer (MS).

Organic mixed waste analyses are performed for samples containing up to 100 nCi/g (solids/sludges) or 100 nCi/L (solutions) alpha, beta, or gamma. Higher level samples are analyzed on a case-by-case basis. New methods are being developed for routine analysis of mixed waste greater than 100 nCi/g (or 100 nCi/L).

2. Quality Evaluation Program.

a. Introduction. Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of several general types: calibration standards, reagent blanks, process blanks, matrix blanks, duplicates, spikes, and reference materials. Analysis of control samples fills two needs in analytical work: (1) it provides QC over analytical procedures so that problems that might occur can be identified and corrected, and (2) data obtained from analysis of control samples permit evaluation of the capabilities of a particular analytical technique to determine a given element or constituent under a certain set of circumstances.

Blind QC samples are numbered to resemble unknown samples in a set. The concentrations of the analytes of interest are not revealed until after the data have been formally reported. These samples are submitted to the laboratory at regular intervals and are analyzed in association with other samples; that is, they are not handled as a unique set of samples. Up to 10% of stable constituent, organic, and selected radioactive constituent analyses are run as QC samples using the materials described above. A detailed description of EM-9's QAP and a complete listing of results have been published annually since 1976 (Gautier 1991).

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, ^{3}H, ^{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 intercomparison program. NIST provides several soil and sediment standard reference materials (SRMs) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{238}Pu, ^{239}Pu, ^{241}Am, and several other nuclides. The DOE's Environmental Measurements Laboratory also provides QA samples.

Soil, rock, and ore samples obtained from the Canadian Geological Survey (CGS) are used for QA of uranium and thorium determinations in silicate matrices. EM-9's own in-house standards are prepared by adding known quantities of liquid SRMs for radioactivity, prepared by NIST to blank matrix materials.

c. Stable Constituents. QA for the stable constituent analysis program is maintained through analyses of certified or well-characterized environmental materials. NIST has a large set of silicate, water, and biological SRMs. EPA distributes standards for minerals and other trace constituents in water . Rock and soil reference materials have been obtained from the CGS and the United States Geological Survey. Details of this program have been published elsewhere (Gautier 1991). Stock solutions of inorganic analytes are prepared and spiked on blank matrices by EM-9's Quality Assurance Section.

The analytical QC program for a specific batch of samples is a combination of many factors. These include the "fit of the calibration," instrument drift, calibration of the instrument and/or reagents, recovery for SRMs, and precision of results.

d. Organic Constituents. Soil samples are analyzed for VOCs, SVOCs, pesticides, and herbicides for compliance work done under RCRA. Certified matrix-based reference materials are not available for these analyses, so stock solutions of the analytes are prepared and spiked directly on blank soil by the Quality Assurance Section. Because homogeneity of the sample can not 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 1992 were environmental compliance samples analyzed for pesticides, herbicides, 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. QC samples for PCBs are prepared by diluting EPA standards or by preparing standards in hexane from the neat analyte. In the United States, the only PCBs that have been found in transformers have been PCBs 1242, 1254, and 1260. Samples submitted for analysis have contained only these PCBs, so only these have been used to spike QC samples. Vacuum pump oil was chosen for the oil base blank after an experiment with various brands of motor oil was complicated by excessive matrix interferences.

3. Data Handling of Radiochemical Samples.

Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the

analytical technique. Consequently, individual measurements can result in values of positive or negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is determined from the propagated sources of analytical error.

Standard deviations for the station and group (off-site regional, off-site perimeter, and on site) means are calculated using the following equation:

where

ci = sample i,

$^{\infty}c^{+}$ = 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:

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):

Standard deviations of *R* are calculated assuming a normal distribution of the population of analytical determinations (*N*):

These calculated values are presented as the EM-9 "Ratio | Std Dev" in Tables D-25 to D-33. 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, 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:

where $_X+_E$ is the experimentally determined mean elemental concentration based on *N* measurements, and $_X+_C$ is the certified or consensus mean elemental concentration. The total standard deviation, S_T, of X_E - X_C is given by:

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.
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:

The test statistics used in this document are based on 5% and 0.2% levels of significance. The respective critical regions are defined for values of z between 2 and 3. Data having a calculated z value 2 are accepted as in control at the 5% level of significance. Data that have a calculated z value >2 and 3 are considered at the warning level, or the 0.2% level of significance. Data with a z value >3 are considered out of control. These test statistics are also incorporated in the QACHECK computer program.

The percentage of the tests for each parameter where $_X+_E$ - $_X+_C$ fell within 2 S_T (under control), between 2S_T and 3S_T (warning level), or outside >3S_T (out of control) is shown in Tables D-26 to D-33. A summary of the overall state of statistical control for analytical work done by EM-9 is also provided in Table VIII-2.

Table VIII-3 summarizes recovery information on organic surrogate compounds required for use in the EPA-Contract Laboratory Program protocol. Table VIII-4 summarizes EM-9's overall record of meeting EPA SW-846-specified holding times for samples during 1992. The data include all samples for which holding times were missed and the customer elected to either resample or accept the data as usable. Table D-34 reports the incidence of false positive results for blank QC samples and false negative results for spiked QC samples at the 95% confidence level.

For all radiochemical and inorganic analyses, more than 90% are within <2 propagated standard deviations of the certified/consensus mean values (under control). EM-9's performance on most classes of inorganic matrices and

most classes of radiochemical matrices has remained virtually unchanged since 1991, while it improved its analyses for radiochemicals in biological samples. Most stable element matrices were in control and were unchanged from 1991 but the overall control of stable elements on filters declined compared with the 1991 record. This area will be the focus of increased QA/QC efforts in the future. Data on analytical detection limits are given in Table D-35.

Table VIII-2. Overall Summary of EM-9 Quality Assurance Tests for 1992

Analysis	No. of QC tests with CV[a]	Under Control $<2S_T$ (%)	Warning $2\|3S_T$ (%)	Out of Control $>3S_T$ (%)
Stable Elements				
Filters	14	71	29	+
Soil	432	86	6	8
Water	3,470	95	3	2
Radiochemical Elements				
Biologicals	53	94	6	+
Filters	240	96	2	2
Soils	455	92	4	4
Water	1,007	97	2	1
Organic Compounds				
Filters	224	99	1	+
Bulk Materials	464	96	1	3
Soil	3,918	95	2	3
Charcoal Tube	1,712	95	4	1
Water	1,179	94	2	4

[a]CV = Certified values.

Table VIII-3. Summary of Organic Surrogate Compounds as Required for Compliance with EPA SW-846 Criteria for 1992

Analysis	EPA SW-846 Range Low	EPA SW-846 Range High	Number of Surrogates In-Range	Number of Surrogates Total	% In-Range	% of Samples Run with Surrogate
Volatile Organic Compounds						
In Soil						
1,2-Dichloroethane d4	70	121	181	210	86	100
Toluene d8	81	117	193	210	92	100
4-Bromofluorobenzene	74	121	192	210	92	100
In Water						
1,2-Dichloroethane d4	76	114	70	88	80	98
Toluene d8	88	110	66	88	75	98
4-Bromofluorobenzene	86	115	81	88	92	98
Semivolatile Organic Compounds						
In Soil						
2-Fluorophenol	25	121	355	372	95	100
Phenol d6	24	113	363	372	98	100
Nitrobenzene d5	23	120	363	372	98	100
2-Fluorobiphenyl	30	115	360	372	97	100
2,4,6-Tribromophenol	19	122	359	372	97	100
p-Terphenyl d14	18	137	330	372	89	100
In Water						
2-Fluorophenol	21	100	57	73	78	100
Phenol d6	10	94	61	73	84	100
Nitrobenzene d5	35	114	56	73	77	100
2-Fluorobiphenyl	43	116	56	73	77	100
2,4,6-Tribromophenol	10	123	71	73	97	100
p-Terphenyl d14	33	141	55	73	75	100
Pesticides						
In Soil						
Dibutyl chlorendate	20	150	95	101	94	100
In Water						
Dibutyl chlorendate	24	154	12	13	92	100

Table VIII-4. EM-9's Record for Meeting EPA SW-846-Specified Holding Times during 1992

Organic Analysis Type	Number of Analyses Meeting EPA Critera	Total Number of Analyses Performed	% Within EPA Criteria
Extraction holding times			
Volatiles in soils	150	158	95
Volatiles in waters	59	68	87
Semivolatiles in soils	341	342	100
Semivolatiles in waters	41	49	84
Pesticides in soils	75	75	100
Pesticides in waters	7	7	100
Herbicides in soils	47	48	98
Herbicides in waters	5	6	83
PCBs in soils	185	252	73
PCBs in waters	26	28	93
Instrument analysis holding times			
Volatiles in soils	158	158	100
Volatiles in waters	68	68	100
Semivolatiles in soils	342	342	100
Semivolatiles in waters	49	49	100
Pesticides in soils	75	75	100
Pesticides in waters	7	7	100
Herbicides in soils	48	48	100
Herbicides in waters	6	6	100
PCBs in soils	252	252	100
PCBs in waters	15	28	54

IX. PUBLICATIONS

N.M. Becker, "Quantification of Uranium Transport away from Firing Sites at Los Alamos National Laboratory|A Mass Balance Approach," in *Proceedings of the Symposium on Waste Management, Working Towards a Cleaner Environment*, R.G. Post, Ed., March 1-5, Tucson, Arizona (1992).

N.M. Becker, "Explosives in Soils Resulting from Dynamic Testing and Machining," presentation at 11th Rocky Mountain Regional Meeting, American Chemical Society, June 10-12, Albuquerque, New Mexico (1992).

N.M. Becker and E.B. Vanta, "Uranium Transport Investigations Near Firing Sites|Leaching Analyses," paper presented at 11th Rocky Mountain Regional Meeting, American Chemical Society, June 10-12, Albuquerque, New Mexico (1992).

R.W. Ferenbaugh, E.S. Gladney, L.F. Soholt, K.A. Lyall, M. K. Wallwork-Barber, and L.E. Hersman, "Environmental Interactions of Sulphlex Pavement," *Environmental Pollution* **76**, 141-145 (1992).

M.A. Gautier, G.H. Brooks, E.S. Gladney, E.A. Jones, N. Koski, W.D. Moss, and B.T. O'Malley, "Quality Assurance for Health and Environmental Chemistry: 1991," Los Alamos National Laboratory report LA-12436-MS (1992).

E.S. Gladney, and R.W. Ferenbaugh, "Elemental Analysis of Saguaro National Monument Soils," an invited presentation at the Saguaro National Air Quality Review, September 1-4, Tucson, Arizona (1992).

E.S. Gladney, R.W. Ferenbaugh, and K.W. Stolte, "An Investigation of the Impact of Inorganic Air Pollutants on Saguaro National Monument," in *Proceedings of the Symposium on Research in Saguaro National Monument*, C.P. Stone and E. S. Bellatoni, eds., (USDI National Park Service 1992), pp. 223-234.

A.R. McFarland and J.C. Rodgers, "Use of Shrouded Probes for Sampling Stacks and Ducts," Los Alamos National Laboratory report, in press (1992).

Pajarito Ornithological Survey, "Atlas of the Breeding Birds of Los Alamos County, New Mexico," Los Alamos National Laboratory report LA-12206 (October 1992).

J.C. Rodgers, "Representative Sampling and Monitoring of Airborne Radioactive Effluent at Los Alamos National Laboratory," Los Alamos National Laboratory report, in press (1992).

T.M. Sandoval, C. Jacquez, L. Hupke, "1992 Annual PCB Document for Los Alamos National Laboratory," Los Alamos National Laboratory report LA-UR-92-2628 (July 1992).

A.K. Stoker, S.G. McLin, W.D. Purtymun, M.N. Maes, and B.G. Hammock, "Water Supply at Los Alamos during 1989," Los Alamos National Laboratory report LA-12276-PR (May 1992).

X. REFERENCES

Abrahams 1966: J.H. Abrahams, Jr., "The Hydrology and the Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, NM, January 1956 through June 1975," USGS Administrative Release (January 1966).

Adams 1991: A.I. Adams and F. Goff, "A Regional Study of Stable Isotopes and Tritium in Precipitation in the Los Alamos Region of New Mexico," (abs): Geol Soc Amer., Abs with Programs, v. 23, no. 5, p. 115.

APHA 1989: American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, Standard Methods for the Examination of Water and Wastewater, Seventeenth ed. (American Public Health Association, Washington, DC, 1989).

Aron 1965: G. Aron and V.H. Scott, "Simplified Solutions for Decreasing Flow in Wells," *Journal of the Hydraulics Division, American Society of Civil Engineers*, 91 (HY 5), pp. 1-12 (1965).

Becker 1985: N.M. Becker, W.D. Purtymun, and N.M. Maes, "Movement of Depleted Uranium by Storm Runoff," in "Environmental Surveillance at Los Alamos in 1984," Los Alamos National Laboratory report LA-10421-MS, pp. 75-80 (April, 1985).

BEIR IV 1988: National Research Council, Committee on the Biological Effects of Ionizing Radiations, "Health Risks of Radon and Other Internally Deposited Alpha Emitters" (National Academy Press, Washington, DC, 1988).

BEIR V 1990: National Research Council, Committee on the Biological Effects of Ionizing Radiations, "Health Effects of Exposures to Low Levels of Ionizing Radiation" (National Academy Press, Washington, DC, 1990).

Bennett 1990: K.D. Bennett, "Annotated Bibliography of Geologic, Hydrogeologic, and Environmental Studies Relevant to Solid Waste Management Units at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-90-3216 (1990).

Bevington 1969: P.R. Bevington, "Data Reduction and Error Analysis for the Physical Sciences," (McGraw-Hill, New York, 1969).

Brown 1990: R.M. Brown, G.L. Ogram, and F.S. Spencer, "Oxidation and Dispersion of HT in the Environment: The August 1986 Field Experiment at Chalk River," *Health Physics* **58**, 171-181 (1990).

Crowe 1978: B.M. Crowe, G.W. Linn, G. Heiken, and M.L. Bevier, "Stratigraphy of the Bandelier Tuff in the Pajarito Plateau," Los Alamos National Laboratory report LA-7225-MS (April 1978).

Dahl 1977: D.A. Dahl and L.J. Johnson, "Aerosolized U and Be from LASL Dynamic Experiments," Los Alamos Scientific Laboratory document LA-UR-77-681 (1977).

Devaurs 1985: M. Devaurs, "Core Analyses and Observation Well Data from Mesita del Buey Waste Disposal Areas and in Adjacent Canyons," Los Alamos National Laboratory document LA-UR-85-4003 (November 1990).

Dixon 1969: W.J. Dixon and F.J. Massey, Introduction to Statistical Analysis, (McGraw-Hill Book Co., New York, 1969), pp. 82|83.

DOE 1979: US Department of Energy, "Final Environmental Impact Statement: Los Alamos Scientific Laboratory Site, Los Alamos, New Mexico," US Department of Energy report DOE/EIS-0018 (December 1979).

DOE 1981: US Department of Energy, "A Guide for Environmental Radiological Surveillance at US Department of Energy Installations," US Department of Energy report DOE/EP-0023 (July 1981).

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

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

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

DOE 1989a: US Department of Energy, "Environmental Restoration and Waste Management, Five-Year Plan," US Department of Energy report DOE/S-0070 (August 1989).

DOE 1989b: US Department of Energy, "General Operations Quality Assurance," US Department of Energy Order 5700.6B, Revision II (July 1989).

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

DOE 1990b: US Department of Energy, "Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1992-1996," DOE/S-0078P, Washington, DC (June 1990).

DOE 1990c: US Department of Energy, "Effluent and Environmental Monitoring Program Requirements," US Department of Energy Order 5484.1 (June 1990).

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

EPA 1979: US Environmental Protection Agency, "National Emission Standards for Identifying, Assessing, and Regulating Airborne Substances Posing a Risk of Cancer," *Federal Register* **44,** 197 58643 (October 1979).

EPA 1986a: US Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," US Environmental Protection Agency report AP-42, Supplement A (October 1986).

EPA 1986b: US Environmental Protection Agency, "Guideline on Air Quality Models (Revised)," US Environmental Protection Agency report EPA-450/2-78-027R (July 1986).

EPA 1989a: US Environmental Protection Agency, US Army Corps of Engineers, US Fish and Wildlife Service, and USDA Soil Conservation Service, "Federal Manual for Identifying and Delineating Jurisdiction Wetlands," US Government Printing Office (January 10, 1989).

EPA 1989b: US Environmental Protection Agency, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143 (1989).

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

EPA 1989d: US Environmental Protection Agency, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846," Third Edition (1989).

EPA 1990a: US Environmental Protection Agency, "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities," proposed rule, Title 40, Parts 264, 265, 270, and 271, *Federal Register*, Vol. 55, p. 30798 (July 27, 1990).

EPA 1990b: US Environmental Protection Agency, "CAP-88 Clean Air Act Assessment Package," distributed by the Radiation Shielding Information Center, RS1C Code Package CCC-542 (1990).

EPA 1991: US Environmental Protection Agency, "Guidelines Establishing Test Procedures for Analysis of Pollutants," *Code of Federal Regulations*, Title 40, Part 136 (1991).

EPG 1990: Environmental Protection Group, "Environmental Surveillance at Los Alamos During 1989," Los Alamos National Laboratory report LA-12000-ENV (June 1990).

EPG 1992: Environmental Protection Group, "Environmental Surveillance at Los Alamos during 1990," Los Alamos National Laboratory report LA-12271-MS (March 1992).

EPG 1993: Environmental Protection Group, "Environmental Surveillance at Los Alamos during 1991," Los Alamos National Laboratory report LA-12572-MS (August 1993).

ESG 1978: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1977," Los Alamos Scientific Laboratory report LA-7263-MS (April 1978).

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

ESG 1988: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1987," Los Alamos National Laboratory report LA-11306-ENV (May 1988).

ESG 1989: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1988," Los Alamos National Laboratory report LA-11628-ENV (June 1989).

Fresquez 1992a: P. Fresquez, "Radionuclide Concentrations in Fruit, Stem, and Soil Samples Collected from Fruit Trees Growing in the Vicinity of TA-1," Los Alamos National Laboratory memorandum EM-8:92-1599 to Harry Otway (June 12, 1992)

Fresquez 1992b: P. Fresquez, "Radionuclide Concentrations in Soil and Fruit Samples Collected From the TA-1 Fruit Tree during the 1992 Growing Season," Los Alamos National Laboratory memorandum EM-8:92-3204 to Harry Otway (October 21, 1992).

Gautier 1986: M.A. Gautier and E.S. Gladney, Eds., "Health and Environmental Chemistry at Los Alamos: Analytical Techniques, Data Management, and Quality Assurance," Los Alamos National Laboratory report LA-10300 (1986), Vols. 1 and 2.

Gautier 1991: M.A. Gautier, E.S. Gladney, N. Koski, E.A. Jones, and B.T. O'Malley, "Quality Assurance for Health and Environmental Chemistry: 1990," Los Alamos National Laboratory report LA-12208-MS (October 1991).

Gilbert 1975: R.O. Gilbert, "Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group," Battelle Pacific Northwest Laboratories report BNWL-B-368 (September 1975).

Goff 1991: Personal communication between A.K. Stoker (EM-8, Los Alamos National Laboratory) and F. Goff (ESS-1, Los Alamos National Laboratory), 1991.

Goff 1993: Personal communication between A.K. Stoker (EM-8, Los Alamos National Laboratory) and F. Goff (ESS-1, Los Alamos National Laboratory), 1993.

Graf 1993: W.L. Graf, "Geomorphology of Plutonium in the Northern Rio Grande System," Los Alamos National Laboratory document LA-UR-93-1963 (1993).

Hakonson 1976a: T.E. Hakonson and K.V. Bostick, "Cesium-137 and Plutonium in Liquid Waste Discharge Areas at Los Alamos," and F.R. Miera, Jr., and R.J. Peters, "The Distribution of Plutonium and Cesium of Alluvial Soils in the Los Alamos Environs," both in *Radioecology and Energy Resources* (Dowden, Hutchinson, and Ross, Stroudsburg, Pennsylvania, 1976).

Hakonson 1976b: T.E. Hakonson, J.W. Nyhan, and W.D. Purtymun, "Accumulation and Transport of Soil Plutonium in Liquid Waste Discharge Areas at Los Alamos," in "Transuranium Nuclides in the Environment" (proceedings), International Atomic Energy Agency report IAEA-SM-199/99 (1976).

ICRP 1970: International Commission on Radiological Protection, "Protection Against Ionizing Radiation from External Sources," International Commission on Radiological Protection report No. 15 (Pergamon Press, New York, 1970).

ICRP 1975: International Commission on Radiological Protection, "Report on the Task Group on Reference Man," ICRP Publication 23 (1975).

ICRP 1977: International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection," adopted January 17, 1977, ICRP Publication No. 26, *Annals of the ICRP* **1**(3) (1977).

ICRP 1979: International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Parts 1, 2, 3, and 4 and their supplements, *Annals of the ICRP* **2**(3/4)-**8**(4) (1979-1982), and **19**(4) (1988).

John 1974: H.E. John and J.R. Cunningham, The Physics of Radiobiology, Third Ed. (C.C. Thomas, Springfield, Illinois, 1974).

Kaimal 1984: J.C. Kaimal, J.E. Gaynor, P.L. Findelstein, M.E. Graves, and T.J. Lockhart, "An Evaluation of Wind Measurements by Four Doppler SODARs," NOAA/ERL report No. 5 (1984).

Kocher 1980: "Effects of Indoor Residence on Radiation Doses from Routine Releases of Radionuclides to the Atmosphere," Nuclear Technology, V.48 (April 1980).

Kocher 1981: DC Kocher, "Dose-Rate Conversion Factors for External Exposure to Photons and Electrons," US Nuclear Regulatory Commission report NUREG/CR-1918 (August 1981).

Kramer 1992: Kramer, Callahan, and Associates, "Particulate Emissions Test Results, Barber-Green Asphalt Batch Plant, Los Alamos, New Mexico," Kramer, Callahan, and Associates report, (August 17, 1992).

Lane 1985: L.J. Lane, W.D. Purtymun, and N.M. Becker, "New Estimating Procedures for Surface Runoff, Sediment Yield, and Contaminant Transport in Los Alamos County, New Mexico," Los Alamos National Laboratory report LA-10335-MS (April 1985).

LLNL 1990: Steven G. Homann, computer code HOTSPOT Ver. 6.0 (Lawrence Livermore National Laboratory, Livermore, CA 1990).

Lyons 1992: S.W. Lyons, "Feebleness and Transcience of a Southwestern United States Monsoon," National Weather Service Southern Region Forecaster Notes No. 2 (1992).

Meeker 1990: K. Meeker, F. Goff, J.N. Gardner, P.E. Trujillo, and D. Counce, "Environmental Sampling and Mud Sampling Program of CSDP Core Hole VC-2B, Valles Caldera, New Mexico," Los Alamos National Laboratory report LA-11759-OBES (1990).

META 1992: T.L. Waldron, MET Associates, "Quality Assurance Project Report for the Meteorological Monitoring Network Operated by the University of California for Los Alamos National Laboratory," MET Associates Report (1992).

Natrella 1963: M.G. Natrella, "Experimental Statistics," National Bureau of Standards Handbook 91 (National Bureau of Standards, Washington, DC, 1963).

NCRP 1975a: National Council on Radiation Protection and Measurements, "Review of the Current State of Radiation Protection Philosophy," National Council on Radiation Protection and Measurements report No. 43 (1975), pp. 2|3.

NCRP 1975b: National Council on Radiation Protection and Measurements, "Natural Background Radiation in the United States," National Council on Radiation Protection and Measurements report No. 45 (November 1975).

NCRP 1984: National Council on Radiation Protection and Measurements, "Exposures from the Uranium Series with Emphasis on Radon and Its Daughters," National Council on Radiation Protection and Measurements report No. 77 (March 15, 1984).

NCRP 1987a: National Council on Radiation Protection and Measurements, "Ionizing Radiation Exposure of the Population of the United States," National Council on Radiation Protection and Measurements report No. 93 (September 1987).

NCRP 1987b: National Council on Radiation Protection and Measurements, "Exposure of the Population in the United States and Canada from Natural Background Radiation," National Council on Radiation Protection and Measurements report No. 94 (December 1987).

NMEIB 1991: New Mexico Environmental Improvement Board, State of New Mexico, "NM Water Supply Regulations" (as amended through April 1991).

NMWQCC 1991: New Mexico Water Quality Control Commission, "Water Quality Standards for Interstate and Intrastate Streams in New Mexico" (effective through November 12, 1991).

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

POS 1992: Pajarito Ornithological Survey, "Atlas of the Breeding Birds of Los Alamos County, New Mexico," Los Alamos National Laboratory report LA-12206 (October 1992).

Purtymun 1971: W.D. Purtymun, "Plutonium in Stream Channel Alluvium in the Los Alamos Area, New Mexico," Los Alamos Scientific Laboratory report LA-4561 (1971).

Purtymun 1974a: W.D. Purtymun, "Storm Runoff and Transport of Radionuclides in DP Canyon, Los Alamos County, New Mexico," Los Alamos Scientific Laboratory report LA-5744 (1974).

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

Purtymun 1974c: W.D. Purtymun, "Dispersion and Movement of Tritium in a Shallow Aquifer in Mortandad Canyon," Los Alamos Scientific Laboratory report LA-5716-MS (September 1974).

Purtymun 1974d: W.D. Purtymun, F.G. West, and H. Adams, "Preliminary Study of Quality of Water in the Drainage Area of the Jemez River and Rio Guadalupe," Los Alamos Scientific Laboratory report LA-5595-MS (April 1974).

Purtymun 1977: W.D. Purtymun, J.R. Buchholz, and T.E. Hakonson, "Chemical Quality of Effluents and the Influence on Water Quality in a Shallow Aquifer," *Journal of Environmental Quality* **6**(l) (January|March 1977).

Purtymun 1980a: W.D. Purtymun and H. Adams, "Geohydrology of Bandelier National Monument, New Mexico," Los Alamos Scientific Laboratory report LA-8461-MS (1980).

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

Purtymun 1983: W.D. Purtymun, W.R. Hansen, and R.J. Peters, "Radiochemical Quality of Water in the Shallow Aquifer in Mortandad Canyon 1967|1978," Los Alamos National Laboratory report LA-9675-MS (March 1983).

Purtymun 1984: W.D. Purtymun, "Hydrologic Characteristics of the Main Aquifer in the Los Alamos Area: Development of Groundwater Supplies," Los Alamos National Laboratory report LA-9957-MS (January 1984).

Purtymun 1987a: W.D. Purtymun, R.J. Peters, T.E. Buhl, M.N. Maes, and F.H. Brown, "Background Concentrations of Radionuclides in Soils and River Sediments in Northern New Mexico, 1974|1986," Los Alamos National Laboratory report LA-11134-MS (November 1987).

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

Purtymun 1988a: W.D. Purtymun, R.W. Ferenbaugh, M.C. Williams, and M.N. Maes, "Water Quality in the Vicinity of Fenton Hill, 1985 and 1986," Los Alamos National Laboratory report LA-11210-PR (March 1988).

Purtymun 1988b: W.D. Purtymun and M.N. Maes, "Environmental Study of the Pueblo of San Ildefonso: Reference to Water, Soil, and Sediments," Los Alamos National Laboratory document LA-UR-88-3646 (November 1988).

Purtymun 1988c: W.D. Purtymun and A.K. Stoker, "Water Supply at Los Alamos: Current Status of Wells and Future Water Supply," Los Alamos National Laboratory report LA-11332-MS (August 1988).

Purtymun 1990a: W.D. Purtymun, R. Peters, and M.N. Maes, "Transport of Plutonium in Snowmelt Run-Off," Los Alamos National Laboratory report LA-11795-MS (July 1990).

Purtymun 1990b: W.D. Purtymun, R.J. Peters, and M.N. Maes. "Plutonium Deposition and Distribution from Worldwide Fallout in Northern New Mexico and Southern Colorado," Los Alamos National Laboratory report LA-11794-MS, (1990).

Purtymun 1990c: W.D. Purtymun and A.K. Stoker, "Perched Zone Monitoring Well Installation," Los Alamos National Laboratory report LA-UR-90-3230 (September 1990).

Salazar 1984: J.G. Salazar, "Produce and Fish Sampling Program of Los Alamos National Laboratory," Los Alamos National Laboratory report LA-10186-MS (September 1984).

Shevenell, in press: L. Shevenell and F. Goff, "The Use of Tritium in Groundwater to Determine Fluid Mean Residence Times of Valles Caldera Hydrothermal Fluids, New Mexico, USA," (to be published in *Jour. Volcanol. and Geotherm. Res.*).

Soholt 1990: L. Soholt, "Environmental Surveillance at Low-level Radioactive-Waste-Management Areas at Los Alamos During 1987," Los Alamos National Laboratory report LA-UR-90-3283 (1990).

Spangler 1992: Personal communication between A.K. Stoker, EM-8, and R. Spangler, Chem-Nuclear Geotech, Inc., Grand Junction, Colorado, 1992.

Stoker 1991: A.K. Stoker, W.D. Purtymun, S.G. McLin, and M.N. Maes, "Extent of Saturation in Mortandad Canyon," Los Alamos National Laboratory report LA-UR-91-1660 (May 1991).

Stoker 1993: A.K. Stoker, W.D. Purtymun, S.G. McLin, and M.N. Maes, "Water Supply at Los Alamos during 1990," Los Alamos National Laboratory report LA-12471-PR (February 1993).

Theis 1962: C.V. Theis and C.S. Conover, "Pumping Tests in Los Alamos Canyon Well Field Near Los Alamos, New Mexico," US Geological Survey, Water Supply Paper 1619-I, Government Printing Office, Washington, DC (1962).

USBC 1991: US Bureau of the Census, Provisional Data for 1990 for New Mexico Counties, US Bureau of the Census report (February 1991).

USGS 1993: US Geological Survey, "Water Resource Data for New Mexico Water Year 1991," US Geological Survey Water Data NM-92-1 (1993).

Vuataz 1986: F.D. Vuataz and F. Goff, "Isotope Geochemistry of Thermal and Nonthermal Waters in the Valles Caldera, Jemez Mountains, Northern New Mexico," *Jour. Geophys. Res.* 91(B2), (1986).

Williams 1990: M.C. Williams, "Handbook for Sample Collection, Preservation, and Instrumental Techniques," Los Alamos National Laboratory report LA-17738-M (February 1990 and updates).

APPENDIX A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

Throughout this report, concentrations of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, and foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 5400.1, "General Environmental Program;" 5400.5, "Radiation Protection of the Public and the Environment;" 5480.1, "Environmental Protection, Safety, and Health Protection Standards;" 5480.11, "Requirements for Radiation Protection for Occupational Workers;" and 5484.1, "Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements," Chap. III, "Effluent and Environmental Monitoring Program Requirements."

Radiation Standards. DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50 yr dose commitments were calculated using the dose factors from Refs. A1 and A2. The dose factors adopted by DOE are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP).[A3]

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard (RPS) for the public.[A4] Table A-1 lists currently applicable RPSs, now referred to as public dose limits (PDLs), for operations at the Laboratory. DOE's comprehensive PDL for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 mrem/yr. The PDLs and the information in Refs. A1 and A2 are based on recommendations of the ICRP and the National Council on Radiation Protection and Measurements.[A3,A4]

The EDE is the hypothetical whole-body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure to an individual organ. It is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the ICRP. The EDE includes doses from both internal and external exposure.

Radionuclide concentrations in air and water in uncontrolled areas measured by the Laboratory's surveillance program are compared with DOE's derived air concentrations (DACs) and derived concentration guides (DCGs), respectively (Table A-2).[A5] These guides represent the smallest estimated concentrations in water or air, taken in continuously for a period of 50 years, that will result in annual EDEs equal to the PDL of 100 mrem in the 50th year of exposure.

In addition to the 100 mrem/yr effective dose PDL, exposures from the air pathway are also limited by the Environmental Protection Agency's (EPA's) 1989 standard of 10 mrem/yr (effective dose equivalent).[A6] To demonstrate compliance with these standards, doses from the air pathway are compared directly with the EPA dose limits. This dose limit of 10 mrem/yr replaced the previous EPA limits of 25 mrem/yr (whole body) and 75 mrem/yr (any organ).[A7]

Nonradioactive Air Quality Standards. Federal and state ambient air quality standards for nonradioactive pollutants are shown in Table A-3. New Mexico nonradiological standards are generally more stringent than national standards.

Drinking Water Standards. For chemical constituents in drinking water, regulations issued by EPA and adopted by the New Mexico Environment Department (NMED) (Table A-4).[A8] EPA's primary maximum contaminant level (MCL) is the maximum permissible level of a contaminant in 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

Table A-1. DOE Public Dose Limits (PDL) for External and Internal Exposures

Exposure of Any Member of the Public[a]

	EDE[b] at Point of Maximum Probable Exposure
All Pathways	100 mrem/yr[c]

	EDE at Point of Maximum Probable Exposure
Air Pathway Only[d]	+10 mrem/yr
Drinking Water	++4 mrem/yr

Occupational Exposure[a]

Stochastic Effects	+5 rem (annual EDE[e])
Nonstochastic Effects	
Lens of eye	15 rem (annual EDE[e])
Extremity	50 rem (annual EDE[e])
Skin of the whole body	50 rem (annual EDE[e])
Organ or tissue	50 rem (annual EDE[e])
Unborn Child	
Entire gestation period	+0.5 rem (annual EDE[e])

[a]In keeping with DOE policy, exposures shall be limited to as small a fraction of the respective annual dose limits as practicable. DOE's PDL applies to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, and global fallout; self-irradiation; and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from Ref. A4. Limits for occupational exposure are taken from DOE Order 5480.11.

[b]As used by DOE, EDE includes both the EDE from external radiation and the committed EDE to individual tissues from ingestion and inhalation during the calendar year.

[c]Under special circumstances and subject to approval by DOE, this limit on the EDE may be temporarily increased to 500 mrem/yr, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem/yr.

[d]This level is from EPA's regulations issued under the Clean Air Act (40 CFR 61, Subpart H).

[e]Annual EDE is the EDE received in a year.

Table A-2. DOE's Derived Concentration Guides (DCGs) for Water and Derived Air Concentrations (DACs)[a]

Nuclide	DCGs for Water in Uncontrolled Areas (μCi/mL)	DCGs for Drinking Water Systems (μCi/mL)	DACs (μCi/mL) Uncontrolled Areas	DACs (μCi/mL) Controlled Areas
^{3}H	$2 + 10^{-3}$	$8 + 10^{-5}$	$1 + 10^{-7}$	$2 + 10^{-5}$
^{7}Be	$1 + 10^{-3}$	$4 + 10^{-5}$	$4 + 10^{-8}$	$8 + 10^{-6}$
^{89}Sr	$2 + 10^{-5}$	$8 + 10^{-7}$	$3 + 10^{-10}$	$6 + 10^{-8}$
^{90}Sr[b]	$1 + 10^{-6}$	$4 + 10^{-8}$	$9 + 10^{-12}$	$2 + 10^{-9}$
^{137}Cs	$3 + 10^{-6}$	$1.2 + 10^{-7}$	$4 + 10^{-10}$	$7 + 10^{-8}$
^{234}U	$5 + 10^{-7}$	$2 + 10^{-8}$	$9 + 10^{-14}$	$2 + 10^{-11}$
^{235}U	$6 + 10^{-7}$	$2.4 + 10^{-8}$	$1 + 10^{-13}$	$2 + 10^{-11}$
^{238}U	$6 + 10^{-7}$	$2.4 + 10^{-8}$	$1 + 10^{-13}$	$2 + 10^{-11}$
^{238}Pu	$4 + 10^{-8}$	$1.6 + 10^{-9}$	$3 + 10^{-14}$	$3 + 10^{-12}$
^{239}Pu[b]	$3 + 10^{-8}$	$1.2 + 10^{-9}$	$2 + 10^{-14}$	$2 + 10^{-12}$
^{240}Pu	$3 + 10^{-8}$	$1.2 + 10^{-9}$	$2 + 10^{-14}$	$2 + 10^{-12}$
^{241}Am	$3 + 10^{-8}$	$1.2 + 10^{-9}$	$2 + 10^{-14}$	$2 + 10^{-12}$
	(μg/L)	**(μg/L)**	**(pg/m^3)**	**(pg/m^3)**
Natural Uranium	$8 + 10^{-1}$	$3 + 10^{-2}$	$1 + 10^{5}$	$3 + 10^{7}$

[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.

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 water standards, which are not included in the NM Water Supply Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water.[A9] There may be health effects associated with considerably higher concentrations of these contaminants.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141[A9] and New Mexico Water Supply Regulations, Sections 206 and 207.[A8] These regulations provide that combined ^{226}Ra and ^{228}Ra may not exceed $5 + 10^{-9}$ μCi/mL. Gross alpha activity (including ^{226}Ra, but excluding radon and uranium) may not exceed $15 + 10^{-9}$ μCi/mL.

A screening level of $5 + 10^{-9}$ μCi/mL for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water (Table A-4) and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

For manmade beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem/yr, calculated according to a specified procedure. In

addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem/yr. DCGs for drinking water systems based on this requirement are in Table A-2.

Surface Water Standards. In its Resource Conservation and Recovery Act (RCRA) regulations, EPA has established minimum concentrations of certain contaminants in water extracted from wastes that will cause the waste to be designated as hazardous because of its toxicity.[A10] The toxicity characteristic leaching procedure (TCLP) must follow steps outlined by the EPA in 40 CFR 261, Appendix II. In this report, the TCLP minimum concentrations (Table A-5) are used for comparison with concentrations of selected constituents extracted from the Laboratory's active waste areas.

NMED used numeric Livestock and Wildlife Watering Standards (Table A-6)[A11] to evaluate requirements for National Pollutant Discharge Elimination System (NPDES) discharges into normally dry canyons whose only use is livestock and wildlife watering. In this report, results of analyses of surface waters and shallow alluvial water samples are compared with these values whether or not the water is directly from an NPDES outfall so that compliance can be demonstrated.

Table A-3. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary
Sulfur dioxide	Annual arithmetic mean	ppm	0.02	0.03	
	24 hours[a]	ppm	0.10	0.14	
	3 hours[a]	ppm			0.5
Total suspended particulate matter	Annual geometric mean	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours[a]	$\mu g/m^3$	150		
PM_{10}[b]	Annual arithmetic mean	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
Carbon monoxide	8 hours[a]	ppm	8.7	9	
	1 hour[a]	ppm	13.1	35	
Ozone	1 hour[c]	ppm	0.06	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. Maximum Contaminant Levels (MCLs) in the Water Supply for Inorganic Chemicals, Organic Chemicals, and Radiochemicals[a]

Inorganic Chemical Contaminants

Primary Standards	**MCL (mg/L)**
Ag	0.05
As	0.05
Ba	1
Cd	0.010
Cr	0.05
F	4.0
Hg	0.002
NO_3 (as N)	10
Se	0.01
	Action Levels (mg/L)
Pb	0.015
Cu	1.3

Secondary Standards

Cl	250
Cu	1
Fe	0.3
Mn	0.05
SO_4	250
Zn	5.0
TDS[c]	500
pH	6.5–8.5

Radiochemical Contaminants

	MCL
Gross alpha[b]	$15 + 10^{-9}$ µCi/mL
Gross beta & photon	4 mrem/yr
^{3}H	$20{,}000 + 10^{-9}$ µCi/mL
^{90}Sr	$+8 + 10^{-9}$ µCi/mL
^{226}Ra & ^{228}Ra	$+5 + 10^{-9}$ µCi/mL
	Screening Limits
Gross alpha[b]	$+5 + 10^{-9}$ µCi/mL (5 pCi/L)
Gross beta	$50 + 10^{-9}$ µCi/mL (50 pCi/L)

Table A-4. (Cont.)

Organic Chemical Contaminants	MCL (mg/L)
Insecticides:	
Endrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8a-octa hydro-1,4-endo, endo-5, 8-dimethano napthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2, 2-bis[p-methoxyphenyl] ethane)	0.1
Toxaphene (C_{10} H_{10} C_{l8} - technical chlorinated camphene, 67-69 percent chlorine)	0.005
Herbicides:	
2,4-D, (2,4-Dichlorophenoxyacetic acid)	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophenoxy-propionic acid)	0.01
Total trihalomethanes (TTHM)	0.10
Other Organic Contaminants:	
Benzene	0.005
Vinyl Chloride	0.002
Carbon tetrachloride	0.005
1,2-Dichloroethane	0.005
Trichloroethylene	0.005
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.20
para-Dichlorobenzene	0.075

Microbiological Contaminants	MCL
Presence of total coliforms	5% of samples/month
Presence of fecal coliforms or *Escherichia coli*	0 sample/month

[a]Refs. A8 and A9.

[b]See text for discussion of application of gross alpha MCL and gross alpha screening level of $5 + 10^{-9}$ µCi/mL.

[c]Total dissolved solids.

Table A-5. Levels of Contaminants Determined by the Toxicity Characteristic Leaching Procedure[a]

Contaminant	(mg/L)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0
m-Cresol	200.0
p-Cresol	200.0
Cresol	200.0
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor (and its epoxide)	0.008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TP (Silvex)	1.0
Vinyl chloride	0.2

[a]Ref. A[10].

Table A-6. Wildlife Watering Standards[a]

Livestock Contaminant	Concentration (mg/L)
Dissolved Al	5.0
Dissolved As	0.02
Dissolved B	5.0
Dissolved Cd	0.05
Dissolved $Cr^{(+3, +6)}$	1.0
Dissolved Co	1.0
Dissolved Cu	0.5
Dissolved Pb	0.1
Total Hg	0.01
Dissolved Se	0.05
Dissolved V	0.1
Dissolved Zn	25.0
^{226}Ra, ^{228}Ra	30 pCi/L

[a] Ref. All

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).

APPENDIX B

UNITS OF MEASUREMENT

Throughout this report the International System of Units (SI) or metric system of measurements has been used, with some exceptions. For units of radiation activity, exposure, and dose, US Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively.

Table B-1 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is $2.0 + 10^3$, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the right of its present location. The number would then read 2,000. If the value given is $2.0 + 10^{-5}$, the decimal point should be moved five numbers to the left of its present location. The result would become 0.00002.

Table B-2 presents conversion factors for converting SI units into US Customary Units. Table B-3 presents abbreviations for common measurements.

Table B-1. Prefixes Used with SI (Metric) Units

Prefix	Factor	Symbol
mega	1 000 000 or 10^6	M
kilo	1 000 or 10^3	k
centi	0.01 or 10^{-2}	c
milli	0.001 or 10^{-3}	m
micro	0.000001 or 10^{-6}	μ
nano	0.000000001 or 10^{-9}	n
pico	0.000000000001 or 10^{-12}	p
femto	0.000000000000001 or 10^{-15}	f
atto	0.000000000000000001 or 10^{-18}	a

Table B-2. Approximate Conversion Factors for Selected SI (Metric) Units

Multiply SI (Metric) Unit	By	To Obtain US Customary Unit
Celsius (|C)	9/5 + 32	Fahrenheit (|F)
Centimeters (cm)	0.39	Inches (in.)
Cubic meters (m^3)	35.7	Cubic feet (ft^3)
Hectares (ha)	2.47	Acres
Grams (g)	0.035	Ounces (oz)
Kilograms (kg)	2.2	Pounds (lb)
Kilometers (km)	0.62	Miles (mi)
Liters (L)	0.26	Gallons (gal.)
Meters (m)	3.28	Feet (ft)
Micrograms per gram (µg/g)	1	Parts per million (ppm)
Milligrams per liter (mg/L)	1	Parts per million (ppm)
Square kilometers (km^2)	0.386	Square miles (mi^2)

Table B-3. Common Measurement Abbreviations and Measurement Symbols

aCi	attocurie
ac ft	acre feet
Bq	becquerel
Btu/yr	British thermal unit per year
cc/sec	cubic centimeters per second
cfm	cubic feet per minute
cfs	cubic feet per second
Ci	curie
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot
gal.	gallon
in.	inch
kg	kilogram
kg/h	kilogram per hour
L	liter
lb	pound
lb/h	pound per hour
lin ft	linear feet
m^3/s	cubic meter per second

Table B-3. (Cont.)

µCi/L	microcurie per liter
µCi/mL	microcurie per milliliter
µg/g	microgram per gram
$\mu g/m^3$	microgram per cubic meter
mL	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter
µR	microroentgen
mCi	millicurie
mR	milliroentgen
mrad	millirad
mrem	millirem
mSv	millisievert
nCi	nanocurie
nCi/dry g	nanocurie per dry gram
nCi/L	nanocurie per liter
ng/m^3	nanogram per cubic meter
pCi/dry g	picocurie per dry gram
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m^3	picocurie per cubic meter
pCi/mL	picocurie per milliliter
pg/g	picogram per gram
pg/m^3	picogram per cubic meter
PM_{10}	small particulate matter (less than 10 µm diameter)
R	roentgen
S_T or σ	standard deviation
Sv	sievert
sq ft (ft^2)	square feet
TU	tritium unit
>	greater than
<	less than
|	plus or minus

APPENDIX C

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Fig. II-4. The main programs conducted at each of the areas are listed in this Appendix.

TA-0, Town Site: The Laboratory has about 180,000 sq ft of leased space for training, support, architectural engineering design, unclassified research and development, and the publicly accessible Community Reading Room and Bradbury Science Museum. DOE's Los Alamos Area Office is also located at the townsite.

TA-2, Omega Site: Omega West Reactor, an 8-MW nuclear research reactor, is located here. It served as a research tool by providing a source of neutrons for fundamental studies in nuclear physics and associated fields, before it was shut down this year.

TA-3, Core Area: In this main technical area of the Laboratory is the Administration Building that contains the Director's office and administrative offices and laboratories for several divisions. Other buildings house central computing facilities, chemistry and materials science laboratories, and earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, a Van de Graaff accelerator, the main cafeteria, and the Study Center. TA-3 contains about 50% of the Laboratory's employees and floor space.

TA-5, Beta Site: This site contains some physical support facilities such as an electrical substation, test wells, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, Two-Mile Mesa Site: The site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending disposal.

TA-8, GT Site (or Anchor Site West): This is a dynamic testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (x ray machines with potentials up to 1,000,000 V and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East: At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site: Facilities are located here for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q Site: This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.

TA-15, R Site: This is the home of PHERMEX (the pulsed high-energy radiographic machine emitting x rays) a multiple-cavity electron accelerator capable of producing a very large flux of x rays for weapons development testing. It is also home to DARHT (the dual-axis radiographic hydrotest facility), whose major feature is its intense high-resolution, dual-machine radiographic capability. This site is also used for the investigation of weapons functioning and systems behavior in non-nuclear tests, principally through electronic recordings.

TA-16, S Site: Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons warhead systems. TA-16 is the site of the new Weapons Engineering Tritium Facility for tritium handled in gloveboxes. Development and testing of high explosives, plastics, and adhesives and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18, Pajarito Laboratory Site: The fundamental behavior of nuclear chain reactions with simple, low-power reactors called critical assemblies is studied here. Experiments are operated by remote control and observed by closed-circuit television. The machines are housed in buildings known as kivas and are used primarily to provide a controlled means of assembling a critical amount of fissionable material so that the effects of various shapes, sizes, and configurations can be studied. These machines are also used as a large-quantity source of fission neutrons for experimental purposes.

TA-21, DP Site: This site has two primary research areas: DP West and DP East. DP West is gradually being decontamination and decommissioning. DP East is a tritium research site.

TA-22, TD Site: This site is used in the development of special detonators to initiate high explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-28, Magazine Area A: This is an explosives storage area.

TA-33, HP Site: An old high-pressure, tritium handling facility located here is being phased out. An intelligence technology group and the National Radio Astronomy Observatory's Very Large Baseline Array Telescope are located at this site.

TA-35, Ten Site: Nuclear safeguards research and development, which are conducted here, are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research is done on reactor safety, laser fusion, optical sciences, pulse-power systems, and high-energy physics. Tritium fabrication, metallurgy, ceramic technology, and chemical plating are also done here.

TA-36, Kappa Site: Phenomena of explosives, such as detonation velocity, are investigated at this dynamic testing site.

TA-37, Magazine Area C: This is an explosives storage area.

TA-39, Ancho Canyon Site: The behavior of non-nuclear weapons is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, explosions involving other materials, shock wave physics, equation state measurements, and pulsed-power systems design.

TA-40, DF Site: This site is used in the development of special detonators to initiate high explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with the physics of explosives.

TA-41, W Site: Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.

TA-43, Health Research Laboratory and Center for Human Genome Studies: This site is adjacent to the Los Alamos Medical Center in the townsite. Research performed at this site includes structural, molecular, and cellular radiobiology, biophysics, mammalian radiobiology, mammalian metabolism, biochemistry, and genetics.

TA-46, WA Site: Applied photochemistry, which includes development of technology for laser isotope separation and laser enhancement of chemical processes, is investigated here. The Sanitary Wastewater System

Consolidation project has been installed at the east end of this site. Environmental management operations are also located here.

TA-48, Radiochemistry Site: Laboratory scientists and technicians at this site study nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made, and hot cells are used for remote handling of radioactive materials. The Hazardous Devices Team Training Facility is located here.

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.

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 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 serves 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 San Ildefonso Pueblo on the east, is isolated from most of the Laboratory and contains significant concentrations of archaeological sites and an endangered species breeding area. The site also contains Laboratory water wells and future wellfields.

APPENDIX D

Supplementary Environmental Information

Table D-1. Hazardous Waste Management Facilities at Los Alamos National Laboratory

Technical Area/Building	Facility Type	Inclusion in Part B Permit Application or Interim Status[a]
3-29[b]	Container (2 Units)	Interim S
3-102-118A	Container	Closed
14-35	OB/OD[c] (2 Units)	Interim T
15-184[b]	OB/OD	Interim T
16, Area P	Landfill	Closure in Progress
16	OB/OD (6 Units)	Interim T
16	Surface Impoundment	Closure in Progress
16-88[b]	Container	Interim S
16-1150	Incinerator	Interim T
21-61[b]	Container	Interim S
22-24	Container	Closed
35-85	Surface Impoundment	Closure in Progress
35-125	Surface Impoundment	Closure in Progress
36-8[b]	OB/OD	Interim T
39-6	OB/OD	Interim T
39-57	OB/OD	Interim T
40, SDS	OB/OD	Closure in Progress
40-2	Container	Closed
50-1-60A[b]	Container	Interim TS
50-1-60D[b]	Container	Interim S
50-1-BWTP	Aboveground Tank	Permitted TS
50-37-115[b]	Aboveground Tank (2 Units)	Interim S
50-37-115[b]	Container	Interim S
50-37-117	Container	Permitted S
50-37-117[b]	Container	Interim S
50-37-118[b]	Container	Interim S
50-37-CAI[b]	Incinerator	Interim T
50-37-CAI	Incinerator	Permitted T
50-69[b]	Container	Interim S
50-69[b]	Container	Interim S
50-114	Container	Permitted S
50-114[b]	Container	Interim S
50-137[d]	Container	Permitted S
50-138[d]	Container	Permitted S
50-139[d]	Container	Permitted S
50-140[d]	Container	Permitted S
53-166[b]	Surface Impoundment	Interim S
53-166[b]	Surface Impoundment	Interim S
53-166[b]	Surface Impoundment	Interim S
54, Area G Over Pit 33[b]	Container	Interim S
54, Area G	Landfill	Closure in Progress

Table D-1. (Cont.)

Technical Area/Building	Facility Type	Inclusion in Part B Permit Application or Interim Status[a]
54, Area G Pad 1[b]	Container	Interim S
54, Area G Pad 2[b]	Container	Interim S
54, Area G Pad 4[b]	Container	Interim S
54, Area G Over Pit 30[b]	Container	Interim S
54, Area G Shaft 145[b]	Container	Interim S
54, Area G Shaft 146[b]	Container	Interim S
54, Area G Shaft 148[b]	Container	Interim S
54, Area G Shaft 147[b]	Container	Interim S
54, Area G Shaft 149[b]	Container	Interim S
54, Area H	Landfill	Closure in Progress
54, Area L	Aboveground Tank (4 Tanks)	Permitted T
54, Area L Shaft 36[b]	Container	Interim S
54, Area L Shaft 37[b]	Container	Interim S
54, Area L Gas Cyl[b]	Container	Interim S
54, Area L Gas Cyl	Container	Permitted S
54-8[b]	Container	Interim S
54-31	Container	Permitted S
54-32	Container	Permitted S
54-33[b]	Container	Interim S
54-48[b]	Container	Interim S
54-49[b]	Container	Interim S
54-68	Container	Permitted S
54-69	Container	Permitted S
55, Near Bldg 4[b]	Container	Interim S
55-4[b]	Container (3 Units)	Interim S
55-4[b]	Tank (13 Tanks)	Interim TS
55-4[b]	Container	Interim S
55-4[b]	Container	Interim S
55-4[b]	Container	Interim TS
55-4[b]	Container	Interim S

[a]S = Storage; T = Treatment.
[b]Designates mixed waste units.
[c]OB/OD = open burning/open detonation.
[d]These units have not yet been constructed.

Table D-2. Types of Discharges and Parameters Monitored at the Laboratory under NPDES Permit NM0028355

EPA Identification No.	Type of Discharge	Outfalls	Number of Monitoring Required	Sampling Frequency
01A	Power plant	1	Total suspended solids, free available chlorine, pH, flow	Monthly
02A	Boiler blowdown	2	pH, total suspended solids, flow, copper, iron, phosphorus, sulfite, total chromium	Weekly
03A	Treated cooling water	31	Total suspended solids, free available chlorine, phosphorus, pH, flow	Weekly
04A	Noncontact cooling water	45	pH, flow	Weekly
051	Radioactive waste treatment plant (TA-50)	1	Ammonia, chemical oxygen demand, total suspended solids, cadmium, chromium, copper, iron, lead, mercury, zinc, pH, flow	Weekly
05A	High explosives wastewater	18	Chemical oxygen demand, pH, flow, total suspended solids	Weekly
06A	Photo waste water	14	Cyanide, silver, pH, flow	Weekly
07A	Asphalt Plant	1	pH, total suspended solids, chemical oxygen demand, oil and grease	Quarterly
128	Printed circuit board	1	pH, chemical oxygen demand, total suspended solids, iron, copper, silver, flow	Weekly
S	Sanitary wastewater	2	Biochemical oxygen demand, flow, pH, total suspended solids, fecal coliform bacteria	Variable frequency, from three per month to once quarterly

Table D-3. Limits Established by NPDES Permit NM0028355 for Sanitary Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01S TA-3 Treatment Plant	BOD[a]	_30.0	45.0	mg/L
		225.2	N/A	lb/day
	TSS[b]	_30.0	45.0	mg/L
		225.2	N/A	lb/day
	Fecal coliform bacteria	1,000.0	2,000.0	org/100 ml
	pH	6_9	6_9	standard unit
05S TA-21 Package Plant	BOD	100.0[c]	175.0[c]	mg/L
		_12.5[c]	N/A	lb/day
	TSS	150.0[c]	200.0[c]	mg/L
		_12.5[c]	N/A	lb/day
	pH	5.5_11.5[c]	5.5_11.5[c]	standard unit

[a]Biochemical oxygen demand.
[b]Total suspended solids.
[c]Interim effluent limitations in effect pursuant to Federal Facilities Compliance Agreement (FFCA) dated November 22, 1991.

Table D-4. NPDES Permit Monitoring of Effluent Quality at Sanitary Sewage Treatment Outfalls, 1992[a]

Discharge Location (Outfall)	Permit Parameters	Number of Deviations
TA-3 (01S)	BOD[b]	0
	TSS[c]	0
	Fecal coliform bacteria	0
	pH	16.0
TA-9 (02S)	BOD	0
	TSS	0
	pH	0
TA-16 (03S)	BOD	0
	TSS	0
	pH	0
TA-18 (04S)	BOD	0
	TSS (90)[d]	0
	pH	0
TA-21 (05S)	BOD	0
	TSS	0
	pH	0
TA-35 (10S)	BOD	0
	TSS (90)	0
	pH	0
TA-41 (06S)	BOD	0
	TSS	0
	Fecal coliform bacteria	0
	pH	0
TA-46 (07S)	BOD	0
	TSS	0
	pH	0
TA-46 (12S)	BOD	0
	TSS	0
	pH	0
TA-53 (09S)	BOD	0
	TSS (90)	0
	pH	0

[a]Limits set by the NPDES permit are presented in Table D-3.

[b]Biochemical oxygen demand.

[c]Total suspended solids.

[d]Interim limit of 90 mg/L granted by the Environmental Protection Agency (EPA).

Table D-5. Limits Established by NPDES Permit NM0028355 for Industrial Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01A Power plant	TSS[a]	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	pH	6–9	6–9	standard unit
02A Boiler blowdown	TSS	30	100	mg/L
	Fe	10	40	mg/L
	Cu	1	1	mg/L
	P	20	40	mg/L
	SO_3	35	70	mg/L
	Cr	Report[b]	Report	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
	P	20.0[b]	40.0[c]	mg/L
04A Noncontact cooling water	pH	6–9	6–9	standard unit
051 Radioactive waste treatment plants	COD[d]	94.0	156.0	lb/day
	TSS	18.8	62.6	lb/day
	Cd	0.06	0.3	lb/day
	Cr	0.19	0.38	lb/day
	Cu	0.63	0.63	lb/day
	Fe	1.0	2.0	lb/day
	Pb	0.06	0.15	lb/day
	Hg	0.003	0.09	lb/day
	Zn	0.62	1.83	lb/day
	pH	6–9	6–9	standard unit
05A High explosive	COD	150.0	250.0	mg/L
	TSS	30.0	45.0	mg/L
	pH	6–9	6–9	standard unit
06A Photo waste	CN	0.2	0.2	mg/L
	Ag	0.5	1.0	mg/L
	pH	6–9	6–9	standard unit

Table D-5 (Cont.)

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
07A Asphalt Plant	COD	125.0	115/-	mg/L
	TSS	30.0	45.0	mg/L
	O&G[e]	100.0	100.0	
	pH	6-9	6-9	standard unit
128 Printed circuit board	COD	1.9	3.8	lb/day
	TSS	1.25	2.5	lb/day
	Fe	0.05	0.1	lb/day
	Cu	0.05	0.1	lb/day
	Ag	Report	Report	lb/day
	pH	6–9	6–9	standard unit

[a]Total suspended solids

[b]Effluents are reported to EPA but are not subject to limits.

[c]Interim effluent limitations in effect pursuant to FFCA dated November 22, 1991.

[d]COD = chemical oxygen demand

[e]O&G = oil and grease

Table D-6. NPDES Permit Monitoring of Effluent Quality at Industrial Outfalls, 1992[a]

Discharge Category	Outfall No.	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls with Deviations
Power plant	01A	1	TSS[b]	0	_	0
			Free Cl	0	_	0
			pH	0	_	0
Boiler blowdown	02A	2	pH	3	9.3_9.4	1
			TSS	3	128.0_155.0	2
			Cu	0	_	0
			Fe	0	_	0
			P	0	_	0
			SO_3	0	_	0
			Cr	0	_	0
Treated cooling water	03A	38	TSS	0	_	0
			Free Cl	3	0.6_15.4	3
			P	5	5.8_7.7	4
			pH	1	2.8	1
Noncontact cooling water	04A	52	pH	0	_	0
Radioactive waste treatment plant	051 and 050	2	COD[c]	0	_	0
			TSS	0	_	0
			Cd	0	_	0
			Cr	0	_	0
			Cu	0	_	0
			Fe	0	_	0
			Pb	0	_	0
			Hg	0	_	0
			Zn	0	_	0
			pH	0	_	0
High explosive	05A	21	COD	1	1,640.0[d]	1
			TSS	0	_	0
			pH	2	5.4_9.5	2

Table D-6. (Cont.)

Discharge Category	Outfall No.	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls with Deviations
Photo waste	06A	13	CN	2	0.46_0.49	2
			Ag	0	_	0
			TSS	0	_	0
			pH	0	_	0
Printed circuit board	128	1	pH	0	_	0
			COD	0	_	0
			Ag	0	_	0
			Fe	0	_	0
			Cu	0	_	0
			TSS	0	_	0
		130				

[a]Limits set by the NPDES permit are presented in Table D-5.

[b]Total suspended solids.

[c]Chemical oxygen demand.

[d]This exceedance, experienced on September 16, 1992, was caused by a breakthrough of activated _carbon filters. The filters were subsequently replaced. Other upgrades in the treatment system _have been ordered.

Table D-7. Federal Facilities Compliance Agreement and Admnistrative Order: Schedule for Upgrading the Laboratory's Wastewater Outfalls

Outfalls	Date	Status or Target Date
Outfall 05A (HE Wastewater Treatment)		
Complete conceptual design report	July 1992	Completed
Complete design criteria	June 1993	June 30, 1993
Begin line item project	January 1994	January 31, 1994
Complete Title I design	July 1994	July 31, 1994
Complete Title II design	July 1995	July 31, 1995
Advertisement of construction	August 1996	August 31, 1996
Award of construction contract	October 1996	October 31, 1996
Construction completion	September 1997	September 30, 1997
Achieve compliance with final permit limits	October 1997	October 31, 1997
Waste Stream Identification and Characterization		
Completion of waste stream final report	March 1994	March 31, 1994
Complete 25% corrective actions	September 1994	September 30, 1994
Complete 50% corrective actions	September 1995	September 30, 1995
Complete 100% corrective actions	September 1996	September 30, 1996
Achieve compliance with permit limitations	October 1996	October 31, 1996

Table D-8. Locations of Air Sampling Stations[a]

Station	New Mexico State Plane Coordinates Northing	Easting
Regional (28–44 km)		
1. Española	1819247.9	54436954
2. Pojoaque	1770753.2	564196.6
3. Santa Fe	1698592.5	297029.1
Perimeter (0–4 km)		
4. Barranca School	1783276.3	490540.6
5. Arkansas Avenue	1783435.0	472030.6
6. 48th Street	1776555.5	476714.3
7. Shell Station	1775843.3	483461.3
8. McDonald's	1774932.1	485435.7
9. Los Alamos Airport	1776244.0	492348.4
10. East Gate	1773917.6	498437.5
11. Well PM-1	1768256.6	507326.5
12. Royal Crest Trailer Park	1772809.5	485105.5
13. White Rock- Piñon School	1754709.8	511035.6
14. Pajarito Acres	1743891.3	512275.3
15. White Rock Fire Station	1756934.4	513175.6
16. White Rock Church of the Nazarene	1754506.1	508400.5
17. Bandelier National Monument	1739541.6	495304.8
18. North Rim	(non-active)	
On Site Stations, Controlled Areas		
19. TA-21 DP Site	1773715.6	494734.2
20. TA-21 Area B	1774828.5	491772.0
21. TA-6	1771795.4	471440.1
22. TA-53 (LAMPF)	1771895.6	495063.1
23. TA-52 Beta Site	1767650.1	492181.5
24. TA-16 S Site	1764329.7	468060.8
25. TA-16-450	1760923.5	469442.7
26. TA-49	1756028.7	479579.8
27. TA-54 Area G	1757907.9	503080.9
28. TA-33 HP Site	1740552.3	497858.9
29. TA-2 Omega Site	1770682.3	495062.9
30. Booster P-2	1762897.1	495802.5
31. TA-3	1773116.5	478357.4
32. TA-48	1774935.5	480119.8
00. TA-59 OHL	1770897.2	480387.6
Waste Site Stations, Controlled Areas		
33. Area AB	1755216.2	485590.5
34. Area G-1 NE Corner	1757855.5	504906.8
35. Area G-2 South Fence	1757153.7	501450.2
36. Area G-3 Gate	1758458.7	501560.4
37. Area G-4 H_2O Tank	1756065.1	505642.7

[a]See Figure IV-4 for station locations.

Table D-9. Annual and Quarterly Wet Deposition Statistics for 1990 and 1991

	Quarter				
1990	**First**	**Second**	**Third**	**Fourth**	**Annual**
Field pH					
Log Mean	5.2	5.1	5.0	5.3	5.1
Minimum	4.4	4.4	4.6	4.8	4.4
Maximum	6.0	5.6	5.6	5.6	6.0

	Quarter				
1991	**First**	**Second**	**Third**	**Fourth**	**Annual**
Field pH					
Log Mean	6.2	4.7	4.9	5.0	5.5
Minimum	4.7	4.5	4.7	4.8	4.5
Maximum	6.7	4.8	5.1	5.1	6.7

Table D-10. Locations of Surface Water Sampling Stations[a]

Station	Latitude or Northing Coordinate[b]	Longitude or Easting Coordinate[b]	Map Designation[a]	
OFF-SITE STATIONS				
REGIONAL STATIONS				
Rio Chama at Chamita	30_05_	106_07_	Chamita	
Rio Grande at Embudo	36_12_	105_58_	Embudo	
Rio Grande at Otowi	1 773 000	532 300	Otowi	
Rio Grande at Cochiti	35_37_	106_19_	Cochiti	
Rio Grande at Bernalillo	35_17_	106_36_	Bernalillo	
Jemez River	35_40_	106_44_	Jemez	
PERIMETER STATIONS				
Radioactive Effluent Release Areas				
Acid-Pueblo Canyons				
Acid Weir	1 778 741	484 214[b1]	49	
Pueblo 1	1 778 817	484 165[b1]	50	
Pueblo 2	1 776 803	495 013[b1]	51	
Los Alamos Canyon				
Los Alamos at Rio Grande	1 773 000	532 300[b2]	3	
Other Areas				
Guaje Canyon	1 794 000	471 600[b2]	8	
Los Alamos Reservoir	1 777 200	468 600[b2]	7	
Mortandad at Rio Grande	1 756 595	523 638[b3]	38	
Pajarito at Rio Grande	1 747 532	516 715[b3]	35	
Frijoles at Park Headquarters	1 737 929	494,140[b3]	9	
Frijoles at Rio Grande	1 729 494	499 198[b3]	37	
ON-SITE STATIONS				
Radioactive Effluent Release Areas				
Acid-Pueblo Canyons				
Pueblo 3	1 774 826	506 429[b1]	52	
Pueblo at SR 502	1 771 862	512 695[b1]	S27	
DP_Los Alamos Canyons				
DPS-1		1 774 796	493 081[b1]	57
DPS-4		1 773 228	497 258[b1]	58
Mortandad Canyon				
GS-1	1 770 230	486 502[b1]	68	
Other Areas				
Cañada del Buey	1 766 666	491 631[b1]	46	
Pajarito Canyon	1 759 676	497 730—	47	
Water Canyon at Beta	1 757 513	485 058—	48	
Sandia Canyon				
SCS-1		1 773 872	480 978[b1]	65
SCS-2		1 771 081	492 581[b1]	66
SCS-3		1 770 207	495 655[b1]	67
Ancho at Rio Grande	1 735 497	509 307[b3]	36	

[a]Off-site regional surface water sampling locations are shown in Figure V1-5; off-site perimeter and on-site sampling locations are given in Figure IV-6.
[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-11. Locations of Sediment Sampling Stations

Station	Latitude or Northing Coordinate	Longitude or Easting Coordinate	Map Designation[a]
OFF-SITE STATIONS			
REGIONAL STATIONS			
Chamita[b]	36°05”	106°07”	Chamita
Embudo[b]	36°12”	106°58”	Embudo
Rio Grande at Otowi[b]	35°52”	106°08”	Otowi
Rio Grande at Sandia[c]	1758925	525014	Sandia
Rio Grande at Pajarito[c]	1747532	516715	Pajarito
Rio Grande at Water[c]	1741139	514154	Water
Rio Grande at Ancho[c]	1735497	509307	Ancho
Rio Grande at Frijoles[c]	1729494	499198	Frijoles
Rio Grande at Cochiti[b]	35°37”	106°19”	Cochiti
Rio Grande at Bernalillo[b]	35°17”	106°36”	Bernalillo
Jemez River[b]	35°40”	106°44”	Jemez
PERIMETER STATIONS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyon			
Acid Weir[d]	1778741.5	484213.6	22
Pueblo 1[d]	1778817.4	484165.4	23
Pueblo 2[d]	1776802.8	495013.5	24
DP-Los Alamos Canyon			
Los Alamos at Totavi	1772357.9	519683.8	36
Los Alamos at LA-2[d]	1777157.0	526680.1	37
Los Alamos at Otowi	1774114.9	531709.9	38
Other Canyons			
Guaje at SR 502	1777366.5	525674,0	12
Bayo at SR 502	1774361.7	522361.8	13
Sandia at Rio Grande[c]	1758925	525014	Sandia
Cañada Ancha at Rio Grande	N/A[e]	N/A	Cañada Ancha
Pajarito at Rio Grande[c]	1747532	516715	Pajarito
Frijoles at National Monument Headquarters	1737929.3	494139.8	21
Frijoles at Rio Grande[c]	1729494	499198	Frijoles
Mortandad Canyon on San Ildefonso Pueblo Lands			
Mortandad A-6	N/A	N/A	A-6
Mortandad A-7	N/A	N/A	A-7
Mortandad A-8	N/A	N/A	A-8
Mortandad at SR 4 (A-9)[d]	1763782.7	509436.7	15
Mortandad A-10	N/A	N/A	A-10
Mortandad at Rio Grande (A-11)[b]	1756595	523638	Mortandad(A-11)

Table D-11. (Cont.)

Station	Latitude or Northing Coordinate	Longitude or Easting Coordinate	Map Designation[a]
ON-SITE STATIONS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyon			
Hamilton Bend Spring[d]	1775857.4	502232.8	25
Pueblo 3[d]	1774826.4	506425.0	26
Pueblo at SR 502[d]	1771862.0	512694.7	27
DP-Los Alamos Canyon			
DPS-1[d]	1774796.3	493080.9	28
DPS-4[d]	1773227.8	497258.4	29
Los Alamos at Bridge[d]	1775550.8	478015.5	30
Los Alamos at LAO-1[d]	1773884.4	489162.8	31
Los Alamos at GS-1[d]	1770827.3	507906.9	32
Los Alamos at LAO-3[d]	1773012.4	497803.4	33
Los Alamos at LAO-4.5[d]	1772073.7	503410.1	34
Los Alamos at SR 4[d]	1771473.8	511651.0	35
Mortandad Canyon			
Mortandad near CMR Building[d]	1772092.7	479491.8	39
Mortandad west of GS-1	N/A	N/A	40
Mortandad at GS-1[d]	1770229.5	486502.2	41
Mortandad at MCO-5[d]	1769482.7	492212.1	42
Mortandad at MCO-7[d]	1768419.6	494306.2	43
Mortandad at MCO-9[d]	1768309.1	497813.6	44
Mortandad at MCO-13 (A-5)[d]	1767168.7	501051.6	45
Other Canyons			
Sandia at SR 4[d]	1767568.8	507558.5	14
Cañada del Buey at SR 4[d]	1756281.4	511459.2	16
Pajarito at SR 4[d]	1754333.2	508284.8	17
Potrillo at SR 4[d]	1751097.4	505375.0	18
Fence at SR 4	1751220.5	505153.7	46
Water at SR 4[d]	1749965.7	500428.6	19
Indio at SR 4	1747798.3	501075.1	47
Ancho at SR 4	1741156.4	500015.5	20
Water at Rio Grande[c]	1741139	514154	Water
Ancho at Rio Grande[c]	1735497	509307	Ancho
Chaquehiu at Rio Grande[c]	1733012	502768	Chaquehui
Solid Radioactive Waste Management Areas			
Area G, TA-54[d]			
G-1	1757654.9	501645.5	G-1
G-2	1757160.7	502094.9	G-2
G-3	1756706.5	503162.6	G-3
G-4	1756643.1	503955.1	G-4
G-5	1756592.8	504153.1	G-5
G-6	1756494.6	504786.9	G-6

Table D-11. (Cont.)

Station	Latitude or Northing Coordinate	Longitude or Easting Coordinate	Map Designation[a]
Area G, TA-54[d] (Cont.)			
G-7	1757361.2	505155.7	G-7
G-8	1757539.2	506507.4	G-8
G-9	1758521.8	505236.2	G-9
Area AB, TA-49[d]			
AB-1	1775633.2	484290.4	AB-1
AB-2	1755169.0	485200.5	AB-2
AB-3	1755569.9	485238.6	AB-3
AB-4	1755640.2	486640.9	AB-4
AB-4A	1755773.2	486638.4	AB-4A
AB-5	1754799.9	485631.3	AB-5
AB-6	1754684.8	485643.4	AB-6
AB-7	1754417.4	485583.5	AB-7
AB-8	1754383.4	484698.5	AB-8
AB-9	1756396.7	488195.0	AB-9
AB-10	1754547.5	488279.6	AB-10
AB-11	1752019.9	488479.1	AB-11

[a]Sediment sampling locations in Figures IV-8 and IV-9.
[b]Latitude/Longitude data from US Geological Survey (USGS).
[c]Coordinate data from GPS, estimated accuracy _2 to 5 m.
[d]Coordinate data from standard land survey.
[e]Not available.

Table D-12. Location and Description of Soil Sampling Stations

Station	Latitude or Northing Coordinate	Longitude or Easting Coordinate	Map Designation[a]	Description of Nearby LANL Contaminant Sources
Regional Soils				
Rio Chama[b]	36_05'	106_07'	Chamita	
Embudo[b]	36_12'	105_58'	Embudo	
Otowi[b]	35_52'	106_08'	Otowi	
Near Santa Cruz[b]	35_59'	105_54'	Santa Cruz	
Cochiti[b]	35_37'	106_19'	Cochiti	
Bernalillo[b]	35_17'	106_36'	Bernalillo	
Jemez[b]	35_40'	106_44'	Jemez	
Perimeter Soils				
L.A. Sportsman Club	1788074.0	496249.0	S1	
North Mesa[c]	1780010.3	490085.7	S2	
Near TA-8 (GT Site)	1771742.0	470821.0	S3	
Near TA-49[c]	1752276.0	489350.8	S4	Inactive Waste Site
White Rock (east)[c]	1758239.4	514872.4	S5	
Tsankawi[c]	1768048.2	507740.9	S6	
On-Site Soils				
TA-21 (DP Site)[c]	1774927.1	491022.1	S7	Pu/Chem. Research
East of TA-53[c]	1773526.6	486055.2	S8	LAMPF Accelerator
TA-50	1769486.5	486145.8	S9	Rad. Water Treatment
Two-Mile Mesa	1769432.4	476142.2	S10	Main Technical Area
East of TA-54[c]	1757820.7	504918.6	S11	Rad. Disposal Site
R-Site Road East	1761861.2	485618.9	S12	PHERMEX Accelerator
Potrillo Drive[c]	1751838.6	490581.7	S13	HE Detonation
S-Site (TA-16)[b]	1759266.8	478624.5	S14	HE Res.; ^{3}H Facility
Near Test Well DT-9[c]	1752276.0	489350.8	S15	Inactive Waste Site
Near TA-33[c]	1740744.1	498243.9	S16	Ex ^{3}H Facility

[a]Soil sampling locations are given in Figures IV-8 and IV-11.
[b]Latitude/Longitude data from USGS.
[c]Coordinate data from standard land survey.

Table D-13. Locations of Beehives[a]

Station		Northing[b]	Easting[b]
OFF-SITE STATIONS, UNCONTROLLED AREAS			
Regional (28_44 km)			
	San Pedro	1809664.111	554217.954
	Pojoaque	1783159.441	568681.063
	San Juan	1839089.577	548510.294
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	1765802.436	472882.859
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	484363.401
12.	TA-53	1770340.109	499720.283
13.	TA-54	1757000.077	503475.736

[a]Approximate locations of off-site regional behives are presented in Figure IV-13; on-site beehives are presented in Figure IV-14.
[b]New Mexico State Plane Coordinates.

Table D-14. TA-6 Tower Variables.

Wind

U horizontal wind speed (m/s) at z = 11.5, 23, 46, and 92 m

- σ_u standard deviation of wind speed
- $\overline{U}$ 24-h mean wind speed
- U_{mx} maximum gust in in a 24-h period
- t_{mx} time of the maximum gust
- U_{mx1} maximum 1-min gust at z = 11.5 m in a 24-h period
- t_{mx1} time of the 1-min gust

θ horizontal vector wind direction (deg) at z = 11.5, 23, 46, and 92 m

- σ_θ standard deviation of wind direction
- θ_{mx} direction of the maximum gust
- θ_{mx1} direction of the maximum 1-min gust at z = 11.5m

w vertical wind speed (m/s) at z = 11.5, 23, 46, 92 m

u2* friction velocity squared (m^2/s^2) at z = 11.5 m; toward the surface is positive

$u2^* = \overline{u'w'}$

Atmospheric State

Temperature

T air temperature (°C) at z = 1.2, 11.5, 23, 46, and 92 m

- T_{mx} maximum temperature at z = 1.2 m in a 24-h period
- t_{mx} time of the maximum temperature
- T_{mn} minimum temperature at z = 1.2 m in a 24-h period
- t_{mn} time of the minimum temperature

T' air temperature fluctuations measured by a thermocouple at z = 11.5 m

T_d dew point temperature (°C) at z = 1.2 m

T_d = f($VP(h,SVP(T,h))$), where VP and SVP are the vapor pressure and saturation vapor pressure and h is the relative humidity

- $\overline{T_d}$ 24-h mean value
- T_{dmx} maximum dew point temperature in a 24-h period
- T_{dmn} minimum dew point temperature in a 24-h period

T_s soil temperature (°C) at z = -10 cm

Table D-14. (Cont.)

Humidity

h relative humidity (%) at z = 1.2 m

$\overline{h}$ 24-h mean relative humidity
h_{mx} maximum relative humidity in a 24-h period
h_{mn} minimum relative humidity in a 24-h period

q' absolute humidity fluctuations (g water/m^3 of air) at z = 11.5 m

Atmospheric Pressure

p pressure (mb) at z = 1.2 m

p_{mx} maximum pressure in a 24-h period
p_{mn} minimum pressure in a 24-h period

Precipitation

r total precipitation in 15 min (in./100), water equivalent when snow; logged as -1 for a trace.

r total precipitation in a 24-h period

Surface Energy Exchange

Radiation Flux Densities

K↓ incoming solar radiation flux (W/m^2) at z = 1.5 m; toward the surface is positive

$$K\downarrow = \int^{24} K\downarrow \, dt \quad (\text{kW h/m}^2)$$

K↑ reflected solar radiation at z = 1.5 m; away from the surface is positive

$$K\uparrow = \int^{24} K\uparrow \, dt$$

L↓ incoming longwave radiation flux (W/m^2) at z = 1.5 m; toward the surface is positive

$$L\downarrow = \int^{24} L\downarrow \, dt \quad (\text{kW h/m}^2)$$

L↑ outgoing longwave radiation flux at z = 1.5 m; away from the surface is positive

$$L\uparrow = \int^{24} L\uparrow \, dt$$

Table D-14. (Cont.)

Q^* net all-wave radiation (W/m^2) at z = 1.5 m; toward the surface is positive

$Q^* = L\downarrow + L\uparrow + K\downarrow + K\uparrow$

$Q^* = \int^{24} Q^* \, dt$ (kW h/m^2)

Heat Flux Densities

Q_g ground heat flux (W/m^2) at z = - 1 cm; away from the surface is positive; the heat storage term is neglected

$Q_g = \int^{24} Q_g \, dt$ (kW h/m^2)

Q_h sensible heat flux (W/m2) at z = 11.5 m; away the surface is positive

$Q_h = 1.08 c_p \rho \overline{w'T} + 0.1 Q_e$, where c_p is the specific heat of air at constant pressure (= 1 J/g • K at 10°C)

$Q_h = \int^{24} Q_h \, dt$ (kW h/m^2)

Q_e latent heat flux (W/m^2) at z = 11.5 m; away from the surface is positive

$Q_e = L \overline{w'q'}$, where L is the specific heat of vaporization of water (= 2480 J/g)

$Q_e = \int^{24} Q_e \, dt$ (kW h/m^2)

Table D-15. Meteorological Variables Measured by the Exiting Tower Network

Table D-16. Summary of Selected Radionuclides Half-Life Information

Nuclide	Half-Life
^{3}H	12.3 yr
^{7}Be	53.4 d
^{11}C	20.5 min
^{13}N	10.0 min
^{15}O	122.2 s
^{22}Na	2.6 yr
^{32}P	14.3 d
^{40}K	1,277,000,000 yr
^{41}Ar	1.83 h
^{54}Mn	312.7 d
^{56}Co	78.8 d
^{57}Co	270.9 d
^{58}Co	70.8 d
^{60}Co	5.3 yr
^{75}Se	119.8 d
^{85}Sr	64.8 d
^{89}Sr	50.6 d
^{90}Sr	28.6 yr
^{131}I	8 d
^{134}Cs	2.06 yr
^{137}Cs	30.2 yr
^{234}U	244,500 yr
^{235}U	703,800,000 yr
^{238}U	4,468,000,000 yr
^{238}Pu	87.7 yr
^{239}Pu	24,131 yr
^{240}Pu	6,569 yr
^{241}Pu	14.4 yr
^{241}Am	432 yr

NOTE: For the half-life of the principal airborne activation products, see discussion on page V_2.

Table D-17. 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-18. Dose Conversion Factors for Calculating External Doses

Radionuclide[a]	EDE ([mrem/yr]/[μCi/m³])
^{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-19. Locations of Groundwater Sampling Stations

Station	Northing Coordinate	Easting Coordinate	Map Designation[a]
MAIN AQUIFER ON SITE			
Test Wells			
Test Well 1	1772014.8[b]	509797.3	39
Test Well 3	1773076.0	497483.2	41
Test Well 8	1769444.5	492329.6	43
Test Well DT-5A	1754923.5	485098.3	42
Test Well DT-9	1752318.4	489300.0	44
Test Well DT-10	1755228.5	488780.9	45
Water Supply Wells			
Pajarito Well Field			
Well PM-1	1768050.0	507490.1	89
Well PM-2	1760264.0	496542.0	90
Well PM-3	1769364.0	502386.8	91
Well PM-4	1764612.0	495472.4	92
Well PM-5	1767747.0	492839.0	93
MAIN AQUIFER OFF SITE			
Test Wells			
Test Well 2	1777205.8	493986.9	40
Water Supply Wells			
Guaje Well Field			
Well G-1	1783547.0	515946.4	82
Well G-1A	1784291.0	514996.6	83
Well G-2	1785061.0	513966.2	84
Well G-3	1786156.0	511432.1	85
Well G-4	1786390.0	508704.8	86
Well G-5	1787845.0	506705.3	87
Well G-6	1786789.0	504580.1	88
Los Alamos Well Field			
Well LA-1B	1776890.0	528003.5	76
Well LA-2	1777157.0	526680.1	77
Well LA-3	1777123.0	525746.8	78
Well LA-5	1772471.0	519582.1	80
Well LA-6	1774531.0	522637.9	81
San Ildefonso Wells			
Westside Artesian Well	N/A[c]	N/A	SI 10
Halladay Well	N/A	N/A	SI _8
Pajarito Well (Pump 1)	N/A	N/A	SI _3
Eastside Artesian Well	N/A	N/A	SI _9
Don Juan Playhouse Well	N/A	N/A	SI 17
MAIN AQUIFER SPRINGS			
White Rock Canyon Springs (Perimeter and Off-Site)			
Group I			
Sandia Spring[d]	1761428	522938	13
Spring 3[d]	1753500	521243	14
Spring 3A[d]	1753236	521276	15

Table D-19. (Cont.)

Station	Northing Coordinate	Easting Coordinate	Map Designation[a]
Group I (Cont.)			
Spring 3AA[d]	1750988	521047	16
Spring 4[d]	1747825	515784	17
Spring 4A[b]	1747800	515900	18
Spring 5[d]	1742479	515812	19
Spring 5AA[b]	1742500	510900	20
Ancho Spring[b]	1739900	505400	21
Group II			
Spring 5A[d]	1741943	515121	22
Spring 5B[b]	1738100	510800	96
Spring 6[d]	1735455	508638	23
Spring 6A[d]	1734210	506318	24
Spring 7[b]	1733500	504800	25
Spring 8[b]	1733400	504200	26
Spring 8A[d]	1733446	503574	27
Spring 8B[b]	1733500	503000	97
Spring 9[d]	1733255	503191	28
Spring 9A[d]	1733085	502498	29
Doe Spring[d]	1733536	502081	30
Spring 10[d]	1728100	497779	31
Group III			
Spring 1[d]	1767795	527684	32
Spring 2[d]	1766286	527068	33
Group IV			
La Mesita Spring[b]	1770700	516300	10
Spring 2A[b]	1754800	522400	95
Spring 3B[d]	1749752	521110	34
Other Off-Site Springs			
Sacred Spring[b]	1780300	529800	11
Indian Spring[b]	1777200	525700	12
ALLUVIAL CANYON AQUIFERS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyons			
Hamilton Bend Spring	1776160.6	502420.0	53
DP-Los Alamos Canyons			
LAO-C	1775187.8	481913.6	59
LAO-1	1773894.3	489150.7	60
LAO-2	1773033.8	497363.4	61
LAO-3	1773036.3	497766.3	62
LAO-4	1772667.4	500507.7	63
LAO-4.5	1772025.6	503414.8	64
Mortandad Canyon			
MCO-3	1770174.7	487118.3	69
MCO-4	1769725.8	490970.1	70
MCO-5	1769475.9	492221.9	71
MCO-6	1768950.7	493391.1	72

Table D-19. (Cont.)

Station	Northing Coordinate	Easting Coordinate	Map Designation[a]	
Mortandad Canyon (Cont.)				
MCO-7	1768447.8	494273.6	73	
MCO-7.5	1768378.4	495210.6	74	
Other Areas				
Pajarito Canyon				
PCO-1		1759928.6	497675.1	102
PCO-2		1757380.8	501456.2	103
PCO-3		1755427.3	505844.4	104
PERCHED SYSTEM IN CONGLOMERATES AND BASALT				
(Pueblo/LosAlamos/Sandia Canyon Area)				
Test Well 1A	1772003.7	509812.7	54	
Test Well 2A	1777226.0	493940.6	55	
Basalt Spring[b]	1770700	516300	56	
PERCHED AQUIFER IN VOLCANICS				
Water Canyon Gallery[b]	1762500	463900	94	

[a]See Figure VII-1 for off-site perimeter and on-site groundwater sampling locations.
[b]Coordinates estimated from USGS quadrangle map.
[c]Not available.
[d]Coordinate data from GPS, estimated accuracy _2 to 5 m.

Table D-20. Volatile Organic Compounds in Water Determined by PAT[a] Analyses

Compound	CAS[b] #	Representative Limit of Quantification[c] (μg/L)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,2-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-2	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
Vinyl acetate	108-05-4	10
2-Butanone	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
1-Chlorohexane	544-10-5	5
Ethylbenzene	100-41-4	5
m,p-Xylene (total)	108-38-3 + 106-42-3	5
o-Xylene	95-47-6	5
Styrene	100-42-5	5

Table D-20. (Cont.)

Compound	CAS[b] #	Representative Limit of Quantification[c] (μg/L)
1,1,2,2-Tetrachloroethane	79-34-5	5
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	95-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
1,2,4-Trichlorobenzene	120-82-1	N/A
Naphthalene	91-20-3	N/A
1,2,3-Trichlorobenzene	87-61-6	N/A
Hexachlorobutadiene	87-68-3	N/A
Dichlorodifluonomethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5
2-Chloroethylvinylether	110-75-8	50
Acrylonitrile	107-13-1	100
Acrolein	107-02-8	100

[a]Purge-and-trap gas chromatography/mass spectrometry.
[b]Chemical abstract service.
[c]Column: Supelco SPB-5 60 m ± 0.25 mm ± 1.0 μm. Limits of detection estimated by minimum signal required to yield identifiable mass spectral scan.

Table D-21. Volatile Organic Compounds in Solids Determined by SW-846 Method 8260

Compound	CAS[a] #	Limit of Quantification[b] (mg/kg)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,5-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-4	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
Vinyl acetate	108-05-4	10
2-Butanone (MEK)	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-2	5
c-1,3-Dichloropropene	1006-10-1	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone (MIK)	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-8	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
1-Chlorohexane	544-10-5	5
Ethylbenzene	100-41-4	5
Mixed Xylene (total)	1330-20-7	5
Styrene	100-42-5	5
1,1,2,2-Tetrachloroethane	79-34-5	5

Table D-21. (Cont.)

Compound	CAS[a] #	Limit of Quantification[b] (mg/kg)
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	98-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
1,2,4-Trichlorobenzene	120-82-1	N/A
Naphthalene	91-20-3	N/A
1,2,3-Trichlorobenzene	87-61-6	N/A
Hexachlorobutadiene	87-68-3	N/A
Dichlorodifluonomethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5
2-Chloroethylvinylether	110-75-8	50
Acrylonitrile	107-13-1	100
Acrolein	107-02-8	100

[a]Chemical abstract service.
[b]Column: 60 m ± 0.32 mm SPB-5 fused silica capillary, using a methanolic partition with purge and trap. Limits of quantification are calculated from the intercept of the external calibration curve using a flame-ionization detector.

Table D-22. Semivolatile Organics in Water

Compound	CAS[a] #	Limit of Quantification (μg/L)
N-Nitrosodimethylamine	62-75-9	10
Aniline	62-55-3	10
Phenol	108-95-2	10
bis(-2-Chloroethyl)ether	111-44-4	10
2-Chlorophenol	95-57-8	10
1,3-Dichlorobenzene	541-73-1	10
1,4-Dichlorobenzene	106-46-7	10
Benzyl alcohol	100-51-6	10
1,2-Dichlorobenzene	95-50-1	10
2-Methylphenol	95-48-7	10
bis(2-Chloroisopropyl)ether	39638-32-9	10
4-Methylphenol	106-44-5	10
N-Nitroso-di-*n*-propylamine	621-64-7	10
Hexachloroethane	67-72-1	10
Nitrobenzene	98-95-3	10
Isophorone	78-59-1	10
2-Nitrophenol	88-75-5	10
2,4-Dimethylphenol	105-67-9	10
Benzoid acid	65-85-0	10
bis(-2-Chloroethoxy)methane	111-91-1	10
2,4-Dichlorophenol	120-83-2	10
1,2,4-Trichlorobenzene	120-82-1	10
Naphthalene	91-20-3	10
4-Chloroaniline	106-47-8	10
Hexachlorobutadiene	87-68-3	10
4-Chloro-3-methylphenol	59-50-7	10
2-Methylnaphthalene	91-57-6	10
Hexachlorocyclopentadiene	77-47-4	10
2,4,6-Trichlorophenol	88-06-2	10
2,4,5-Trichlorophenol	95-95-4	10
2-Chloronaphthalene	91-58-7	10
2-Nitroaniline	88-74-4	10
Dimethyl phthalate	131-11-3	10
Acenaphthylene	208-96-8	10
3-Nitroaniline	99-09-2	10
Acenaphthene	83-32-9	10
2,4-Dinitrophenol	51-28-5	10
4-Nitrophenol	100-02-7	10
Dibenzofuran	132-64-9	10
2,4-Dinitrotoluene	121-14-2	10
2,6-Dinitrotoluene	606-20-2	10
Diethylphthalate	84-66-2	10
4-Chlorophenyl-phenylether	7005-72-3	10
Fluorene	86-73-7	10
4-Nitroaniline	100-01-6	10
4,6-Dinitro-2-methylphenol	534-52-1	10
N-Nitrosodiphenylamine	86-30-6	10

Table D-22. (Cont.)

Compound	CAS #	Limit of Quantification (μg/L)
Azobenzene	103-33-3	10
4-Bromophenyl-phenylether	101-55-3	10
Hexachlorobenzene	118-74-1	10
Pentachlorophenol	87-86-5	10
Phenanthrene	85-01-8	10
Anthracene	120-12-7	10
Di-*n*-butylphthalate	84-74-2	10
Fluoranthene	206-44-0	10
Benzidine	92-87-5	10
Pyrene	129-00-0	10
Butylbenzylphthalate	85-68-7	10
3,3ó-Dichlorobenzidine	91-94-1	10
Benzo(*a*)anthracene	56-55-3	10
bis(2-Ethylhexyl)phthalate	117-81-7	10
Chrysene	218-01-9	10
Di-*n*-octyl phthalate	117-84-0	10
Benzo(*b*)fluoranthene	205-99-2	10
Benzo(*k*)fluoranthene	207-08-9	10
Benzo(*a*)pyrene	50-32-8	10
Indeno(1,2,3-*cd*)pyrene	193-39-5	10
Dibenzo(*a*,*h*)anthracene	53-70-3	10
Benzo(*g*,*h*,*i*)perylene	191-24-2	10

[a]Chemical abstract service.

Table D-23. Volatiles Determined in Air (Pore Gas)

Compound	CAS[a] #	Limit of Quantification (μg/tube)
Chloroform	67-66-3	8.0
1,1,1-Trichloroethane	71-56-6	8.0
Benzene	71-43-2	8.0
Carbon tetrachloride	56-23-5	8.0
Trichloroethene	79-01-6	8.0
Toluene	108-88-3	8.0
Tetrachloroethene	127-18-4	8.0
Chlorobenzene	108-90-7	8.0
Ethylbenzene	100-41-4	8.0
o-Xylene	95-47-6	8.0
m,*p*-Xylene (total)	108-38-3 + 106-42-3	8.0
1,2,4-Trimethylbenzene	95-63-6	8.0
Bromobenzene	108-86-1	8.0

[a]Chemical abstract service.

Table D-24. Toxicity Characteristic Leaching Procedure Target Organic Contaminants

Contaminant	Regulatory Level (mg/L)
Compound	
Acrylonitrile	5.0
Benzene	0.07
Carbon disulfide	14.4
Carbon tetachloride	0.07
Chlorobenzene	1.4
Chloroform	0.07
1,2-Dichloroethane	0.04
1,1-Dichlorethylene	0.1
Isobutanol	25
Methylene chloride	8.6
Methyethyl ketone	7.2
1,1,1,2-Tetachloroethane	10.0
1,1,2,2-Tetachloroethane	1.3
Tetachloroethylene	0.1
Toluene	14.4
1,1,1-Trichloroethane	25
1,1,2-Trichloroethane	1.2
Trichloroethylene	0.07
Vinyl chloride	0.05
o-Cresol	10.0
m-Cresol	10.0
p-Cresol	10.0
Pentachlorophenol	3.6
Phenol	14.4
2,3,4,6-Tetachlorophenol	1.5
2,4,5-Trichlorophenol	5.8
2,4,6-Trichlorophenol	0.30
Bis(2-chloroethyl)ether	0.05
1,2-Dichlorobenzene	4.3
1,4-Dichlorobenzene	10.8
2,4-Dinitrotoluene	0.13
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.72
Hexachloroethane	4.3
Nitrobenzene	0.13
Pyridine	5.0
Heptachlor	0.001
Insecticides	
Endrin	0.003
Lindane(γ-BHC)	0.06
Methoxychlor	1.4
Toxaphene	0.07
Herbicides	
2,4-D	1.4
2,3,5-TP (Silvex)	0.14

Table D-25. Summary of EM-9 Quality Assurance Tests for 1992
(Stable Element Analyses in Filters)

Analysis	Number of Quality Control (QC) Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Be	11	73	27	_	0.90 _ 0.08
Pb	3	67	33	_	0.77

Table D-26. Summary of EM-9 Quality Assurance Tests for 1992
(Stable Element Analyses in Soil)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Ag	2	100	_	_	_[a]
Al	28	75	14	11	0.79 _ 0.19
As	7	86	14	_	0.83 _ 0.32
B	15	93	7	_	1.33 _ 0.34
Ba	23	91	_	9	0.93 _ 0.11
Be	22	100	_	_	1.06 _ 0.31
Ca	12	100	_	_	0.85 _ 0.08
Cd	24	92	8	_	1.64 _ 0.62
Co	22	91	5	5	1.43 _ 1.72
Cr	26	65	12	23	0.84 _ 0.56
Cu	11	73	_	27	0.85 _ 0.26
Fe	27	100	_	_	0.89 _ 0.08
H_2O - (unbound water)	3	100	_	_	0.91 _ 0.06
Hg	12	83	17	_	1.06 _ 0.47
K	12	92	_	8	0.89 _ 0.15
Li	1	100	_	_	_
Mg	13	100	_	_	0.88 _ 0.07
Mn	17	100	_	_	0.97 _ 0.18
Mo	2	100	_	_	_
Na	13	85	_	15	0.77 _ 0.30
Ni	32	69	22	9	1.02 _ 1.49
Pb	27	85	4	11	1.29 _ 0.97
Sb	21	90	5	5	5.70 _ 5.98
Se	2	100	_	_	_
Sn	2	100	_	_	0.95
Sr	3	100	_	_	0.92 _ 0.06
Tl	19	89	5	5	20.72 _ 37.95
V	17	88	_	12	1.33 _ 1.02
Zn	16	56	13	31	0.79 _ 0.33

[a]The constituents with _ shown occurred at below detection-limit levels in the QC samples. The control status can be evaluated, but no EM-9 Ratio can be calculated.

Table D-27. Summary of EM-9 Quality Assurance Tests for 1992
(Stable Element Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Ag	218	98	_	2	1.02 _ 0.11
Al	93	98	_	2	0.99 _ 0.08
As	199	97	1	2	1.02 _ 0.24
Au	1	100	_	_	_[a]
B	69	100	_	_	1.03 _ 0.06
Ba	171	94	2	4	1.03 _ 0.08
Be	126	98	1	1	1.01 _ 0.32
Bi	1	100	_	_	_
Ca	69	99	1	_	1.05 _ 0.09
Cd	174	95	3	2	1.02 _ 0.11
Ce	1	100	_	_	_
Cl	32	100	_	_	0.95 _ 0.05
CN	27	78	11	11	0.78 _ 0.11
Co	92	95	4	1	1.07 _ 0.20
COD	2	100	_	_	0.85
Conductivity	40	95	3	3	0.98 _ 0.06
Cr	183	92	7	2	1.05 _ 0.13
Cs	1	100	_	_	_
Cu	82	91	4	5	1.18 _ 1.04
Dy	1	100	_	_	_
Er	1	100	_	_	_
Eu	1	100	_	_	_
F	33	100	_	_	1.01 _ 0.10
Fe	90	99	_	1	1.03 _ 0.07
Ga	1	100	_	_	_
Gd	1	100	_	_	_
Ge	1	100	_	_	_
Hardness	17	94	6	_	1.10 _ 0.10
Hf	1	100	_	_	_
Hg	203	96	2	2	0.98 _ 0.13
Ho	1	100	_	_	_
In	1	100	_	_	_
Ir	1	100	_	_	_
K	68	93	6	1	0.98 _ 0.13
La	1	100	_	_	_
Li	14	100	_	_	1.09 _ 0.17
Lu	1	100	_	_	_
Mg	73	99	1	_	1.02 _ 0.07
Mn	87	94	6	_	1.08 _ 0.14
Mo	55	96	4	_	1.11 _ 0.13
Na	68	99	1	_	1.03 _ 0.06
Nb	1	100	_	_	_

Table D-27. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Nd	1	100	_	_	_
NH_3-N (Ammonia Nitrogen)	3	100	_	_	1.00
Ni	131	98	_	2	1.04 _ 0.14
NO_2-N (Nitrite Nitrogen)	1	100	_	_	1.11
NO_3-N (Nitrate Nitrogen)	43	100	_	_	0.98 _.05
Oil and Grease	6	100	_	_	0.92 _ 0.09
Pb	189	94	2	5	1.02 _ 0.18
Pd	1	100	_	_	_
pH	39	100	_	_	1.01 _ 0.01
PO_4-P (Phosphate Phosphorus)	23	100	_	_	0.97 _ 0.05
Pr	1	100	_	_	_
Pt	1	100	_	_	_
Rb	1	100	_	_	_
Rh	1	100	_	_	_
Ru	1	100	_	_	_
Sb	100	90	3	7	1.06 _ 0.40
Se	169	94	4	2	0.99 _ 0.11
SiO_2	38	100	_	_	1.05 _ 0.06
Sm	1	100	_	_	_
Sn	8	88	_	13	4.36 _ 8.19
SO_4	34	94	6	_	0.95 _ 0.09
Sr	51	100	_	_	1.02 _ 0.06
Ta	1	100	_	_	_
Total Alkalinity	35	97	3	_	1.11 _ 0.10
Tb	1	100	_	_	_
TDS (total dissolved solids)	38	92	5	3	1.00 _ 0.15
Te	1	100	_	_	_
Th	1	100	_	_	_
Ti	1	100	_	_	0.96
Total Kjeldahl Nitrogen	1	100	_	_	1.12
Tl	89	90	8	2	1.01 _ 0.20
Tm	1	100	_	_	_
V	72	93	7	_	1.03 _ 0.10
W	1	100	_	_	_
Y	1	100	_	_	_
Yb	1	100	_	_	_
Zn	80	86	6	8	1.04 _ 0.27
Zr	1	100	_	_	_

[a]The constituents with _ shown occurred at below detection-limit levels in the QC samples. The control status can be evaluated, but no EM-9 Ratio can be calculated.

Table D-28. Summary of EM-9 Quality Assurance Tests for 1992 (Radiochemical Analyses)

Matrix	Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Biologicals						
	^{241}Am	1	100	_	_	0.99
	^{137}Cs	14	86	14	_	1.02 _ 0.40
	^{238}Pu	10	100	_	_	1.10 _ 0.05
	^{239}Pu	10	100	_	_	1.06 _ 0.04
	^{90}Sr	8	100	_	_	1.70 _ 1.19
	U	10	90	10	_	1.07 _ 0.15
Filters						
	Alpha	87	100	_	_	0.89 _ 0.08
	^{241}Am	11	45	9	45	0.86 _ 0.07
	Beta	87	100	_	_	0.82 _ 0.05
	^{238}Pu	11	100	_	_	1.00 _ 0.06
	^{239}Pu	11	82	18	_	1.00 _ 0.07
	U	33	97	3	_	1.04 _ 0.09
Soil						
	Alpha	17	76	18	6	1.18 _ 0.53
	^{241}Am	16	100	_	_	1.21 _ 0.17
	Beta	17	82	12	6	1.10 _ 0.25
	^{137}Cs	45	91	7	2	1.08 _ 0.34
	Gamma	32	88	6	6	0.96 _ 0.27
	^{3}H	29	66	17	17	1.09 _ 0.27
	^{238}Pu	47	96	2	2	1.07 _ 0.14
	^{239}Pu	47	96	2	2	1.00 _ 0.10
	^{90}Sr	14	100	_	_	1.00 _ 0.07
	U	171	94	1	5	0.94 _ 0.10
	^{234}U	1	100	_	_	0.96
	^{235}U	1	100	_	_	0.86
	$^{235/238}$U	17	100	_	_	1.00 _ 0.07
	^{238}U	1	100	_	_	0.95
Water						
	Alpha	215	98	1	1	0.94 _ 0.27
	^{241}Am	7	86	14	_	1.03 _ 0.23
	Beta	213	96	2	2	0.85 _ 0.21
	^{137}Cs	37	84	16	_	1.05 _ 0.23
	Gamma	185	99	1	_	1.01 _ 0.14
	^{3}H	146	99	1	_	1.00 _ 0.08
	^{238}Pu	11	100	_	_	1.10 _ 0.12
	^{239}Pu	10	100	_	_	1.07 _ 0.12
	^{226}Ra	3	100	_	_	1.09
	^{90}Sr	28	100	_	_	1.03 _ 0.03
	U	106	92	_	8	1.05 _ 0.26
	^{234}U	1	100	_	_	1.04
	^{235}U	1	100	_	_	0.88
	$^{235/238}$U	44	100	_	_	1.00 _ 0.09

Table D-29. Summary of EM-9 Quality Assurance Tests for 1992 (Organic Analyses in Filters)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Mixed-Aroclor	56	98	2	_	1.02 _ 0.27
Aroclor 1242	56	98	2	_	0.87 _ 0.32
Aroclor 1254	56	100	_	_	1.13 _ 0.25
Aroclor 1260	56	100	_	_	0.89 _ 0.11

Table D-30. Summary of EM-9 Quality Assurance Tests for 1992 (Organic Analyses in Bulk Materials)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Mixed-Aroclor	116	94	3	3	1.21 _ 1.29
Aroclor 1242	116	96	1	3	1.22 _ 0.42
Aroclor 1254	116	97	1	2	1.53 _ 1.85
Aroclor 1260	116	97	_	3	0.89 _ 0.27

Table D-31. Summary of EM-9 Quality Assurance Tests for 1992 (Organic Analyses in Soil)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Acenaphthene	31	90	6	3	0.63 _ 0.09
Acenaphthylene	31	100	_	_	_[a]
Acetone	23	22	30	48	0.48 _ 0.11
Aldrin	7	100	_	_	_
Aniline	31	68	3	29	0.37 _ 0.36
Anthracene	31	100	_	_	0.76 _ 0.10
Mixed-Aroclor	53	91	2	8	0.81 _ 0.31
Aroclor 1242	53	98	_	2	0.88 _ 0.28
Aroclor 1254	53	96	_	4	0.59 _ 0.20
Aroclor 1260	53	96	2	2	0.84 _ 0.33
Azobenzene	31	100	_	_	_
beta-BHC	6	83	17	_	0.75
delta-BHC	7	100	_	_	_
alpha-BHC	7	71	14	14	0.64 _ 0.14
Benzene	23	100	_	_	0.92 _ 0.03
m-Benzidine	31	100	_	_	_
Benzo[*a*]anthracene	31	97	_	3	0.70 _ 0.20
Benzo[*a*]pyrene	31	100	_	_	_

Table D-31. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Benzo[*b*]fluoranthene	31	100	_	_	0.73 _ 0.13
Benzo[*g*,*h*,*i*]perylene	31	100	_	_	_
Benzo[*k*]fluoranthene	31	100	_	_	0.60
Benzoic acid	31	74	_	26	0.15
Benzyl alcohol	31	100	_	_	_
Bis(2-chloroethoxy)methane	31	97	3	_	0.64
Bis(2-chloroethyl)ether	31	97	_	3	0.46
Bis(2-chloroisopropyl)ether	31	100	_	_	_
Bis(2-ethylhexyl)phthalate	31	100	_	_	_
Bromobenzene	23	96	4	_	0.61
Bromochloromethane	23	100	_	_	_
Bromodichloromethane	23	100	_	_	1.16 _ 0.30
Bromoform	23	100	_	_	0.91 _ 0.10
Bromomethane	23	100	_	_	_
4-Bromophenylphenyl ether	31	100	_	_	_
2-Butanone	23	43	26	30	0.58 _ 0.13
Butyl benzyl phthalate	31	100	_	_	_
n-Butylbenzene	23	100	_	_	1.02 _ 0.04
sec-Butylbenzene	23	100	_	_	0.69
tert-Butylbenzene	23	100	_	_	_
Carbon disulfide	23	100	_	_	1.01 _ 0.17
Carbon tetrachloride	23	100	_	_	1.11 _ 0.13
Chlordane	6	100	_	_	_
4-Chloro-3-methylphenol	31	97	_	3	0.68 _ 0.14
4-Chloroaniline	31	90	_	10	0.28
Chlorobenzene	23	100	_	_	1.07 _ 0.08
Chlorodibromomethane	23	100	_	_	1.18 _ 0.24
Chloroethane	23	100	_	_	_
Chloroform	23	100	_	_	0.95 _ 0.17
Chloromethane	23	100	_	_	_
2-Chloronaphthalene	31	84	13	3	0.56 _ 0.06
o-Chlorophenol	31	68	26	6	0.57 _ 0.11
4-Chlorophenylphenyl ether	31	100	_	_	_
p-Chlorotoluene	23	87	_	13	0.70
o-Chlorotoluene	23	96	4	_	0.92 _ 0.27
Chrysene	31	97	_	3	0.85 _ 0.40
2,4-D	5	100	_	_	0.88 _ 0.14
p,p'-DDD	7	57	14	29	0.48 _ 0.14
p,p'-DDE	6	100	_	_	0.86
p,p'-DDT	6	33	17	50	0.71 _ 0.41
Di-*n*-butyl phthalate	31	97	_	3	_
Di-*n*-octyl phthalate	31	97	3	_	0.52
Dibenzo[*a*,*h*]anthracene	31	100	_	_	_
Dibenzofuran	31	90	6	3	0.62 _ 0.09
1,2-Dibromo-3-chloropropane	23	100	_	_	1.22 _ 0.53
Dibromomethane	23	100	_	_	_
o-Dichlorobenzene (1,2)	54	96	_	4	0.49
m-Dichlorobenzene (1,3)	54	93	4	4	0.80 _ 0.32

Table D-31. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
p-Dichlorobenzene (1,4)	54	89	7	4	0.80 _ 0.23
3,3'-Dichlorobenzidine	31	100	_	_	_
Dichlorodifluoromethane	23	100	_	_	_
1,2-Dichloroethane	23	100	_	_	1.20 _ 0.25
1,1-Dichloroethane	23	100	_	_	0.70
1,1-Dichloroethene	23	100	_	_	1.52 _ 0.07
trans-1,2-Dichloroethene	23	100	_	_	_
cis-1,2-Dichloroethylene	23	100	_	_	1.42 _ 0.14
2,4-Dichlorophenol	31	81	13	6	0.53 _ 0.07
2,4-Dichlorophenylacetic acid	1	100	_	_	_
2,2-Dichloropropane	23	100	_	_	_
1,2-Dichloropropane	23	100	_	_	_
1,3-Dichloropropane	23	100	_	_	1.32 _ 0.08
trans-1,3-Dichloropropene	23	100	_	_	_
1,1-Dichloropropene	23	100	_	_	_
cis-1,3-Dichloropropene	23	100	_	_	_
Dieldrin	7	100	_	_	_
Diethyl phthalate	31	97	_	3	0.79 _ 0.11
Dimethyl phthalate	31	100	_	_	_
2,4-Dimethylphenol	31	84	6	10	0.41 _ 0.11
2,4-Dinitrophenol	31	94	_	6	0.40
2,4-Dinitrotoluene	31	81	13	6	0.59 _ 0.09
2,6-Dinitrotoluene	31	100	_	_	_
Endosulfan I	7	100	_	_	_
Endosulfan II	7	100	_	_	_
Endosulfan sulfate	7	100	_	_	_
Endrin	6	67	_	33	0.73 _ 0.07
Endrin aldehyde	6	100	_	_	_
Ethylbenzene	23	96	_	4	0.88 _ 0.14
Ethylene dibromide	23	100	_	_	_
Fluoranthene	31	100	_	_	_
Fluorene	31	100	_	_	0.96 _ 0.06
Heptachlor	7	100	_	_	_
Heptachlor epoxide	6	83	17	_	0.72 _ 0.18
Hexachlorobenzene	31	100	_	_	0.88 _ 0.11
Hexachlorobutadiene	31	94	_	6	0.52
Hexachlorocyclopentadiene	31	100	_	_	_
Hexachloroethane	31	68	6	26	0.39 _ 0.09
2-Hexanone	23	70	22	9	0.71 _ 0.17
Indeno[1,2,3-*cd*]pyrene	31	100	_	_	_
Isophorone	31	100	_	_	0.77 _ 0.11
Isopropylbenzene	23	100	_	_	_
4-Isopropyltoluene	23	100	_	_	_
Lindane	6	83	_	17	0.58
Methoxychlor	7	100	_	_	0.61
Methyl iodide	23	100	_	_	_
4-Methyl-2-pentanone	23	100	_	_	1.00 _ 0.24
2-Methyl-4,6-dinitrophenol	31	77	13	10	0.54 _ 0.14
Methylene chloride	23	100	_	_	1.00 _ 0.25

Table D-31. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
2-Methylnaphthalene	31	100	_	_	_
2-Methylphenol	31	94	3	3	0.54 _ 0.07
4-Methylphenol	31	100	_	_	_
Naphthalene	31	94	3	3	0.57 _ 0.10
4-Nitroaniline	31	100	_	_	_
3-Nitroaniline	31	87	6	6	0.51 _ 0.05
2-Nitroaniline	31	97	_	3	0.69
Nitrobenzene	31	100	_	_	_
2-Nitrophenol	31	94	6	_	0.56 _ 0.09
4-Nitrophenol	31	74	23	3	0.56 _ 0.11
N-Nitrosodi-*n*-propylamine	31	100	_	_	_
N-Nitrosodimethylamine	31	100	_	_	_
N-Nitrosodiphenylamine	31	97	3	_	0.69 _ 0.09
Pentachlorophenol	31	100	_	_	_
Phenanthrene	31	97	_	3	_
Phenol	31	87	6	6	0.53 _ 0.09
Propylbenzene	23	100	_	_	0.69
Pyrene	31	97	3	_	0.66 _ 0.07
Styrene	23	100	_	_	0.85 _ 0.13
2,4,5-T	5	100	_	_	0.93 _ 0.12
2,4,5-TP	5	100	_	_	0.85 _ 0.13
1,1,1,2-Tetrachloroethane	23	100	_	_	_
1,1,2,2-Tetrachloroethane	23	100	_	_	_
Tetrachloroethylene	23	100	_	_	_
Toluene	23	100	_	_	1.03 _ 0.26
Toxaphene	7	100	_	_	_
1,1,2-Trichloro-1,2,2-trifluoroethane	23	100	_	_	_
1,2,4-Trichlorobenzene	31	87	10	3	0.57 _ 0.06
1,1,1-Trichloroethane	23	100	_	_	_
1,1,2-Trichloroethane	23	100	_	_	_
Trichloroethene	23	100	_	_	_
Trichlorofluoromethane	23	100	_	_	_
2,4,6-Trichlorophenol	31	90	3	6	0.66
2,4,5-Trichlorophenol	31	94	_	6	_
1,2,3-Trichloropropane	23	96	4	_	1.10 _ 0.47
1,3,5-Trimethylbenzene	23	100	_	_	_
1,2,4-Trimethylbenzene	23	96	_	4	_
Vinyl acetate	23	78	9	13	1.05 _ 0.41
Vinyl chloride	23	100	_	_	_
Mixed-Xylenes (*o* + *m* + *p*)	23	87	_	13	_

[a]The constituents with _ shown occurred at below detection-limit levels in the QC samples. The control status can be evaluated, but no EM-9 Ratio can be calculated.

Table D-32. Summary of EM-9 Quality Assurance Tests for 1992 (Organic Analyses in Charcoal Tubes)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Benzene	140	94	4	1	0.88 _ 0.21
Bromobenzene	140	94	5	1	0.88 _ 0.19
Carbon tetrachloride	140	91	5	4	0.82 _ 0.24
Chlorobenzene	140	94	4	2	0.82 _ 0.16
Chloroform	140	95	3	2	0.90 _ 0.31
Ethylbenzene	140	99	1	_	0.96 _ 0.22
Tetrachloroethylene	140	97	3	_	0.89 _ 0.18
Toluene	140	94	5	1	0.92 _ 0.22
1,1,1-Trichloroethane	140	95	4	1	0.90 _ 0.27
Trichloroethene	140	97	3	_	0.95 _ 0.20
1,2,4-Trimethylbenzene	140	96	3	1	0.80 _ 0.15
o-Xylene	32	100	_	_	_
Mixed-Xylenes (*o* + *m* + *p*)	140	91	6	3	0.83 _ 0.20

Table D-33. Summary of EM-9 Quality Assurance Tests for 1992 (Organic Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Acenaphthene	7	71	14	14	0.66
Acenaphthylene	7	100	_	_	_[a]
Acetone	10	80	_	20	0.85 _ 0.38
Aldrin	2	100	_	_	_
Aniline	7	100	_	_	0.87
Anthracene	7	57	14	29	0.37
Mixed-Aroclor	8	88	_	13	0.64 _ 0.12
Aroclor 1242	8	88	_	13	0.57
Aroclor 1254	8	100	_	_	0.66 _ 0.12
Aroclor 1260	8	100	_	_	_
Azobenzene	7	100	_	_	_
beta-BHC	2	50	50	_	0.60
delta-BHC	2	100	_	_	_
alpha-BHC	2	100	_	_	0.85
Benzene	10	100	_	_	_
m-Benzidine	7	100	_	_	_
Benzo[*a*]anthracene	7	86	_	14	0.37
Benzo[*a*]pyrene	7	100	_	_	_
Benzo[*b*]fluoranthene	7	71	29	_	0.53
Benzo[*g*,*h*,*i*]perylene	7	100	_	_	_
Benzo[*k*]fluoranthene	7	86	_	14	0.18
Benzoic acid	7	86	_	14	0.63 _ 0.34
Benzyl alcohol	7	100	_	_	_
Bis(2-chloroethoxy)methane	7	100	_	_	0.69
Bis(2-chloroethyl)ether	7	86	_	14	0.39
Bis(2-chloroisopropyl)ether	7	100	_	_	_
Bis(2-ethylhexyl)phthalate	7	100	_	_	_
Bromobenzene	10	100	_	_	0.66
Bromochloromethane	10	100	_	_	_
Bromodichloromethane	10	100	_	_	0.98 _ 0.16
Bromoform	10	100	_	_	0.98 _ 0.18
Bromomethane	10	100	_	_	_
4-Bromophenylphenyl ether	7	100	_	_	_
2-Butanone	10	60	20	20	1.98 _ 2.09
Butyl benzyl phthalate	7	100	_	_	_
n-Butylbenzene	10	100	_	_	_
sec-Butylbenzene	10	100	_	_	0.70
tert-Butylbenzene	10	100	_	_	_
Carbon disulfide	10	100	_	_	0.64 _ 0.04
Carbon tetrachloride	10	80	10	10	0.67 _ 0.31

Table D-33. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Chlordane	2	100	_	_	_
4-Chloro-3-methylphenol	7	71	14	14	0.87
4-Chloroaniline	7	86	_	14	1.12
Chlorobenzene	10	100	_	_	0.84
Chlorodibromomethane	10	100	_	_	1.04 _ 0.20
Chloroethane	10	100	_	_	_
Chloroform	10	100	_	_	0.81
Chloromethane	10	100	_	_	_
2-Chloronaphthalene	7	86	_	14	0.41
o-Chlorophenol	7	71	14	14	0.66
4-Chlorophenylphenyl ether	7	100	_	_	_
p-Chlorotoluene	10	90	_	10	0.82
o-Chlorotoluene	10	70	30	_	0.74 _ 0.15
Chrysene	7	86	_	14	0.45
2,4-D	2	100	_	_	1.00
p,p'-DDD	2	100	_	_	0.83
p,p'-DDE	2	50	_	50	0.33
p,p'-DDT	2	50	_	50	0.62
Di-*n*-butyl phthalate	7	100	_	_	_
Di-*n*-octyl phthalate	7	86	_	14	0.17
Dibenzo[*a*,*h*]anthracene	7	100	_	_	_
Dibenzofuran	7	100	_	_	0.73
1,2-Dibromo-3-chloropropane	10	100	_	_	1.25
Dibromomethane	10	100	_	_	_
o-Dichlorobenzene (1,2)	17	94	_	6	0.68
m-Dichlorobenzene (1,3)	17	88	_	12	0.59 _ 0.16
p-Dichlorobenzene (1,4)	17	82	_	18	0.65 _ 0.19
3,3'-Dichlorobenzidine	7	100	_	_	_
Dichlorodifluoromethane	10	100	_	_	_
1,1-Dichloroethane	10	100	_	_	0.67
1,2-Dichloroethane	10	100	_	_	1.05 _ 0.18
trans-1,2-Dichloroethene	10	100	_	_	1.54
1,1-Dichloroethene	10	100	_	_	0.96 _ 0.04
cis-1,2-Dichloroethylene	10	100	_	_	1.19
2,4-Dichlorophenol	7	86	_	14	0.64 _ 0.15
1,3-Dichloropropane	10	100	_	_	_
2,2-Dichloropropane	10	100	_	_	_
1,2-Dichloropropane	10	100	_	_	_
1,1-Dichloropropene	10	100	_	_	_
cis-1,3-Dichloropropene	10	100	_	_	1.22
trans-1,3-Dichloropropene	10	90	_	10	_

Table D-33. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
Dieldrin	2	100	_	_	_
Diethyl phthalate	7	86	_	14	0.21
Dimethyl phthalate	7	100	_	_	_
2,4-Dimethylphenol	7	71	_	29	0.27
2,4-Dinitrophenol	7	100	_	_	_
2,6-Dinitrotoluene	7	100	_	_	_
2,4-Dinitrotoluene	7	100	_	_	0.79
Endosulfan I	2	100	_	_	_
Endosulfan II	2	100	_	_	_
Endosulfan sulfate	2	100	_	_	_
Endrin	2	100	_	_	0.75
Endrin aldehyde	2	100	_	_	_
Ethylbenzene	10	80	_	20	0.56 _ 0.13
Ethylene dibromide	10	100	_	_	_
Fluoranthene	7	100	_	_	_
Fluorene	7	100	_	_	1.36
Heptachlor	2	100	_	_	_
Heptachlor epoxide	2	100	_	_	_
Hexachlorobenzene	7	100	_	_	1.02
Hexachlorobutadiene	7	100	_	_	0.65
Hexachlorocyclopentadiene	7	100	_	_	_
Hexachloroethane	7	71	_	29	0.30
2-Hexanone	10	70	20	10	0.81 _ 0.26
Indeno[1,2,3-*cd*]pyrene	7	100	_	_	_
Isophorone	7	100	_	_	_
Isopropylbenzene	10	100	_	_	_
4-Isopropyltoluene	10	100	_	_	0.80
Lindane	2	50	_	50	0.50
Methoxychlor	2	100	_	_	_
Methyl iodide	10	100	_	_	_
4-Methyl-2-pentanone	10	100	_	_	1.16 _ 0.42
2-Methyl-4,6-dinitrophenol	7	100	_	_	1.96
Methylene chloride	10	100	_	_	0.97 _ 0.24
2-Methylnaphthalene	7	100	_	_	_
2-Methylphenol	7	100	_	_	0.78
4-Methylphenol	7	100	_	_	_
Naphthalene	7	86	14	_	0.50
2-Nitroaniline	7	86	_	14	0.57
3-Nitroaniline	7	71	_	29	0.49 _ 0.38
4-Nitroaniline	7	100	_	_	_
Nitrobenzene	7	100	_	_	_

Table D-33. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2_3σ (%)	Out of Control >3σ (%)	EM-9 Ratio _ Std Dev
4-Nitrophenol	7	100	_	_	0.65
2-Nitrophenol	7	100	_	_	0.94
N-Nitrosodi-*n*-propylamine	7	100	_	_	_
N-Nitrosodimethylamine	7	100	_	_	_
N-Nitrosodiphenylamine	7	100	_	_	_
Pentachlorophenol	7	100	_	_	_
Phenanthrene	7	100	_	_	_
Phenol	7	86	_	14	_
Propylbenzene	10	100	_	_	0.69
Pyrene	7	100	_	_	_
Styrene	10	90	_	10	0.60
2,4,5-T	2	100	_	_	0.98
2,4,5-TP	2	100	_	_	1.00
1,1,2,2-Tetrachloroethane	10	100	_	_	_
1,1,1,2-Tetrachloroethane	10	100	_	_	_
Tetrachloroethylene	10	100	_	_	_
Toluene	10	90	10	_	0.72 _ 0.13
Toxaphene	2	100	_	_	_
1,1,2-Trichloro-1,2,2-trifluoroethane	10	100	_	_	_
1,2,4-Trichlorobenzene	7	57	_	43	0.39 _ 0.05
1,1,2-Trichloroethane	10	100	_	_	_
1,1,1-Trichloroethane	10	90	_	10	_
Trichloroethene	10	100	_	_	_
Trichlorofluoromethane	10	100	_	_	_
2,4,6-Trichlorophenol	7	100	_	_	0.72
2,4,5-Trichlorophenol	7	100	_	_	_
1,2,3-Trichloropropane	10	100	_	_	1.33 _ 0.27
1,2,4-Trimethylbenzene	10	100	_	_	_
1,3,5-Trimethylbenzene	10	100	_	_	_
Vinyl acetate	10	70	_	30	1.10 _ 0.37
Vinyl chloride	10	100	_	_	_
Mixed-Xylenes (*o* + *m* + *p*)	10	100	_	_	1.02

[a]The constituents with _ shown occurred at below detection-limit levels in the QC samples. The control status can be evaluated, but no EM-9 Ratio can be calculated.

Table D-34. Summary of EM-9 False Positive/False Negative QC Samples for EM-8 Samples Run in 1993

Matrix/Analyte	False Positive	False Negative	Total QC Samples
RADIOCHEMICAL ANALYSES			
Biologicals			
^{137}Cs	0	0	14
^{238}Pu	0	0	13
^{239}Pu	4	0	13
^{90}Sr	0	0	11
U	0	0	7
^{235}	0	0	1
^{238}U	0	0	1
Filters			
Alpha	0	0	158
^{241}Am	0	0	16
Beta	0	0	155
^{238}Pu	0	0	19
^{239}Pu	0	0	19
^{234}U	2	0	13
^{235}U	0	0	13
^{238}U	1	0	13
Soils			
Alpha	0	0	8
^{241}Am	0	0	19
Beta	0	0	8
^{137}Cs	0	0	20
Gamma	0	1	32
^{3}H	8	0	21
^{238}Pu	1	0	31
^{239}Pu	7	0	30
^{90}Sr	1	0	11
U	0	0	26
^{234}U	0	0	8
^{235}U	0	0	8
^{238}U	0	0	8
Waters			
Alpha	0	0	255
^{241}Am	0	0	10
Beta	1	0	253
^{137}Cs	2	0	67
Gamma	1	0	222
^{3}H	2	0	215
^{238}Pu	0	0	27
^{239}Pu	0	0	27
Ra	0	0	1
^{226}Ra	0	0	1
^{90}Sr	0	0	31
U	0	0	83
$^{235/238}U$	0	0	1
^{238}U	0	0	2

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
INORGANIC ANALYSES			
Biologicals			
B	0	0	1
Filters			
Be	0	0	16
Bulk Materials			
Ag	0	1	1
As	0	0	1
Ba	0	0	1
Cd	0	0	1
Cr	0	0	1
Flashpoint	0	0	1
Hg	0	0	1
Pb	0	0	1
Se	0	0	1
Soils			
Al	0	0	7
As	0	0	23
B	0	0	2
Ba	0	0	17
Be	0	0	21
Cd	0	0	13
Co	0	0	3
Cr	0	0	19
Cu	0	0	6
Fe	0	0	7
Ga	0	0	4
H_2O- (unbound water)	0	0	8
Hg	0	1	31
Mn	0	0	2
Mo	0	0	1
Ni	0	0	14
Pb	0	1	27
Sb	0	0	13
Se	0	0	4
Sr	0	0	1
Th	0	0	4
V	0	0	2
Zn	0	0	2
Waters			
Ag	0	4	224
Al	1	0	82
As	1	2	306
B	2	0	80
Ba	3	0	244
Be	4	0	246
Br	0	0	1
Ca	0	0	50

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
INORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
Cd	0	1	248
Cl	0	0	93
CN	0	0	2
Co	0	0	84
Chemical Oxygen Demand	0	0	3
Conductivity	0	0	55
Cr	1	1	257
Cu	2	0	117
F	0	0	58
Fe	0	0	74
Ga	0	0	5
Hardness	0	0	26
Hg	0	0	166
K	0	0	43
Li	1	0	62
Mg	0	0	51
Mn	0	0	98
Mo	1	0	98
Na	0	0	47
NH_3-N (Ammonia Nitrogen)	0	0	4
Ni	1	0	194
NO_3-N (Nitrate Nitrogen)	0	0	71
Oil and Grease	0	0	9
P	0	0	2
Pb	2	0	283
pH	0	0	60
PO_4-P (Phosphate Phosphorus)	0	0	49
Sb	1	1	140
Se	0	1	304
SiO_2	0	0	58
Sn	0	0	54
SO_4	0	0	68
Sr	0	0	82
Total Alkalinity	0	0	49
Total Dissolved Solids	0	0	62
Th	0	0	4
Ti	0	0	5
Total Kjeldahl Nitrogen	0	0	2
Tl	0	0	167
TSS	0	0	13
V	0	0	98
Zn	0	0	107

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES			
Filters			
Mixed-Aroclor	0	1	15
Aroclor 1242	0	1	15
Aroclor 1254	0	0	15
Aroclor 1260	0	0	15
Bulk Materials			
Acetone	1	0	8
Mixed-Aroclor	1	3	101
Aroclor 1242	0	2	100
Aroclor 1254	1	1	100
Aroclor 1260	1	1	100
Benzene	0	0	10
Bromobenzene	0	0	8
Bromochloromethane	0	0	8
Bromodichloromethane	0	0	8
Bromoform	0	0	8
Bromomethane	0	0	8
2-Butanone	4	0	8
n-Butylbenzene	0	0	8
sec-Butylbenzene	0	0	8
tert-Butylbenzene	0	0	8
Carbon disulfide	0	0	8
Carbon tetrachloride	0	0	8
Chlorobenzene	0	0	10
Chlorodibromomethane	0	0	8
Chloroethane	0	0	8
Chloroform	0	0	8
Chloromethane	0	0	8
o-Chlorotoluene	0	0	8
p-Chlorotoluene	0	0	8
1,2-Dibromo-3-chloropropane	0	0	8
Dibromomethane	0	0	8
o-Dichlorobenzene (1,2)	0	0	8
m-Dichlorobenzene (1,3)	0	0	8
p-Dichlorobenzene (1,4)	0	0	8
Dichlorodifluoromethane	0	0	8
1,1-Dichloroethane	0	0	10
1,2-Dichloroethane	0	0	8
1,1-Dichloroethene	0	0	8
trans-1,2-Dichloroethene	0	0	8
cis-1,2-Dichloroethylene	0	0	8
1,2-Dichloropropane	0	0	8
1,3-Dichloropropane	0	0	8
2,2-Dichloropropane	0	0	8
1,1-Dichloropropene	0	0	8
cis-1,3-Dichloropropene	0	0	8
trans-1,3-Dichloropropene	0	0	8

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES			
Bulk Materials (Cont.)			
Ethylbenzene	0	0	8
Ethylene dibromide	0	0	8
2-Hexanone	0	0	8
Isopropylbenzene	0	0	8
4-Isopropyltoluene	0	0	8
Methyl iodide	0	0	8
4-Methyl-2-pentanone	0	0	8
Methylene chloride	3	0	8
Propylbenzene	0	0	8
Styrene	0	0	8
1,1,1,2-Tetrachloroethane	0	0	8
1,1,2,2-Tetrachloroethane	0	0	8
Tetrachloroethylene	0	0	8
Toluene	0	0	10
1,1,2-Trichloro-1,2,2-trifluoroethane	2	0	8
1,1,1-Trichloroethane	0	0	8
1,1,2-Trichloroethane	0	0	8
Trichloroethene	0	0	10
Trichlorofluoromethane	1	0	8
1,2,3-Trichloropropane	0	0	8
1,2,4-Trimethylbenzene	0	0	8
1,3,5-Trimethylbenzene	0	0	8
Vinyl acetate	0	0	5
Vinyl chloride	0	0	8
Mixed-Xylenes (*o* + *m* + *p*)	0	0	8
Soils			
Acenaphthene	0	0	42
Acenaphthylene	0	0	42
Acetone	7	0	79
Aniline	0	0	42
Anthracene	0	0	42
Mixed-Aroclor	0	0	14
Aroclor 1242	0	0	14
Aroclor 1254	0	0	14
Aroclor 1260	0	0	14
Azobenzene	0	0	42
Benzene	0	0	79
m-Benzidine	0	0	42
Benzo[*a*]anthracene	0	0	42
Benzo[*a*]pyrene	0	0	42
Benzo[*b*]fluoranthene	0	0	42
Benzo[*g*,*h*,*i*]perylene	0	0	42
Benzo[*k*]fluoranthene	0	0	42
Benzoic acid	0	1	42
Benzyl alcohol	0	0	42

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
Bis(2-chloroethoxy)methane	0	0	42
Bis(2-chloroethyl)ether	0	0	42
Bis(2-chloroisopropyl)ether	0	0	42
Bis(2-ethylhexyl)phthalate	0	0	42
Bromobenzene	0	0	79
Bromochloromethane	0	0	79
Bromodichloromethane	0	0	79
Bromoform	0	0	79
Bromomethane	0	0	79
4-Bromophenylphenyl ether	0	0	42
2-Butanone	0	0	79
Butyl benzyl phthalate	0	0	42
n-Butylbenzene	0	0	79
sec-Butylbenzene	0	0	79
tert-Butylbenzene	0	0	79
Carbon disulfide	1	0	79
Carbon tetrachloride	0	0	79
4-Chloro-3-methylphenol	0	0	42
4-Chloroaniline	0	1	42
Chlorobenzene	0	0	79
Chlorodibromomethane	0	0	79
Chloroethane	0	0	79
Chloroform	0	0	79
Chloromethane	0	0	79
2-Chloronaphthalene	0	0	42
o-Chlorophenol	0	0	42
4-Chlorophenylphenyl ether	0	0	42
o-Chlorotoluene	0	0	79
p-Chlorotoluene	0	0	79
Chrysene	0	0	42
Di-*n*-butyl phthalate	7	0	42
Di-*n*-octyl phthalate	0	0	42
Dibenzo[*a*,*h*]anthracene	0	0	42
Dibenzofuran	0	0	42
1,2-Dibromo-3-chloropropane	1	0	79
Dibromomethane	0	0	79
o-Dichlorobenzene (1,2)	1	0	121
m-Dichlorobenzene (1,3)	1	0	121
p-Dichlorobenzene (1,4)	1	0	121
3,3'-Dichlorobenzidine	0	0	42
Dichlorodifluoromethane	0	0	79
1,1-Dichloroethane	0	0	79
1,2-Dichloroethane	0	0	79
1,1-Dichloroethene	0	0	79
trans-1,2-Dichloroethene	0	0	79
cis-1,2-Dichloroethylene	0	0	79

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
2,4-Dichlorophenol	0	0	42
1,2-Dichloropropane	0	1	79
1,3-Dichloropropane	0	0	79
2,2-Dichloropropane	0	0	79
1,1-Dichloropropene	0	0	79
cis-1,3-Dichloropropene	0	0	79
trans-1,3-Dichloropropene	0	1	79
Diethyl phthalate	0	0	42
Dimethyl phthalate	0	0	42
2,4-Dimethylphenol	0	0	42
2,4-Dinitrophenol	0	0	42
2,4-Dinitrotoluene	0	0	42
2,6-Dinitrotoluene	0	0	42
Ethylbenzene	0	0	79
Ethylene dibromide	0	0	79
Fluoranthene	0	0	42
Fluorene	0	0	42
Hexachlorobenzene	0	0	42
Hexachlorobutadiene	0	0	42
Hexachlorocyclopentadiene	0	0	42
Hexachloroethane	0	0	42
2-Hexanone	0	0	79
Indeno[1,2,3-*cd*]pyrene	0	0	42
Isophorone	0	0	42
Isopropylbenzene	0	0	79
4-Isopropyltoluene	0	1	79
Methyl iodide	0	0	79
4-Methyl-2-pentanone	0	0	79
2-Methyl-4,6-dinitrophenol	0	0	42
Methylene chloride	9	0	79
2-Methylnaphthalene	0	0	42
2-Methylphenol	0	0	42
4-Methylphenol	0	0	42
Naphthalene	0	0	42
2-Nitroaniline	0	0	42
3-Nitroaniline	0	0	42
4-Nitroaniline	0	0	42
Nitrobenzene	0	0	42
2-Nitrophenol	0	0	42
4-Nitrophenol	0	0	42
N-Nitrosodi-*n*-propylamine	0	0	42
N-Nitrosodimethylamine	0	0	42
N-Nitrosodiphenylamine	0	0	42
Pentachlorophenol	0	0	42
Petroleum Hydrocarbons, Total Recoverable	0	0	8

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
Phenanthrene	0	0	42
Phenol	0	0	42
Propylbenzene	0	0	79
Pyrene	0	0	42
Styrene	0	0	79
1,1,1,2-Tetrachloroethane	0	0	79
1,1,2,2-Tetrachloroethane	0	0	79
Tetrachloroethylene	0	0	79
Toluene	0	0	79
1,1,2-Trichloro-1,2,2-trifluoroethane	1	0	79
1,2,4-Trichlorobenzene	0	0	42
1,1,1-Trichloroethane	0	0	79
1,1,2-Trichloroethane	0	0	79
Trichloroethene	1	0	79
Trichlorofluoromethane	0	0	79
2,4,5-Trichlorophenol	0	0	42
2,4,6-Trichlorophenol	0	0	42
1,2,3-Trichloropropane	0	0	79
1,2,4-Trimethylbenzene	0	0	79
1,3,5-Trimethylbenzene	0	0	79
Vinyl acetate	0	6	46
Vinyl chloride	0	0	79
Mixed-Xylenes (*o* + *m* + *p*)	0	0	79
Charcoal Tubes			
Acetone	1	0	28
Benzene	0	0	85
Bromobenzene	0	1	85
Bromochloromethane	6	0	28
Bromodichloromethane	0	0	28
Bromoform	0	0	28
Bromomethane	0	0	28
2-Butanone	0	0	28
Carbon disulfide	0	0	28
Carbon tetrachloride	0	0	85
Chlorobenzene	0	0	85
Chlorodibromomethane	0	0	28
Chloroethane	0	0	28
Chloroform	0	0	85
Chloromethane	0	0	28
Dibromomethane	2	0	28
o-Dichlorobenzene (1,2)	0	0	28
m-Dichlorobenzene (1,3)	0	0	28
p-Dichlorobenzene (1,4)	0	0	28
Dichlorodifluoromethane	0	0	28
1,1-Dichloroethane	0	0	28
1,2-Dichloroethane	0	0	28

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Charcoal Tubes (Cont.)			
1,1-Dichloroethene	0	0	28
trans-1,2-Dichloroethene	0	0	28
cis-1,2-Dichloroethylene	0	0	28
1,2-Dichloropropane	0	0	28
1,1-Dichloropropene	0	0	28
cis-1,3-Dichloropropene	0	0	28
trans-1,3-Dichloropropene	0	0	28
Ethylbenzene	0	0	85
2-Hexanone	0	0	28
4-Methyl-2-pentanone	0	0	28
Methylene chloride	2	0	28
Propylbenzene	0	0	28
Styrene	3	0	28
1,1,1,2-Tetrachloroethane	0	0	28
1,1,2,2-Tetrachloroethane	0	0	28
Tetrachloroethylene	0	0	85
Toluene	0	0	85
1,1,2-Trichloro-1,2,2-trifluoroethane	0	0	28
1,1,1-Trichloroethane	0	0	85
1,1,2-Trichloroethane	0	0	28
Trichloroethene	0	0	85
Trichlorofluoromethane	0	0	28
1,2,4-Trimethylbenzene	0	0	85
1,3,5-Trimethylbenzene	0	0	28
Vinyl chloride	2	0	28
Mixed-Xylenes (*o* + *m* + *p*)	0	0	85
Waters			
Acenaphthene	0	0	34
Acenaphthylene	0	0	30
Acetone	2	0	61
Aniline	0	1	30
Anthracene	0	1	30
Mixed-Aroclor	0	1	20
Aroclor 1242	0	0	20
Aroclor 1254	0	1	20
Aroclor 1260	0	0	20
Azobenzene	0	0	30
Benzene	1	0	61
m-Benzidine	0	0	30
Benzo[*a*]anthracene	0	0	30
Benzo[*a*]pyrene	0	0	30
Benzo[*b*]fluoranthene	0	0	30
Benzo[*g,h,i*]perylene	0	0	30
Benzo[*k*]fluoranthene	0	0	30
Benzoic acid	0	1	30
Benzyl alcohol	4	0	30

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
Bis(2-chloroethoxy)methane	0	0	30
Bis(2-chloroethyl)ether	0	0	30
Bis(2-chloroisopropyl)ether	0	0	30
Bis(2-ethylhexyl)phthalate	2	0	30
Bromobenzene	0	0	61
Bromochloromethane	0	0	61
Bromodichloromethane	0	0	61
Bromoform	6	0	61
Bromomethane	0	0	61
4-Bromophenylphenyl ether	0	0	30
2-Butanone	2	0	61
Butyl benzyl phthalate	0	0	30
n-Butylbenzene	0	0	61
sec-Butylbenzene	0	0	61
tert-Butylbenzene	0	0	61
Carbon disulfide	0	0	61
Carbon tetrachloride	0	0	61
4-Chloro-3-methylphenol	0	0	34
4-Chloroaniline	0	0	30
Chlorobenzene	0	0	61
Chlorodibromomethane	8	0	61
Chloroethane	0	0	61
Chloroform	0	0	61
Chloromethane	0	0	61
2-Chloronaphthalene	0	0	30
o-Chlorophenol	0	0	34
4-Chlorophenylphenyl ether	0	0	30
o-Chlorotoluene	0	0	61
p-Chlorotoluene	0	0	61
Chrysene	0	0	30
Di-*n*-butyl phthalate	0	0	30
Di-*n*-octyl phthalate	0	0	30
Dibenzo[*a*,*h*]anthracene	0	0	30
Dibenzofuran	0	0	30
1,2-Dibromo-3-chloropropane	3	0	61
Dibromomethane	0	0	61
o-Dichlorobenzene (1,2)	1	0	91
m-Dichlorobenzene (1,3)	1	0	91
p-Dichlorobenzene (1,4)	1	0	95
3,3'-Dichlorobenzidine	0	0	30
Dichlorodifluoromethane	0	0	61
1,1-Dichloroethane	0	0	61
1,2-Dichloroethane	1	0	61
1,1-Dichloroethene	0	0	61
trans-1,2-Dichloroethene	0	1	61
cis-1,2-Dichloroethylene	1	0	61

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
2,4-Dichlorophenol	0	0	30
1,2-Dichloropropane	0	0	61
1,3-Dichloropropane	0	0	61
2,2-Dichloropropane	0	0	61
1,1-Dichloropropene	0	0	61
cis-1,3-Dichloropropene	0	1	61
trans-1,3-Dichloropropene	2	0	61
Diethyl phthalate	0	1	30
Dimethyl phthalate	0	0	30
2,4-Dimethylphenol	0	0	30
2,4-Dinitrophenol	0	1	30
2,4-Dinitrotoluene	1	0	34
2,6-Dinitrotoluene	0	0	30
Ethylbenzene	0	0	61
Ethylene dibromide	0	0	61
Fluoranthene	0	0	30
Fluorene	0	0	30
Hexachlorobenzene	0	1	30
Hexachlorobutadiene	0	0	30
Hexachlorocyclopentadiene	0	0	30
Hexachloroethane	0	0	30
2-Hexanone	0	1	61
Indeno[1,2,3-*cd*]pyrene	0	0	30
Isophorone	0	0	30
Isopropylbenzene	0	1	61
4-Isopropyltoluene	0	1	61
Methyl iodide	0	0	61
4-Methyl-2-pentanone	0	0	61
2-Methyl-4,6-dinitrophenol	0	0	30
Methylene chloride	4	0	61
2-Methylnaphthalene	0	0	30
2-Methylphenol	0	0	30
4-Methylphenol	0	0	30
Naphthalene	0	0	30
2-Nitroaniline	0	0	30
3-Nitroaniline	0	0	30
4-Nitroaniline	0	0	30
Nitrobenzene	0	0	30
2-Nitrophenol	0	0	30
4-Nitrophenol	0	0	34
N-Nitrosodi-*n*-propylamine	0	0	34
N-Nitrosodimethylamine	0	0	30
N-Nitrosodiphenylamine	0	0	30
Pentachlorophenol	0	1	34
Petroleum Hydrocarbons, Total Recoverable	0	0	1
Phenanthrene	0	0	30

Table D-34. (Cont.)

Matrix/Analyte	False Positive	False Negative	Total QC Samples
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
Phenol	0	0	34
Propylbenzene	1	0	61
Pyrene	0	0	34
Styrene	0	1	61
1,1,1,2-Tetrachloroethane	0	0	61
1,1,2,2-Tetrachloroethane	0	0	61
Tetrachloroethylene	0	0	61
Toluene	0	0	61
1,1,2-Trichloro-1,2,2-trifluoroethane	0	0	61
1,2,4-Trichlorobenzene	0	0	34
1,1,1-Trichloroethane	0	0	61
1,1,2-Trichloroethane	0	0	61
Trichloroethene	0	0	61
Trichlorofluoromethane	2	0	61
2,4,5-Trichlorophenol	0	0	30
2,4,6-Trichlorophenol	0	0	30
1,2,3-Trichloropropane	0	0	61
1,2,4-Trimethylbenzene	0	0	61
1,3,5-Trimethylbenzene	0	0	61
Vinyl acetate	0	4	32
Vinyl chloride	0	0	61
Mixed-Xylenes (*o* + *m* + *p*)	0	0	61

Table D-35. 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
Uranium (delayed neutron)	2.0×10^4 m^3	60 s	1	pg/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
Uranium (delayed neutron)	2 g	20 s	0.2	µg/g

GLOSSARY OF TERMS

activation products Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.

ALARA As low as reasonably achievable. The term that describes an approach to radiation exposure control or management whereby the exposures and resulting doses are maintained as far below the limits specified for the appropriate circumstances as economic, technical, and practical considerations permit.

alpha particle A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.

ambient air The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.

aquifer A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

AEC Atomic Energy Commission**.** A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian applications. It was abolished by the Energy Reorganization Act of 1974 and was succeeded by the Energy Research and Development Administration (now part of the US Department of Energy and the US Nuclear Regulatory Commission).

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*.

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 The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

controlled area Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

Ci Curie. Unit of radioactivity. One Ci equals $3.70 + 10^{10}$ nuclear transformations per second.

cosmic radiation High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.

DOE US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production.

dose A term denoting the quantity of radiation energy absorbed.

- ***absorbed dose*** The energy imparted to matter by ionizing radiation per unit mass of irradiated material. (The unit of absorbed dose is the rad.)
- ***effective dose*** The hypothetical whole-body dose that

equivalent 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 + 0.12 = 12 mrem.

equivalent dose A term used in radiation protection that expresses all types of radiation (alpha, beta, and so on) on a common scale for calculating the effective absorbed dose. It is the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the rem.)

maximum boundary dose The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to a hypothetical individual who is in an uncontrolled area where the highest dose rate occurs. It assumes that the hypothetical individual is present 100% of the time (full occupancy), and it does not take into account shielding (for example, by buildings).

maximum individual dose The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.

population dose The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)

whole body dose A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).

dosimeter A portable detection device for measuring the total accumulated exposure to ionizing radiation.

EA Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.

effluent A liquid waste discharged to the environment.

EIS Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.

emission A gaseous waste discharged to the environment.

environmental surveillance The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media to determine environmental quality of an industry or community. It is commonly performed at sites containing nuclear facilities.

EPA Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.

exposure A measure of the ionization produced in air by x ray or gamma radiation. (The unit of exposure is the roentgen).

external radiation Radiation originating from a source outside the body.

fission products Atoms created by the splitting of larger atoms into smaller ones accompanied by release of energy.

friable asbestos Asbestos that is brittle or readily crumbled.

gallery An underground collection basin for spring discharges.

gamma radiation Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.

gross alpha The total amount of measured alpha activity without identification of specific radionuclides.

gross beta The total amount of measured beta activity without identification of specific radionuclides.

groundwater A subsurface body of water in the zone of saturation.

^{3}H Tritium. A radionuclide of hydrogen with a half-life of 12.3 years. The very low energy of its radioactive decay makes it one of the least hazardous radionuclides.

half-life, radioactive The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains (1/2 + 1/2), after three half-lives, one-eighth (1/2 + 1/2 + 1/2), and so on.

hazardous waste Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose

a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.

hazardous waste constituent — The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.

HSWA — Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

internal radiation — Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms.

ion — An atom or compound that carries an electrical charge.

ionizing radiation — Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x rays and other diagnostic exposures.

isotopes — Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.

+ long-lived isotope - A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
+ short-lived isotope - A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

LDR — Land Disposal Restrictions (land ban). A regulatory program that identifies hazardous wastes that are restricted from land disposal. The regulations incorporate a phasing-in of restrictions in three stages.

MCL — Maximum Contaminant Level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet

of the ultimate user of a public water system (see Appendix A and Table A-4). The MCLs are specified by the EPA.

mixed waste Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).

mrem Millirem (10^{-3} rem). See definition of rem. The dose equivalent that is one-thousandth of a rem.

NEPA National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment prior to decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.

NESHAP National Emission Standards for Hazardous Air Pollutants. These standards are found in the Clean Air Act; they set limits for such pollutants as beryllium and radionuclides.

nonpoint source Any nonconfined area from which pollutants are discharged into a body of water (e.g., agricultural run off, construction run off, and parking lot drainage).

NPDES National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.

nuclide A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content; or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.

PA Performance Assessment. A systematic analysis of the potential risks posed by waste management systems to the public and environment, and a comparison of those risks to established performance objectives.

part B permit Part of the RCRA permitting process that is submitted by organizations that treat, store, or dispose of hazardous wastes. It covers in detail the procedures followed at a facility to protect human health and the environment.

PCBs Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. They are also produced in certain combustion processes. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the

fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976. In general, PCBs are not as toxic in acute short-term doses as some other chemicals, although acute and chronic exposure can cause liver damage. PCBs have also caused cancer in laboratory animals. When tested, most people show traces of PCBs in their blood and fatty tissues.

PDL — Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).

perched water — A groundwater body above an impermeable layer that is separated from an underlying main body of groundwater by an unsaturated 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).

ppb — Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or µg/kg.

ppm — Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L. Also used to express the weight/weight ratio as µg/g or mg/kg.

QA — Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.

QC — Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

R — Roentgen. A unit of radiation exposure that expresses exposure in terms of the amount of ionization produced by x rays in a volume of air. One roentgen (R) is $2.58 + 10^{-4}$ coulombs per kilogram of air.

rad A unit of absorbed dose from ionizing radiation. A dose of 1 rad equals the absorption of 100 ergs of radiation energy per gram of absorbing material.

radiation The emission of particles or energy as a result of an atomic or nuclear process.

radionuclide An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

RCRA Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.

reagent Any substance used in a chemical reaction to detect or measure another substance or to convert one substance into another.

release Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.

rem The unit of radiation dose equivalent that takes into account different kinds of ionizing radiation and permits them to be expressed on a common basis. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the necessary modifying factors.

RPS Radiation Protection Standards. See PDL.

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.

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 of compacted volcanic ash and dust.

uncontrolled area An area beyond the boundaries of a controlled area (see controlled area 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 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.

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