ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1985

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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Aerial view looking west toward the Jemez Mountains across the Pajarito Plateau, which is cut into numerous narrow mesas by southeast-trending canyons. The Los Alamos townsite is in the center of the photo, the main Laboratory technical area (TA-3) is in the upper left, and the airport is at left center.

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Environmental Surveillance Group

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

The four most recent reports in this unclassified series are LA-9349-ENV, LA-9762-ENV, LA-10100-ENV, and LA-10421-ENV.

FOREWORD

Suggestions on How to Read this Report

This report addresses both laypeople and scientists. These people may have a 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. Layperson with Limited Interest. Read Part I, the Executive Summary, which describes the Laboratory's environmental monitoring operations and summarizes environmental data for this year. Emphasis is on the significance of findings and environmental regulatory compliance. A glossary is in the back.

2. Layperson with Comprehensive Interest. Follow directions for the "Layperson with Limited Interest" given above. Also, summaries of each section of the report are in boldface type and precede the technical text. Read summaries of those sections that interest you. Further detail is in the text following each summary. Appendix A (Standards for Environmental Contaminants) and Appendix F (Description of technical Areas and Their Associated Programs) may also be helpful.

3. Scientist with Limited Interest. Read Part I, the Executive Summary, to determine the parts of the Laboratory's environmental program that interest you. You may then read summaries and technical details of these parts in the body of the report. Detailed data tables are in Appendix G.

4. Scientist with Comprehensive Interest. Read Part I, the Executive Summary, which describes the Laboratory's environmental programs and summarizes environmental data for this year. Read the boldface summaries that head each major subdivision of this report. Further detail is in the text and appendixes.

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ACKNOWLEDGMENTS

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by

ENVIRONMENTAL SURVEILLANCE GROUP

ABSTRACT

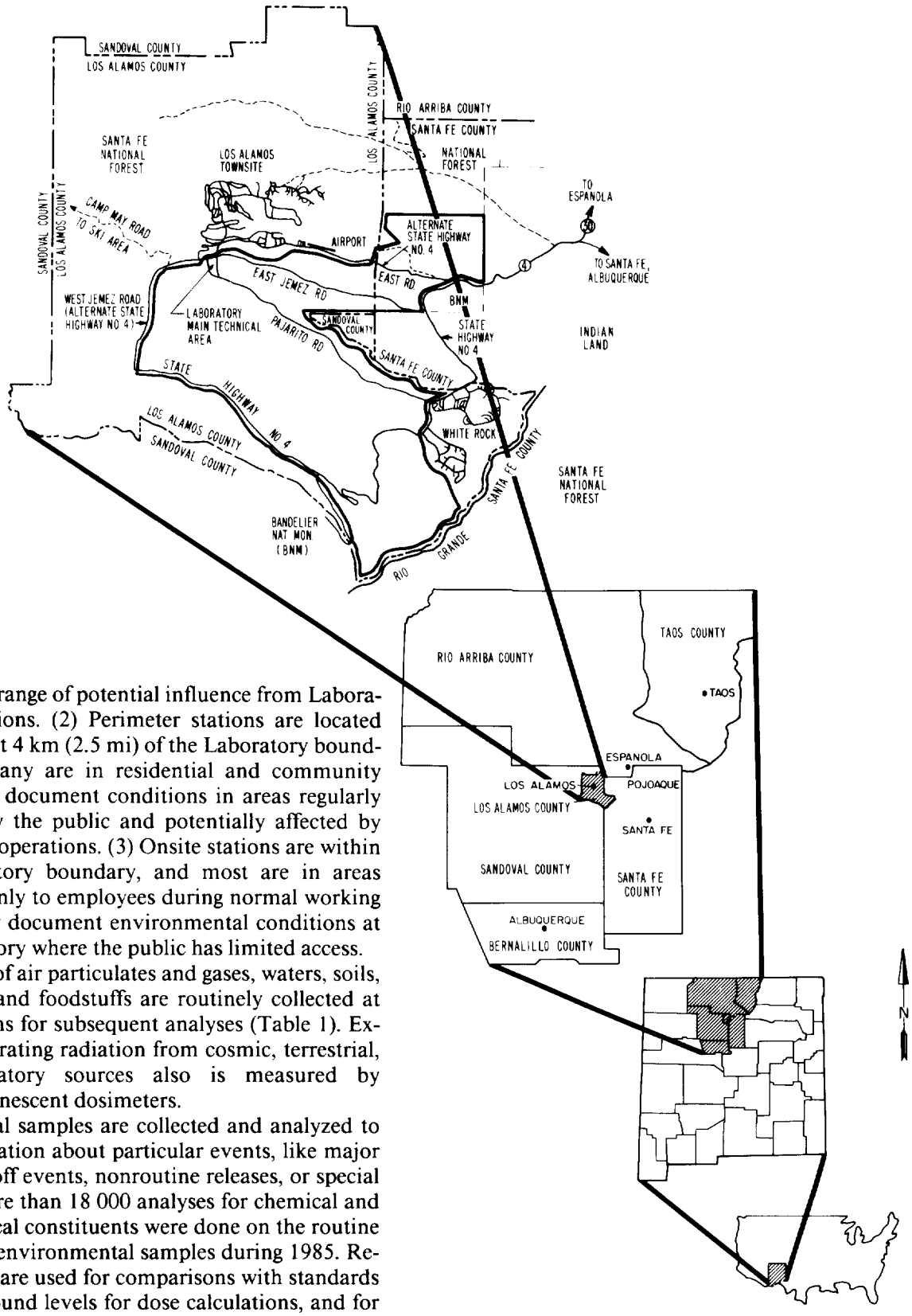
This report describes the environmental surveillance program conducted by Los Alamos National Laboratory during 1985. Routine monitoring for radiation and radioactive or chemical substances is conducted on the Laboratory site as well as in the surrounding region. Monitoring results are used to determine compliance with appropriate standards and to permit early identification of possible undesirable trends. Results and interpretation of data for 1985 cover: external penetrating radiation; chemical and radiochemical quality of ambient air, surface and ground waters, municipal water supply, soils and sediments, and foodstuffs; quantities of airborne emissions and liquid effluents; and environmental compliance. Comparisons with appropriate standards, regulations, and background levels from natural or other non-Laboratory sources provide the basis for concluding that environmental effects attributable to Laboratory operations are insignificant and are not considered hazardous to the population of the area or Laboratory employees.

I. EXECUTIVE SUMMARY

A. Monitoring Operations

The Laboratory maintains an ongoing environmental surveillance program as required by US Department of Energy (DOE) Orders 5480.1 ("Environmental Protection, Safety, and Health Protection Programs," May 1980) and 5484.1 ("Environmental Protection, Safety, and Health Protection Information Reporting Requirements," February 1981). Routine monitoring for radiation, radioactive materials, and chemical substances on the Laboratory site and in the surrounding region documents compliance with appropriate standards, identifies undesirable trends, provides information for the public, and contributes to general environmental knowledge. If an undesirable trend is discovered, more detailed environmental studies are carried out to determine the extent of the problem and to provide the basis for specific remedial actions. The monitoring program also supports the Laboratory's policies to protect the public, employees, and environment from harm that could be caused by Laboratory activities and to reduce negative environmental impacts to the greatest degree practicable. Environmental monitoring information complements data on specific releases, such as those from radioactive liquid waste treatment plants and stacks at nuclear research facilities.

Monitoring and sampling locations for various types of measurements are organized into three groups: (1) Regional stations are located within the five counties surrounding Los Alamos County (Fig. 1) 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 Laboratory operations. (2) 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. (3) Onsite 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 the public has limited access.

Samples of air particulates and gases, waters, soils, sediments, and foodstuffs are routinely collected at these stations for subsequent analyses (Table 1). External penetrating radiation from cosmic, terrestrial, and Laboratory sources also is measured by thermoluminescent dosimeters.

Additional samples are collected and analyzed to gain information about particular events, like major surface runoff events, nonroutine releases, or special studies. More than 18 000 analyses for chemical and radiochemical constituents were done on the routine and special environmental samples during 1985. Resulting data are used for comparisons with standards and background levels for dose calculations, and for interpretations as to relative risks associated with Laboratory operations.

Fig. 1. Regional location of Los Alamos.

Table 1. Number of Sampling Locations

Type of Monitoring	Regional	Perimeter	Onsite
External radiation	4	12	139
Air	3	11	12
Surface and ground water[a]	6	32	37
Soils and sediments	16	16	34
Foodstuffs	10	8	11

[a]An additional 22 stations for the water supply and 33 special surface and ground water stations related to the Fenton Hill Geothermal Program were also sampled and analyzed as part of the monitoring program.

B. Estimated Doses and Risks from Radiation Exposure

1. Radiation Doses. Calculated individual whole body radiation doses to the public attributable to Laboratory operations are compared with applicable standards in this report. They are expressed as a percentage of DOE Radiation Protection Standard (RPS). This RPS is for doses from exposures excluding contributions from natural background, fallout, and radioactive consumer products. Calculated doses are those believed to be possible doses to individuals under realistic conditions of exposure.

Historically, estimated doses from Laboratory operations have been less than 7% of the 500 mrem/yr standard that was in effect prior to 1985 (Fig. 2). These doses have principally resulted from external radiation from the Laboratory's airborne releases. In 1985, DOE issued interim guidelines that lowered its RPS for whole body doses via the air

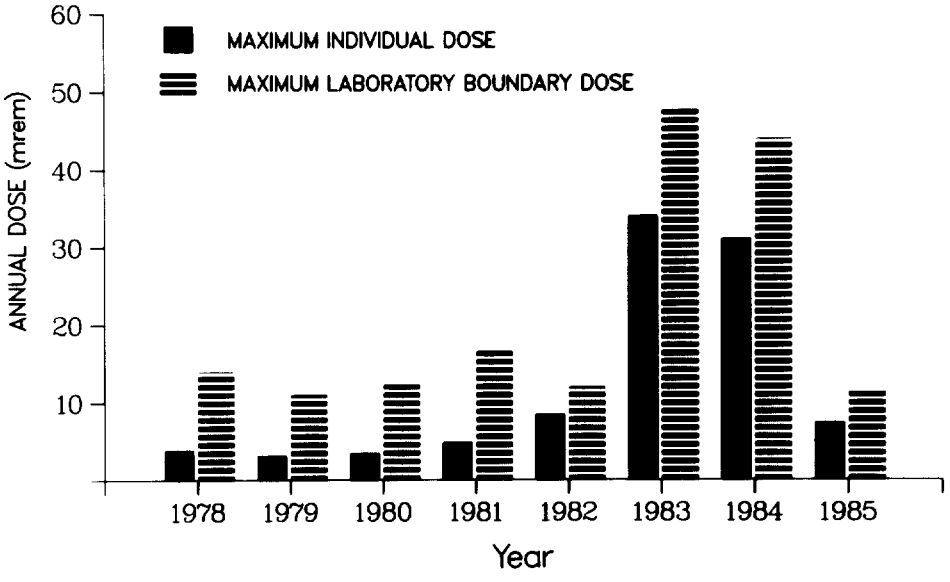


Fig. 2. Summary of estimated maximum individual and maximum Laboratory boundary doses (excluding contributions from cosmic, terrestrial, and medical diagnostic sources) from Laboratory operations.

pathway from 500 mrem/yr to 25 mrem/yr in accordance with requirements of the US Environmental Protection Agency (EPA) (Appendix A). In 1985, the estimated maximum individual dose was 7.3 mrem, or 29% of the 25 mrem limit. This dose resulted mostly from external radiation from short-lived airborne emissions from a linear particle accelerator, the Los Alamos Meson Physics Facility (LAMPF).

Another perspective is gained by comparing these estimated doses with the estimated whole body dose attributable to background radiation. The highest estimated dose caused from Laboratory operations was about 6% of the 125 mrem from naturally occurring radioactivity in Los Alamos in 1985.

2. Significance of Radiation Doses. Estimates of the added risk of cancer were calculated to provide a perspective for comparing the significance of radiation exposures. Incremental cancer risks to residents of Los Alamos townsite due to 1985 Laboratory operations was estimated to be 1 chance in 56 000 000 (Table 2). This risk is less than 0.2% of the 1 chance in 26 000 cancer risk from natural background radiation and the 1 chance in 110 000 risk from medical radiation [based on Publication 26 of the International Commission on Radiological Protection (ICRP)].

Potential Laboratory contribution to cancer risk is small when compared with overall cancer risks. 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.

C. External Penetrating Radiation

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 monitored with thermoluminescent dosimeters (TLDs) at 155 locations divided into three networks.

The TLD network monitoring radiation from airborne activation products released by the LAMPF measured 11 ± 2 mrem/yr (excludes background radiation from cosmic and terrestrial sources). This value was significantly lower than the value of 44 ± 2 mrem/yr obtained in 1984 (Fig. 2). Engineering improvements at LAMPF are responsible for reducing

Table 2. Added Individual Lifetime Cancer Mortality Risks Attributable to 1985 Radiation Exposure

Exposure Source	Incremental Dose (mrem) Used in Risk Estimate	Added Risk (Chance) to an Individual of Cancer Mortality
Average Exposure from Laboratory Operations		
Los Alamos Townsite	0.18	1 in 56 000 000
White Rock Area	0.12	1 in 83 000 000
Natural Radiation		
Cosmic, Terrestrial, Self-Irradiation, and Radon Exposure		
Los Alamos Townsite	125[a]	1 in 26 000[b]
White Rock Area	111[a]	1 in 27 000[b]
Medical X-Rays (Diagnostic Procedures)		
Average Whole Body Exposure	92	1 in 110 000

[a]A lung exposure of 0.2 WLM was used to estimate the risk from inhaling ^{222}Rn and its transformation products.
[b]The risks from whole body natural radiation were estimated to be 1 chance in 80 000 in Los Alamos and 1 chance in 86 000 in White Rock. The risk of lung cancer from radon exposure was estimated to be 1 chance in 38 000 for both locations. Risk estimates are derived from ICRP Publication 26.

airborne activation products released from the facility.

Radiation levels (including natural background radiation from cosmic and terrestrial sources) are also measured at regional, perimeter, and onsite locations in the Environmental TLD Network. No measurements at regional or perimeter locations showed statistically distinguishable increases in radiation attributable to Laboratory operations. Some measurements at onsite stations were above background levels, as expected, reflecting ongoing research activities at the Laboratory.

D. Air Monitoring

Measurements of radioactivity in air are compared with guides based upon the DOE's RPS (Appendix A). These guides are concentrations of radioactivity in air breathed continuously throughout the year that result in effective doses equal to DOE's Radiation Protection Standards of 100 mrem/yr for offsite areas and occupational limits for onsite areas. Annual average concentrations of longer-lived radionuclides in air were less than 1% of the concentration guides during 1985.

Airborne radioactive emissions were monitored at 87 release points at the Laboratory. In general, airborne radioactive emissions declined from 1984 (Table 3), This was principally due to an 83% decrease in releases of air activation products from the Los Alamos Meson Physics Facility (LAMPF). Changes in design and operation resulted in these reduced emissions from LAMPF.

Air is routinely sampled for tritium, americium, plutonium, uranium, and gross beta activity. Only the atmospheric tritium concentrations showed any measurable impact from radionuclides due to Laboratory operations. Annual average concentrations of tritium remained much less than 1% of DOE's Derived Concentration Guides at all stations and posed no environmental or health problems in 1985.

Operations at the Laboratory in 1985 complied with New Mexico Air Quality Control Regulations, Source Registration, Source Permitting, Emission Limits, and Ambient Air Quality requirements as well as with federal Clean Air Act and National Emission Standards for Hazardous Air Pollutants requirements. The power plant, steam plants, beryllium shop, explosives burning and detonation operations, and asbestos removal operations all met applicable regulations.

E. Water, Soil, and Sediment Monitoring

Liquid effluents containing low levels of radioactivity were routinely released from two waste treatment plants and one sanitary sewage lagoon system. Concentrations at all three discharge points were well below the DOE's Concentration Guides for Controlled Areas. The only noticeable trends were lower radionuclide concentrations in LAMPF (TA-53) effluent and an increase in tritium discharge from TA-50 (Table 3). This decrease was due to redesign of LAMPF and altered operations. The source of the increased tritium discharge is unknown.

Surface and ground waters are monitored to detect potential dispersion of radionuclides from Laboratory operations. Only the surface and shallow ground waters in onsite liquid effluent release areas contain radioactivity in concentrations that are above natural terrestrial and worldwide fallout levels. These concentrations are insignificant fractions of DOE's Concentration Guides. These onsite waters are not a source of industrial, agricultural, or municipal water supplies. The radiochemical quality of water from regional, perimeter, water supply, and onsite areas (where no effluents are or have been released) show no significant effects from Laboratory releases.

The potable water supply met all applicable EPA radiochemical and chemical standards. The integrity of geological formations protecting the deep ground water aquifer was confirmed by lack of any measurements indicative of radioactive or chemical contamination in municipal water supply sources due to Laboratory operations.

Measurements of radioactivity in samples of soils and sediments provide data on less direct pathways of exposure. Measurements of radioactivity in soils and sediments are also useful for monitoring and understanding hydrological transport of radioactivity that occurs in intermittent stream channels in and adjacent to low level radioactive waste management areas. Pueblo, Los Alamos, and Mortandad Canyons all have concentrations of radioactivity on sediments at levels higher than those attributable to natural terrestrial sources or worldwide fallout. The low levels of cesium, plutonium, and strontium in Mortandad Canyon are from treated liquid effluents from a waste treatment plant. No radioactivity on sediments or in water has been measured in sampling locations beyond the Laboratory boundary in Mortandad Canyon. However, small amounts of radioactivity on sediments in Pueblo Canyon (from

Table 3. Comparison of 1984 and 1985 Radioactive Releases from the Laboratory

Airborne Stack Emissions

Radioactive Constituent	Units	Activity Released 1984	Activity Released 1985	Ratio 1985/1984
^{3}H	Ci	14 869	8 638	0.6
^{32}P	μCi	33	53	1.6
^{41}Ar	Ci	335	390	1.2
^{131}I	μCi	73	146	2.0
U	μCi	1 205	728	0.6
$^{238,239,240}Pu$	μCi	140	213	1.5
Gaseous Mixed Activation Products	Ci	734 111	126 079	0.2
Mixed Fission Products	μCi	1 617	1 230	0.8
Particulate/Vapor Activation Products	Ci	2 500	0.2	0.0
Total	Ci	751 815	135 107	0.2

Liquid Effluents

Radioisotopes	Activity Released (mCi) 1984	Activity Released (mCi) 1985	Ratio 1985/1984
^{3}H	46 942	76 850	1.6
$^{89,90}Sr$	269	10.3	0.0
^{137}Cs	19.7	<0.1	0.0
^{234}U	7.4	0.6	0.1
$^{238,239,240}Pu$	14.4	9.7	0.6
^{241}Am	9.0	5.5	0.6
Other	8 299	271	0.0
Total	55 561	77 142	1.4

pre-1964 effluents) and upper Los Alamos Canyon (from 1952 to current treated effluents) have probably been transported during runoff events to the Rio Grande. Theoretical estimates, confirmed by measurements, show the incremental effect on Rio Grande sediments from this transported radioactivity is insignificant when compared with concentrations of radioactivity in soils and sediments attributable to worldwide fallout and natural sources.

Environmental monitoring is done at 1 active and 10 inactive waste management areas at the Laboratory. The general public is excluded from these controlled-access sites. There is some transport by surface runoff of low-level contamination from the active and several of the inactive disposal areas into controlled-access canyons. Extracts from the surface contamination indicate the presence of no constituents in excess of EPA guidelines for hazardous waste.

F. Foodstuffs Monitoring

Most fruit, vegetable, fish, bee, and honey samples from regional locations showed no radioactivity distinguishable from that attributable to natural sources or worldwide fallout. Some fruit samples from onsite locations had slightly elevated tritium concentrations. These levels were less than 1% of DOE's Concentration Guides for tritium in water (there are no concentration guides for fruits). The Laboratory released about 8600 Ci of tritium in 1985, principally to the air (Table 3).

G. Unplanned Releases

There were no unplanned releases of radioactive or hazardous materials in 1985.

H. Environmental Compliance Activities

1. Resource Conservation and Recovery Act. The Resource Conservation and Recovery Act (RCRA) is a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. It regulates nonradioactive hazardous wastes. The EPA has transferred full authority for administering RCRA to New Mexico's Environmental Improvement Division (EID). In 1985, the Laboratory had numerous interactions with EID and prepared documentation to comply with all RCRA requirementsof EPA and EID. The Laboratory is also revising RCRA Part A and B permit applications, originally submitted in 1985.

2. Clean Water Act. Regulations under the Clean Water Act set water quality standards and effluent limitations. The two primary programs at the Laboratory to comply with the Clean Water Act are the National Pollutant Discharge Elimination System (NPDES) and the Spill Prevention, Controls and Countermeasures programs (SPCC).

The NPDES requires permits for nonradioactive constituents at all point source discharges. A single NPDES permit for the Laboratory authorizes liquid effluent discharges from 95 industrial outfalls and 11 sanitary sewage treatment outfalls; the permit expires in September 1986. The Laboratory was in compliance with the NPDES permit in about 89% and 98% of the analyses done on samples collected for compliance monitoring at sanitary and industrial waste discharges, respectively. Chronically noncompliant discharges are being upgraded under an EPA/DOE Federal Facility Compliance Agreement and an Administrative Order from EPA.

The SPCC program provides for cleanup of spills and requires preparation of a SPCC plan. The Laboratory has many elements that are required in a SPCC plan and is currently assembling a Laboratory-wide formal SPCC plan for completion by late 1986.

3. National Environmental Policy Act. The Laboratory Environmental Review Committee reviews environmental documentation required by National Environmental Policy Act legislation. The Committee also identifies and reviews other environmental items of interest or concern to the Laboratory. An Environmental Evaluations Coordinator assists the Committee by helping prepare the required DOE documentation, which usually is an Action Description Memorandum (an environmental evaluation document). The Laboratory Environmental Review Committee approved 35 Action Description Memorandums and 4 Environmental Assessments in 1985.

4. Clean Air Act. During 1985, the Laboratory's operations remained in compliance with all federal and state air quality regulations. State regulations are required to be as stringent as federal regulations, and many air quality standards are more stringent. The Laboratory's existing and planned beryllium machining and processing operations are in the process of being permitted. Stack emission tests are planned for FY 86 for the permitted sources. A document for the safe handling, removal, and disposal of asbestos materials has been completed. The improved procedures, discussed in this document are in the process of being implemented. Radionuclide emissins meet all relevant standards.

5. Safe Drinking Water Act. Municipal and industrial water supply for the Laboratory and community is from 16 deep wells and 1 gallery (collection system fed by springs). The wells range in depth from 265 to 942 m (869 to 3090 ft). The chemical and radiochemical quality of the water easily met EPA's National Interim Primary Drinking Water Standards (40 CFR 141) in 1985.

6. Federal Insecticide, Fungicide, and Rodenticide Act. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires registration of all pesticides, restricts use of certain pesticides, recommends standards for pesticide applicators, and regulates disposal and transportation of pesticides. The Laboratory stores, uses, and discards pesticides in compliance with this act.

7. Archaeological and Historical Protection. The Laboratory Environmental Evaluations and Quality Assurance programs provide protection as mandated by law for the over 450 archaeological and historical resources on Laboratory land. Mitigation of unavoidable, adverse effects from Laboratory activity is determined in consultation with the New Mexico State Historical Preservation Office. The Laboratory completed salvage fieldwork of a homesteading complex (New Mexico Laboratory of Anthropology No. 16806), dismantled a homesteader's cabin (the

Romero Cabin), and donated it to the Los Alamos Historical Society. It has been reconstructed near the Los Alamos County Museum. The Laboratory conducted one public archaeological tour during 1985, at the Nakemuu ruin.

8. Comprehensive Environmental Response, Compensation, and Liability Act. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) mandated clean up of toxic and hazardous contaminants at closed and abandoned hazardous waste sites. Laboratory compliance activities related to CERCLA are being done as part of Albuquerque Operations (DOE) Comprehensive Environmental Assessment and Response Program (CEARP) and a Site Characterization Program, begun in 1983. The programs are evaluating all technical and waste disposal areas at the Laboratory for possible environmental contamination by radioactive and nonradioactive materials. Remedial actions will be taken where appropriate.

9. Toxic Substances Control Act. The Toxic Substances Control Act (TSCA) regulates the manufacture, processing, distribution, use, storage, and labeling of chemical substances, including polychlorinated biphenyls (PCBs). The Laboratory has EPA authorization to bury packaged PCB wastes at its Chemical Waste Landfill and burn radioactive and PCB contaminated wastes at its Controlled Air Incinerator (99.9999% combustion efficiency). The Laboratory is in compliance with EPA's conditions for authorizing onsite disposal of PCB contaminated wastes.

II. SETTING OF LOS ALAMOS AREA

A. Geographic Setting

Los Alamos National Laboratory and the associated residential areas of Los Alamos and White Rock are located in Los Alamos County, northcentral New Mexico, approximately 100 km (60 mi) NNE of Albuquerque and 40 km (25 mi) NW of Santa Fe (Fig. 1). The 111 km^2 (43 mi^2) Laboratory site and adjacent communities are situated on Pajarito Plateau. The plateau consists of a series of finger-like mesas separated by deep east-west oriented canyons cut by intermittent streams (Fig. 3). Mesa tops range in elevation from approximately 2400 m (7800 ft) on the flank of the Jemez Mountains to about 1800 m (6200 ft) at their eastern termination above the Rio Grande valley.

All Los Alamos County and vicinity locations referenced in this report are identified by the Laboratory cartesian coordinate system, which is based upon US Customary units of measurement. This system is standard throughout the Laboratory, but is independent of the US Geological Survey and New Mexico State Survey coordinate systems. The major coordinate markers shown on the maps are at 3048 km (10 000 ft) intervals, and, for the purpose of this report, locations are reported to the nearest 0.30 km (1000 ft). The DOE controls the area within the Laboratory boundary and has the option to completely restrict access. This control can be instituted if necessary.

B. Land Use

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 held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County (see the inside back cover). The San Ildefonso Pueblo borders the Laboratory to the east.

Laboratory land is used for building sites, test areas, waste disposal locations, roads, and utility rights-of-way (Figure 4 and Appendix F). However, these account for only a small fraction of the total land area. Most land provides isolation for security and safety and is a reserve for future structure locations. The Long Range Site Development Plan (Engineering 1982) assures adequate planning for the best possible future uses of available Laboratory lands.

Limited access by the public is allowed in certain areas of the Laboratory reservation. An area north of

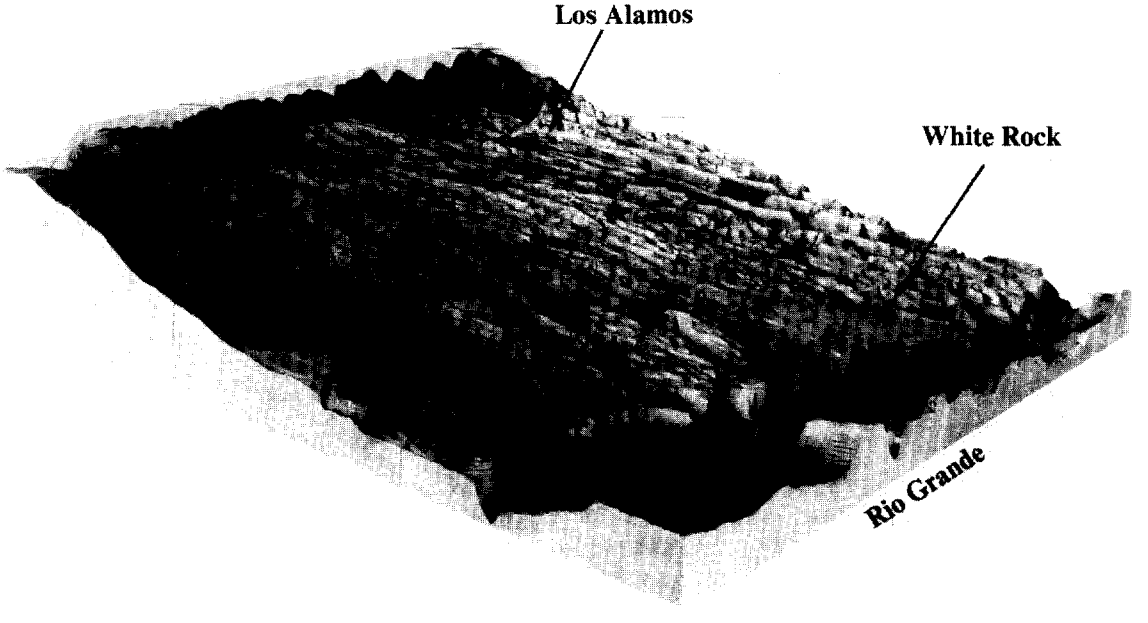


Fig. 3. Topography of the Los Alamos area.

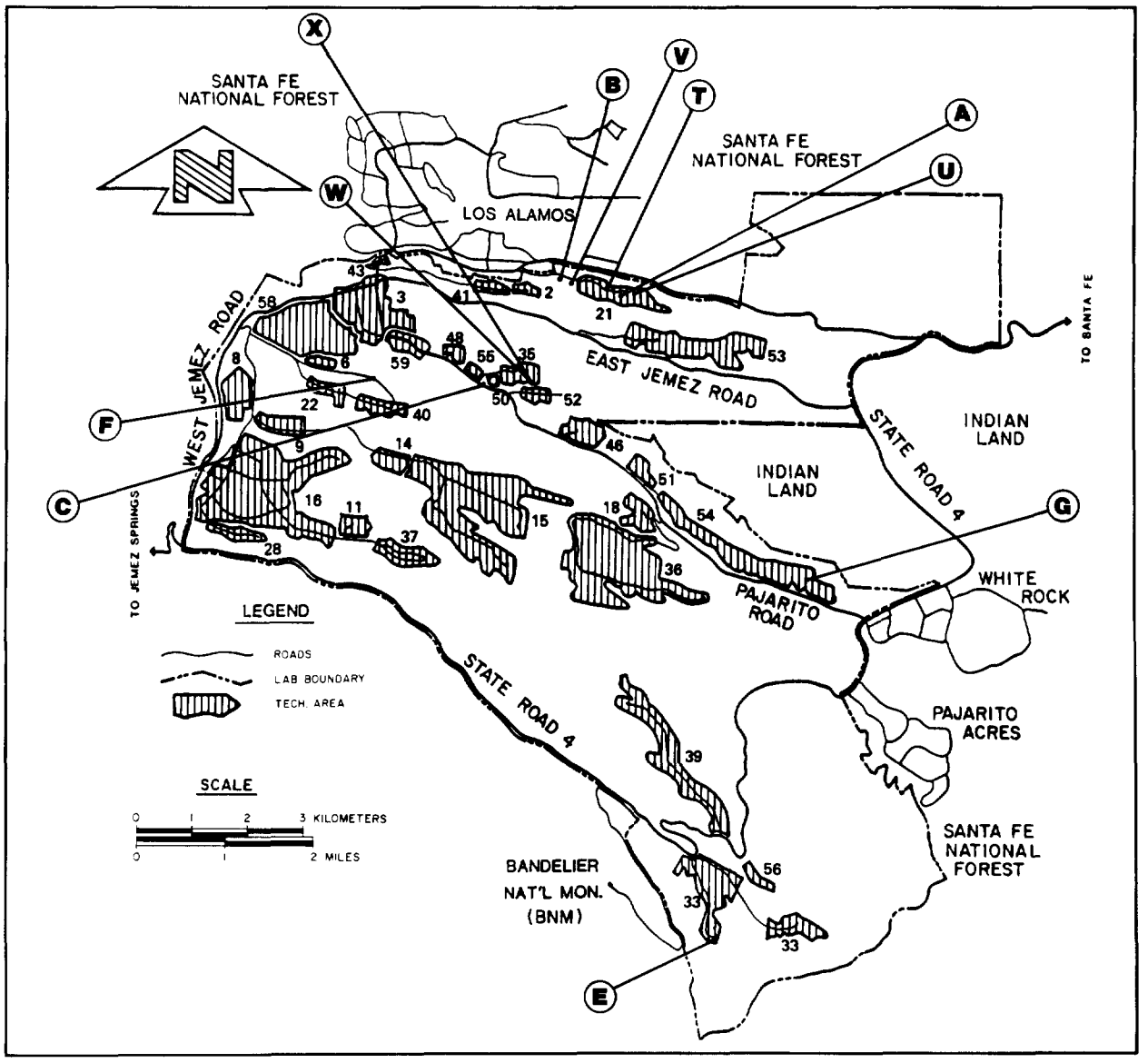


Fig. 4. Los Alamos National Laboratory's technical areas (TAs) and adjacent communities.

Ancho Canyon 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. An archeological site (Otowi Tract) northwest of State Road 4 at the White Rock "Y" is open to the public subject to restrictions of cultural resource protection regulations.

C. Geology-Hydrology

Most of the finger-like mesas in the Laboratory area are formed in Bandelier Tuff (Fig. 5). Ashfall, ashfall pumice, and rhyolite tuff form the surface of Pajarito Plateau. The tuff ranges from nonwelded to welded and is in excess of 300 m (1000 ft) thick in the western part of Pajarito Plateau and thins to about 80

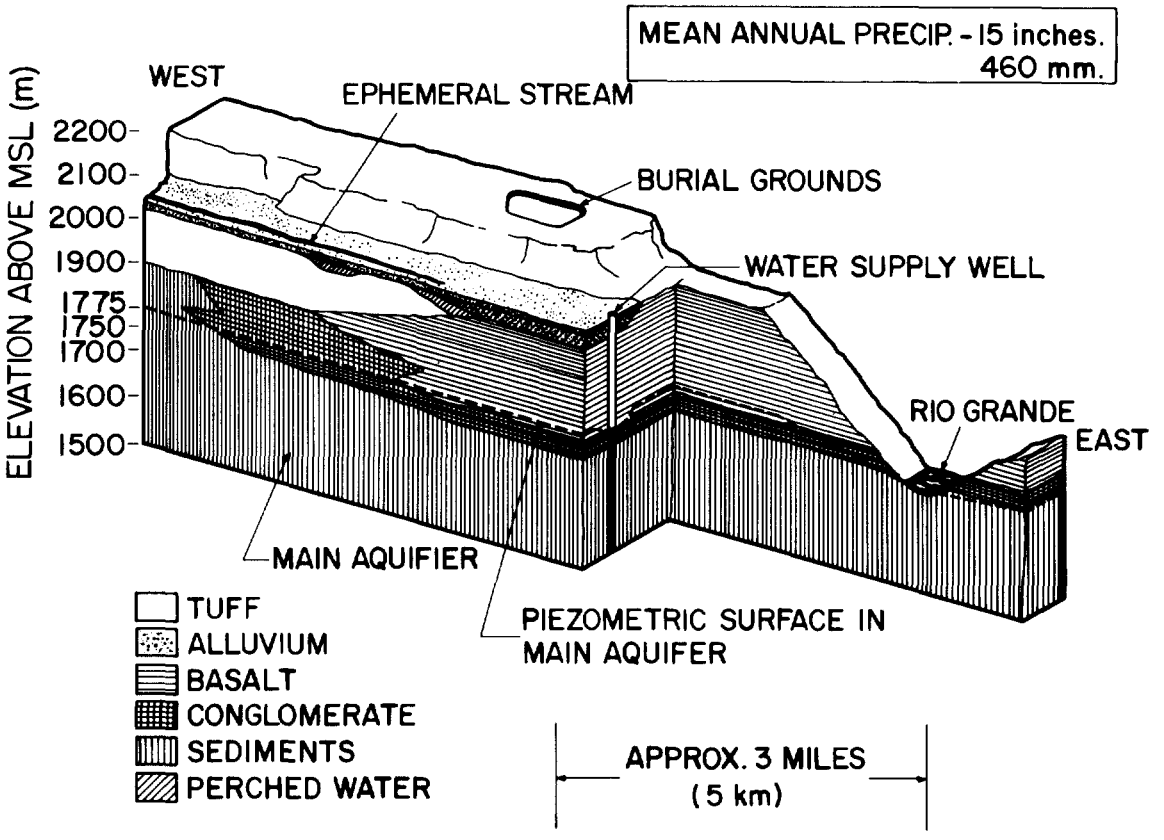


Fig. 5. Conceptual illustration of geologic-hydrologic relationships in the Los Alamos area.

m (260 ft) toward the east above the Rio Grande. It was deposited as a result of a major eruption of a volcano in the Jemez Mountains to the west about 1.1 to 1.4 million years ago.

The tuffs lap onto older volcanics of the Tschicoma Formation, which form the Jemez Mountains along the western edge of the plateau. They are underlain by the conglomerate of the Puye Formation (Fig. 5) in the central and eastern edge along the Rio Grande. Chino Mesa basalts (Fig. 5) interfinger with the conglomerate along the river. These formations overlie the siltstone/sandstone Tesuque Formation (Fig. 5), which extends across the Rio Grande valley and is in excess of 1000 m (3300 ft) thick.

Los Alamos area surface water is primarily in intermittent streams. Springs on flanks of the Jemez Mountains supply base flow into upper reaches of some canyons, but the amount is insufficient to maintain surface flows across the Laboratory site before it is depleted by evaporation, transpiration, and infiltration. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande several times a year. Effluents from sanitary sewage, industrial waste treatment plants, and cooling tower blowdown are released to some canyons at rates sufficient to maintain surface flows for about 1.5 km (1 mi).

Ground water occurs in three modes in the Los Alamos area: (1) water in shallow alluvium in canyons, (2) perched water (a ground water body above an impermeable layer that is separated from an underlying main body of ground water by an unsaturated zone), and (3) the main aquifer of the Los Alamos area (Fig. 5).

Intermittent stream flows in canyons of the Plateau have deposited alluvium that ranges from less than 1 m (3 ft) to as much as 30 m (100 ft) in thickness. The alluvium is quite permeable, in contrast to the underlying volcanic tuff and sediments. Intermittent runoff in canyons infiltrates the alluvium until its downward movement is impeded by the less permeable tuff and volcanic sediment. This results in a shallow alluvial ground water body that moves downgradient in the alluvium. As water in the alluvium moves downgradient, it is depleted by evapotranspiration and movement into underlying volcanics (Purtymun 1977).

Perched water occurs in a limited area about 40 m (120 ft) beneath the mid-reach of Pueblo Canyon and in a second area about 50 to 70 m (150 to 200 ft) beneath the surface in lower Pueblo and Los Alamos Canyons near their confluence. The second area is mainly in basalts (Fig. 5) and has one discharge point at Basalt Springs in Los Alamos Canyon.

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 aquifer decreases from 360 m (1200 ft) along the western margin of the plateau to about 180 m (600 ft) at the eastern margin. The main aquifer is isolated from alluvial water and perched water by about 110 to 190 m (350 to 620 ft) of dry tuff and volcanic sediments. Thus, there is no hydrologic connection or potential for recharge to the main aquifer from alluvial or perched water.

Water in the main aquifer is under water table conditions in the western and central part of the Plateau and under artesian conditions in the eastern part and along the Rio Grande (Purtymun 1974B). The major recharge area to the main aquifer is from the intermountain basin of the Valles Caldera in the Jemez Mountains west of Los Alamos. The water table in the caldera is near land surface. The underlying lake sediment and volcanics are highly permeable and recharge the aquifer through Tschicoma Formation interflow breccias (rock consisting of sharp fragments embedded in a fine-grained matrix) and the Tesuque Formation. The Rio Grande receives ground water discharge from springs fed by the main aquifer. The 18.4 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 6.8×10^3 m^3 (4300 to 5500 acre-feet) annually from the aquifer.

D. Climatology

Los Alamos has a semiarid, temperate mountain climate. Average, annual precipitation is nearly 45 cm (18 in.). Forty per cent of the annual precipitation occurs during July and August due to thundershowers. The rest of the precipitation is from winter storms moving through New Mexico. Winter precipitation falls primarily as snow, with accumulations of about 130 cm (51 in.) annually.

Summers are generally sunny with moderately warm days and cool nights. Maximum temperatures are usually below 32°C (90°F). Brief afternoon and evening thundershowers are common, especially in July and August. High altitude, light winds, clear skies, and dry atmosphere allow night temperatures to drop below 16°C (60°F) after even the warmest days. Winter temperatures typically range from about −9 to −4°C (15 to 25°F) during the night and from −1 to 10°C (30 to 50°F) during the day. Occasionally, temperatures drop to near −18°C (0°F) or below. Many winter days are clear with light winds, so strong sunshine can make conditions quite comfortable even when air temperatures are cold. Snowstorms with accumulations exceeding 10 cm (4 in.) are common in Los Alamos.

Surface winds in Los Alamos often vary dramatically with time-of-day and with location because of complex terrain. With light, large-scale winds and clear skies, a distinct daily wind cycle often exists: a light southeasterly to southerly upslope wind during the day and a light westerly to northwesterly drainage wind during the night. However, several miles to the east toward the edge of Pajarito Plateau, near the Rio Grande Valley, a different daily wind cycle is common: a moderate southwesterly up-valley wind during the day and either a light northwesterly to northerly drainage wind or moderate southwesterly wind at night. On the whole, the predominant winds are southerly to westerly over Los Alamos County.

Historically, no tornadoes have been reported to have touched down in Los Alamos County. However strong dust devils can potentially produce strong winds up to 35 m/s (75 mph) or so at isolated spots in the county, especially at lower elevations. Strong winds with gusts exceeding 30 m/s (60 mph) are common and widespread during the spring. Lightning is very common over Pajarito Plateau. There are 58 thunderstorm days during an average year, with most occurring during the summer. Lightning protection is an important design factor for most facilities at the Laboratory. Hail damage can also occur. Hailstones with diameters up to 0.64 cm (0.25 in.) are common, while 1.3 cm (0.5 in.) diameter hailstones are rather rare.

Atmospheric mixing or dispersion characteristics affect the transport of contaminants released into the air. Good mixing conditions result in greater transport and dilution of released contaminants. Under poorer mixing conditions, potential increases for exposure to higher air concentrations of released contaminants.

Frequent clear skies and light winds promote good daytime atmospheric dispersion at Los Alamos. Complex terrain and forested vegetation also

enhance vertical and horizontal mixing of the atmosphere and contaminants released into the air. During the night, light winds and clear skies favor the formation of temperature inversions, restricting atmospheric dispersion. Air flow channeling by terrain features also reduces nighttime dispersion. Poor atmospheric dispersion conditions frequently exist during the day and night in canyon bottoms. The frequency of atmospheric stability, an estimate of the dispersion capability of the atmosphere, is approximately 40% unstable (good mixing), 35% neutral (fair mixing), and 25% stable (poor mixing) on the mesa tops of the Los Alamos area.

E. Population Distribution

Los Alamos County has an estimated 1985 population of approximately 19 200 (based on the 1980 census adjusted for 1985). Two residential and related commercial areas exist in the county (Fig. 4). The Los Alamos townsite, the original area of development (and now including residential areas known as the Eastern Area, the Western Area, North Community, Barranca Mesa, and North Mesa), has an estimated population of 12 050. The White Rock area (including the residential areas of White Rock, La Senda, and Pajarito Acres) has about 7160 residents. About one-third of those employed in Los Alamos commute from other counties. Population estimates for 1985 place about 170 000 people within an 80 km (50 mi) radius of Los Alamos (Table 4).

F. Programs at Los Alamos National Laboratory

The Laboratory is administered by the University of California for the Department of Energy. The Laboratory's environmental program, conducted by the Environmental Surveillance Group, is part of a continuing investigation and documentation program.

Since its inception in 1943, the Laboratory's primary mission has been nuclear weapons research and development. Programs include weapons development, magnetic and inertial fusion, nuclear fission, nuclear safeguards and security, and laser isotope separation. There is also basic research in the areas of physics, chemistry, and engineering that support such programs. Research on peaceful uses of nuclear energy has included space applications, power reactor programs, radiobiology, and medicine. Other programs include applied photochemistry, astrophysics, earth sciences, energy resources, nuclear fuel safeguards, lasers, computer sciences, solar energy, geothermal energy, biomedical and environmental research, and nuclear waste management research. Appendix F summarizes activities at the Laboratory's 32 active Technical Areas (TAs).

In August 1977, the Laboratory site, encompassing 111 km^2 (43 mi^2), 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 understanding of how man 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 (DOE 1979) that assesses potential cumulative environmental impacts associated with current, known future, and continuing activities at the Laboratory was completed in 1979. The report provides environmental input for decisions regarding continuing activities at the Laboratory. It also provides detailed information on the environment of the Los Alamos area.

Table 4

1985 Population Within 80 km of Los Alamos[a,b]

Direction	1-2	2-4	4-8	8-15	15-20	20-30	30-40	40-60	60-80
N	---	---	---	---	---	---	1082	---	350
NNE	---	---	---	539	---	516	1649	1710	210
NE	1	---	---	---	302	14 256	962	1063	3589
ENE	---	---	---	1623	1489	2272	2480	1131	2153
E	---	---	69	21	465	958	582	---	1434
ESE	---	---	---	---	---	245	19 365	1030	1426
SE	---	---	7163	---	---	---	44 769	2044	7
SSE	---	---	---	---	---	---	356	3637	79
S	---	---	---	50	---	181	349	3989	---
SSW	---	---	---	20	---	464	114	4674	19 000
SW	---	---	---	---	---	---	179	2359	---
WSW	---	---	---	---	---	179	177	1444	117
W	---	---	---	---	---	---	---	93	75
WNW	---	1521	6927	---	---	---	---	---	1748
NW	---	555	1824	---	---	---	---	1370	---
NNW	---	613	614	---	---	---	---	61	59

[a]This distribution represents the resident, nonworkforce population with respect to the Los Alamos Meson Physics Facility's stack at TA-53. A slightly different distribution for Los Alamos County was used to model releases from the TA-2 stack, which is located closer to Los Alamos.
[b]Total population within 80 km of Los Alamos is 169 778.

III. RADIATION DOSES

Some incremental radiation doses—above those received from natural background, worldwide fallout, and medical and dental diagnostic procedures—are received by Los Alamos County residents as a result of Laboratory operations. The largest estimated dose at an occupied location was 7.3 mrem or 29% of DOE's recently implemented 25 mrem Radiation Protection Standard for the air pathway. This estimate is based on boundary dose measurements of airborne and scattered radiation from the linear particle accelerator at the Los Alamos Meson Physics Facility. Other minor exposure pathways may result in several mrem/year doses to the public.

No significant exposure pathways are believed to exist for radioactivity released in treated liquid waste effluents. Most of the radioactivity is absorbed in alluvium inside the Laboratory boundaries. Some is transported offsite in stream channel sediments during heavy runoff. The radioactivity levels in these sediments, however, are only slightly above natural background levels.

The total cumulative whole-body dose attributable to Laboratory operations received by the population living within 80 km of the Laboratory during 1985 was conservatively estimated to be 3.2 person-rem. This is about 0.02% of the 19 000 person-rem dose received by the same population from natural radiation sources and 0.02% of the 16 000 person-rem dose received from diagnostic medical procedures. About 90% of this dose, 2.9 person-rem, was received by persons living in Los Alamos County. This dose is 0.1% of the 2300 person-rem received by the population of Los Alamos County from natural background radiation and 0.2% of the 1800 person-rem from diagnostic medical and dental procedures.

In 1985, the average added risk of cancer mortality to Los Alamos townsite residents from radiation from this year's Laboratory operations was 1 chance in 56 000 000. This risk is much less than the 1 chance in 26 000 from background radiation. The Environmental Protection Agency has estimated average lifetime risk for overall cancer incidence as 1 chance in 4 and for cancer mortality as 1 chance in 5.

A. Introduction

The impact of environmental releases of radioactivity is evaluated by estimating doses received by the public from exposure to these releases. These doses are then compared with applicable standards and with doses from background radiation and medical and dental radiation.

Prior to 1985, DOE's Radiation Protection Standards for whole body dose were established at 500 mrem/yr for members of the general public and 5000 mrem/yr for workers. In 1985, DOE issued interim guidelines revising the standard for the general public (DOE 1985). The standard now limits the effective dose equivalent to 100 mrem/yr for all pathways of exposure. In accordance with EPA regulations (40 CFR 61), whole body doses received via the air pathway alone are limited to 25 mrem/yr. The principal pathway of exposure at Los Alamos has been via release of radionuclides into the air resulting in external radiation doses. Other pathways contribute finite but negligible doses. Occupational standards remain unchanged. Detailed discussion of standards is presented in Appendix A.

The exposure pathways considered for the Los Alamos area are atmospheric transport of airborne radioactive emissions, hydrologic transport of liquid effluents, food chains, and direct exposure to external penetrating radiation. Exposures to radioactive materials or radiation in the environment were determined by direct measurements of some airborne and waterborne contaminants, of contaminants in foodstuffs, and of external penetrating radiation. Theoretical dose calculations based on atmospheric dispersion modeling were made for other airborne emissions present at levels too low for direct measurement.

Doses were calculated from measured or derived exposures using models based on the recommendations of the International Commission on Radiological Protection (Appendix D). These doses are summarized in Table 5 for the most important exposure categories, as defined in DOE Order 5484.1 (DOE 1981B) as:

1. *Maximum Boundary Dose, or "Fence-Post" Dose Rate:* Maximum dose at the Laboratory boundary where the highest dose rate occurs. This dose does not take into account shielding or occupancy and does not require that an individual actually receive this dose.
2. *Maximum Individual Dose:* Maximum dose to an individual in an offsite location where the highest dose rate occurs and where there is a person. It includes corrections for shielding (for example, for being inside a building) and occupancy (what fraction of the year the person is in the area).
3. *Average Dose:* Average doses to residents of Los Alamos and White Rock.
4. *Whole Body Cumulative Dose:* The whole body cumulative dose for the population within an 80-km (50-mi) radius of the Laboratory.

The maximum boundary dose and the maximum individual dose over the past 8 years are summarized in Fig. 2. Over 95% of each of these doses results from emissions of air activation products from the Los Alamos Meson Physics Facility.

In addition to compliance with dose standards, which define an upper limit for doses to the public, there is a concurrent commitment to maintain radiation exposure to individuals and population groups to levels as low as reasonably achievable (ALARA). This policy is followed at the Laboratory by applying strict controls on airborne emissions, liquid effluents, and operations to minimize doses to the public and to limit releases of radioactive materials to the environment. Ambient monitoring described in this report documents the effectiveness of these controls.

B. Estimate of Radiation Doses

1. Doses from Background, Medical and Dental Radiation. Doses from natural background and from medical and dental uses of radiation are estimated to provide a comparison with doses resulting from Laboratory operations. Exposure to background radiation results principally in whole body doses and in localized doses to the lung. Whole body dose is incurred from exposure to cosmic rays, external terrestrial radiation from naturally occurring radioactivity in the earth's surface and from global fallout and internal radiation from radionuclides deposited in the body through inhalation or ingestion.

Whole body doses from background radiation can vary each year depending on factors such as snow cover and the solar cycle (see Section IV.A). In 1985, estimates were 125 mrem at Los Alamos and 111 mrem at White Rock.

These estimates are based on measured external radiation background levels of 116 mrem (Los Alamos) and 101 mrem (White Rock) due to 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 at Los Alamos, 52 mrem at White Rock) by 10% to allow for shielding by structures, and the terrestrial component (56 mrem at Los Alamos and 49 mrem at White Rock) by 20% to allow for shielding by structures and 20% for self-shielding by the body (NCRP 1975B). To these estimates based on measurements were added 11 mrem at Los Alamos and 9 mrem at White Rock from neutron cosmic radiation (10% shielding assumed) and 24 mrem from internal radiation, values taken from the National Council on Radiation Protection and Measurements (NCRP 1975B).

In addition to whole body 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 the decay of ^{226}Ra, a member of the uranium series, which is naturally present in the construction materials in a building and in its underlying soil. Background exposure to ^{222}Rn and its decay products is taken to be 0.2 Working Level Month (WLM)/year (NCRP 1984B). 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 recently recommended by the National Council on Radiation Protection and Measurements (NCRP 1984A).

The use of medical and dental radiation in the United States accounts for an average annual per capita dose of 92 mrem (NRC 1980). This estimate includes doses from both x-rays and radiopharmaceuticals.

2. Doses to Individuals from Inhalation of Airborne Emissions. The maximum individual doses attributable to inhalation of airborne emissions are summarized in Table G-1 and compared with DOE's limit for individual, whole body doses, 25 mrem/yr (Appendix A).

Table 5. Summary of Annual, Whole Body[a] Doses Due to 1985 Laboratory Operations

	Maximum Dose at Laboratory Boundary[b]	Maximum Dose to an Individual[c]	Average Dose to Nearby Residents		Cumulative Dose to Population Within 80 km of the Laboratory
			Los Alamos	White Rock	
Dose	11.4 ± 2 mrem	7.3 mrem	0.18 mrem	0.12 mrem	3.2 person rem
Location	Boundary N. of TA-53	Residence N. of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
Radiation Protection Standard	—	25 mrem	25 mrem	25 mrem	—
% of Radiation Protection Standard	—	29%	0.7%	0.5%	—
Natural background	125 mrem	125 mrem	125 mrem	111 mrem	19 000 person-rem
% of natural background	9%	6%	0.1%	0.1%	0.02%

[a]Organ receiving largest percentage of DOE's Radiation Protection Standard.
[b]Maximum boundary dose is the dose to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs. It assumes that the hypothetical individual is at the Laboratory boundary continuously (24 hours a day, 365 days a year).
[c]Maximum individual dose is the dose to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where there is a person. It takes into account occupancy (the fraction of time a person is actually at that location), self-shielding, and shielding by buildings.

Exposures to airborne ^{3}H (as tritiated water vapor), uranium, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am were determined by measurement. Correction for background was made assuming that natural radioactivity and worldwide fallout were represented by data from the three regional sampling stations at Española, Pojoaque, and Santa Fe. Doses were calculated using the procedures described in Appendix D.

The inhalation dose that was the highest percentage of the DOE's Radiation Protection Standard was 0.45 mrem to the bone surface; this is 0.6% of the 75 mrem/yr standard for dose to any organ from the air pathway.

Emissions of air activation products from the Los Alamos Meson Physics Facility (LAMPF) resulted in negligible inhalation exposures. External radiation from these emissions was detectable, however.

All other atmospheric releases of radioactivity (Table G-2) were evaluated by theoretical calculations. All potential doses from these other releases were less than the smallest ones presented in this section and were thus considered insignificant.

3. Doses to Individuals from External Penetrating Radiation (from Airborne Emissions and Direct Radiation). The thermoluminescent dosimeter network at the Laboratory boundary north of the LAMPF indicated a 11.4 mrem increment above cosmic and terrestrial background radiation during 1985. This increment is attributed to emission of air activation products from LAMPF.

Based on 20% shielding from being inside buildings, 20% self-shielding (NCRP 1975B), and 100% occupancy, this 11.4 mrem increment translates to an estimated 7.3 mrem whole body dose to an individual living along State Road 4 north of LAMPF. The 7.3 mrem is 29% of DOE's 25 mrem/yr standard for a member of the public receiving exposure via the air pathway (Appendix A). This location north of LAMPF has been the area where the highest boundary and individual doses have been measured since the dosimeter monitoring began.

As seen in Figure 2, the 11.4 mrem dose at this location during 1985 is approximately 25% of the 44 mrem measured during 1984. Emissions at LAMPF decreased significantly in 1985 as a result of the beam stop area at LAMPF being modified to reduce exposure from airborne activation products.

A maximum onsite dose to a member of the public from external penetrating radiation from all Laboratory airborne emissions was calculated from a Gaussian dispersion meteorological model (Slade 1968) to be 0.0012 mrem (whole body), less than 0.005% of the 25 mrem standard for protection of a member of the public (Appendix A). This dose was calculated (using credible worst-case conditions) for a person spending 4 hours at the Laboratory's science museum, an area readily accessible to the public.

Average dose to residents in Los Alamos townsite attributable to Laboratory operations was 0.18 mrem (whole body). The corresponding dose to White Rock residents was 0.12 mrem (whole body). These doses are 0.7% and 0.5%, respectively, of the 25 mrem standard. They were calculated using measured stack releases (Table G-2) and 1985 meteorological data.

Onsite measurements of external penetrating radiation reflected Laboratory operations and do not represent potential exposure to the public except in the vicinity of TA-18 on Pajarito Road. Members of the public regularly using the DOE-controlled road passing by TA-18 would likely receive no more than 4 mrem/yr of direct gamma and neutron radiation, which is 4% of the DOE's 100 mrem/yr standard for protection from exposure by all pathways (Appendix A). This value was based on 1985 field measurements of gamma plus neutron dose rates using thermoluminescent dosimeters.

Exposure time was estimated assuming that a person passed TA-18 at an average speed of 20 km/h (12 mph) while a test was being conducted. In 1985, there were less than 3 h during which the assemblies at TA-18 were operating and when this exposure could occur.

The onsite thermoluminescent dosimeter station (Station 24 in Fig. 6) near the northeast Laboratory boundary recorded an above background dose of 70 mrem. This reflects a localized accumulation of ^{137}Cs on sediments transported from treated effluent released from TA-21 prior to 1964 (Gunderson 1983).

4. Doses to Individuals from Liquid Effluents. Liquid effluents do not flow beyond the Laboratory boundary but are retained in alluvium of the receiving canyons. These effluents are monitored at their point of discharge and their behavior in the alluvium of the canyons below outfalls has been studied (Hakonson 1976A, Hakonson 1976B, Purtymun 1971A, and Purtymun 1974A).

Small quantities of radioactive contaminants transported during periods of heavy runoff have been measured in canyon sediments beyond the Laboratory boundary. Calculations made for the radiological survey of Acid, Pueblo, and Los Alamos canyons (ESG 1981) indicate a potential exposure pathway (eating liver from a steer that drinks water from and grazes in lower Los Alamos Canyon) to man from these canyon sediments. This pathway

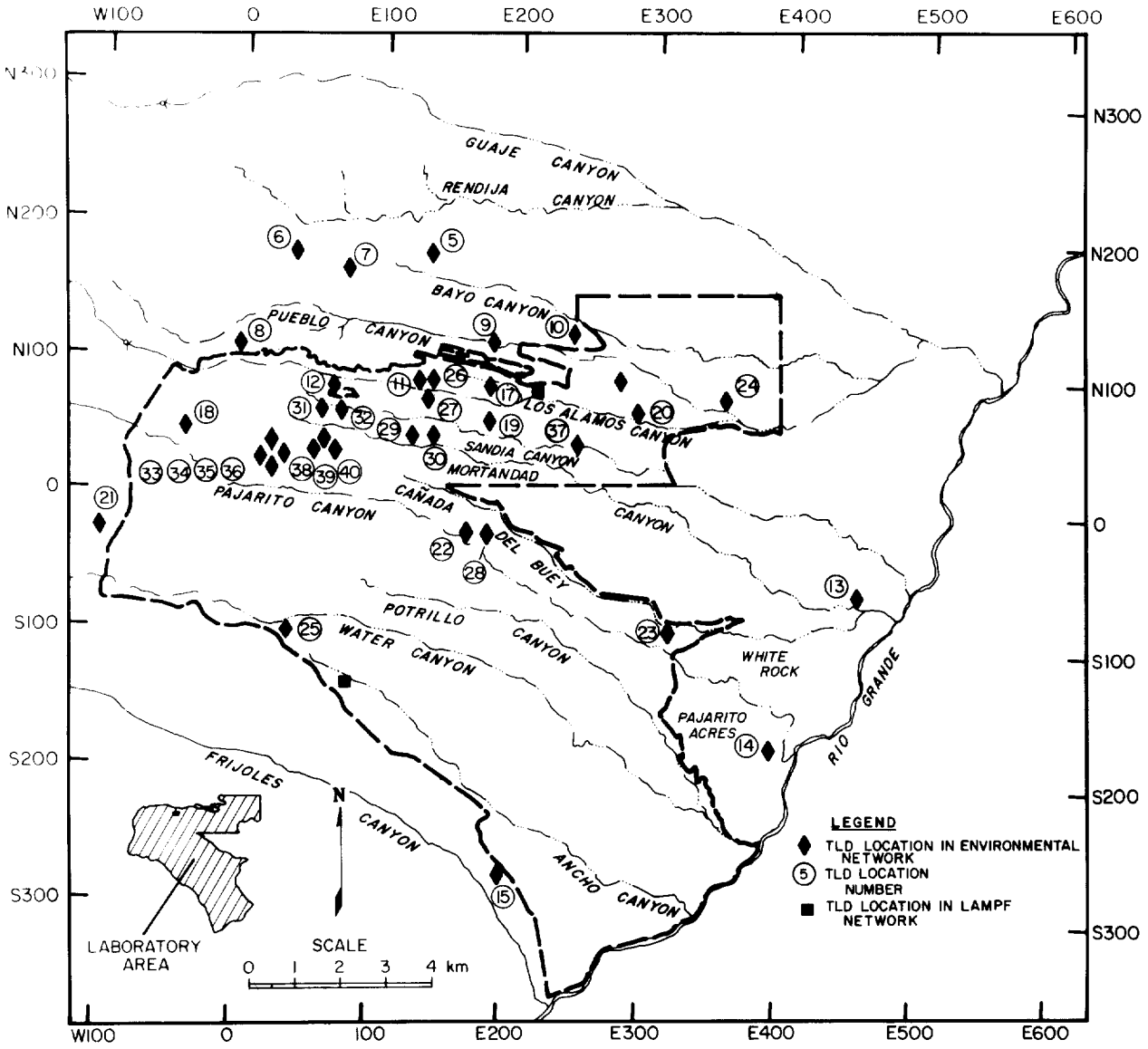


Fig. 6. Thermoluminescent dosimeter locations on or near the Laboratory site.

could result in a maximum 50-year dose commitment of 0.0013 mrem to the bone.

5. Doses to Individuals from Ingestion of Foodstuffs. Data from sampling of fruit, vegetables, fish, and honey during 1985 (Section VII) were used to estimate doses caused from eating these foodstuffs. All calculated doses are less than 0.1% of the DOE's 100 mrem/yr standard (Appendix A).

Fruit and vegetable samples were analyzed for five radionuclides (^{3}H, ^{137}Cs, total uranium, ^{238}Pu and $^{239,240}Pu$). Only ^{3}H at Los Alamos townsite and uranium at onsite locations were statistically distinguishable from background. Maximum effective dose equivalents that would result from ingesting one quarter of an annual consumption of fruits and vegetables (160 kg) from the offsite locations were 0.05 mrem and a 50-year dose equivalent to bone surface of 0.01 mrem. These doses are less than 0.1% of the DOE's Radiation Protection Standards for protecting members of the public (Appendix A).

Ingestion of produce collected onsite is not a significant exposure pathway because of the small amount

of edible material and because of the low radionuclide concentrations.

Fish samples were analyzed for ^{90}Sr, ^{137}Cs, natural uranium, ^{238}Pu, and $^{239,240}Pu$. Radionuclide concentrations in fish from Cochiti Reservoir, the sampling location downstream from the Laboratory, were statistically indistinguishable from or less than concentrations in fish taken from upstream reservoirs except for uranium in viscera samples and ^{90}Sr in tissue samples from higher trophic level feeders. It is believed that these concentration differences for uranium are caused by natural phenomena, particularly ingestion of suspended sediments containing natural uranium that are higher at Cochiti than at upstream reservoirs. The ^{90}Sr levels were barely distinguishable from background and is believed to be a result of worldwide fallout. Strontium concentrations vary from year to year; in 1984, ^{90}Sr concentrations in bottom feeders were statistically higher at upstream locations, reflecting influences of fallout at higher elevations. The maximum effective dose equivalent to an individual eating 21 kg of fish from Cochiti Reservoir is 0.05 mrem, which is 0.05% of DOE's 100 mrem standard (DOE 1985A). Maximum organ dose is 0.6 mrem to bone surface.

Trace amounts of radionuclides were found in honey. The maximum effective dose equivalent one would get from eating 5 kg of this honey, if it were made available for consumption, would be 0.03 mrem, which is <0.1% of DOE's 100 mrem standard.

6. Whole Body Cumulative Doses. The cumulative (or population) 1985 whole body dose attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory is calculated to be 3.2 person-rem. This dose is 0.02% of the 19 000 person-rem exposure from natural background radiation (whole body) and 0.02% of the 16 000 person-rem exposure from medical radiation (Table 6).

The cumulative dose from Laboratory operations was calculated from measured radionuclide emission rates (Table G-2), atmospheric model using measured meteorological data for 1985, and population data based on the 1980 Bureau of Census count adjusted to 1985 (Table 4 and Appendix D).

The cumulative dose from whole body natural background radiation was calculated using the background radiation levels given above. The dose to the 80-km population from medical and dental radiation was calculated using a mean annual dose of 92 mrem

Table 6. Estimated Whole Body Population Doses During 1985

Exposure Mechanism	Estimated Los Alamos County Whole-Body Population Dose (person-rem) (19 200 persons)	Estimated 80-km Region Whole-Body Population Dose (person-rem[a]) (170 000)
Atmospheric Tritium	0.17	0.17
Atmospheric ^{11}C, ^{13}N, ^{15}O, ^{41}Ar	2.73	3.00
Total Due to Laboratory Releases	2.90	3.17
Total Due to Natural Sources of Radiation[b]	2300	19 000
Average Due to Airline Travel [~0.22 mrem/h at 9 km (NCRP 1975B)]	29	---[c]
Diagnostic Medical Exposure [~92 mrem/yr per person (NRC 1980)]	1800	16 000

[a]Includes doses reported for Los Alamos County.
[b]Calculations are based on thermoluminescent dosimeter measurements. They include a 10% reduction in cosmic radiation from shielding by structures, a 20% reduction in terrestial radiation from shielding by structures and a 20% reduction in terrestial radiation from self-shielding by the body.
[c]Not estimated for the population in the 80-km region.

per capita. The population distribution in Table 4 was used in both these calculations to obtain the total cumulative dose.

Also shown in Table 6 is the cumulative dose in Los Alamos County from Laboratory operations, natural background radiation (whole body), and medical and dental radiation. Approximately 90% of the total cumulative dose from Laboratory operations is to Los Alamos county residents. This dose is 0.1% of the cumulative dose to the same population from natural background and 0.2% of the cumulative dose from medical and dental radiation.

Population centers outside of Los Alamos County are farther away, so dispersion, dilution, and decay in transit (particularly for ^{11}C, ^{13}N, ^{14}O, ^{15}O, and ^{41}Ar) reduce their dose to less than 10% of the total. The cumulative dose to the population outside of Los Alamos County and within 80 km (50 mi) of the Laboratory is 0.002% of the dose from natural background radiation and 0.002% of the dose from medical and dental radiation.

C. Risk to an Individual from Laboratory Releases

1. Estimating Risks. Risk estimates of possible health effects from radiation doses to the public resulting from Laboratory operations have been made to provide perspective in interpreting these radiation doses. These calculations, however, may overestimate actual risk for low-LET (linear energy transfer) radiation. The National Council on Radiation Protection and Measurements (NCRP 1975A) has warned "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 radiations, 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.

The International Commission on Radiological Protection (ICRP 1977) estimated that the total risk of cancer mortality from uniform whole body radiation for individuals is 0.0001 per rem, that is, there is 1 chance in 10 000 that an individual exposed to 1000 mrem (1 rem) of whole body radiation would develop a fatal cancer during his lifetime due to that radiation exposure. In developing risk estimates, the International Commission on Radiological Protection (ICRP 1977) has warned "radiation risk estimates should be used only with great caution and with explicit recognition of the possibility that the actual risk at low doses may be lower than that implied by a deliberately cautious assumption of proportionality."

2. Risk from Natural Background Radiation and Medical and Dental Radiation. During 1985, persons living in Los Alamos and White Rock received an average of 125 and 111 mrem, respectively, of whole body radiation from natural sources (including cosmic, terrestrial, and self-irradiation sources with allowances for shielding and cosmic neutron exposure, but excluding radiation from airline travel, luminous dial watches, building materials, and so on). Thus the added cancer mortality risk attributable to natural whole body radiation in 1985 was 1 chance in 80 000 in Los Alamos and 1 chance in 90 000 in White Rock (Table 2).

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 due to natural radiation sources that was not included in the estimate for whole body radiation. The National Council on Radiation Protection and Measurements has estimated that a 1 WLM exposure over a year would give an age-averaged risk of lung cancer of 0.00013 per WLM, or 13 chances in 100 000 for each WLM of exposure (NCRP 1984B). For the background exposure of 0.2 WLM (Section III.B.1), the added risk due to exposure to natural ^{222}Rn and its decay products is 1 chance in 38 000.

This lung cancer risk estimate based on recommendations of the National Council on Radiation Protection and Measurements is used because it is more current than an estimate based on the lung cancer risk factor of the International Commission on Radiological Protection, and because it is meant to be used in environmental, rather than occupational, conditions.

The total cancer mortality risk from natural background radiation is 1 chance in 26 000 for Los Alamos and 1 chance in 27 000 for White Rock. The additional risk of cancer mortality from exposure to medical and dental radiation is 1 chance in 110 000.

3. Risk from Laboratory Operations. The risks calculated above from natural background radiation and medical and dental radiation can be compared to the incremental risk due to radiation from Laboratory operations. The average doses to individuals in Los Alamos and White Rock because of 1985 Laboratory activities were 0.18 mrem and 0.12 mrem, respectively. These doses are estimated to add lifetime risks of about 1 chance in 56 000 000 in Los Alamos and 1 chance in 83 000 000 in White Rock to an individual's risk of cancer mortality (Table 2). These risks are less than 0.2% 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 a cancer and a 1 in 5 chance of dying from the disease (EPA 1979A). The Los Alamos incremental dose attributable to Laboratory operations is equivalent to the additional exposure from cosmic rays a person would get from flying in a commercial jet aircraft for 50 min.

The exposure from Laboratory operations to Los Alamos County residents is well within variations in exposure to these people from natural cosmic and terrestrial sources and global fallout. For example, one study (Yeates 1972) showed the annual dose rate on the second floor of single-family frame dwellings was 14 mrem/yr less than the dose rate on the first floor. Energy conservation measures, such as sealing and insulating houses and installing passive solar systems, are likely to contribute much more to the total risk to Los Alamos County residents than Laboratory operations because of increased ^{222}Rn levels inside the homes. The Environmental Protection Agency has estimated the annual whole body dose to individuals from global fallout to be 4.4 mrem (Klement 1972).

IV. EXTERNAL PENETRATING RADIATION

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 monitored with thermoluminescent dosimeters. No measurement for regional locations showed any statistically discernible increase in radiation levels for 1985. The only boundary or perimeter measurements showing an effect attributable to Laboratory operations were those from dosimeters located north of the Los Alamos Meson Physics Facility (a linear particle accelerator). They showed an above-background radiation measurement of 11 ± 2 mrem in 1985. This is a four-fold reduction from the 1984 measurement of 44 ± 2 mrem. Some onsite measurements were above background levels, as expected, reflecting research activities and waste management operations at the Laboratory.

A. Introduction

Natural external penetrating radiation comes from terrestrial and cosmic sources. The natural terrestrial component results from decay of ^{40}K and from radioactive daughters in the dacay chains of ^{232}Th, ^{235}U, and ^{238}U. Natural terrestrial radiation in the Los Alamos area is highly variable with time and location. During any year, external radiation levels can vary 15 to 25% at any location because of changes in soil moisture and snow cover (NCRP 1975B). There are also fluctuations because of different soil and rock types in the area (ESG 1978). If 1985 quarterly measurements at regional and perimeter stations were extrapolated over the year (i.e., multiplied by 4), estimated, annual background radiation would range from 73 to 154 mrem.

The cosmic source of natural ionizing radiation increases with elevation because of reduced shielding by the atmosphere. At sea level, it produces measurements between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km (1.4 mi), receives about 60 mrem/yr from the cosmic component. However, the regional locations 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 for the cosmic component. This cosmic component can vary up to about ±5% because of solar modulations (NCRP 1975B).

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

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) deployed in three independent networks. These networks are used to measure radiation levels at: (1) the Laboratory and regional areas, (2) the Laboratory boundary north of LAMPF, and (3) low-level radioactive waste management areas.

B. Environmental TLD Network

The environmental network consists of 40 stations divided into three groups. The regional group consists of four locations, 28 to 44 km from the Laboratory boundary in the neighboring communities of Española, Pojoaque, and Santa Fe, along with the Fenton Hill Site 30 km west of Los Alamos (Fig. 6). The perimeter group consists of 12 stations within 4 km of the boundary; 24 locations within the Laboratory boundary comprise the onsite group (Fig. 6). Details of methodology for this network can be found in Appendix B.

Annual averages for the groups did not differ statistically between 1984 and 1985 (Fig. 7). Regional and perimeter stations showed no statistically discernible increase in radiation levels attributable to Laboratory operations (Table G-3). Some comparisons are useful to establish perspective for evaluating the measurements shown. For instance, the average person in the United States receives about 92 mrem/yr from medical diagnostic procedures (NRC 1980). The DOE's standard is 25 mrem/yr for whole body dose received via the air pathways (Appendix A). This value is in addition to normal background, self-irradiation, and medical diagnostic sources. The standard applies to locations of maximum probable exposure to an individual in an offsite, uncontrolled area.

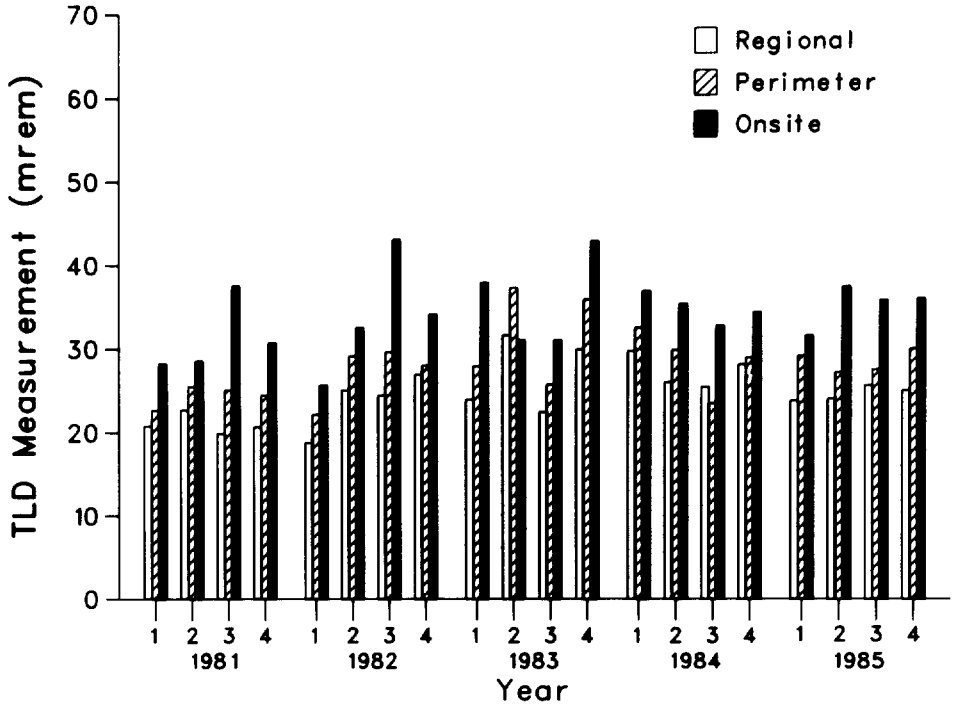


Fig. 7. Thermoluminescent dosimeter (TLD) measurements (includes contributions from cosmic, terrestrial, and Laboratory radiation sources).

C. Los Alamos Meson Physics Facility (LAMPF) TLD Network

This network monitors radiation from airborne activation products (gases, particles, and vapors) released by LAMPF, TA-53. The prevailing winds are from the south and southwest (Section II). Twelve TLD sites are located downwind at the Laboratory boundary north of LAMPF along 800 m of canyon rim. Twelve background TLD sites are about 9 km from the facility along a canyon rim near the southern boundary of the Laboratory (Fig. 6). This background location is not influenced by any Laboratory radiation sources.

The 24 TLDs are changed each calendar quarter or sooner, if LAMPF's operating schedule dictates (start-up or shut-down of the accelerator for extended periods mid-way in a calendar quarter). The radiation measurement (above background) for this network was 11 ± 2 mrem for 1985. This value is obtained by subtracting the annual measurement at the background sites from the annual measurement at the Laboratory's boundary north of LAMPF (Appendix B). Figure 2 shows the above-background measurements from LAMPF's operations for the last 8 years. This year's measurement is one-fourth the value measured in 1984. The decrease is the result of improvements in the design of the accelerator's beam stop to reduce the amount of airborne activation products generated.

D. TLD Network for Low-Level Radioactive Waste Management Areas

This network of 91 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. Results from this network will be published in a separate report in mid-1986. Monitoring in other media is summarized in this report.

V. AIR MONITORING

Airborne radioactive emissions were monitored as released from 87 points at the Laboratory. The largest airborne release, 125 700 Ci of short-lived (2 to 20 min half-lives) air activation products from the Los Alamos Meson Physics Facility (LAMPF), has decreased by 83% from 1984 because of modifications in the LAMPF beam stop area. Worldwide background atmospheric radioactivity is composed of fallout from atmospheric nuclear weapon tests, natural radioactive constituents in dust from the earth's surface, and radioactive materials resulting from interactions with cosmic radiation. Air is routinely sampled at several locations on Laboratory land, along the Laboratory perimeter, and in distant areas to determine the existence and composition of any contributions to airborne radionuclide levels from Laboratory operations. Atmospheric concentrations of tritium, uranium, plutonium, americium, and gross beta are measured. The highest measured and annual average concentrations of these radioactive materials were much less than 0.1% of concentrations that would result in DOE's Radiation Protection Standards being exceeded. Nonradioactive emissions are also monitored at several Laboratory sites. Activities monitored included beryllium operations, steam and power generation, and burning and detonation of explosives. No nonradioactive emissions during 1985 exceeded standard levels for protection of human health and the environment.

A. Radioactive Emissions

1. Introduction. Atmospheric radioactivity samples are collected at 26 continuously operating air sampling stations (see Appendix B for a complete description of sampling procedures). The regional monitoring stations, located 28 to 44 km (18 to 28 mi) from the Laboratory at Española, Pojoaque, and Santa Fe (Figure 8), are reference points for determining regional background levels of atmospheric radioactivity. The 11 perimeter stations are within 4 km (2.5 mi) of the Laboratory boundary; 12 onsite stations are within the Laboratory boundary (Figure 8, Table G-4).

Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made in the Laboratory's air sampling program. Worldwide background atmospheric radioactivity is largely composed of fallout from past atmospheric nuclear weapons tests, natural radioactive constituents from the decay chains of thorium and uranium in dust, and materials resulting from interactions with cosmic radiation (e.g., natural tritiated water vapor produced by interactions of cosmic radiation and stable water). Background radioactivity concentrations in the atmosphere are summarized in Table G-5 and are useful in interpreting the air sampling data.

Atmospheric particulates result primarily from soil particles that are blown by the wind. Consequently, there are often large daily and seasonal fluctuations and location in airborne radioactivity levels caused by changing meteorological conditions. Windy, dry days can result in relatively high concentrations of airborne particulates, whereas precipitation (rain or snow) can wash out many particles from the atmosphere.

2. Airborne Emissions. Radioactive airborne emissions are monitored and discharged at the Laboratory from 87 stacks. These emissions consist primarily of filtered exhausts from gloveboxes, experimental facilities, operational facilities (such as liquid waste treatment plants), a research nuclear reactor, and a linear particle accelerator at LAMPF. The emissions receive appropriate treatment before discharge, such as filtration for particulates, catalytic conversion and adsorption for activation gases. Quantities of airborne radioactivity released depend on the kinds of research being done, so can vary significantly from year to year (Figs. 9-11).

During 1985, the most significant releases were 125 700 Ci of air activation products (gases, particulates, and vapors) from the linear particle accelerator LAMPF. This is a decrease of 83% from the 734 118 Ci released in 1984, as a result of modifications of the LAMPF beam stop area. The principal airborne activation products (half-lives in parentheses) were ^{11}C (20 min), ^{13}N (10 min), ^{14}O (71 sec),

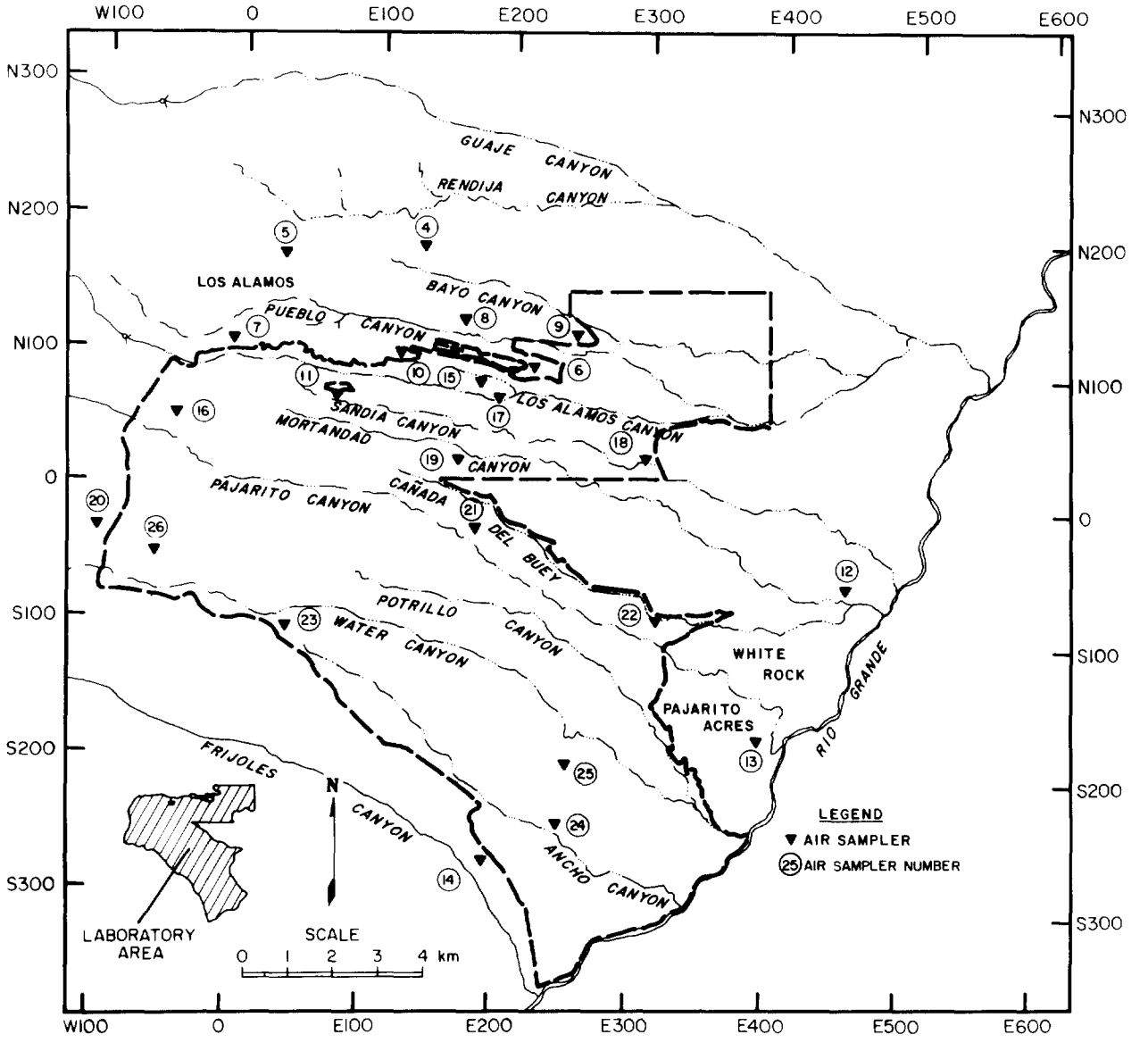


Fig. 8. Air sampler locations on or near the Laboratory site.

^{15}O (123 sec), ^{41}Ar (1.83 h), ^{192}Au (4.1 h), and ^{195}Hg (9.5 h). Over 95% of the radioactivity was from the ^{11}C, ^{13}N, ^{14}O, and ^{15}O radioisotopes, which have half-lives that range from 2 to 20 min. Therefore, the radioactivity from these radionuclides decays very rapidly.

Airborne tritium emissions decreased by 42% from 14 869 Ci in 1984 to 8638 Ci in 1985. This was principally due to decreases in tritium releases at TA-33 and TA-41.

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 524 kg (1150 lb) of depleted uranium were used in such experiments in 1985 (Table G-13). This mass contains about 0.24 Ci of activity. Most debris from these experiments is deposited on the ground in the vicinity of the firing sites. Limited experimental data indicates that no more than about 10% of the depleted uranium becomes airborne. Dispersion calculations indicate that resulting airborne concentrations are in the same range as attributable to natural crustal abundance of uranium in resuspended dust.

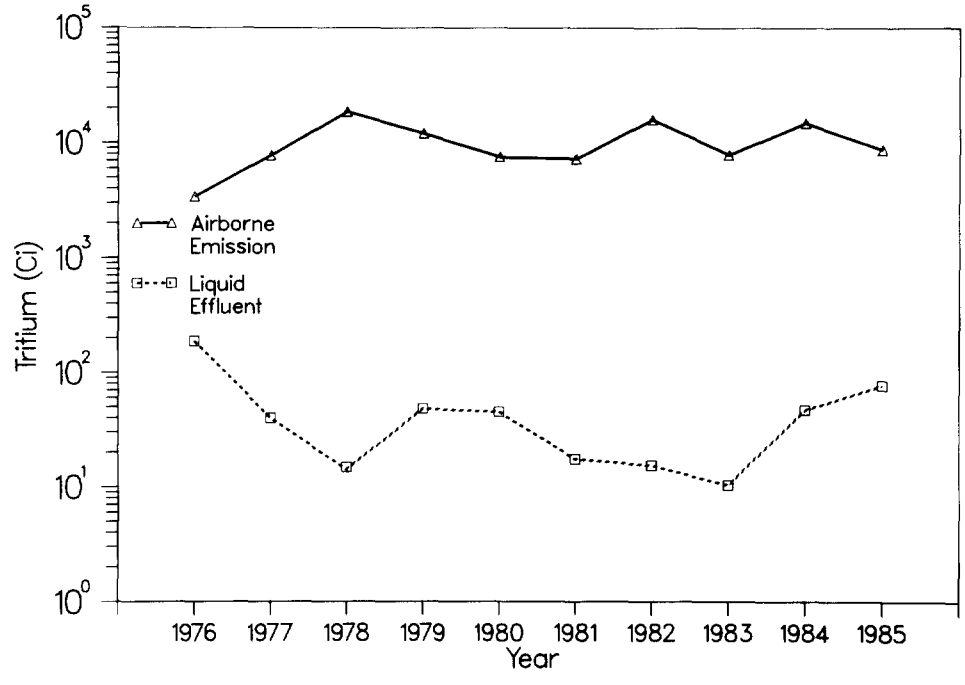


Fig. 9. Summary of tritium releases (airborne emissions and liquid effluents).

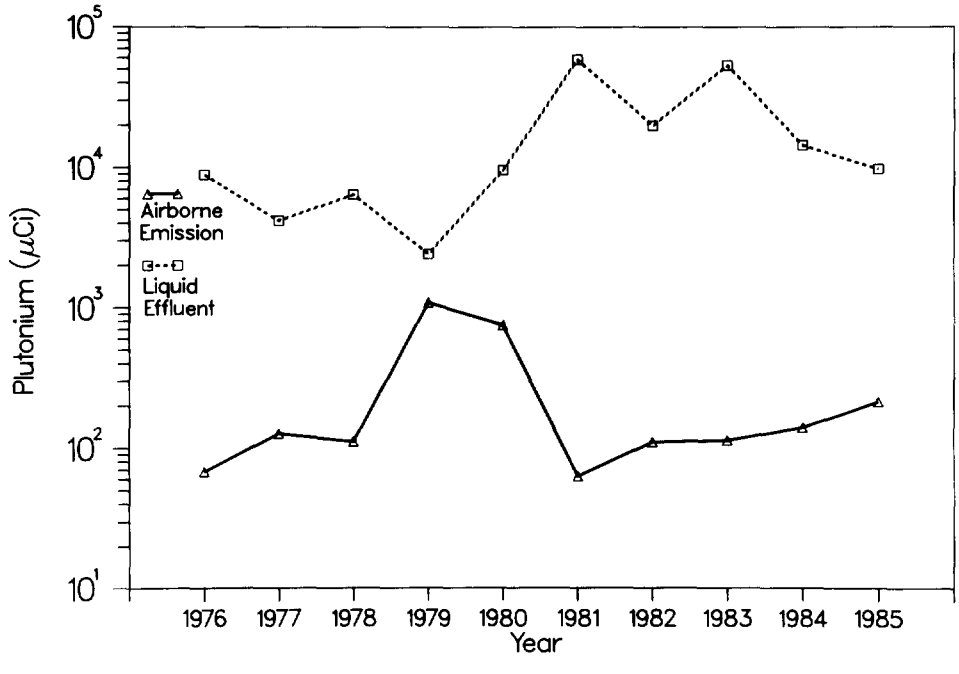


Fig. 10. Summary of plutonium releases (airborne emissions and liquid effluents).

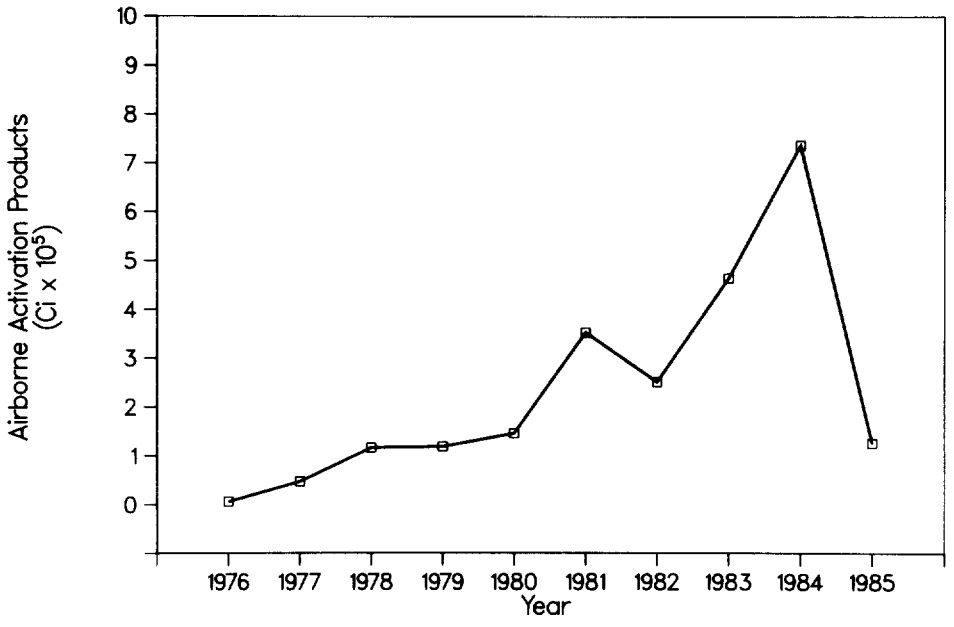


Fig. 11. Airborne activation product emissions (^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar, ^{192}Au, ^{195}Hg) from the Los Alamos Meson Physics Facility (TA-53).

The EPA limits radiation doses from airborne radioactive emissions to 25 mrem/yr (whole body) under the auspices of National Emission Standards for Hazardous Air Pollutants (EPA 1985). As discussed in Section III, the maximum individual dose due to Laboratory operations during 1985, which resulted from releases of air activation products at LAMPF, was 7.3 mrem to the whole body. This dose is 29% of the EPA limit of 25 mrem/yr to the whole body.

3. Gross Beta Radioactivity. Gross beta analyses help in evaluating general radiological air quality. Figure 12 shows gross beta activity at a regional sampling location (Española, Station 1, see Fig. 8) about 30 km from the Laboratory and at an onsite sampling location (TA-59). The annual mean gross beta activity in 1985 was slightly but statistically significantly higher at the onsite station (20×10^{-15} μCi/mℓ) than at the regional station (10×10^{-15} μCi/mℓ). These gross beta levels are less than 0.1% of the concentration guide for gross beta activity in Uncontrolled Areas based on DOE's Radiation Protection Standard (Appendix A).

4. Tritium. In 1985, regional annual mean (3.2×10^{-12} μCi/mℓ) was slightly but statistically significantly lower than the perimeter annual mean (14.8×10^{-12} μCi/mℓ) and the onsite annual mean (31.3×10^{-12} μCi/mℓ) (Table G-6). This reflects the slight impact of Laboratory tritium operations. The TA-54 (Station 22) annual mean (75.8×10^{-12} μCi/mℓ) and the TA-33 (Station 24) annual mean (106×10^{-12} μCi/mℓ) were the two highest annual means measured in 1985. Both these stations are located within the Laboratory boundary near areas where tritium is disposed or used in operations. These tritium levels are 0.0015 and 0.0021%, respectively, of the concentration guide for tritium in air based on DOE's RPSs for Controlled Areas (Appendix A).

5. Plutonium and Americium. Of the 104 air sample analyses performed in 1985 for ^{238}Pu, four were above the minimum detectable limit of 2.0×10^{-18} μCi/mℓ. All four samples were collected onsite. The concentrations of ^{238}Pu in these samples were $4.5 \pm 1.3 \times 10^{-18}$ μCi/mℓ (TA-21, second quarter), $4.9 \pm 1.1 \times 10^{-18}$ μCi/mℓ (TA-54, second quarter), $2.2 \pm 1.1 \times 10^{-18}$ (TA-54, third quarter), and $61.3 \pm 3.8 \times 10^{-18}$ (TA-16-450, fourth quarter). These concentrations are less than 0.01% of the DOE's Derived Concentration Guide for ^{238}Pu, 3×10^{-14} μCi/mℓ (Appendix A). The other 100 samples are not tabulated in this report

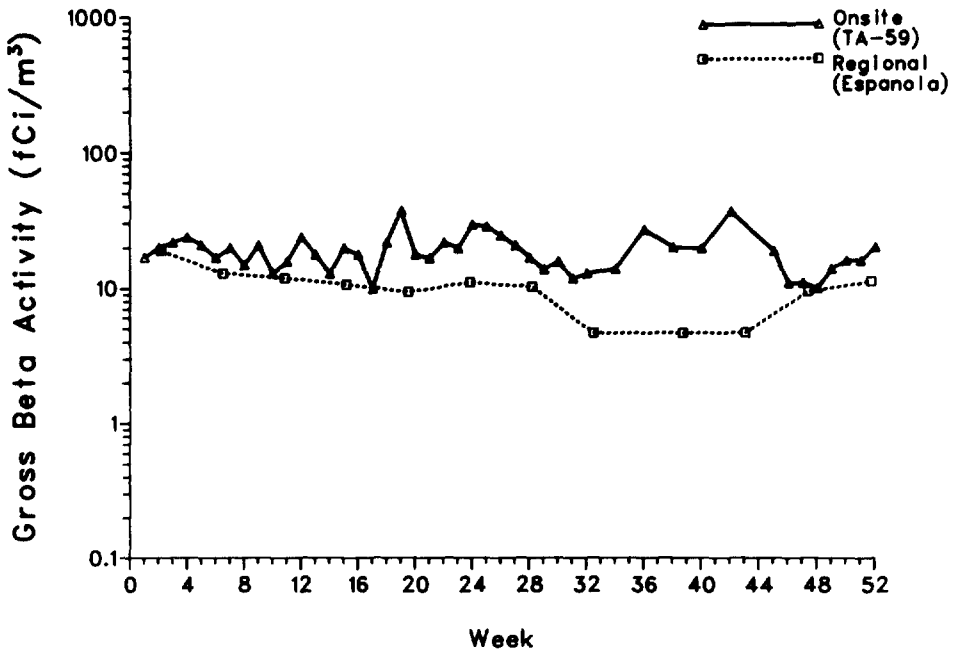


Fig. 12. Atmospheric gross beta activity at a regional (background) station and an onsite station during 1985.

because they all contained less-than-detectable activity.

The 1985 annual means for $^{239,240}Pu$ concentrations in air for the regional (0.8×10^{-18} μCi/mℓ), perimeter (0.7×10^{-18} μCi/mℓ), and onsite (3.3×10^{-18} μCi/mℓ) stations were all less than 0.01% of the concentration guides for Controlled or Uncontrolled Areas (Appendix A).

Measured concentrations of ^{241}Am were all less than 0.1% of concentration guides for Controlled and Uncontrolled Areas (Appendix A).

The detailed results are in Tables G-7 and G-8.

6. 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. Those stations with relatively higher annual averages or maximums are in dusty areas, where a higher filter dust loading accounts for collection of more natural uranium from resuspended soil particles.

The 1985 annual means of the regional stations (46 pg/m^3), perimeter stations (28 pg/m^3), and onsite stations (32 pg/m^3) were statistically indistinguishable (Table G-9). All measured annual means were less than 0.1% of the concentration guides for uranium in Controlled or Uncontrolled Areas (Appendix A).

B. Nonradioactive Emissions

1. Air Quality.

a. Particulate Air Quality. Measurements of total suspended particulates (TSP) in Los Alamos and White Rock are made once every 6 days at a site on West Road in Los Alamos and at the sewage treatment plant in White Rock by the New Mexico EID. The state and federal ambient air quality standards were easily met in both Los Alamos and White Rock (Table 7). The 24-h standards are not to be exceeded more than once per year. There is both a primary and a secondary standard for TSP. The primary standard is to protect human health and the secondary standard is to protect general welfare, such as the prevention of soiling and material damage. The state 24-h standard is as stringent as the federal secondary standard.

The highest TSP concentrations were measured in the winter in Los Alamos and there was no seasonal

Table 7. Particulate Air Quality ($\mu g/m^3$)

Federal and State Ambient Air Quality Standards		Measurements	
Type	**Concentration**	**Los Alamos**	**White Rock**
24-hour average[a]		64.2[c] (72.3)[d]	71.2[c] (92.6)[d]
State[b]	150		
Federal			
Primary	260		
Secondary	150		
7-day average[b]	110		
30-day average[b]	90		
Annual Geometric Mean		26.6	25.6
Primary	75		
Secondary	60		

[a]Not to be exceeded more than once per year.
[b]New Mexico state standard only.
[c]Second highest.
[d]Highest.

Table 8. Particulate Air Quality, Seasonal Averages ($\mu g/m^3$)

	Winter	**Spring**	**Summer**	**Fall**
Los Alamos	42.6	28.8	22.9	22.2
White Rock	27.4	---	26.8	26.6

variation in White Rock (Table 8). No measurements were taken during the spring in White Rock. The seasonal pattern is different from last year when the highest concentrations were measured in the spring in both Los Alamos and White Rock. Measurements are not made for the 7- and 30-day average state standards. Based upon the data, these standards are not expected to have been exceeded.

b. Bandelier National Monument. The Laboratory operates a wet deposition station located at the Bandelier National Monument. The station is part of the National Atmospheric Deposition Program Network. Sampling results are presented in Section XI.

An ambient air quality monitoring station has been established on Laboratory land adjacent to Bandelier National Monument. The station began partial operation in December 1985. The station is designed to measure carbon monoxide, nitrogen oxides, ozone, sulfur dioxide, and total suspended particulates.

2. Air Emissions.

a. Beryllium Operations. Beryllium (Be) machining operations are located in shop 4 at TA-3-39 and in shop 13 at TA-3-102. Machining of beryllium in shop 13 takes place intermittently, tens

of days per year, and emissions are not monitored. A new beryllium machine shop and a beryllium-uranium oxide processing facility are planned for 1986. The former is to be located at TA-35-213 and the latter at TA-3-141. Exhaust air from each of these operations passes through or will pass through air pollution control equipment before exiting from a stack. A baghouse type filter is used to control emissions from shop 4. The other operations use or will use HEPA filters to control emissions. Air pollution control systems have >99.9% particulate removal efficiencies.

A total of 1.7 mg of beryllium particulates were emitted from shop 4 during 1985 (Table G-10) compared with 1.9 mg emitted during 9 months of 1985. Emissions in both years were well below EPA's 10 g/day limit (40 CFR 42). EPA reference methods were not required in sampling and were not used. Stack emission tests, using EPA and New Mexico EID approved methods, will be performed for each of the beryllium operations during 1986.

b. Steam and Power Plants. Fuel consumption and emission estimates for the natural-gas fired steam plants and power plant are reported in Table G-11. One-half to three-quarters of the emissions come from the TA-3 power plant. A computerized boiler control system installed at the TA-3 power plant in September, 1984, resulted in a substantial decrease in NO_x emissions from 1984 to 1985. The decrease in emissions from the TA-21 steam plant was caused by the decrease in fuel consumption from 1984 to 1985. The Western Area steam plant, used as a standby plant, was not operated during 1985. The TA-3 power plant's SO_x in exhaust gases were below minimum detectable levels.

The NO_x and SO_x emissions from the TA-3 power plant were estimated based upon boiler exhaust gas measurements. Other emissions at TA-3 and emissions at the steam plants were estimated using EPA's emission factors (EPA 1984).

c. Motor Vehicle Emissions. Direct emissions from the vehicles as well as emissions caused by evaporative losses from fuel storage tanks were estimated. Hydrocarbons, carbon monoxide, nitrogen oxides, sulfur oxides and particulate emissions were estimated based upon motor vehicle class, age and the vehicle miles traveled. Fuel storage evaporative losses were estimated based upon the fuel usage. The EPA's emission factors were used in making the estimates (EPA 1981, 1984). There was a small change in emissions from 1984 to 1985 (Table 9).

d. Asphalt Plant. Particulate emissions from the asphalt concrete plant were low but increased from 1984 to 1985 because of an increase in production (Table 10). A multicyclone and a wet scrubber are used to clean the exhaust gas stream before it is released into the atmosphere. The particulate emission estimates were based upon stack testing data (Kramer 1977) and production data.

e. Chemical Usage. The Laboratory complex uses large quantities of various volatile chemicals and gases, some of which are released into the atmosphere by evaporation or exhaust. Using data based upon records of chemical transactions for both

Table 9. Estimate of Air Pollutant Emissions Associated with the Operation of the Vehicle Fleet (1000 kg)

	1984	1985	Incremental % Change
Fuel Storage Evaporative Losses	5.7	6.2	7.4
Hydrocarbons	16.4	16.6	1.1
Carbon Monoxide	197.1	202.3	2.5
Nitrogen Oxides	23.8	23.6	−0.8
Sulfur Oxides	2.3	2.2	−1.6
Particulates			
Exhaust	1.0	1.0	−1.9
Tire Wear	1.4	1.4	1.6

Table 10. Asphalt Plant Particulate Emissions

Year	Production (tons/year)	Emissions (lb/year)	Incremental % Change from 1984
1984	13773	458	
1985	24659	820	79.0

Table 11. Estimated Air Pollutant Emissions from the Open Burning of Waste Explosives (kg)

Pollutant	1984	1985
Oxides of Nitrogen	575	653
Particulates	334	389
Carbon Monoxide	149	169
Hydrocarbons	1.9	2.2

the chemical warehouse and the Van Waters and Rogers (VWR) managed warehouse, a table of patterns of chemical usage over the past 5 years has been compiled (Table G-12). Fourteen chemicals were used in quantities exceeding or equal to EPA Reportable Quantities (40 CFR 302).

f. Burning and Detonation of Explosives. During 1985, over 21600 kg (47,700 lb) of high-explosive wastes were disposed of by open burning at the TA-16 open incinerator. Estimates were made of air emissions (Table 11) using data from experimental work carried out by Mason and Hanger-Silas Mason Co., Inc. (MHSM 1976). Total emissions were 13.5% higher than those for 1984 (Table 11).

Dynamic experiments employing conventional explosives are routinely conducted in certain test areas at the Laboratory. In some experiments these explosives contain toxic metals including uranium, beryllium, and lead (Table G-13). There were no beryllium emissions in 1985. Uranium emissions decreased 32% and lead emissions increased 118% from 1984.

Estimates of average concentrations of these toxic metals downwind from the detonations are reported in Table G-13. Applicable standards are also presented in this table. Estimated concentrations were less than 0.1% of the applicable standards. These estimates are based upon information concerning the proportion of material aerosolized provided from limited field experiments involving aircraft sampling and the amounts of toxic metals used in the 1985 experiments.

VI. WATER, SOILS, AND SEDIMENTS MONITORING

Surface and ground waters, soils, and sediments were sampled to monitor dispersion of radionuclides and chemicals from Laboratory operations. Radiochemical and chemical quality of water from areas where there has been no direct discharge of treated effluent evidenced no observable effects due to Laboratory operations. Water in onsite effluent release areas contained trace amounts of radionuclides below concentration guides. Chemical quality of surface waters from noneffluent discharge areas varied within the range of normal seasonal fluctuations. Some constituents of water from onsite, effluent release areas exhibited greater concentrations than found in unaffected waters. Although the quality of surface and shallow ground waters in effluent release areas reflected some impact from Laboratory operations, these waters were confined within the Laboratory and were not a source of municipal, industrial, or agricultural supply.

Regional and perimeter soil stations contained radioactivity at or near background levels. One station in the solid waste area contained $^{239,240}Pu$ in excess of worldwide fallout. Regional and perimeter sediment stations contained radioactivity near or below background levels. Sediments from former and present effluent release areas contained radionuclides in excess of background. In general, concentrations were highest near points of effluent discharge and decreased downgradient due to dispersion and dilution with storm runoff. Runoff samples from Los Alamos Canyon indicated that the major route of plutonium transport is in suspended sediments rather than solution. Sediments from regional reservoirs on the Rio Chama and the Rio Grande contained radionuclides derived from worldwide nuclear fallout or from naturally occurring deposits.

A. Effluent Quality

Treated liquid effluents containing low levels of radioactivity are released from the Central Liquid Waste Treatment Plant (TA-50), a smaller plant serving laboratories at TA-21, and a sanitary sewage lagoon system serving LAMPF (TA-53) (Tables 3, G-14, G-15, and Figs. 9, 10, and 13).

Radionuclide concentrations in effluents from the larger radioactive liquid waste treatment plant (TA-50) were well below DOE's Concentration Guides for Controlled Areas, based on DOE's occupational Radiation Protection Standards (Table G-14). Except for tritium, discharge of radionuclides declined from 1984 to 1985. Volumes of discharge were reduced by computer monitoring and rapid response actions at the treatment plant. The source of increased tritium discharge has not been found. Although tritium release from TA-50 increased sharply, Laboratory-wide release of tritium remained within the range of previous years (Fig. 9). Effluents are discharged into a normally dry stream channel in Mortandad Canyon where surface flow has not passed beyond the Laboratory boundary since before the plant began operation.

All radionuclide concentrations in effluents from the smaller plant (TA-21) were well within DOE's Concentration Guides for Controlled Areas (Table G-14). Discharges declined from 1984 because all effluents were pumped to TA-50 after June. Discharges from TA-21 enter DP Canyon, a tributary of Los Alamos Canyon. Runoff in DP Canyon does at times flow past the Laboratory boundary and transports some residual radionuclides that have adsorbed on sediments.

All radionuclide concentrations found in the TA-53 lagoon effluent in 1985 were lower than those found in 1984. This is due to the lower radionuclide production, because of accelerator beam-stop modification. The source of the radioactivity was activated water from the beam-stop cooling systems. All radionuclide concentrations were well below the DOE's Concentration Guides (Table G-15). Discharge declined because an extra lagoon compartment increased evaporation and storage capacity and, thus, eliminated overflow after August. The effluent sinks into alluvium of Los Alamos Canyon within the Laboratory's boundary.

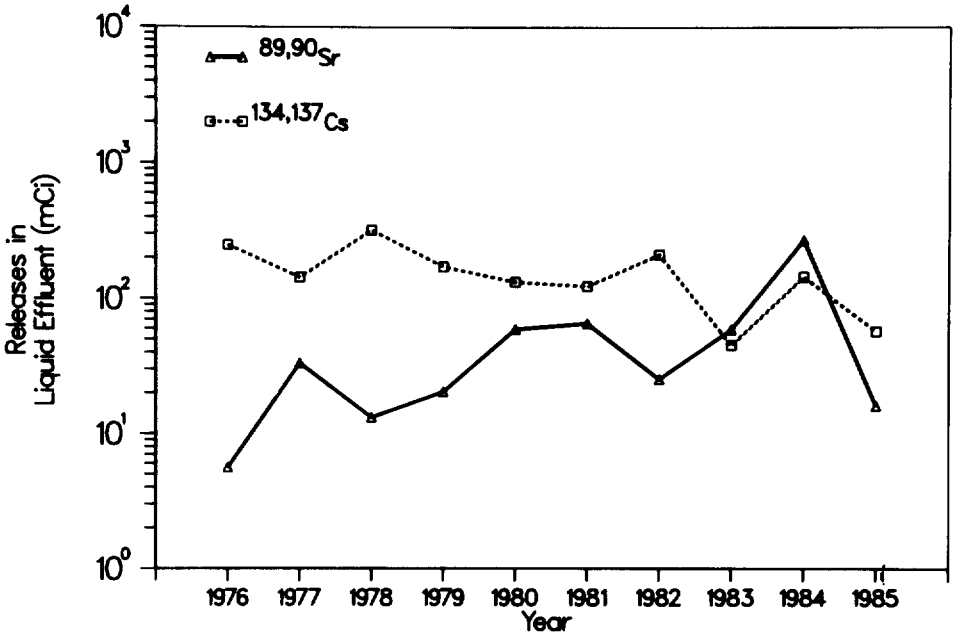


Fig. 13. Summary of strontium and cesium liquid effluent releases.

B. Radiochemical and Chemical Quality of Surface and Ground Water

1. Introduction. Surface and ground waters from regional, perimeter, and onsite stations are monitored to provide routine surveillance of Laboratory operations (Figs. 14 and 15, Table G-16). If a sample from a particular station was not taken this year, it was because the station was dry or a water pump was broken. Concentrations of radionuclides in water samples are compared with concentration guides derived from DOE's Radiation Protection Standard (RPS) (Appendix A). Regional and perimeter stations are in Uncontrolled Areas (RPS = 100 mrem/yr), while onsite stations are within Controlled Areas occupational RPSs. Concentration guides do not account for concentrating mechanisms that may exist in environmental media. Consequently, other media such as sediments, soils, and foodstuffs are also monitored (see discussion in subsequent sections).

Routine chemical analyses of water samples are done for many of constituents. These analyses have been done for a number of years and are an excellent screening tool to detect changes in the chemical quality of water from a single source. A subset of five of these chemical constituents is compared with drinking water standards.

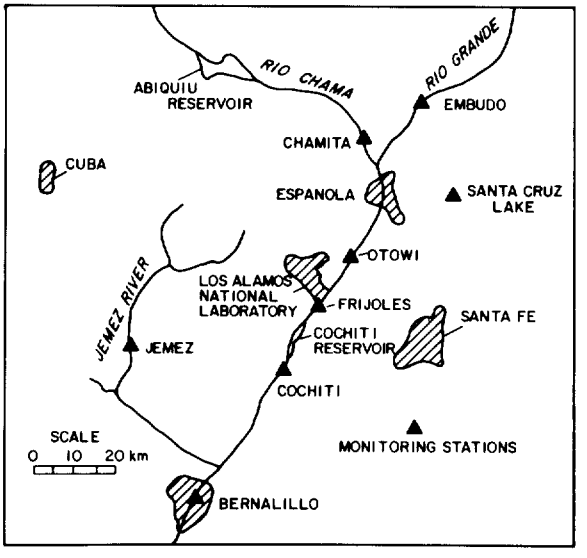


Fig. 14. Regional surface water, sediment, and soil sampling locations.

2. Regional Stations. Regional surface water samples were collected within 75 km (47 mi) of the Laboratory from 6 stations on the Rio Grande, Rio Chama, and Jemez River (Fig. 14). The six sampling

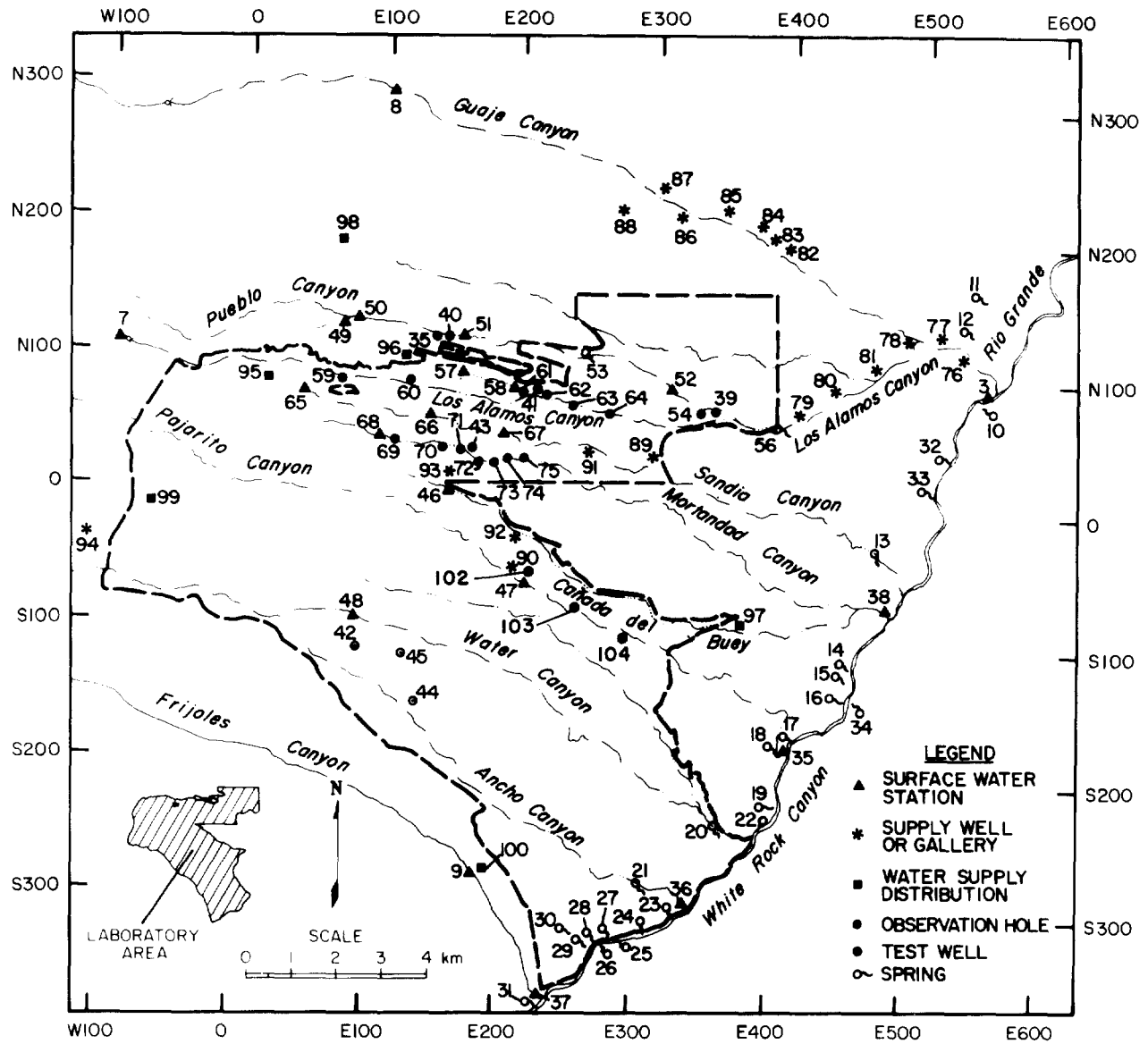


Fig. 15. Surface and ground water sampling locations on or near the Laboratory site.

stations were located at U.S. Geological Survey Gaging Stations. These waters provided baseline data for radiochemical and chemical analyses in areas beyond the Laboratory boundary. Stations on the Rio Grande were: Embudo, Otowi, Cochiti, and Bernalillo. The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 37,040 km^2 (14,300 mi^2) in southern Colorado and northern New Mexico. Discharge for the period of record (1895-1905, 1909-1984) has ranged from a minimum of 1.7 m^3/sec (60 ft^3/sec) in 1902 to 691 m^3/sec (24,400 ft^3/sec) in 1920. The discharge for water year 1984 ranged from 9.7 m^3/sec (340 ft^3/sec) on October 27 to 277 m^3/sec (9770 ft^3/sec) on May 17 (USGS 1985).

The Rio Chama is tributary to the Rio Grande north of Los Alamos (Fig. 14). At Chamita on the Rio Chama, the drainage area above the station is 8143 km^2 (3143 mi^2) in northern New Mexico and a small part in southern Colorado. Since 1971, some flow has resulted from transmountain diversion water from the San Juan Drainage. Flow at the gage is governed by release from several reservoirs. Discharge at Chamita during water year 1984 ranged from 0.99

m^3/sec (35 ft^3/sec) in July to 137 m^3/sec (4840 ft^3/sec) in June.

The station at Jemez on the Jemez River drains an area of the Jemez Mountains west of Los Alamos. The drainage area is small, about 1220 km^2 (471 mi^2). During the water year 1984, the discharge ranged from 0.31 m^3/sec (11 ft^3/sec) in December to 10 m^3/sec (350 ft^3/sec) in April. The river is tributary to the Rio Grande below Los Alamos.

Surface waters from the Rio Grande, Rio Chama, and Jemez River are used for irrigation of crops in the river valley both upstram and downstream from Los Alamos. Water from these rivers is part of recreational areas on state and federal lands.

a. Radiochemical Analyses. Surface water samples from regional stations were collected in March and September 1985. Cesium, plutonium, tritium, total uranium, and gross gamma radioactivity levels in these waters were low (Table G-17). Samples collected downgradient from the Laboratory showed no effect from the Laboratory's operation. Results from 1985 exhibited no significant differences from 1984. Maximum concentrations of radioactivity in regional surface water samples were well below Derived Concentration Guides for Uncontrolled Areas (Table 12).

b. Chemical Analyses. Surface water samples from regional stations were collected in March 1985. Maximum concentrations in regional water samples were well below drinking water standards (Tables 13 and G-17). There were some variations in concentrations of constituents when compared with previous years' results. These fluctuations result from slight chemical changes that occur from variations in discharges at the various stations. This is normal and no inference should be made that the water quality at these stations is deteriorating.

3. Perimeter Stations. Perimeter stations within 4 km of Los Alamos included surface water stations at Los Alamos Reservoir, Guaje Canyon, and Frijoles Canyon and three springs stations (La Mesita, Indian, and Sacred springs). Other perimeter stations were in White Rock Canyon along the Rio Grande just east of the Laboratory. Included in this group were stations at 22 springs, 3 streams, and a sanitary effluent release (Fig. 15 and Table G-16).

Los Alamos Reservoir in upper Los Alamos Canyon on the flanks of the mountains, west of Los Alamos, has a capacity of 51×10^3 m^3 (41 acre-ft) and a drainage area of 16.6 km^2 (6.4 mi^2) above the intake. The reservoir is used for storage and recreation. Water flows by gravity through about 10.2 km (6.4 mi) of water lines for irrigation of lawns and shrubs at the Laboratory's Health Research Building, the Los Alamos High School, and University of New Mexico's Los Alamos Branch.

The station in Guaje Canyon is below Guaje Reservoir. Guaje Reservoir in upper Guaje Canyon has a capacity of 0.9×10^3 m^3 (0.7 acre-ft) and a drainage area above the intake of about 14.5 km^2 (5.6 mi^2). The reservoir is used for diversion rather than storage as flow in the canyon is maintained by perennial springs. Water flows by gravity through 9.0 km (5.6 mi) of water lines for irrigation of lawns and shrubs at Los Alamos Middle School and Guaje Pines Cemetery. The stream and reservoir are also used for recreation.

The waterlines from Guaje and Los Alamos Reservoirs are not a part of the municipal or industrial water supply at Los Alamos. They are owned by DOE and operated by Zia Company. Diversion for irrigation is usually from May through October.

Surface flow in Frijoles Canyon was sampled at Bandelier National Park Headquarters. Flow in the canyon is from spring discharge in the upper reach of the canyon. The discharge decreases as it crosses Pajarito Plateau because of seepage and evapotranspiration losses. The drainage area above the Park Headquarters is about 45 km^2 (17 mi^2) (Purtymun 1980A).

La Mesita Springs is east of the Rio Grande, while Indian and Sacred Springs are west of the river in lower Los Alamos Canyon. The springs discharge from faults in the siltstones and sandstones of the Tesuque Formation and form small seep areas. Total discharge at each spring is probably less than 1 ℓ/sec (0.25 gal/sec).

Perimeter stations in White Rock Canyon are composed of four groups of springs. The springs discharge from the main aquifer. Three groups (Group I, II, and III) have similar aquifer-related chemical quality. Water from these springs is part of the main aquifer beneath the Pajarito Plateau (Purtymun 1980B). Chemical quality of Spring 3B (Group IV) reflects local conditions in the aquifer discharging through a fault in volcanics.

Part of the heavy runoff in the Rio Grande in 1985 was stored in Cochiti Reservoir. In September, when the springs were sampled, six springs were below the reservoir level and thus were not sampled.

Three streams that flow to the Rio Grande were also sampled. Streams in Pajarito and Ancho Canyons are fed from Group I springs. The stream in Frijoles Canyon at the Rio Grande is fed by a spring

Table 12. Maximum Concentrations of Radioactivity in Surface and Ground Waters from Offsite and Onsite Stations

	Number of Stations[a]	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	$^{239,240}Pu$ (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)	Gross Gamma (counts/min/ℓ)
Analytical Limits of Detection		40	0.009	0.03	0.7	1.0	50
Offsite Stations (Uncontrolled Areas)							
Derived Concentration Guide (DCG) for Uncontrolled Areas[b]		3 000	400	300	2 000	800	—
Regional	6	140 ± 60	0.015 ± 0.013	0.035 ± 0.025	5.1 ± 0.7	3.6 ± 0.6	140 ± 60
Perimeter							
Adjacent	7	121 ± 58	0.014 ± 0.016	0.021 ± 0.015	2.8 ± 0.5	28 ± 2.0	110 ± 60
White Rock	21	108 ± 41	0.014 ± 0.001	0.010 ± 0.010	1.0 ± 0.4	19 ± 1.0	250 ± 70
Offsite Station Group Summary:							
Maximum Concentration	—	140 ± 60	0.015 ± 913	0.035 ± 0.025	5.1 ± 0.7	28 ± 2.0	—
Maximum Concentration as % DCG for Uncontrolled Areas	—	5	<1	<1	<1	4	—
Onsite Stations (Controlled Areas)							
Concentration Guide (CG) for Controlled Areas[b]		400 000	100 000	100 000	100 000	60 000	—
Noneffluent Areas							
Ground Water (Main Aquifer)	6	66 ± 38	0.016 ± 0.016	0.055 ± 0.017	3.4 ± 0.5	3.4 ± 0.6	40 ± 60
Surface Water	3	47 ± 40	0.000 ± 0.010	0.019 ± 0.013	2.4 ± 0.5	1.2 ± 0.4	140 ± 60
Pajarito Canyon	3	74 ± 49	0.024 ± 0.015	0.016 ± 0.011	1.3 ± 0.4	3.8 ± 0.8	60 ± 60
Effluent Areas							
Acid-Pueblo Canyon	8	93 ± 47	0.032 ± 0.013	0.446 ± 0.052	2.9 ± 0.5	1.7 ± 0.2	90 ± 60
DP-Los Alamos Canyon	8	106 ± 43	0.494 ± 0.049	0.276 ± 0.037	26 ± 3.0	31 ± 3.0	110 ± 60
Sandia Canyon	3	98 ± 53	0.022 ± 0.017	0.012 ± 0.009	3.7 ± 0.5	2.9 ± 0.3	70 ± 60
Mortandad Canyon	7	95 ± 45	1.23 ± 0.084	5.76 ± 0.223	48 ± 5.0	8.1 ± 0.8	560 ± 50
Onsite Group Summary:							
Maximum Concentration	—	106 ± 43	1.23 ± 0.084	5.76 ± 0..223	48 ± 5.0	31 ± 3.0	560 ± 50
Maximum Concentration as % CG for Controlled Areas	—	<1	<1	<1	<1	<1	—

[a]One or two analyses from each station.
[b]See Appendix A.

Table 13. Maximum Chemical Concentrations in Surface and Ground Waters

	Number of Stations	mg/ℓ				
		Cl	F	NO_3 (as N)	TDS	pH
Standard[a]	---	250	2.0	10	500	6.5 - 8.5
Offsite Stations						
Regional Stations	6	22	0.4	0.4	252	7.9
Perimeter Stations						
Adjacent	6	33	1.4	1.5	252	8.0
White Rock Canyon	21	72	1.8	8.8	588	8.0
Summary: Offsite Stations						
Maximum Concentration		72	1.8	8.8	588	8.0
Maximum Concentration as Per Cent of Standard		29	9.0	8.8	118	---
Onsite Stations						
Noneffluent Areas						
Ground Water	6	24	0.5	5.1	250	9.0
Surface Water	3	34	0.3	1.8	163	7.5
Pajarito Canyon	3	68	0.7	1.7	298	7.5
Effluent Release Areas						
Acid-Pueblo Canyon	7	153	0.9	12	356	7.7
DP-Los Alamos Canyon	8	154	6.0	3.4	431	7.9
Sandia Canyon	3	127	1.2	9.2	476	7.4
Mortandad Canyon	7	49	4.7	111	1049	8.7
Summary: Onsite Stations						
Maximum Concentration		154	6.0	111	1049	9.0
Maximum Concentration as Per Cent of Standard		61	300	1110	210	---

[a]EPA (1976, 1979B).

on the flanks of the mountains west of Pajarito Plateau and flows through Bandelier National Monument to the Rio Grande.

Treated sanitary effluent from the community of White Rock was also sampled in Mortandad Canyon at its confluence with the Rio Grande.

A sample of water from Ashley Pond near the center of Los Alamos was sampled and analyzed (Table G-18). No anomalies in quality were noted.

Detailed results of radiochemical and chemical analyses of samples collected from the perimeter stations are shown in Table G-18.

a. Radiochemical Analyses. Cesium, plutonium, tritium, total uranium, and gross gamma activity were low and well below DOE's Derived Concentration Guides for Uncontrolled Areas (Table 12).

b. Chemical Analyses. Maximum chemical concentrations (chloride, fluoride, nitrate, total dissolved solids, and pH) in samples from the perimeter stations were below drinking water standards (Table 13). Concentrations in water samples from the 17 springs and 3 streams in White Rock Canyon were also below drinking water standards. The perimeter

springs, streams, and sanitary effluents, as well as the Rio Grande, are not sources of municipal water supply downstream from Los Alamos.

4. Onsite Stations. Onsite sampling stations are grouped according to those that are not located in effluent release areas (noneffluent release areas) and those that are located in areas receiving or that have received treated industrial effluents (Fig. 15, Table G-16).

a. Onsite Noneffluent Release Areas. Onsite noneffluent sampling stations consist of five deep test wells, three surface water sources, and three new, shallow observation wells. The five deep test wells are completed into the main aquifer.

Test Wells 1 and 2 are in the lower and midreach of Pueblo Canyon. Depths to the top of the main aquifer are 181 to 231 m (594 and 758 ft), respectively. Test Well 3 is in the midreach of Los Alamos Canyon with a depth of 228 m (748 ft) to the top of the main aquifer. These wells are in canyons that have received (Pueblo Canyon) or are now receiving (Los Alamos Canyon) industrial effluents. Test Wells DT-5A and DT-10 are at the southern edge of the Laboratory. Depths to the top of the main aquifer are 359 and 332 m (1180 and 1090 ft), respectively. Test Well 8 is in the midreach of Mortandad Canyon, an area that receives industrial effluents. The top of the aquifer lies at about 295 m (968 ft). These test wells are constructed to seal out all water above the main aquifer. The wells monitor any possible effect that the Laboratory's operation may have on water quality in the main aquifer.

Surface water samples were collected in Cañada del Buey and Pajarito and Water canyons below technical areas to monitor releases of cooling water and/or sanitary effluents. Surface water in these canyons also includes runoff from snowmelt and seasonal precipitation.

Three shallow observation wells were drilled in 1985 and cased through the alluvium [thickness about 4 m (12 ft)] in Pajarito Canyon (Fig. 15 and Table G-16). Water in the alluvium is perched on the underlying tuff and is recharged through storm runoff. The observation wells were constructed to determine if technical areas in the canyon or adjacent mesas were affecting the quality of shallow ground water (Tables 12, 13, and G-19).

Radiochemical concentrations from ground water (test and observation wells in Pajarito Canyon) and surface water sources showed no effects of Laboratory operations (Tables 12, G-20, G-21, and G-22). Concentrations of cesium and plutonium were at or below limits of detection. Concentrations of all radionuclides were well below DOE's Concentration Guides for Controlled Areas.

Chemical quality of ground water from the test wells into the main aquifer reflected local conditions of the aquifer around the well. Quality of surface water and of observation wells in Pajarito Canyon varied slightly and may have been affected by releases of cooling water or sanitary effluents from technical areas upgradient from sampling stations. The effect, if any, was slight.

Maximum concentrations of five chemical constituents in the onsite surface and ground water samples were within drinking water standards (Tables 13, G-21, and G-22). Ground waters from test wells and surface water sources were not a source of municipal, industrial, or irrigation supply.

b. Onsite Effluent Release Areas. Onsite effluent release areas are canyons that receive or have received treated industrial or sanitary effluents. These are DP-Los Alamos, Sandia, and Mortandad canyons. Also included is Acid-Pueblo Canyon, which is a former release area for industrial effluents. Acid-Pueblo Canyon received untreated and treated industrial effluents that contained residual amounts of radioactivity from 1944 to 1964 (ESG 1981). The canyon also receives treated sanitary effluents from the Los Alamos County treatment plants in the upper and middle reaches of Pueblo Canyon. Sanitary effluents form some perennial flow in the canyon but do not reach State Road 4.

Water occurs seasonally in the alluvium dependent on the volume of surface flow from sanitary effluents and storm runoff. Three observation wells in the alluvium of Pueblo Canyon were not used as part of the monitoring network because they were dry most of the year. Hamilton Bend Springs discharges from alluvium in the lower reach of Pueblo Canyon and is dry part of the year. The primary sampling stations are surface water stations at Acid Weir, Pueblo 1, Pueblo 2, and Pueblo 3 (Table G-16). Other sampling stations are Test Well T-2A [drilled to a depth of 40.5 m (133 ft)], which penetrates the alluvium and Bandelier Tuff and is completed into the Puye Conglomerate). Aquifer tests indicated the perched aquifer is of limited extent. Water level measurements over a period of time indicate the perched aquifer is hydrologically connected to the stream in Pueblo Canyon.

Perched water in the basaltic rocks occurs in Test Well 1A in Lower Pueblo Canyon and Basalt Springs

east in lower Los Alamos Canyon. Recharge to the perched aquifer in the basalt occurs near Hamilton Bend Springs and is mainly sanitary effluents from the Bayo Treatment Plant near Hamilton Bend Springs. Travel time from the recharge area near Hamilton Bend Spring to Test Well 1A is estimated to be 1 to 2 months and another 2 to 3 months to Basalt Springs.

DP-Los Alamos Canyon receives treated industrial effluents that contain some radionuclides and some sanitary effluents from treatment plants at TA-21. Industrial effluents have been released into the canyon since 1952. In the upper reaches of Los Alamos Canyon (above Station LAO-1), there are occasional releases of cooling water from the research reactor at TA-2. On the flanks of the mountains, Los Alamos Reservoir impounds runoff from snowmelt and rainfall. Stream flow from this impoundment into the canyon is intermittent, dependent on precipitation to cause runoff to reach the Laboratory boundary at State Road 4. Infiltration of effluents and natural runoff maintains a shallow body of water in the alluvium of Los Alamos Canyon. Water levels are highest in late spring from snowmelt runoff and late summer from thundershowers. Water levels decline during the winter and early summer as natural storm runoff is at a minimum. Sampling stations consist of two surface water stations in DP Canyon and six observations wells completed into alluvium [about 6 m (20 ft) thick] in Los Alamos Canyon (Table G-16).

Sandia Canyon has a small drainage area that heads on Pajarito Plateau in TA-3. The canyon receives cooling tower blowdown from the TA-3 power plant and some treated sanitary effluents from TA-3 facilities. Effluents from a sanitary treatment plant form a perennial stream in a short reach of the upper canyon. Only during heavy summer thundershowers in the drainage area does stream flow reach the Laboratory boundary at State Road 4. Two monitoring holes in the lower canyon just west of State Road 4 indicated no perched water in the alluvium in this area. There are three surface water sampling stations in the reach of the canyon that contain perennial flow (Table G-16).

Mortandad Canyon has a small drainage area that heads on the western edge of Pajarito Plateau. Industrial liquid wastes containing radionuclides are collected and processed at the Industrial Waste Treatment Plant at TA-50. After treatment that removes most of the radioactivity, the effluents are released into Mortandad Canyon. Release of effluents from TA-50 and wastnes of the Laboratory. Velocity of water movement in the perched aquifer ranges from 18 m/day (59 ft/day) in the upper reach to about 2 m/day (7 ft/day) in the lower reach (Purtymun 1974C, 1983A). The top of the main aquifer is about 290 m (950 ft) below the perched aquifer. Hydrologic studies in the canyon began in 1960. Since that time, there has been no surface flow beyond the Laboratory boundary from the small drainage area of the canyon and thick sections of unsaturated alluvium. Monitoring stations in the canyon are one surface water station (Gaging Station 1, GS-1) and six observation wells completed into the shallow alluvial aquifer. At times, wells in the lower reach of the canyon are dry.

Acid-Pueblo (Table G-19), DP-Los Alamos (Table G-23), and Mortandad (Table G-24) canyons all contained surface and shallow ground waters with measurable amounts of radioactivity. The radioactivity is well below DOE's Concentration Guides for Controlled Areas (Table 12). Radionuclide concentrations from treated effluents decreased downgradient in the canyons due to dilution with surface and shallow ground water and with their adsorption on alluvial sediments (Table G-24). Surface and shallow ground waters in these canyons were not a source of municipal, industrial, or agricultural supply. Only during periods of heavy precipitation or snowmelt would waters from Acid-Pueblo, DP-Los Alamos, or Sandia canyons (Table G-25) extend beyond Laboratory boundaries and reach the Rio Grande. In Mortandad Canyon there has been no surface runoff to the Laboratory's boundary since hydrologic studies were initiated in 1960. This was 3 years before the treatment plant at TA-50 began operation and effluents were released into the canyon (Purtymun 1983).

Relatively high chlorides, nitrates, and total dissolved solids resulted from effluents released into the canyons (Tables G-19 through G-25). Relatively high fluoride and nitrate concentrations were found in waters from Mortandad Canyon (Purtymun 1977). Mortandad Canyon receives the largest volume of industrial effluents.

Though the concentrations of some chemical constituents in the waters in these canyons were high when compared with drinking water standards (Table 13), these onsite waters were not a source of municipal, industrial, or agricultural supply. Maximum chemical concentrations occurred in water samples taken near effluent outfalls (Table G-19 through G-25). Chemical quality of the water improved downgradient from the outfalls. Surface flows in Acid-Pueblo and DP-Los Alamos canyons reach

the Rio Grande only during spring snowmelt or heavy summer thunderstorms. There has been no surface runoff to Laboratory boundaries recorded in Mortandad Canyon since 1960, when observations began.

5. Transport of Radionuclides in Surface Runoff. The major transport of radionuclides from canyons that have received or are now receiving treated low-level radioactive effluents is by surface runoff (solution and sediments). Radionuclides in the effluents become adsorbed or attached to sediment particles in the stream channels. Concentration of radioactivity in the alluvium is highest near the effluent outfall and decreases in concentration downgradient in the canyon as the sediments and radionuclides are transported and dispersed by other industrial effluents, sanitary effluents, and surface runoff.

Surface runoff occurs in two modes. Spring snowmelt runoff occurs over a long period of time (days) at a low discharge rate and sediment load. Summer runoff from thunderstorms occurs over a short period of time (hours) at a high discharge rate and sediment load.

Samples of runoff were collected and analyzed for radionuclides in solution and suspended sediments. Radioactivity in solution is defined as the filtrate passing through a 0.45 μm pore-size filter, whereas radioactivity in suspended sediments is defined as the residue on the filter. The solution was analyzed for ^{238}Pu, $^{239,240}Pu$, and total U, and suspended sediments were analyzed for ^{238}Pu and $^{239,240}Pu$.

Samples of snowmelt and summer runoff were collected in Los Alamos Canyon at State Road 4 (SR-4) and at the Rio Grande. Also sampled at SR-4 were Pueblo and Guaje canyons, which are tributary to Los Alamos Canyon. Samples were also collected at Pajarito and Water canyons at SR-4 and on the Rio Grande above Otowi (Fig. 16).

Snowmelt runoff during 1985 occurred in Los Alamos. The volume of water passing the gaging station in Los Alamos Canyon at SR-4 was about 841 $\times 10^3$ m^3, and about 80 $\times 10^3$ m^3 reached the Rio Grande. The ^{238}Pu in solution in samples collected at the four sampling stations was below background. Trace amounts of $^{239,240}Pu$ were found in solution, but were below background. Water (solution and suspended sediments) entering Los Alamos Canyon from Guaje Canyon contained levels below background (Table 14). Uranium in solution occurred at natural levels in all samples.

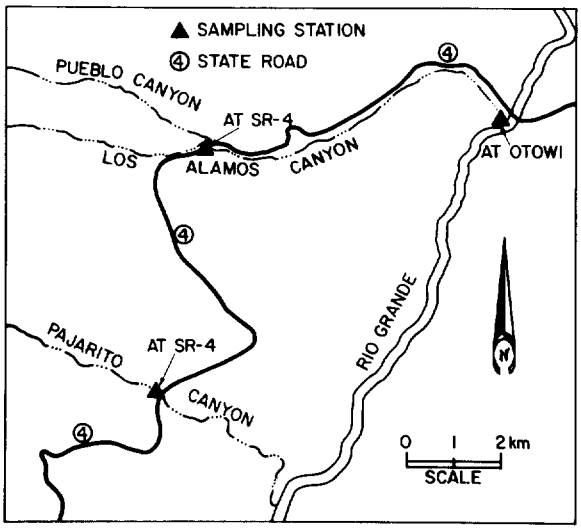


Fig. 16. Locations of surface runoff sampling stations at State Road 4 (SR-4).

The suspended sediments in Los Alamos Canyon at SR-4 and at Otowi contained ^{238}Pu and $^{239,240}Pu$ in concentrations slightly above background as did suspended sediments from Pueblo Canyon. Both Los Alamos and Pueblo canyons west of SR-4 received treated low-level radioactive effluents. The plutonium concentrations were low and were dispersed and diluted by storm runoff before they reached the Rio Grande.

Snowmelt samples were also collected in Pajarito and Water canyons near SR-4, where about 434 $\times 10^3$ m^3 passed the gaging station. The runoff (in solution and suspended sediments) contained only background concentrations of plutonium and uranium (Table 14).

Trace amounts of plutonium in solution and suspended sediments were found in water from the Rio Grande above Otowi (Table 14). The plutonium was at or below detection limits and was the result of worldwide fallout. Uranium in solution was naturally occurring.

Storm runoff from summer thundershowers was collected and analyzed for two runoff events in October (Table 15). The two events in Los Alamos Canyon exhibited the same radiochemical characteristics as the snowmelt runoff events. There was little or no ^{238}Pu in solution. Total uranium in solution was naturally occurring, and $^{239,240}Pu$ in solution and ^{238}Pu,

Table 14. Average Plutonium and Total Uranium Concentrations in Solution and Average Plutonium Concentrations in Suspended Sediment

		Solution			Suspended Sediments	
	Number of Analyses	^{238}Pu (pCi/ℓ)	$^{239,240}Pu$ (pCi/ℓ)	Total Uranium (μg/ℓ)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Los Alamos Canyon						
Los Alamos at SR-4	32 to 33	−0.001 ± 0.037	0.031 ± 0.217	0.4 ± 1.1	0.668 ± 1.51	4.78 ± 8.93
Pueblo at SR-4	7 to 8	0.007 ± 0.030	0.020 ± 0.026	0.6 ± 0.8	0.047 ± 0.146	4.57 ± 5.00
Guaje at SR-4	3	−0.034 ±0.094	0.007 ± 0.010	0.6 ± 0.5	0.001 ± 0.001	0.017 ± 0.014
Los Alamos at Rio Grande	21	−0.003 ± 0.053	0.033 ± 0.108	1.0 ± 1.2	0.146 ± 0.290	1.75 ± 2.25
Pajarito Canyon						
Pajarito at SR-4	28 to 30	0.001 ± 0.017	0.007 ± 0.025	0.7 ± 0.8	−0.092 ± 0.397	0.010 ± 0.270
Water Canyon						
Water at SR-4	2	−0.011 ± 0.001	0.006 ± 0.016	−0.5 ± 2.4	−0.002 ± 0.091	0.064 ± 0.008
Rio Grande						
Above Otowi	6 to 7	−0.006 ± 0.021	0.016 ± 0.068	2.1 ± 1.4	0.004 ± 0.038	0.036 ± 0.102
Background[a]	—	0.027	0.082	3.5	0.042	0.138
Limits of Detection	—	0.009	0.03	0.03	0.003	0.002

[a]Maximum values ($\bar{x} + s$) in solution or suspended sediment of analyses from Rio Grande above Otowi, 1985.

Table 15. Average Plutonium and Total Uranium Concentrations in Solution and Average Plutonium Concentration in Suspended Sediments in Summer Runoff

		Solution			Suspended Sediments	
	1985 (month-day)	^{238}Pu (pCi/ℓ)	$^{239,240}Pu$ (pCi/ℓ)	Total Uranium (μ g/ℓ)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Los Alamos Canyon						
Los Alamos at SR-4	10-11	-0.004 ± 0.026	0.018 ± 0.026	2.0 ± 0.4	0.001 ± 0.002	0.011 ± 0.002
Los Alamos at Rio Grande	10-11	0.016 ± 0.028	0.032 ± 0.030	4.1 ± 0.8	0.009 ± 0.008	0.094 ± 0.016
Los Alamos at SR-4	10-16	0.005 ± 0.030	0.009 ± 0.002	1.3 ± 0.4	0.780 ± 0.050	0.379 ± 0.56
Pajarito Canyon						
Pajarito at SR-4	10-11	0.025 ± 0.050	0.000 ± 0.020	0.5 ± 0.4	---	---
Pajarito at SR-4	10-16	-0.013 ± 0.026	0.006 ± 0.022	1.9 ± 0.4	---	---

and $^{239,240}Pu$ in suspended sediments were at or slightly above background and reflect transport of radionuclide out of the two low-level radioactive disposal areas, DP and Acid-Pueblo canyons.

Samples for the two events in Pajarito Canyon contained concentrations of ^{238}Pu and $^{239,240}Pu$ in solution at or below limits of detection or below background. Total uranium was naturally occurring.

C. Radioactivity in Soils and Sediments

1. Background Levels of Radioactivity in Soil and Sediments. Routine samples collected and analyzed for radionuclides from Regional Stations from 1978 through 1985 (Purtymun 1986c) were used to establish background levels of ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, total U, ^{3}H, and gross gamma radioactivity in soils and sediments for this report (Table 16). Average concentrations plus twice the standard deviation ($\bar{x} + 2s$) were used to establish the upper limits of the background concentrations. The number of analyses used to establish background ranged from 15 (^{90}Sr) to 40 (^{137}Cs) for soils and 9 (^{90}Sr) to 30 (^{137}Cs, ^{238}Pu, and $^{239,240}Pu$) for sediments. Samples were collected from five regional soil stations and four regional sediment stations. See Appendix B for description of method for collection of soil and sediment samples.

2. Regional Soils and Sediments. Regional soil and sediment samples were collected in the same general locations as the regional water samples (Figs. 14, 17, and 18). Additional regional sediment samples were collected from the Rio Grande and tributary streams entering the Rio Grande from Otowi Bridge to Cochiti Reservoir (Fig. 18). The locations are listed in Table G-26 and detailed results of radiochemical analyses of the regional soils and sediments are in Table G-27.

Soil samples were collected for seven stations and analyzed for six types of radioactivity (Table 16). Maximum 1985 concentrations of radioactivity were below background levels.

Sediments were collected from 15 regional sediment stations and analyzed for 5 types of radioactivity (Table 16). Maximum 1985 concentrations of ^{137}Cs (one sample), ^{238}Pu (one sample), and ^{239}Pu (one sample) were elevated slightly above background. Concentrations are low and do not reflect contamination from the Laboratory.

3. Perimeter Soils and Sediments. Six perimeter soil stations were sampled within 4 km (2.5 mi) of the Laboratory. Nine sediment stations near the Laboratory's boundary and on intermittent streams that cross Pajarito Plateau were sampled. Perimeter soil and sediment sampling stations are listed in Table G-26 and Figs. 17 and 18.

Analyses of perimeter soil samples indicate that the 1985 maximum concentration of ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and ^{3}H were at or below established regional background levels. Concentrations of total uranium (4 samples) and gross gamma radioactivity (one sample) exceeded background levels (Table G-28). Uranium levels varied because of different natural uranium concentrations found in parent rock from which the soil was derived. Gross gamma radioactivity can also reflect naturally occurring radioactivity found as minerals in the parent rock.

Analyses of Perimeter Sediments from 10 locations indicated that ^{238}Pu and $^{239,240}Pu$ concentrations were below background levels. Cesium-137, total uranium, and gross gamma (one sample each) exceeded the background levels. The ^{137}Cs concentration was only slightly above background (Table 16).

4. Onsite Soils and Sediments. Onsite soil samples were collected from 10 stations within the Laboratory boundaries. Onsite sediment samples were collected from 21 stations within liquid effluent release areas (Table G-26, Figs. 17 and 18).

The maximum ^{137}Cs concentration in the 10 soil samples was below regional background. The concentrations of ^{238}Pu (one sample) and $^{239,240}Pu$ (four samples) were above background (Table G-29). One sample with 11.9 pCi/g ^{238}Pu and 0.281 pCi/g of $^{239,240}Pu$ was collected inside Area G and probably reflects airborne contamination from solid radioactive disposal. Plutonium was probably entrained in air during waste handling and burial. The $^{239,240}Pu$ concentration in the other three samples was only slightly above background levels (Table G-29).

Eight samples contained total uranium in excess of background. Seven were slightly above background concentrations, while the other (28 μg/g) may have been the result of fallout from tests conducted on the mesa (Location S-12, Fig. 17). Three samples had concentrations of gross gamma radioactivity in excess of the background. The concentrations were only slightly above background, probably reflecting natural sources of radioactivity.

Sediment samples from stations in Acid-Pueblo, DP-Los Alamos, and Mortandad canyons had radionuclide concentrations above background levels (Tables 16 and G-19). These canyons have received

Table 16. Maximum Concentrations of Radioactivity in Soils and Sediments from Regional, Perimeter, and Onsite Stations

	Number of Stations	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{90}Sr (pCi/g)	Total U (μg/g)	^{3}H (10^{-6} μCi/mℓ)	Gross Gamma (counts/min/g)
Analytical Limits of Detection	—	0.1	0.003	0.002	—	0.03	0.7	0.1
Soil								
Background (1978-1985)[a]	—	1.18	0.005	0.036	0.68	3.5	7.1	6.6
Regional Stations	7	0.94 ± 0.18 (0)	0.001 ± 0.001 (0)	0.026 ± 0.003 (0)	—	3.5 ± 0.2 (0)	0.0 ± 0.3 (0)	6.2 ± 0.7 (0)
Perimeter Stations	6	1.0 ± 0.36 (0)	0.004 ± 0.002 (0)	0.035 ± 0.004 (0)	—	5.9 ± 0.5 (4)	−0.2 ± 0.3 (0)	11 ± 1.0 (1)
Onsite Stations	10	0.96 ± 0.18 (0)	11.9 ± 0.475 (1)	0.281 ± 0.015 (4)	—	28 ± 2.0 (8)	10 ± 1.0 (1)	10 ± 1.0 (3)
Sediments								
Background (1978-1985)[a]	—	0.52	0.002	0.011	1.15	4.8	—	8.1
Regional Stations	15	0.53 ± 0.07 (1)	0.004 ± 0.001 (1)	0.026 ± 0.004 (1)	—	3.5 ± 0.3 (0)	—	5.5 ± 0.6 (0)
Perimeter Stations	10	0.60 ± 0.14 (1)	0.002 ± 0.002(0)	0.008 ± 0.002 (0)	—	7.1 ± 0.4 (1)	—	13 ± 1.0 (1)
Onsite Station, Effluent Release Areas								
Acid-Pueblo Canyon	6	0.78 ± 0.12 (2)	0.087 ± 0.006 (4)	13.3 ± 0.370 (6)	0.63 ± 0.08 (0)	7.0 ± 5.0 (1)	—	—
DP-Los Alamos Canyon	11	11 ± 1.7 (6)	2.69 ± 0.156 (9)	8.11 ± 0.355 (11)	9.8 ± 0.30 (1)	5.4 ± 0.4 (1)	—	31 ± 3.0 (6)
Mortandad Canyon	7	35 ± 5.0 (5)	28.1 ± 0.121 (6)	64.4 ± 0.242 (7)	6.8 ± 0.20 (1)	4.5 ± 0.3 (0)	—	110 ± 10 (3)

[a] $\bar{x}$ + 2s of a number of background analyses for soils and bed sediments (Purtymun 1985).

Note: Number in parentheses indicate number of stations exceeding background concentrations.

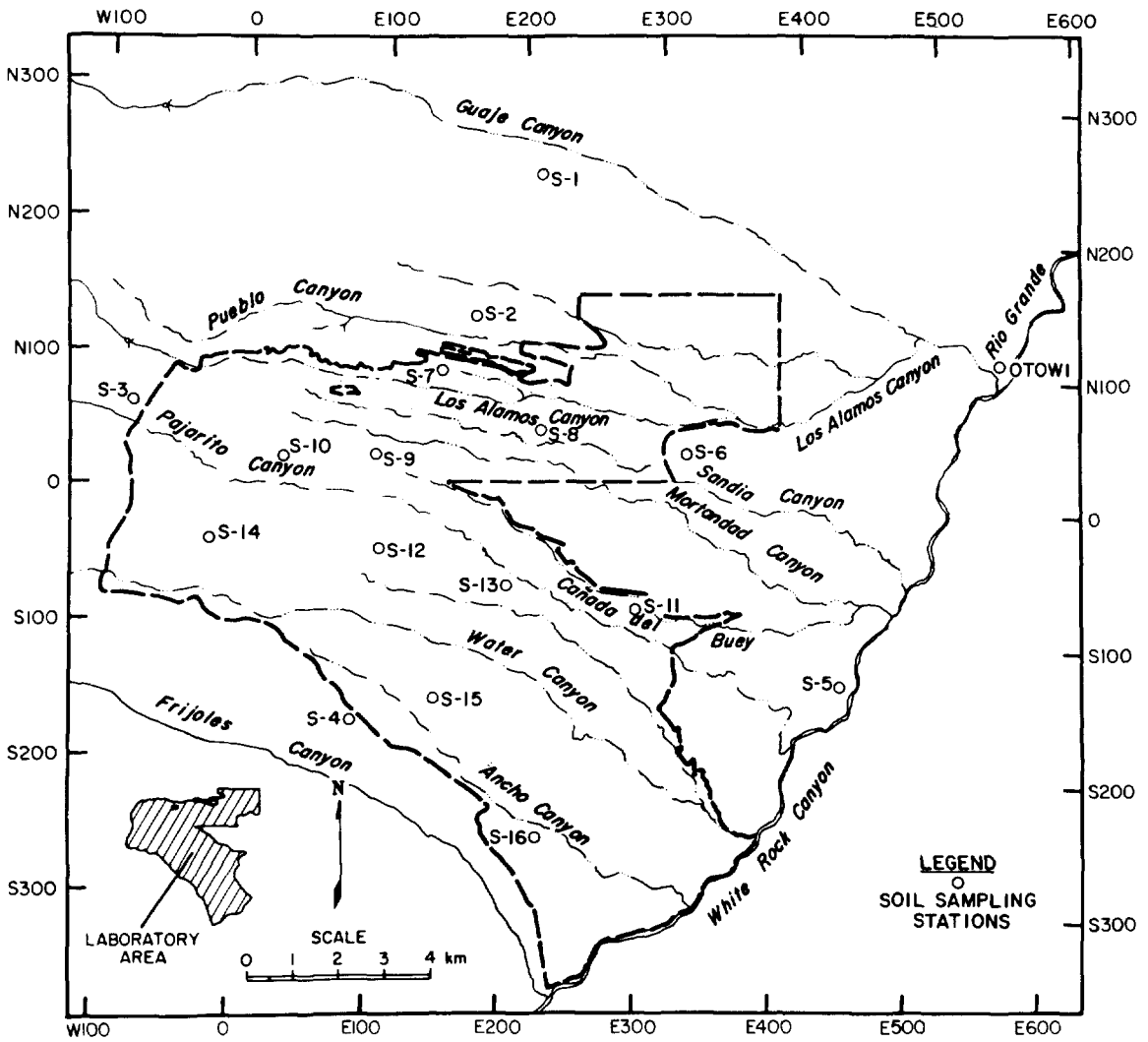


Fig. 17. Soil sampling locations on or near the Laboratory site.

or are now receiving treated industrial effluents containing trace amounts of radioactivity.

Acid-Pueblo Canyon received effluents from about 1944 through 1964. The major radionuclide released in treated effluents into Acid-Pueblo Canyon was $^{239,240}Pu$. Concentrations of ^{137}Cs (two samples), ^{238}Pu (four samples), $^{238,239}Pu$ (six samples), and total uranium (one sample) were above background levels in the seven samples collected.

DP-Los Alamos and Mortandad canyons are now receiving treated industrial effluents. Major radionuclides above background levels of eleven samples collected from DP-Los Alamos Canyon were ^{137}Cs (six samples), ^{238}Pu (nine samples), $^{239,240}Pu$ (eleven samples), ^{90}Sr (one sample), total uranium (one sample), and gross gamma (six samples). The largest concentrations occur in DP Canyon, which received effluent, and below the junction of DP Canyon into Los Alamos Canyon. Concentrations decreased from the outfall downgradient in the canyon.

There were seven sediment stations in Mortandad Canyon. All showed some radioactive contamination (Table 16). Major contaminants in sediments were ^{238}Pu and $^{239,240}Pu$. All contamination in Mortandad Canyon was within the Laboratory boundary as there has been no surface flow to the boundary since the first release of effluents into the canyon in 1963.

In the canyons that receive or have received treated radioactive wastes, concentrations decrease downgradient in the canyon. Radionuclides are

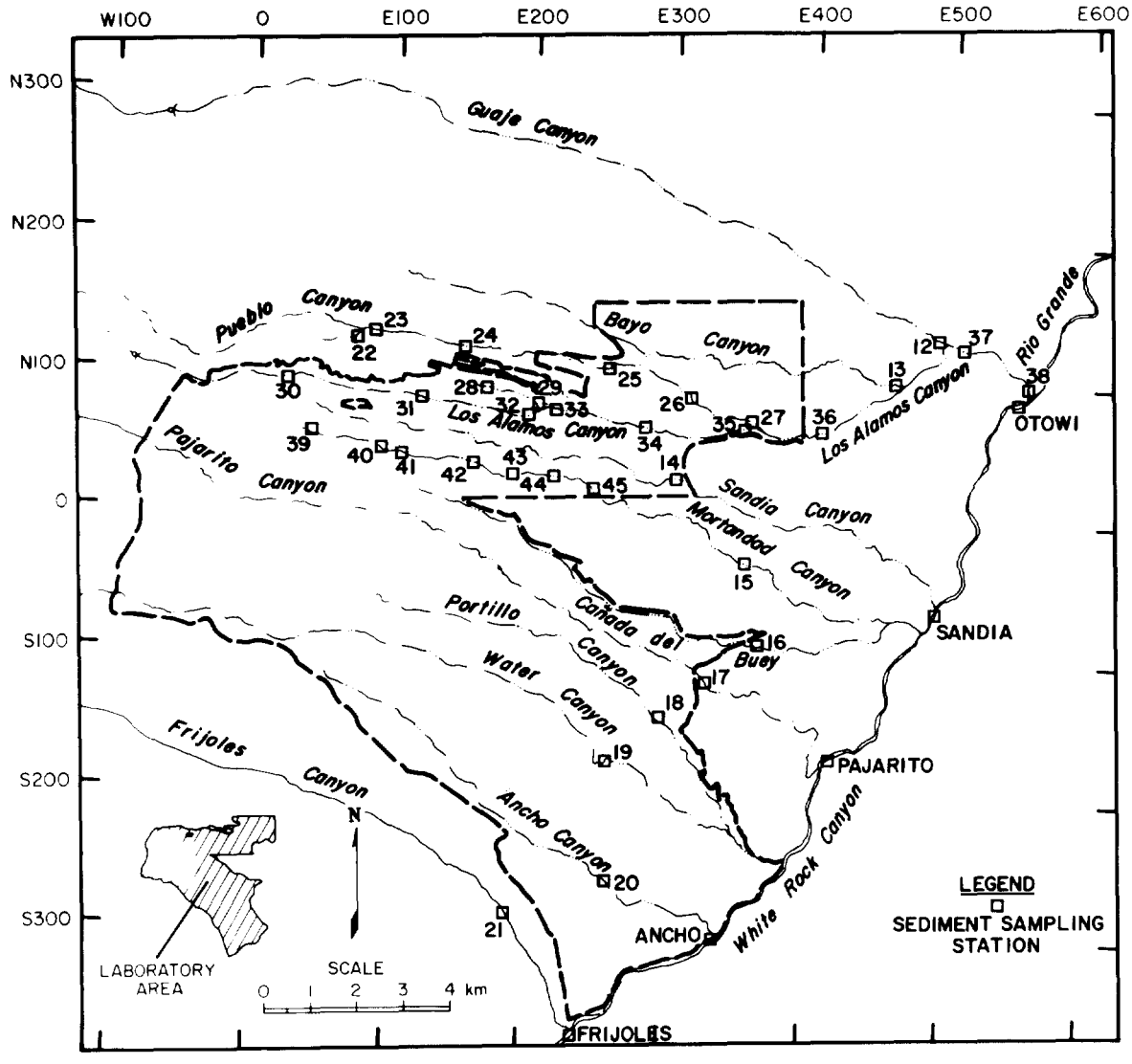


Fig. 18. Sediment sampling locations on or near the Laboratory site.

adsorbed or attached to sediment particles in the canyon stream channels (Purtymun 1971, 1974A). This reduces the amount of radionuclides available to be in solution. Radionuclide concentrations are generally highest near the points of effluent discharge and decrease downstream as sediments and radionuclides are dispersed by surface runoff.

5. Sediments in Regional Reservoirs. The reservoir sediments were collected from Heron, El Vado, and Abiquiu Reservoirs on the Rio Chama. Drainage occurs along the Continental Divide in southern Colorado and northern New Mexico, northwest of Los Alamos. Sediments were sampled from Cochiti Reservoir, which is on the Rio Grande, below the confluence with Rio Chama, and south of Los Alamos (Fig. 19).

Three samples were taken from each reservoir (Fig. 19). Sediments were collected in the upper, middle, and lower (near dam) parts of the reservoirs. A boat and Eckman dredge were used to collect bottom samples to a depth of about 6 cm (2 in.). Samples were collected in water depths ranging from 6 to 20 m (20 to 65 ft). The sediments consisted of fine-grained silts, clays, and some organic material (there were considerably more organic materials in sediments

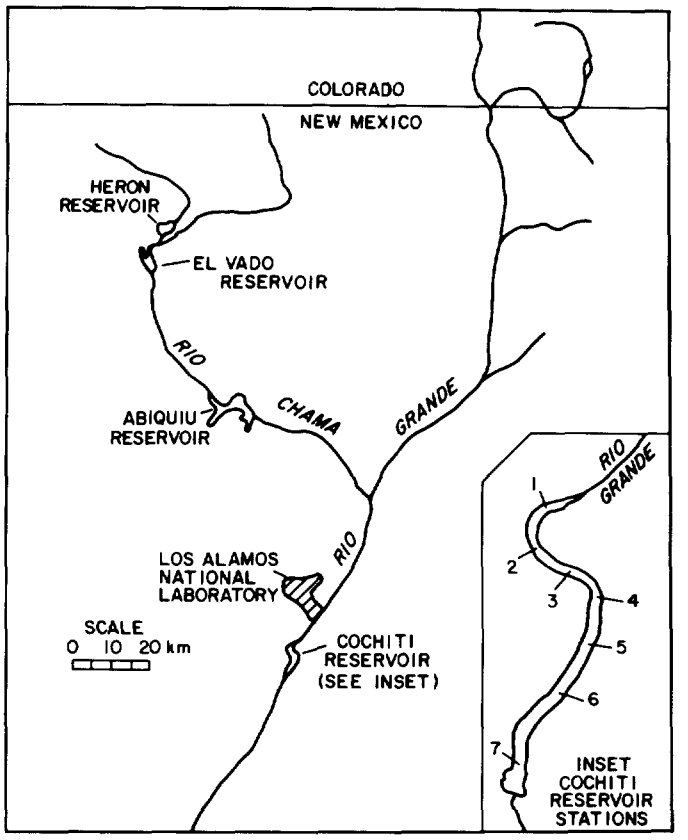


Fig. 19. Special regional sediment sampling locations.

from Cochiti Reservoir than from the other reservoirs). The samples were analyzed only for ^{238}Pu and $^{239,240}Pu$ (Table G-30). Analyses for plutonium were performed on 1 kg (2 lb) samples (100 times the usual mass used for analyses) of reservoir sediments. These large samples increase the sensitivity of the plutonium analyses, which is necessary to effectively evaluate background plutonium concentrations in fallout from atmospheric nuclear tests.

Concentrations of ^{238}Pu in the reservoir sediments ranged from 0.0002 to 0.0016 pCi/g (Table G-30). Individual analyses were below background levels of 0.002 pCi/g. Concentrations of $^{239,240}Pu$ in reservoir sediments ranged from 0.0047 to 0.0292 pCi/g (Table G-30). Concentrations varied but were highest in Cochiti Reservoir. Individual samples exceeded background levels in two samples from Heron Reservoir and from the two samples in Cochiti Reservoir. The distribution of plutonium in the sediments was similar to those collected in previous years (1979, 1982, and 1984). Analysis of the current and previous years' data revealed significantly higher levels of plutonium in Cochiti Reservoir than in upstream reservoirs. Cochiti sediments contain higher fractions of fine particles and organic material than sediments from the other reservoirs. These two features enhance the capacity of the sediment to adsorb plutonium and other metal ions. The difference does not appear to be attributable to Laboratory activities. Ratios of $^{239,240}Pu$ to ^{238}Pu did not differ significantly from the ratio characteristic of worldwide fallout. This indicates that worldwide fallout is the probable source of the plutonium found in reservoir sediments. Plutonium that is incorporated into the foodchain from the reservoirs contributes only a minute fraction of the dose received by the regional population (Sections III and VII).

6. Distribution of Radioactivity in Lower Los Alamos Canyon. A study was made of the distribution of radioactivity in the active channel, inactive channel,

and from the bank at five sections in Lower Los Alamos Canyon. As mentioned above, storm runoff has transported radioactivity in solution (trace amounts), in suspended sediments, and bedload from effluent release areas in the upper canyon. The samples were collected at five sections starting about 2 km (1 mi) below the junction of Pueblo Canyon with Los Alamos Canyon and then at intervals of about 1 km (0.5 mi) apart with the last section in Los Alamos Canyon just above its confluence with the Rio Grande (Fig. 18).

At each section, two samples were collected from the active channel, inactive channel, and from the bank. The two samples were composited so that three samples were submitted for analyses at each section (Table 17). The samples were collected using a soil ring sample, 9 cm (4 in.) in diameter, driven into the sediments about 10 cm (4 in.).

The active channel carries snowmelt runoff and small events from summer storms. These events probably occur 2 to 10 times annually. Flow under these conditions may occur only along short reaches of the canyon, never reaching the Rio Grande. Prolonged snowmelt occurring in the active channel will reach the Rio Grande. The active channels above the active channel will carry runoff from summer storms 1 to 6 times annually, while the overflow to the bank will occur once or twice every 2 years.

The ^{137}Cs concentrations were at or below background levels in sections 2 to 5. In section 1, the samples collected in the active channel were about background (0.52 pCi/g), and above background in the inactive channel (1.9 pCi/g), and bank (1.3 pCi/g). There were only trace amounts of ^{238}Pu in all sections of the canyon in the active channel, inactive

Table 17. Distribution of Radioactivity in Lower Los Alamos Canyon

	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Total U (μg/g)	Gross Gamma (counts/min/g)
Active Channel					
Section 1	0.52 ± 0.11	0.006 ± 0.002	0.281 ± 0.015	1.7 ± 0.2	2.2 ± 0.40
Section 2	0.60 ± 0.12	0.009 ± 0.002	0.289 ± 0.016	3.7 ± 0.4	7.2 ± 0.80
Section 3	0.40 ± 0.10	0.005 ± 0.002	0.126 ± 0.008	2.6 ± 0.3	2.8 ± 0.40
Section 4	0.26 ± 0.07	0.008 ± 0.003	1.98 ± 0.091	3.1 ± 0.3	4.5 ± 0.50
Section 5	0.22 ± 0.08	0.004 ± 0.002	0.102 ± 0.008	2.0 ± 0.2	2.8 ± 0.40
$\bar{x} \pm s$	0.40 ± 0.33	0.006 ± 0.004	0.556 ± 1.60	2.6 ± 1.6	3.9 ± 4.1
Inactive Channel					
Section 1	1.9 ± 0.31	0.013 ± 0.004	0.581 ± 0.025	4.1 ± 0.4	7.9 ± 0.80
Section 2	0.56 ± 0.14	0.005 ± 0.002	0.264 ± 0.014	4.4 ± 0.4	7.1 ± 0.80
Section 3	0.25 ± 0.05	0.003 ± 0.002	0.100 ± 0.008	3.0 ± 0.3	4.1 ± 0.50
Section 4	0.25 ± 0.09	−0.002 ± 0.002	0.147 ± 0.010	2.6 ± 0.3	3.3 ± 0.40
Section 5	0.60 ± 0.13	0.011 ± 0.003	0.145 ± 0.010	2.5 ± 0.3	3.4 ± 0.40
$\bar{x} \pm s$	0.71 ± 1.4	0.006 ± 0.012	0.247 ± 0.392	3.3 ± 1.8	5.1 ± 4.4
Bank					
Section 1	1.3 ± 0.22	0.015 ± 0.003	0.670 ± 0.029	4.2 ± 0.4	8.2 ± 0.90
Section 2	0.28 ± 0.08	0.000 ± 0.001	0.116 ± 0.008	2.4 ± 0.2	3.3 ± 0.40
Section 3	0.39 ± 0.12	0.000 ± 0.001	0.113 ± 0.008	2.7 ± 0.3	4.3 ± 0.50
Section 4	0.12 ± 0.11	0.006 ± 0.002	1.54 ± 0.068	3.5 ± 0.4	5.6 ± 0.60
Section 5	0.11 ± 0.07	0.000 ± 0.002	0.070 ± 0.006	2.6 ± 0.3	3.5 ± 0.50
$\bar{x} \pm s$	0.44 ± 0.99	0.004 ± 0.013	0.502 ± 0.1.26	3.1 ± 1.5	4.9 ± 4.0
Background (1978 - 1983)	0.52	0.002	0.011	4.8	8.1
Limits of Detection	0.1	0.003	0.002	0.03	0.1

channel, and from the bank (Table 17). The ^{238}Pu was not a major radionuclide in waste effluents.

Total uranium and gross gamma in the five sections in the active and inactive channels, and from the bank were below regional background levels. These radioactivities were of naturally occurring radionuclides in tuff and underlying rock of the Pajarito Plateau.

The ^{239,240}Pu concentrations in all sections of samples collected from active and inactive channels and from the bank were above background and resulted from transport radionuclides in sediment by storm runoff from the upper canyon. Concentrations in the active channel and bank varied from one section to the other. Only in the inactive channel was a general decline shown in concentrations downgradient in the canyon. Average concentrations of the ^{239,240}Pu in the active channel and from the bank showed only a slight decrease in concentration downgradient; however, occasional small areas with greater than 1 pCi/g occurred in the active channel and from the bank in Section 4. Average concentrations in the active channel and from the banks were of about the same magnitude.

In summary, ^{239,240}Pu in sediments have been transported from the upper canyon into the lower canyon. Plutonium was found in the active and inactive channels and from the bank of the stream. It appears that the major transport occurred during heavy summer runoff that spreads and disperses the plutonium not only in active and inactive channels but also in the banks.

7. Radionuclide Transport in Sediments and Runoff at Area G. Radionuclides transported by surface runoff have an affinity for attachment to sediment particles by ion exchange or adsorption. Thus, radionuclides in surface runoff tend to concentrate on sediments in stream channels. Nine sampling stations were established in 1982 outside the perimeter fence at Area G to monitor any possible transport of radionuclides by storm runoff (Fig. 20). These stations are sampled annually.

The ^{137}Cs, total uranium, and gross gamma radioactivity from the nine stations were near or below background levels. Tritium was above background at stations 4, 5, 6, 7, and 8 ranging from 7.4 to 27×10^{-6} μCi/mℓ. The ^{238}Pu concentrations above background (0.005 pCi/g) at stations 6, 7, and 9 ranged from 0.011 to 0.061 pCi/g. Sediment samples with ^{239,240}Pu concentrations above background (0.036 pCi/g) were

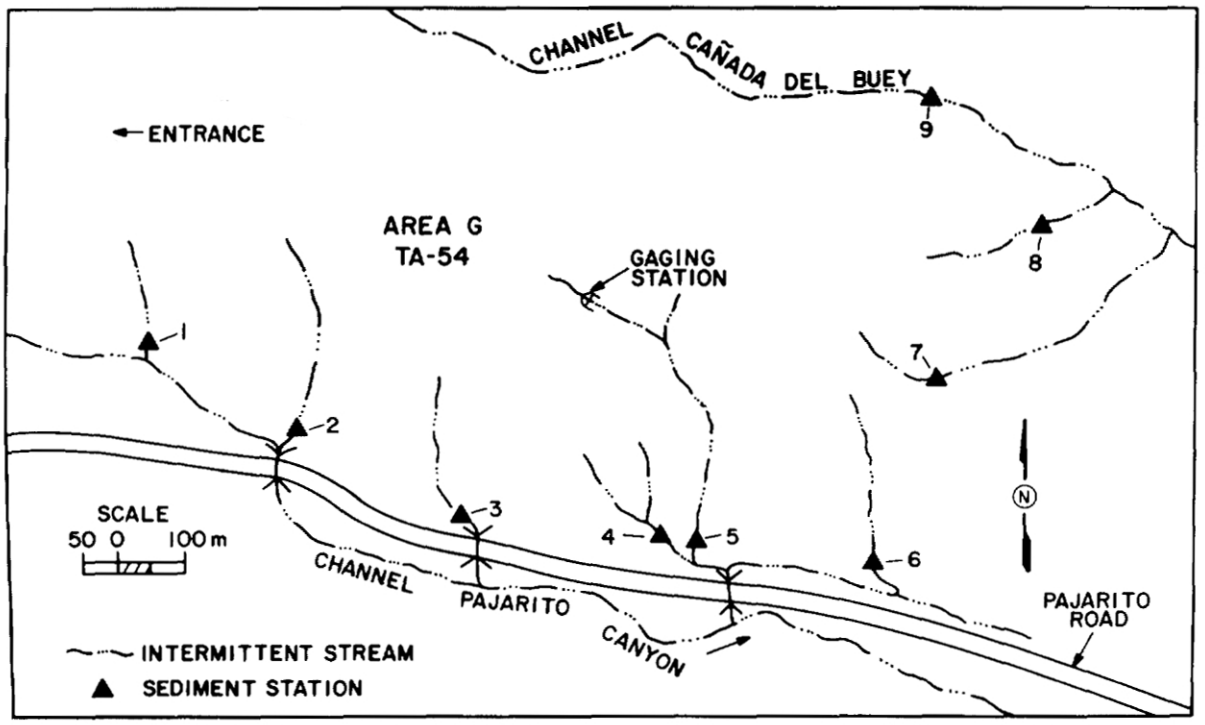


Fig. 20. Surface water gaging station in Area G (TA-54) and sediment sampling stations adjacent to Area G.

from stations 6 and 7. These concentrations were 0.319 and 0.165 pCi/g, respectively. These results showed slight amounts of transport of plutonium from Area G to several stations. This is the result of surface contamination within the solid radioactive waste area at Area G, as noted in the discussion of onsite soil monitoring.

Five samples of runoff were collected in the center of Area G during 1985 (Fig. 20). The samples were analyzed for several radioactive constituents in solution and for plutonium in suspended sediments (Table 18). Radioactivity in solution is defined as filtrate passing through 0.45 μm pore-size filter, whereas the radioactivity in the sediments is defined as residue on the filter.

The ^{137}Cs, total uranium, tritium, and gross gamma were below background levels for those radionuclides in solution (Table18). Of the five runoff events, only one (8-6) contained ^{238}Pu above background (0.035×10^{-9} μCi/mℓ in solution). All $^{239,240}Pu$ in solution was below background (0.082×10^{-9} μCi/mℓ). The concentrations in suspended sediments from four runoff events contained ^{238}Pu (range 0.181 to 0.270 pCi/g) above background (0.138 pCi/g). All $^{239,240}Pu$ concentrations were below background (0.138 pCi/g) in suspended sediments. There is some surface contamination at Area G. It is low level and mainly plutonium. There was no detectable plutonium in the sediments at State Road 4 in Cañada del Buey or in Pajarito Canyon.

8. Transport of Chemicals in Sediments from Areas G and L. Inorganic chemicals also have an affinity to attach to sediment or soil and are also subject to transport in storm runoff. The main chemical disposal and storage is at Area L, on the mesa at TA-54 about 1 km west of Area G.

Stations at Area G were sampled (4,5,6 combined and sampled as one—a road culvert) with one station added in Cañada del Buey in the channel about 300 m below Area L. All surface runoff from Area L is in Cañada del Buey. Sediment samples were analyzed for a number of inorganics (Table 19). Eight constituents have limits set for EP toxic concentrations (Appendix A), while the remaining five constituents and pH have no limits but were analyzed as the others. The eight inorganics analyzed for EP toxicity were well below maximum EP toxic concentrations and below limits of detection. Of the five other inorganics (nickel through nitrate), all were below limits of detection with the exception of beryllium. Natural background for beryllium in other samples ranged from 1.2 to 2.7 μg/g, averaging 1.7 μg/g. Beryllium reported in the samples was naturally occurring. The sediments were slightly acid, ranging in pH from 5.0 to 5.8 (Table 19).

Table 18. Radiochemical analyses of Runoff and Sediments, Area G, TA-54

Station	Sediments (October 16, 1985)					
	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)
1	0.20 ± 0.08	0.000 ± 0.001	0.016 ± 0.003	4.8 ± 0.6	2.0 ± 0.2	2.4 ± 0.4
2	0.25 ± 0.10	0.003 ± 0.001	0.007 ± 0.002	3.5 ± 0.5	2.6 ± 0.3	4.4 ± 0.5
3	0.23 ± 0.08	0.000 ± 0.001	0.009 ± 0.002	2.9 ± 0.5	2.4 ± 0.2	3.4 ± 0.4
4	0.10 ± 0.07	0.008 ± 0.002	0.013 ± 0.002	27 ± 3.0	3.2 ± 0.3	6.4 ± 0.7
5	0.23 ± 0.08	0.003 ± 0.001	0.008 ± 0.002	11 ± 1.0	4.1 ± 0.4	6.1 ± 0.7
6	0.22 ± 0.08	0.021 ± 0.003	0.319 ± 0.016	9.0 ± 1.0	3.4 ± 0.3	4.0 ± 0.5
7	0.15 ± 0.08	0.061 ± 0.006	0.165 ± 0.011	7.4 ± 0.9	2.6 ± 0.3	4.4 ± 0.5
8	0.32 ± 0.10	0.005 ± 0.003	0.007 ± 0.003	25 ± 3.0	2.8 ± 0.3	4.6 ± 0.5
9	0.08 ± 0.07	0.011 ± 0.006	0.014 ± 0.002	3.4 ± 0.5	2.4 ± 0.2	
Background (1978-1985)[a]	1.18	0.005	0.036	7.1	3.5	3.1 ± 0.4
Limits of Detection	0.1	0.003	0.002	0.7	0.03	7.1 0.1

Runoff in Area G at Gaging Station

Date	Solution						Suspended Sediments	
	^{137}Cs (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	$^{239,240}Pu$ (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
4-30-85	66 ± 65	0.004 ± 0.010	0.013 ± 0.010	0.4 ± 0.4	0.3 ± 0.5	−30 ± 60	—	—
6-25-85	21 ± 40	0.008 ± 0.008	0.004 ± 0.007	−0.5 ± 0.4	−0.7 ± 0.5	−30 ± 60	0.236 ± 0.010	0.063 ± 0.004
7-30-85	77 ± 41	0.013 ± 0.018	0.009 ± 0.012	−0.8 ± 0.4	0.0 ± 0.5	−140 ± 60	0.270 ± 0.017	0.099 ± 0.009
8-1-85	—	0.005 ± 0.010	0.016 ± 0.012	−1.5 ± 0.4	—	−40 ± 60	0.181 ± 0.013	0.123 ± 0.010
8-6-85	—	0.035 ± 0.015	0.016 ± 0.009	−1.0 ± 0.4	—	—	0.004 ± 0.008	−0.004 ± 0.008
Background	200[b]	0.027[c]	0.082[c]	5.8[b]	3.5[c]	200[b]	0.042[c]	0.138[c]
Limits of Detection	40	0.009	0.03	0.7	1	50	0.003	0.002

[a] $\bar{x} + s$ of a number of background soil analyses (Purtymun 1986).
[b] $\bar{x} + s$ of a number of analyses from the Rio Grande, Rio Chama, and Jemez River.
[c] $\bar{x} + s$ of a number of analyses from Rio Grnde above Otowi, 1985 (solution and suspended sediments).

Table 19. Inorganic Chemical Concentration in Solution Extracted from Sediments Downgradient from Areas G and L at TA-54

Chemical Parameter[a]	Maximum EP Toxic Concentration[b]	Limits of Detection	Stations 1	2	3	4,5,6[c]	7	8	9	10
Arsenic (As)	5.0	0.075	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Barium (Ba)	100	2	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Cadmium (Cd)	1.0	0.2	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Chromium (Cr)	5.0	1	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Lead (Pd)	5.0	1	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Mercury (Hg)	2.0	0.002	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Selenium (Se)	1.0	0.075	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Silver (Ag)	5.0	1	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Nickel (Ni)	—	0.2	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Beryllium (Be)[d]	—	0.1	1.9	1.9	1.3	1.3	2.7	2.5	1.2	1.7
Cyanide (Cy)	—	0.01	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Sulfate (SO_4)	—	0.4	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Nitrate (NO_3)	—	1.8	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
pH (no units)	—	—	5.5	5.6	5.8	5.3	5.7	5.8	5.0	5.3

[a]Concentrations in mg/ℓ.
[b]New Mexico Hazardous Waste Management Regulations (HWMR) 201 B.5.; EP = Extraction Procedure.
[c]Collected three drainage samples as one at road culvert.
[d]Units are µg/g of solids.

Note: BLD = below limits of detection; analyses and extraction procedures followed methods outlined in EPA (1985).

VII. FOODSTUFFS MONITORING

Most fruit, vegetable, fish, and honey samples collected near the Laboratory showed no apparent influence from Laboratory operations. Some fruit and honey samples from onsite and perimeter locations contained slightly elevated levels of tritium and other radionuclides. These elevated levels may be due to Laboratory operations and were generally found near areas of Laboratory releases to the environment. The amounts of radionuclides in foodstuffs was sufficient to constitute only a minute fraction of the Laboratory's contribution to individual and population doses received by the public in the vicinity.

A. Introduction

Fruit, vegetables, garden soil, fish, and honey have been routinely sampled to monitor for potential radioactivity from Laboratory operations. Foodstuffs collected in the Rio Grande Valley and fish netted at Abiquiu, Heron, and El Vado Reservoirs are not affected by Laboratory operations (Fig. 21). These regional sampling locations are upstream from the confluence of the Rio Grande and intermittent streams that cross the Laboratory. They are also sufficiently distant from the Laboratory as to be unaffected by airborne emissions. Consequently, these regional areas are used as background sampling locations for the foodstuff sampling program.

B. Fruit, Vegetables, and Garden Soil

Data in Table G-31 summarize fruit, vegetable and garden soil sample results for ^{3}H (in tritiated water), ^{90}Sr, ^{137}Cs, $^{239,240}Pu$, ^{238}Pu and total uranium. The sampling and preparation methods are described in another report (Salazar 1984) and Appendix B.

Concentrations of ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs in fruit and vegetables from regional, perimeter, and onsite sampling locations were statistically indistinguishable (at the 95% confidence level) from concentrations in samples taken in background areas. These findings were also reflected in the garden soil concentrations (Table G-31).

Uranium concentrations were found to be elevated in onsite fruits and soils. There also appear to be higher levels of uranium in soils at Cochiti than at White Rock, Pajarito Acres, and Los Alamos. However, the fruit and vegetables grown in the Cochiti soil did not exhibit statistically higher uranium levels than any of the other sampling sites.

Higher levels of ^{3}H were found in Los Alamos fruits and vegetables and in onsite soils than in the other sites. The Laboratory releases tritium and the samples from the perimeter and onsite locations reflect these releases.

C. Fish

1. Radiochemical Monitoring. Fish were sampled in four reservoirs (Fig. 21). Heron, El Vado, and Abiquiu Reservoirs are upstream from the Laboratory on the Rio Chama and serve as background sampling locations. Cochiti Reservoir could potenially be affected by Laboratory operations because it is downstream from the Laboratory on the Rio Grande. Sampling procedures are described in another report (Salazar 1984) and in Appendix B.

The fish were dissected into two samples. The viscera sample included gills, major organs, and gastrointestinal tract. The carcass sample included the head, skin, fins, bones, and muscles. Fish were radiochemically analyzed within species for ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and total uranium. For smaller species composites were made within species of up to six fish per composite. The radiochemical results were further combined into two trophic levels, bottom feeders and higher level feeders for analysis. For ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and uranium no statistic difference was apparent (Remington 1970) between the upstream and downstream samples. Thus, statistically higher concentrations of plutonium in Cochiti sediments were not reflected in the food chain. In previous years higher levels of ^{137}Cs had been observed in fish upstream. Uranium levels within species exhibited distinct patterns (Table 20). Two trends are obvious in the data. Body burdens of uranium tended to increase down the watershed from Heron to Cochiti reservoirs. Body burdens in bottom feeders tended to be higher than those found in higher trophic level feeders. Levels of ^{90}Sr in fish exhibited no evident patterns.

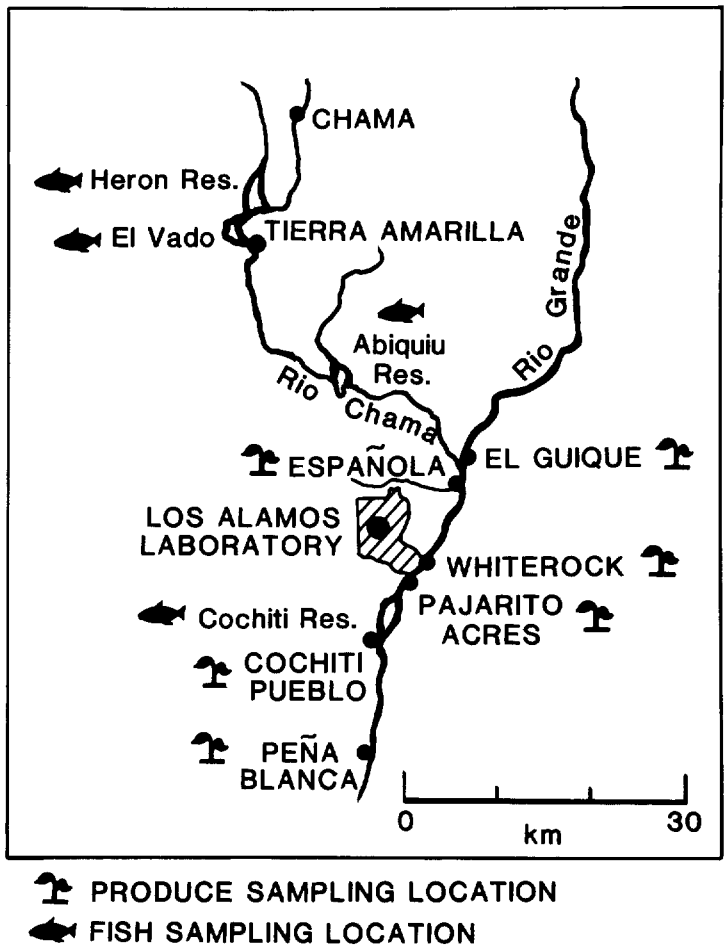


Fig. 21. Fish and produce sampling locations.

In all cases body burdens of radionuclides contribute only a small fraction of dose if ingested by humans (Section III).

The radiochemical results used for the trophic level analysis are shown in Table G-32.

2. Biological and Use Summary. Fish were collected from Cochiti Reservoir as part of the annual surveillence program of foodstuffs in the region surrounding Laboratory lands. Species collected were identified as carp, carpsucker, white sucker, channel catfish, black bullhead, bluegill, green sunfish, white crappie, largemouth bass, and northern pike. The carpsucker, bullhead and green sunfish were not large enough to constitute a significant portion of the fish biomass and were saved as voucher specimens only. Although there were only two largemouth bass and one northern pike, these fish were radiochemically analyzed because of their predatory nature and high position in the food web. This year, number, weight, age and relative importance to the fish community biomass were measured for white suckers, carp, white crappie, bluegill, largemouth bass, northern pike and channel catfish (Table G-33).

To evaluate the importance of these fish in terms of public use, we compared our random net catch with those species preferred by fishermen. A creel census for Cochiti Reservoir was conducted by the New Mexico Department of Game and Fish. The census showed 35% of the catch was catfish, 34% was crappie and 19% was sunfish.

Of the major groups, only the crappie and sunfish were collected in sufficient numbers to analyze age and growth. The majority of bluegill and crappie were in the 2- and 3-year age classes. By knowing fish ages we can better understand cumulative amounts of

Table 20. Uranium Levels (mg/g dry weight) in Fish Species[a]

Species	Heron	El Vado	Abiquiu	Cochiti
Carcass				
Carpsucker[c]			3.73 ± 0.84 (5)	
Channel Catfish[c]			10.4 ± 8.5 (3)	13.1 (1)
Sucker[c]	4.83 ± 0.15 (3)	6.52 ± 1.70 (4)	8.86 ± 1.10 (5)	12.7 ± 2.3 (4)
Carp[c]	6.44 ± 3.37 (2)	9.10 ± 2.72 (2)	13.0 ± 2.6 (5)	51.2 (1)
Brown Trout[d]		1.53 ± 0.04 (4)		
Coho[d]	3.77 (1)			
Northern Pike[d]				1.76 (1)
Largemouth Bass[d]				3.32 (1)
Bluegill[d]				7.58 ± 1.98 (2)
Crappie[d]			3.65 ± 0.97 (5)	5.86 ± 1.38 (5)
Viscera				
Carpsucker[c]			24.8 ± 21.6 (5)	
Channel Catfish[c]			138.1 ± 73.4 (5)	55.1 (1)
Sucker[c]	118.4 ± 45.5 (3)	35.3 ± 21.4 (4)	57.4 ± 37.0 (5)	52.5 ± 12.1 (4)
Carp[c]	16.1 ± 3.2 (2)	24.2 ± 6.0 (2)	38.6 ± 16.0 (5)	47.3 (1)
Brown Trout[d]		7.39 ± 3.18 (2)		
Coho[d]	9.50 (1)			
Northern Pike[d]				8.04 (1)
Largemouth Bass[d]				61.8 (1)
Bluegill[d]				27.2 (1)
Crappie[d]			12.1 ± 2.2 (5)	17.6 ± 4.4 (5)

[a]$\bar{x} \pm s$ (n).
[b]Samples were individual fish in Abiquiu and composites in the other reservoirs.
[c]Bottom feeders.
[d]Higher level feeders.

radionuclides in a fish species as well as population turnover time which becomes important in the food chain assessment of doses to humans. Although there is a significant difference in average size among age classes, growth rate appears to be slow between the second and third year (Table G-33).

Diet may play an important role in the differing growth rates. Suckers are bottom feeders for their entire lives, while bluegill and crappie become more predatory as they grow. We found algae and zooplankton as the main food in the gastrointestinal tract of all three species. Although we would expect this to be the case for suckers, finding that situation for predators indicates a lack of good quality food.

Bottom feeders (carp, catfish, suckers) have a greater probability than higher trophic levels of consuming radionuclides associated with sediments. Higher level feeders that were sampled in the monitoring program included largemouth bass, trout, salmon, crappie, walleye, and pike.

D. Honey and Bees

The honey bee hive locations are listed in Table G-34 and shown on the map in Figure 22. The most recent data are from September of 1984 and are shown in Table G-35, although the analyses of the same 1984 and all 1985 samples are not yet complete. The 1984 data show essentially the same general patterns as in previous years. Uranium concentrations are elevated at DP Canyon, and certain activation products are elevated at TA-53 (LAMPF). There

are elevated radiocesium concentrations in the hive at the TA-50 outfall. Tritium concentrations are elevated in all onsite hives. These results reflect activities that are ongoing at the Laboratory. There are some anomalous results for ^{54}Mn in honey from the hive at Chimayo and for ^{83}Rb in honey from hives at TA-8 and TA-33. These results are probably artifacts, but the results from the 1985 samples will be checked closely to see if similar results are obtained.

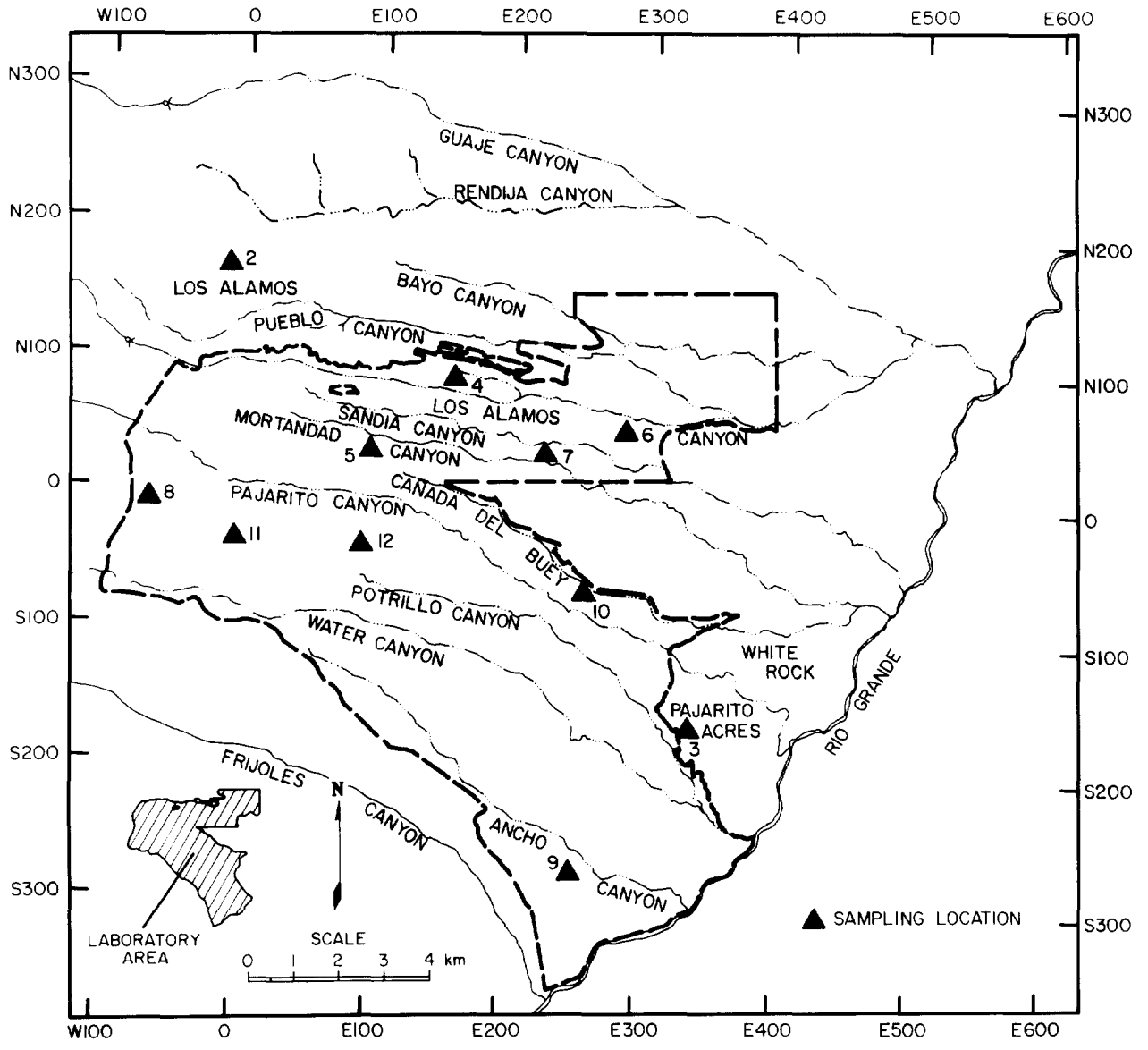


Fig. 22. Locations of beehives.

VIII. ENVIRONMENTAL COMPLIANCE

In accordance with the policy of the Department of Energy, the Laboratory must comply with both federal and state environmental requirements. These requirements address handling, transport, release, and disposal of hazardous materials as well as protection of ecological, archeological, historical, atmospheric, and aquatic resources. The Laboratory is currently in the process of applying for federal and state permits for operating hazardous waste storage areas and for new beryllium machining facilities, as well as renewing its permit for discharge of liquid effluents. The Laboratory was in compliance with liquid discharge permit limits in 89% and 98% of monitoring analyses from sanitary and industrial effluent outfalls, respectively. Some sanitary waste treatment facilities are currently being upgraded to improve compliance. All airborne releases were well within regulatory limits during 1985. A total of 33 asbestos removal jobs were carried out by Laboratory contractors during the year, and appropriate notification was provided to state regulators. Concentrations of constitutents in the drinking water distribution system remained within federal water supply standards, although a few consitituents exceeded limits at the wellhead. The Laboratory carried out one mitigation action at an onsite historical complex and provided DOE with a preliminary list of over 70 sites potentially eligible for nomination to the Federal Register of Historic Places. During 1985, 44 documents were prepared to ensure environmental compliance of new Laboratory activities.

A. Resource Conservation and Recovery Act (RCRA)

1. Background. The Resource Conservation and Recovery Act (RCRA) is a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. On November 9, 1984, the President signed into law significant changes to RCRA known as the Hazardous and Solid Waste Amendments of 1984 (HSWA). Major emphasis of the amendments is reducing hazardous waste volume and toxicity and the minimizing land disposal of hazardous waste. Major requirements under HSWA that impact waste handling at the Laboratory are presented in Table 21.

The Environmental Protection Agency (EPA) granted the State of New Mexico interim RCRA authorization on September 30, 1983, transferring regulatory control of hazardous wastes from EPA to the State of New Mexico's Environmental Improvement Division (EID). State authority for hazardous waste regulation is the New Mexico State Hazardous Waste Act and Hazardous Waste Management Regulations (HWMR). Although EID received final authorization in January 1985, it has not yet obtained authorization for implementing the 1984 RCRA amendments.

The Laboratory produces a wide variety of hazardous wastes. Discarded laboratory chemicals include a wide variety of small chemical volumes, some of which may be acutely hazardous. Given the diversity of research at the Laboratory, small volumes of all chemicals listed under 40 CFR 261.33 could occur at the Laboratory. Process wastes are generated from ongoing manufacturing operations that support research, such as liquid wastes from circuit board preparation and lithium hydride scrap from metal machining. Although they occur in larger volumes than discarded laboratory chemicals, process wastes are few in number, well defined, and not acutely toxic. High-explosive wastes are small pieces of explosives or explosive-contaminated trash that are thermally treated onsite.

2. Permit Application. The Los Alamos Area Office of the DOE has submitted both Part A and Part B applications under RCRA and the New Mexico Hazardous Waste Act for the Laboratory (Table 22). The original Part A was submitted in 1980, but revised Part A applications were submitted in 1985 to respond to changes in waste handling, comments from New Mexico's EID, and changes in regulations. In 1984, EPA and EID requested submission of the Laboratory's RCRA Part B application. Formal Part B application was submitted on May 1, 1985, although drafts had been reviewed previously. On September 18, 1985, the New Mexico EID issued a

Table 21. Major Regulatory Requirements of the Hazardous and Solid Waste Amendments of 1984 Impacting Waste Management at Los Alamos National Laboratory

The Hazardous and Solid Waste Amendments of 1984:

- prohibit the placement of bulk liquids, containerized liquid hazardous waste, or free bulk or free liquids, even with adsorbents, in landfills.
- prohibit the landfill disposal of certain waste and require that the EPA review all listed wastes to determine their suitability for land disposal.
- establish minimum technology requirements for landfills to include double liners and leak detection.
- require the EPA to establish minimum technology requirements for underground tanks.
- require that generators of manifested wastes certify that they have minimized the volume and toxicity of wastes to the degree economically feasible.
- require that the operators of landfills or surface impoundments certify that a ground water monitoring program is in place or a waiver demonstrated by November 8, 1985, with failure to do so resulting in loss of interim status on November 23, 1985.
- require that federal installations submit an inventory of hazardous waste facilities by January 31, 1986.
- require the preparation by August 8, 1985, of a health assessment for landfills and surface impoundments seeking a Part B permit.

Notice of Deficiency (NOD), resulting from the administrative review of the Part B. The NOD cited 125 deficiencies and allowed 30 days for reply. The Laboratory submitted revised Parts A and B on October 16, 1985, in response to the NOD. The revised applications are currently under review by EID.

Landfill of hazardous wastes has been discontinued, and existing landfills will be closed under interim authority. Storage facilities holding wastes for less than 90 days need not obtain a Part B permit. All facilities listed in Table G-36 as having interim status, but not included in the Part B Application, must be closed before the Part B is approved.

3. Audits and Inspections. The Laboratory and New Mexico EID met on February 5 and March 7, 1985, to discuss seven outstanding issues arising from a Notice of Violation (NOV) issued by EID the previous June. The meeting resulted in a Compliance Order/Schedule issued by EID on May 7, 1985. Major requirements of the compliance order are: demonstration of inspection requirements, demonstration of training requirements, and drilling, coring, and sampling at TA-54, Areas L and G, to support a ground water monitoring waiver application.

On July 10 and 11, 1985, EPA and New Mexico EID conducted a joint hazardous waste compliance inspection (Table 23). Subsequently, EID issued a NOV on August 26, 1985. The NOV cited deficiencies in closure and post-closure plans, lack of proper labeling for less than 90-day storage facilities, deficiencies in the Part B Contingency Plan and Waste Analysis Plan, and lack of a closure plan and ground water monitoring at TA-16, Area P. The Laboratory's replies were accepted by New Mexico's EID, and, on August 26, 1985, the NOV was closed.

In addition to the NOV, the July 10 and 11 inspection determined that inspection records for TA-54, Area L, and several short-term storage areas were not in order. The EID cited the Laboratory for violation of the May 7 Compliance Order/Schedule and

Table 22. Environmental Permits Under Which the Laboratory Operated in 1985

Type	Permitted Activity	Issue Date	Expiration Date	Administering Agency
RCRA Hazardous Waste Facility	Hazardous Waste Handling	Revised Application Submitted October 16, 1985	---	EID[a]
PCB	Disposal of PCBs	June 5, 1985	---	EPA[b]
PCB Oil	Incineration of PCB Oils	May 21, 1984	---	EPA
NPDES—Los Alamos	Discharge of Industrial and Sanitary Liquid Effluents	September 9, 1981	September 24, 1985	EPA
NPDES—Fenton Hill	Discharge of Industrial and Sanitary Liquid Effluents	October 15, 1979	June 30, 1983[c]	EPA
Ground Water Discharge Plan—Fenton Hill	Discharge to Ground Water	June 5, 1985	June 1990	OCD[d]
NESHAPS	Construction and Operation of Beryllium Shop at TA-35-213	December 26, 1985	December 26, 1986	EID
Open Burning	Burning of TA-22-1	January 17, 1985	---	EID
Open Burning	Burning of TA-16-525	November 22, 1985	---	EID

[a]New Mexico Environmental Improvement Division.
[b]US Environmental Protection Agency.
[c]Renewal pending.
[d]New Mexico Oil Conservation Division.

Table 23. Environmental Appraisals Conducted at the Laboratory in 1985

Date (1985)	Purpose	Performing Agency
May 20-24	Appraisal of Environmental, Safety, and Health Management	Albuquerque Operations Office, U.S. Department of Energy
July 8-12	Appraisal of Hazardous Waste Management	Albuquerque Operations Office, U.S. Department of Energy
July 10-11	Compliance Evaluation Inspection of Hazardous Waste Activities	New Mexico Environmental Improvement Division and US Environmental Protection Agency
September 10	Tour of Activities in Response to EID Compliance Order	New Mexico Environmental Improvement Division
September 30	Review of Surveillance Data	U.S. General Accounting Office
November	Inspection of Hazardous Waste Management	Environmental Surveillance Group, HSE-8

proposed a penalty of $100,000. The proposed penalty is currently under negotiation.

A complete listing of interactions between the EID and the Laboratory in 1985 is given in Table G-37.

4. Other RCRA Activities. Areas L and G are located at TA-54 on Mesita del Buey and have been used for disposal of hazardous wastes (Appendix F) and they are therefore subject to RCRA regulations. A ground water monitoring waiver application for both Area L and Area G was submitted to the New Mexico EID in June 1984. The bases for requesting a waiver are (1) the waste management units are separated from the uppermost aquifer by 200-250 m (700-800 ft) of dry tuff and (2) the semiarid climate of the area results in little or no deep infiltration of precipitation. Under the May 7 Compliance Order/Schedule, vadose zone (partially saturated above the water table) monitoring beneath the landfills and perched water monitoring in the adjacent canyons are being conducted over the next 2 years to substantiate the waiver (Sec. IX.B.2).

New Mexico's EID stated on November 5, 1985, that the Laboratory had demonstrated that there is a low potential for migration of hazardous wastes to the uppermost aquifer, which is adequate for a waiver under interim status. Data gathered under the Compliance Order will substantiate or refute this position as well as provide information for a demonstration of no potential for migration of contaminants from the facility. This is required prior to closure or permitting of disposal facilities.

The HSWA required that operators of regulated landfills certify to the existence of a ground water monitoring program or a ground water monitoring waiver by November 8, 1985, or submit by November 23, 1985, a closure plan to close the landfill under interim authority. Considering the dependence of the ground water monitoring waiver on vadose zone sampling in progress, and the lack of viable expansion of the Area L landfill under HSWA, the Laboratory did not certify to a ground water monitoring plan for Area L. The Area G closure plan had already been submitted to the EID calling for closure under interim authority. The Area L closure plan in the Part B application was amended to close the landfill under interim authority. The Part B application is being revised to delete the Area L landfill and produce the Area L closure/post-closure plan as a separate document.

Area P at TA-16 is a landfill that had been used to dispose of sand and residue from burning scrap high explosives and high-explosive-contaminated equipment. The recognition that Area P was a hazardous waste landfill occurred in September 1984, when two of six samples of residues placed in the landfill exceeded the EP toxicity limit for barium. Information on Area P was submitted to the New Mexico EID and

a closure/post-closure plan submitted on November 25, 1985. Disposal of wastes at Area P has been discontinued.

Table G-36 lists several storage areas and one thermal treatment area currently under interim status but for which a Part B permit is not being sought. TA-3-102, used to store drummed lithium hydride scrap, will be closed under interim authority and reopened as a less than 90-day storage area. TA-22-24 and TA-40-2 are magazines used for storage of high-explosive wastes. These will be closed to waste storage and replaced by other less than 90-day storage facilities. The TA-40 scrap detonation pit used for destroying scrap high explosives will be closed to waste detonation and future scrap handled at other detonation sites included in the Part B application. Closure plans for these facilities have been submitted to New Mexico's EID.

A controlled air incinerator is located at TA-50-37. A trial burn plan was submitted with the Part B application. Because only pure, nonwaste chemicals will be incinerated in the test burn, the Laboratory is requesting from New Mexico's EID a finding that the trial burn will not constitute creation of a hazardous waste facility. The Laboratory does not wish the incinerator to be designated as a hazardous waste facility until the issue of mixed waste is resolved. The Laboratory has requested that the burn plan be approved and the trial burn be conducted before approval of the Part B.

B. Clean Water Act

1. Laboratory Liquid Discharge Permits. The primary goal of the Clean Water Act (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 all point source effluent discharges to the Nation's waters. The permit estabishes specific chemical, physical, and biological criteria that an effluent must meet prior to discharge. The DOE has two NPDES permits, one for Laboratory facilities in Los Alamos and one for the hot dry rock geothermal facility, located 50 km (30 mi) west of Los Alamos in the Jemez Mountains (Table 22). Both permits are issued and enforced by EPA Region VI, Dallas, Texas. However, through a federal/state agreement and grant, New Mexico's EID performs compliance monitoring and reporting as agents for EPA.

The NPDES permit in effect for the Laboratory in 1985 (NM0028355) was issued September 9, 1981, and expires September 24,1986. It lists 95 industrial outfalls and 11 sanitary outfalls. Each outfall represents a sampling station for permit compliance monitoring. The outfalls are classified into 7 categories of wastewater effluent (Table G-38).

Weekly sampling results are tabulated in a Discharge Monitoring Report (DMR) and submitted through DOE to EPA and New Mexico's EID on a monthly basis. Deviations from NPDES permit limitations are reported separately to EPA and EID as soon as the permittee becomes aware of a noncompliance (Tables G-39, G-40, and G-41). During 1985, 89% and 98% of monitoring analyses complied with NPDES limits at sanitary and industrial outfalls, respectively (Fig. 23).

Modification of NPDES Permit NM0028355 was requested of EPA during 1985 by DOE. The modifications included: elimination of six outfalls, combining five outfalls, reclassifying one outfall to active status, reclassifying three outfalls to inoperative status, and adding four new outfalls. Because the Laboratory's permit was due to be reissued in 1986, EPA elected to withhold changes until the final permit is reissued. The reissued permit will incorporate the modifications.

2. Federal Facility Compliance Agreement. In March 1983 the Los Alamos Area Office of DOE signed a Federal Facility Compliance Agreement (FFCA) that contained an abatement schedule with compliance dates ranging from 1983 to 1985. The FFCA called for abatement efforts to be completed at three high-explosive, liquid-waste treatment plants and one sanitary sewage treatment plant in 1984. Improved administrative procedures at two of the high-explosive waste treatment plants were responsible for achieving compliance. Compliance at the third location was achieved by constructing a lined evaporation pit. Reconstruction of a sand filter at the TA-35 sanitary sewage treatment plant was to put the plant back in compliance in 1984. The schedule was delayed and the sand filters were slated for completion by December 31, 1985.

During September, EPA transmitted to DOE a revised draft FFCA, which extended compliance dates that had not been achieved under the original FFCA schedule. The draft FFCA also included compliance schedules for additional outfalls that were not part of the original FFCA (Table G-42).

3. Administrative Order. On February 12, 1985 EPA Region VI issued an Administrative Order (AO) to DOE regarding NPDES Permit NM0028355. The

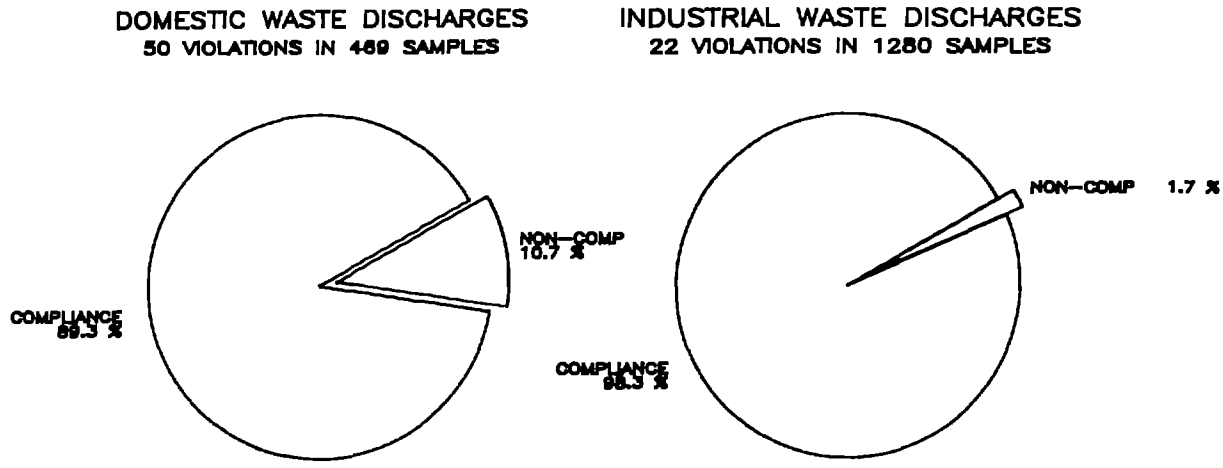


Fig. 23. 1985 Summary of Clean Water Act Compliance, NPDES Permit NM0028355.

AO was based on self-monitoring reports submitted by the Laboratory that identified a number of individual parameter violations occurring at outfalls during 1984.

DOE responded to the AO in two separate submittals to EPA. The response dated March 14, 1985 stated that corrective action was taken and completed on the industrial outfalls, numbers 02A, 03A, 05A, 06A, 050, and 051. The response dated May 23, 1985 proposed a schedule of compliance for the sanitary wastewater outfalls, numbers 01S, 03S, 05S, 06S, 07S, 08S, 10S, and 11S.

4. Fenton Hill Geothermal Project NPDES Permit. The NPDES permit for the Fenton Hill Geothermal Project was issued to regulate the discharge of mineral-laden water from the recycle loop of the geothermal wells (Table 22). NPDES permit NM0028576 was issued October 15, 1979 with an expiration date of June 30, 1983. Although the Laboratory applied for permit renewal more than 180 days prior to the expiration date, EPA Region VI has not yet acted upon the application. Therefore, the existing permit has been administratively continued until it is supplanted by a new permit.

The Fenton Hill Geothermal Project did not have a discharge during 1985. The NPDES permit regulates a single outfall. The daily monitoring requirements for the outfall during discharge include: arsenic, boron, cadmium, fluoride, lithium, pH, and flow. Concentrations for each of these parameters are to be reported. However, only the parameter pH has a limit, i.e., it must be within the range of 6.0 to 9.0 standard units.

New Mexico's Water Quality Control Commission regulations require that no facility shall cause or allow effluent or leachate to discharge so that it may move into ground water except under an approved discharge plan. A discharge plan was submitted for the Fenton Hill Geothermal Project to the New Mexico Energy and Minerals Department, Oil Conservation Division (OCD) for approval June 1984, and supplemental materials were submitted April 19, 1985. On June 5, 1985, the Oil Conservation Division approved the discharge plan (GW-31) for the Fenton Hill Geothermal Project (Table 22). The discharge plan approval is for a period of 5 years.

The approved discharge plan has the following provisions:

1. The service pond will be relined and modified to contain a leak detection system, pursuant to OCD approval. Plans and specifications are expected to be submitted in 1986 following the completion of the well workover project.
2. All discharge events to the service pond shall be reported in writing to the OCD. When effluent is held in the service pond, the leak detection system shall be monitored via the system's catchment basin at least weekly and a log book shall document the inspection with date. There was no discharge from the geothermal loop into the pond during the period of discharge plan approval in 1985.
3. If storage requirements for emergency venting exceed the capacity of the one-million gallon service pond, the larger water reservoir will be used for the excess. Any such events shall be

reported in writing to the OCD. No reports were necessary in 1985.

The discharge plan approval letter states that there will be no routine monitoring or reporting requirements other than those mentioned above.

5. Storm Water Runoff. On September 26,1984, EPA published final rules defining storm water point sources and making them subject to NPDES permits. A storm water point source means a conveyance or system of conveyances (including pipes, conduits, ditches, and channels) primarily used for collecting and conveying storm water runoff and which: a) is located at an urbanized area, b) discharges from lands or facilities used for industrial or commercial activities, or c) is designated by EPA. Storm water point sources are divided into two groups in the regulations. Group 1 consists of storm water point sources that are subject to effluent limitation guidelines, new source performance standards, or toxic pollutant effluent standards, located at industrial plants or in plant associated areas, or designated as Group 1 by EPA. Group 2 includes all others.

Group 1 dischargers must submit a NPDES permit application by December 31, 1987, while the Group 2 dischargers have until June 30. 1989. On August 19. 1985 DOE submitted an NPDES application package for storm water point sources to EPA Region VI that included the Laboratory and the Fenton Hill Geothermal Project. Thirty specific Technical Areas or portions of Technical Areas were designated as falling into Group 2, while only two Technical Areas (TA-50 and 54) were designated as having the characteristics of a Group 1 storm water point source. Sampling and analyses will be implemented in 1986 to support the required permit applications.

6. Spill Prevention Control and Countermeasure (SPCC) Plan. During 1985, a contract was negotiated with a consulting engineering firm to prepare a comprehensive Spill Prevention Control and Countermeasure (SPCC) Plan and Compliance Recommendation Report (CRR) for the Laboratory. The SPCC Plan will address facilities improvements (e.g., dikes, berms, or other runoff control), operational procedures, and reporting of hazardous substances and oil spills to the appropriate regulatory authority. The CRR will evaluate each Laboratory Technical Area and make specific recommendations for achieving compliance with four federal environmental regulations: 90 CFR 109, Criteria for State, Local, and Regional Oil Removal Contingency Plan; 40 CFR 113, Oil Pollution Prevention; 40 CFR 125 (Subpart K), Criteria and Standards for Best Management Practices (BMP); and 40 CFR 117, Reportable Quantities of Hazardous Substances. Technical work on the contract began in September. In 1985, surveys and inventories of regulated substances were completed at all Laboratory technical areas, except: Technical Areas 11, 16, 28, 37, and 39. Remaining surveys will be completed during January, 1986.

Regulated substances inventoried (in order of quantity) include: dielectric oils in tanks, capacitors, transformers, and drums; lubrication oils in drums; acids and bases in tanks; photographic chemicals in shipping containers and plastic vats; and toxic chemicals (approximately 210 compounds).

The plans are expected to be completed towards the end of 1986. These reports will include among other outputs, recommended best management practices for controlling discharges from specific technical areas.

7. Sanitary Wastewater Systems Consolidation. During 1985, the Laboratory initiated consideration of the Sanitary Wastewater Systems Consolidation (SWSC) project. The objective of the SWSC is to provide an area-wide wastewater treatment system for the Laboratory. The project, which is being proposed as a line-item project for 1990, includes a new centralized sewage treatment plant capable of treating approximately 3 to 4×10^3 m^3/day (1.0 to 1.3 $\times 10^6$ gal/day). The project also includes a new collection system to transport sewage to the treatment plant. The proposed project will eliminate 9 existing sanitary wastewater plants (01S at TA-3, 02S at TA-9, 03S at TA-16, 04S at TA-18, 06S at TA-41, 07S at TA-46, 08S at TA-48, 010S at TA-35, 011S at TA-8), and 29 individual septic tanks.

The wastewater collection system will tentatively consist of 15,630 m (51,280 ft) of gravity sewer, 9050 m (29,680 ft) of force main, three lift stations, four suspension bridges, and 24,000 m (79,000 ft) of maintenance road.

The treatment process selected is an extended aeration process utilizing an oxidation ditch, secondary clarification, and disinfection. A lift station at the consolidated treatment plant and force main will convey treated effluent back to the central (TA-3) power plant for use as recycled water. Storage reservoirs at the treatment plant and the power plant will provide temporary storage prior to recycling. Therefore, discharge of effluent from the treatment plant should occur infrequently.

When constructed, the new consolidated wastewater system will reduce the number of NPDES

permit noncompliances caused by existing inadequate sanitary wastewater systems, reduce the number of Laboratory sanitary wastewater discharge points requiring sampling and analysis, provide a state-of-the-art facility that will meet NPDES permit requirements, reduce wastewater treatment operation and maintenance costs, provide collection facilities for land areas subject to Laboratory expansion, provide water conservation through recycling, and eliminate many individual septic tanks.

C. National Environmental Policy Act (NEPA) Activities.

The National Environmental Policy Act (NEPA) of 1969 requires that proposed federal actions be evaluated for their potential environmental impacts. Initial DOE compliance with NEPA generally takes the form of an Action Description Memorandum (ADM). The ADM provides a brief description of the proposed action and serves as a basis for determining the required level of further NEPA documentation, if any. Further documentation may consist of preparing either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) at the request of DOE. The Laboratory Environmental Review Committee (LERC) reviews most Laboratory environmental documentation. A Laboratory Environmental Evaluation Coordinator assists project personnel to prepare the appropriate document and present it to the LERC.

The LERC approved 31 ADMs in 1985, 4 revised ADMs, 3 EAs, and 1 revised EA. Table G-43 tabulates these documents by Laboratory Technical Area.

D. Clean Air Act

1. Radioactive Emissions. Under the authority of the Clean Air Act, EPA has promulgated regulations for control of airborne radioactive releases from DOE facilities (40 CFR 61, Subpart H). In 1985, DOE adopted EPA's limits as the Radiation Protection Standards for the general public for exposure via the air pathway (DOE 1985). Occupational protection standards have remained unchanged. Laboratory operations are in compliance with these standards (Section III). Further discussion is presented in Appendix A.

2. Nonradioactive Emissions

a. National Emission Standards for Hazardous Air Pollutants (NESHAPS). This regulation sets reporting, emission control, disposal, stack testing and other requirements for specified operations involving hazardous air pollutants. New Mexico Air Quality Control Regulation (AQCR) 751 adopts the Federal NESHAPS regulations. The following nonradioactive air pollutants are currently listed under NESHAPS: asbestos, benzene, beryllium, inorganic arsenic, mercury and vinyl chloride. Laboratory operations regulated under NESHAPS include asbestos removal (primarily from heating, air conditioning and ventilation systems) and beryllium machining.

Notification, emission control and disposal requirements for operations involving the removal of friable asbestos are specified under the NESHAPS regulations. Asbestos materials were widely used in buildings constructed prior to the early 1970's. These materials are being replaced by safer materials such as fiberglass insulation and are removed from buildings prior to their demolition. During 1985, the Zia Company performed a total of 33 asbestos jobs involving the removal of 1150 m (3770 ft) of asbestos materials on pipe and 750 m^2 (8070 ft^2)on other facility components. Six asbestos notifications were made to the New Mexico EID during 1985, including the annual notification for small renovation jobs. Small renovation jobs involved 85% of the removal jobs, 57.3% of the quantity of asbestos removed from pipe, and 5.7% of asbestos removed from other facility components. Asbestos wastes are discarded at TA-54.

The final draft of a document for the safe handling, removal and disposal of asbestos, to be included with other specifications in Laboratory contracts, was completed in 1985. A similar write-up is in preparation for the Health and Safety manual. The requirements specified in these documents are to upgrade existing procedures and are in the process of being implemented.

NESHAPS includes notification, emission limit and stack testing requirements for beryllium machine shops. Two notifications were made to the New Mexico EID concerning existing, planned and modified beryllium machining operations. There are plans to modify the main Be shop located at TA-3-39.

There is an existing operation located at TA-3-102 which performs machining on an intermittent basis and which is a satellite operation to the main Be shop. A new Be shop is planned for TA-35-213. Emission estimates and stack gas sampling results from the main Be shop indicate that the emissions from these operations will be several orders of magnitude below the the 10 g/day emission limit. Stack emission tests, using EPA and New Mexico EID appoved methods, are planned for 1986. The stack tests are required under NESHAPS.

New Mexico AQCR 702 requires the permitting of any new or modified source which, if it were uncontrolled, would emit greater than 4.5 kg/h (10 lb/h) or 25,000 kg/yr (25 tons/yr) of any contaminant or would emit any hazardous air pollutant. The hazardous air pollutants covered are those regulated under NESHAPS.

Under this regulation, four permit applications were submitted to the New Mexico EID during 1985 (Table 22). They were submitted for the following hazardous air pollutant sources: the dynamic testing of explosives which emits Be particulates, the Be machine shops and a Be-uranium oxide processing facility planned for TA-3-141. New Mexico's EID ruled that because the operation involving the dynamic testing of explosives started operation prior to the date this regulation went into effect, a permit was not required. New Mexico EID issued the permit for the Be machine shop to be located at TA-35-213 and is in the process of reviewing the other permit applications.

The Be emissions from the Be machine shops and the Be-uranium oxide operation are or will be negligible. The impact on air quality of all Laboratory Be operations are or will be several orders of magnitude below New Mexico ambient air quality standards. As required by New Mexico AQCR 702, stack testing is planned during 1986 for Be operations being permitted.

b. National Ambient Air Quality Standards (NAAQS). National and New Mexico Ambient Air Quality Standards are shown in Table 24. New Mexico Air Quality Control Regulation (AQCR) 201 sets ambient air quality standards. Based upon available monitoring data and modeling, there has not been an exceedance of National nor New Mexico Ambient Air Quality Standards caused by Laboratory Sources. State standards are required to be at least as stringent as the national standards. New Mexico standards are generally more stringent than the national standards. Pollutants emitted by Laboratory Sources covered under these standards include: sulfur dioxide, particulates, carbon monoxide, nitrogen dioxide, lead, beryllium, heavy metals, and nonmethane hydrocarbons. Laboratory sources that emit these pollutants include beryllium machining and processing, the TA-3 power plant, the steam plants, the motor vehicle fleet, the asphalt plant, chemical usage, and the burning and detonation of explosives. Emissions from these sources by Pollutant are presented in Section V.B.

c. Prevention of Significant Deterioration (PSD). PSD regulations have stringent requirements (preconstruction review, permitting, best available control technology for emissions, air quality increments not to be exceeded, visibility protection requirements and air quality monitoring) for construction of any new major stationary source or major modification located near a Class I Area, such as the wilderness area of Bandelier National Monument. New Mexico AQCR 707 is New Mexico's PSD regulation. The Laboratory's emissions have not exceeded levels invoking PSD requirements. A review of the Action Description Memorandum for the Solid Waste Fired Boiler proposed to be located adjacent to the TA-16 steam plant indicated that the source emissions were close to being defined as a new major stationary source subject to PSD. It was recommended that the emissions from this source, if built, be controlled to the extent to which it would not be subject to PSD.

d. Open Burning. New Mexico AQCR 301 regulates open burning. Under this regulation the open burning of explosive materials is permitted where the transportation of such materials to other facilities could be dangerous (Table 22). Under this provision, the Laboratory is permitted to burn waste explosives and explosive-contaminated wastes. Waste explosives are burned at the TA-16 burn ground, whereas explosive-contaminated wastes are burned at the TA-16 open incinerator. A burn permit was submitted and issued for the burning of TA-16-525. This building was located within the explosives exclusion area and was potentially contaminated with high explosives. A burn permit was submitted and issued for another potentially explosive-contaminated building, TA-22-1. This building was never burned because it was determined to have historical value.

Table 24. Federal and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	Units	New Mexico	Federal	
				Primary	Secondary
Sulfur dioxide	Annual Arithmetic Mean	ppm	0.02	0.03	
	24 hour[a]	ppm	0.1	0.14	
	3 hour[a]	ppm			0.5
Total Suspended Particulates	Annual Geometric Mean	$\mu g/m^3$	60	75	60
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hour[a]	$\mu g/m^3$	150	260	150
Carbon monoxide	8 hour[a]	ppm	8.7	9	
	1 hour[a]	ppm	13.1	35	
Ozone	1 hour[b]	ppm	0.06	0.12	0.12
Nitrogen dioxide	Annual Arithmetic Mean	ppm	0.05	0.053	0.053
	24 hour[a]	ppm	0.10		
Lead	Calendar Quarter	$\mu g/m^3$	1.5	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		
Non-Methane	3 hour	ppm	0.19		

[a]Maximum concentration not to be exceeded more than once per year.
[b]The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the limit is equal to or less than one.

e. Visible Emissions. New Mexico AQCR 401 controls smoke and visible emissions. No Laboratory source was subject to this regulation during 1985. The proposed solid waste fired boiler, if built, would be subject to this regulation.

f. New Source Performance Standards (NSPS). NSPS applies to 72 source categories. Its provisions include emission standards, notification, and emission testing procedures and reporting and emission monitoring requirements. New Mexico AQCR 750

adopts the Federal NSPS regulations. The Laboratory has not yet been subject to NSPS. The proposed solid waste fired boiler at TA-16 (discussed above), if built, would be subject to NSPS.

g. Source Registration. New Mexico AQCR 703 requires the registration of any stationary source which emits more than 910 kg/yr (2000 lb/yr) of any contaminant. Several Laboratory sources have been registered (TA-3 power plant and the steam plants) but no sources required registration during 1985.

h. Asphalt Plant. New Mexico AQCR 501 sets emission standards according to process rate and requires the control of fugitive emissions from asphalt processing equipment. The asphalt concrete plant operated by Zia is subject to this regulation. This plant is an old plant subject to leaking and it is inspected on a semiannual basis. During the two inspections which took place during 1985, leaks causing fugitive emissions were discovered. The Zia Company promptly repaired the leaks.

The asphalt plant meets the stack emission standard for particulates as specified in this regulation. The plant is required to meet a particulates emission limit of 16 kg/h (35 lb/h). A stack test of the asphalt plant in 1977 indicated an average emission rate of 0.82 kg/h (1.8 lb/h) and a maximum rate of 1.0 kg/h (2.2 lb/h) over 3 tests (Kramer, 1977). Though the plant is old and not required to meet the New Source Performance Standards stack emission limits for asphalt plants, it could also easily meet these standards (Kramer, 1977).

i. Standards for Gas-Burning Equipment. New Mexico AQCR 604 requires gas burning equipment built prior to January 10, 1973 to meet an emission standard for nitrogen oxides (NO_x) of 0.3 lb/10^6 Btu when its natural gas consumption exceeds 10^{12} Btu/yr/unit. The TA-3 power plant's boilers have the capacity to operate at heat inputs that exceed the 10^{12} Btu/yr/unit limit but have not operated beyond this limit. Thus, these boilers have not been subject to the requirements of this regulation. In 1985, the power plant's boilers, numbered 1, 2 and 3, consumed 0.711, 0.317 and 0.642 $\times$ 10^{12} Btu of natural gas, respectively.

Because the power plant has the potential to be subject to this regulation, the Laboratory is required by the New Mexico's EID to submit an annual fuel consumption report for the plant. The report for 1985 was submitted to EID during January 1986.

The TA-3 power plant easily meets the NO_x emission standard under New Mexico AQCR 604, although it is not required to do so. The emission standard is equivalent to a flue gas concentration of 248 cm^3/m^3 (ppm by volume). The TA-3 boilers meet the standard with measured flue gas concentrations between 14 and 22 cm^3/m^3 (ppm), 6 to 9% of the standard.

3. Operational Improvements. Operational improvements which took place during 1985 included asphalt plant repairs and an ongoing process of upgrading the procedures for removal, handling and disposal of asbestos materials. These improvements are discussed above.

E. Safe Drinking Water Act (Municipal and Industrial Water Supply)

1. Introduction. The federal Safe Drinking Water Act (42 U.S.C. 300f et seq.), as amended, requires adoption of national drinking water regulations as part of the effort to protect the quality of the Nation's drinking water. The EPA is responsible for the administration of the Act and has promulgated National Interim Primary Drinking Water regulations. Although EPA is designated by law as the administrator of the Act, assignment of responsibilities to a state is permitted, and "primacy" for administration and enforcement of the federal drinking water regulations has been approved for New Mexico.

The state administers and enforces the drinking water requirements through regulations adopted by the New Mexico Environmental Improvement Board (EIB) and implemented by New Mexico's EID. During 1985, chemical quality reports regarding trihalomethane and inorganic chemical concentrations in the Laboratory's water supply were submitted to New Mexico's EID pursuant to EIB regulations. Municipal and industrial water supply for the Laboratory easily met the EIB regulations.

The main aquifer is the only aquifer in the area capable of municipal and industrial water supply (Section II.C). Water for the Laboratory and community is supplied from 16 deep wells in 3 well fields and 1 gallery. The well fields are on Pajarito Plateau and in canyons east of the Laboratory (Fig. 24). The gallery is west of the Laboratory on the flanks of the mountains. Production from the wells and gallery for 1985 was 6.1×10^9 ℓ (1.6×10^9 gal).

The Los Alamos well field is composed of five producing wells and one standby well. During 1985,

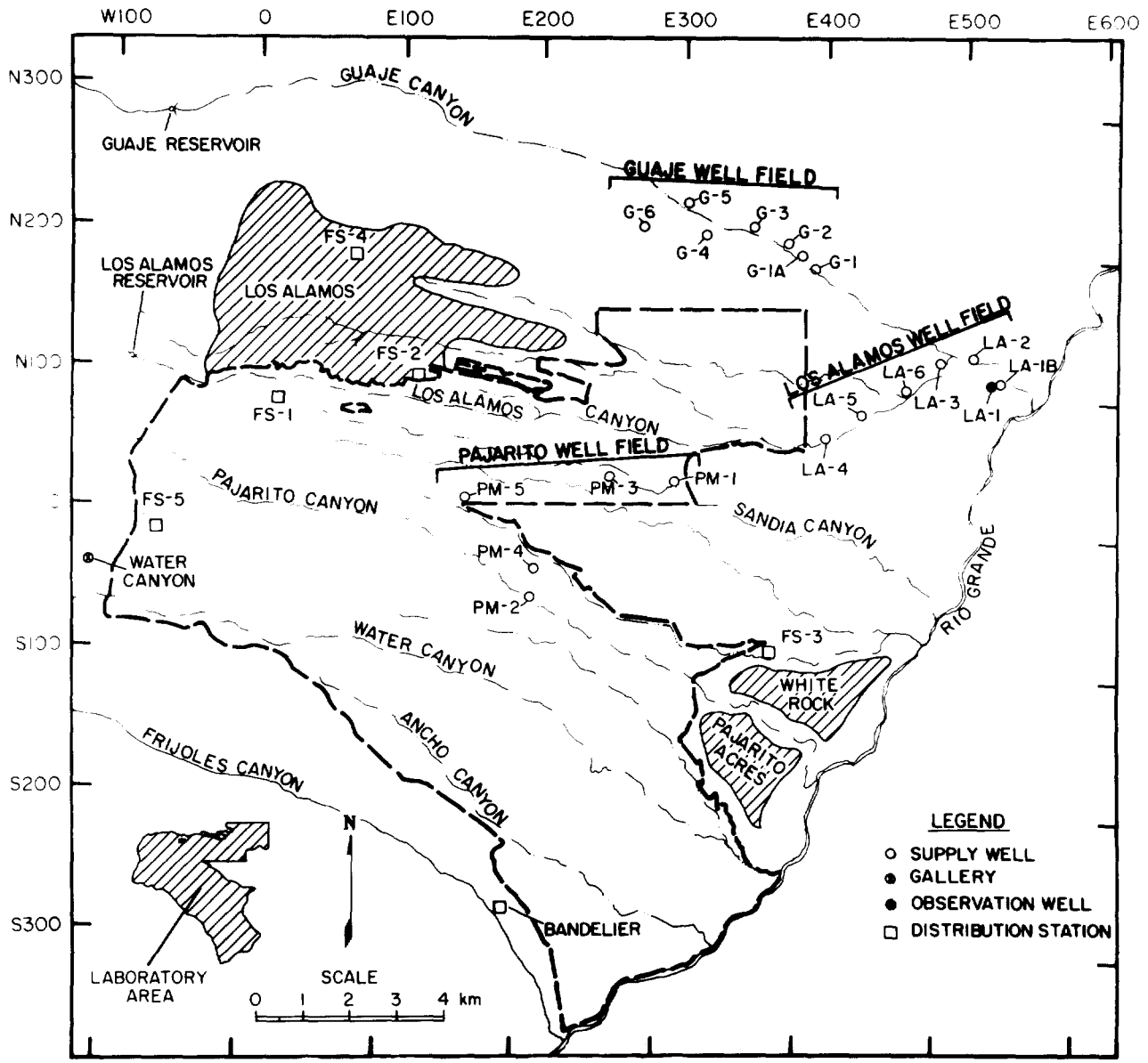


Fig. 24. Locations of reservoirs, well fields, supply wells, and gallery water supply.

Well LA-5 was down for repairs for part of the year and consequently was not sampled. Well LA-6 is on standby status, to be used only in case of emergency. Water from Well LA-6 contains excessive amounts of natural arsenic (up to 0.200 mg/ℓ) that cannot be reduced to acceptable limits by mixing in the distribution system (Purtymun 1977). Wells in the field range in depth from 265 to 600 m (869 to 2000 ft). Movement of water in the upper 411 m (1350 ft) of the main aquifer in this area is eastward at about 6 m/yr (20 ft/yr) (Purtymun 1984).

The Guaje well field is composed of seven producing wells. Wells in the field range in depth from 463 to 610 m (1520 to 2000 ft). Movement of water in the upper 430 m (1410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

The Pajarito well field is composed of five wells, of which four were producing in 1985. Well PM-5, a new well, has not been placed in service at this time. Wells range in depth from 701 to 942 m (2300 to 3090 ft). Movement of water in the upper 535 m (1750 ft) of the aquifer is eastward at 29 m/yr (85 ft/yr).

The Water Canyon gallery collects spring discharge from a perched water zone in the volcanics on the flanks of the mountains west of Los Alamos and Pajarito Plateau (Fig. 24). The canyon supplies a small but important part of the production with use of very little energy.

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. The well is about 133 m (436 ft) deep completed in volcanics. During 1985 the well produced about 22×10^6 ℓ (5.8×10^9 gal). The TA-57 water is not a part of the Los Alamos supply.

All water comprising the municipal and industrial supply is pumped from wells, piped through transmission lines, and lifted by booster pumps into reservoirs for distribution to the community and Laboratory. Water from the gallery flows by gravity through a microfilter station and is pumped into one of the reservoirs for distribution. All supply water is chlorinated prior to entering the distribution system.

Water in the distribution systems was sampled at five community and Laboratory locations (fire stations), Bandelier National Monument, and Fenton Hill (Fig. 24, Table G-16). Though federal and state standards (Appendix A) require analyses every 3 years, the Laboratory performs the analyses on an annual basis.

2. Radioactivity in Municipal and Industrial Water Supply. The maximum radioactivity concentrations found in the supply (wells and gallery) and distribution (including Fenton Hill) systems are compared with the Environmental Protection Agency's National Interim Primary Drinking Water Standards (EPA 1976) in Table 25.

Water collected from Well PM-3 in March 1985 contained traces of ^{238,239}Pu (Table G-44). The well was resampled in June and the ^{238,239}Pu concentrations were at or below limits of detection. Thus, the trace of plutonium reported in the March sample was probably contaminated in the laboratory either during analyses or during sample handling.

Gross alpha concentrations in water from Well LA-1B exceed EPA standards by about 40%; however, dilution of the gross alpha with pumpage from the other wells reduced the concentrations to acceptable levels within the distribution system. Gross alpha activity resulted from naturally occurring uranium found in the water. Gross alpha and uranium concentrations varied, and with increased pumpage the concentrations decreased. This was also true for chemical constituents in the water.

With the exception of gross alpha in Well LA-1B, a comparison of maximum radioactive concentrations from the supply and distribution to the Environmental Protection Agency's standards shows that the two systems (Los Alamos and Fenton Hill) were in compliance with federal regulations.

3. Chemical Quality of Municipal and Industrial Water Supply. Water from the distribution systems complied with EPA's primary and secondary standards (Table 26 and Appendix A). Chemical constituents in water from the distribution systems (Los Alamos, Bandelier National Monument, and Fenton Hill Site) complied with primary standards. Maximum concentrations of arsenic in water from Well G-2 and fluoride from Well LA-1B were at or above primary standards (Table 26). However, mixing in the distribution system reduced the concentrations to acceptable levels. Arsenic and fluoride occur naturally in the aquifer. The chemical quality of water from each well reflected nearby aquifer characteristics. As stated above, chemistry of the water in Wells LA-1B and G-2 changed slightly with increased pumping. Fluoride concentrations in water from Well LA-1B decreased slightly with pumpage, while arsenic concentrations in Well G-2 increased slightly with pumpage. Mixing of water from Wells LA-1B and G-2 with other wells in the fields reduced the concentrations to acceptable levels in the distribution system (Table 26).

Water from the wells and distribution system complied with the secondary standards with one exception (Table 26). Water from the gallery contained a high concentration of iron. The sample was collected prior to entering the microfilter station. Water was transmitted from the gallery to the microfilter station through an iron pipe. Water picked the iron up from the pipe. Because of dilution in the system, all iron analyses were below standards within the distribution system.

The quality of water from the wells varied with local conditions within the same aquifer (G-44). Water quality depends on well depth, lithology of aquifer adjacent to well, and yield from beds within the aquifer.

F. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires registration of all

Table 25. Maximum Concentrations of Radioactivity in Municipal Water Supply, Well, and Distribution System

	Number of Stations	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	$^{239,240}Pu$ (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μg/mℓ)	Total U (μg/ℓ)	Gross Gamma (counts/min/ℓ)
Analytical Limits of Detection	—	40	0.009	0.03	3	3	0.7	1.0	50
Maximum Contaminant Level (MCL)[a]	—	200	15	15	15[b]	—	20	1800[c]	—
Wells									
Maximum Concentration	17	55 ± 48	0.019 ± 0.012	0.034 ± 0.014	21 ± 5.0	7.4 ± 0.9	−0.4 ± 0.3	6.8 ± 1.0	60 ± 50
Maximum Concentration as Per Cent of MCL	—	28	<1	<1	140	—	6	<1	—
Distribution System (Los Alamos)									
Maximum Concentration	6	76 ± 99	0.012 ± 0.014	0.026 ± 0.013	2.0 ± 0.8	5.7 ± 0.8	3.2 ± 0.5	4.6 ± 0.5	100 ± 60
Maximum Concentration as Per Cent of MCL	—	38	<1	<1	13	—	16	<1	—
Distribution System (Fenton Hill)									
Maximum Concentration	1	24 ± 48	−0.009 ± 0.011	−0.005 ± 0.010	2.4 ± 1.0	6.1 ± 0.8	0.3 ± 0.4	2.1 ± 0.2	−40 ± 60
Maximum Concentration as Per Cent of MCL	—	12	<1	<1	16	—	1	<1	—

[a]EPA (1976).
[b]Environmental Protection Agency's Maximum Contaminant Level for gross alpha is 15×10^{-9} μCi/mℓ. However, gross alpha results in the distribution system that exceed EPA's limit of 5×10^{-9} μci/mℓ require isotopic analysis to determine radium content.
[c]Level recommended by International Commission on Radiological Protection.

Table 26. Maximum Chemical Concentrations in Water Supply and Distribution Systems (results in mg/ℓ)

Inorganic Chemical Contaminant	Standards	Supply		Distribution	
		Well and Gallery	Per Cent of Standard	Los Alamos Bandelier TA-57	Per Cent of Standard
Primary[a]					
Ag	0.05	<0.001	<2	<0.001	<2
As	0.05	0.050	100	0.012	24
Ba	1.0	0.07	7	0.07	7
Cd	0.01	<0.0002	<2	<0.0002	<2
Cr	0.05	0.025	50	0.006	12
F	2.0	3.0	150	0.7	4
Hg	0.002	<0.0001	<5	<0.0002	<10
NO_3(N)	10	5.3	53	0.5	5
Pb	0.05	0.020	40	<0.002	<10
Se	0.01	<0.003	<30	<0.003	<30
Secondary[b]					
Cl	250	15	6	15	6
Cu	1.0	0.060	6	0.021	2
Fe	0.3	0.990	330	0.036	12
Mn	0.05	0.011	22	<0.001	<2
SO_4	250	32	13	6	2
Zn	5.0	1.35	27	0.05	1
TDS	500	446	89	236	47
pH	6.5 - 8.5	8.4	98	8.2	96

[a]EPA (1976).
[b]EPA (1979B).

pesticides, restricts use of certain pesticides, recommends standards for pesticide applicators, and regulates disposal and transportation of pesticides. A pesticide is defined as any substance intended to prevent, destroy, repel, or mitigate pests. The Laboratory stores, uses, and discards pesticides in compliance with the provisions of FIFRA. A Laboratory pest control policy was established in June 1984 to establish procedures and identify suitable pesticides for control of plant and animal pests. Anything outside the scope of the policy must be approved by the Pest Control Oversight Committee. No unusual events associated with compliance occurred during 1985.

G. Archaeological and Historical Protection

The Laboratory contains more than 450 known archaeological and historical resources. Cultural resources are routinely identified in advance of construction projects. Protection of these resources is mandated by numerous laws and regulations, including the National Historic Preservation Act of 1966 (Public Law 89 665) as implemented by 36 CFR, Part 800, Protection of Historic and Cultural Properties, and the New Mexico Cultural Properties Act of 1969 as amended. The Laboratory Environmental Evaluation Coordination and Quality Assurance Programs

oversee management and protection of cultural resources. Archaeologists employed by the Laboratory survey construction sites in advance of construction to determine the presence or absence of cultural resources.

Mitigation of unavoidable adverse impact to cultural resources is determined in consultation with the New Mexico State Historical Preservation Office (SHPO) and, at the SHPO's discretion, the National Advisory Council on Historic Preservation. During 1985, two principal mitigative actions occurred. The SHPO determined that the World War II explosives subassembly site of the Fat Man Bomb (Building TA-22-1) was of sufficient historical significance to prohibit demolition. Major mitigation of adverse impact to the Romero Homesteading Complex (Laboratory of Anthropology No. 16806), begun in 1984, continued. The Romero homestead cabin was dismantled and restored at a site near the Los Alamos County Historical Museum. The DOE transferred ownership of the cabin in October 1985 to the Los Alamos Historical Society. The cabin will be curated by the Los Alamos County Historical Museum. Laboratory archaeologists completed fieldwork at the original homesteading site; analysis of artifacts continues.

The Laboratory conducted one public archaeological tour during 1985, to the Nakemuu Indian Ruin (LA 12655).

H. Endangered Species and Floodplains/Wetlands Activities

The Laboratory conducted a biological assessment of potential threat to the peregrine falcon (*Falco peregrinus anatum*), an endangered species, from a proposed weapons firing range in Los Alamos Canyon. Los Alamos Canyon is within the known hunting range of falcons inhabiting a local eyrie. The Laboratory forwarded the study to the DOE.

During 1985, the New Mexico State Legislature passed an Endangered Plant Species Act (House Bill 347, as amended, 37th Legislature, 1st session, Chapter 143, 1985). To date, Laboratory botanists have identified within the Laboratory and Los Alamos County one plant on the most current (September 6, 1985) New Mexico Endangered Species list: several populations of Grama grass cactus, *Toumeya papyracantha* syn. *Pediocactus papyracanthus.*

In compliance with the Endangered Species Act and with Executive Orders 11988, Floodplain Management, and 11990, Protection of Wetlands, as implemented in 10 CFR 1022, Compliance with Floodplain/Wetlands Environmental Review Requirements, Laboratory botanists surveyed portions of four canyons for potential impact from proposed construction. They identified no endangered, unusual, or rare plant species within the survey areas. Pursuant to 10 CFR 1022, an Involvement Notification and a Statement of Findings were submitted to DOE for publication in the Federal Register for a fiber optic cable to be constructed in Los Alamos Canyon. Botanists collected 67 representative species of vascular and nonvascular plants from Los Alamos Canyon for accession into the Environmental Surveillance Group's herbarium.

I. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) passed by Congress in 1980 mandated cleanup of toxic and hazardous contaminants at closed and abandoned hazardous waste sites. DOE provided guidance on implementing CERCLA for DOE facilities in DOE Order 5480.14 issued on April 26, 1985. This order presents a phased approach to achieving compliance with CERCLA. The first phase, Installation Assessment, is to be completed by April 26, 1986. The installation assessment activities are included in two programs that have merged at the Laboratory. One is the Site Characterization Program (SCP) begun in 1983 within the Laboratory (Section IX.C.2), and the other, the Comprehensive Environmental Assessment and Response Program (CEARP) begun by DOE's Albuquerque Operations Office in 1984 (Section IX.C.1). The Laboratory's Phase I report will be submitted to DOE before April 26, 1986. Phase II (confirmation of the findings from Phase I) activities were started in 1985 with supplemental funding provided by DOE/AL. Also with this supplemental funding, two abandoned firing sites (TA-4 and TA-5) were cleaned up and some structure removal was done at abandoned firing site TA-20. This corresponds to the Phase IV activity of remedial action.

J. Toxic Substances and Control Act (TSCA)

The TSCA (15 U.S.C. et seq.) establishes a list of toxic chemicals for which the manufacture, use, storage, handling, and disposal are regulated. This is accomplished by requiring premanufacturing notification for new chemicals, testing of new or existing chemicals suspected of presenting unreasonable risk to human health or the environment,

and control of chemicals found to pose an unreasonable risk.

Part 761 of TSCA contains the regulations applicable to Polychlorinated Biphenyls (PCBs). This part applies to all persons who manufacture, process, distribute in commerce, use, or dispose of PCBs or PCB items. Substances that are regulated by this rule include, but are not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, paints, sludges, slurries, dredge spoils, soils, materials contaminated as a result of spills, and other chemical substances. Most of the provisions of the regulations apply to PCBs only if the PCBs are present in concentrations above a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to materials at PCB concentrations of 50 ppm and above. At the Laboratory, materials with >500 ppm PCBs are transported offsite for disposal.

During 1985 the Laboratory continued to inventory and mark PCB articles such as transformers and capacitors. The Laboratory's inventory of PCB transformers and PCB capacitors includes 134 and 2,837 units, respectively. The Laboratory marked and registered all (134) PCB transformers with fire response personnel and building owners by December 1, 1985, as required by regulation. All proximal means of access to PCB transformers were also marked to aid fire response personnel, and a survey was made of combustible materials stored or located in near proximity to PCB transformers. Visual inspections of PCB transformers are conducted at least quarterly, and inspection records maintained pursuant to the regulations.

The Laboratory received approval from EPA Region VI on June 5, 1980 to dispose of PCB-contaminated articles, oils, and materials in the chemical waste landfill located at TA-54, Area G (Table 22). The approval requires semiannual reporting to EPA regarding the type and weight of PCB articles disposed of, and monitoring information regarding chemical quality of storm water runoff and natural springs in the area. Cumulative weights of specific types of PCB articles which were disposed at TA-54 during 1985 are listed in Table 27.

K. Engineering Quality Assurance

The Laboratory has a Quality Assurance program (Facilities 1983) for engineering, construction, modification, installation, and maintenance of Department of Energy facilities. The purpose of the program is to minimize the chance of deficiencies in construction; to improve the cost effectiveness of facility design, construction, and operation; and to protect the environment. A major goal of engineering

Table 27. Quantities (kg) of PCB Contaminated Articles Discarded at TA-54 in 1985[a].

PCB Article(s)	Shaft C10	Shaft C11	Pit 29
Transformer Carcasses			8,165
Absorbed PCB Oil	5,281	2,359	159
Rags/Dirt (drummed)	1,134	227	363
Empty Drums			68
Asphalt/Dirt (non-containerized)		2,722	4,354
Miscellaneous Items		1,792	18,870
Total	6,415	7,099	31,979
	Grand Total	45,492	

[a]PCB article and oils which contain ≥ 500 ppm PCB are shipped out-of-state for disposal.

Quality Assurance is to ensure operational compliance with all applicable environmental regulations. The Quality Assurance program is implemented from inception of design through completion of construction by a project team approach. The project team consists of individuals from the Department of Energy's program division, Department of Energy's Albuquerque Operations and Los Alamos Area Offices, Laboratory's operating group(s), Laboratory's Facility Engineering Division, design contractor, inspection organization, and construction contractor.

IX. ENVIRONMENTAL SUPPORT ACTIVITIES

In addition to environmental surveillance and compliance activities, the Laboratory carries out a number of related environmental activities. Selected studies are briefly described below. Many of these are ongoing and will provide supplemental information for the surveillance and compliance activities at the Laboratory.

A. Meteorological Monitoring Activities (B. Bowen)

1. Weather Summary. Los Alamos received heavy rainfall and snowfall during 1985. Snowfall during the winter of 1984-1985 totaled 308.6 cm (121.5 in.)—second only to the 313.9 cm (123.6 in.) that fell during the winter of 1957-1958 and nearly 2.5 times normal (Table G-45). Unusually heavy precipitation during the spring (March-May) gave Los Alamos its second wettest spring on record. Above normal rainfall also occurred in September and October, giving Los Alamos its wettest year [64.9 cm (25.6 in.) of precipitation] since 1969, when 65.2 cm (25.7 in.) fell. The year as a whole had near normal temperatures (Fig. 25, Tables G-45, G-46, and G-47).

Weather during January was cool with below normal precipitation. However, snowfall was above normal with 36.3 cm (14.3 in.). An arctic air mass arrived in New Mexico on the 31st of the month and lingered into the first few days of February. Temperatures dipped below the −18°C (0°F) mark for three consecutive mornings. The −23°C (−9°F) low temperatures on February 1 and 2 were the coldest temperatures recorded in Los Alamos since late in 1978. February's temperatures were below normal, while snowfall for the month was heavy at 34.3 cm (13.5 in.)—nearly twice the normal. Very heavy precipitation and snowfall occurred during March. A storm dumped 4.5 cm (1.8 in.) of precipitation on the 11th and 12th, with 28 cm (11 in.) of snow falling on

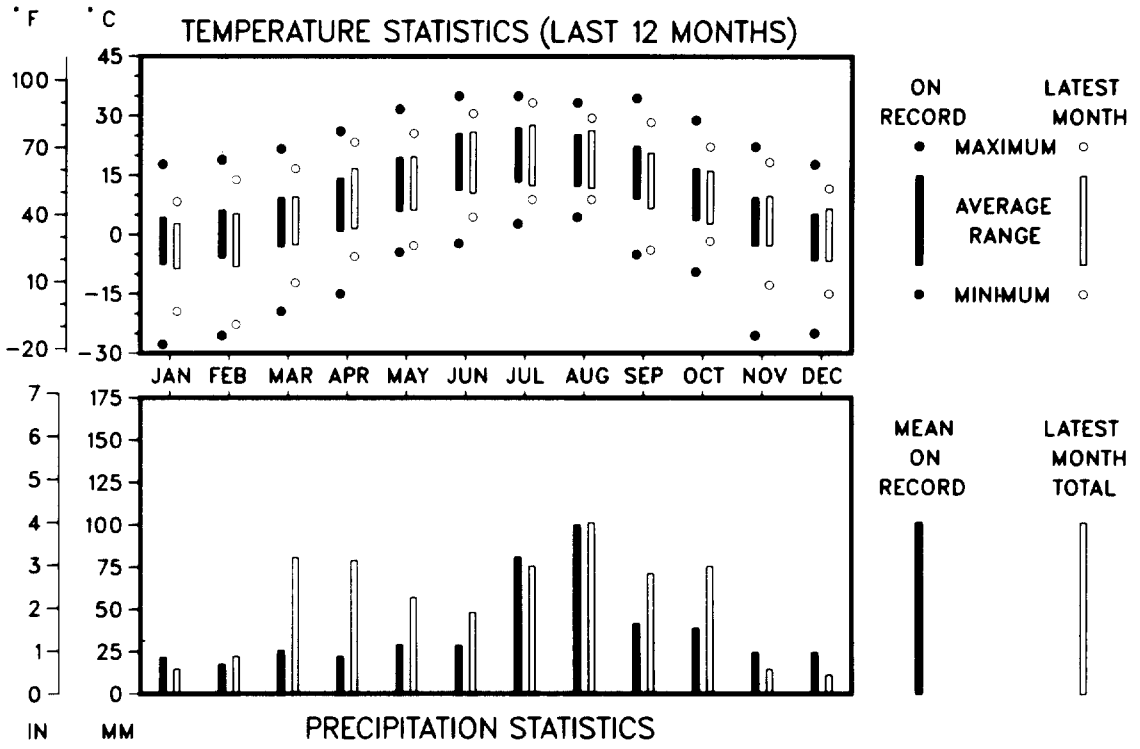


Fig. 25. Summary of 1985 weather in Los Alamos (data from Occupational Health Laboratory, OHL, TA-59.

the 12th. Another snowfall of 28 cm (11 in.) fell on the 29th and 30th. The month's precipitation of 8.1 cm (3.2 in.) was over 3 times the normal, making it the 3rd wettest March on record. The 71.9 cm (28.3 in.) of snow that fell during the month was also nearly 3 times the normal. Heavy precipitation extended into April, with most of it falling as rain. Once again during April, the total precipitation of 7.8 cm (3.1 in.) was over 3 times the normal for the month. After more above-normal rainfall in May of 5.7 cm (2.2 in.), the spring (March-May) of 1985 became the second wettest spring on record with 22 cm (8.5 in.) of precipitation.

Summer began with above-normal rainfall and some intense thunderstorms. Power outages occurred in Los Alamos County because of lightning and strong winds on the 18th and 19th of June, respectively. Another thunderstorm on the 25th caused a peak wind of 56 mph. Hot and dry weather dominated during the first half of July. The temperature exceeded 32°C (90°F) on four consecutive days staring on the 5th. In contrast, rainy and cool weather occurred during the last week. The high temperatures were only 20 and 19°C (68 and 66°F) on the 28th and 29th, respectively. Typical temperatures and thundershowers occurred during August. An intense band of thunderstorms moved through the county on the 10th, which caused heavy rains and interruptions in electrical power service. Over 3.8 cm (1.5 in.) of rain fell over the entire county, with 6.9 cm (2.7 in.) falling at the East Gate station.

Very cool weather along with heavy rainfall occurred in September. The month became the coldest September on record with an average mean temperature of 13.7°C (56.6°F)—2°C (3.6°F) below the normal. Rainfall was also heavy at 7.1 cm (2.8 in.) Much of the rainfall occurred on the 18th-20th due to a slow, eastward moving storm through the southwestern states. The final passage of the storm on the 20th caused a freak tornado in Albuquerque. The storm track remained unusually far south through New Mexico in October, causing precipitation to total nearly 8 cm (3 in.), twice the normal

The weather pattern became much drier during November, with only 1.4 cm (0.57 in.) falling. The dry weather extended into December, with the major exception on the 10th, when a storm dumped 25 cm (10 in.) of snow. Cold air accompanied the storm and lingered several days after the storm. However, the rest of the month saw mild temperatures along with dry conditions.

2. Wind Roses. The 1985 surface wind speed and direction measured from sites at Los Alamos are plotted in wind roses for day, night, and total hours (Figs. 26 through 28). A wind rose is a circle with lines extending from the center representing the direction from which the wind blows. The length of each line is proportional to the frequency of the wind speed interval from that particular direction. Each direction is one of 16 primary compass points (N, NNE, etc.) and is centered on a 22.5° sector of the circle. The frequency of the calm winds, defined as those having speeds less than 0.5 m/sec (1.1 mph), is given in the circle's center. Day and night are defined by the times of sunrise and sunset.

The wind roses represent winds at OHL, TA-59 [2248 m (7373 ft) above sea level or MSL], TA-50 [2216 (7268 ft) MSL], East Gate [2140 (7019 ft) MSL], and Area G [2039 (6688 ft) MSL]. Wind data were measured at heights of 23 m (69 ft) at OHL and about 11 m (33 ft) at the other three sites.

Winds at Los Alamos are generally light with the average speed of nearly 3 m/s (7 mph). Wind speeds greater than 5 m/s (11 mph) occurred with frequencies ranging from 10% at TA-50 to 16% at East Gate. Nearly 50% of winds at all sites were less than 2.5 m/s.

Distribution of winds varies with site and time of day primarily because of the terrain features found at Los Alamos. On days with sunshine and light large-scale winds, a thermally driven upslope wind develops over the Pajarito Plateau. Note the high frequency of SE through S winds during the day at OHL, TA-50, and East Gate (Fig. 26). Upslope winds are generally light, <2.5 m/s (5.5 mph). In contrast, winds are predominantly SSW and SW at Area G with a secondary maximum evident from the NE. The winds here are more affected by the Rio Grande Valley than the plateau. Channeling of large-scale winds by the valley contributes to the high frequency of SSW and SW winds, along with NE or down-valley winds. In addition, a thermally driven up-valley wind probably causes much of the SW winds under 2.5 m/s (5.5 mph).

Winds are dramatically different during the night. A drainage wind often forms and flows down the plateau on clear nights with light large-scale winds. These winds are generally less than 2.5 m/s (5.5 mph). Wind maxima from the NW and W are evident at OHL and TA-50, respectively, while the drainage wind at Area G is evenly distributed from

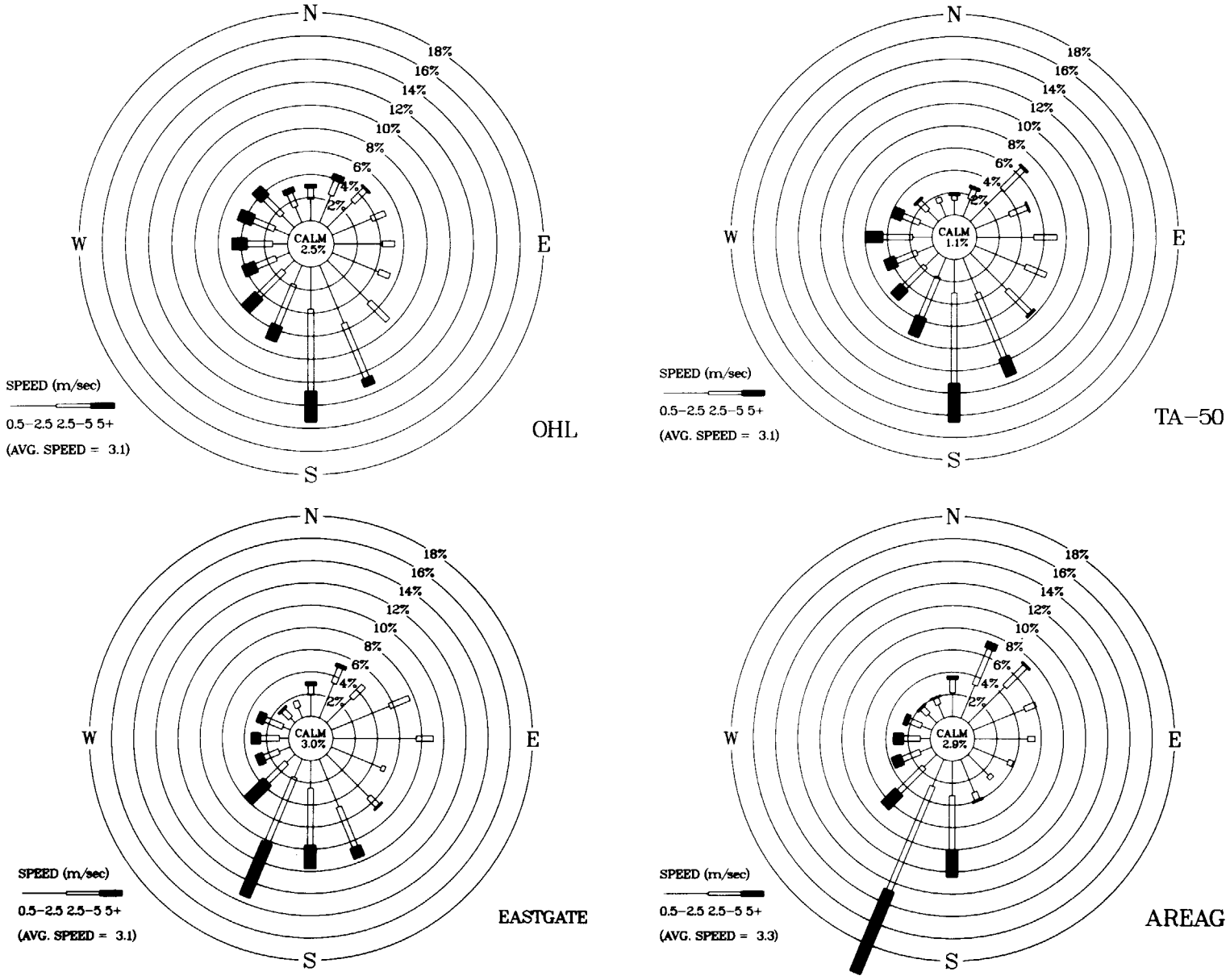


Fig. 26. Daytime wind roses at Laboratory stations in 1985.

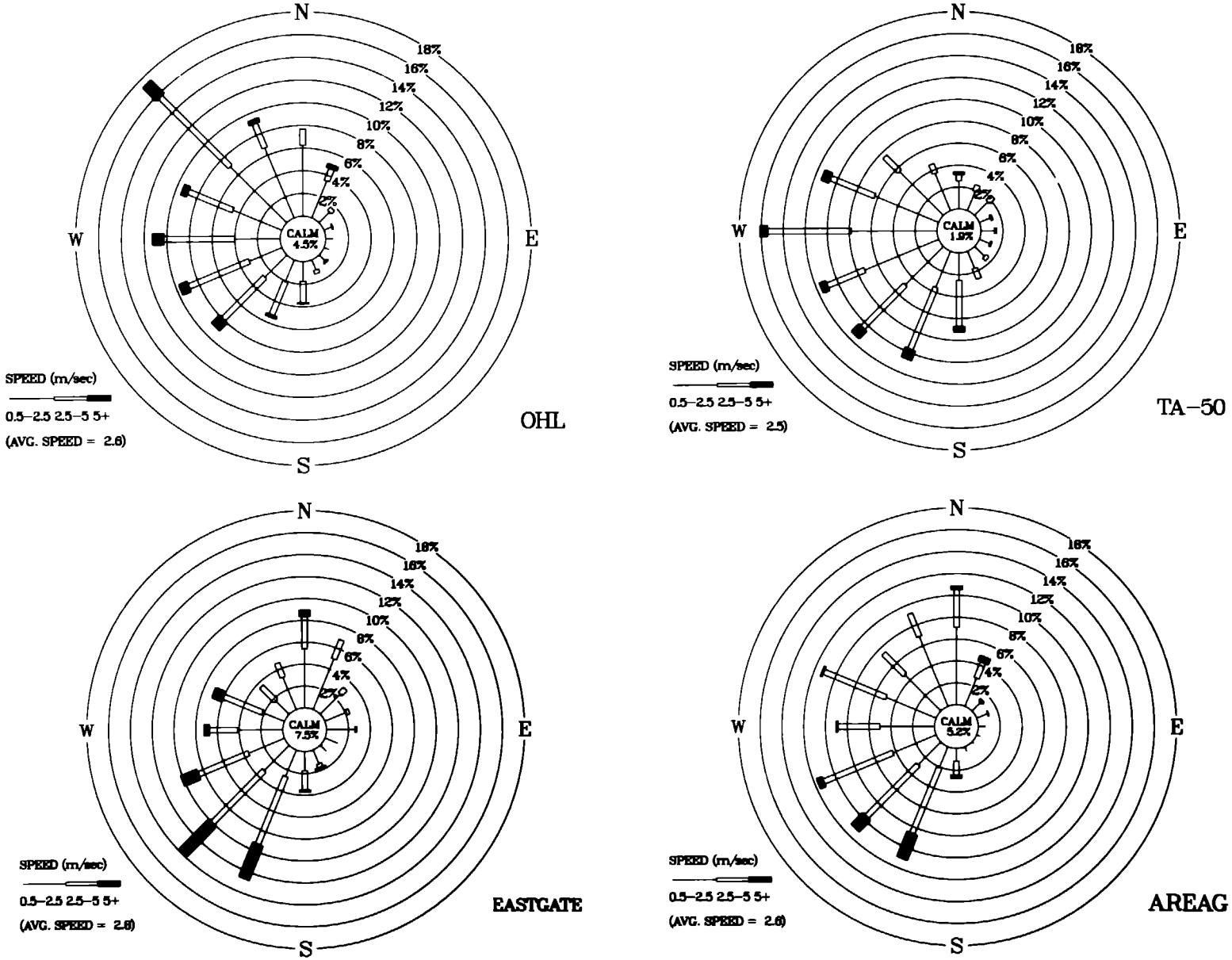


Fig. 27. Nighttime wind roses at Laboratory stations in 1985.

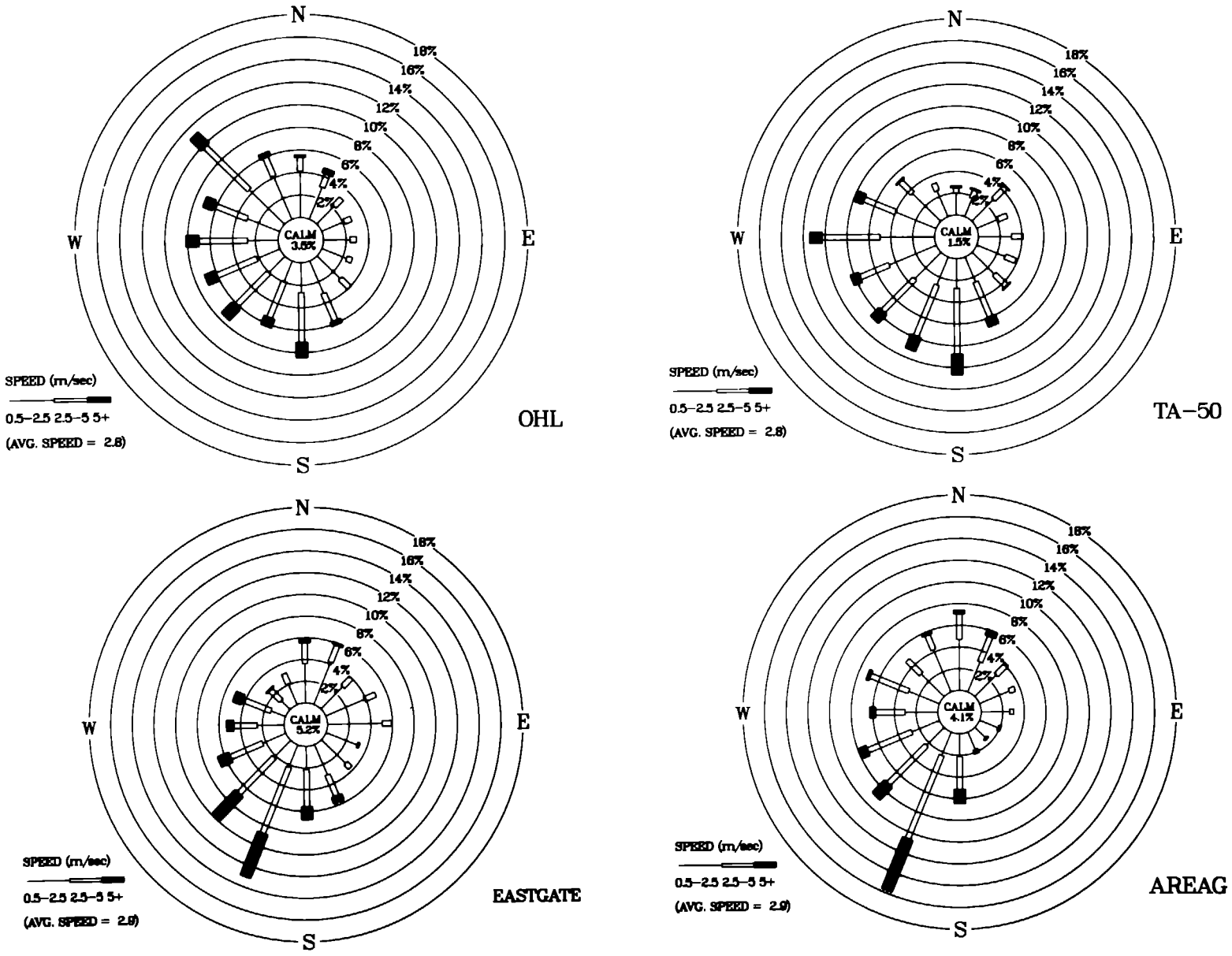


Fig. 28. Cumulative wind roses at Laboratory stations in 1985.

the WNW through the N. Note the absence of downslope winds at East Gate (Fig. 28). Another maximum of winds from the SW and SSW occur at East Gate and Area G due to the channeling effects of the Rio Grande.

3. Rainfall Summary. Precipitation in Los Alamos was heavy during 1985. Figure 29 shows 1985 quarterly and annual precipitation data from five locations in Los Alamos County (see Fig. 30 for locations and Table G-39 for monthly precipitation totals). Precipitation totals were relatively high in the first two quarters due to the unusually stormy weather during the spring months (March-May). Precipitation was nearly 3 times the normal during those months. Normally, only the third quarter has relatively high precipitation totals due to summer thundershowers. Precipitation generally increases with elevation and proximity to the Jemez Mountains.

B. Waste Management

1. Soil Stabilization Studies (D. Smith and R. Ferenbaugh). Radioactive contamination scenarios frequently involve the discharge of radioactive materials onto soil surfaces. In order to prevent further dispersal of contaminated material, some method of soil stabilization is necessary to prevent soil particle resuspension until cleanup can be effected. Such soil stabilization is usually accomplished through chemical application. Studies were undertaken during the summer of 1985 to determine the most efficacious chemical to use as a soil stabilizer, the most appropriate application rate, and the associated ecological effects. Initially, a literature survey was conducted to ascertain the chemicals to be used in the study. Several chemicals were selected for further investigation: Coherex, Norlig A, dust

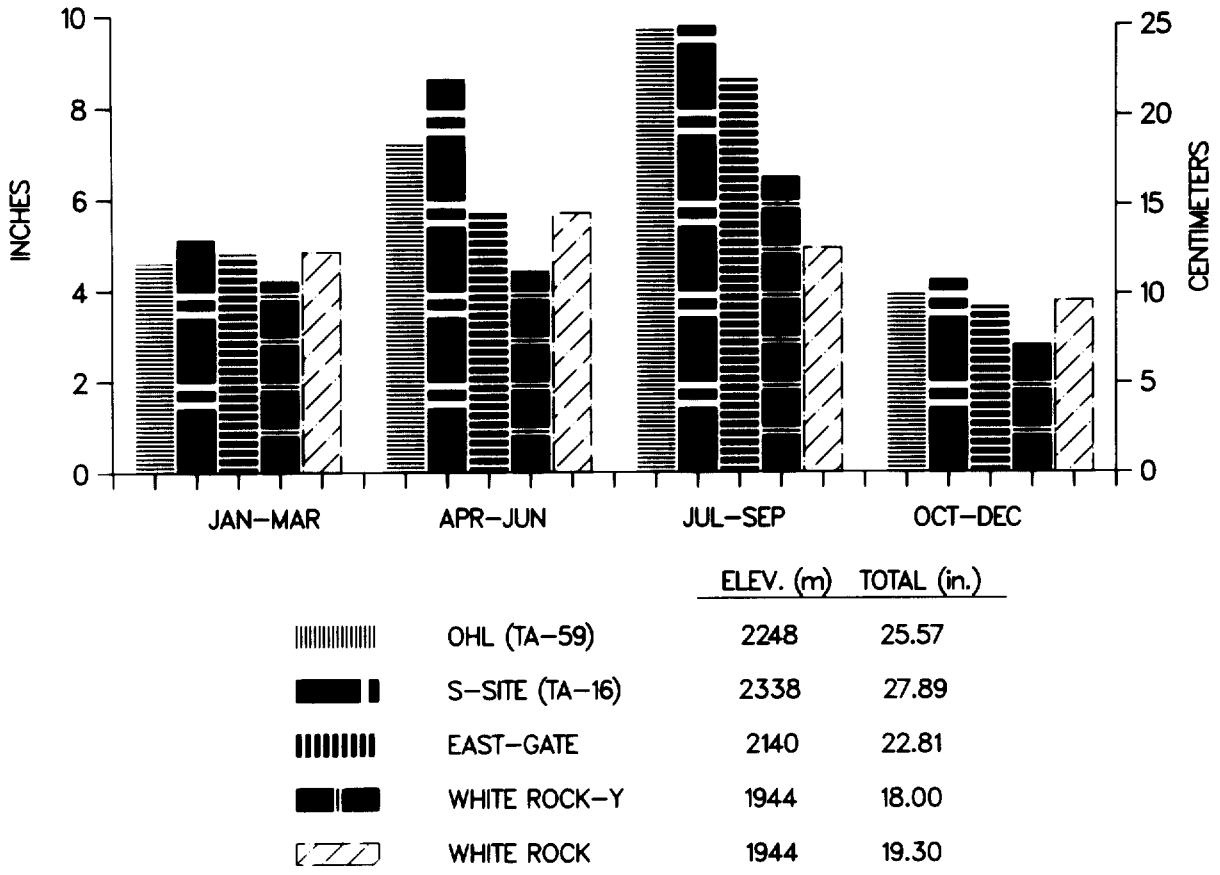


Fig. 29. Summary of precipitation in the Los Alamos area for 1985.

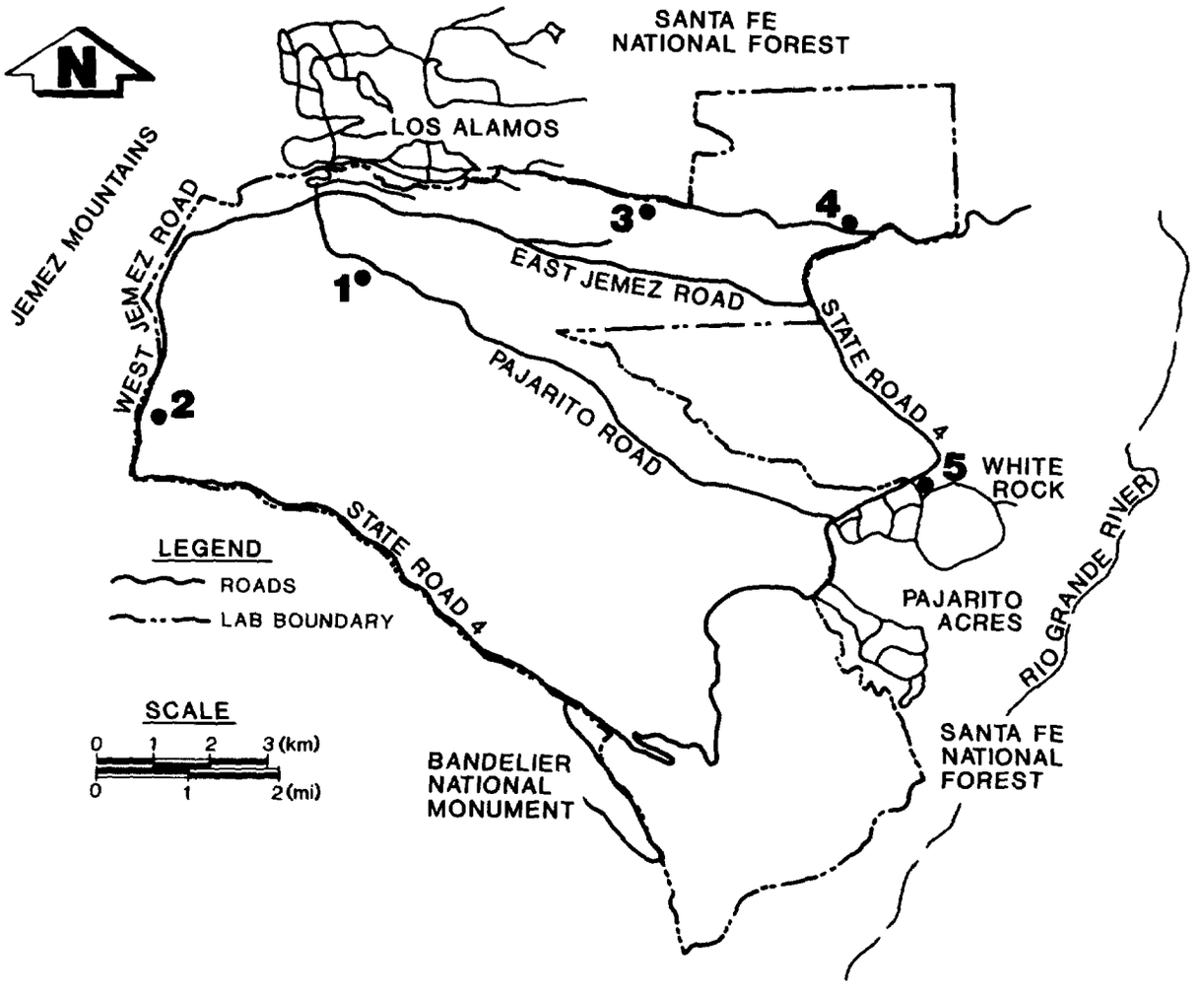


Fig. 30. Locations of rain gage stations.

control oil, and ferric chloride solution. The following greenhouse experiments were conducted using these chemicals:

1. Resuspension studies were conducted by treating flats of plants with the stabilization chemicals and subsequently placing the flats in a wind tunnel. Stable scandium was used as a tracer to determine amount of soil resuspended.
2. Solutions of the stabilization chemicals were applied to soil columns, which were subsequently leached with water and the leachate analyzed for various chemical constituents to determine if the stabilization chemicals had any effect on soil chemical processes.
3. Visual observations of the effects of the soil stabilization chemicals on plant growth were made.
4. Germinating seeds were treated with the stabilization chemicals to see if there was any effect on germination.

The analytical data from these studies are not yet complete.

2. Vadose Zone Characterization at Area L and Area G (M. Devaurs and D. McInroy). The Resource Conservation and Recovery Act (RCRA) requires that hazardous waste disposal facilities such as Los Alamos National Laboratory either (1) perform ground water monitoring or (2) obtain a ground water monitoring waiver. To evaluate whether or not the Laboratory can obtain a ground water monitoring waiver, the State of New Mexico (which has legal authority to enforce RCRA) has defined a vadose

zone characterization program that the Laboratory must complete at waste disposal Areas L and G. The vadose zone is defined as the subsurface volume above the ground water table, containing porous material partially saturated with water. The tasks are defined in a Compliance Order/Schedule (Docket Number 001007) issued by the New Mexico Environmental Improvement Division (EID) on May 7, 1985 under the New Mexico Hazardous Waste Management Act. Bendix Field Engineering Corporation assisted the Laboratory in performing the required geohydrological investigation.

The overall objective of this study at Areas G and L is twofold: (1) to characterize the hydrogeology of the vadose zone and (2) to evaluate the potential for contaminant migration from these two waste disposal areas. Figure 31 shows the approximate locations of the 18 drill holes drilled in and around Areas L and G. Major areas of field data collection at or near Areas L and G are: (1) determination of soil physical properties (i.e., intrinsic permeability, moisture characteristic curve and unsaturated hydraulic conductivity) of five 125 ft deep holes (three at Area L, two at Area G); (2) core and pore gas analyses of seven 100 ft deep holes (2 at Area G, 4 near Area L, and one background hole); (3) moisture distribution with neutron probe and soil psychrometer installations, respectively (two 100-ft holes at Area L, two 50-ft holes at Area G).

Sampling was conducted in accordance with EPA procedures (US EPA, 1985). Hollow-stem-auger continuous coring of tuff was accomplished using a truck-mounted drill rig. The holes were continuously cored using a 8-cm (3-in.) diameter, 1.5-m (5-ft) long, split-barrel sampler attached to the center drill stem of standard 17 m (6-5/8 in.) O.D. hollow-stem auger. Cores were obtained in (1.5-m) 5-ft intervals. Core samples for laboratory analysis were taken at 3-m (10-ft) intervals. From each 10-ft section of core, two representative samples were taken—one for volatile organic analyses and one for inorganic analyses, respectively.

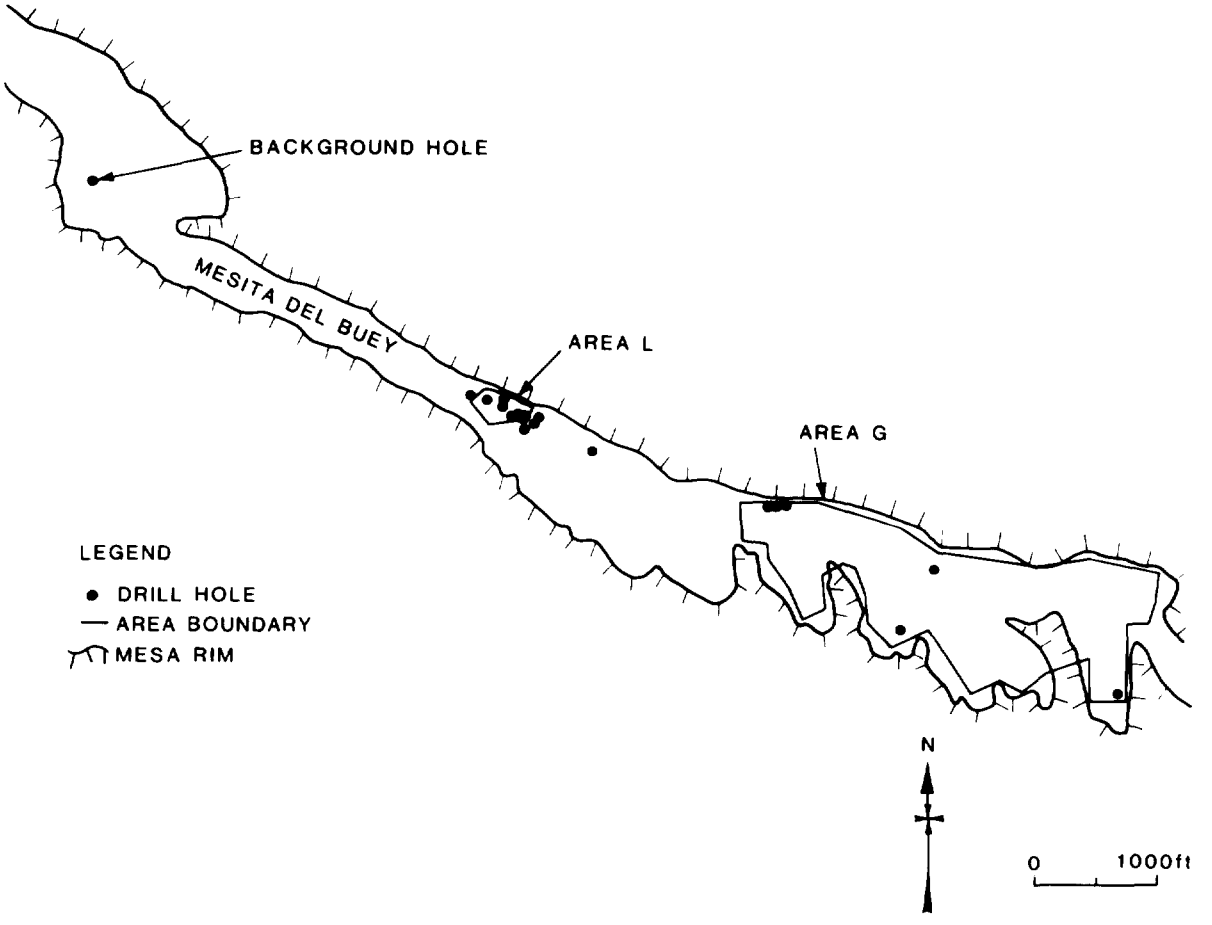


Fig. 31. Locations of drill holes for vadose zone characterization at Areas G and L.

The Laboratory's November 20, 1985 response to the Compliance Order/Schedule provided the EID with results of core analyses and perched water analyses. The Laboratory supplied the EID with two reports: (1) "Hydrologic Characteristics of the Alluvial Acquifers in Mortandad, Canada del Buey and Pajarito Canyons," (Devaurs 1985A) which documents the applicability of research in Mortandad Canyon, and (2) "Core Analyses and Observation Well Data from Mesita del Buey Waste Disposal Areas and Adjacent Canyons," (Devaurs 1985B) which presents data from seven test holes near waste disposal sites (Areas L and G) on Mesita del Buey and from seven observation wells in adjacent canyons.

The Laboratory is required to submit the results of tuff soil physical properties by March 31, 1986. A thorough interpretation of all field data will be presented in a comprehensive final report on this study, to be submitted to the state March 31, 1987.

C. Comprehensive Environmental Assessment and Response Program (CEARP) [R. Vocke, J. Ahlquist, R. Ferenbaugh, M. Martz, K. Rea, N. Becker, R. Gonzales, B. Perkins, and L. Scholl-Fritz]

1. Background. The DOE facilities operate under a policy of full compliance with applicable environmental regulations. The DOE's Albuquerque Operations Office (AL) initiated the Comprehensive Environmental Assessment and Response Program (CEARP) in mid-1984 to help fulfill that commitment at installations within the AL Complex, including facilities in California, Colorado, Florida, Missouri, New Mexico, Ohio, and Texas. The Program assists DOE in setting environmental priorities and in justifying funding enhancements of existing programs or remedial actions. Implementation of CEARP is being accomplished through the combined efforts of the AL complex.

The Program is designed to identify, assess, and correct existing or potential environmental concerns. The scope includes the review of major environmental regulations, with emphasis on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). The program includes evaluation of management practices for hazardous substances. Additionally, assessment of pollution control and monitoring programs for hazardous substances emphasizes both adequate understanding of environmental pathways and regulatory compliance. Implementation of CEARP is intended to help fulfill DOE's obligations for federal facilities under the EPA's CERCLA program . The CEARP is being implemented in five phases.

Phase I, Installation Assessment, will assist in determining present compliance with environmental laws and ascertaining the magnitude of potential environmental concerns. Where insufficient data exist to accomplish this, information needed to complete the evaluation will be identified. Sites posing a hazardous substance release threat will be scored as to their relative hazard. Sites having significant potential for release of hazardous substances, that is, sites meeting USEPA criteria for being listed on the National Priorities List (NPL), will be recommended for future action in order to quantify the potential for hazardous substance migration problem. Sites not meeting USEPA criteria for listing on the NPL, but exceeding other applicable DOE remedial action criteria/guidelines and sites posing potential regulatory compliance concerns may also receive future attention under CEARP.

Phase II, Confirmation and Evaluation, will (1) obtain needed information identified during Phase I, and (2) confirm the presence or absence of potential environmental concerns identified in Phase I. This will be accomplished through planning and carrying out measurement and sampling programs designed to examine potential sources of contaminants and potential environmental pathways.

Phase III, Technology Assessment, will propose and assess alternative approaches for eliminating or controlling environmental problems identified in Phase II. The evaluation will include assessment of technology effectiveness; impacts on health, safety, and the environment; and cost-benefit analysis, as appropriate. Phase III also will include identifying and developing site-specific criteria for field application and performing environmental impact evaluation as required by the National Environmental Policy Act.

Phase IV, Remedial Action, will implement recommended site-specific remedial measures. This could include applying engineering design and construction for remediation or control of environmental concerns.

Phase V, Compliance and Verification, will (1) verify and document the adequacy of remedial actions, and (2) identify and plan for monitoring requirements.

Phase I of CEARP is currently being carried out by personnel of the Laboratory's Environmental Surveillance Group. Phase I activities and reports should be completed during 1986. Monitoring plans are in

preparation and should be completed by during 1986. Reconnaissance surveys (e.g., limited sampling of hazardous substances and geophysical surveys) will be conducted, as appropriate, to support site-specific plan development. Additionally, site characterization activities will be initiated for several high priority AL installation sites during 1986.

2. Los Alamos Laboratory Site Activities [J. Ahlquist and L. Scholl-Fritz]. To date, Phase I activities have included conducting 24 in-person and 30 telephone interviews. Half of the interviewees were at Los Alamos during World War II. Surveys have been done to mark locations at six technical areas and two material disposal areas. Photographic documentation of current conditions was made of 10 material disposal areas and 13 technical areas. Over 100 cubic feet of records including memoranda, letters, progress reports, sample data sheets, notebooks, drawings and aerial photographs have been reviewed. A preliminary radiation survey was done at one technical area.

With supplemental funding from AL, Phase II (confirmation of Phase I findings) activities were conducted at abandoned technical areas (and former firing sites) 20, 27, and 33. Results are pending. Also with the supplemental funding cleanup (Phase IV - Remedial Actions) of abandoned firing sites at TA-4 and TA-5 was accomplished. Some structure removal from TA-20 was also accomplished.

D. Preoperational Surveys [W. J. Wenzel, J. S. Kent, G. Brooks, and K. Jacobson]

Four Preoperational Surveys were conducted during the 1985 calendar year according to individual protocols written to fulfill the DOE Order 5484.1a and DOE Draft Order 5480.2. These surveys establish the baseline radioecological status for the Nuclear Materials Storage Facility (NMSF) at TA-55, the Test Fabrication Facility (TFF) at TA-35, the Tritium Processing Facility (TPF) at TA-16, and the Ground Test Accelerator (GTA) and Weapons Neutron Research Facility (WNRF) at TA-53. The data collected at each survey site was digitized and permanent computer files created. A detailed Preoperational Survey Report will be written for each site before they become operational.

The TA-55 complex includes many diverse facilities such as TA-48, TA-35, TA-50, and plutonium operations in TA-55. About one-third of all laboratory operations are near TA-55. The 1984 and 1985 preoperational survey protocols required extensive air, TLD, soil, litter, plant, and animal sampling and monitoring in the canyons and mesa tops surrounding these facilities. In 1984, 12 sites were sampled and, in 1985, 31 sites were sampled. Each sampling site was characterized ecologically to interpret the sampling data. The ecological data for in-depth transect sites included a site description, plant and animal species list, percentage ground cover measurement, tree and shrub crown area, diameter-at-breast-height, height, and tree age. These data were digitized for each transect and added to the radionuclide and soil hydrological data. Soils sampled from the in depth transects were submitted for nutrient and hydrological analyses. Radiochemical analyses were carried out for the soil, litter, plant and animal samples were done by the Environmental Chemistry Group (HSE-9) for $^{239,240}Pu$, ^{137}Cu, total uranium, and scandium. Cadmium, lead, chromium, and mercury were also analyzed along with PCBs in screening samples. PCBs were chosen for analysis because waste oil is routinely dumped into Mortandad Canyon and 10-Site canyons and its tributarys from several TA-35 mesa top facilities.

In addition to the preoperational survey screening and in-depth site sampling, 96 soil samples were analyzed as part of the Romero cabin study. These data have been incoporated into the preoperational survey data base.

The TFF will routinely handle gram levels of tritium. Tritium (HTO) air monitoring is routinely done near TA-52 southeast of TA-55. These long term airbourne tritium results are the major data set for the preoperational survey baseline. Additional tritium samples were taken on 29 sites surrounding the TFF in the major mesa top drainages and on two of the in-depth transect sites. The tritium soil, litter, and plant samples were collected in sealed glass jars in the field. The samples were then frozen until analysis to reduce cross contamination and to arrest bacterial tritium transformation. Tritium distillation was done by the beaker and watchglass method.

One in-depth transect site directly south of TA-16, TPF, and nine surrounding soil screening sites were sampled in 1985 for tritium, $^{239,240}Pu$, ^{137}Cs, total uranium, scandium, lead, cadmium, mercury, and chromium. The sampling and analysis procedures were done according to protocol as described above for the TA-55 samples. TA-16 will be resampled and the protocol expanded due to a new facility and operations for the TPF.

Two ongoing studies at LAMPF have gathered considerable environmental survey data for the waste pond outfall and the LAMPF stack. An operational Health Physics TLD network for gamma and neutron radiation have been in place for many years.

The 1985 LAMPF preoperational survey consisted of one in depth transect site and eleven screening sites surrounding the ATSU and WNRF. Gamma TLDs were placed at each sampling site. Neutron dosimeters are being developed and calibrated for employment on these sites. Soil, litter, plant, and animal samples were analyzed for ^{7}Be, ^{57}Co, ^{134}Cs, ^{3}H, ^{54}Mn, ^{22}Na, ^{83}Rb, total uranium, scandium, ^{137}Cs, mercury, cadmium, lead, and chromium. Tritium samples were handled and analyzed as described above.

E. BIOTRAN Models [W. J. Wenzel and A. F. Gallegos]

Validation of BIOTRAN for the soil, hydrological, plant, and climate subroutines is the current goal of the BIOTRAN program. Current emphasis in validating the BIOTRAN models is focused on comparing the Cray computer simulations with real field data for several portions of the model. Two areas of validations are in progress, one using the decommissioned radioactive waste site Area B data for scandium, uranium, cesium, and plutonium and the other using the Los Alamos 35 year weather record. The validation procedure is to statistically compare each subroutine with real data. After the validation is completed the analysis shows areas where the model could be changed to increase resolution.

Scandium, uranium, ^{137}Cs, and $^{239,240}Pu$ were analyzed for the 1982 Area B soil, litter, leaf, bole bark, bole wood, root bark, and root wood samples. The Area B data set is unique because it is the only data set where mature trees (greater than 27 years old) have been found and sampled growing in transuranic glovebox waste. This unique data set was used to calibrate the radionuclide transport and root uptake portions of BIOTRAN. The range of concentration between soil and wood (xylem) in the trees was 4-6 orders of magnitude. BIOTRAN was expanded to calculate the particle loading on the tree surfaces (leaves, bark, branches, bole, roots) as well as internally from uptake. The 1982 soil radionuclide concentrations taken near and under the sampled plants were used as input to the BIOTRAN soil subroutine WATFLX. Simulations were carried out by integrating the soil source term from the Area B data over depth for four vegetation types (contaminated ponderosa pine 5, remaining Ponderosa pines, deciduous trees, and shrubs). The 1982 Area B soil source term was then input to WATFLX in layers and a 40 year simulation was done. Simulated concentrations after 40 simulation years in and on the litter, leaves, bole bark, bole wood, root bark, and root wood for the four plant types were then regressed against the measured Area B data for the same plant types and elements. For scandium, a natural element not disposed at Area B. the regression coefficient $r = 0.96$. For uranium $r = 0.98$ and cesium was 0.81. Plutonium was lower at 0.33. A higher correlation ($r = 0.86$) was achieved for cesium by increasing the soil surface source term by the ratio of the litter to the soil data. A higher correlation was also achieved ($r = 0.92$) for plutonium by multiplying the surface soil source term by the ratio of the externally contaminated compartments (litter, leaves and bark) and by multiplying by the ratio of the internal compartments to increase or decrease the deep (second 50 cm soil layer) soil source term. These analyses are described in detail in a new Area B report (Wenzel 1986). The regression analyses indicate that a greater effort (more thorough sampling) should be made to sample the soil source term in three dimensions. It would then be possible to back calculate the actual source term (as well as predict future transport) using environmental samples. The Area B analysis also substantiates the utility of sampling scandium, a widespread soil element, to act as a marker for analysis. Since scandium was not discarded at Area B, its distribution was much more homogeneous on the site as reflected in the regressions.

F. Air Pollution Studies

1. Acid Rain Studies [D. Nochumson and M. Trujillo.] The Laboratory operates a wet deposition station that is part of the National Atmospheric Deposition Program Network. The station is located at the Bandelier National Monument. Weekly samples are collected and sent out for analysis to a central laboratory located at Colorado State University. The results of the analysis, since the 1984 Annual Surveillance Report, are reported in Tables G-48 and G-49. The ionic concentrations and the quantities deposited are quite variable. This variation reflects the variability in the cleanliness of the atmosphere that the storm clouds have come in contact with. The ions in the rainwater are from both nearby and distant, manmade, and natural sources. The natural pH of the rainfall, without manmade contribution, is unknown. The natural pH is most likely higher than 5.6,

for rainwater in equilibrium with atmospheric carbon dioxide because of the contribution from alkaline soils. Seventy-five percent of the precipitation samples had pH's below 5 which indicates contributions from acidic species.

2. Piñon Pine Sulfur Dioxide Study [R. Ferenbaugh, E. Gladney, L. Nelson, and M. Trujillo]. During 1985, a piñon pine study was initiated under an interagency agreement with the National Park Service. There are two parts to this study. One part consists of fumigating piñon pine seedlings with sulfur dioxide to determine injury thresholds. The other part consists of collecting piñon pine foliage and soil samples from selected national parks and monuments for chemical analysis to determine background sulfur content.

There are three sets of fumigations to be completed in the fumigation studies. One-year-old piñon pine seedlings have been fumigated at various sulfur dioxide levels for three hour periods to determine the visible injury threshold for acute fumigations. One-year-old piñon pine seedlings are to be fumigated for 6-week periods at subvisible injury sulfur dioxide concentrations to ascertain the effects of chronic fumigations. Finally, germinating piñon pine seeds are to be fumigated with sulfur dioxide to determine the effects of the fumigation on germination success. The acute fumigation experiments have been completed. Preliminary examination of the data indicates that the threshold for visible injury is a 3-hour exposure at a sulfur dioxide concentration of 3.25-3.75 ppm.

During 1984, soil and piñon pine vegetation samples were collected from Bandelier National Monument, Canyonlands National Park, Chaco Culture National Historic Park, and Mesa Verde National Park. A reconnaissance trip was made to Petrified Forest National Park, but samples will not be collected there until the spring of 1986. The vegetation samples already collected have been separated into year classes of needles, dried, and ground for analysis. The Mesa Verde samples have been analyzed for sulfur content. A preliminary evaluation of the data indicates sulfur concentrations within ranges reported elsewhere for pine foliage.

G. Studies at the Los Alamos Meson Physics Facility

1. Measurement and Modeling of External Radiation from LAMPF Emissions [B. M. Bowen, W. A. Olsen, D. M. Van Etten, and A. I. Chen]. Portable, pressurized ionization chambers (PICs) continued to measure short-term gamma radiation levels produced by air activation products released from LAMPF. These measurements were in addition to those made by the thermoluminescent dosimeter (TLD) network that measures long-term levels. A Gaussian-type atmospheric dispersion model that uses a dose conversion factor assuming an infinite plume (uniform radionuclide concentrations are assumed around receptor point) was used to predict the radiation levels. Onsite meteorological and stack release data were inputs to the model.

Short-term external radiation levels were measured by PICs at azimuths of 0° (north), 22° (north-northeast), and 45° (northeast) from the LAMPF stack across Los Alamos Canyon on State Road 4. The average distance of each site from LAMPF is 800 m (2600 ft). Daily and hourly contributions of external radiation due to LAMPF were determined by subtracting the background levels at all sites. The background levels were estimated by using the radiation levels during periods when the LAMPF plume was not affecting the sites.

Predominant winds in the LAMPF area (East Gate) are from the south to southwest (Figs. 26-28). These winds carry the largest amount of radionuclides and associated external radiation levels to the north and northeast of LAMPF toward the PICs.

Daily model predictions, based on the integration of 15-minute predictions, were made and compared with measured values at the three sites (Fig. 32). There is good correlation between the predicted and measured data. Correlation is especially strong at the NNE site. The slopes of the regression lines indicate that the model as a whole closely predicts at the N PIC, slightly overpredicts at the NNE site, and slightly underpredicts at the NE site. Both the measured and predicted values were approximately 70% less than the levels during 1984, due to the implementation of emissions control.

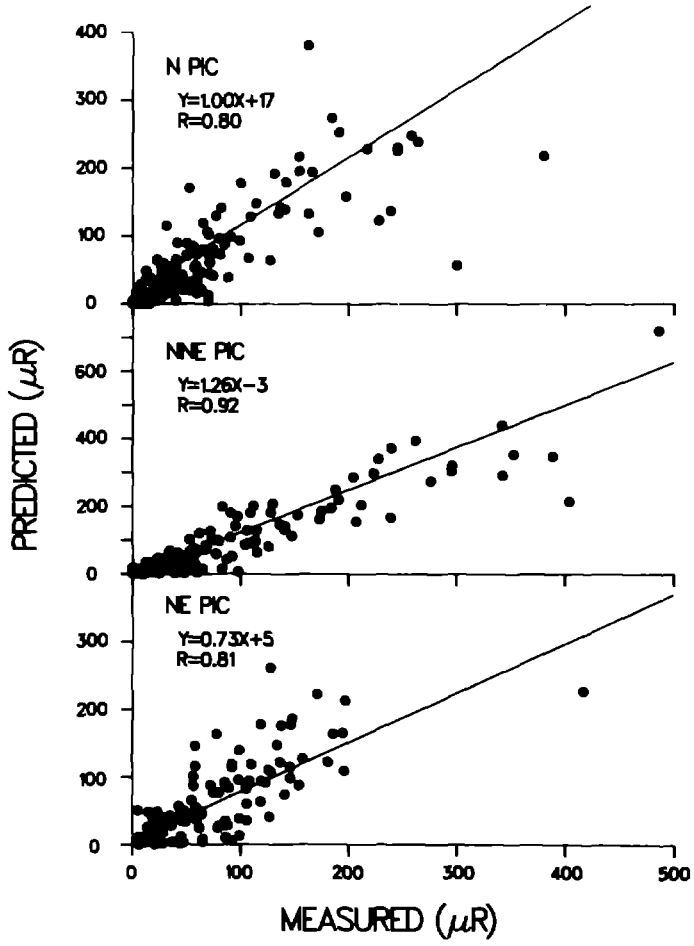


Fig. 32. Predicted versus measured daily external radiation due to LAMPF emissions at sites N, NNE, and NE of LAMPF on State Road 4.

Comparison of total measured external radiation due to LAMPF with predicted values from the model were made for 86 days on which necessary data were available (Table 28). Note that the sum of the 24-hour predictions closely match the measured values. The long-term model, using average wind conditions for the 86 days, also correlates well with the measured values.

Average hourly external radiation levels over 86 days were also measured and predicted. Measured radiation was relatively uniform at the N site, while the diurnal variation is quite noticeable at the other two sites, especially at the NE site. This diurnal variability is due to the persistent SSW and SW winds occurring at night, due to the channeling by the Rio Grande Valley. Predicted levels routinely exceed measured levels during the daytime hours, at the N and NNE sites. It may be that some of the radionuclides mix down into the canyon during the daytime when turbulent mixing is the greatest.

The model was also used to predict annual external radiation on State Road 4 during 1985 due to LAMPF emissions. Predicted levels were slightly higher than the measured values: 21 mR to the NNE of LAMPF, 18 mR to the NE, 16 mR to the N, 11 mR to the NNW, and 6 mR to the NW. This compares with the 11.4 mrem measured by the TLD network.

Table 28. Comparison of Measured External Radiation Levels (mR) by PICS with Predicted Levels Due to LAMPF Emissions for 86 days during 1985

Site	Measured	Sum of 24-Hour Predictions	Long-Term Model
N	5.6	5.1	7.0
NNE	8.0	8.3	9.3
NE	7.0	5.9	7.9

2. Transport of Radionuclides from the LAMPF Lagoons [G. H. Brooks, Jr. (HSE-9), R. W. Ferenbaugh, and W. D. Purtyman]. The effluent release area near the Los Alamos Meson Physics Facility's (LAMPF's) storage lagoons was sampled for a variety of radionuclides (^{7}Be, ^{54}Mn, ^{83}Rb, ^{22}Na, ^{57}Co, ^{3}H, and ^{134}Cs) twice during 1985, July and Decemer (Table G-50). Samples were taken from 8 stations progressing downstream from the point of discharge (station 1) to the confluence with Los Alamos Creek (station 8).

The concentration of each radionuclide in the samples taken at LAMPF's effluent was less than 1% of the Department of Energy's Concentration Guide for Controlled areas. In general, all of the radionuclides' concentrations were lower than in previous years. Specifically, ^{7}Be found in the sediments in the December sampling period, and ^{3}H (water from the July period and sediment from the December period) were the lowest found since the inception of this study (May 1979). Concentrations were found to be half to ten-fold less of those seen in previous data (ESG 1983, 1984, 1985).

Concentrations in the limited sediment samples collected during the December period were found to be ten-fold less than those collected during the same 1984 period (with the exception of ^{54}Mn, which was about half the previous value). Because no water samples were taken during the December collection period due to the lack of any effluent flow, the July data can only be compared with last year's figures. As has been previously seen, there is a reduction in concentrations from the winter to summer collection periods; this is mainly due to the increased biotic activity found during the summer periods. This activity incorporates these isotopes into the metabolic processes (Odum 1971, Menzel 1965, and Woodwell 1967). The data appear consistent with the previous years.

At the point of discharge, the concentrations in sediment are significantly lower than those of the next sampling point. This is primarily due to the lack of an adequate medium that will adsorb the radionuclides, such as found further down the stream. As has been seen in previous years, the concentrations of all of the radionuclides declines drastically past sampling station 4, where effluent sinks into the alluvium precluding any further movement of radionuclides down the stream channel.

It was noted earlier that all of the sediment concentrations calculated in the December period were greatly reduced from either the July 1985 or December 1984 sampling period. This can be attributed to the redesign of the LAMPF lagoon area, where this year a third lagoon was implemented into the design of the facility. The third lagoon is directly south of the existing lagoons, approximately 1.3 times larger that either of the two. With this third lagoon in place, little (if any) effluent is now released to the stream channel, thus drastically reducing both the recharge rate that the stream channel encounters, and the active concentrations found in the samples. Because the effluent flow has been all but eliminated, the concentrations in the sediments can be seen to decrease within the short sampling times of our schedule.

With the new configuration of the LAMPF lagoon system, the radionuclide concentrations in the sediments should decrease over the next several sampling periods (especially apparent with the short-lived isotopes, such as ^{7}Be and ^{54}Mn). This phenomenom should be apparent (but not as pronounced) in the water concentrations, where longer holding times provided by the third pond will allow longer decay times and lower levels of activity discharged to the stream channel. Activity concentrations in water being discharged to the lagoons from the beam stop and other areas are governed by the use of the beam line

and other associated experiments, which still produce high levels in the discharge to the ponds.

H. Related Environmental Studies [N. Becker]

1. Heavy Metals in Runoff. Snowmelt runoff samples were collected in four canyons within the Laboratory boundary; they were Pajarito Canyon at Tech Area 18, Water Canyon at State Road 4, Potrillo Canyon above Eenie Site, Fence Canyon at Meenie Site, and Fence Canyon below Moe Site. All these canyons drain Laboratory firing sites. Runoff samples were collected about once a week for as long as there was runoff at the collection site. Samples were analyzed for beryllium,lead, and mercury.

Analyses for metals in solution in snowmelt runoff are presented in Table 29. The limits of detection in the analysis present difficulty in interpreting the data. Lead in solution, when taking into account the standard deviation of the results, could exceed primary drinking water standards (Table 29). However, none of this water is used for municipal, agricultural, or industrial purposes.

Mercury in solution is, in all instances, below primary drinking water standards. There are no standards for beryllium in water, all concentrations are below 50 μg/ℓ.

Analyses for metals in suspended sediments in snowmelt runoff are presented in Table 30. The limits of detection in the analyses present difficulty in interpreting the data. Beryllium in suspended sediments is less than 10 μg/g in all instances (Table 30). This compares with a mean beryllium concentration of about 1 μg/g in background soil samples in northern New Mexico and 2 μg/g in averaged background soil samples collected on Sigma Mesa on Laboratory land for preoperational surveys, before construction activities began in that area (Ahlquist 1977, Ferenbaugh 1986). Lead in suspended sediment in runoff ranges from less than 34 to 130 μg/g (Table 30). This compares with an average background sample of 23

Table 29. Metals in Water - 1985
(μg/ℓ)

	Number of Samples	Mean	Standard Deviation
Beryllium			
Pajarito Canyon at TA-18	19	<21	16
Water Canyon at State Road 4	1	<50	—
Potrillo Canyon Above Eenie Site	10	<31	16
Fence Canyon at Meenie Site	2	<50	0
Fence Canyon Below Moe Site	2	<19	0
Lead			
Pajarito Canyon at TA-18	19	<106	48
Water Canyon at State Road 4	1	<100	—
Potrillo Canyon Above Eenie Site	10	<95	17
Fence Canyon at Meenie Site	2	<100	0
Fence Canyon Below Moe Site	2	<77	0
Drinking Water Standards[a]		50	
Mercury			
Pajarito Canyon at TA-18	19	<0.6	0.8
Water Canyon at State Road 4	1	<0.2	—
Potrillo Canyon Above Eenie Site	10	<0.3	0.2
Fence Canyon at Meenie Site	2	<0.2	0
Fence Canyon Below Moe Site	2	0.2	0
Drinking Water Standards[a]		2	

[a]Maximum Concentration in Drinking Water, U.S. Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," U.S. Environmental Protection Agency report EPA-570/9-76-0033 (1976).

Table 30. Metals in Suspended Sediments - 1985
(μg/g)

	Number of Samples	Mean	Standard Deviation
Beryllium			
Pajarito Canyon at TA-18	18	<10	7
Water Canyon at State Road 4	1	<10	—
Potrillo Canyon Above Eenie Site	10	<6	3
Fence Canyon at Meenie Site	2	2	0
Fence Canyon Below Moe Site	2	<6	6
Lead			
Pajarito Canyon at TA-18	18	<87	56
Water Canyon at State Road 4	1	130	—
Potrillo Canyon Above Eenie Site	10	<88	69
Fence Canyon at Meenie Site	2	74	94
Fence Canyon Below Moe Site	2	<34	36
Mercury			
Pajarito Canyon at TA-18	18	<1	2
Water Canyon at State Road 4	1	0.3	—
Potrillo Canyon Above Eenie Site	10	<0.8	0.9
Fence Canyon at Meenie Site	2	<0.03	0.03
Fence Canyon Below Moe Site	2	0.8	0.5

μg/g in Sigma Mesa background samples (Ferenbaugh 1986). Mercury in suspended sediment in runoff is less than 1 μg/g (Table 30). This compares with an average background sample of 0.02 μg/g (Ferenbaugh 1986).

2. Environmental Monitoring at the Fenton Hill Site [W. D. Purtymun, N. M. Becker, R. W. Ferenbaugh, M. N. Maes, and M. C. Williams (HSE-9)]

a. Introduction. The Los Alamos National Laboratory is currently evaluating the feasibility of extracting thermal energy from the hot dry rock geothermal reservoir at the Fenton Hill Geothermal Site (TA-57). The site is located about 45 km west of Los Alamos on the southwestern edge of the Valles Caldera. The hot dry rock energy concept involves drilling two deep holes, connecting these holes by hydraulic fracturing, and bringing the thermal energy to the surface by circulating water through the system. Environmental monitoring is done at the site to assess any impacts of the geothermal operations.

b. Chemical Quality of Surface and Ground Water. The chemical quality of surface and ground water in the vicinity of TA-57 (Fig. 33) has been determined for use in geohydrologic and environmental studies. These water quality studies began before construction and testing of the hot dry rock system (Purtymun, 1974D). As samples are collected in November or December, results are published the following year.

Surface water stations (13 on the Jemez River, the Rio Guadalupe, and their tributaries) are divided into four general groups based on common chemical properties of predominate ions and TDS (Table 31). The predominate ions are (1) sodium and chloride, (2) calcium and bicarbonate, (3) calcium and sulfate, and (4) sodium and bicarbonate.

Ground water stations (five mineral and hot springs, one well, and five springs) are grouped with predominate ions: (1) sodium and chloride, (2) calcium and bicarbonate, and (3) sodium and bicarbonate (Table 31).

There was no significant change in the chemical quality of surface and ground water at the individual stations in 1983 when compared with previous years'

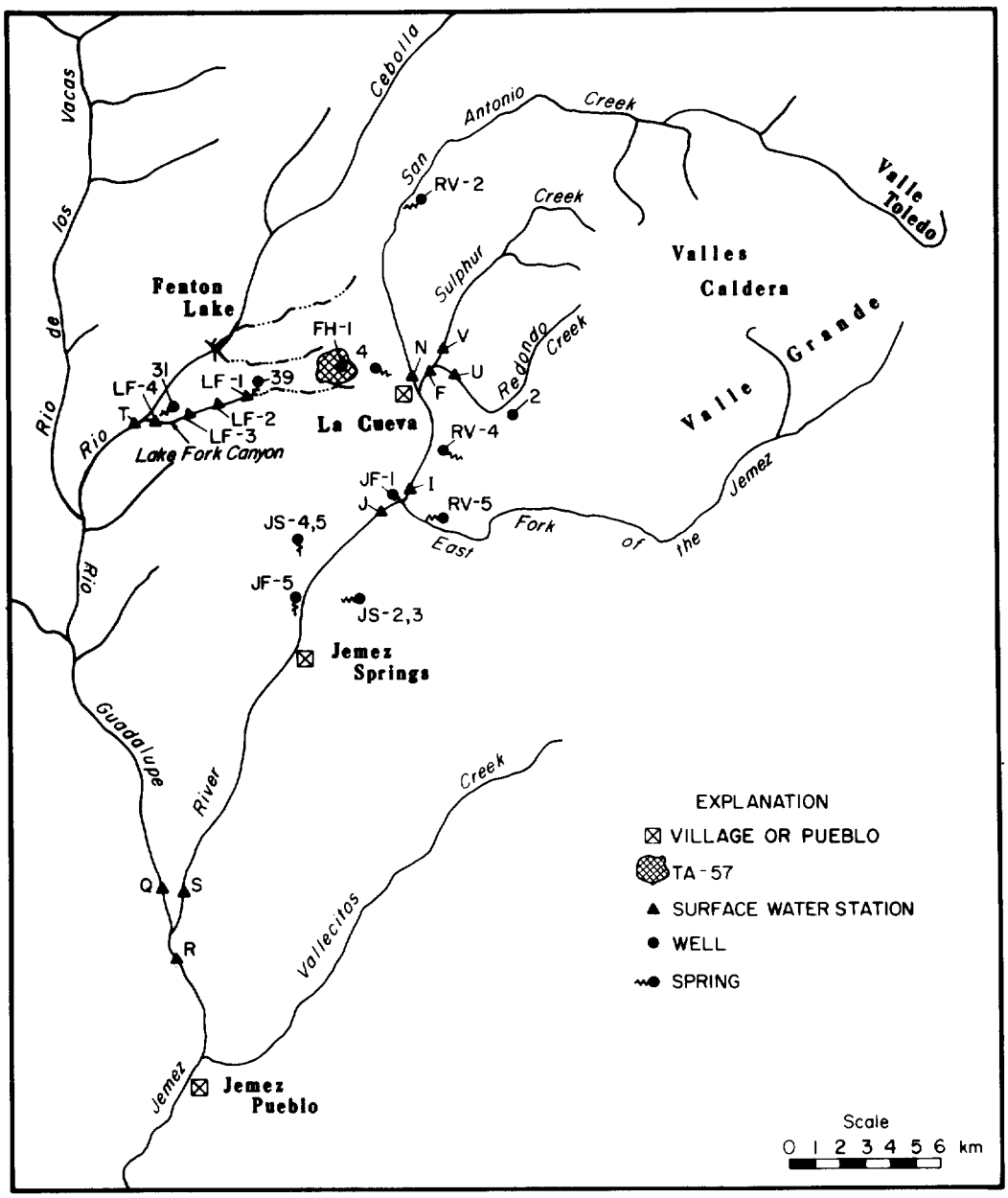


Fig. 33. Sample stations for surface and ground water near the Fenton Hill Site (TA-57).

Table 31. Predominate Ions in Surface and Ground Waters and Ponds at Fenton Hill Geothermal Site (concentrations in mg/ℓ) November 1984[a]

Surface Water

	Na	Cl	TDS
Sodium Chloride			
Redondo Creek (U)	10	39	117
Jemez River (R)	68	92	364
Jemez River (S)	74	92	376
	Ca	**HCO_3**	**TDS**
Calcium Bicarbonate			
San Antonio Creek (N)	13	55	126
Rio Cebolla (T)	19	74	156
Rio Guadalupe (Q)	45	139	212
Lake Fork 1 (LF-1)	19	60	152
Lake Fork 2 (LF-2)	20	80	183
Lake Fork 3 (LF-3)	13	55	97
Lake Fork 4 (LF-4)	13	71	110
	Cac	**SO_4**	**TDS**
Calcium Sulfate			
Sulphur Creek (V)	54	295	518
Sulphur Creek (F)	59	94	168
	Na	**HCO_3**	**TDS**
Sodium Biocarbonate			
Jemez River (J)	16	57	168

Ground Water

	Na	Cl	TDS
Sodium Chloride			
Loc. JF-1 (Hot Spr)	925	1100	1754
Loc. JF-5 (Hot Spr)	965	2500	3268
	Ca	**HCO_3**	**TDS**
Calcium Bicarbonate			
FH-1 (Supply Well)	38	112	219
Loc. 39 (Spr)	15	41	102
	Na	**HCO_3**	**TDS**
Sodium Bicarbonate			
JS-2, 3 (Spr)	17	90	200
JS-4, 5 (Spr)	17	84	174
Loc. 4 (Spr)	32	140	220
Loc. 31 (Spr)	13	59	111
RV-2 (Hot Spr)	23	48	145
RV-4 (Hot Spr)	54	119	230
RV-5 (Hot Spr)	20	70	148

[a]See Fig. 33 for sampling locations. One sample taken at each location.

chemical analyses. Some slight variations are caused by normal seasonal variations.

c. Fenton Hill Soil and Vegetation Samples. Samples of vegetation and soil from the channel bottom and the canyon bank below Pond GTP-3 have been collected annually, except for 1984, since 1978. The collected samples are analyzed for arsenic, boron, cadmium, fluoride, and lithium. The sampling locations are at distances of 100, 200, 400, and 1000 m down canyon from the Pond GTP-3 discharge point. An additional sample is collected from the canyon bottom far down the canyon at its junction with Lake Fork Canyon. The most recent data are shown in Table G-51.

Since last year's surveillance report, the only new data are 1982 arsenic data for roots and foliage and 1983 fluoride and lithium data for roots, foliage, and soil. The 1983 flouride data from roots and foliage generally represent a decrease from the 1982 data, but fluoride in roots and foliage has been quite variable from year to year, so this is not necessarily indicative of any trend. The other new data do not show the trend of decrease with progression down the canyon that has been evident in previous years. This may indicate that what appeared to be an accumulation of these elements immediately below the discharge point is dissipating since discharges from the ponds have ceased.

X. PUBLICATIONS OF THE ENVIRONMENTAL SURVEILLANCE GROUP IN 1985

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos during 1984" Los Alamos National Laboratory report LA-10421-ENV (April 1985).

R. W Ferenbaugh, "Environmental interactions of Sulphlex pavement, an alternative to asphalt" Invited paper presented at the annual meeting of the Pacific Division of the American Association for the Advancement of Science, Missoula, MT (June 10-13,1985).

T. S. Foxx and G. D. Tierney, "Status of the Flora of the Los Alamos National Environmental Research Park. Checklist of Vascular Plants of the Pajarito Plateau and Jemez Mountains" Los Alamos National Laboratory report LA-8050-NERP, Vol. III (June 1985).

W. R. Hansen and J. C. Rodgers, "Radiological Survey and Evaluation of the Fallout Area from the Trinity: Chupadera Mesa and White Sands Missile Range, New Mexico" Los Alamos National Laboratory report LA-110256-MS (June 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).

B. Perkins and G. L. DePoorter, "Plants and their Relationship to Soil Moisture and Tracer Movement" Los Alamos National Laboratory report LA-10216-MS (November 1985).

W. D. Purtymun, N. M. Becker, and M. Maes, "Water Supply at Los Alamos During 1983" Los Alamos National Laboratory report LA-10327-PR (February 1985).

R. W. Vocke, "Case Histories of EA Documents for Nuclear Waste" Los Alamos National Laboratory report LA-UR-85-507 (March 1985).

M. K. Wallwork-Barber, K. A. Lyall, and R. W. Ferenbaugh, "Thallium movement in a simple aquatic ecosystem" Journal of Environmental Science and Health A20: 689-700 (1985).

W. J. Wenzel and A. F. Gallegos 1985. "EFFECTS: Documentation and Verification for a BEIR III Cancer Risk Model Based on Age, Sex, and Population Dynamics for BIOTRAN." Los Alamos National Laboratory report LA-10371-MS

REFERENCES

Ahlquist 1977: A. John Alquist, A. K. Stoker, L. K. Trocki, "Radiological Survey and Decontamination of the Former Main Technical Area (TA-1) at Los Alamos, New Mexico," Los Alamos Scientific Laboratory report LA-6887 (1977).

Devaurs 1985A: M. and W. D. Purtymun, "Hydrologic Characteristics of the Alluvial Aquifers in Mortandad, Canada del Buey and Pajarito Canyons," Los Alamos National Laboratory report LA-UR-85-4002 (November 1985).

Devaurs 1985B: Devaurs, M., "Core Analyses and Observation Well Data from Mesita del Buey Waste Disposal Areas and in Adjacent Canyons," Los Alamos National Laboratory report LA-UR-85-4008 (November 1985).

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/EIS0018 (December 1979).

DOE 1981A: US Department of Energy Order 5480.1A, Chapter XI, "Requirements for Radiation Protection," (April 1981).

DOE 1981B: US Department of Energy Order 5484.1, Chapter III, "Effluent and Environmental Monitoring Program Requirements" (February 1981).

DOE 1985: US Department of Energy, "DOE-Derived Concentration Guides for Drinking Water and Breathing Air Contaminated with Radionuclides by Members of the Public (sic)," attachment to memorandum from R. J. Stern, Director, Office of Environmental Guidance, US Department of Energy (February, 28, 1986).

Engineering 1982: Engineering Division, "Los Alamos National Laboratory Long-Range Site Development Plan," for Los Alamos National Laboratory (September 1982).

EPA 1976: US Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," US Environmental Protection Agency report EPA-570/9-76-0033 (1976).

EPA 1979A: US Environmental Protection Agency, "National Emission Standards for Identifying, Assessing, and Regulating Airborne Substances Posing a Risk of Cancer," Federal Register **44** (197), October 10, 1979, p. 58643.

EPA 1979B: US Environmental Protection Agency, "National Secondary Drinking Water Regulations," Federal Register **44** (140), July 19, 1979.

EPA 1981: US Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors: Highway Mobile Sources," US Environmental Protection Agency report EPA-460/3-81-005 (1981).

EPA 1984: US Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," US Environmental Protection Agency report AP-42, Supplement 15, Third Edition (January 1984).

EPA 1985: US Environmental Protection Agency "Code of Federal Regulations, Protection of the Environment 40, Parts 190 to 399, Special Edition of Federal Register, Revised July 1, 1985, Part 261, Appendix II (July 1, 1985).

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 1984: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1983," Los Alamos National Laboratory report LA-10100-ENV (April 1984).

ESG 1985: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos during 1984" Los Alamos National Laboratory report LA-10421-ENV (April 1985).

Facilities 1983: Facilities Engineering Division, "Laboratory Quality Assurance Manual for Engineering and Construction," Los Alamos National Laboratory Manual (September 1983, Revision 5).

Ferenbaugh 1986: R. W. Ferenbaugh, E. S. Gladney, and G. H. Brooks, Jr. "Sigma Mesa—Background Elemental Concentrations in Soil and Vegetation: 1979," Los Alamos National Laboratory report (in preparation).

Gunderson 1983: T. Gunderson, T. Buhl, R. Romero, and J. Salazar, "Radiological Survey Following Decontamination Activities Near the TA-45 Site," Los Alamos National Laboratory report LA-9831-MS (July 1983).

Hakonson 1976A: T. E. Hakonson and K. V. Bostick, "Cesium-137 and Plutonium in Liquid Waste Discharge Areas at Los Alamos," 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, Inc., 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," Proc. Transuranium Nuclides in the Environment, International Atomic Energy Agency report IAEA-SM-199/99 (1976).

ICRP 1977: International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection," adopted January 17, 1977, Annals of the ICRP 1 (3) (1977), ICRP Publication No. 26.

Klement 1972: A. W. Klement, Jr., C. R. Miller, R. P. Minx, and B. Shleien, "Estimates of Ionizing Radiation Doses in the United States 1960-2000," US Environmental Protection Agency report ORP/CSD 72-1 (August 1972).

Kramer 1977: Kramer, Callahan, and Associates, "Particulate Analyses of Drier Exhaust Emissions at the Zia Company Asphalt Plant, Los Alamos, New Mexico" (September 1977).

Menzel 1965: R. G. Menzel, "Soil-Plant Relationships of Radioactive Elements," Health Physics 11, 1325-1332 (1965).

MHSM 1976: Mason and Hanger-Silas Mason Co., Inc., "Disposal of Waste or Excess High Explosives," MHSM quarterly progress reports (January 1971 through March 1976).

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).

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 1984A: 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 (1984).

NCRP 1984B: National Council on Radiation Protection and Measurements, "Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the United States," National Council on Radiation Protection and Measuremnts report No. 78 (May 1984).

NRC 1980: National Research Council, Committee on the Biological Effects of Ionizing Radiations, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980," National Academy Press, Washington, D.C. (1980).

Odum 1971: E. P. Odum, *Fundamentals of Ecology* (W. B. Saunders Co., Philadelphia, 1971), pp. 86-99.

Paxton 1975: H. C. Paxton, "Safety and Analysis of the Los Alamos Critical Experiments Facility," Los Alamos Scientific Laboratory report LA-6206, Vol. II (October 1975).

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 W. 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 Their Influence on Water Quality in a Shallow Aquifer," J. of Environmental Quality **6** (1) (January-March 1977).

Purtymun 1980A: W. D. Purtymun and H. Adams, "Geohydrology of Bandelier National Monument," Los Alamos Scientific Laboratory report LA-8461-MS (July 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 Ground Water Supplies," Los Alamos National Laboratory report LA-9957-MS (January 1984).

Purtymun 1986: W. D. Purtymun, R. J. Peters, T. H. Buhl, and M. Maes, "Recap of Radionuclides in Soils and Sediments from Regional Stations, 1978-85," Los Alamos National Laboratory report (in preparation).

Salazar 1984: J. G. Salazar, "Produce and Fish Sampling Program of Los Alamos National Laboratory's Environmental Surveillance Group," Los Alamos National laboratory report LA-10186-MS (September 1984).

Slade 1968: D. H. Slade, Ed., "Meteorology and Atomic Energy 1967," US Atomic Energy Commission document TID-24190 (1968).

USGS 1985: U. S. Geological Survey, "Water Resource Data for New Mexico Water Year 1984," U. S. Geological Survey water data report NM-84-1 (1985).

Wenzel 1986: W. J. Wenzel, T. S. Foxx, G. Tierney, J. C. Rodgers and A. F. Gallegos "^{137}CS, ^{239}Pu, Scandium and Uranium in Trees and Shrubs Growing in Transuranic Waste at Area B." LA-MS Report (in preparation).

Woodwell 1967: G. M. Woodwell, "Toxic Substances and Ecological Cycles," Scientific American 216 (3), 24-31 (1967).

Yeates 1972: D. B. Yeates, A. S. Gilden, and D. W. Moeller, "Natural Radiation in the Urban Environments," Nuclear Safety 13 (4), 2754 (July-August 1972).

APPENDIX A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

Throughout this report, concentrations of radioactive and chemical contaminants in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. Comparable standards for soils, sediments, and foodstuffs are not available. Laboratory operations are conducted in accordance with directives and procedures regarding compliance with environmental standards. These directives are contained in DOE Order 5480.1A (Environmental Protection, Safety, and Health Protection Program for DOE Operations) Chapter XI (Requirements for Radiation Protection); DOE Order 5484.1 (Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements), Chapter III (Effluent and Environmental Monitoring Program Requirements); and DOE Order 5480.4 (Environmental Protection, Safety, and Health Protection Standards). All of these DOE orders are in the process of being revised, and, although draft orders have been prepared, they have not been finalized.

The DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received. 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 involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-year dose commitments were calculated using dose factors from Reference A1. The dose factors adopted by DOE are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP).[A2] Those factors used in this report are presented in Appendix D.

In 1985, DOE adopted interim limits that lowered its Radiation Protection Standard (RPS) for members of the general public, in accordance with EPA regulations outlined in 40 CFR 61.[A3,A4] Table A-1 lists currently applicable RPSs for operations at the Laboratory. Concentrations of radionuclides that are measured at onsite stations are compared with DOE's Concentration Guides (CGs) for Controlled Areas as listed in Chapter XI, DOE Order 5480.1 (Table A-2). Offsite measurements are compared with DOE's Derived Concentration Guides (DCGs) for Uncontrolled Areas, based upon a revised RPS for the general public of 100 mrem/yr effective dose equivalent.[A5] These DCGs represent the smallest estimated concentrations in water or air, taken in continuously for a period of 50 years, that will result in annual effective dose equivalents equal to the RPS of 100 mrem. The new RPSs and the information in Reference A1 are based on recommendations of the ICRP, the recommendations of EPA's 40 CFR 61, and the National Commission on Radiation Protection and Measurements (NCRP).[A2,A3,A4]

The DCG for airborne radioactivity is the concentration that, if inhaled continuously, will result in an effective dose equivalent equal to the DOE's RPS of 100 mrem/year for all pathways.[A3] The effective dose equivalent is the hypothetical whole body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure. The effective dose 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 effective dose equivalent includes dose from both internal and external exposure.

For each radionuclide, the DCG was calculated by

$$DCG = RPS/(BR \cdot DCF)$$

where, RPS = 0.1 rem/year, the DOE Radiation Protection Standard,[A3]

BR = 8.400×10^9 mℓ/year, the breathing rate for the standard man,[A2] and

DCF = the dose conversion factor giving the effective dose in rem/μCi inhaled.[A1]

Table A-1. DOE Radiation Protection Standards for External and Internal Exposures

Exposure of Any Member of the Public[a]

1. All pathways

	Annual Effective Dose Equivalent[b] at Point of Maximum Probable Exposure
Occasional annual[c] exposure	500 mrem
Prolonged annual[c] exposure	100 mrem

No individual organ shall receive an annual dose equivalent in excess of 5000 mrem.

2. Air pathway only[d]

	Annual Dose Equivalent at Point of Maximum Probable Exposure
Whole body dose	25 mrem
Any organ	75 mrem

Occupational Exposures[a]

Type of Exposure	Exposure Period	Dose Equivalent
Whole body, head and trunk, gonads, lens of the eye[e], red bone marrow, active blood forming organs	Year	5 000 mrem
	Calendar Quarter	3 000 mrem
Unlimited area of the skin (except hands and forearms); other organs, tissues, and organ systems (except bone)	Year	15 000 mrem
	Calendar Quarter	5 000 mrem
Bone	Year	30 000 mrem
	Calendar Quarter	10 000 mrem
Forearms[f]	Year	30 000 mrem
	Calendar Quarter	10 000 mrem
Hands and feet[f]	Year	75 000 mrem
	Calendar Quarter	25 000 mrem

[a]In keeping with DOE policy, exposures shall be limited to as small a fraction of the respective annual dose limits as practicable. These Radiation Protection Standards apply to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, 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 Reference A3. Limits for occupational exposure are taken from DOE Order 5480.1, Chapter XI.

[b]As used by DOE, effective dose equivalent includes both the effective dose equivalent from external radiation and the committed effective dose equivalent to individual tissues from ingestion and inhalation during the calendar year.

[c]For the purposes of DOE's Radiation Protection Standard, a prolonged exposure will be one that lasts, or is predicted to last, longer than 5 years.

[d]These levels are from EPA's regulations promulgated under the Clean Air Act (40 CFR 61, Subpart H).

[e]Beta exposure below 700 keV will not penetrate the lens of the eye; therefore, the applicable limit for beta radiation of these energies would be that for skin, 15 000 mrem/year.

[f]All reasonable effort should be made to keep exposure of forearms and hands within the general limit for skin.

Table A-2. DOE's Derived Concentration Guides (DCG) for Uncontrolled Areas and Concentration Guides (CG) for Controlled Areas (μCi/mℓ)[a]

Nuclide	DCGs for Uncontrolled Areas		CGs for Controlled Areas	
	Air	Water	Air	Water
^{3}H	1×10^{-7}	2×10^{-3}	5×10^{-6}	1×10^{-1}
^{7}Be	5×10^{-8}	1×10^{-3}	1×10^{-6}	5×10^{-2}
^{89}Sr	3×10^{-10}	2×10^{-5}	3×10^{-8}	3×10^{-4}
^{90}Sr[b]	9×10^{-12}	1×10^{-6}	1×10^{-9}	1×10^{-5}
^{137}Cs	4×10^{-10}	3×10^{-6}	1×10^{-8}	4×10^{-4}
^{234}U	9×10^{-14}	5×10^{-2}	1×10^{-10}	1×10^{-4}
^{235}U	1×10^{-13}	6×10^{-7}	1×10^{-10}	1×10^{-4}
^{238}U	1×10^{-13}	6×10^{-7}	7×10^{-11}	2×10^{-5}
^{238}Pu	3×10^{-14}	4×10^{-7}	2×10^{-12}	1×10^{-4}
^{239}Pu[b]	2×10^{-14}	3×10^{-7}	2×10^{-12}	1×10^{-4}
^{240}Pu	2×10^{-14}	3×10^{-7}	2×10^{-12}	1×10^{-4}
^{241}Am	2×10^{-14}	6×10^{-8}	6×10^{-12}	1×10^{-4}
	(pg/m^3)	(mg/ℓ)	(pg/m^3)	(mg/ℓ)
U, natural[c]	$1 \times 10^{+5}$	8×10^{-1}	$2 \times 10^{+8}$	$6 \times 10^{+1}$

[a]Guides for uncontrolled areas are based upon DOE's Radiation Protection Standard (RPS) for the general public;[A5] those for controlled areas are based upon occupational RPSs from DOE Order 5480.1, Chapter XI. Guides apply to concentrations in excess of that occurring naturally or due to fallout.

[b]Guides for ^{239}Pu and ^{90}Sr are the most appropriate to use for gross alpha and gross beta, respectively.

[c]One curie of natural uranium is equivalent to 3000 kg of natural uranium. Therefore, uranium masses may be converted to DOE's "uranium special curie" by multiplying by 3.3×10^{-13} μCi/pg.

Similarly, the DCGs for waterborne radioactivity are the concentrations that will result in an effective dose equivalent of 100 mrem/year if ingested continuously. They are calculated using

$$DCG = RPS/(ING \cdot DCF)$$

where, RPS = 0.1 rem/year, the DOE Radiation Protection Standard,[A3]

ING = 7.3×10^5 mℓ/year, the rate of ingestion of drinking water for the standard man,[A2] and

DCF = the dose conversion factor giving the effective dose in rem per μCi ingested.[A1]

Radionuclide concentrations in air and water in uncontrolled areas measured by the Laboratory's surveillance program are compared to these DCGs in this report. In addition to the 100 mrem/year effective dose RPS, exposures from the air pathway are also limited by the EPA's standard of 25 mrem/year (whole body) and 75 mrem/year (any organ) (Table A-1). To demonstrate compliance with these standards, doses from the air pathway are compared directly with these dose limits in this report.

For chemical pollutants in drinking water, standards have been promulgated by the Environmental Protection Agency and adopted by the New Mexico Environmental Improvement Division (Table A-3). The EPA's primary Maximum Contaminant Level (MCL) is the maximum permissible level of a contaminant in water that is delivered to the outlet of the ultimate user of a public water system.[A7] The EPA's secondary water standards control contaminants in drinking water that primarily affect esthetic qualities associated with public acceptance of drinking water.[A8] At considerably higher concentrations of these contaminants, health implications may arise.

Table A-3. Maximum Contaminant Level (MCL) in Water Supply for Inorganic Chemicals and Radiochemicals[a]

Inorganic Chemical Contaminant	MCL (mg/ℓ)	Radiochemical Contaminant	MCL (μCi/mℓ)
	Primary Standard		
Ag	0.05	^{137}Cs	200×10^{-9}
As	0.05	Gross alpha[b]	15×10^{-9}
Ba	1.0	^{3}H	20×10^{-6}
Cd	0.010	^{238}Pu	15×10^{-9}
Cr	0.05	^{239}Pu	15×10^{-9}
F[c]	2.0		
Hg	0.002		
NO_3	45		
Pb	0.05		
Se	0.01		
	Secondary Standards		
Cℓ	250		
Cu	1.0		
Fe	0.3		
Mn	0.05		
SO_4	250		
Zn	5.0		
TDS	500		
pH	6.5 - 8.5		

[a]Source: References A7 and A8.
[b]See text for discussion of application of gross alpha MCL and gross alpha screening level of 5×10^{-9} μCi/mℓ.
[c]Based on annual average of the maximum daily air temperature of 14.6 to 17.7°C.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141.[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 is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with the gross alpha standard for drinking water (Table A-3). For manmade beta and photon emitting radionuclides, drinking water concentrations are limited to concentrations that would result in doses not exceeding 4 mrem/yr, calculated according to a specified procedure.

The EPA[A9] established minimum concentrations of certain contaminants in a water extract from wastes for designation of these wastes as hazardous by reason of toxicity. The Extraction Procedure (EP) must follow steps outlined by EPA in 40 CFR 261, Appendix II. In this report, the EP toxicity minimum concentrations (Table A-4) are used to compare to concentrations of selected constituents in extracts from the Laboratory's active waste areas.

REFERENCES

A1. U.S. Department of Energy, "Committed Dose Equivalent Tables for U.S. Department of Energy Population Dose Calculations," prepared by J.P. Corley, Ed. for the U.S. Department of Energy (draft, 1985).

A2. International Commission on Radiological Protection, "Report of the Task Group on Reference Man," ICRP Publication 23 (1975).

Table A-4. Minimum Concentrations of Inorganic Contaminants for Meeting EPA's Extraction Procedure Toxicity Characteristic for Hazardous Waste[a]

Contaminant	Criteria Concentration (mg/ℓ)
Arsenic	5.0
Barium	100.0
Cadmium	1.0
Chromium	1.0
Lead	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0

[a]Source: Reference A9.

A3. U.S. Department of Energy, "Radiation Standards for the Protection of the Public in the Vicinity of DOE Facilities," memorandum from William A. Vaughan, Assistant Secretary for Environment, Safety, and Health, U.S. Department of Energy (August 5, 1985).

A4. U.S. Environmental Protection Agency, "National Emission Standard for Radionuclide Emissions from Department of Energy Facilities," Code of Federal Regulations, Title 40, Part 61, Subpart H (1985).

A5. U.S. Department of Energy, "DOE-Derived Concentration Guides for Drinking Water and Breathing Air Contaminated with Radionuclides by Members of the Public [sic]," attachment to memorandum from R. J. Stern, Director, Office of Environmental Guidance, U.S. Department of Energy (February 28, 1986).

A6. Federal Radiation Council, "Background Material for the Development of Radiation Protection Standards," Federal Radiation Protection Council report No. 1 (1960).

A7. US Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," US Environmental Protection Agency report EPA-570/9-70-003 (1976) and 40 CFR 141.

A8. US Environmental Protection Agency, "National Secondary Drinking Water Regulations," Federal Register 44(140) (July 19, 1979).

A9. Environmental Protection Agency, "Part 261—Identification and listing of hazardous waste. Table 1—Maximum concentration of contaminants for characteristics of EP toxicity," Federal Register 45: 33122 (May 19, 1980).

APPENDIX B

PROCEDURES SAMPLING, DATA HANDLING, AND QUALITY ASSURANCE

A. Thermoluminescent Dosimeters

The thermoluminescent dosimeters (TLDs) used at the Laboratory are 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 at 400°C for 1 h and then cooled rapidly to room temperature. This is followed by annealing at 100°C for 1 h and again cooling rapidly to room temperature. In order 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 all can be placed at once into the ovens maintained at 400°C and 100°C.

Four LiF chips constitute a dosimeter. The LiF chips are contained 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 set contains from 20 to 50 dosimeters. These are irradiated at levels in the range between 0 mR and 80 mR using an 8.5 mCi ^{137}Cs source calibrated by the National Bureau of Standards.

A factor of 1 rem (tissue) = 1.050 mR is used in evaluating the dosimeter data. This factor is the reciprocal of the product of the roentgen-to-rad conversion factor of 0.958 for muscle for ^{137}Cs and the factor 0.994, which corrects for attenuation of the primary radiation beam at electronic equilibrium thickness. A rad-to-rem conversion factor of 1.0 for gamma rays is used as recommended by the International Commission on Radiation Protection.[B1,B2] A method of weighted least squares linear regression is used to determine the relationship between TLD reader response and dose (weighting factor is the variance).[B3]

The TLD chips used are all from the same production batch and were selected by the manufacturer so that the measured standard deviation in TL sensitivity is 2.0 to 4.0% of the mean at a 10 R exposure. At the end of each field cycle, whether calendar quarter or the Los Alamos Meson Physics Facility operation cycle, the dose at each network location is estimated from the regression along with the regression's upper and lower 95% confidence limits at that estimated value.[B4] At the end of the calendar year, individual field cycle doses are summed for each location. Uncertainty is calculated as summation in quadrature of the individual uncertainties.[B3]

B. Air Sampling

Samples are collected monthly at 26 continuously operating stations.[B5] Air pumps with flow rates of about 3 ℓ/sec are used. Atmospheric aerosols are collected on 79 mm diameter polystyrene filters. Each filter is mounted on a cartridge that contains charcoal. This charcoal is not routinely analyzed for radioactivity. However, if an unplanned release occurs, the charcoal can be analyzed for any ^{131}I it may have collected. Part of the total air flow (2.4 to 3.1 mℓ/sec) is passed through a cartridge containing silica gel to adsorb atmospheric water vapor for tritium analyses. Air flow rates through both sampling cartridges are measured with rotameters and sampling times recorded. The entire air sampling train at each station is cleaned, repaired, and calibrated on an as-needed basis.

Two clean, control filters are used to detect any possible contamination of the 26 sampling filters while they are in transit. The control filters accompany the 26 sampling filters when they are placed in the air samplers and when they are retrieved. Then the control filters are analyzed for radioactivity just like the 26 sampling filters. Analytical results for the

control filters are subtracted from the appropriate gross analytical results to obtain net analytical data.

At one onsite location (N050-E040) atmospheric radioactivity samples are collected weekly. Atmospheric particulate matter on each weekly filter is counted for gross alpha and gross beta activities, which help trace temporal variations in atmospheric radioactivity concentrations. The same measurements are made on a monthly filter from the Española (Station 1) regional air sampler.

On a quarterly basis, the monthly filters for each station are cut in half. The filter halves are combined to produce two quarterly composite samples for each station. The first group is analyzed for ^{238}Pu, $^{239,240}Pu$, and ^{241}Am (on selected filters). The second group of filter halves is saved for uranium analyses.

Filters from the first composite group are ignited in platinum dishes, treated with $HF\text{-}HNO_3$ to dissolve silica, wet ashed with $HNO_3\text{-}H_2O_2$ to decompose organic residue, and treated with $HNO_3\text{-}HCl$ to ensure isotopic equilibrium. Plutonium is separated from the resulting solution by anion exchange. For 11 selected stations, americium is separated by cation exchange from the eluent solutions resulting from the plutonium separation process. The purified plutonium and americium samples are separately electrodeposited and measured for alpha-particle emission with a solid state alpha detection system. Alpha particle energy groups associated with the decay of ^{238}Pu, $^{239,240}Pu$, and ^{241}Am are integrated and the concentration of each radionuclide in its respective filter sample calculated. This technique does not differentiate between ^{239}Pu and ^{240}Pu. Uranium analyses by neutron activation analysis (see Appendix C) are done on the second group of filter halves.

Silica gel cartridges from the 26 air sampling stations are analyzed monthly for tritiated water. The cartridges contain a small amount of blue "indicating" gel at each end to indicate the degree of dessicant saturation. During cold months of low absolute humidity, sampling flow rates are increased to ensure collection of enough water vapor for analysis. Water is distilled from each silica gel cartridge and an aliquot of the distillate is analyzed for tritium by liquid scintillation counting. The amount of water absorbed by the silica gel is determined by the difference between weights of the gel before and after sampling.

Analytical quality control for analyses done in the air sampling program are described in Appendix C. In brief, both blanks and standards are analyzed in conjunction normal analytical procedures. About 10% of the analyses are devoted to quality control.

C. Water Sampling

Surface and ground water sampling stations are grouped by location (regional, perimeter, onsite) and hydrologic similarity. Water samples are taken once or twice a year. Samples from wells are collected after sufficient pumpage or bailing to ensure that the sample is representative of the aquifer. Spring samples (ground water) are collected at the discharge point.

The water samples are collected in 4-ℓ (for radiochemical) and 1-ℓ (for chemical) polyethylene bottles. The 4-ℓ bottles are acidified in the field with 5 ml of concentrated nitric acid and returned to the laboratory within a few hours of sample collection for filtration through a 0.45-μm pore membrane filter. The samples are analyzed radiochemically ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{3}H and total U, as well as for gross alpha, gross beta, and gamma activities. Water samples for chemical analyses are handled similarly.

Storm runoff samples are analyzed for radionuclides in solution and suspended sediments. The samples are filtered through a 0.45-μm filter. Solution is defined as filtrate passing through the filter, while suspended sediment is defined as the residue on the filter.

D. Soil and Sediment Sampling

Two soil sampling procedures are used. The first procedure is used to take surface composite samples. Soils samples are collected by taking 5 plugs, 75 mm (3.0 in.) in diameter and 50 mm (2.0 in.) deep, at the center and corners of a square area 10 m (33 ft) on a side. The five plugs are combined to form a composite sample for radiochemical analysis.

The second procedure is used to take surface and subsurface samples at one sampling location. Samples are collected from three layers in the top 30 cm (12 in.) of soil. A steel ring is placed on the surface of the soil at the sampling point. The soil enclosed by the ring is then collected by under-cutting the ring with a metal spatula. A second spatula is then placed on top of the ring and the sample is transfered into a plastic bag. The plastic bag is then marked with identifying information: collection date, location, initials of collector, and depth of soil collected.

The second step is to use a stainless steel core to collect a sample from the 1- to 10-cm (0.4 to 4 in.) layer. The core is placed directly on the surface cleared by the first sample and driven into the ground. When the core is at surface level, the surounding soil is cleared away from the core to avoid cross contamination of the sample. Next a

shovel or spatula is driven horizontally under the core and the sample is transferred into a plastic bag. The bag is labelled as described in the previous paragraph.

A scoop or shovel is driven vertically downward from the bottom of the 1- to 10-cm (0.4 to 4 in.) sample cavity to collect a sample from the 10- to 30-cm (4 to 12 in.) layer. Care is exercised to prevent cross contamination from surrounding soil. The collected sample is transfered into a plastic bag and labelled.

All three layers are preserved by freezing. All equipment used for collection of these samples is washed with a soap and water solution and dried with paper towels. This is done before each sample is taken to reduce the potential for cross contamination.

Sediment samples are collected from dune buildup behind boulders in the main channels of perenially flowing streams. Samples from the beds of intermittently flowing streams are collected in the main channel.

Depending on the reason for taking a particular soil or sediment sample, it may be analyzed to detect any of the following: gross alpha and gross beta activities, total uranium, ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$. Moisture distilled from soil samples may be analyzed for ^{3}H.

E. Foodstuff Sampling

1. Garden Soils, Vegetables and Fruit. Two separate sets of samples are taken at each garden, one set for tritium and the other set for other radionuclides.[B7] For tritium analysis, samples are sealed in a 500 mℓ plastic bottle and then placed within a 1-ℓ glass jar while in the field. All tritium samples are then frozen until analysis using the beaker and watchglass method.

Samples of ^{90}Sr, uranium, plutonium, and ^{137}Cs are placed in plastic bags and frozen until analysis time. Vegetables and fruit 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 before analysis. A complete sample bank is kept until all radiochemical analyses are completed.

2. Fish, Sediment, and Reservoir Sampling. At each reservoir, gill nets are used to trap fish.[B7] Fish, sediment, and water samples are transported under ice to the Laboratory for preparation. Sediment and water samples are submitted directly for radiochemical analysis. Fish are individually washed as if for consumption, dissected, and wet, dry, and ash weights determined quantitatively.

F. Meteorological Monitoring

Meteorological data are continuously monitored on instrumented towers at five Laboratory locations. Measurements include wind speed and direction, standard deviations of wind speed and direction, vertical wind speed and its standard deviation, air temperature, dewpoint temperature, relative humidity, solar radiation, and precipitation.

These parameters are measured at discrete levels on the towers at heights ranging from ground level to 91 m (300 ft). Each parameter is measured every 3 to 5 sec and averaged or summed over 15 min intervals. Data are recorded on digital cassette tape or transmitted by phone line to a microcomputer at the Occupational Health Laboratory at TA-59.

Data validation is accomplished with automated and manual screening techniques. One computer code compares measured data with expected ranges and makes comparisons based on known meteorological relationships. Another code produces daily plots of data from each tower. These graphics are reviewed to provide another check of the data. This screening also helps to detect problems with the instrumentation that might develop between the annual or semi-annual (depending upon the instrument) calibrations.

G. Data Handling

Measurements of the radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values that are lower than the minimum detection limit of an analytical technique (see Appendix C) are sometimes obtained. Consequently, individual measurements can result in values of zero 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.[B6]

Uncertainties are reported as the standard deviation for maximum and minimum concentrations; these values are associated with the estimated variance of counting. These values indicate the precision of the maximum and minimum count.

Standard deviations (s) for the station and group (regional, perimeter, onsite) means are calculated using the following equation:

$$s_{\bar{c}} = \sqrt{\frac{\sum_{i=1}^{N} (\bar{c} - c_i)^2}{N(N-1)}}$$

where,

c_i = concentration for sample i
$\bar{c}$ = mean of samples from a given station or group, and
n = number of samples comprising a station or a group.

This value is reported as the uncertainty for the station and group means.

H. Quality Assurance

Collection of samples for chemical and radiochemical analyses follow a set procedure to ensure proper sample collection, documentation, submittal for chemical analysis, and posting of analytical results.

Before sample collection, the schedule and procedures to be followed are discussed with the chemist or chemists involved with doing the analyses.

The discussion includes:

1. Number and type of samples.
2. Type of analyses and required limits of detection.
3. Proper sample containers.
4. Preparation of sample containers with preservative, if needed.
5. Sample schedule to ensure minimum holding time of analyses to comply with EPA criteria.

The Chemistry Group issues to the collector a block of sample numbers (e.g., 86.0071) with individual numbers assigned by the collector to individual station. These sample numbers follow the sample from collection through analyses and posting of individual results.

Each number, a single sample, is assigned to a particular station that is entered into the collector's log book. After the sample is collected, the date, time, temperature (if water), other pertinent information, and remarks are entered opposite sample number and station previously listed in the log book.

The sample container contains station name, sample number, date, and preservative, if added.

After the sample is collected, it is delivered to the Chemistry Group section leader. The section leader took part in the preliminary discussion before sample collection. The section leader makes out a request form entitled "HSE-9 Analytical Chemical Request." The form is numbered. This request form number is entered in the collector's log book opposite sample numbers submitted along with the date delivered to chemist. The Analytical Request form serves as an informal "Chain of Custody" for the samples.

The analytical request form contains the following information related to ownership and sample program submitted as (1) requester (i.e., sample collector), (2) program code, (3) sample owner (i.e., program manager), (4) date, and (5) total number of samples. The second part of the request form contains (1) sample number or numbers, (2) matrix (e.g., water), (3) type of analyses (i.e., specific radionuclide and/or chemical constituent), (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 his file and the other copies follow the sample.

Quality control, analytical methods and procedures, and limits of detection related to the Chemistry Group in analytical work are presented in Appendix C.

The analytical results are returned to the sample collector who posts data according to sample number and station taken from the log book. These data sheets are included in the report and are used to interpret data for the report.

REFERENCES

B1. H. E. John and J. R. Cunningham, *The Physics of Radiobiology*, 3rd Edition (C. C. Thomas, Springfield, Illinois, 1974).

B2. 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).

B3. P. R. Bevington, *Data Reduction and Error Analysis for the Physical Sciences* (McGraw-Hill, New York, 1969).

B4. M. G. Natrella, *Experimental Statistics* (National Bureau of Standards Handbook 91, Washington, D.C., 1963).

B5. T. C. Gunderson, "Environmental and Emergency Response Capabilities of Los Alamos Scientific Laboratory's Radiological Air Sampling Program," Los Alamos Scientific Laboratory report LA-8379-MS (May 1980).

B6. 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).

B7. J. G. Salazar, "Produce and Fish Sampling Program of Los Alamos National Laboratory's Environmental Surveillance Group," Los Alamos National Laboratory report LA-10186-MS (September 1984).

APPENDIX C

ANALYTICAL CHEMISTRY METHODOLOGY

INTRODUCTION

All analytical chemistry is provided by Group HSE-9.

A. Radioactive Constituents

Environmental samples are routinely analyzed for the following radioactive constituents: gross alpha, gross beta, gross gamma, isotopic plutonium, americium, uranium, cesium, tritium, and strontium. The detailed procedures have been published in this appendix in previous years.[C1,C2] 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 Ge(Li) detectors. Depending upon the concentration and matrix, ^{226}Ra is measured by emanation[C3] or by gamma-ray spectrometry of its ^{214}Bi decay product.[C4] Uranium isotopic ratios ($^{235}U/^{238}U$) are measured by neutron activation analysis where precisions of $\pm 5\%$ are adequate.[C5] More precise work requires mass spectrometry.

B. 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 matrix, and Environmental Protection Agency (EPA) regulations.

Instrumental techniques available include neutron activation, atomic absorption, ion chromatography, color spectrophotometry (manual and automated), potentiometry, and combustion analysis. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capabilities include flame, furnace, mercury cold vapor, and hydride generation, as well as flame emission spectophotometry. The methods used and references for determination of various chemical constituents are summarized in Table C-1.

C. Organic Constituents

Environmental samples are analyzed for organic compounds primarily by following EPA's analytical methods. These methods include 601 (purgeable halocarbons), 602 (purgeable aromatics), 604 (phenols), 606 (phthalate esters), 608 (organochlorine pesticides and PCB's), 609 (nitroaromatics), 610 (polynuclear aromatic hydrocarbons), 612 (chlorinated hydrocarbons), 624 (purgeables by gas chromatography/mass spectrometry [GC/MS]), and 625 (semivolatiles by GC/MS). For samples in a solid matrix, comparable methods found within EPA's document SW-846 are used. Some EPA methods are adapted to take advantage of available instrumentation and state-of-the-art techniques. All methods are supported by documented recoveries, standard curves, and quality assurance samples.

Instrumentation available for organic analyses include gas chromatography with flame ionization, electron capture, nitrogen-phosphorous and mass spectrometer detection; high performance liquid chromatography with refractive index and uv-visible detection; infrared spectrometry; and uv-visible spectrometry. Techniques used for sample preparation are soxhlet extraction, liquid-liquid extraction, kuderna danish concentration, column separation, headspace and purge-and-trap. The methods used for analyses in 1985 along with references are shown in Table C-2. Tables C-3 through C-8 show compounds determined by these methods and representative minimum detection limits.

D. Analytical Chemistry Quality Evaluation Program

1. 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

Table C-1. Analytical Methods for Various Stable Constituents

Technique	Stable Constituents Measured	References
Standard Chemical Methods	Total Alkalinity, Hardness, SO_3^{-2}, SO_4^{-2}, TDS, Conductivity, COD	C6
Color Spectrophotometry	NO_3^-, PO_4^-, Si, Pb, Ti, B	C6
Neutron Activation		
Instrumental Thermal	Al, Sb, As, Ba, Br, Ca, Ce, Cs, Cl, Cr, Co, Dy, Eu, Au, Hf, In, I, Fe, La, Lu, Mg, Mn, K, Rb, Sm, Sc, Se, Na, Sr, S, Ta, Tb, Th, Ti, W, V, Yb, Zn	C7, 12, 13, 14, 15
Instrumental Epithermal	Al, Sb, As, Ba, Br, Cs, Cr, F, Ga, Au, In, I, La, Mg, Mn, Mo, Ni, K, Sm, Se, Si, Na, Sr, Th, Ti, W, U, Zn, Zr	C7, 9, 16, 17, 18, 19, 20, 21
Thermal Neutron Capture Gamma Ray	Al, B, Ca, Cd, C, Gd, H, Fe, Mg, N, P, K, Si, Na, S, Ti	C7, 22, 23, 24, 25, 26, 27, 28, 29
Radiochemical	Sb, As, Cu, Au, Ir, Hg, Mo, Os, Pd, Pt, Ru, Se, Ag, Te, Th, W, U, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Yb, Lu, $^{235}U/^{238}U$, ^{238}Pu, ^{239}Pu	C5, 6, 7, 30, 31, 32, 33, 34, 35, 36 37, 38, 51
Delayed Neutron Assay	U	C7, 8, 10, 11, 39, 40
Atomic Absorption	Sb, As, Ba, Be, Bi, Cd, Ca, Cr, Co, Cu, Ga, In, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, K, Se, Si, Ag, Na, Sr, Te, Tl, Sn, Ti, V, Zn, Al	C6, 41, 43, 44, 45, 46, 47, 48, 52, 53, 54
Ion Chromatography	F^-, Cl^-, Br^-, NO_2^-, NO_3^- SO_4^{-2}, PO_4^{-3}	C49
Potentiometric	F^-, NH_4^+, pH, Br^-, Cl_2 (total) Cl_2 (free)	C50, C55
Combustion	C, N, H, S, Total Organic Carbon	C29, C62, C63
Corrosivity	---	C56, C57
Ignitability	---	C56, C58
Automated Colorimetry	CN^-, NH_4^- PO_4^{-3}, NO_3^-, NO_2^-, Cl^-, COD, TKN	C59, C60, C62, C6

Table C-2. Summary of Methods Used for Analyses of Organic Constituents

Analyte	Matrix	Method	Technique[a]	References
Volatiles)	water	601	PT/GC/EC	C64
			PT/GC/FI	C65
		602	PT/GC/FI	C64,C65
	soil	8010	PT/GC/FI	C64
			PT/GC/FI	C65
		8020	PT/GC/FI	C66
	air	---	PT/GC/MS	C65
EP Toxicity	soil	1310,8080, 8150	GC/EC	C66
PCB's	water	606	GC/EC	C64
	soil	8080	GC/EC	C66
	oil	IH 320	GC/EC	C65

[a]GC - Gas Chromatography
PT - Purge-and-Trap
EC - Electron Capture
FI - Flame Ionization
MS - Mass Spectrometry

blanks, matrix blanks, duplicates, and standard reference materials. Analysis of control samples fill two needs in the analytical work. First, they provide quality control over analytical procedures so that problems that might occur can be identified and corrected. Secondly, data obtained from analysis of control samples permit evaluation of the capabilities of a particular analytical technique for determination of a given element or constituent under a certain set of circumstances. The former function is analytical quality control; the latter is quality assurance.

No attempt is made to conceal the identity of control samples from the analyst. They are submitted to the laboratory at regular intervals and analyzed in association with other samples; that is, they are not handled as a unique set of samples. We feel it would be difficult for analysts to give the samples special attention, even if they are so inclined. We endeavor to run at least 10% of stable constituent analyses and selected radioactive constituent analyses as quality assurance samples using the materials described above. A detailed description of our Quality Assurance program and a complete listing of our annual results have been published.[C68-C75]

2. Radioactive Constituents. Quality control and quality assurance samples for radioactive constituents are obtained from outside agencies as well as prepared internally. The Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA—Las Vegas) provides water, foodstuff, and air filter standards for analysis of gross alpha, gross beta, ^{3}H, ^{40}K, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{106}Ru, ^{134}Cs, ^{137}Cs, ^{226}Ra, and $^{239,240}Pu$ as part of an ongoing laboratory intercomparison program. They also distribute reference soil samples that have been characterized for ^{235}U, ^{238}U, ^{228}Th, ^{230}Th, ^{232}Th, ^{226}Ra, ^{228}Ra, and ^{210}Pb. The National Bureau of Standards (NBS) provides two soil and sediment Standard Reference Materials (SRM) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{230}Th, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and several other nuclides. The DOE's Environmental Measurements Laboratory also provides quality assurance samples.

Soil, rock, and ore samples obtained from the Canadian Geological Survey (CGS) are used for quality assurance of uranium and thorium determinations in silicate matrices. Our own "in-house" standards are prepared by adding known

Table C-3. Volatiles Determined by EPA Method 601

Compound	Representative Detection Limits, μg/ℓ[a]
Chloromethane	---
Bromomethane	---
Dichlorodifluoromethane	---
Vinyl chloride	---
Chloroethane	---
Methylene chloride	5
Trichlorofluoromethane	---
1,1-Dichloroethene	---
trans- 1,2-Dichloroethene	5
Chloroform	10
1, 2-Dichloroethane	8
1,1,1-Trichloroethene	15
Carbon tetrachloride	20
Bromodichloromethane	10
1,2-Dichloropropane	5
trans- 1,3, -Dichloropropane	---
Trichloroethene	5
Dibromochloromethane	10
1,1,2-Trichloroethane	15
Cis- 1,3-dichloropropene	---
2-Chloroethylvinyl ether	---
Bromoform	10
1,1,2,2-Tetrachloroethene	20
Tetrachloroethene	20
Chlorobenzene	12
1,3-Dichlorobenzene	5
1,2-Dichlorobenzene	5
1,4-Dichlorobenzene	5

[a]Column 60 m × 0.25 mm SPB-5 fused silica capillary, using purge and trap method. Detection limit is calculated from intercept of external calibration curve using a Flame Ionization Detector.

Table C-4. Volatiles Determined by EPA Method 602

Compound	Representative Detection Limits, μg/ℓ[a]
Benzene	5
Toluene	5
Ethyl benzene	8
Chlorobenzene	12
1,4-Dichlorobenzene	5
1,3-Dichlorobenzene	5
1,2-Dichlorobenzene	5

[a]Column: 60 m × 0.25 mm fused silica capillary, using purge-and-trap method. Detection limit is calculated from intercept of external calibration curve using a Flame Ionization Detector.

quantities of liquid NBS radioactivity SRMs to blank matric materials.

3. Stable Constituents. Quality assurance for the stable constituent analysis program is maintained by analysis of certified or well-characterized environmental materials. The NBS has a large set of silicate, water, and biological SRMs. The EPA distributes mineral analysis and trace analysis water standards. Rock and soil reference materials have been obtained from the CGS and the United States Geological Survey (USGS). Details of this program have also been published.[C75]

The analytical quality control program for a specific batch of samples is the 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. In addition, there is a program for evaluation of the quality of results for an individual water sample.[C76] These individual water sample quality ratios are the sum of the milliequivalent (meq) cations to the sum of meq anions, the meq hardness to the sum of meq Ca^{+2} and Mg^{+2}, the observed total dissolved solids (TDS) to the sum of solids, the observed conductivity to the sum of contributing conductivities, as well as the two ratios obtained by multiplying (0.01) × (conductivity) and dividing by the meq cations, and the meq anions.

4. Indicators of 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 analysis of reference materials. These results are normalized to the known quantity in the reference material to permit comparison among reference materials of similar matrix containing different concentrations of the analyte:

$$r = \frac{\text{Reported Quantity}}{\text{Known Quantity}} .$$

Table C-5. Volatiles Determined by SW-846 Method 8010

Compound	Representative Detection Limits (μg/kg)[a]
Bis (2-chloroethoxy)methane	---
Bis(2-chlorisopropy)ether	---
Bromobenzene	2292
Bromodichloromethane	1042
Bromoform	1042
Carbon tetrachloride	2083
Chloracetaldehyde	---
Chlorobenzene	1250
Chloroethane	---
Chloroform	1042
1-Chlorohexane	---
2-Chloroethyl vinyl ether	---
Chloromethane	---
Chlorotoluene	---
Dibromochloromethane	1042
Dibromomethane	---
1,2-Dichlorobenzene	521
1,3-Dichlorobenzene	521
1,4-Dichlorobenzene	521
Dichlorodifluoromethane	---
1,1-Dichloroethane	1042
1,2-Dichloroethane	833
1,1-Dichloroethylene	---
trans- 1,2-Dichloroethylene	521
Dichloromethane	521
1,2-Dichloropropane	521
trans- 1,3-Dichloropropylene	---
1,1,2,2-Tetrachloroethane	2083
1,1,1,2-Tetrachloroethane	---
Tetrachloroethylene	2083
1,1,1-Trichloroethane	1563
1,1,2-Trichloroethane	1527
Trichloroethylene	521
Trichlorofluoromethane	---
Trichloropropane	---
Vinyl chloride	---

[a]Column: 60 m × 0.32 mm SPB-5 fused silica capillary, using methanolic partition with purge-and-trap. Detection limit is calculated from intercept of external calibration curve using a Flame Ionization Detector.

Table C-6. Volatiles Determined by SW-846 Method of 8020

Compound	Representative Detection Limits (μg/kg)[a]
Benzene	521
Chlorobenzene	1250
1,4-Dichlorobenzene	521
1,3-Dichlorobenzene	521
1,2-Dichlorobenzene	521
Toluene	521
Ethyl Benzene	833
Xylenes	---

[a]Column: 60 m × 0.32 mm SPB-5 fused silica capillary, using methanolic partition with purge-and-trap. Detection limit is calculated from intercept of external calibration curve using a Flame Ionization Detector.

A mean value (R) for all normalized analyses of a given type is calculated as follows for a given matrix type (N is total number of analytical determinations):

$$R = \frac{\Sigma_i r_i}{N} \quad .$$

The standard deviation (s) of R is calculated assuming a normal distribution of the population of analytical determinations (N):

$$s = \sqrt{\frac{\Sigma_i (R - r_i)^2}{(N-1)}} \quad .$$

These calculated values are presented in Table C-9. The mean value of R is a measure of the accuracy of a procedure. Values of R greater than unity indicate a positive bias and values less than unity a negative bias in the analysis.

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 ^3H determinations is quite large because many standards approached the limits of detection of a measurement. We are attempting to address this issue by calculating a new quality assurance parameter:

$$| \bar{X}_E - \bar{X}_c | < \sqrt{(S_E)^2 + (S_c)^2}$$

where $\bar{X}_E$ and $\bar{X}_c$ are the experimentally determined and certified/consensus mean elemental concentrations, respectively. The S_E and S_c parameters are the

standard deviations associated with $\bar{X}_E$ and $\bar{X}_c$, respectively. An analysis will be considered under control when this condition is satisfied for a certain element in a given matrix. Details on this approach are presented elsewhere.[C75]

Data on analytical detection limits are in Table C-10.

Table C-7. Volatiles Determined in Air

Compound	Representative Detection Limits (μg)[a]	Compound	Representative Detection Limits (μg)[a]
Bis(2-chloroethoxy)methane	---	1.1-Dichloroethane	---
Bis(2-chloroisopropyl)ether	---	1,2-Dichloroethane	---
Benzene	---	1,1-Dichloroethylene	---
Bromobenzene	---	trans-1,2-Dichloroethylene	---
Bromodichloromethane	---	Dichloromethane	---
Bromoform	---	1,2-Dichloropropane	---
Carbon tetrachloride	1.0	trans-1,3-Dichloropropylene	---
Chloracetaldehyde	---	Ethylbenzene	---
Chlorobenzene	---	1,1,2,2-Tetrachloroethane	---
Chloroethane	---	1,1,1,2-Tetrachloroethane	---
Chloroform	1.0	Tetrachloroethylene	1.0
1-Chlorohexane	---	Toluene	0.8
2-Chloroethyl vinyl ether	---	1,1,1-Trichloroethane	3.0
Chloromethane	---	1,1,2-Trichloroethane	---
Chlorotoluene	---	Trichloroethylene	1.0
Dibromochloromethane	---	Trichlorofluoromethane	3.0
Dibromomethane	---	Trichloropropane	---
1,2-Dichlorobenzene	---	Vinyl chloride	---
1,2-Dichlorobenzene	---	Xylenes	1.1
1,4-Dichlorobenzene	---		
Dichlorodifluoromethane	3.0		

[a]60 m × 0.25 mm SPB-5 fused silica capillary. Collection on charcoal tube, desorption with carbon disulfide. Detection limit is calculated from intercept of external calibration curves using mass spectrometer detection.

Table C-8. EP Toxicity Organic Contaminants

Contaminant	Maximum Concentration (mg/ℓ)	Representative Detection Limits (mg/ℓ)[a]
Endrin (1,2,3,4,10,10-Hexachloro-1 7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1 4-endo, endo-5, 8-dimethanoaphthalene)	0.02	0.006
Lindane (1,2,3,4,5,6-Hexachlorocyclohexane, gamma isomer)	0.4	0.0002
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxphenyl)ethane)	10.0	0.004
Toxaphene ($C_{10}H_{10}Cl_8$, Technical chlorinated camphene, 67-69% chlorine)	0.5	0.020
2,4-D (2,4-Dichlorophenoxyacetic acid)	10.0	0.016
2,4,5-TP (Silvex) (2,4,5-Trichlorophenoxypropionic acid)	1.0	0.005

[a]Column: 30 m × 0.32 mm SPB-5 fused silica capillary. Detection limit is calculated from GC response being equal to four times the GC background noise using an electron capture detector.

Table C-9. 1985 Summary of CV Ratio for Stable Elements and Selected Radiochemical Analyses by Matrix

	Silicate	Water	Biological	Air Filter	Bulk Materials
Aroclor 1260	1.13(1)				0.87 ± 0.08 (7)
Aroclor 1254					0.98 (2)
Aroclor 1262					0.95 ± 0.04 (3)
Aroclor 1242					0.94 ± 0.16 (5)
Gasoline	0.71 ± 0.07 (3)				
Ag		1.04 ± 0.20 (35)			
Al		1.22 ± 0.21 (9)			
Alpha		1.11 ± 0.30 (38)		0.91 ± 0.15 (19)	
^{241}Am	1.19 ± 0.30 (7)	1.17 ± 0.03 (3)		1.02 ± 0.10 (8)	
As		1.01 ± 0.08 (42)	0.99 ± 0.14 (17)		
Ba	0.99 ± 0.12 (30)	1.12 ± 0.27 (8)			
Be	1.01 ± 0.10 (3)	1.01 ± 0.03 (10)	0.96 ± 0.09 (8)		
^{7}Be				0.88 (2)	
Beta		1.04 ± 0.20 (36)		0.85 ± 0.15 (19)	
Br			1.09 ± 0.07 (8)		
Ca		0.99 ± 0.04 (13)			
Cd	0.98 ± 0.10 (5)	1.01 ± 0.11 (64)	1.26 ± 0.41 (13)		
Cl		0.96 ± 0.14 (66)	1.03 ± 0.08 (4)		
Co		0.97 ± 0.03 (7)			
^{60}Co		0.97 ± 0.30 (7)	1.07(1)		
Cond		1.00 ± 0.04 (12)			
Cr	1.02 ± 0.13 (25)	0.98 ± 0.15 (28)			
^{51}Cr		1.69 ± 0.40 (6)			
Cs	0.99 ± 0.07 (23)		0.94 ± 0.10 (7)		
^{134}Cs		1.10 ± 0.20 (18)			
^{137}Cs	1.01 ± 0.09 (67)	1.01 ± 0.15 (67)	1.01 ± 0.12 (13)	0.86 (2)	
Cu		0.98 ± 0.06 (41)	1.24 ± 0.26 (8)		
F		1.08 ± 0.22 (104)			
Fe		1.02 ± 0.08 (43)			
Gamma	0.95 ± 0.06 (26)	1.10 ± 0.07 (42)			
^{3}H		0.94 ± 0.20 (171)			
Hard		0.98 ± 0.06 (7)			
Hg	1.27 ± 0.13 (3)	0.98 ± 0.15 (58)	0.99 ± 0.07 (8)		
^{131}I			0.71 ± 0.35 (6)		
K		1.01 ± 0.02 (9)			
^{40}K	1.12 ± 0.12 (3)				
Li	0.71 ± 0.13 (4)				
Mg		1.01 ± 0.05 (11)	0.90 ± 0.05 (8)		
Mn		1.00 ± 0.10 (35)			
^{54}Mn		1.02 ± 0.01 (4)		0.84 (2)	
Na		1.00 ± 0.04 (18)	1.03 (2)		
Ni		1.06 ± 0.12 (13)	1.02 ± 0.07 (8)		
NO_3-N		1.02 ± 0.08 (83)			
P		1.00 ± 0.13 (6)			
Pb	0.97 ± 0.10 (17)	0.99 ± 0.07 (74)			
pH		1.00 ± 0.01 (5)			
^{238}Pu		0.93 ± 0.02 (7)	0.93 ± 0.01 (3)	0.88 ± 0.08 (12)	
^{239,240}Pu	1.00 ± 0.07 (27)	0.91 ± 0.07 (16)	0.96 ± 0.04 (7)	0.93 ± 0.10 (14)	
^{226}Ra		0.94 ± 0.03 (11)			
^{106}Ru		1.72 ± 0.90 (6)			

Table C-9 (cont)

	Silicate	Water	Biological	Air Filter	Bulk Materials
S			0.99 ± 0.06 (174)		
Sc	1.01 ± 0.03 (27)		0.93 ± 0.10 (23)	1.04 ± 0.07 (8)	
Se		0.97 ± 0.09 (41)			
Si		1.11 ± 0.08 (8)			
SO_4		0.96 ± 0.08 (67)			
Sr			0.98 ± 0.04 (9)		
^{90}Sr	1.17 ± 1.36 (9)	0.86 ± 0.08 (19)	1.05 ± 0.24 (15)		
TDS		1.01 ± 0.09 (18)			
Th	0.97 ± 0.07 (40)				
Ti			1.02 ± 0.18 (8)		
Tot Alk		1.00 ± 0.02 (12)			
U	0.99 ± 0.05 (172)	0.94 ± 0.06 (50)	1.02 ± 0.11 (40)	0.95 ± 0.03 (20)	
$^{235}U/^{238}U$	0.98 (2)				
Zn		1.04 ± 0.10 (41)			
^{65}Zn		1.22 ± 0.25 (6)			

Table C-10. 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	50 min	1×10^{-12} μCi/mℓ
^{238}Pu	2.0×10^4 m^3	8×10^4 sec	2×10^{-18} μCi/mℓ
$^{239,240}Pu$	2.0×10^4 m^3	8×10^4 sec	3×10^{-18} μCi/mℓ
^{241}Am	2.0×10^4 m^3	8×10^4 sec	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 sec	1 pg/m^3
Water Sample			
Tritium	0.005 ℓ	50 min	7×10^{-7} μCi/mℓ
^{137}Cs	0.5 ℓ	5×10^4 sec	4×10^{-8} μCi/mℓ
^{238}Pu	0.5 ℓ	8×10^4 sec	9×10^{-12} μCi/mℓ
$^{239,240}Pu$	0.5 ℓ	8×10^4 sec	3×10^{-11} μCi/mℓ
^{241}Am	0.5 ℓ	8×10^4 sec	2×10^{-10} 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
Uranium (Delayed neutron)	0.025 ℓ	50 sec	1 μ/ℓ
Soil Sample			
Tritium	1 kg	50 min	0.003 pCi/g
^{137}Cs	100 g	5×10^4 sec	10^{-1} pCi/g
^{238}Pu	10 g	8×10^4 sec	0.003 pCi/g
$^{239,240}Pu$	10 g	8×10^4 sec	0.002 pCi/g
^{241}Am	10 g	8×10^4 sec	0.01 pCi/g
Gross alpha	2 g	100 min	1.4 pCi/g
Gross beta	2 g	100 min	1.3 pCi/g
Uranium (Delayed neutron)	2 g	20 sec	0.03 μg/g

C1. Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1979," Los Alamos Scientific Laboratory report LA-8200-ENV (April 1980).

C2. Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1980," Los Alamos National Laboratory report LA-8810-ENV (April 1981).

C3. J. H. Harley, Ed. (1972 annual supplements), Environmental Measurements Laboratory Procedures Manual HASL-300.

C4. E. S. Gladney, W. Eberhardt, and R. J. Peters, "The Determination of Radium-226 in CCRMP Reference Samples by Independent Nuclear Methods," Geostandards Newsletter **6**, 5-6 (1982).

C5. E. S. Gladney, D. R. Perrin, and R. J. Peters, "The Determination of U-235/U-238 Ratio in Natural Waters by Chelex-100 Ion Exchange and Neutron Activation Analysis," Anal. Chem. 55:976-977 (1983).

C6. American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, *Standard Methods for the Examination of Water and Wastewater,* 15th edition (1980).

C7. E. S. Gladney, D. B. Curtis, D. R. Perrin, J. W. Owens, and W. E. Gooe, "Nuclear Techniques for the Chemical Analysis of Environmental Materials," Los Alamos National Labortory report LA-8192-MS (1980).

C8. E. S. Gladney, J. W. Owens, and J. W. Starner, "Simultaneous Determination of Uranium and Thorium in Ores by Instrumental Epithermal Neutron Activation Analysis," Anal. Chim Acta **104**, 121 (1979).

C9. E. S. Gladney, D. R. Perrin, J. P. Balagna, and C. L. Warner, "Evaluation of a Boron Filtered Epithermal Neutron Irradiation Facility," Anal. Chem. **52**, 2128 (1980).

C10. S. A. Amiel, "Analytical Applications of Delayed Neutron Emission in Fissionable Elements," Anal. Chem. **34**, 1683 (1962).

C11. E. S. Gladney, W. K. Hensley, and M. M. Minor, "Comparison of Three Techniques for the Measurement of Depleted Uranium in Soils," Anal. Chem. **50**, 652 (1978).

C12. G. E. Gordon, K. Randle, G. G. Goles, J. B. Corliss, M. H. Beeson, and S. S. Oxley, "Instrumental Activation Analysis of Standard Rocks with High Resolution γ-Ray Detectors," Geochim. et Cosmochim. Acta **32**, 369 (1968).

C13. R. Dams, J. A. Robbins, K. A. Rahn, and J. W. Winchester, "Nondestructive Neutron Activation Analysis of Air Pollution Particulates," Anal. Chem. **42**, 861 (1970).

C14. B. Salbu, E. Steinnes, and A. C. Pappas, "Multielement Neutron Activation of Fresh Water Using Ge(Li) Gamma Spectrometry," Anal. Chem. **47**, 1011 (1975).

C15. G. R. Van der Linden, F. DeCorte, and J. Hoste, "Activation Analysis of Biological Materials with Ruthenium as a Multi-Isotopic Comparator," Anal. Chim. Acta **71**, 263 (1974).

C16. E. Steinnes, "Epithermal Neutron Activation Analysis of Geological Materials," in *Activation Analysis in Geochemistry and Cosmochemistry,* A. O. Brumfelt and E. Steinnes, Eds., UNIVERSITETSFORLAGET, Oslo, Norway, pp. 113-128 (1971).

C17. E. S. Gladney, L. E. Wangen, and R. D. Aquilar, "Comparison of Three Techniques for Rapid Determinatio of Sr i Soils and Vegetation," Anal. Lett. **10**, 1083 (1977).

C18. L. E. Wangen and E. S. Gladney, "Determination of As and Ga in Standard Materials by Instrumental and Epithermal Neutron Activation Analysis," Anal. Chim. Acta **96**, 271 (1978).

C19. E. S. Gladney, J. W. Owens, M. L. Marple, and D. L. Dreesen, "A Comparison of Thermal and Epithermal Neutron Activation for the Measurement of Se in Vegetation," Anal. Lett. **A11**, 1001 (1978).

C20. E. S. Gladney and D. R. Perrin, "Quantitative Analysis of Silicates by Instrumental Epithermal Neutron Activation Using (n,p) Reactions," Anal. Chem. **51**. 2297 (1979).

C21. E. S. Gladney and D. R. Perrin, "Determination of Bromine in Biological, Soil, and Geological Standard Reference Materials by Instrumental Epithermal Neutron Activation Analysis," Anal. Chem. **51**, 2015 (1979).

C22. E. S. Gladney, E. T. Jurney, and D. B. Curtis, "Nondestructive Determination of Boron and Cadmium in Environmental Materials by Thermal Neutron Prompt Gamma-Ray Spectrometry," Anal. Chem. **48**, 2139 (1976).

C23. E. T. Jurney, D. B. Curtis, and E. S. Gladney, "Nondestructive Determination of Sulfur in Environmental Materials by Thermal Neutron Prompt Gamma-Ray Spectroscopy," Anal. Chem. **49**, 1741 (1977).

C24. E. S. Gladney, D. B. Curtis, and E. T. Jurney, "Multielement Analysis of Major and Minor Elements by Thermal Neutron Capture Gamma-Ray Spectrometry," J. Radioanal. Chem. **46**, 299 (1978).

C25. D. B. Curtis, E. S. Gladney, and E. T. Jurney, "Potential Interference in the Determination of Sulfur by Thermal Neutron Induced Prompt Gamma-Ray Spectrometry," Anal. Chem. **51**, 158 (1979).

C26. E. S. Gladney, D. B. Curtis, and E. T. Jurney, "Simultaneous Determination of Nitrogen, Carbon, and Hydrogen Using Thermal Neutron Prompt Gamma-Ray Spectrometry," Anal. Chim. Acta **110**, 339 (1979).

C27. E. S. Gladney, "A Literature Survey of Chemical Analysis by Thermal Neutron Induced Capture Gamma-Ray Spectrometry," Los Alamos National Labortory report LA-8028-MS (Sept. 1979).

C28. M. P. Failey, D. L. Anderson, W. H. Zoller, G. E. Gordon, and R. M. Lindstrom, "Neutron Capture Prompt Gamma-Ray Activation Analysis for Multielement Determination in Complex Samples," Anal. Chem. **51**, 2209 (1979).

C29. T. G. Schofield, E. S. Gladney, F. R. Miera, and P. E. Trujillo, "Comparative Determination of Carbon, Nitrogen, and Hydrogen in Environmental Standard Reference Materials by Instrumental Combustion Analysis and Thermal Neutron Capture Gamma Ray Spectrometry," Anal. Lett. **A13**, 75 (1980).

C30. E. S. Gladney and H. L. Rook, "Determination of Tellurium and Uranium in Environmental Materials," Anal. Chem. **47**, 1554 (1975).

C31. E. S. Gladney, J. W. Owens, and J. W. Starner, "The Determination of Uranium in Natural Waters by Neutron Activation Analysis," Anal. Chem. **48**, 973 (1976).

C32. E. S. Gladney, "Copper Determination in Standard Materials Using Neutron Activation and Srafion NMRR Anion Exchange Resin," Anal. Chim. Acta **91**, 353 (1977).

C33. E. S. Gladney, "Determination of As, Sb, Mo, Th, and W in Silicates by Thermal Neutron Activation and Inorganic Ion Exchange," Anal. Lett. **A11**, 429 (1978).

C34. E. S. Gladney and J. W. Owens, "Determination of As, W, and Sb in Natural Waters by Neutron Activation and Inorganic Ion Exchange," Anal. Chem. **48**, 2220 (1976).

C35. R. A. Nadkarni and G. H. Morrison, "Determination of the Noble Metals in Geological Materials by Neutron Activation Analysis," Anal. Chem. **46**, 232 (1974).

C36. R. A. Nadkarni and G. H. Morrison, "Determination of Molybdenum by Neutron Activation and Srafion NMRR Ion Exchange Resin Separation," Anal. Chem. **50**, 294 (1978).

C37. R. A. Nadkarni and G. H. Morrison, "Determination of Silver in rocks by Neutron Activation Analysis," Anal. Chem. **47**, 2285 (1975).

C38. D. Knab and E. S. Gladney, "Determination of Selenium in Environmental Materials by Neutron Activation and Inorganic Ion Exhcnage," Anal. Chem. **52**, 825 (1980).

C39. E. S. Gladney, D. R. Perrin, W. K. Hensley, and M. E. Bunker, "Uranium Content of 25 Silicate Standard Materials," Geostandards Newsletter **4**, 243 (1980).

C40. E. S. Gladney, D. R. Perrin, and W. K. Hensley, "Determination of Uranium in NBS Biological Standard Reference Materials by Delayed Neutron Assay," J. Radioanal. Chem. **59**, 249 (1980).

C41. Perkin-Elmer Corporation, "Analytical Methods Using the HGA Graphite Furnace," Perkin-Elmer, Norwalk, Connecticut (1977).

C42. R. D. Ediger, "Atomic Absorption Analysis with the Graphite Furnace Using Matrix Modification," Atomic Absorption Newslett. **14**, 127 (1975).

C43. J. W. Owens and E. S. Gladney, "Determination of Beryllium in Environmental Materials by Flameless Atomic Absorption Spectrometry," Atomic Absorption Newslett. **15**, 95 (1976).

C44. J. W. Owens and E. S. Gladney, "Lithium Metaborate Fusion and the Determination of Trace Metals in Fly Ash by Flameless Atomic Absorption," Atomic Absorption Newslett. **15**, 95 (1976).

C45. J. W. Owens and E. S. Gladney, "The Determination of Arsenic in Natural Waters by Flameless Atomic Absorption," Atomic Absorption Newslett. **15**, 47 (1976).

C46. E. S. Gladney, "Matrix Modification for the Determination of Bi by Flameless Atomic Absorption," Atomic Absorption Newslett. **16**, 114 (1977).

C47. E. S. Gladney and J. W. Owens, "Determination of Hg Using a Carrier-Free Combustion Separation and Flameless Atomic Absorption," Anal. Chim. Acta **90**, 271 (1977).

C48. E. S. Gladney, J. W. Owens, and D. R. Perrin, "The Determination of Mercury in Environmental Materials," Los Alamos National Laboratory report LA-7865-MS (June 1979).

C49. F. C. Smith and R. A. Wetzel, "Operation and Maintenance Manual for Dionex Model 10 and Model 14 Ion Chromatographs," Dionex Corp., Sunnyvale, California (1978).

C50. American Society for Testing and Materials, *1977 Annual Book of ASTM Standards: Part 31: Water,* ASTM, Philadelphia, Pennsylvania (1977).

C51. E. S. Gladney and D. Knab, "Determination of 13 Rare Earth Elements in Geological Materials via Thermal and Epithermal Neutron Activation with Pre-irradiation Chemical Separation," (in preparation).

C52. F. J. Fernandez, M. M. Beaty, and W. B. Barnett, "Use of L'Vov Platform for Furnace Atomic Absorption Applications," Atomic Spectroscopy **2**, 16 (1981).

C53. T. C. Rains, M. S. Epstein, and S. R. Koirtyohann, "Atomic Absorption Spectroscopy," American Chemical Society—A Short Course.

C54. C. R. Parker, "Water Analysis by Atomic Spectroscopy," Varian Techtron Ltd, Springvale, Australia (1972).

C55. D. Knab, "An Investigation of the Analysis of Environmental Samples for Fluoride" (in preparation).

C56. Code of Federal Regulations, Protection of Environment 40 Parts 190-399, Office of the Federal Register, National Archives and Record Service, General Services Administration (1983).

C57. NACE Standard TM-01-67, "Laboratory Corrosion Testing of Metals for the Process Industries," National Association of Corrosion Engineers, Houston, Texas (1972).

C58. ASTM Method 093-77 or D93-80, American Society for Testing Materials, Philadelphia, Pa.

C59. Methods for Chemical Analysis of Water and Waste, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio (1983).

C60. Industrial Methods for Technician Auto Analyzer II, Technicon Industrial Systems, Tarrytown, NY (1977-1982).

61. M. C. Williams, "Automated Method for the Determination of Cyanide" (in preparation).

C62. B. B. Bernard and D. L. Vann, "Model 700: Total Organic Carbon Analyzer Operating Procedures and Service Manual," OIC Corp. (1984).

C63. N. W. Bower, E. S. Gladney, and R. W. Ferenbaugh, "Critical Comparison of X-Ray Fluorescence and Combustion-Infrared Methods for the Determination of Sulfur in Biological Matrices," Analyst, **110**: (in press, 1985).

C64. Federal Register, Part III (Dec. 3, 1979).

C65. M. A. Gautier and E. S. Gladney, "Health and Environmental Chemistry at Los Alamos: Analytical Methods, Sample and Data Management," LA-10300 (in press, 1985).

C66. USEPA, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846 Second Edition (July 1982).

C67. E. S. Gladney, J. W. Owens, T. C. Gunderson, and W. E. Goode, "Quality Assurance for Environmental analytical Chemistry: 1976-1979," Los Alamos Scientific Laboratory report LA-8730-MS (1981).

C68. E. S. Gladney, W. E. Goode, D. R. Perrin, and C. E. Burns, "Quality Assurance for Environmental Analytical Chemistry: 1980," Los Alamos National Laboratory report LA-8966-MS (1981).

C69. E. S. Gladney, C. E. Burns, D. R. Perrin, and R. D. Robinson, "Quality Assurance for Environmental Analytical Chemistry: 1981," Los Alamos National Laboratory report LA-9579-MS (1982).

C70. E. S. Gladney, C. E. Burns, D. R. Perrin, R. D. Robinson, and D. Knab, "Quality Assurance for Environmental Analytical Chemistry: 1982," Los Alamos National Laboratory report LA-9950-MS (1984).

C71. E. S. Gladney, D. R. Perrin, and W. E. Goode, "Quality Assurance for Environmental Analytical Chemistry at Los Alamos," Proceedings of the 4th DOE Environmental Protection Information Meeting, Denver, Co., Dec. 7-9, 1982, CONF-821215, pp. 107 -118 (1983).

C72. E. S. Gladney, C. E. Burns, D. R. Perrin, R. D. Robinson, and N. A. Raybold, "Quality Assurance for Environmental Analytical Chemistry: 1983," Los Alamos National Laboratory report LA-10115-MS (1984).

C73. M. A. Gautier, E. S. Gladney, and D. R. Perrin, "Quality Assurance for Health and Environmental Chemistry: 1984," Los Alamos National Laboratory report LA-10508-MS (1985).

C74. M. A. Gautier, E. S. Gladney, and B. O'Malley, "Quality Assurance for Health and Environmental Chemistry: 1985, Los Alamos National Laboratory report (in press).

C75. R. D. Robinson, D. Knab, and D. R. Perrin, "An Individual Water Sample Quality Assurance Program," Los Alamos National Laboratory report LA-10163-MS (1985).

APPENDIX D

METHODS FOR DOSE CALCULATIONS

A. Introduction

Annual radiaton doses are evaluated for three principal exposure pathways: inhalation, ingestion, and external exposure (which includes exposure from immersion in air containing radionuclides and direct and scattered penetrating radiation). Estimates are made of:

1) Maximum boundary dose to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs. It assumes the individual is outside at the Laboratory boundary continuously (24 hours a day, 365 days a year).
2) Maximum individual dose to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where there is a person. It takes into account occupancy (the fraction of time that a person actually occupies that location), shielding by buildings, and self-shielding.
3) Average doses to nearby residents.
4) Whole body person-rem dose for the population living within an 80-km (50-mi) radius of the Laboratory.

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.[D1,D2]

If the impact of Laboratory operations is not detectable by environmental measurements, population doses attributable to Laboratory activites are estimated through modeling of releases.

Dose conversion factors used for inhalation and ingestion calculations are given in Table D-1. These dose conversion factors are taken from the US DOE,[D3] which are based on factors in Publication 30 of the International Commission on Radiological Protection (ICRP).[D4]

The dose conversion factors for inhalation assume a 1 μm activity median aerodynamic diameter, as well as the lung solubility category that will maximize the whole body or organ dose (for comparison with DOE's air pathway Radiation Protection Standard [RPS]) if more than one category is given. The ingestion dose conversion factors are chosen to maximize the effective dose or organ dose if more than one gastrointestinal tract uptake is given (for comparison with DOE's 100 mrem/yr RPS for all pathways).

These dose conversion factors calculate the 50-yr dose commitment for internal exposure. The 50-yr dose commitment is the total dose received by an organ during the 50-yr period following the intake of a radionuclide.

External doses are calculated using the dose-rate conversion factors published by Kocher.[D5] These factors, which are given in Table D-2, give the photon dose rate in mrem/yr per unit radionuclide air concentration in μCi/mℓ. The factors are used primarily in the calculation of the whole-body population dose for the 80-km (50-mi) area.

B. Inhalation Dose

Annual average air concentrations of ^{3}H, total U, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am, determined by the Laboratory's air monitoring network, are corrected for background by subtracting the average concentrations measured at regional stations. These net concentrations are then multiplied by a standard breathing rate of 8400 m^3/yr[D6] to determine total annual intake via inhalation, in μCi/yr, for each radionuclide. Each intake is multiplied by appropriate dose conversion factors to convert radionuclide intake into 50-yr dose commitments. Following ICRP methods, doses are calculated for all organs that contribute over 10% of the total effective dose for each radionuclide (see Appendix A for definition of effective dose).

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

Table D-1. Dose Conversion Factors (rem/μCi intake) for Calculating Internal Doses

Inhalation:

Radionuclide	Target Organ: Soft Tissue	Lung	Bone Surface	Red Marrow	Liver	Gonads	Effective Dose
^{3}H	6.3×10^{-5}						6.3×10^{-5}
^{234}U		$1.1 \times 10^{+3}$					$1.3 \times 10 \times 10^{+2}$
^{235}U		$1.0 \times 10^{+3}$					$1.2 \times 10 \times 10^{+2}$
^{238}U		$1.0 \times 10^{+3}$					$1.2 \times 10 \times 10^{+2}$
^{238}Pu			$8.1 \times 10^{+3}$	$6.7 \times 10 \times 10^{+2}$	$1.8 \times 10^{+3}$	$1.0 \times 10 \times 10^{+2}$	$4.6 \times 10 \times 10^{+2}$
$^{239,240}Pu$			$9.3 \times 10^{+3}$	$7.4 \times 10 \times 10^{+2}$	$2.0 \times 10^{+3}$	$1.2 \times 10 \times 10^{+2}$	$5.1 \times 10 \times 10^{+2}$
^{241}Am			$9.3 \times 10^{+3}$	$7.4 \times 10 \times 10^{+2}$	$2.0 \times 10^{+3}$	$1.2 \times 10 \times 10^{+2}$	$5.2 \times 10 \times 10^{+2}$

Ingestion:

Radionuclide	Target Organ: Bone Surface	Red Marrow	Liver	Gonads	Kidney	Lungs	Breast	Thyroid
^{3}H								
^{7}Be		4.4×10^{-5}		2.1×10^{-4}				
^{90}Sr	1.6×10	7.0×10^{-1}						
^{137}Cs	4.8×10^{-2}	4.8×10^{-2}		5.2×10^{-2}		4.8×10^{-3}	4.4×10^{-3}	4.8×10^{-2}
^{234}U	4.1×10	2.7×10^{-1}			1.7×10			
^{235}U	3.7×10	2.5×10^{-1}			1.6×10			
^{238}U	3.7×10	2.5×10^{-1}			1.5×10			
^{238}Pu	6.7×10	5.5×10^{-1}	1.5×10	8.5×10^{-2}				
$^{239,240}Pu$	7.8×10	5.9×10^{-1}	1.6×10	9.6×10^{-2}				
^{241}Am	$4.1 \times 10^{+1}$	3.1×10	8.5×10	5.2×10^{-1}				

Radionuclide	Target Organ: Soft Tissue	LLI[a] Wall	SI[a] Wall	ULI[a] Wall	Remainder	Effective Dose
^{3}H	6.3×10^{-5}					6.3×10^{-5}
^{7}Be		4.4×10^{-4}	2.0×10^{-4}	2.7×10^{-4}		1.1×10^{-4}
^{90}Sr						1.3×10^{-1}
^{137}Cs		$5.2 \times 10^{-2}1$	5.2×10^{-2}		5.5×10^{-2}	5.0×10^{-2}
^{234}U						2.6×10^{-1}
^{235}U		2.0×10^{-1}				2.5×10^{-1}
^{238}U						2.3×10^{-1}
^{238}Pu						3.8×10^{-1}
$^{239,240}Pu$						4.3×10^{-1}
^{241}Am						2.2×10

[a]LLI = lower lower-intestine; SI = small intestine; ULI = upper lower-intestine.

Table D-2. Dose Conversion Factors [(mrem/yr)/(μCi/mℓ)] for Calculating External Doses[a]

^{10}C	$9.8 \times 10^{+9}$
^{11}C	$5.6 \times 10^{+9}$
^{13}N	$5.6 \times 10^{+9}$
^{16}N	$2.5 \times 10^{+10}$
^{14}O	$1.8 \times 10^{+10}$
^{15}O	$5.6 \times 10^{+9}$
^{41}Ar	$7.5 \times 10^{+9}$

[a]Dose conversion factors for ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar were taken from Kocher (1980). Dose conversion factors for the remaining radionuclides, which were not presented by Kocher, were calculated from:

$$DCF\ [(mrem/yr)/(\mu Ci/m\ell)] = 0.25 \times \bar{E} \times 3.2 \times 10^{+10}$$

where $\bar{E}$ is the average gamma ray energy in MeV.[D9] The calculated factors were reduced by 30% to account for self-shielding by the body, so that they would be directly comparable with the factors from Kocher.

throughout the entire year (8760 h). This assumption is made for the boundary dose, dose to the maximum exposed individual, and dose to the population living within 80 km (50 mi) of the site.

Organ doses and effective dose are determined at all sampling sites for each radionuclide. A final calculation estimates the total inhalation organ doses and effective dose by summing over all radionuclides.

C. Ingestion Dose

Results from foodstuff sampling (Section VII) are used to calculate organ doses and effective doses 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 from sampling stations not affected by Laboratory operations. The radionuclide concentration in a particular foodstuff is multiplied by the annual consumption rate[D2] to obtain total annual intake of that radionuclide. Multiplication of the annual intake by the radionuclide's ingestion dose conversion factor for a particular organ gives the estimated dose to the organ. Similarly, effective dose is calculated using the effective dose conversion factor (Table D-1).

Doses are evaluated for ingestion of ^{3}H, ^{137}Cs, total U, ^{238}Pu, and $^{239,240}Pu$ in fruits and vegetables; ^{3}H, ^{7}Be, ^{22}Na, ^{54}Mn, ^{57}Co, ^{83}Rb, ^{134}Cs, ^{137}Cs, and total U in honey; and ^{137}Cs, total U, ^{238}Pu, and $^{239,240}Pu$ in fish.

D. External Radiation

Environmental thermoluminescent dosimeter (TLD) measurements are used to estimate external radiation doses.

Nuclear reactions with air in the target areas at the Los Alamos Meson Physics Facility (LAMPF, TA-53) cause the formation of air activation products, principally ^{11}C, ^{13}N, ^{14}O, and ^{15}O. These isotopes are all positron emitters and have 20.4 min, 10 min, 71 sec, and 122 sec half lives, respectively. Neutron reactions with air at the Omega West Reactor (TA-2) and the LAMPF also form ^{41}Ar, which has a 1.8 h half-life.

The radioisotopes ^{11}C, ^{13}N, ^{14}O, and ^{15}O are also sources of photon radiation because of formation of two 0.511 MeV photons through positron-electron annihilation. The ^{14}O emits a 2.3 MeV gamma with 99% yield. The ^{41}Ar emits a 1.29 MeV gamma with 99% yield.

TLD measurements are corrected for background to determine the contribution to the external radiation field from Laboratory operations. Background estimates at each site, based on historical data, consideration of possible nonbackground contributions, and, if possible, values measured at locations of similar geology and topography, are then subtracted from each measured value. This net dose is assumed to represent the dose from Laboratory activities that an individual would receive if he or she were to spend 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 offsite locations where residences are present, an occupancy factor of 1.0 was used.

Two types of shielding are considered: shielding by buildings and self-shielding. Each shielding type is estimated to reduce the external radiation dose by 20%.[D9]

Boundary and maximum individual doses from ^{41}Ar releases from the Omega West Reactor are estimated using a standard Gaussian dispersion model and measured stack releases (from Table G-2). Procedures used in making the calculations are described in the following section.

Neutron doses from the critical assemblies at TA-18 were based on 1985 measurements. Neutron

fields were monitored principally with TLDs placed in cadmium-hooded 23-cm (9-in.) polyethylene spheres.

At onsite locations at which above-background doses were measured, but at which public access is limited, doses based on a more realistic estimate of exposure time are also presented. Assumptions used in these estimates are in the text.

E. Population Dose

Calculation of whole body population dose estimates (in person-rem) are based on measured data to the extent possible. For background radiation, average measured background doses for Los Alamos, White Rock, and regional stations are multiplied by the appropriate population number. Tritium average doses are calculated from average measured concentrations in Los Alamos and White Rock above background (as measured by the regional stations).

These doses are multiplied by population data incorporating results of the 1980 census (Section II.E). The population data have been slightly modified [increased from 155 077 in 1980 to 169 792 persons in 1985 within 80 km (50 mi) of the boundary] to account for population changes between 1980 and 1985. These changes are extrapolated from an estimate of the 1983 New Mexico population, by county, that was made by the U.S. Bureau of the Census.[D7]

Radionuclides emitted by the LAMPF and, to a lesser extent, by the Omega West Reactor, contribute over 95% of the population dose.

For ^{41}Ar, ^{11}C, ^{13}N, ^{14}O, and ^{15}O, atmospheric dispersion models are used to calculate an average dose to individuals living in the area in question. The air concentration of the isotope $[\chi(r,\theta)]$ at a location (r,θ) due to its emission from a particular source is found using the annual average meteorological dispersion coefficient $[\chi(r,\theta)/Q]$ (based on Gaussian plume dispersion models Slade 19685) and the source term Q. Source terms, obtained by stack measurements, are in Table G-2.

The dispersion factors were calculated from 1985 meteorological data collected near LAMPF during the actual time periods when radionuclides were being released from the stacks. Dispersion coefficients used to calculate the χ/Q's were determined from measurements of the standard deviations of wind direction. The χ/Q includes the reduction of the source term due to radioactive decay.

The gamma dose rate in a semi-infinite cloud at time t, $\gamma_\infty(r,\theta,t)$ can be represented by the equation

$$\gamma_\infty(r,\theta,t) = (DCF)\,\chi(r,\theta,t)$$

where $\gamma_\infty(r,\theta,t)$ = gamma dose rate (mrem/yr) at time t, at a distance r, and angle θ,

DCF = dose rate conversion factor from Kocher.[D5]

$\chi(r,\theta,t)$ = pume concentration in $\mu Ci/m\ell$.

The annual dose is multiplied by the appropriate population figure to give the estimated population dose.

Background radiation doses because of airline travel are based on the number of trips taken by Laboratory personnel. It was assumed that 85% of these trips were taken by Laboratory personnel residing in Los Alamos County and that non-Laboratory travel was 10% of the Laboratory trips. Average air time at altitude for each trip was estimated to be 4.5 h, where the average dose rate is 0.22 mrem/h.[D9]

REFERENCES

D1. U.S. Department of Energy, "A Guide for Environmental Radiological Surveillance at U.S. Department of Energy Installations," U.S. Department of Energy report DOE/EP-0023 (July 1981).

D2. U.S. Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," U.S. Nuclear Regulatory Commission Regulatory Guide 1.109 (1977).

D3. U.S. Department of Energy, "Committed Dose Equivalent Tables for U.S. Department of Energy Population Dose Calculations," prepared by J.P. Corley, Ed., for the U.S. Department of Energy, U.S. Department of Energy report DOE/EH- (draft, 1985).

D4. 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*, Vol. 2, No. 3/4 through Vol. 8, No. 4 (1979-1982).

D5. D.C. Kocher, "Dose-Rate Conversion Factors for External Exposure to Photon and Electron Radiation from Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities," *Health Physics*, Vol. 38, pp. 543-621 (1980).

D6. International Commission on Radiological Protection, "Report on the Task Group on Reference Man," ICRP Publication 23 (1975).

D7. U.S. Bureau of the Census, "Local Population Estimates, Estimates of the Population of New Mexico Counties and Metropolitan Areas: July 1, 1981, 1982, and 1983," U.S. Bureau of the Census report, Series P-26, No. 83-31-C (1985).

D8. D.H. Slade, Ed., "Meteorology and Atomic Energy 1968," U.S. Atomic Energy Commission document TID-24190 (1968).

D9. National Council on Radiation Protection and Measurements, "Natural Background Radiation in the United States," NCRP Report Number 45 (1975).

APPENDIX E

UNITS OF MEASUREMENT

Throughout this report the International (SI) or Metric System of measurement has been used, with some exceptions. For units of radiation activity, exposure, and dose, customary units [i.e., Curie (Ci), Roentgen (R), rad, and rem] are retained 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 E-1 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Table E-2 presents conversion factors for converting from SI units to U.S. Customary units.

Table E-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

Table E-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	Cubic Feet (ft^3)
Hectares (ha)	2.5	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)	3.3	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)	0.39	Square Miles (mi^2)

APPENDIX F

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the 32 active technical areas (TA) operated by the Laboratory are shown in Fig. 4. The main programs conducted at each are listed in this appendix.

TA-2, Omega Site: Omega West Reactor, an 8 megawatt nuclear research reactor, is located here. It serves as a research tool in providing a source of neutrons for fundamental studies in nuclear physics and associated fields.

TA-3, South Mesa Site: 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 the Central Computing Facility, Administration offices, Materials Department, the science museum, Chemistry and Materials Science Laboratories, Physics Laboratories, technical shops, cryogencis laboratories, a Van de Graaf accelerator, and cafeteria.

TA-6, Two Mile Mesa Site: This is one of three sites (TA-22 and TA-40 are the other two sites) used in development of special detonators for initiation of high explosive systems. Fundamental and applied research in support of this activity includes investigation of phenomena associated with initiation of high explosives, and research in rapid shock-induced reactions with shock tubes.

TA-8, GT Site (or Anchor Site West): This is a nondestructive 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 weapon components to checking of high pressure dies and molds. Principal tools include radiographic techniques (x-ray machines to 1 million volts, a 24-MeV betatron), radioactive isotopes, ultrasonic testing, penetrant testing, and electromagnetic 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 explosive components and systems under a variety of extreme physical environments. The facilities are arranged so 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 firing site is used for running various tests on relatively small explosive charges and for fragment impact tests.

TA-15, R-Site: This is the home of PHERMEX—a multiple cavity electron accelerator capable of producing a very large flux of x-rays for certain weapons development problems and tests. This site is also used for the investigation of weapon functioning and weapon system behavior in nonnuclear tests, principally by electronic recording means.

TA-16, S-Site: Investigations at this site include development, engineering design, pilot manufacture, environmental testing, and stockpile production liaison for nuclear weapon warhead systems. Development and testing of high explosives, plastics and adhesives, and 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 materials. This is done to study the effects of various shapes, sizes, and configurations. These machines are also used as source of fission neutrons in large quantities for experimental purposes.

TA-21, DP-Site: This site has two primary research areas, DP West and DP East. DP West is concerned with chemistry research. DP East is the high temperature chemistry and tritium site.

TA-22, TD Site: See TA-6.

TA-28, Magazine Area "A": Explosives storage area.

TA-33, HP-Site: A major high-pressure tritium handling facility is located here. Laboratory and office space for Geosciences Division related to the Hot Dry Rock Geothermal Project are also here.

TA-35, Ten Site: Nuclear safeguards research and development, which is conducted here, is concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research in reactor safety and laser fusion is also done here.

TA-36, Kappa Site: Various explosive phenomena, such as detonation velocity, are investigated here.

TA-37, Magazine Area "C": Explosives storage area.

TA-39, Ancho Canyon Site: Nonnuclear weapon behavior is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interaction of explosives, and explosions with other materials.

TA-40, DF-Site: See TA-6.

TA-41, W-Site: Personnel at this site are engaged primarily in engineering design and development of nuclear components, including fabrications and evaluation of test materials for weapons.

TA-43, Health Research Laboratory: The Biomedical Research Group does research here in cellular radiobiology, molecular radiobiology, biophysics, mammalian radiobiology, and mammalian metabolism. A large medical library, special counters used to measure radioactivity in humans and animals, and animal quarters for dogs, mice and monkeys are also located in this building.

TA-46, WA-Site: Here, applied photochemistry, which includes development of technology for laser isotope separation and laser-enhancement of chemical processes, is investigated. Solar energy research, particularly in the area of passive solar heating for residences, is done.

TA-48, Radiochemistry Site: Laboratory scientists and technicians at this site study nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made and "hot cells" are used for remote handling of radioactive materials.

TA-50, Waste Management Site: Personnel at this site have responsibility for treating and disposing of most industrial liquid waste received from Laboratory technical areas, for development of improved methods of solid waste treatment, and for containment of radioactivity removed by treatment. Radioactive liquid waste is piped to this site for treatment from many of the technical areas.

TA-51, Animal Exposure Facility: Here, animals are exposed to nonradioactive toxic materials to determine biological effects of high and low exposures.

TA-52, Reactor Development Site: A wide variety of activities related to nuclear reactor performance and safety are done here.

TA-53, Meson Physics Facility: The Los Alamos Meson Physics Facility (LAMPF), a linear particle accelerator, is used to conduct research in the areas of basic physics, cancer treatment, material studies, and isotope production.

TA-54, Waste Disposal Site: This is a disposal area for solid radioactive and toxic wastes.

TA-55, Plutonium Processing Facilities: Processing of plutonium and research in plutonium metallurgy are done here.

TA-57, Fenton Hill Site: This is the location of the Laboratory's Hot Dry Rock geothermal project. Here scientists are studying the possibility of producing energy by circulating water through hot, dry rock located hundreds of meters below the earth's surface. The water is heated and then brought to the surface to drive electric generators.

TA-58, Two Mile Mesa. Undeveloped technical area.

TA-59, Occupational Health Site: Occupational health and environmental science activities are conducted here.

APPENDIX G

ENVIRONMENTAL DATA TABLES

Table G-1. Estimated Maximum Individual 50-Year Dose Commitments from 1985 Airborne Radioactivity[a]

Isotope	Critical Organ	Location	Estimated Dose (mrem/yr)	Percentage of Radiation Protection Standard
^{3}H	Whole Body	Royal Crest (Station 11)[b]	0.03	0.1%
^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar	Whole body	East Gate (Station 6)[b]	7.3	29%
U, ^{238}Pu, $^{239,240}Pu$, ^{241}Am	Bone Surface	LA Airport (Station 8)[b]	0.45	0.6%

[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 there is a person. It takes into account occupancy factors.
[b]See Fig. 8 for station locations.

Table G-2. Airborne Radioactive Emissions Totals[a]

Location	$^{238,239,240}Pu$[b] (μCi)	$^{235,238}U$[c] (μCi)	Mixed Fission Products (μCi)	^{131}I (μCi)	^{41}Ar[d] (Ci)	^{32}P (μCi)	^{3}H (Ci)	Mixed Activation Products	
								Gaseous[e] (Ci)	Particulate/Vapor[f] (Ci)
TA-2					390.0				
TA-3	194.9	344.1	34.7	146.0			2119.2		
TA-9									
TA-15									
TA-18									
TA-21	10.6	381.9	0.4				366.6		
TA-33							4870.0		
TA-35	0.6						5.3		
TA-41							1270.0		
TA-43	1.8					53.0			
TA-46		0.03							
TA-48	2.1	1.9	1206.5						
TA-50	2.0		8.5						
TA-53									
TA-54	0.01						7	126079.4	0.2
TA-55	1.1								
Totals	213.1	727.9	1250.1	146.0	390.0	53.0	8638.1	126079.4	0.2

[a]As reported on DOE Forms F-5821.1

[b]Plutonium values contain indeterminant traces of ^{241}Am, a transformation product of ^{241}Pu.

[c]Does not include aerosolized uranium from explosives testing (Table G-13).

[d]Does not include 50.8 Ci of ^{41}Ar present in gaseous, mixed activation products.

[e]Includes the following constituents: ^{16}N - 0.9%; ^{10}C - 2.0%; ^{14}O - 1.2%; ^{15}O - 35.6%; ^{13}N - 21.7%; ^{11}C - 38.2%; ^{41}Ar - 0.4%.

[f]Includes 38 nuclides, including 0.07 Ci of ^{183}Os (particulate) and 0.03 Ci of ^{82}Br (vapor).

Table G-3. Thermoluminescent Dosimeter Measurements

Station Location	Coordinates	Annual[a] Measurement (mrem)
Regional Stations (28-44 km)—Uncontrolled Areas		
1. Española	---	77 ± 4
2. Pojoaque	---	103 ± 4
3. Santa Fe	---	94 ± 4
4. Fenton Hill	---	119 ± 4
Perimeter Stations (0-4)—Uncontrolled Areas		
5. Barranca School	N180 E130	97 ± 4
6. Arkansas Avenue	N170 E030	104 ± 4
7. Cumbres School	N150 E090	114 ± 4
8. 48th Street	N110 W010	120 ± 4
9. LA Airport	N110 E170	120 ± 4
10. Bayo Canyon	N120 E250	135 ± 4
11. Exxon Station	N090 E120	136 ± 4
12. Royal Crest Trailer Court	N080 E080	123 ± 4
13. White Rock	S080 E420	108 ± 4
14. Pajarito Acres	S210 E380	94 ± 4
15. Bandelier Lookout Station	S280 E200	115 ± 5
16. Pajarito Ski Area	N150 W200	108 ± 4
Onsite Stations—Controlled Areas		
17. TA-21 (DP West)	N095 E140	114 ± 4
18. TA-6 (Two-Mile Mesa)	N025 E030	121 ± 4
19. TA-53 (LAMPF)	N070 E090	145 ± 4
20. Well PM-1	N030 E305	141 ± 4
21. TA-16 (S-Site)	S035 W025	112 ± 4
22. Booster P-2	S030 E220	148 ± 4
23. TA-54 (Area G)	S080 E290	223 ± 5
24. State Hwy 4	N070 E350	177 ± 4
25. TA-49 (Frijoles Mesa)	S165 E085	116 ± 4
26. TA-2 (Omega Stack)	N075 E120	117 ± 4
27. TA-2 (Omega Canyon)	N085 E120	162 ± 4
28. TA-18 (Pajarito Site)	S040 E205	187 ± 4
29. TA-35 (Ten Site A)	N040 E105	141 ± 4
30. TA-35 (Ten Site B)	N040 E110	125 ± 7
31. TA-59 (Occupational Health Lab)	N050 E040	159 ± 4
32. TA-3 (Van de Graaff)	N050 E020	129 ± 4
33. TA-3 (Guard Station)	N050 E020	153 ± 4
34. TA-3 (Alarm Building)	N050 E020	183 ± 4
35. TA-3 (Guard Building)	N050 E020	141 ± 4
36. TA-3 (Shops)	N050 E020	110 ± 5
37. Pistol Range	N040 E240	114 ± 4
38. TA-55 (Plutonium Facility South)	N040 E240	111 ± 4
39. TA-55 (Plutonium Facility West)	N040 E080	121 ± 5
40. TA-55 (Plutonium Facility North)	N040 E080	118 ± 5

[a]Estimate ± 95% Confidence Increments.

Table G-4. Locations of Air Sampling Stations

Station	Latitude or N-S Coord	Longitude or E-W Coord
Regional (28-44 km)		
1. Española	36°00′	106°06′
2. Pojoaque	35°52′	106°02′
3. Santa Fe	35°40′	106°56′
Perimeter (0-4 km)		
4. Barranca School	N180	E130
5. Arkansas Avenue	N170	E030
6. East Gate	N090	E210
7. 48th Street	N110	W010
8. LA Airport	N110	E170
9. Bayo STP	N120	E250
10. Exxon Station	N090	E120
11. Royal Crest	N080	E080
12. White Rock	S080	E420
13. Pajarito Acres	S210	E380
14. Bandelier	S280	E200
Onsite		
15. TA-21	N095	E140
16. TA-6	N025	E030
17. TA-53 (LAMPF)	N070	E090
18. Well PM-1	N030	E305
19. TA-52	N020	E155
20. TA-16	S035	W025
21. Booster P-2	S030	E180
22. TA-54	S080	E290
23. TA-49	S165	E085
24. TA-33	S245	E225
25. TA-39	S190	E230
26. TA-16-450	S055	W070

Table G-5. Average Background Concentrations of Radioactivity in the Atmosphere

Radioactive Constituent	Units	EPA[a] 1982-1985	Laboratory[b] 1985	Uncontrolled Area Guide[c]
Gross beta	10^{-15} μCi/mℓ	12 ± 8	10 ± 4	9×10^3
^{3}H	10^{-12} μCi/mℓ	Not reported	3.2 ± 0.6	2×10^5
U (natural)	pg/m^3	70 ± 26	46 ± 11	1×10^5
^{238}Pu	10^{-18} μCi/mℓ	0.2 ± 0.1	<2[d]	3×10^4
$^{239,240}Pu$	10^{-18} μCi/mℓ	1.2 ± 0.9	0.8 ± 1.3	2×10^4
^{241}Am	10^{-18} μCi/mℓ	Not reported	2.8 ± 1.3	2×10^4

[a]Environmental Protection Agency, "Environmental Radiation Data," Reports 31 through 42. Data are from Santa Fe, New Mexico sampling location and were taken from August 1982 through June 1985, excluding the periods from May 1983 through February 1984 and January 1985 through February 1985 for which data were not available.
[b]Data annual averages are from the regional stations (Española, Pojoaque, Santa Fe) and were taken during calendar year 1985.
[c]See Appendix A.
[d]Minimum detectable limit.

Table G-6. Atmospheric Tritiated Water Concentrations for 1985

Station Location[a]	Total Air Volume (m^3)	Number of Monthly Samples	Number of Samples <MDL[b]	Concentrations—pCi/m^3 (10^{-12} μCi/mℓ) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Regional Stations (24-44 km)—Uncontrolled Areas							
1. Española	147.88	11	5	12.0 ± 3.0	−1.0 ± 1.0	3.0 ± 1.1	< 0.1
2. Pojoaque	154.97	11	5	27.0 ± 6.0	−1.0 ± 1.0	3.8 ± 2.1	< 0.1
3. Santa Fe	155.74	11	6	18.0 ± 4.0	−2.0 ± 1.0	2.7 ± 1.5	< 0.1
Regional Group Summary	458.59	33	16	27.0 ± 6.0	−2.0 ± 1.0	3.2 ± 0.3	< 0.1
Perimeter Stations (0-4 km)—Uncontrolled Areas							
4. Barranca School	120.28	11	2	28.0 ± 6.0	1.0 ± 1.0	10.9 ± 2.7	< 0.1
5. Arkansas Avenue	121.85	11	4	17.0 ± 3.0	0.2 ± .40	5.8 ± 1.7	< 0.1
6. East Gate	114.63	11	2	36.0 ± 7.0	1.2 ± 0.4	12.3 ± 3.3	< 0.1
7. 48th Street	111.77	11	5	43.0 ± 9.0	−0.5 ± 0.9	14.3 ± 4.3	< 0.1
8. LA Airport	100.26	10	0	60.0 ± 10.0	1.4 ± 0.4	10.1 ± 4.4	< 0.1
9. Bayo STP	109.50	11	4	19.0 ± 4.0	0.0 ± 0.2	5.8 ± 1.7	< 0.1
10. Exxon Station	120.88	10	1	60.0 ± 10.0	2.0 ± 0.7	14.3 ± 4.2	< 0.1
11. Royal Crest	86.22	11	0	100.0 ± 20.0	2.3 ± 0.7	39.9 ± 9.7	< 0.1
12. White Rock	116.66	11	2	130.0 ± 30.0	0.1 ± 0.9	18.3 ± 9.9	< 0.1
13. Pajarito Acres	105.30	10	3	33.0 ± 7.0	1.0 ± 0.5	9.4 ± 2.8	< 0.1
14. Bandelier	133.32	12	1	70.0 ± 10.0	3.0 ± 1.0	21.7 ± 6.5	< 0.1
Perimeter Group Summary	1240.67	119	24	130.0 ± 30.0	−0.5 ± 0.9	14.8 ± 2.8	< 0.1
Onsite Stations—Controlled Areas							
15. TA-21	122.38	11	0	70.0 ± 10.0	1.9 ± 0.6	15.9 ± 5.3	< 0.1
16. TA-6	116.43	11	3	23.0 ± 5.0	0.0 ± 1.0	8.3 ± 1.9	< 0.1
17. TA-53 (LAMPF)	121.81	11	1	36.0 ± 7.0	1.8 ± 0.9	12.1 ± 2.6	< 0.1
18. Well PM-1	122.51	11	0	190.0 ± 40.0	3.0 ± 1.0	27.8 ± 14.3	< 0.1
19. TA-52	118.22	10	1	30.0 ± 6.0	4.0 ± 2.0	12.4 ± 2.2	< 0.1
20. TA-16	118.26	11	2	35.0 ± 7.0	0.0 ± 1.0	8.9 ± 2.7	< 0.1
21. Booster P-2	112.26	11	3	80.0 ± 10.0	1.0 ± 1.0	20.1 ± 6.1	< 0.1
22. TA-54	116.96	11	0	190.0 ± 40.0	9.0 ± 2.0	75.8 ± 14.8	< 0.1
23. TA-49	81.20	11	5	160.0 ± 30.0	−2.0 ± 2.0	36.2 ± 15.6	< 0.1
24. TA-33	121.86	11	0	300.0 ± 60.0	38.0 ± 7.0	105.9 ± 21.8	< 0.1
25. TA-39	122.88	11	0	240.0 ± 50.0	2.7 ± 0.8	41.6 ± 18.2	< 0.1
26. TA-16-450	113.82	11	6	36.0 ± 7.0	−1.0 ± 3.0	10.1 ± 3.7	< 0.1
Onsite Group Summary	1388.59	131	21	300.0 ± 60.0	−2.0 ± 2.0	31.3 ± 8.4	< 0.1

[a]See Fig. 8 for map of station locations.
[b]Minimum detectable limit = 1×10^{-12} μCi/mℓ.
[c]Uncertainties are ±s (see Appendix B).
[d]Controlled Area DOE Concentration Guide = 5×10^{-6} μCi/mℓ.
Uncontrolled Area Derived Concentration Guide = 2×10^{-7} μCi/mℓ.

Table G-7. Atmospheric ^{239,240}Pu Concentrations for 1985

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations—aCi/m^3 (10^{-18} µCi/mℓ) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Regional Stations (28-44 km)—Uncontrolled Areas							
1. Española	90 196	4	3	9.9 ± 1.2	−1.5 ± 1.4	2.2 ± 5.2	< 0.1
2. Pojoaque	92 563	4	4	0.6 ± 0.4	−0.8 ± 0.8	−0.1 ± 0.7	< 0.1
3. Santa Fe	96 045	4	4	1.3 ± 0.9	−0.8 ± 0.7	0.2 ± 0.9	< 0.1
Regional Group Summary	278 804	12	11	9.9 ± 1.2	−1.5 ± 1.4	0.8 ± 1.3	< 0.1
Perimeter Stations (0-40 km)—Uncontrolled Areas							
4. Barranca School	95 356	4	4	0.0 ± 0.8	−0.5 ± 0.6	−0.2 ± 0.2	< 0.1
5. Arkansas Avenue	89 327	4	4	0.9 ± 0.7	−0.6 ± 0.5	−0.1 ± 0.7	< 0.1
6. East Gate	69 477	4	3	3.1 ± 1.1	−0.1 ± 0.9	1.2 ± 1.5	< 0.1
7. 48th Street	98 677	4	4	0.1 ± 0.5	−0.5 ± 0.7	−0.3 ± 0.3	< 0.1
8. LA Airport	78 555	4	3	18.2 ± 2.8	0.5 ± 0.7	5.50 ± 8.5	< 0.1
9. Bayo STP	73 795	4	4	1.1 ± 0.9	−0.3 ± 0.7	0.3 ± 0.6	< 0.1
10. Exxon Station	82 645	4	4	2.2 ± 1.3	−0.1 ± 0.6	1.0 ± 1.1	< 0.1
11. Royal Crest	28 993	4	4	0.5 ± 1.4	−1.9 ± 1.8	−0.6 ± 1.1	< 0.1
12. White Rock	79 972	4	4	0.8 ± 0.7	−0.5 ± 0.7	0.0 ± 0.6	< 0.1
13. Pajarito Acres	101 489	4	3	5.5 ± 0.7	−0.5 ± 0.5	1.6 ± 2.7	< 0.1
14. Bandelier	109 238	4	4	0.1 ± 0.5	−0.5 ± 0.5	−0.3 ± 0.2	< 0.1
Perimeter Group Summary	907 524	44	41	18.2 ± 2.8	−1.9 ± 1.8	0.7 ± 1.7	< 0.1
Onsite Stations—Controlled Areas							
15. TA-21	85 823	4	4	1.0 ± 0.8	−0.1 ± 0.7	0.4 ± 0.5	< 0.1
16. TA-6	82 356	4	4	1.0 ± 0.7	−0.6 ± 0.6	0.4 ± 0.7	< 0.1
17. TA-53 (LAMPF)	110 329	4	4	0.8 ± 0.6	0.1 ± 0.5	0.4 ± 0.3	< 0.1
18. Well PM-1	109 273	4	4	0.1 ± 0.5	−0.3 ± 0.4	−0.1 ± 0.2	< 0.1
19. TA-52	88 606	4	4	0.2 ± 0.5	−0.5 ± 0.5	−0.1 ± 0.3	< 0.1
20. TA-16	101 750	4	3	31.9 ± 2.5	−0.2 ± 0.5	8.0 ± 16.0	< 0.1
21. Booster P-2	88 195	4	4	1.0 ± 0.9	−0.4 ± 0.6	0.3 ± 0.6	< 0.1
22. TA-54	100 026	4	0	50.8 ± 3.3	4.2 ± 1.0	29.5 ± 19.7	< 0.1
23. TA-49	59 073	4	4	2.3 ± 1.3	−0.3 ± 1.9	0.5 ± 1.2	< 0.1
24. TA-33	105 173	4	4	0.1 ± 0.5	−0.5 ± 0.5	−0.2 ± 0.2	< 0.1
25. TA-39	96 517	4	4	0.3 ± 0.6	−0.8 ± 0.7	−0.2 ± 0.5	< 0.1
26. TA-16-450	95 795	4	3	3.9 ± 1.0	−0.5 ± 0.4	0.7 ± 2.1	< 0.1
Onsite Group Summary	1 122 916	48	42	50.8 ± 3.3	−0.8 ± 0.7	3.3 ± 8.6	< 0.1

[a]See Fig. 8 for map of station locations.
[b]Minimum detectable limit = 3×10^{-18} µCi/mℓ.
[c]Uncertainties are ±s (see Appendix B).
[d]Controlled Area DOE Concentration Guide = 2×10^{-12} µCi/ℓ.
Uncontrolled Area Derived Concentration Guide = 2×10^{-14} µCi/mℓ.

Table G-8. Atmospheric ^{241}Am Concentrations for 1985

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations—aCi/m^3 (10^{-18} μCi/mℓ) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Regional Stations (28-44 km)—Uncontrolled Areas							
3. Santa Fe	96 045	4	3	10.5 ± 2.6	0.8 ± 0.3	2.8 ± 1.3	<0.1
Perimeter Stations (0-40 km)—Uncontrolled Areas							
6. East Gate	69 477	4	2	11.4 ± 8.5	1.7 ± 0.9	4.9 ± 3.9	<0.1
8. LA Airport	78 555	4	0	4.8 ± 1.2	1.9 ± 0.8	3.7 ± 1.1	<0.1
9. Bayo STP	73 795	4	0	4.6 ± 1.3	2.1 ± 0.7	3.3 ± 0.9	<0.1
12. White Rock	79 972	4	1	3.3 ± 0.8	1.1 ± 0.8	2.1 ± 0.8	<0.1
Perimeter Group Summary	301 799	16	3	11.4 ± 8.5	1.1 ± 0.8	3.5 ± 1.1	<0.1
Onsite Stations—Controlled Areas							
16. TA-6	82 356	4	0	4.1 ± 1.3	2.6 ± 0.8	3.4 ± 0.5	<0.1
17. TA-53 (LAMPF)	110 329	4	0	2.5 ± 0.6	1.5 ± 0.5	2.0 ± 0.3	<0.1
20. TA-16	101 750	4	0	4.0 ± 1.2	1.8 ± 0.6	3.0 ± 1.0	<0.1
21. Booster P-2	88 195	4	1	2.8 ± 1.0	0.0 ± 0.4	1.5 ± 1.0	<0.1
22. TA-54	100 026	4	0	28.5 ± 2.0	3.2 ± 1.0	18.5 ± 9.7	<0.1
23. TA-49	59 073	4	1	8.0 ± 1.6	2.9 ± 1.0	5.2 ± 2.2	<0.1
Onsite Group Summary	541 729	24	2	28.5 ± 2.0	0.0 ± 0.4	5.6 ± 6.5	<0.1

[a]See Fig. 8 for map of station locations.
[b]Minimum detectable limit = 2×10^{-18} μCi/mℓ.
[c]Uncertainties are ±s (see Appendix B).
[d]Controlled Area DOE Concentration Guide = 6×10^{-12} μCi/ℓ.
Uncontrolled Area Derived Concentration Guide = 2×10^{-14} μCi/mℓ.

Table G-9. Atmospheric Uranium Concentrations for 1985

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations (pg/m^3) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Regional Stations (24-44 km)—Uncontrolled Areas							
1. Española	90 196.00	4	0	63.0 ± 6.1	34.7 ± 4.6	50.0 ± 12.9	<0.1
2. Pojoaque	92 563.00	4	0	64.8 ± 7.2	43.5 ± 4.5	54.6 ± 9.4	<0.1
3. Santa Fe	96 045	4	0	54.1 ± 5.6	20.2 ± 2.2	33.0 ± 14.9	<0.1
Regional Group Summary	278 804	12	0	64.8 ± 7.2	20.2 ± 2.2	45.9 ± 11.4	<0.1
Perimeter Stations (0-4 km)—Uncontrolled Areas							
4. Barranca School	95 356	4	0	48.7 ± 5.1	19.5 ± 2.3	32.2 ± 12.1	<0.1
5. Arkansas Avenue	89 327	4	0	31.2 ± 4.2	8.9 ± 1.3	18.5 ± 9.7	<0.1
6. East Gate	69 477	4	0	41.2 ± 4.6	35.4 ± 4.0	39.4 ± 2.7	<0.1
7. 48th Street	98 677	4	0	21.0 ± 2.8	10.0 ± 1.4	17.6 ± 5.1	<0.1
8. LA Airport	78 555	4	0	67.4 ± 7.0	26.4 ± 3.1	42.0 ± 17.9	<0.1
9. Bayo STP	73 795	4	0	34.2 ± 3.7	15.9 ± 2.1	26.3 ± 8.2	<0.1
10. Exxon Station	82 645	4	0	86.3 ± 9.3	19.5 ± 2.4	45.9 ± 28.4	<0.1
11. Royal Crest	28 993	4	1	38.9 ± 4.7	2.0 ± 4.7	25.8 ± 17.3	<0.1
12. White Rock	79 972	4	0	53.3 ± 5.3	9.1 ± 1.5	26.0 ± 19.3	<0.1
13. Pajarito Acres	101 489	4	0	30.8 ± 3.4	15.9 ± 1.9	22.8 ± 6.2	<0.1
14. Bandelier	109 238	4	0	22.7 ± 2.6	9.2 ± 1.3	15.0 ± 5.6	<0.1
Perimeter Group Summary	907 524	44	1	86.3 ± 9.3	2.0 ± 4.7	28.3 ± 10.3	<0.1
Onsite Stations—Controlled Areas							
15. TA-21	85 823	4	0	51.6 ± 5.4	33.7 ± 4.4	42.4 ± 7.3	<0.1
16. TA-6	82 356	4	0	62.4 ± 6.5	12.9 ± 1.7	38.6 ± 20.4	<0.1
17. TA-53 (LAMPF)	110 329	4	0	42.6 ± 4.5	16.3 ± 1.9	26.8 ± 11.3	<0.1
18. Well PM-1	109 273	4	0	28.7 ± 3.1	12.9 ± 1.6	18.2 ± 7.1	<0.1
19. TA-52	88 606	4	0	44.2 ± 4.9	8.5 ± 1.3	32.4 ± 16.8	<0.1
20. TA-16	101 750	4	0	49.8 ± 5.2	10.5 ± 1.4	29.2 ± 16.1	<0.1
21. Booster P-2	88 195	4	0	51.7 ± 5.7	13.7 ± 1.8	33.1 ± 16.7	<0.1
22. TA-54	100 026	4	0	83.0 ± 9.3	35.3 ± 3.7	63.9 ± 20.5	<0.1
23. TA-49	59 073	4	0	44.8 ± 5.0	12.2 ± 2.1	25.3 ± 15.9	<0.1
24. TA-33	105 173	4	0	34.7 ± 3.7	8.1 ± 1.2	19.3 ± 11.2	<0.1
25. TA-39	96 517	4	0	45.0 ± 4.8	27.6 ± 3.0	33.2 ± 8.1	<0.1
26. TA-16-450	95 795	4	0	43.0 ± 4.6	12.4 ± 2.2	26.4 ± 12.6	<0.1
Onsite Group Summary	1 122 916	48	0	83.0 ± 9.3	8.1 ± 1.2	32.4 ± 12.2	<0.1

[a]See Fig. 8 for map of sampling locations.
[b]Minimum detectable limit = 1 pg/m^3.
[c]Uncertainties are ±s (see Appendix B)
[d]Controlled Area Derived Concentration Guide = 2×10^8 pg/m^3.
Uncontrolled Area Derived Concentration Guide = 1×10^5 pg/m^3.

Note: One curie of natural uranium is equivalent to 3000 kg of natural uranium. Hence, uranium masses can be converted to the DOE "uranium special curie" by using the factor 3.3×10^{-13} μCi/pg.

Table G-10. Stack-Gas Sampling Results from Beryllium Shop 4

Sample Date	Be on Filter (ug)	Hours Operated	Stack Concentration (ng/m^3)	Emissions (mg)
2-08-85	0.03	50.6	0.16	0.024
3-15-85	0.12	51.8	0.62	0.097
4-19-85	0.17	51.3	0.89	0.137
5-16-85	0.50	46.2	2.90	0.403
6-19-85	0.80	61.0	3.51	0.644
8-02-85	0.11	51.4	0.57	0.089
8-30-85	0.11	48.6	0.61	0.089
11-05-85	0.21	50.1	1.12	0.169
12-03-85	0.12	50.0	0.64	0.097
		Average	1.22	Total 1.748

Table G-11. Emissions (tons/yr) and Fuel Consumption (10^9 Btu/yr) from the TA-3 Power Plant and Steam Plants

Pollutant	Year	Location TA-3	TA-16	TA-21	Total
Particulates	1984	2.4	0.4	0.2	3.0
	1985	2.3	0.4	0.1	2.8
	% Change	−5.3	6.7	−44.7	−6.4
Oxides of Nitrogen	1984	31.2	20.3	8.1	59.7
	1985	18.1	19.9	5.2	43.2
	% Change	−42.0	−1.9	−36.3	−27.7
Carbon Monoxide	1984	31.4	5.1	2.0	38.6
	1985	30.3	5.0	1.3	36.6
	% Change	−3.5	−2.4	−35.5	−5.3
Hydrocarbons	1984	1.3	0.8	0.3	2.5
	1985	1.3	0.8	0.2	2.3
	% Change	−1.0	3.1	−28.8	−7.0
Fuel Consumption	1984	1689	312	125	2126
	1985	1670	314	81	2064
	% Change	−1.2	0.4	−34.9	−2.9

Table G-12. Quantities of Volatile Chemicals and Compressed Gases Used at Los Alamos (kg)[a,b]

	1981	1982	1983	1984	1985
Acids					
Acetic Acid	230	170	---	99	65
Hydrochloric Acid	6500	6000	1400	1655	758
Hydroflouric Acid	420	270	640	191	278[c]
Nitric Acid	99500	70500	52100	55976	54212[c]
Perchloric Acid	230	180	60	321	88
Phosphoric Acid	480	490	30	111	59
Sulfuric Acid	2200	2200	2600	692	830[c]
Gases					
Ammonia	2900	1800	2400	2177	2404[c]
Carbon Monoxide	6200	9600	---	2965	0
Chlorine	1200	610	140	1238	3066[c]
Freon	3300	1600	2600	4137	4368
Hydrogen Flouride	1000	1600	1600	1134	2812[c]
Nitrogen Oxides	440	330	410	354	435[c]
Sulfur Dioxide	370	210	30	0	0
Sulfur Hexafluoride	10600	8800	14200	9507	14560[c]
Inorganic Chemicals					
Ammonium Hydroxide	1900	1200	2100	797	331
Mercury	200	210	60	24	1[c]
Sodium Hydroxide	---	---	39500	73539	44821[c]
Organic Chemicals					
Acetone	10200	10700	10900	10118	6735[c]
Benzene	---	---	70	12	78
Carbon Tetrachloride	180	190	60	103	238
Chloroform	250	320	500	177	208
Ethanol	11800	12800	13500	7024	9420
Freons	12500	32200	28400	22006	27097
Kerosene	5300	5500	2800	1315	614
Methanol	3400	3100	730	3298	1607
Methylene Chloride	230	430	100	1876	2028[c]
Methyl Ethyl Ketone	21000	400	6200	5805	4238
Perchloroethylene	9100	340	---	2	32
Tetrahydrofuran	---	---	---	30	79
Tuolene	60	60	190	337	83
Trichlorethane	39300	25600	31100	27674	29665[c]
Trichlorethylene	3200	390	4200	2204	3041[c]
Xylene	---	---	70	59	135

[a]This table does not include chemicals received under special orders.
[b]1 kg = 2.2 lb.
[c]Greater than or equal to EPA Reportable Quantity (40 CFR 302).

Table G-13. Estimated Concentrations of Toxic Elements Aerosolized by Dynamic Experiments

Element	1985 Total Usage (kg)	Fraction Aerosolized (%)	Annual Average Concentration (ng/m^3) (4 km)	Annual Average Concentration (ng/m^3) (8 km)	Applicable Standard (ng/m^3)
Uranium	524.0	10	0.05	0.02	9000[a]
Be	0.0	2	0.0000	0.0000	10[b]
Pb	163.2	100[c]	0.18	0.07	1500[d]

[a]DOE 1981.
[b]Thirty day average. New Mexico Air Quality Control Regulation 201.
[c]Assumed percentage aerosolized.
[d]Three month average. 40 CFR 50.12.

Table G-14. Quality of Effluents from Liquid Radioactive Waste Treatment Plants for 1985[a]

Radioactive Isotopes	Waste Treatment Plant Location: TA-50 Activity Released (mCi)	TA-50 Mean Concentration (μCi/mℓ)	TA-50 Mean as % CG[b]	TA-21 Activity Released (mCi)	TA-21 Mean Concentration (μCi/mℓ)	TA-21 Mean as % CG[b]
^{238}Pu	3.9	1.4×10^{-7}	0.14	0.019	1.2×10^{-8}	0.012
$^{239,240}Pu$	5.8	2.0×10^{-7}	0.20	0.029	1.9×10^{-8}	0.019
^{241}Am	5.4	1.9×10^{-7}	0.19	0.14	9.1×10^{-8}	0.091
^{89}Sr	9.0	3.1×10^{-7}	1.0	0.0061	4.0×10^{-9}	0.001
^{90}Sr	1.2	4.2×10^{-8}	0.42	0.056	3.6×10^{-8}	0.36
^{3}H	69,400	2.4×10^{-3}	2.4	750	4.9×10^{-4}	0.49
^{137}Cs	---	---	---	0.052	3.4×10^{-8}	0.011
^{234}U	0.43	1.5×10^{-8}	0.015	0.17	1.1×10^{-7}	0.11
Total Effluent Volume:		2.86×10^{7} ℓ			1.54×10^{6} ℓ	

Nonradioactive Constituent	Waste Treatment Plant Location: TA-50 Mean Concentration (mg/ℓ)	TA-21 Mean Concentration (mg/ℓ)
Cd[c]	0.001	0.003
Ca	47	7.5
Cl	100	22
Cr (total)[c]	0.06	0.044
Cu[c]	1.0	0.07
F	28	6.8
Hg[c]	0.001	0.0005
Mg	1.6	0.7
Na	896	250
Pb[c]	0.016	0.004
Zn[c]	0.10	0.04
CN	0.3	---
COD[c]	84	55
$NO_3(N)$	376	2.4
PO_4	1.6	0.6
TDS	3,570	815
pH[c]	6.9–11.7	7.7–12.0
Total Effluent Volume	2.86×10^{7} ℓ	1.54×10^{6} ℓ

[a]As reported on DOE forms F-5821.1.
[a]Department of Energy's Concentration Guide for Controlled Areas (Appendix A).
[b]Constituents regulated by National Pollutant Discharge Elimination System permit.

Table G-15. Quality of Effluent from the Los Alamos Meson Physics Facility's (TA-53) Lagoons

Radioactive Isotope	Activity Released (mCi)	Mean Concentration (μCi/mℓ)	Mean as % CG[a]
^{3}H	6700	7.1×10^{-4}	0.71
^{7}Be	120	1.3×10^{-5}	0.026
^{22}Na	41	4.3×10^{-6}	0.48
^{54}Mn	21	2.2×10^{-6}	0.073
^{57}Co	21	2.2×10^{-6}	0.011
^{60}Co	11	1.1×10^{-6}	0.11
^{134}Cs	57	6.0×10^{-6}	2.0
Total Effluent Volume	9.5×10^{6} ℓ		

[a]Department of Energy's Concentration Guide for Controlled Areas (Appendix A).

Table G-16. Location of Surface and Ground Water Sampling Stations

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Regional Surface Water				
Rio Chama at Chamita	36°05′	106°07′	---	SW
Rio Grande at Embudo	36°12′	105°58′	---	SW
Rio Grande at Otowi	35°52′	106°08′	---	SW
Rio Grande at Cochiti	35°37′	106°19′	---	SW
Rio Grande at Bernalillo	35°17′	106°36′	---	SW
Jemez River	35°40′	106°44′	---	SW
Perimeter Stations				
Los Alamos Reservoir	N105	W090	7	SW
Guaje Canyon	N300	E100	8	SW
Frijoles	S280	E180	9	SW
La Mesita Spring	N080	E550	10	GWD
Sacred Spring	N170	E540	11	GWD
Indian Spring	N140	530	12	GWD
White Rock Canyon				
Group I				
Sandia Spring	S030	E470	13	SWR
Spring 3	S110	E450	14	SWR
Spring 3A	S120	E445	15	SWR
Spring 3AA	S140	E440	16	SWR
Spring 4	S170	E110	17	SWR
Spring 4A	S150	E395	18	SWR
Spring 5	S220	E390	19	SWR
Spring 5AA	S240	E360	20	SWR
Ancho Spring	S280	E305	21	SWR
Group II				
Spring 5A	S230	E390	22	SWR
Spring 6	S300	E330	23	SWR
Spring 6A	S310	E310	24	SWR
Spring 7	S330	E295	25	SWR
Spring 8	S335	E285	26	SWR
Spring 8A	S315	E280	27	SWR
Spring 9	S270	E270	28	SWR
Spring 9A	S325	E265	29	SWR
Doe Spring	S320	E250	30	SWR
Spring 10	S370	E230	31	SWR

[a]Regional surface water sampling locations in Fig. 14; Perimeter, White Rock Canyon, Onsite, and Effluent Release Area sampling locations in Fig. 15.
[b]SW = surface water, GWD = deep or main aquifer, GWS = shallow or alluvial aquifer, SWR = spring at White Rock Canyon, and D = water supply distribution system.

Table G-16 (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
White Rock Canyon				
Group III				
Spring 1	N040	E520	32	SWR
Spring 2	N015	E505	33	SWR
Group IV				
Spring 3B	S150	E465	34	SWR
Streams				
Pajarito	S180	E410	35	SWR
Ancho	S295	E340	36	SWR
Frijoles	S365	E235	37	SWR
Sanitary Effluent				
Mortandad	S070	E480	38	SWR
Onsite Stations				
Test Well 1	N070	E345	39	GWD
Test Well 2	N120	E150	40	GWD
Test Well 3	N080	E215	41	GWD
Test Well DT-5A	S110	E090	42	GWD
Test Well 8	N035	E170	43	GWD
Test Well DT-9	S155	E140	44	GWD
Test Well DT-10	S120	E125	45	GWD
Cañada del Buey	N010	E150	46	SW
Pajarito	S060	E215	47	SW
Water Canyon at Beta	S090	E090	48	SW
Pajarito Canyon (Onsite)				
PCO-1	S054	E212	102	GWS
PCO-2	S081	E255	103	GWS
PCO-3	S098	E293	104	GWS
Effluent Release Areas				
Acid-Pueblo Canyon				
Acid Weir	N125	E070	49	SW
Pueblo 1	N130	E080	50	SW
Pueblo 2	N120	E155	51	SW
Pueblo 3	N085	E315	52	SW
Hamilton Bend Springs	N110	E250	53	S
Test Well 1A	N070	E335	54	GWS
Test Well 2A	N120	E140	55	GWS
Basalt Spring	N065	E395	56	S

Table G-16 (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
DP-Los Alamos Canyon				
DPS-1	N090	E160	57	SW
DPS-4	N080	E200	58	SW
LAO-C	N085	E070	59	GWS
LAO-1	N080	E120	60	GWS
LAO-2	N080	E210	61	GWS
LAO-3	N080	E220	62	GWS
LAO-4	N070	E245	63	GWS
LAO-4.5	N065	E270	64	GWS
Sandia Canyon				
SCS-1	N080	E040	65	SW
SCS-2	N060	E140	66	SW
SCS-3	N050	E185	67	SW
Mortandad Canyon				
GS-1	N040	E100	68	SW
MCO-3	N040	E110	69	GWS
MCO-4	N035	E150	70	GWS
MCO-5	N030	E160	71	GWS
MCO-6	N030	E175	72	GWS
MCO-7	N025	E180	73	GWS
MCO-7.5	N030	E190	74	GWS
MCO-8				
Water Supply and Distribution				
Los Alamos Well Field				
Well LA-1B	N115	E530	76	GWD
Well LA-2	N125	E505	77	GWD
Well LA-3	N130	E490	78	GWD
Well LA-4	N070	E405	79	GWD
Well LA-5	N076	E435	80	GWD
Well LA-6	N105	E465	81	GWD
Guaje Well Field				
Well G-1	N190	E385	82	GWD
Well G-1A	N197	E380	83	GWD
Well G-2	N205	E365	84	GWD
Well G-3	N215	E350	85	GWD
Well G-4	N213	E315	86	GWD
Well G-5	N228	E295	87	GWD
Well G-6	N215	E270	88	GWD

Table G-16 (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Pajarito Well Field				
Well PM-1	N030	E305	89	GWD
Well PM-2	S055	E202	90	GWD
Well PM-3	N040	E255	91	GWD
Well PM-4	S030	E205	92	GWD
Well PM-5	N015	E155	93	GWD
Water Canyon Gallery	S040	W125	94	GWD
Fire Station 1	N080	E015	95	D
Fire Station 2	N100	E120	96	D
Fire Station 3	S085	E375	97	D
Fire Station 4	N185	E070	98	D
Fire Station 5	S010	W065	99	D
Bandelier National Monument Headquarters	S270	E190	100	D
Fenton Hill (TA-57)	35°53′	106°40′	101	D

Table G-17. Radiochemical and Chemical Quality of Surface Water from Regional Stations

Station	1985 (month-day)	Radiochemical					
		^{137}Cs (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	$^{239,240}Pu$ (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)
Rio Chama at Chamita	3-11	48 ± 48	0.008 ± 0.011	0.008 ± 0.008	0.5 ± 0.3	3.3 ± 0.6	−40 ± 50
Rio Chama at Chamita	9-9	140 ± 60	0.000 ± 0.010	0.008 ± 0.010	3.8 ± 0.5	2.1 ± 0.2	140 ± 60
Rio Grande at Embudo	3-11	46 ± 48	−0.008 ± 0.006	0.013 ± 0.009	0.8 ± 0.3	2.3 ± 0.7	−80 ± 50
Rio Grande at Embudo	9-9	−40 ± 60	−0.011 ± 0.006	0.000 ± 0.010	1.9 ± 0.4	0.7 ± 0.2	70 ± 60
Rio Grande at Otowi	3-11	2 ± 45	0.000 ± 0.010	0.006 ± 0.014	0.5 ± 0.3	3.6 ± 0.6	−10 ± 50
Rio Grande at Otowi	9-9	−143 ± 65	−0.007 ± 0.009	0.004 ± 0.006	5.1 ± 0.7	1.9 ± 0.2	−10 ± 50
Rio Grande at Cochiti	3-12	−10 ± 37	0.011 ± 0.012	0.004 ± 0.006	0.6 ± 0.3	3.0 ± 0.6	10 ± 50
Rio Grande at Cochiti	9-11	−69 ± 47	−0.004 ± 0.004	0.000 ± 0.010	1.0 ± 0.4	3.0 ± 0.3	−10 ± 50
Rio Grande at Bernalillo	3-12	8 ± 35	−0.004 ± 0.004	0.016 ± 0.010	0.3 ± 0.3	3.5 ± 0.6	0 ± 50
Rio Grande at Bernalillo	9-11	−19 ± 50	0.015 ± 0.013	−0.005 ± 0.087	0.0 ± 0.4	0.9 ± 0.5	−70 ± 60
Jemez River at Jemez	4-4	7 ± 45	−0.013 ± 0.016	−0.004 ± 0.004	−1.2 ± 0.3	1.1 ± 0.3	−40 ± 50
Jemez River at Jemez	9-11	78 ± 58	−0.009 ± 0.016	0.035 ± 0.025	0.5 ± 0.4	1.6 ± 0.2	0 ± 60
No. of Analyses		12	12	12	12	12	12
Minimum		−143 ± 65	−0.013 ± 0.016	−0.005 ± 0.004	−1.2 ± 0.3	0.7 ± 0.2	−70 ± 60
Maximum		140 ± 60	0.015 ± 0.013	0.035 ± 0.025	5.1 ± 0.7	3.6 ± 0.6	140 ± 60
Average		4	−0.002	0.007	1.1	2.2	−3
s		72	0.009	0.011	1.7	1.1	60
Limits of Detection		40	0.009	0.03	0.7	1	50

Table G-17 (cont)

Station	1984 (month-day)	Chemical (concentrations in mg/l) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
Rio Chama at Chamita	3-11	13	44	9.9	3.1	22	0	105	<0.5	70	6	0.3	0.4	252	141	7.7	40
Rio Grande at Embudo	3-11	24	30	6.0	2.4	15	0	88	<0.5	34	4	0.4	<0.2	179	95	7.8	26
Rio Grande at Otowi	3-11	19	37	7.7	2.6	18	0	95	<0.5	48	5	0.4	<0.2	218	116	7.7	32
Rio Grande at Cochiti	3-12	20	38	7.1	2.4	16	0	97	<0.5	51	5	0.4	<0.2	202	118	7.9	32
Rio Grande at Bernalillo	3-12	21	38	6.6	2.8	17	0	105	<0.5	41	5	0.4	<0.2	225	117	7.6	33
Jemez River at Jemez	4-4	34	28	3.9	5.0	24	0	70	<0.5	12	22	0.3	<0.2	175	68	7.6	26
No. of Analyses		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Minimum		13	28	3.9	2.4	15	—	70	—	12	4	0.3	<0.2	175	68	7.6	26
Maximum		34	44	9.9	5.0	24	—	105	—	70	22	0.4	0.4	252	141	7.9	40
Average		22	36	6.9	3.1	19	0	93	<0.5	43	8	0.4	<0.2	208	109	7.7	32
s		7	6	2.0	1.0	3	—	13	—	19	7	0.1	0.1	25	25	0.1	5

Table G-18. Radiochemical and Chemical Quality of Surface and Ground Waters from Perimeter Stations

Station	Map Designation	1985 (month-day)	Radiochemical					
			^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	$^{239,240}Pu$ (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)	Gross Gamma (counts/min/ℓ)
Los Alamos Reservoir	7	4-4	−5 ± 40	0.000 ± 0.010	0.006 ± 0.006	−0.6 ± 0.3	0.4 ± 0.4	−30 ± 50
Los Alamos Reservoir	7	9-9	97 ± 41	0.000 ± 0.010	0.016 ± 0.011	0.4 ± 0.4	0.0 ± 0.2	110 ± 60
Guaje Canyon	8	4-4	2 ± 36	0.005 ± 0.012	0.005 ± 0.016	−1.1 ± 0.3	0.9 ± 0.4	30 ± 50
Guaje Canyon	8	9-30	100 ± 50	0.000 ± 0.010	0.009 ± 0.009	−0.8 ± 0.4	1.6 ± 0.2	−30 ± 60
Frijoles Canyon	9	3-14	16 ± 36	0.000 ± 0.010	0.009 ± 0.011	0.6 ± 0.3	0.9 ± 0.5	−30 ± 50
Frijoles Canyon	9	9-10	−39 ± 47	0.014 ± 0.016	0.021 ± 0.015	0.0 ± 0.4	0.2 ± 0.2	40 ± 60
La Mesita Spring	10	3-14	44 ± 43	0.000 ± 0.010	0.005 ± 0.011	0.1 ± 0.3	20 ± 2.0	0 ± 50
La Mesita Spring	10	9-10	100 ± 53	0.011 ± 0.010	0.000 ± 0.010	0.5 ± 0.4	0.9 ± 0.2	10 ± 60
Sacred Spring	11	3-14	121 ± 58	−0.005 ± 0.011	0.000 ± 0.010	0.0 ± 0.3	28 ± 2.0	20 ± 50
Sacred Spring	11	9-9	−60 ± 45	0.011 ± 0.013	0.004 ± 0.006	0.7 ± 0.4	11.3 ± 0.2	80 ± 60
Indian Spring	12	9-9	−8 ± 68	−0.059 ± 0.059	−0.029 ± 0.052	2.8 ± 0.5	11 ± 1.1	80 ± 60
Ashley Pond	—	6-8	28 ± 49	−0.004 ± 0.007	0.013 ± 0.009	0.1 ± 0.4	3.8 ± 0.8	20 ± 60
No. of Analyses			12	12	12	12	12	12
Minimum			−60 ± 45	−0.059 ± 0.059	−0.029 ± 0.052	−1.1 ± 0.3	0.0 ± 0.2	−30 ± 60
Maximum			121 ± 58	0.014 ± 0.016	0.021 ± 0.015	2.8 ± 0.5	28 ± 2.0	110 ± 60
Average			33	−0.002	0.004	0.2	5.8	21
s			60	0.019	0.017	1.0	9.0	48
Limits of Detection			40	0.009	0.03	0.7	1	50

Table G-18 (cont)

Station	Map Designation	1985 (month-day)	Chemical (concentrations in mg/l) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
Los Alamos Reservoir	7	4-4	38	7	2.5	2.0	4	0	20	<0.5	10	3	<0.1	0.3	95	28	7.0	8
Guaje Canyon	8	4-4	61	9	3.1	3.1	7	0	39	<0.5	8	3	<0.1	<0.2	130	31	7.5	10
Frijoles Canyon	9	3-14	50	9	3.2	2.5	9	0	37	<0.5	10	3	0.2	<0.2	162	37	7.5	11
La Mesita Spring	10	3-14	28	42	2.0	2.6	34	0	146	<0.5	24	9	0.3	1.5	252	111	8.0	38
Sacred Springs	11	3-14	48	34	2.9	2.6	27	0	141	<0.5	6	12	0.5	0.7	222	98	7.3	35
Ashley Pond	—	6-8	32	14	1.5	5.0	70	0	120	<0.5	7	33	1.4	0.4	220	40	7.6	36
No. of Analyses			6	6	6	6	6	0	6	6	6	6	6	6	6	6	6	6
Minimum			28	7	1.5	2.0	4	—	20	—	6	2	<0.1	<0.2	95	28	7.0	8
Maximum			61	42	3.2	5.0	70	0	146	<0.5	24	33	1.4	1.5	252	111	8.0	38
Average			42	19	2.5	3.0	25	—	84	—	11	10	<0.4	<0.6	180	58	7.5	23
s			12	15	0.7	1.1	25	—	58	—	6	12	0.5	0.5	61	37	0.3	14

Station	Map Designation	1985 (month-day)	Miscellaneous Chemical (concentrations in mg/l) Ag	As	Ba	Cd	Cr	Hg	Pd	Se	Cu	Fe	Mn	Zn
Ashley Pond	—	6-18	<0.001	0.011	0.133	<0.0002	0.008	<0.0002	0.003	<0.003	0.023	0.028	0.005	0.010

Table G-19. Radiochemical and Chemical Quality of Surface and Ground Waters from Acid-Pueblo Canyon, A Former Effluent Release Area

Station	Map Designation	1985 (month-day)	Radiochemical					
			^{137}Cs (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	$^{239,240}Pu$ (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)
Acid Weir	49	4-8	−47 ± 53	−0.005 ± 0.012	0.446 ± 0.052	−0.2 ± 0.3	1.1 ± 0.4	80 ± 50
Acid Weir	49	9-18	23 ± 37	−0.006 ± 0.010	0.017 ± 0.012	2.7 ± 0.5	0.7 ± 0.2	−30 ± 60
Pueblo 1	50	4-8	89 ± 39	0.011 ± 0.012	0.011 ± 0.012	−0.9 ± 0.3	1.1 ± 0.4	60 ± 50
Pueblo 1	50	9-18	−47 ± 40	0.008 ± 0.012	−0.008 ± 0.007	0.7 ± 0.4	0.8 ± 0.2	40 ± 60
Pueblo 2	51	4-8	21 ± 48	0.000 ± 0.010	0.056 ± 0.017	0.5 ± 0.3	0.5 ± 0.2	60 ± 50
Pueblo 2	51	10-2	66 ± 44	−0.017 ± 0.010	0.207 ± 0.031	0.2 ± 0.4	1.4 ± 0.2	−120 ± 60
Pueblo 3	52	4-8	56 ± 37	−0.004 ± 0.001	0.033 ± 0.013	0.7 ± 0.3	0.9 ± 0.4	70 ± 50
Pueblo 3	52	9-18	−94 ± 52	0.008 ± 0.015	0.000 ± 0.010	0.0 ± 0.4	1.7 ± 0.2	40 ± 60
Hamilton Bend Spring	53	4-8	62 ± 35	−0.004 ± 0.007	−0.009 ± 0.006	−0.6 ± 0.3	1.5 ± 0.5	10 ± 50
Hamilton Bend Spring	53	9-18	−86 ± 36	−0.005 ± 0.014	0.038 ± 0.015	0.4 ± 0.4	1.3 ± 0.2	30 ± 60
Test Well 1A	54	3-19	−47 ± 56	0.032 ± 0.013	0.014 ± 0.010	−0.6 ± 0.3	1.0 ± 0.5	50 ± 50
Test Well 1A	54	9-17	−37 ± 36	−0.014 ± 0.012	0.028 ± 0.013	2.9 ± 0.5	1.1 ± 0.2	90 ± 60
Test Well 2A	55	4-3	93 ± 47	0.000 ± 0.010	0.012 ± 0.009	1.8 ± 0.4	0.4 ± 0.4	90 ± 50
Test Well 2A	55	10-3	20 ± 48	0.026 ± 0.013	0.038 ± 0.014	−0.3 ± 0.3	0.9 ± 0.1	−110 ± 60
Basalt Spring	56	9-18	91 ± 39	0.000 ± 0.010	0.012 ± 0.010	0.4 ± 0.4	1.1 ± 0.1	−40 ± 60
No. of Analyses			15	15	15	15	15	15
Minimum			−94 ± 52	−0.017 ± 0.010	−0.009 ± 0.006	−0.9 ± 0.3	0.4 ± 0.4	−120 ± 60
Maximum			93 ± 47	0.032 ± 0.013	0.446 ± 0.052	2.9 ± 0.5	1.7 ± 0.2	90 ± 60
Average			11	0.002	0.060	0.5	1.0	21
s			66	0.013	0.148	1.1	0.3	67
Limits of Detection			40	0.009	0.03	0.7	1	50

Table G-19 (cont)

Station	Map (month-day)	1985 SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
		Chemical (concentrations in mg/l)															
Acid Weir	4-8	18	17	2.4	4.0	110	0	42	<0.5	11	153	0.6	0.3	356	48	7.5	67
Pueblo 1	4-8	43	16	3.0	8.1	56	0	60	6.0	21	35	0.6	8.3	270	48	6.5	40
Pueblo 2	4-8	48	14	2.8	6.5	53	0	51	4.5	19	54	0.6	3.8	242	44	7.3	35
Pueblo 3	4-8	54	18	3.3	9.5	66	0	73	8.3	21	52	0.7	7.0	299	54	7.1	46
Hamilton Bend Spring	4-8	58	16	4.9	9.1	77	0	96	8.3	24	66	0.9	3.6	314	58	7.3	51
Test Well 1A	3-19	56	23	6.8	7.9	71	0	105	4.4	27	49	0.8	12	339	82	7.7	52
Test Well 2A	4-3	20	29	6.4	4.2	22	0	76	<0.5	21	37	0.3	<0.2	183	94	7.5	33
No. of Analyses		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Minimum		18	16	2.4	4.0	22	—	51	<0.5	11	35	0.3	<0.2	183	44	6.5	33
Maximum		58	29	6.8	9.5	110	0	105	8.3	27	153	0.9	12	356	94	7.7	67
Average		42	19	4.2	7.0	65	—	72	<4.6	21	64	0.6	<5.0	286	61	7.3	46
s		17	5	1.8	2.2	26	—	23	3.2	5	41	0.2	4.4	60	19	0.4	12

Table G-20. Radiochemical and Chemical Quality of Surface and Ground Water from White Rock Canyon

Station	1985 (month-day)	Radiochemical ^{137}Cs (10^{-9} μCi/mℓ)	Radiochemical ^{238}Pu (10^{-9} μCi/mℓ)	Radiochemical $^{239,240}Pu$ (10^{-9} μCi/mℓ)	Radiochemical ^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)	Gross Gamma (counts/min/ℓ)
Group I							
Sandia Spring	9-24	108 ± 41	0.000 ± 0.010	−0.004 ± 0.004	−0.7 ± 0.4	1.9 ± 0.2	−90 ± 60
Spring 3	9-24	15 ± 19	−0.010 ± 0.010	−0.015 ± 0.008	−0.3 ± 0.4	1.3 ± 0.2	0 ± 60
Spring 3A	9-24	−37 ± 55	−0.019 ± 0.015	−0.005 ± 0.010	−0.4 ± 0.4	2.1 ± 0.2	40 ± 60
Spring 3AA	9-24	−56 ± 39	0.008 ± 0.012	0.000 ± 0.016	−0.7 ± 0.4	1.4 ± 0.2	10 ± 60
Spring 4	9-24	60 ± 45	0.014 ± 0.001	0.000 ± 0.010	−0.8 ± 0.4	2.0 ± 0.2	220 ± 60
Spring 4A	9-24	37 ± 53	−0.008 ± 0.005	−0.008 ± 0.008	−0.3 ± 0.4	1.9 ± 0.2	90 ± 60
Spring 5	9-24	28 ± 39	−0.004 ± 0.015	−0.004 ± 0.004	0.0 ± 0.4	1.2 ± 0.2	−10 ± 60
Spring 5AA	9-24	25 ± 63	−0.010 ± 0.014	0.010 ± 0.010	0.2 ± 0.4	1.0 ± 0.2	50 ± 60
Ancho Spring	9-25	−25 ± 40	0.004 ± 0.014	0.000 ± 0.010	−1.5 ± 0.4	1.2 ± 0.2	−25 ± 40
Group II							
Spring 5A	9-24	−13 ± 41	0.000 ± 0.010	0.008 ± 0.009	−0.1 ± 0.4	2.9 ± 0.3	250 ± 70
Spring 8A	9-25	101 ± 53	−0.012 ± 0.007	−0.008 ± 0.010	−0.8 ± 0.4	0.7 ± 0.2	30 ±60
Sprng 9	9-25	32 ± 38	0.012 ± 0.014	0.000 ± 0.010	0.4 ± 0.4	1.3 ± 0.2	40 ± 60
Spring 9A	9-25	−25 ± 31	−0.008 ± 0.006	−0.008 ± 0.006	−0.9 ± 0.4	1.2 ± 0.2	100 ± 60
Doe Spring	9-25	−26 ± 45	−0.010 ± 0.010	−0.005 ± 0.005	1.0 ± 0.4	1.0 ± 0.2	−50 ± 60
Group III							
Spring 1	9-24	59 ± 45	0.000 ± 0.020	−0.004 ± 0.004	−0.3 ± 0.4	3.0 ± 0.3	−30 ± 60
Spring 2	9-24	33 ± 56	−0.015 ± 0.013	0.005 ± 0.008	−0.3 ± 0.4	3.7 ± 0.4	160 ± 60
Group IV							
Spring 3B	9-24	12 ± 33	−0.009 ± 0.009	0.000 ± 0.010	−1.1 ± 0.4	19 ± 1.0	160 ± 60
Streams							
Pajarito	9-24	11 ± 60	0.000 ± 0.010	−0.004 ± 0.010	−0.8 ± 0.4	1.2 ± 0.2	60 ± 60
Ancho	9-25	−26 ± 46	0.004 ± 0.012	0.004 ± 0.008	−0.6 ± 0.4	0.7 ± 0.2	70 ± 60
Frijoles	9-25	65 ± 41	−0.012 ± 0.010	0.006 ± 0.006	−0.1 ± 0.4	0.6 ± 0.2	60 ± 60
Sanitary Effluent							
Mortandad	9-24	−33 ± 60	−0.008 ± 0.010	0.004 ± 0.010	−0.7 ± 0.4	2.0 ± 0.2	20 ± 60
No. of Analyses		21	21	21	21	21	21
Minimum		−56 ± 39	−0.019 ± 0.015	−0.015 ± 0.008	−1.5 ± 0.4	0.6 ± 0.2	−90 ± 60
Maximum		108 ± 41	0.014 ± 0.001	0.010 ± 0.010	1.0 ± 0.4	19 ± 1.0	250 ± 70
Average		16	−0.004	−0.001	−0.4	2.4	50
s		46	0.009	0.006	0.6	3.9	82
Limits of Detection		40	0.009	0.03	0.7	1	50

Table G-20 (cont)

Station	Chemical (concentrations in mg/l) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
Group																
Sandia Spring	46	29	1.6	2.6	15	0	102	<0.1	6	3	0.5	0.2	165	81	7.3	23
Spring 3	52	20	1.4	2.9	15	0	78	<0.1	5	3	0.5	0.6	147	64	7.5	18
Spring 3A	51	20	1.5	3.0	15	0	79	<0.1	5	3	0.4	0.4	152	59	7.3	18
Spring 3AA	60	26	0.9	4.7	22	0	143	<0.1	4	6	0.9	<0.1	243	95	7.7	30
Spring 4	58	23	4.1	2.7	14	0	85	<0.1	11	7	0.6	0.9	178	80	7.2	23
Spring 4A	70	20	4.2	2.2	12	0	80	<0.1	7	6	0.6	0.8	172	78	7.2	21
Spring 5	71	20	4.2	2.0	13	0	86	<0.1	6	5	0.5	0.1	174	72	7.8	19
Spring 5AA	59	29	5.0	2.5	14	0	110	<0.1	7	6	0.5	0.1	193	100	7.3	26
Ancho Spring	74	14	3.1	2.2	10	0	65	<0.1	3	3	0.4	0.3	152	52	7.1	14
Group II																
Spring 5A	55	31	2.8	3.2	26	0	65	<0.1	12	5	0.5	0.3	211	93	7.1	30
Spring 8A	78	10	2.6	2.1	12	0	59	<0.1	3	2	0.4	<0.1	147	39	7.5	13
Spring 9	77	9	2.5	1.7	12	0	77	<0.1	2	2	0.5	<0.1	128	40	7.0	13
Spring 9A	74	10	2.9	1.5	11	0	58	<0.1	2	2	0.4	<0.1	143	41	7.2	13
Doe Spring	75	12	3.1	1.6	12	0	63	<0.1	2	2	0.6	<0.1	155	46	7.1	14
Group III																
Spring 1	33	17	1.0	2.1	31	0	102	<0.1	8	3	0.7	<0.1	171	54	7.5	24
Spring 2	36	22	1.1	1.4	61	0	171	<0.1	8	4	1.5	<0.1	235	64	7.9	36
Group IV																
Spring 3B	48	23	1.8	4.8	16	0	324	<0.1	17	4	1.1	1.9	431	30	7.7	67
Streams																
Pajarito	66	20	4.2	2.5	14	0	84	<0.1	6	6	0.5	0.5	188	72	7.9	21
Ancho	73	14	3.1	2.0	27	0	68	<0.1	3	3	0.4	<0.1	152	56	7.8	15
Frijoles	60	9	3.0	2.1	10	0	51	<0.1	4	3	0.2	<0.1	141	42	7.7	12
Sanitary Effluent																
Mortandad	118	29	7.1	13	76	0	196	14	49	72	1.8	8.8	588	135	8.0	64
No. of Analyses	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Minimum	33	9	0.9	1.4	10	—	51	<0.1	2	2	0.2	<0.1	128	30	7.0	12
Maximum	118	31	7.1	13	76	—	374	14	49	72	1.8	8.8	588	135	8.0	64
Average	64	19	2.9	3.0	76	0	102	<0.8	8.1	7.1	0.6	<0.8	203	66	7.5	24
s	18	7	1.5	2.5	17	—	113	3.0	10	15	0.4	1.9	109	26	0.3	15

Table G-21. Radiochemical and Chemical Quality of Surface and Ground Water from Onsite Stations

Station	Map Designation	1985 (month-day)	Radiochemical					
			^{137}Cs (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	$^{239,240}Pu$ (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)
Test Well 1	39	3-19	66 ± 38	0.008 ± 0.010	0.016 ± 0.011	−0.1 ± 0.3	3.4 ± 0.6	20 ± 50
Test Well 1	39	9-17	−49 ± 34	0.004 ± 0.013	0.000 ± 0.010	2.7 ± 0.5	0.6 ± 0.2	−30 ± 60
Test Well 2	40	4-3	10 ± 40	0.000 ± 0.010	0.000 ± 0.010	−0.8 ± 0.3	1.0 ± 0.3	0 ± 50
Test Well 2	40	10-3	−47 ± 42	0.011 ± 0.015	0.000 ± 0.010	−0.8 ± 0.3	1.2 ± 0.1	−60 ± 60
Test Well 3	41	3-19	−7 ± 32	−0.004 ± 0.007	0.000 ± 0.010	−0.7 ± 0.3	0.8 ± 0.5	−30 ± 50
Test Well 3	41	9-17	−12 ± 31	0.014 ± 0.014	0.055 ± 0.017	2.5 ± 0.5	0.8 ± 0.2	40 ± 60
Test Well DT-5A	42	3-26	66 ± 41	0.013 ± 0.009	0.004 ± 0.007	−1.1 ± 0.3	1.2 ± 0.5	0 ± 50
Test Well DT-5A	42	9-17	61 ± 38	0.016 ± 0.016	0.040 ± 0.014	3.4 ± 0.5	0.1 ± 0.2	30 ± 60
Test Well 8	43	4-3	54 ± 53	−0.009 ± 0.009	−0.009 ± 0.009	−0.2 ± 0.3	0.6 ± 0.4	−10 ± 50
Test Well 8	43	9-16	44 ± 38	0.009 ± 0.009	0.009 ± 0.009	−0.6 ± 0.4	0.8 ± 0.2	10 ± 60
Test Well 10	45	3-26	46 ± 31	0.004 ± 0.007	0.000 ± 0.010	−1.0 ± 0.3	0.6 ± 0.5	−50 ± 50
Test Well 10	45	10-3	26 ± 49	−0.022 ± 0.014	0.000 ± 0.010	−0.7 ± 0.4	1.4 ± 0.2	−40 ± 60
Cañada del Buey	46	3-25	−16 ± 46	−0.006 − 0.006	0.000 ± 0.010	0.1 ± 0.3	1.0 ± 0.5	20 ± 50
Cañada del Buey	46	9-16	−76 ± 48	−0.032 ± 0.012	−0.009 ± 0.009	1.3 ± 0.4	−0.2 ± 0.1	−10 ± 60
Pajarito Canyon	47	3-25	33 ± 36	−0.005 ± 0.008	0.019 ± 0.013	0.1 ± 0.3	0.7 ± 0.5	0 ± 50
Pajarito Canyon	47	9-16	0 ± 34	0.000 ± 0.010	−0.004 ± 0.004	2.4 ± 0.5	0.4 ± 0.2	−20 ± 60
Water Canyon at Beta	48	4-11	47 ± 40	−0.007 ± 0.007	0.007 ± 0.012	−0.3 ± 0.3	1.2 ± 0.4	70 ± 50
Water Canyon at Beta	48	10-9	—	0.000 ± 0.010	−0.029 ± 0.020	−0.5 ± 0.3	0.9 ± 0.2	140 ± 60
No. of Analyses			17	18	18	18	18	18
Minimum			−76 ± 48	−0.032 ± 0.012	−0.029 ± 0.022	−0.8 ± 0.3	−0.2 ± 0.1	−60 ± 60
Maximum			66 ± 38	0.016 ± 0.016	0.055 ± 0.017	3.4 ± 0.5	3.4 ± 0.6	140 ± 60
Average			14	0.000	0.006	0.3	0.9	4
s			44	0.025	0.018	1.4	0.8	47
Limits of Detection			40	0.009	0.03	0.7	1	50

Table G-21 (cont)

Station	1985 (month-day)	Chemical (concentrations in mg/l) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
Test Well 1	3-19	42	42	8.8	3.3	12	0	91	<0.5	19	24	0.5	5.1	250	133	7.8	35
Test Well 2	4-3	80	15	3.9	1.3	10	0	64	<0.5	3	6	0.4	0.4	154	52	7.8	14
Test Well 3	3-19	88	18	5.8	2.3	13	0	83	<0.5	3	3	0.4	0.4	195	64	7.8	18
Test Well DT-5A	3-26	70	9	2.6	1.8	12	0	51	<0.5	2	2	0.3	0.8	125	31	7.5	11
Test Well 8	4-3	55	11	3.8	1.7	11	0	60	<0.5	2	2	0.2	<0.1	118	40	7.6	12
Test Well DT-10	3-26	9	13	2.9	1.7	12	0	64	<0.5	2	2	0.3	0.3	80	40	9.0	13
Cañada del Buey	3-25	28	15	4.4	2.9	22	0	40	<0.5	13	32	0.3	0.4	149	54	7.2	22
Pajarito	3-25	38	15	4.4	3.1	21	0	40	<0.5	13	34	0.3	0.4	145	53	7.2	22
Water at Beta	4-11	30	14	4.8	4.1	20	0	34	<0.5	15	33	0.3	1.8	163	46	7.5	20
No. of Analyses		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Minimum		9	9	2.6	1.3	11	—	34	—	2	2	0.2	0.4	80	40	7.5	11
Maximum		88	42	8.8	4.1	22	0	91	<0.5	19	34	0.5	5.1	250	133	9.0	35
Average		49	17	4.6	2.5	15	—	58	—	8	15	0.3	1.1	153	57	7.7	19
s		26	10	1.8	1.0	5	—	20	—	7	15	0.1	1.6	48	30	0.6	8

Table G-22. Radiochemical and Chemical Quality of Ground Water From Onsite Stations in Pajarito Canyon

Station	1985 (month-day)	Radiochemical: ^{137}Cs (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	$^{239,240}Pu$ (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)	Gross Alpha (10^{-9} µCi/mℓ)	Gross Beta (10^{-9} µCi/mℓ)
PCO-1	6-11	74 ± 49	0.000 ± 0.010	0.005 ± 0.008	−0.4 ± 0.4	1.4 ± 0.5	−50 ± 60	2.0 ± 2.0	8.0 ± 0.9
PCO-2	6-11	70 ± 49	0.000 ± 0.001	0.000 ± 0.001	0.6 ± 0.4	3.8 ± 0.8	60 ± 60	9.0 ± 2.6	16 ± 2.0
PCO-3	6-11	−10 ± 41	0.024 ± 0.015	0.016 ± 0.011	−1.3 ± 0.4	1.5 ± 0.5	40 ± 60	3.0 ± 2.0	4.8 ± 0.6
No. of Analyses		3	3	3	3	3	3	3	3
Minimum		−10 ± 41	0.000 ± 0.001	0.000 ± 0.001	−0.4 ± 0.4	1.4 ± 0.5	−50 ± 60	2.0 ± 2.0	4.8 ± 0.6
Maximum		74 ± 49	0.024 ± 0.015	0.016 ± 0.011	1.3 ± 0.4	3.8 ± 0.8	60 ± 60	9.0 ± 2.6	16 ± 2.0
Average		45	0.008	0.007	0.5	2.2	17	4.6	9.6
s		48	0.014	0.008	0.8	1.3	58	3.8	6.0
Limits of Detection		40	0.009	0.03	0.7	1	50	3	3

Station	1985 (month-day)	Chemical (concentration in mg/ℓ): SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
PCO-1	6-11	31	33	9.9	5.7	47	0	97	<0.2	18	68	0.5	1.7	298	122	6.7	48
PCO-2	6-11	26	18	5.1	4.0	18	0	66	<0.2	10	14	0.3	0.3	143	62	6.8	19
PCO-3	6-11	35	40	9.8	3.6	24	0	150	<0.2	8	22	0.7	0.5	251	141	7.5	38
No. of Analyses		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Minimum		26	18	5.1	3.6	18	—	66	—	8	14	0.3	0.3	143	62	6.7	19
Maximum		35	40	9.9	5.7	47	0	150	—	18	68	0.7	1.7	298	141	7.5	48
Average		31	30	8.7	4.4	30	—	104	<0.2	12	35	0.5	0.8	230	108	7.0	35
s		4	11	2.8	1.1	15	—	42	—	6	29	0.2	0.8	80	41	0.4	14

Table G-22 (cont)

Miscellaneous Chemical
(concentrations in mg/ℓ)

Station	1985 (month-day)	Ag	As	Ba	Cd	Cr	Cu	Fe	Hg	Mn	Pd	Se
PCO-1	6-11	<0.001	0.004	0.196	<0.001	0.006	0.014	0.095	<0.0002	0.018	<0.003	<0.003
PCO-2	6-11	<0.001	0.001	0.096	<0.001	0.006	<0.005	0.071	<0.0002	0.371	0.006	<0.003
PCO-3	6-11	<0.001	0.001	0.104	<0.001	0.005	0.038	0.005	<0.0002	0.388	<0.003	<0.003
No. of Analyses		3	3	3	3	3	3	3	3	3	3	
Minimum		—	0.001	0.096	—	0.005	<0.005	0.005	—	0.018	<0.003	
Maximum		—	0.004	0.196	—	0.006	0.038	0.095	—	0.388	<0.006	
Average		<0.001	0.002	0.132	<0.001	0.006	0.019	0.057	<0.0002	0.259	<0.004	
s		—	0.001	0.056	—	0.001	0.017	0.46	—	0.209	0.002	

Table G-23. Radiochemical and Chemical Quality of Surface and Ground Waters from DP-Los Alamos Canyon, an Active Effluent Release Area

Station	1985 (month-day)	Radiochemical ^{137}Cs (10^{-9} μCi/mℓ)	Radiochemical ^{238}Pu (10^{-9} μCi/mℓ)	Radiochemical $^{239,240}Pu$ (10^{-9} μCi/mℓ)	Radiochemical ^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)	Gross Gamma (counts/min/ℓ)
DPS-1	4-9	72 ± 42	0.494 ± 0.049	0.162 ± 0.027	1.5 ± 0.4	31 ± 3.0	70 ± 50
DPS-1	9-19	−14 ± 39	0.008 ± 0.011	0.012 ± 0.009	0.8 ± 0.4	0.0 ± 0.2	10 ± 60
DPS-4	4-9	106 ± 43	0.068 ± 0.018	0.276 ± 0.037	20 ± 2.0	9.2 ± 2.0	10 ± 50
DPS-4	9-19	68 ± 51	0.079 ± 0.021	0.150 ± 0.025	2.9 ± 0.5	2.9 ± 0.3	20 ± 60
LAO-C	4-9	62 ± 40	−0.004 ± 0.008	0.000 ± 0.010	−0.3 ± 0.3	0.9 ± 0.4	60 ± 50
LAO-C	9-19	−16 ± 42	0.023 ± 0.018	0.009 ± 0.011	0.9 ± 0.4	1.5 ± 0.2	110 ± 60
LAO-1	4-9	47 ± 48	−0.009 ± 0.008	0.022 ± 0.012	19 ± 2.0	1.2 ± 0.4	80 ± 50
LAO-1	9-19	−12 ± 36	−0.005 ± 0.011	0.024 ± 0.014	0.2 ± 0.4	1.6 ± 0.2	40 ± 60
LAO-2	4-9	55 ± 49	0.015 ± 0.013	0.153 ± 0.029	19 ± 2.0	6.4 ± 1.1	100 ± 50
LAO-2	9-19	19 ± 36	0.030 ± 0.017	0.114 ± 0.023	0.7 ± 0.4	2.4 ± 0.2	20 ± 60
LAO-3	4-9	43 ± 38	0.013 ± 0.014	0.004 ± 0.010	26 ± 3.0	2.5 ± 0.8	20 ± 50
LAO-3	9-19	−8 ± 34	0.041 ± 0.017	0.092 ± 0.022	0.5 ± 0.4	2.4 ± 0.3	−50 ± 60
LAO-4	4-9	32 ± 41	0.004 ± 0.009	0.025 ± 0.010	3.3 ± 0.5	0.6 ± 0.4	90 ± 50
LAO-4	9-19	−33 ± 51	0.090 ± 0.013	0.081 ± 0.025	0.9 ± 0.4	2.4 ± 0.2	40 ± 60
LAO-4.5	4-9	−22 ± 36	−0.016 ± 0.009	0.023 ± 0.011	3.5 ± 0.5	2.2 ± 0.7	70 ± 50
LAO-4.5	9-19	17 ± 41	0.024 ± 0.016	0.150 ± 0.028	0.8 ± 0.4	3.0 ± 0.3	30 ± 60
No. of Analyses		16	16	16	16	16	16
Minimum		−33 ± 51	−0.016 ± 0.009	0.000 ± 0.010	−0.3 ± 0.3	0.0 ± 0.2	−50 ± 60
Maximum		106 ± 43	0.494 ± 0.049	0.276 ± 0.037	26 ± 3.0	31 ± 3.0	110 ± 60
Average		29	0.530	0.081	6.2	4.4	41
s		39	0.122	0.080	9.0	8	45
Limits of Detection		40	0.009	0.03	0.7	1	50

Table G-23 (cont)

Station	1985 (month-day)	Chemical (concentration in mg/l) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
DPS-1	4-9	20	30	3.0	9.1	132	0	133	<0.5	22	154	1.6	<0.2	431	86	7.8	78
DPS-4	4-9	14	12	1.9	14	132	0	127	<0.5	23	125	6.0	3.4	407	38	7.8	72
LAO-C	4-9	35	13	3.7	3.9	69	0	51	<0.5	8	99	0.2	<0.2	269	46	7.4	46
LAO-1	4-9	40	27	6.6	5.5	77	0	59	<0.5	18	137	0.6	0.6	363	92	7.4	70
LAO-2	4-9	18	12	2.3	14	128	0	130	<0.5	21	108	5.5	2.3	396	38	7.9	70
LAO-3	4-9	35	20	4.3	13	119	0	116	<0.5	21	133	3.0	2.5	417	65	7.3	74
LAO-4	4-9	33	14	4.4	7.6	44	0	56	<0.5	12	68	1.1	<0.2	212	52	7.4	35
LAO-4.5	4-9	63	16	5.4	5.3	45	0	55	<0.5	11	56	0.7	<0.2	237	58	7.4	36
No. of Analyses		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Minimum		14	12	1.9	3.9	45	—	51	—	8	56	0.2	<0.2	212	38	7.3	35
Maximum		63	30	6.6	14	132	0	133	<0.5	23	154	6.0	3.4	431	92	7.9	78
Average		32	18	3.9	9.0	9	—	91	—	17	110	2.3	<1.2	342	59	7.6	59
s		15	7	1.6	4.2	38	—	38	—	6	34	2.6	1.3	88	20	0.3	18

Table G-24. Radiochemical and Chemical Quality of Surface and Ground Waters from Mortandad Canyon, an Active Effluent Release Area

Station	1985 (month-day)	Radiochemical					
		^{137}Cs (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	$^{239,240}Pu$ (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)
GS-1	4-10	36 ± 38	0.990 ± 0.071	5.76 ± 0.223	4.6 ± 0.6	1.2 ± 0.4	310 ± 50
GS-1	9-23	0 ± 19	0.613 ± 0.061	3.03 ± 0.160	15 ± 2.0	2.9 ± 0.3	30 ± 60
MCO-3	4-10	32 ± 35	1.23 ± 0.084	3.35 ± 1.54	10 ± 1.0	5.4 ± 1.1	560 ± 50
MCO-3	9-23	−85 ± 58	1.12 ± 0.092	4.60 ± 0.222	16 ± 2.0	2.6 ± 0.3	140 ± 60
MCO-4	4-11	83 ± 43	0.944 ± 0.071	3.51 ± 0.157	48 ± 5.0	6.9 ± 1.3	110 ± 50
MCO-4	9-24	−54 ± 45	0.295 ± 0.040	1.59 ± 0.092	20 ± 2.0	7.8 ± 0.8	260 ± 70
MCO-5	4-11	24 ± 48	0.047 ± 0.023	0.136 ± 0.025	28 ± 3.0	1.5 ± 0.5	50 ± 50
MCO-5	9-24	57 ± 46	0.041 ± 0.042	1.40 ± 0.085	32 ± 3.0	4.3 ± 0.4	70 ± 60
MCO-6	4-11	21 ± 59	0.071 ± 0.021	0.176 ± 0.028	28 ± 3.0	3.1 ± 0.9	70 ± 50
MCO-6	9-24	31 ± 43	0.485 ± 0.052	1.29 ± 0.091	22 ± 2.0	6.0 ± 0.6	140 ± 60
MCO-7	4-11	50 ± 53	0.024 ± 0.014	0.034 ± 0.014	31 ± 3.0	5.8 ± 1.2	110 ± 50
MCO-7	9-23	19 ± 63	0.320 ± 0.040	0.870 ± 0.068	21 ± 2.0	8.1 ± 0.8	160 ± 70
MCO-7.5	4-11	95 ± 45	0.048 ± 0.016	0.056 ± 0.015	30 ± 3.0	7.7 ± 1.8	10 ± 50
MCO-7.5	9-23	11 ± 62	0.060 ± 0.021	0.032 ± 0.012	30 ± 3.0	2.8 ± 0.3	80 ± 60
No. of Analyses		14	14	14	14	14	14
Minimum		−85 ± 58	0.024 ± 0.014	0.032 ± 0.012	4.6 ± 0.6	1.2 ± 0.4	10 ± 50
Maximum		95 ± 45	1.23 ± 0.084	5.76 ± 0.223	48 ± 5.0	8.1 ± 0.8	560 ± 50
Average		23	0.449	1.84	24	4.7	150
s		48	0.450	1.89	11	2.4	144
Limits of Detection		40	0.009	0.03	0.7	1	50

Table G-24 (cont)

Station	1985 (month-day)	Chemical (concentration in mg/l) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
GS-1	4-10	43	14	3.1	11	38	0	68	<0.5	6	19	1.0	10	240	48	7.9	31
MCO-3	4-10	26	5	0.3	10	93	0	116	<0.5	17	16	3.2	15	322	14	8.7	47
MCO-4	4-11	16	7	1.8	4.2	200	0	162	<0.5	27	32	4.7	56	642	23	7.7	95
MCO-5	4-11	20	27	6.9	4.6	168	0	168	<0.5	36	37	1.5	61	659	96	7.3	96
MCO-6	4-11	23	28	7.2	4.7	158	0	168	<0.5	32	34	1.4	54	618	98	7.4	95
MCO-7	4-11	25	31	8.0	3.1	289	0	248	<0.5	63	46	1.5	110	1040	108	7.4	154
MCO-7.5	4-11	25	31	8.1	6.3	293	0	247	<0.5	63	49	1.3	111	1049	108	7.4	155
No. of Analyses		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Minimum		16	5	0.3	3.1	38	—	68	—	6	16	1.0	10	240	14	7.3	31
Maximum		43	31	8.0	11	293	0	248	<0.5	63	49	4.7	111	1049	108	8.7	155
Average		25	20	5.1	6.3	177	—	168	—	35	33	2.1	60	653	71	7.7	96
s		8	12	3.2	3.1	94	—	65	—	22	12	1.3	40	313	41	0.5	43

Table G-25. Radiochemical and Chemical Quality of Surface and Ground Water from Sandia Canyon, An Active Effluent Release Area

Station	1985 (month-day)	Radiochemical ^{137}Cs (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	$^{239,240}Pu$ (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)
SCS-1	4-2	89 ± 53	0.000 ± 0.010	0.000 ± 0.010	0.3 ± 0.3	1.4 ± 0.4	60 ± 50
SCS-1	9-11	50 ± 41	0.022 ± 0.017	0.011 ± 0.009	3.7 ± 0.5	2.2 ± 0.3	−70 ± 60
SCS-2	4-2	76 ± 37	−0.008 ± 0.005	0.012 ± 0.009	0.9 ± 0.3	1.0 ± 0.4	40 ± 50
SCS-2	9-11	27 ± 45	0.008 ± 0.014	−0.004 ± 0.007	1.4 ± 0.4	2.2 ± 0.2	70 ± 60
SCS-3	4-2	44 ± 49	−0.013 ± 0.009	0.008 ± 0.010	0.8 ± 0.3	0.8 ± 0.4	−30 ± 50
SCS-3	9-11	98 ± 53	0.000 ± 0.010	0.007 ± 0.010	3.7 ± 0.5	2.9 ± 0.3	10 ± 60
No. of Analyses		6	6	6	6	6	6
Minimum		27 ± 45	−0.013 ± 0.009	−0.004 ± 0.007	0.3 ± 0.3	0.8 ± 0.4	−70 ± 60
Maximum		98 ± 53	0.022 ± 0.017	0.012 ± 0.009	3.7 ± 0.5	2.9 ± 0.3	70 ± 60
Average		64	0.002	0.006	1.8	1.8	13
s		28	0.012	0.006	1.5	0.8	54
Limits of Detection		40	0.009	0.03	0.7	1	50

Station	1985 (month-day)	Chemical (concentration in mg/ℓ) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (mS/m)
SCS-1	4-2	103	21	4.4	13	76	0	88	4.3	25	74	1.0	9.2	419	70	7.0	58
SCS-2	4-7	63	22	4.6	10	117	0	106	4.9	46	122	1.2	0.9	476	73	7.4	73
SCS-3	4-2	57	22	4.5	11	114	0	107	4.3	44	127	1.1	1.3	450	73	7.1	73
No. of Analyses		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Minimum		57	21	4.4	10	76	—	88	4.3	25	74	1.0	0.9	419	70	7.0	58
Maximum		103	22	4.6	13	117	0	107	4.9	46	127	1.2	9.2	476	73	7.4	73
Average		74	22	4.5	11	101	—	100	4.5	38	108	1.1	3.8	448	72	7.2	68
s		25	1	0.1	2	22	—	11	5.3	12	29	0.1	4.7	28	1	0.2	0.8

Table G-26. Locations of Soil and Sediment Sampling Stations

Station	Latitude or N-S Coord	Longitude or E-W Coord	Map Designation[a]
Regional Sediments			
Chamita	36°05′	106°07′	—
Embudo	36°12′	105°58′	—
Otowi	35°52′	106°08′	—
Sandia	S060	E490	—
Pajarito	S185	E410	—
Ancho	S305	E335	—
Frijoles	S375	E235	—
Cochiti	35°37′	106°19′	—
Bernalillo	35°17′	106°36′	—
Jemez River	35°40′	106°44′	—
Perimeter Sediments			
Guaje at SR-4	N135	E480	12
Bayo at SR-4	N100	E455	13
Sandia at SR-4	N025	E315	14
Mortandad at SR-4	S030	E350	15
Cañada del Buey at SR-4	S090	E360	16
Pajarito at SR-4	S105	E320	17
Potrillo at SR-4	S145	E295	18
Water at SR-4	S170	E260	19
Ancho at SR-4	S255	E250	20
Frijoles at National Monument Headquarters	S280	E185	21
Effluent Release Area Sediments			
Acid Pueblo Canyon			
Acid Weir	N125	E070	22
Pueblo 1	N130	E085	23
Pueblo 2	N120	E145	24
Hamilton Bend Spring	N105	E255	25
Pueblo 3	N090	E315	26
Pueblo at SR-4	N070	E350	27
DP-Los Alamos Canyon			
DPS-1	N090	E160	28
DPS-4	N075	E205	29
Los Alamos at Bridge	N095	E020	30
Los Alamos at LAO-1	N080	E120	31
Los Alamos at GS-1	N075	E200	32
Los Alamos at LAO-3	N075	E215	33
Los Alamos at LAO-4.5	N065	E270	34
Los Alamos at SR-4	N065	E355	35
Los Alamos at Totavi	N065	E405	36
Los Alamos at LA-2	N125	E510	37
Los Alamos at Otowi	N100	E560	38

Table G-26 (cont)

Station	Latitude or N-S Coord	Longitude or E-W Coord	Map Designation[a]
Mortandad Canyon			
Mortandad near CMR	N060	E036	39
Mortandad west of GS-1	N045	E095	40
Mortandad at GS-1	N040	E105	41
Mortandad at MCO-5	N035	E155	42
Mortandad at MCO-7	N025	E190	43
Mortandad at MCO-9	N030	E215	44
Mortandad at MCO-13	N015	E250	45
Regional Soils			
Rio Chama at Chamita	36°05′	106°07′	—
Embudo	36°12′	105°58′	—
Otowi	35°52′	106°08′	—
Near Santa Cruz	35°59′	105°54′	—
Cochiti	35°37′	106°19′	—
Bernalillo	35°17′	106°36′	—
Jemez	35°40′	106°44′	—
Perimeter Soils			
Sportsman's Club	N240	E215	S1
North Mesa	N134	E168	S2
TA-8	N060	W075	S3
TA-49	S165	E085	S4
White Rock (east)	N051	E218	S5
Tsankawi	N020	E310	S6
Onsite Soils			
TA-21	N095	E140	S7
East of TA-53	N051	E218	S8
TA-50	N035	E095	S9
Two Mile Mesa	N025	E030	S10
East of TA-54	S080	E295	S11
R-Site Road East	S042	E103	S12
Portillo Drive	S065	E195	S13
S-Site	S035	W025	S14
Near Test Well DT-9	S150	E140	S15
Near TA-33	S245	E225	S16

[a]Soil sampling locations is Figs. 14 and 17; sediment sampling locations in Figs. 14 and 18.

Table G-27. Radiochemical Analyses of Regional Soils and Sediments

Location[a]	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/g)	Gross Gamma (counts/min/g)
Regional Soils						
Chamita	0.67 ± 0.14	0.000 ± 0.001	0.014 ± 0.002	−0.8 ± 0.3	3.1 ± 0.2	3.4 ± 0.4
Embudo	0.94 ± 0.18	0.001 ± 0.001	0.018 ± 0.003	−0.7 ± 0.3	2.2 ± 0.2	3.2 ± 0.4
Otowi	0.54 ± 0.14	0.000 ± 0.001	0.026 ± 0.003	−0.4 ± 0.3	3.5 ± 0.2	6.2 ± 0.7
Near Santa Cruz Lake	0.36 ± 0.11	0.001 ± 0.001	0.008 ± 0.002	−0.8 ± 0.3	3.2 ± 0.2	5.8 ± 0.6
Cochiti	0.39 ± 0.09	0.000 ± 0.001	0.002 ± 0.001	−0.8 ± 0.3	—	4.3 ± 0.5
Bernalillo	0.22 ± 0.09	0.000 ± 0.001	0.001 ± 0.001	0.0 ± 0.3	1.6 ± 0.2	1.2 ± 0.3
Jemez	0.01 ± 0.06	0.000 ± 0.001	0.001 ± 0.001	−0.4 ± 0.3	2.2 ± 0.2	2.5 ± 0.4
No. of Analyses	7	7	7	7	6	7
Minimum	0.01 ± 0.06	0.000 ± 0.001	0.001 ± 0.001	−0.8 ± 0.3	1.6 ± 0.2	1.2 ± 0.3
Maximum	0.94 ± 0.18	0.001 ± 0.001	0.026 ± 0.003	0.0 ± 0.3	3.5 ± 0.2	6.2 ± 0.7
Average	0.45	0.000	0.010	−0.5	2.6	3.8
s	0.30	0.001	0.009	0.3	0.7	1.7
Regional Sediments						
Rio Chama at Chamita	0.22 ± 0.07	0.001 ± 0.001	0.003 ± 0.001	—	1.9 ± 0.2	1.6 ± 0.3
Rio Grande at Embudo	0.09 ± 0.07	−0.001 ± 0.001	0.004 ± 0.002	—	2.9 ± 0.2	2.8 ± 0.4
Rio Grande at Otowi	0.12 ± 0.08	−0.001 ± 0.001	0.003 ± 0.002	—	2.6 ± 0.2	2.3 ± 0.4
Rio Grande at Sandia	0.23 ± 0.08	0.000 ± 0.001	0.002 ± 0.001	—	3.3 ± 2.1	4.2 ± 0.5
Cañada del Ancho at Rio Grande	0.13 ± 0.06	—	—	—	1.6 ± 0.2	0.1 ± 0.3
Sandia Canyon at Rio Grande	0.08 ± 0.07	−0.001 ± 0.001	0.002 ± 0.001	—	1.1 ± 0.2	3.6 ± 0.5
Mortandad Canyon at Rio Grande	0.10 ± 0.07	0.000 ± 0.001	0.001 ± 0.001	—	2.5 ± 0.3	1.5 ± 0.3
Rio Grande at Pajarito Canyon	0.14 ± 0.08	0.001 ± 0.001	0.000 ± 0.001	—	1.6 ± 0.2	4.3 ± 0.5
Pajarito Canyon at Rio Grande	0.17 ± 0.04	0.000 ± 0.001	0.004 ± 0.002	—	3.4 ± 0.3	3.7 ± 0.5
Water Canyon at Rio Grande	0.09 ± 0.07	0.004 ± 0.001	0.001 ± 0.001	—	2.7 ± 0.3	2.4 ± 0.4
Rio Grande at Ancho Canyon	0.53 ± 0.12	−0.002 ± 0.002	0.018 ± 0.003	—	1.4 ± 0.1	4.8 ± 0.6
Ancho Canyon at Rio Grande	0.22 ± 0.09	—	—	—	3.0 ± 0.3	2.6 ± 0.8
Chaquihui at Rio Grande	0.36 ± 0.12	0.002 ± 0.002	0.026 ± 0.004	—	3.5 ± 0.3	5.5 ± 0.6
Frijoles at Rio Grande	0.25 ± 0.09	0.000 ± 0.001	0.004 ± 0.001	—	3.1 ± 0.3	5.3 ± 0.6
Jemez River at Jemez	0.18 ± 0.07	0.000 ± 0.001	0.002 ± 0.001	—	0.7 ± 0.1	−0.2 ± 0.3
No. of Analyses	15	13	13	—	15	15
Minimum	0.08 ± 0.07	−0.002 ± 0.002	0.001 ± 0.001	—	0.7 ± 0.1	−0.2 ± 0.3
Maximum	0.53 ± 0.12	0.004 ± 0.001	0.026 ± 0.004	—	3.5 ± 0.3	5.5 ± 0.6
Average	21	0.000	0.005	—	2.4	3.0
s	12	0.002	0.008	—	0.9	1.8
Limits of Detection	0.1	0.003	0.002	0.7	0.03	0.1

[a]See Figures 17 and 18 for location.

Table G-28. Radiochemical Analyses of Perimeter Soils and Sediments

Location[a]	Sampling Station Number	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{3}H (10^{-6} μCi/ml)	Total U (μg/g)	Gross Gamma (counts/min/g)
Perimeter Soils							
Sportsman Club	S-1	0.50 ± 0.11	−0.001 ± 0.002	0.017 ± 0.003	−1.2 ± 0.3	3.6 ± 0.2	6.3 ± 0.7
North Mesa	S-2	0.31 ± 0.06	0.000 ± 0.001	0.009 ± 0.002	−0.6 ± 0.3	4.0 ± 0.3	5.8 ± 0.7
TA-8	S-3	0.87 ± 0.17	0.004 ± 0.002	0.035 ± 0.004	−0.2 ± 0.3	3.2 ± 0.3	5.2 ± 0.3
TA-49	S-4	0.62 ± 0.12	0.001 ± 0.001	0.012 ± 0.002	−1.0 ± 0.3	4.6 ± 0.3	6.0 ± 0.7
White Rock (East)	S-5	1.0 ± 0.18	0.003 ± 0.001	0.026 ± 0.003	−0.7 ± 0.3	3.3 ± 0.2	7.2 ± 0.8
Tsankawi	S-6	0.43 ± 0.10	0.001 ± 0.001	0.012 ± 0.002	−0.4 ± 0.3	5.9 ± 0.5	11 ± 1.0
No. of Analyses		6	6	6	6	6	6
Minimum		0.31 ± 0.06	−0.001 ± 0.002	0.009 ± 0.002	−1.2 ± 0.3	3.2 ± 0.3	5.2 ± 0.6
Maximum		1.0 ± 0.36	0.004 ± 0.002	0.035 ± 0.004	−0.2 ± 0.3	5.9 ± 0.5	11 ± 1.0
Average		0.62	0.001	0.019	−0.7	4.1	6.9
s		0.26	−0.002	0.010	−0.4	1.1	2.1
Perimeter Sediments							
Guaje at SR-4	12	0.10 ± 0.09	0.001 ± 0.001	0.002 ± 0.001	—	2.1 ± 0.2	3.2 ± 0.4
Bayo at SR-4	13	0.19 ± 0.06	0.000 ± 0.001	0.002 ± 0.001	—	2.0 ± 0.2	2.7 ± 0.4
Sandia at SR-4	14	0.11 ± 0.07	0.002 ± 0.001	0.002 ± 0.001	—	2.2 ± 0.2	4.0 ± 0.5
Mortandad at SR-4	15	0.22 ± 0.10	0.002 ± 0.002	0.004 ± 0.002	—	3.6 ± 0.2	6.0 ± 0.7
Cañada del Buey at SR-4	16	0.07 ± 0.04	0.001 ± 0.001	0.005 ± 0.002	—	2.0 ± 0.2	3.3 ± 0.4
Pajarito at SR-4	17	0.30 ± 0.07	0.000 ± 0.001	0.007 ± 0.002	—	2.4 ± 0.2	3.1 ± 0.4
Potrillo at SR-4	18	0.07 ± 0.06	0.001 ± 0.002	0.002 ± 0.002	—	2.4 ± 0.2	2.2 ± 0.4
Water at SR-4	19	0.20 ± 0.07	0.002 ± 0.002	0.002 ± 0.002	—	1.4 ± 0.2	1.5 ± 0.3
Ancho at SR-4	20	0.26 ± 0.09	0.000 ± 0.001	0.005 ± 0.002	—	1.9 ± 0.2	2.6 ± 0.4
Frijoles at Park	21	0.60 ± 0.14	0.001 ± 0.002	0.008 ± 0.002	—	7.1 ± 0.4	13 ± 1.0
No. of Analyses		10	10	10	—	10	10
Minimum		0.07 ± 0.06	0.000 ± 0.001	0.002 ± 0.001	—	1.4 ± 0.2	1.5 ± 0.3
Maximum		0.60 ± 0.14	0.002 ± 0.002	0.008 ± 0.002	—	7.1 ± 0.4	13 ± 1.0
Average		0.21	0.001	0.004	—	2.7	4.2
s		0.16	0.001	0.002	—	1.6	3.3
Limits of Detection		0.1	0.003	0.002	0.7	0.03	0.1

[a]See Figures 17 and 18 for location.

Table G-29. Radiochemical Analyses of Onsite Soils and Sediments from Effluent Release Areas

Location[a]	Sampling Station Number	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{3}H (10^{-6} µCi/ml)	Total U (µg/g)	Gross Gamma (counts/min/g)	^{241}Am (pCi/g)	^{90}Sr (pCi/g)
Onsite Soils									
TA-21	S-7	0.08 ± 0.07	0.001 ± 0.002	0.051 ± 0.005	−0.6 ± 0.3	3.6 ± 0.2	5.9 ± 0.7	—	—
East of TA-53	S-8	0.59 ± 0.12	0.000 ± 0.001	0.061 ± 0.007	0.6 ± 0.4	5.4 ± 0.4	6.6 ± 0.7	—	—
TA-50	S-9	0.12 ± 0.03	0.002 ± 0.002	0.074 ± 0.006	−0.3 ± 0.3	4.1 ± 0.3	6.9 ± 0.8	—	—
Two-Mile Mesa	S-10	0.68 ± 0.14	0.001 ± 0.001	0.014 ± 0.003	−0.5 ± 0.3	3.8 ± 0.3	5.6 ± 0.6	—	—
In TA-54	S-11	0.14 ± 0.05	11.9 ± 0.475	0.281 ± 0.015	0.0 ± 0.3	4.6 ± 0.4	8.2 ± 0.9	—	—
R-Site Road East	S-12	0.60 ± 0.12	−0.003 ± 0.002	0.009 ± 0.004	0.0 ± 0.3	28 ± 2.0	10 ± 1.0	—	—
Potrillo Drive	S-13	0.76 ± 0.13	−0.002 ± 0.002	0.029 ± 0.004	−0.3 ± 0.3	3.1 ± 0.2	6.7 ± 0.7	—	—
S-Site	S-14	0.29 ± 0.08	−0.002 ± 0.001	0.005 ± 0.002	−1.0 ± 0.3	4.1 ± 0.3	5.8 ± 0.6	—	—
Near DT-9	S-15	0.96 ± 0.18	−0.001 ± 0.002	0.031 ± 0.006	−1.0 ± 0.3	3.3 ± 0.2	7.3 ± 0.8	—	—
Near TA-33	S-16	0.45 ± 0.09	0.002 ± 0.002	0.017 ± 0.003	10 ± 1.0	3.8 ± 0.3	6.8 ± 0.7	—	—
No. of Analyses		10	10	10	10	10	10	—	—
Minimum		0.08 ± 0.07	−0.003 ± 0.002	0.005 ± 0.002	−1.0 ± 0.3	3.1 ± 0.2	5.6 ± 0.6	—	—
Maximum		0.96 ± 0.18	11.9 ± 0.475	0.281 ± 0.015	10 ± 1.0	28 ± 2.0	10 ± 1.0	—	—
Average		0.47	1.19	0.057	0.7	6.3	7.0	—	—[a]
s		0.30	3.75	0.082	3.3	7.5	1.3	—	—
Effluent Release Area - Sediments									
Pueblo Canyon									
Acid Weir	22	0.78 ± 0.12	0.087 ± 0.006	13.3 ± 0.370	—	3.0 ± 0.2	—	0.494 ± 0.080	0.63 ± 0.08
Pueblo 1	23	0.11 ± 0.03	0.001 ± 0.001	0.027 ± 0.003	—	2.3 ± 0.2	—	−0.098 ± 0.032	0.11 ± 0.03
Pueblo 2	24	0.09 ± 0.02	0.016 ± 0.003	1.76 ± 0.089	—	2.6 ± 0.2	—	0.299 ± 0.050	0.11 ± 0.06
Hamilton Bend Springs	25	0.11 ± 0.03	0.006 ± 0.002	1.75 ± 0.120	—	3.8 ± 0.3	—	−0.114 ± 0.040	0.18 ± 0.04
Pueblo 3	26	0.58 ± 0.09	0.025 ± 0.015	6.33 ± 0.270	—	7.0 ± 0.5	—	0.137 ± 0.033	0.23 ± 0.04
Pueblo at SR-4	27	0.01 ± 0.02	0.002 ± 0.002	0.610 ± 0.026	—	2.2 ± 0.2	—	−0.056 ± 0.035	−0.05 ± 0.05
No. of Analyses		6	6	6	—	6	—	6	6
Minimum		0.01 ± 0.02	0.001 ± 0.002	0.027 ± 0.003	—	2.2 ± 0.2	—	−0.114 ± 0.040	−0.05 ± 0.05
Maximum		0.78 ± 0.12	0.087 ± 0.006	13.3 ± 0.370	—	7.0 ± 5.0	—	0.494 ± 0.080	0.63 ± 0.08
Average		0.28	0.023	3.96	—	3.5	—	0.200	0.20
s		0.32	0.038	5.1	—	1.8	—	0.166	0.23

Table G-29 (cont)

Location[a]	Sampling Station Number	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{3}H (10^{-6} µCi/ml)	Total U (µg/g)	Gross Gamma (counts/min/g)	^{241}Am (pCi/g)	^{90}Sr (pCi/g)
DP-Los Alamos Canyon									
DP Canyon at DPS-1	28	10 ± 1.6	2.69 ± 0.156	8.11 ± 0.355	—	5.4 ± 0.4	31 ± 3.0	28.0 ± 4.20	9.8 ± 0.30
DP Canyon at DPS-4	29	11 ± 1.7	0.118 ± 0.008	0.373 ± 0.018	—	1.7 ± 0.2	10 ± 1.0	0.854 ± 0.134	1.7 ± 0.10
Los Alamos at Bridge	30	0.34 ± 0.09	0.001 ± 0.001	0.036 ± 0.004	—	4.3 ± 0.3	7.4 ± 0.8	−0.019 ± 0.025	0.11 ± 0.06
Los Alamos at LAO-1	31	0.16 ± 0.08	0.001 ± 0.001	0.432 ± 0.019	—	2.9 ± 0.2	4.9 ± 0.6	0.092 ± 0.033	0.14 ± 0.03
Los Alamos at GS-1	32	6.2 ± 0.90	0.130 ± 0.008	1.17 ± 0.047	—	4.5 ± 0.3	14 ± 1.0	1.64 ± 0.252	0.28 ± 0.03
Los Alamos at LAO-3	33	0.76 ± 0.14	0.022 ± 0.003	0.450 ± 0.011	—	2.5 ± 0.2	4.2 ± 0.5	0.042 ± 0.047	0.16 ± 0.06
Los Alamos at LAO-4.5	34	6.2 ± 0.90	0.203 ± 0.010	1.49 ± 0.066	—	5.1 ± 0.4	14 ± 1.0	3.42 ± 0.670	0.62 ± 0.08
Los Alamos at SR-4	35	8.6 ± 1.3	0.123 ± 0.008	0.699 ± 0.030	—	4.6 ± 0.3	15 ± 2.0	1.78 ± 0.252	0.17 ± 0.06
Los Alamos at Totavi	36	3.6 ± 0.60	0.044 ± 0.004	0.693 ± 0.030	—	3.5 ± 0.2	8.7 ± 0.9	0.853 ± 0.133	0.11 ± 0.06
Los Alamos at LA-2	37	0.31 ± 0.10	0.005 ± 0.002	0.068 ± 0.005	—	3.0 ± 0.2	4.6 ± 0.5	0.047 ± 0.025	0.07 ± 0.03
Los Alamos at Otowi	38	0.48 ± 0.09	0.005 ± 0.001	0.131 ± 0.007	—	1.8 ± 0.2	1.4 ± 0.3	−0.060 ± 0.036	−0.03 ± 0.04
No. of Analyses		11	11	11	—	11	11	11	11
Minimum		0.16 ± 0.08	0.001 ± 0.001	0.036 ± 0.004	—	1.7 ± 0.2	1.4 ± 0.3	−0.060 ± 0.036	−0.03 ± 0.04
Maximum		11 ± 1.7	2.69 ± 0.156	8.11 ± 0.355	—	5.4 ± 0.4	31 ± 3.0	28.0 ± 4.20	9.8 ± 0.30
Average		4.3	0.304	1.24	—	3.6	10	3.32	1.2
s		4.2	0.540	2.32	—	1.3	8	8.2	2.9
Mortandad Canyon									
Mortandad at CMR	39	−0.01 ± 0.02	0.005 ± 0.002	0.017 ± 0.003	—	1.4 ± 0.2	1.5 ± 0.3	−0.024 ± 0.016	0.02 ± 0.04
Mortandad West of GS-1	40	0.00 ± 0.02	0.011 ± 0.002	0.267 ± 0.010	—	1.7 ± 0.2	2.7 ± 0.2	0.048 ± 0.030	0.05 ± 0.05
Mortandad at GS-1	41	35 ± 5.0	28.1 ± 1.21	64.4 ± 2.42	—	2.8 ± 0.3	110 ± 10	57.0 ± 8.10	6.8 ± 0.20
Mortandad at MCO-5	42	21 ± 3.2	5.09 ± 3.69	30.2 ± 1.26	—	1.7 ± 0.2	35 ± 4.0	22.1 ± 3.33	1.1 ± 0.05
Mortandad at MCO-7	43	35 ± 5.0	1.75 ± 0.060	4.69 ± 0.140	—	1.5 ± 0.2	31 ± 3.0	2.68 ± 0.407	0.50 ± 0.04
Mortandad at MCO-9	44	0.67 ± 0.14	0.002 ± 0.001	0.023 ± 0.003	—	4.5 ± 0.3	8.1 ± 0.9	−0.131 ± 0.054	0.19 ± 0.07
Mortandad at MCO-13	45	0.81 ± 0.14	0.003 ± 0.001	0.031 ± 0.004	—	3.3 ± 0.2	4.8 ± 0.6	−0.095 ± 0.044	0.14 ± 0.06
No. of Analyses		7	7	7	—	7	7	7	7
Minimum		−0.01 ± 0.02	0.002 ± 0.001	0.017 ± 0.003	—	1.4 ± 0.2	1.5 ± 0.3	−0.131 ± 0.054	0.02 ± 0.04
Maximum		35 ± 5.0	28.1 ± 0.121	64.4 ± 2.42	—	4.5 ± 0.3	110 ± 10	57 ± 8.10	6.8 ± 0.20
Average		13	4.99	14.2	—	2.4	28	11.6	1.2
s		16	10.3	24.7	—	1.2	34	21.5	2.5
Limits of Detection		0.1	0.003	0.002	0.7	0.03	0.1	0.01	0.1

[a]See Figures 17 and 18 for location.

Table G-30. Radiochemical Analyses of Reservoir Sediments[a]

	1985 (month-day)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Heron Reservoir			
Upper	6-12	0.0007 ± 0.0002	0.0174 ± 0.0012
Middle	6-12	0.0005 ± 0.0002	0.0114 ± 0.0016
Lower	6-12	0.0002 ± 0.0002	0.0047 ± 0.0004
$\bar{x} \pm s$		0.0005 ± 0.0003	0.0112 ± 0.0064
El Vado Reservoir			
Upper	6-10	0.0004 ± 0.0002	0.0074 ± 0.0012
Middle	6-10	0.0003 ± 0.0002	0.0077 ± 0.0006
Lower	6-10	0.0003 ± 0.0002	0.0083 ± 0.0010
$\bar{x} \pm s$		0.0003 ± 0.0001	0.0078 ± 0.0005
Abiquiu Reservoir			
Upper	5-16	0.0003 ± 0.0002	0.0078 ± 0.0008
Middle	5-16	0.0012 ± 0.0002	0.0094 ± 0.0008
Lower	5-16	0.0005 ± 0.0002	0.0091 ± 0.0008
$\bar{x} \pm s$		0.0007 ± 0.0005	0.0088 ± 0.0009
Cochiti Reservoir			
Upper	5-2	0.0020 ± 0.0002	0.0292 ± 0.0024
Middle	5-2	0.0012 ± 0.0002	0.0189 ± 0.0014
$\bar{x} \pm s$		0.0016 ± 0.0006	0.0241 ± 0.0073
Background[b]			
(1979 - 1985)		0.002	0.011

[a]Based upon 1 kg samples of sediments.
[b]Based upon 10 g sample of river sediments.

Table G-31. Radionuclide Concentrations in Fruits, Vegetables, and Garden Soils

Radionuclide	Background		Offsite			Onsite
	Española (Rio Chama)	Española (Rio Grande)	Cochiti (Rio Grande)	Los Alamos (Community System)	White Rock/ Pajarito Acres (Community System)	
^{238}Pu (pCi/g dry weight)						
Soil						
n	1	2	7	2	3	6
$\bar{x}$	0.0	−0.0008	−0.00034	−0.0042	−0.000067	0.0017
s	—	0.0	0.0018	0.0047	0.0010	0.0021
Min	—	−0.0008	−0.0024	0.0008	−0.0012	−0.0003
Max	—	—	0.0023	0.0075	0.0007	0.0054
Fruit and Vegetables						
n	3	11	17	4	10	11
$\bar{x}$	0.000022	−0.000030	0.00000049	0.000014	−0.000032	0.000042
s	0.000015	0.00010	0.000043	0.00014	0.00014	0.00015
Min	−0.000018	−0.00019	−0.000084	−0.00014	−0.00021	−0.00025
Max	0.000018	0.00019	0.000086	0.00021	0.00032	0.00038
^{239,240}Pu (pci/g dry)						
Soil						
n	1	2	7	2	3	6
$\bar{x}$	0.0050	0.0036	0.0079	0.017	0.0019	0.069
s	—	0.0014	0.0037	0.017	0.0022	0.12
Min	—	0.0026	0.0024	0.0044	0.0004	0.0038
Max	—	0.0046	0.012	0.029	0.0044	0.31
Fruit and Vegetables						
n	3	11	17	4	10	11
$\bar{x}$	0.000043	0.000016	0.000027	−0.000023	−0.00000079	0.00010
s	0.000091	0.000072	0.000074	0.000076	0.000084	0.00015
Min	−0.000018	−0.000091	−0.000059	−0.00014	−0.00014	−0.000034
Max	0.00015	0.00014	0.00024	0.000027	0.00014	0.00045

Table G-31 (cont)

Radionuclide	Background		Offsite			Onsite
	Española (Rio Chama)	Española (Rio Grande)	Cochiti (Rio Grande)	Los Alamos (Community System)	White Rock/ Pajarito Acres (Community System)	
U (ppb dry)						
Soil						
n	1	2	7	2	3	6
x̄	2140	1940	3730	3180	2870	3670
s	—	672	592	247	151	539
Min	—	1460	2550	3000	2750	3160
Max	—	2410	4370	3350	3040	4590
Fruit and Vegetables						
n	3	11	17	4	10	11
x̄	2.37	2.35	1.52	3.88	2.66	8.61
s	2.32	1.90	1.09	3.05	2.13	4.27
Min	0.97	0.25	0.16	0.63	0.73	1.25
Max	5.04	6.31	3.13	7.4	3.8	16.3
^{137}Cs (pCi/g dry)						
Soil						
n	1	2	7	2	3	6
x̄	0.13	0.0090	0.20	0.10	−0.011	0.085
s	—	0.0069	0.11	0.15	0.067	0.14
Min	—	0.0041	0.052	−0.0013	−0.087	−0.092
Max	—	0.014	0.36	0.21	0.041	0.29
Fruit and Vegetables						
n	3	11	17	4	10	11
x̄	−0.021	−0.015	−0.039	0.033	−0.053	−0.022
s	0.029	0.083	0.10	0.080	0.12	0.060
Min	−0.054	−0.21	−0.23	−0.039	−0.32	−0.13
Max	0.0012	0.061	0.15	0.15	0.10	0.069

Table G-31 (cont)

Radionuclide	Background		Offsite			Onsite
	Española (Rio Chama)	Española (Rio Grande)	Cochiti (Rio Grande)	Los Alamos (Community System)	White Rock/ Pajarito Acres (Community System)	
^{3}H (pCi/mℓ)						
Soil						
n	1	2	7	—	1	6
x̄	0.90	0.40	1.4	—	−0.20	21.2
s	—	0.0	0.93	—	—	43.6
Min	—	0.40	0.60	—	—	1.6
Max	—	—	3.0	—	—	110
Fruit and Vegetables						
n	3	8	10	3	7	6
x̄	0.10	−0.44	−0.26	0.40	−0.057	10.8
s	0.60	0.32	0.38	0.10	0.36	21.2
Min	−0.50	−0.90	−0.70	0.30	−0.50	0.10
Max	0.70	0.10	0.50	0.50	0.40	54.0

Table G-32. Radionuclide Concentrations in Fish

Radionuclides	Upstream Reservoirs				Downstream Reservoir			
	Bottom Feeder[a] (Carcass)	Bottom Feeder[b] (Viscera)	Higher Level (Carcass)	Higher Level (Viscera)	Bottom Feeder[c] (Carcass)	Bottom Feeder (Viscera)	Higher Level[d] (Carcass)	Higher Level (Viscera)
^{238}Pu (pCi/g dry wt)								
n	18	18	5	5	6	5	10	6
x̄	−0.0000019	−0.00013	−0.00038	0.000014	−0.000050	−0.00018	−0.000044	−0.000018
s	0.00010	0.00034	0.00080	0.000084	0.000033	0.00031	0.00012	0.000036
Min	−0.00014	−0.0014	−0.0018	−0.000074	−0.00081	−0.00030	−0.000049	−0.000053
Max	0.00035	0.00013	0.000013	0.00014	0.0	0.000081	0.000081	0.000045
$^{239,240}Pu$ (pCi/g dry wt)								
n	18	18	5	5	6	5	10	6
x̄	0.00022	0.00029	0.000018	0.000057	0.000087	0.00030	0.000042	0.00023
s	0.00076	0.00040	0.000021	0.000054	0.000065	0.00028	0.000052	0.00035
Min	−0.000043	−0.000015	0.0	0.0	0.000027	−0.00011	0.0	−0.000072
Max	0.0032	0.0016	0.000013	0.00014	0.00021	0.00068	0.00018	0.00091
U (ppb dry)								
n	18	18	5	5	6	6	9	8
x̄	8.20	53.9	5.68	9.31	19.2	52.1	5.51	23.1
s 4.80	45.3	6.92	2.55	15.8	9.72	2.22	16.8	
Min	3.73	12.9	1.50	5.14	9.57	40.2	1.76	8.04
Max 23.9	156	17.9	12.1	51.2	66.6	8.98	61.8	
^{137}Cs (pCi/g dry)								
n	18	18	5	5	6	6	10	7
x̄	−0.00074	0.045	−0.080	−0.31	0.052	−0.0096	−0.079	−0.091
s	0.092	0.15	0.50	0.37	0.081	0.056	0.15	0.26
Min	−0.17	−0.27	−0.91	−0.75	−0.055	−0.11	−0.25	
Max	0.19	0.42	0.41	0.10	0.14	0.060	0.15	0.30
^{90}Sr (pCi/g dry)								
n	18	18	5	5	6	UU6	10	7
x̄	.091	.15	.051	.13	.080	.12	.12	.21
s	.046	.058	.051	.082	.026	.029	.089	.075
Min	.021	.027	.039	.049	.035	.080	.027	.085
Max	.23	.35	.11	.26	.11	.15	.35	.31

[a]River Carp-Sucker, Carp, White Sucker, Channel Catfish.
[b]White Crappie, Brown Trout, Coho Salmon.
[c]Carp, White Sucker, Channel Catfish.
[d]Northern Pike, Largemouth Bass, White Crappie, Bluegill.

Table G-33. 1985 Fish Data Summary for Cochiti Reservoir

Fish Species	n	Total Wt (g)	Percent Biomass	Age (yrs)	Number[a] Aged	Mean Wt (g)	Mean Length (cm)
White Sucker	18	11481	31%	2	7	484[c]	33.6[c]
				3	10	764[c]	40.0[c]
Channel Catfish[b]	8	7313	20%				
White Crappie	39	5928	16%	2	22	142[c]	21.4[c]
				3	16	161[c]	22.8[c]
				4	1	232	26.0
Carp	3	5004	14%	4	2	1464	47.0
				5	1	2075	52.0
Largemouth Bass	2	2788	8%	2	1	716	24.5
				4	1	2075	48.5
Bluegill	25	2774	8%	2	5	99[c]	16.2
				3	17	111[c]	16.7
				4	2	126	17.5
Northern Pike	1	1490	4%	4	1	1490	59.0

[a]Not all fish of each species could be aged because some had deformed scales.
[b]Channel Catfish were not aged because they have no scales.
[c]Highly significantly different from other age classes ($P < 0.01$).

Table G-34. Locations of Beehives

Station	N-S Coordinate	E-W Coordinate
Regional Station (28-44 km)—Uncontrolled Area		
1. Chimayo	---	---
13. San Pedro	---	---
Perimeter Stations (0-4 km)—Uncontrolled Areas		
2. Northern Los Alamos County	N190	W020
3. Pajarito Acres	S210	E380
Onsite Stations—Controlled Areas		
4. TA-21 (DP Canyon)	N095	E140
5. TA-50 (Effluent Canyon)	N040	E080
6. TA-53 (LAMPF)	N070	E090
7. Mortandad Canyon	N020	E220
8. TA-8	S020	W080
9. TA-33	S245	E225
10. TA-54 (Area G)	S080	E290
11. TA-9	S045	E010
12. TA-15	S040	E100

Table G-35. Radiochemical and Chemical Analyses of Bees and Honey

Analysis	Units	Year	Location[a,b] Chimayo	San Pedro	N. Los Alamos County	Pajarito Acres	Martendale Canyon	TA-8	TA-9	TA-15	TA-21 (DP Canyon)	TA-33	TA-50 (Effluent Canyon)	TA-53 (LAMPF)	TA-54 (Area G)
Bee Analyses															
As	µg/g	1982	0.03	—	0.04	0.03	0.03	0.03	—	—	0.03	0.02	0.07	0.06	0.02
B	µg/g	1980	19	—	14	18	17	11	—	—	15	17	13	—	20
Be	ng/g	1983	2.4	1.5	11	8.5	—	9.0	—	—	5.0	2.2	6.1	5.9	7.1
^{7}Be	pCi/g	1984	0.0	1.3	—	0.0	2.4	1.3	1.0	1.0	<0.6	0.0	2.3	5.8	0.8
Cd	ng/g	1981	—	—	—	<10	8	<500	—	—	<30	16	65	10	—
^{57}Co	pCi/g	1984	0.06	0.00	—	0.09	0.03	0.00	<0.06	0.00	0.24	0.00	<0.05	3.4	<0.01
Cr	µg/g	1981	—	—	6.3	0.4	0.3	<6	—	—	<2	0.1	0.7	0.1	—
^{134}Cs	pCi/g	1984	<0.08	0.04	—	<0.01	0.00	0.04	<0.02	<0.09	0.36	0.12	0.24	0.34	0.09
^{137}Cs	pCi/g	1984	0.11	0.10	—	0.09	0.12	<0.04	<0.02	<0.07	0.35	0.05	0.05	0.05	0.25
F	µg/g	1981	—	—	1.1	4.1	1.5	0.3	—	—	2.8	0.4	1.2	0.9	1.3
Hg	ng/g	1983	7	8	9	5	—	30	—	—	<5	12	14	7	19
^{54}Mn	pCi/g	1984	0.18	<0.07	—	0.19	0.02	0.01	0.03	0.11	0.30	<0.01	<0.03	9.2	0.02
^{22}Na	pCi/g	1984	<0.02	0.08	—	<0.02	0.13	0.00	<0.06	0.17	0.34	0.10	0.00	85	0.00
Pb	µg/g	1983	1.4	1.3	70	0.3	—	0.2	—	—	0.3	130	0.1	3.7	0.5
^{83}Rb	pCi/g	1984	0.16	0.03	—	<0.16	0.17	0.15	0.96	0.39	<0.24	0.22	0.08	0.76	0.22
U	ng/g	1983	44	<6	36	68	—	21	—	—	250	17	44	39	66
Honey Analyses															
As	ng/g	1981	1.7	—	1.5	—	11	3.4	—	—	2.4	2.5	22	—	4.7
Be	ng/g	1983	<0.1	<0.1	<0.1	<0.1	—	<0.1	—	—	<0.1	<0.1	<0.1	<0.1	<0.1
^{7}Be	pCi/ℓ[c]	1984	170	490	—	180	220	50	0	100	170	100	<230	4	100
Cd	ng/g	1981	1.4	—	12	—	2.8	13	—	—	3.1	0.9	9.0	—	16
^{57}Co	pCi/ℓ[c]	1984	17	0.0	—	19	3.4	0.0	<5	<20	5.6	17	29	61	61
Cr	µg/g	1981	0.02	—	0.08	—	0.07	0.09	—	—	0.06	0.07	0.12	—	0.10
^{134}Cs	pCi/ℓ[c]	1984	9	37	—	2.4	0	16	19	0	15	<18	18	35	<4
^{137}Cs	pCi/ℓ[c]	1984	11	22	—	14	<21	<19	26	<8	<8	<11	19	<7	<4
F	µg/g	1982	0.1	—	0.2	0.2	0.1	0.1	—	—	0.4	0.1	0.5	0.1	0.1
Hg	ng/g	1982	1	—	2	1	1	<0.5	—	—	2	<0.5	<0.5	<0.5	3
^{3}H	pCi/ℓ[c]	1984	800	4100	—	4000	12000	4800	1700	4200	29000	99000	12000	50000	37000
^{54}Mn	pCi/ℓ[c]	1984	44	<10	—	<14	0	<13	21	0	2.7	0	<6	32	<17
^{22}Na	pCi/ℓ[c]	1984	2.8	<4	—	0	51	40	<10	10	8.5	<20	<15	560	60
Pb	µg/g	1983	0.2	0.3	0.1	0.1	—	0.1	—	—	0.1	0.1	0.1	<0.1	<0.1
^{83}Rb	pCi/ℓ[c]	1984	<17	<19	—	<14	<10	37	<0.8	18	14	100	<7	<19	0
U	ng/g	1984	1.9	1.7	—	0.8	0.7	1.2	0.7	0.9	5.2	1.5	0.6	<5	2.5

[a]One sample per location per year.
[b]Fig. 22 and Table G-34 for sample locations.
[c]Previous years' data expressed radionuclide levels in honey as pCi/g. To convert, use an average honey density of 1860 g/ℓ.

Table G-36. Hazardous Waste Management Facilities at Los Alamos National Laboratory

Technical Area	Facility Type	Interim Status or <90-Day Storage	Part B Permit Application
TA-54 Area L	Tank Treatment	Yes	Yes
	Container Storage	Yes	Yes
	Landfill[a]	No	No
TA-54 Area G	Landfill[a]	No	No
TA-50-1	Batch Treatment	Yes	Yes
	Container Storage	Yes	Yes
TA-50-37	Controlled Air Incinerator	No	Yes
TA-3-102	Container Storage	Yes	No
TA-3-40	Container Storage	<90-day	No
TA-9-39	Container Storage	<90-day	No
TA-14	Thermal Treatment	Yes	Yes
TA-15	Thermal Treatment	Yes	Yes
TA-36	Thermal Treatment	Yes	Yes
TA-39	Thermal Treatment	Yes	Yes
TA-22-24	Container Storage	Yes	No
TA-22-96	Container Storage	<90-day	No
TA-40-2	Container Storage	Yes	No
TA-40 scrap detonation pit	Thermal Treatment	Yes	No
TA-16	Thermal Treatment	Yes	Yes
TA-16 Area P	Landfill[a]	No	No
TA-46	Tank Storage	<90-day	No

[a]Interim status was terminated in November 1985. These landfills are in the process of being closed in accordance with New Mexico Hazardous Waste Regulations.

Table G-37. 1985 RCRA Interactions Among the Laboratory, Environmental Protection Agency (EPA), and New Mexico's Environmental Improvement Division (EID)

Date	Initiator	Action
February 5	EID	Meeting with Laboratory to discuss outstanding issues from the June 26, 1984, Notice of Violation (NOV) and to discuss a compliance order.
March 7	EID	Second meeting with the Laboratory to discuss compliance order based on the NOV.
April 30	Laboratory	A revised Part A submitted to the EID.
May 1	Laboratory	The Part B permit application, including a revised Part A, submitted to the EID.
May 7	EID	The Laboratory receives a Compliance Order/Schedule based on the June 22, 1984 NOV.
July 10 & 11	EID	The EID and EPA conduct a joint inspection of hazardous waste facilities.
August 9	Laboratory	The Laboratory files a health assessment for TA-54 Area L with the EPA.
August 26	EID	The Laboratory receives a NOV based on the July inspection.
September 18	EID	The Laboratory receives a Notice of Deficiency (NOD) for the Part B.
September 27	Laboratory	The Laboratory replies to the August 26 NOV.
October 16	Laboratory	The Laboratory responds to the NOD issuing a revised Parts A and B.
October 25	EID	The EID cites the Laboratory for violation of the Compliance Order and proposes a penalty of $100,000.
November 4	EID	The EID issues a letter requesting further information relative to the August 26 NOV.
November 5	EID	The Laboratory receives a letter stating that low potential for migration of wastes to the upper aquifer for Area L and Area G has been demonstrated by the ground water waiver application.
November 15	Laboratory	The Laboratory supplies additional information relative to the August 26 NOV.
November 25	Laboratory	The Part B closure plan for TA-54 Area L is amended to close under interim authority and a closure plan for Area P is submitted.
December 10	EID	The EID issues a letter finding the responses to the August 26 NOV adequate, closing the NOV.

Table G-38. Types of Discharges and Parameters Monitored at the Laboratory Under its NPDES Permit NM0028355

EPA ID #	Type of Discharge	Number Outfalls	Monitoring Required and Sample Frequency
01A	Power Plant	1	Total Suspended solids, Free Available Chlorine, pH, Flow (monthly)
03A	Treated Cooling Water	30	Total Suspended Solids, Free Available Chlorine, Phosphorous, pH, Flow (weekly)
04A	Noncontact Cooling Water	29	pH, Flow (weekly)
050	Radioactive Waste Treatment Plant	2	Ammonia, Chemical Oxygen Demand, Total Suspended Solids, Cadmium, Chromium, Copper, Iron, Lead, Mercury, Zinc, pH, Flow (weekly)
05A	High Explosive Discharge	20	Chemical Oxygen Demand, pH, Flow, Total Suspended Solids (weekly)
06A	Photo Wastes	13	Cyanide, Silver, pH, Flow (weekly)
DD	Sanitary Wastes	11	Biochemical Oxygen Demand, Flow, pH, Total Suspended Solids, Fecal Coliform Bacteria, (variable frequency, from 3 months to quarterly)

Table G-39. NPDES Permit NM0028355 Effluent Quality Monitoring of Sanitary Sewage Treatment Outfalls

Discharge Location	Permit Parameters	Number of Deviations	Range of Deviation
TA-3	BOD[a]	7	49.4 to 103.0
	TSS[b]	2	45.6 to 117.0
	Fecal Coliforms[c]	6	20.0 to 290,000
	pH[d]	0	---
TA-8	BOD	0	---
	TSS (90)	0	---
	pH	3	9.1 to 9.35
TA-9	BOD	0	---
	TSS	0	---
	pH	0	---
TA-16	BOD	0	---
	TSS	1	192.0
	pH	0	---
TA-18	BOD	3	46.5 to 71.0
	TSS (90)	2	118.0 to 459.5
	pH	4	9.6 to 10.13
TA-21	BOD	2	51.5 to 61.0
	TSS	2	51.1 to 56.8
	pH	6	9.1 to 11.7
TA-35	BOD	4	47.0 to 190.0
	TSS (90)	1	174.6
	pH	0	---
TA-41	BOD	1	57.0
	TSS	0	---
	Fecal Coliforms	3	2,500.0 to 81,600
	pH	0	---
TA-46	BOD	0	---
	TSS	1	60.8
	pH	0	---
TA-48	BOD	0	---
	TSS	0	---
	pH	0	---
TA-53	BOD	0	---
	TSS (90)	0	---
	pH	2	9.02 to 9.1

[a]Biochemical Oxygen Demand (BOD) permit limits are 30 mg/ℓ (20-day average) and 45 mg/ℓ (7-day average).
[b]Total Suspended Solids (TSS) permit limits are 30 mg/ℓ (20-day average) and 45 mg/ℓ or 90 mg/ℓ (7-day average).
[c]Fecal coliform limits are 2000 organisms/100 ml (daily maximum) and 1000 organisms/100 ml (geometric mean).
[d]Range of permit pH limits is >6.0 and <9.0 standard units.

Table G-40. Limits Established by NPDES Permit NM0028355 for Industrial Outfall Discharges

Discharge Category	Parameter Limited	Daily Average	Daily Maximum	Units of Measurement
Power Plant	TSS	30.0	100.0	mg/ℓ
	Free Cl	0.2	0.5	mg/ℓ
	pH	6-9	6-9	standard units
Treated Cooling Water	TSS	30.0	100.0	mg/ℓ
	Free Cl	0.2	0.5	mg/ℓ
	P	5.0	5.0	mg/ℓ
Noncontact Cooling Water	pH	6-9	6-9	standard units
Radioactive Waste Treatment Plant	COD	18.8	37.5	lb/day
	COD[a]	94.0	156.0	lb/day
	TSS	3.8	12.5	lb/day
	TSS[a]	18.8	62.6	lb/day
	Cd	0.01	0.06	lb/day
	Cd[a]	0.06	0.3	lb/day
	Cr	0.02	0.08	lb/day
	Cr[a]	0.19	0.38	lb/day
	Cu	0.13	0.13	lb/day
	Cu[a]	0.63	0.63	lb/day
	Fe	0.13	0.13	lb/day
	Fe[a]	1.0	2.0	lb/day
	Pb	0.01	0.03	lb/day
	Pb[a]	0.06	0.15	lb/day
	Hg	0.007	0.02	lb/day
	Hg[a]	0.003	0.09	lb/day
	Zn	0.13	0.37	lb/day
	Zn[a]	0.62	1.83	lb/day
	pH	6-9	6-9	standard units
	pH[a]	6-9	6-9	standard units
High Explosives	COD	150.0	250.0	mg/ℓ
	TSS	30.0	45.0	mg/ℓ
	pH	6-9	6-9	standard units
Photo Wastes	CN	0.2	0.2	mg/ℓ
	Ag	0.5	1.0	mg/ℓ
	pH	6-9	6-9	standard units

[a]Limitations for outfall 051 located at TA-50-1.

Table G-41. NPDES Permit Effluent Quality Monitoring of Industrial Outfalls[a]

Discharge Category	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls With Deviations
Power Plant	1	TSS[b]	0	---	0
		Free Cl	1	0.6	1
		pH	1	11.9	1
Treated Cooling Water	30	TSS	0	---	0
		Free Cl	3	1.4 to 9.8	3
		P	0	---	0
		pH	0		
Noncontract Cooling Water	29	pH	0	---	0
Radioactive Waste Treatment Plant	2	COD[c]	0	---	0
		TSS	0	---	0
		Cd	0	---	0
		Cr	0	---	0
		Cu	8	0.64 to 8.86	1
		Fe	3	0.1 to 2.2	2
		Pb	0	---	0
		Hg	0	---	0
		Zn	1	0.4	1
		pH	0	---	0
High Explosives	20	COD	2	178.2 to 1067.0	2
		TSS	0	---	0
		pH	0	---	0
Photo Wastes	13	CN	0	---	0
		Ag	3	1.1 to 19.0	1
		TSS	0	---	0
		pH	0	---	0

[a]Limits set by the NPDES permit are presented in Table G-40.
[b]Total Suspended Solids.
[c]Chemical Oxygen Demand.

Table G-42. Schedule and Status of Upgrading of Laboratory Sanitary Sewage Waste Outfalls

Outfall 01S Located at TA-3	Date	Status
Final design complete	March 1986	In Process
Construction completion	April 1987	Pending
NPDES permit compliance	July 1987	Pending
Outfall 05S Located at TA-21		
Final Design complete	November 1985	Completed
Construction completion	September 1986	Pending
NPDES permit compliance	January 1987	Pending
Outfall 06S Located at TA-41		
Final design complete	May 1986	Completed
Construction completion	June 1987	Pending
NPDES permit compliance	September 1987	Pending
Outfall 09S Located at TA-53		
Final design complete	Completed	Completed
Construction completion	October 1985	Completed
NPDES permit compliance	January 1986	Completed
Outfall 10S Located at TA-35		
Final design complete	Completed	Completed
Construction completion	October 1985	Completed
NPDES permit compliance	January 1986	Completed

Table G-43. Action Description Memorandums and Environmental Assessments Approved by the Laboratory Environmental Review Committee in 1985

Action Description Memorandums

Laboratory-Wide

Jemez Salamander Radiation Implant Study
Jemez Salamander Radiation Implant Study (revised: on Forest Service Land)
Live Firing Range, Los Alamos Canyon, LJ 7343
TRU Waste Inventory Work-Off Plan Inventory

TA-3

Category One Vault Installation, TA-3-29
Diamond Drive Duct Bank, LJ 8129
Diamond/Jemez Spoil Area and Parking Lot, Phase I
Experimental Materials Science Facility, TA-3-32, LJ 7999
Geochemistry Analytical Facility, LJ 7804
Office Building Addition, TA-3-200, LJ 7954
Operational Addition to Chemical Surety Laboratory: Animal Inhalation Studies, TA-3-29
Operational Addition to Chemical Surety Laboratory: Laser Detection of Surety Material, TA-3-29
Operational Addition to Chemical Surety Laboratory: HSE-5 Sorbent Studies, TA-3-29
SDI Weapons Effects Laboratory, LJ 8306
Second CCF Equipment Room, TA-3-32, LJ 7995
Second Story Addition, TA-3-40, LJ 7982
Technical Design Building, TA-3-43, LJ 8195

TA-15

Multidiagnostic Operations Center, LJ 8131

TA-16

Process Equipment Storage Building, LJ 7996
WX-3 Laboratory/Office Building, LJ 8425

TA-18

Plutonium Nitrate Solution Criticality Measurements, TA-18/51

TA-35

Building Modifications, High Energy Density Physics Building, TA-35-86, LJ 8012
High Energy Density Physics Facility, LJ 7548 (revised)
Power Amplifier Module (PAM) Transmission Line, TA-35/52, LJ 7997
Target Fabrication Facility Tritium Fill Room, LJ 8012

Table G-43 (cont)

TA-36

Hardened Precinct Station, TA-36-69, LJ 8068

TA-43

Outdoor Bioaerosol Experiments, TA-43/51

TA-49

Blast Over Pressure Walk-up Study, LJ 8078

TA-51

Life Sciences Facility Improvement, LJ 4787 (revised)

TA-53

Accelerator Maintenance Building Addition, LJ 8179
Polarized Ion Source Upgrade
Transportable Office Complex, LJ 7727
Weapons Neutron Research Facility, Target 4

TA-55

Nuclear Safeguards Technology Laboratory, LJ 5814 (revised)

TA-59

Health, Safety, and Environment Division Relocation, LJ 7948

Environmental Assessments

TA-16

Solid Waste Reduction Facility

TA-53

Accelerator Test Stand Upgrade

TA-55

Nuclear Materials Storage Facility, LJ 6481
Nuclear Materials Storage Facility, LJ 6481 (revised)

Table G-44. Radiochemical and Chemical Quality Water from Municipal Supply and Distribution

		Radiochemical							
	1985 (month-day)	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	$^{239,240}Pu$ (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)	Gross Gamma (counts/min/ℓ)
Well Field and Gallery									
Los Alamos Field									
Well LA-1B	3-20	46 ± 44	0.019 ± 0.012	0.004 ± 0.006	21 ± 5.0	7.4 ± 0.9	−0.5 ± 0.3	6.8 ± 1.0	−30 ± 50
Well LA-2	3-20	14 ± 37	0.004 ± 0.007	0.004 ± 0.007	6.0 ± 1.0	3.2 ± 0.6	−0.7 ± 0.3	3.7 ± 0.6	−30 ± 50
Well LA-3	3-20	19 ± 60	0.014 ± 0.014	0.000 ± 0.010	0.6 ± 0.6	2.2 ± 0.5	−1.0 ± 0.3	1.6 ± 0.6	10 ± 50
Well LA-4	3-20	40 ± 48	0.008 ± 0.011	0.004 ± 0.010	0.8 ± 0.5	3.1 ± 0.5	−0.7 ± 0.3	1.8 ± 0.6	−10 ± 50
Guaje Field									
Well G-1	3-20	−33 ± 44	−0.008 ± 0.009	0.008 ± 0.008	1.2 ± 0.6	3.3 ± 0.6	−0.5 ± 0.3	1.3 ± 0.5	−10 ± 50
Well G-1A	3-20	17 ± 40	0.004 ± 0.008	0.000 ± 0.010	1.2 ± 0.6	3.6 ± 0.6	−1.2 ± 0.3	1.0 ± 0.5	20 ± 50
Well G-2	3-20	98 ± 54	0.008 ± 0.009	−0.008 ± 0.005	0.9 ± 0.6	3.4 ± 0.6	−0.9 ± 0.3	2.3 ± 0.5	30 ± 50
Well G-3	3-20	44 ± 21	0.019 ± 0.009	0.000 ± 0.010	0.9 ± 0.6	2.9 ± 0.5	−0.7 ± 0.3	1.1 ± 0.5	−30 ± 50
Well G-4	3-20	−50 ± 39	0.000 ± 0.010	0.004 ± 0.007	1.8 ± 0.7	2.6 ± 0.5	−0.9 ± 0.3	2.0 ± 0.5	20 ± 50
Well G-5	3-20	37 ± 37	−0.004 ± 0.007	0.004 ± 0.007	1.0 ± 0.5	3.1 ± 0.5	−0.6 ± 0.3	2.0 ± 0.5	−10 ± 50
Well G-6	3-20	−27 ± 30	−0.008 ± 0.008	0.000 ± 0.010	1.2 ± 0.7	3.7 ± 0.6	−0.8 ± 0.3	1.1 ± 0.5	−10 ± 50
Pajarito Field									
Well PM-1	3-20	16 ± 46	0.000 ± 0.010	0.000 ± 0.0010	1.7 ± 0.8	4.8 ± 0.7	−0.4 ± 0.3	2.5 ± 0.6	50 ± 50
Well PM-2	3-20	61 ± 42	0.000 ± 0.010	0.000 ± 0.0010	0.0 ± 0.4	2.6 ± 0.5	−1.2 ± 0.3	1.1 ± 0.5	40 ± 50
Well PM-3	3-20	−7 ± 52	0.007 ± 0.010	0.264 ± 0.032[a]	0.1 ± 0.7	4.2 ± 0.6	−1.0 ± 0.3	1.3 ± 0.5	0 ± 50
Well PM-3	6-18	42 ± 45	0.004 ± 0.012	0.034 ± 0.014	—	—	−0.6 ± 0.4	1.5 ± 0.5	−20 ± 60
Well PM-4	3-20	26 ± 47	−0.004 ± 0.007	−0.004 ± 0.004	0.6 ± 0.5	3.0 ± 0.5	—	0.9 ± 0.5	60 ± 50
Gallery									
Water Canyon	3-20	55 ± 48	0.004 ± 0.011	0.000 ± 0.010	0.8 ± 0.5	3.2 ± 0.5	—	1.0 ± 0.5	10 ± 50
No. of Analyses		17	17	17	16	16	15	17	17
Minimum		−50 ± 39	−0.008 ± 0.009	−0.008 ± 0.05	0.0 ± 0.4	2.2 ± 0.6	−1.2 ± 0.3	0.9 ± 0.5	−30 ± 50
Maximum		55 ± 48	0.019 ± 0.012	0.034 ± 0.014	21 ± 5.0	7.4 ± 0.9	−0.4 ± 0.3	6.8 ± 1.0	60 ± 50
Average		23	0.004	0.018	2.5	3.5	−0.8	1.9	1.8
s		37	0.008	0.064	5.0	1.2	0.3	1.4	28

[a] Reanalysis revealed no plutonium present.

Table G-44. (cont)

	1985 (month-day)	Radiochemical							
		^{137}Cs (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	$^{239,240}Pu$ (10^{-9} µCi/mℓ)	Gross Alpha (10^{-9} µCi/mℓ)	Gross Beta (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)	Gross Gamma (counts/min/ℓ)
Distribution									
Fire Station 1	3-13	18 ± 41	−0.008 ± 0.009	0.008 ± 0.008	−0.1 ± 0.4	4.5 ± 0.6	0.4 ± 0.4	1.4 ± 0.5	−10 ± 60
Fire Station 1	9-5	3 ± 51	0.012 ± 0.012	−0.004 ± 0.006	—	—	3.2 ± 0.5	0.5 ± 0.2	50 ± 60
Fire Station 2	3-13	31 ± 48	−0.004 ± 0.004	0.000 ± 0.010	2.0 ± 0.8	4.5 ± 0.7	−0.4 ± 0.3	1.5 ± 0.5	0 ± 50
Fire Station 2	9-5	−40 ± 69	0.009 ± 0.014	−0.004 ± 0.006	—	—	0.9 ± 0.4	4.6 ± 0.5	−10 ± 60
Fire Station 3	3-13	76 ± 49	−0.008 ± 0.007	0.000 ± 0.010	1.6 ± 0.7	4.2 ± 0.6	−0.4 ± 0.3	1.5 ± 0.5	0 ± 50
Fire Station 3	9-5	3 ± 38	−0.016 ± 0.008	0.000 ± 0.010	—	—	1.6 ± 0.2	70 ± 60	
Fire Station 4	3-13	71 ± 42	−0.016 ± 0.009	0.016 ± 0.011	1.6 ± 0.8	5.4 ± 0.7	−0.03 ± 0.3	2.0 ± 0.5	0 ± 50
Fire Station 4	9-5	−83 ± 42	−0.013 ± 0.008	−0.004 ± 0.004	—	—	3.4 ± 0.5	3.4 ± 0.3	100 ± 60
Fire Station 5	3-13	45 ± 53	−0.004 ± 0.009	0.026 ± 0.013	0.7 ± 0.6	4.0 ± 0.6	−0.1 ± 0.3	1.7 ± 0.5	30 ± 50
Fire Station 5	9-5	61 ± 42	−0.008 ± 0.014	0.008 ± 0.008	—	—	2.2 ± 0.4	2.1 ± 0.2	−90 ± 60
Bandelier National Monument	4-2	37 ± 41	0.004 ± 0.009	−0.009 ± 0.006	0.5 ± 0.5	5.7 ± 0.8	—	2.2 ± 0.6	0 ± 50
Bandelier National Monument	9-5	−71 ± 55	−0.004 ± 0.010	—	—	0.9 ± 0.4	0.8 ± 0.2	10 ± 60	
Fenton Hill (TA-57)	4-4	24 ± 48	−0.015 ± 0.011	−0.015 ± 0.011	2.4 ± 1.0	6.1 ± 0.8	−0.9 ± 0.3	2.1 ± 0.6	−40 ± 50
Fenton Hill (TA-57)	9-11	0 ± 40	−0.009 ± 0.016	−0.005 ± 0.010	—	—	0.3 ± 0.4	1.2 ± 0.2	−90 ± 60
No. of Analyses		14	14	14	7	7	13	14	14
Minimum		−83 ± 42	−0.016 ± 0.009	−0.015 ± 0.011	−0.1 ± 0.4	0.9 ± 0.4	−0.9 ± 0.3	0.5 ± 0.2	−10 ± 60
Maximum		76 ± 99	0.012 ± 0.014	0.026 ± 0.013	2.4 ± 1.0	6.1 ± 0.8	3.2 ± 0.5	4.6 ± 0.5	100 ± 60
Average		12	−0.006	0.006	1.2	4.9	0.8	1.9	1.4
s		99	0.009	0.010	0.9	0.8	1.4	1.0	53
Limits of Detection		40	0.009	0.03	3	3	0.7	1	50
USEPA Maximum Concentration Levels[b]		200	15	15	15[c]	—	20	1800[d]	—

Table G-44. (cont)

	1985 (month-day)	Primary Chemical Quality Required for Municipal Use (concentration in mg/ℓ) Ag	As	Ba	Cd	Cr	F	Hg	N	Pb	Se
Well Fields and Gallery											
Los Alamos Field											
Well LA-1B	3-20	<0.001	0.039	0.05	<0.0002	0.025	3.0	<0.0001	1.2	<0.002	<0.003
Well LA-2	3-20	<0.001	0.010	0.09	<0.0002	0.017	1.1	<0.0001	5.3	<0.002	<0.003
Well LA-3	3-20	<0.001	0.005	0.05	<0.0002	0.008	0.5	<0.0001	1.8	<0.002	<0.003
Well LA-4	3-20	<0.001	<0.001	0.02	<0.0002	0.004	0.4	<0.0001	0.3	0.006	<0.003
Guaje Field											
Well G-1	3-20	<0.001	0.003	−0.06	<0.0002	0.005	0.3	<0.0001	0.4	<0.002	<0.003
Well G-1A	3-20	<0.001	0.013	−0.04	<0.0002	0.008	0.5	<0.0001	0.4	<0.002	<0.003
Well G-2	3-20	<0.001	0.050	−0.07	<0.0002	0.010	0.9	<0.0001	0.5	0.012	<0.003
Well G-3	3-20	<0.001	0.003	<0.01	<0.0002	0.004	0.3	<0.0001	0.2	0.020	<0.003
Well G-4	3-20	<0.001	0.001	0.01	<0.0002	0.003	0.3	<0.0001	0.5	<0.002	<0.003
Well G-5	3-20	<0.001	0.002	<0.01	<0.0002	0.002	0.3	<0.0001	0.5	<0.002	<0.003
Well G-6	3-20	<0.001	0.001	<0.01	<0.0002	0.002	0.3	<0.0001	0.4	<0.002	<0.003
Pajarito Field											
Well PM-1	3-20	<0.001	<0.001	0.07	<0.0002	0.004	0.3	<0.0001	0.5	<0.002	<0.003
Well PM-2	3-20	<0.001	0.002	0.02	<0.0002	0.003	0.2	<0.0001	0.2	0.006	<0.003
Well PM-3	3-20	<0.001	<0.001	0.05	<0.0002	0.004	0.3	<0.0001	<0.2	<0.002	<0.003
Well PM-4	3-20	<0.001	<0.001	0.02	<0.0002	0.006	0.3	<0.0001	0.2	<0.002	<0.003
Well PM-5	—										
Water Canyon											
Gallery	3-20	<0.001	0.003	0.02	<0.0002	0.002	<0.1	<0.0001	<0.2	<0.002	<0.003
Summary of Wells and Gallery											
No. of Analyses		16	16	16	16	16	16	16	16	16	16
Minimum		—	<0.001	<0.01	—	0.002	0.3	—	<0.2	<0.002	—
Maximum		—	0.050	0.07	—	0.025	3.0	—	5.3	0.020	—
Average		<0.001	<0.009	<0.04	<0.0002	0.007	<0.6	<0.0001	<0.8	0.004	<0.003
s		—	0.014	0.02	—	0.006	0.7	—	1.2	0.005	—

	1985 (month-day)	Primary Chemical Quality Required for Municipal Use (concentration in mg/l)									
		Ag	As	Ba	Cd	Cr	F	Hg	N	Pb	Se
Distribution											
Fire Station 1	3-13	<0.001	0.002	0.02	<0.0002	0.005	0.4	<0.0002	0.3	<0.002	<0.003
Fire Station 2	3-13	<0.001	0.012	0.04	<0.0002	0.006	0.6	<0.0002	0.4	<0.002	<0.003
Fire Station 3	3-13	<0.001	0.012	0.02	<0.0002	0.005	0.6	<0.0002	0.5	<0.002	<0.003
Fire Station 4	3-13	<0.001	0.001	0.05	<0.0002	0.004	0.7	<0.0002	0.5	<0.002	<0.003
Fire Station 5	3-13	<0.001	0.010	0.03	<0.0002	0.006	0.6	<0.0002	0.5	<0.002	<0.003
Bandelier National Monument	4-2	<0.001	0.012	0.03	<0.0002	0.006	0.5	<0.0002	0.5	<0.002	<0.003
Fenton Hill (TA-57)	4-2	<0.001	<0.001	0.07	<0.0002	0.005	0.5	<0.0002	<0.2	<0.002	<0.003
Summary of Distribution											
No. of Analyses		7	7	7	7	7	7	7	7	7	7
Minimum		—	<0.001	0.02	—	0.004	0.4	—	<0.2	—	—
Maximum		—	0.012	0.07	—	0.006	0.7	—	0.5	<0.002	—
Average		<0.001	<0.007	0.04	<0.0002	0.005	0.6	<0.0002	<0.4	—	<0.003
s		—	0.005	0.02	—	0.001	0.1	—	0.1	—	—
USEPA and NMFID[c] Maximum Primary Concentration Levels		0.05	0.05	1.0	0.01	0.05	2.0	0.002	1.0	0.05	0.01

Table G-44. (cont)

	1985 (month-day)	Secondary Chemical Quality Required for Municipal Use (concentration in mg/ℓ) Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Los Alamos Field									
Well LA-1B		15	0.005	<0.003	<0.001	32	<0.01	446	8.1
Well LA-2		8	<0.005	<0.003	0.002	10	<0.01	188	8.4
Well LA-3		3	<0.005	<0.003	<0.001	6	<0.01	140	8.2
Well LA-4		3	<0.005	0.009	<0.001	3	<0.01	115	8.2
Guaje Field									
Well G-1		3	<0.005	<0.003	<0.001	4	<0.01	166	8.2
Well G-1A		4	<0.005	<0.003	<0.001	4	<0.01	153	8.3
Well G-2		3	0.016	<0.003	<0.001	4	<0.01	187	8.2
Well G-3		3	0.060	<0.003	<0.001	3	<0.01	144	8.1
Well G-4		4	0.009	<0.003	<0.001	3	<0.01	147	8.1
Well G-5		4	<0.005	<0.003	<0.001	5	<0.01	139	8.0
Well G-6		4	<0.005	<0.003	0.011	3	<0.01	144	8.0
Pajarito Field									
Well PM-1		6	0.043	<0.003	<0.001	5	<0.01	231	8.0
Well PM-2		3	<0.005	<0.003	<0.001	2	1.35	137	7.6
Well PM-3		5	<0.005	<0.003	<0.001	5	<0.01	226	7.8
Well PM-4		3	<0.005	<0.003	<0.001	2	<0.01	152	7.7
Water Canyon									
Gallery		2	<0.005	0.990	0.008	10	0.06	152	7.2
Summary of Wells and Gallery									
No. of Analyses		16	16	16	16	16	16	16	16
Minimum		3	<0.005	<0.003	<0.001	2	<0.01	115	7.2
Maximum		15	0.060	0.990	0.011	32	1.35	446	8.4
Average		4	<0.012	<0.065	<0.002	6	<0.10	179	8.0
S		3	0.016	0.246	0.003	7	0.33	78	0.3
Distribution									
Fire Station 1		3	<0.005	0.006	<0.001	2	0.01	170	8.0
Fire Station 2		3	<0.005	0.013	<0.001	5	<0.01	160	8.1
Fire Station 3		3	<0.005	0.011	<0.001	4	<0.01	172	8.2
Fire Station 4		7	0.021	0.005	<0.001	5	<0.01	228	7.9
Fire Station 5		4	0.015	0.028	<0.001	5	0.02	175	8.2
Bandelier National Monument		4	0.011	0.007	<0.001	4	0.03	181	8.0
Fenton Hill (TA-57)		15	<0.005	0.036	<0.001	6	0.05	236	7.8
Summary of Distribution									
No. of Analyses		7	7	7	7	7	7	7	7
Minimum		3	<0.005	0.006	—	2	<0.01	160	7.8
Maximum		15	0.021	0.036	<0.001	6	0.05	236	8.2
Average		5	<0.010	0.015	—	4	<0.02	188	8.0
S		4	0.006	0.007	—	1	0.02	30	0.2
USEPA									
Maximum Secondary Concentration Levels		250	1.0	0.3	0.05	250	5.0	500	6.5-8.5

Table G-44 (cont)

	1985 (month-day)	Miscellaneous Chemical Analyses (concentration in mg/ℓ)									
		SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hard	Cond. (mS/m)
Well Field and Gallery											
Los Alamos Field											
Well LA-1B	3-20	38	7	0.4	2.6	163	0	308	<0.5	18	72
Well LA-2	3-20	27	8	0.1	1.3	56	0	114	<0.5	21	29
Well LA-3	3-20	34	13	0.3	1.6	29	0	84	<0.5	32	18
Well LA-4	3-20	40	13	0.3	2.3	18	0	67	<0.5	35	15
Well LA-5		—									
Guaje Field											
Well G-1	3-20	90	13	0.6	3.1	21	0	73	<0.5	36	16
Well G-1A	3-20	90	13	0.6	3.1	21	0	73	<0.5	36	16
Well G-2	3-20	73	11	0.6	2.7	37	0	100	<0.5	29	23
Well G-3	3-20	59	14	2.0	2.0	18	0	73	<0.5	41	16
Well G-4	3-20	59	17	3.4	1.9	14	0	77	<0.5	52	17
Well G-5	3-20	54	17	3.9	2.0	12	0	75	<0.5	58	16
Well G-6	3-20	47	17	3.6	2.3	12	0	77	<0.5	58	17
Pajarito Field											
Well PM-1	3-20	77	25	6.5	3.6	20	0	117	<0.5	84	27
Well PM-2	3-20	74	9	2.7	1.8	10	0	56	<0.5	34	11
Well PM-3	3-20	87	24	8.1	3.6	18	0	116	<0.5	87	27
Well PM-4	3-20	88	11	3.6	2.2	12	0	62	<0.5	40	14
Water Canyon											
Gallery		40	8	3.1	2.3	4	0	24	<0.5	30	8
Distribution											
Fire Station 1	3-13	82	11	3.3	2.1	25	0	62	<0.5	38	13
Fire Station 2	3-13	63	12	1.5	2.2	28	0	86	<0.5	38	18
Fire Station 3	3-13	63	13	1.9	2.4	22	0	81	<0.5	39	17
Fire Station 4	3-13	83	25	7.6	3.5	19	0	116	<0.5	91	26
Fire Station 5	3-13	59	12	1.6	2.3	26	0	83	<0.5	35	18
Bandelier National Monument	4-2	62	13	1.7	2.3	26	0	86	<0.5	38	18
Fenton Hill (TA-59)	4-2	76	37	4.0	4.5	13	0	111	<0.5	105	28

[b]Reference (EPA 1976).
[c]The Environmental Protection Agency's MCL for gross alpha is 15×10^{-9} μCi/mℓ. However, gross alpha results from the distributions system that exceed EPA's screening limit of 5×10^{-9} μCi/mℓ require isotopic analysis to determine radium content.
[d]Level recommended by International Commission on Radiological Protection.
[e]Reference (EPA 1979B).

Table G-45. Climatological Survey (1911-1985) for Los Alamos New Mexico[a] Means[b] and Extremes of Temperature and Precipitation

	Temperature (°F)[c]										
	Means			Extremes							
Month	Mean Max	Mean Min	Avg	High Avg	Year	Low Avg	Year	High Daily Max	Date	Low Daily Min	Date
Jan	39.7	18.5	29.1	37.5	1953	20.9	1930	64	1/12/53	-18	1/13/63
Feb	43.0	21.5	32.2	37.4	1934	23.0	1939	66	2/24/36	-14	2/1/51 2/8/33
Mar	48.7	26.5	37.6	45.8	1972	32.1	1948	71	3/26/71 3/30/46	-3	3/11/48
Apr	57.6	33.7	45.6	54.3	1954	39.7	1973	79	4/23/38	5	4/9/28
May	67.0	42.8	54.9	60.5	1956	50.1	1957	89	5/29/35	24	4 Dates
Jun	77.8	52.4	65.1	69.4	1980	60.4	1965	95	6/22/81	28	6/3/19
Jul	80.4	56.1	68.2	71.4	1980	63.3	1926	95	7/11/35	37	7/7/24
Aug	77.4	54.3	65.8	70.3	1936	60.9	1929	92	8/10/37	40	8/16/47
Sept	72.1	48.4	60.2	65.8	1956	56.2	1965	94	9/11/34	23	9/29/36
Oct	62.0	38.7	50.3	54.7	1963	42.8	1984	84	10/1/80	15	10/19/76
Nov	48.7	27.1	37.9	44.4	1949	30.5	1972	72	11/1/50	-14	1/28/76
Dec	41.4	20.3	30.8	38.4	1980	24.6	1931	64	12/27/80	-13	12/9/78
Annual	59.6	36.7	48.1	52.0	1954	46.2	1932	95	7/11/35 6/22/81	-18	1/13/63

	Precipitation (in.)[c]									Mean Number of Days		
	Rain[d]					Snow						
Month	Mean	Mo. Max	Year	Daily Max	Date	Mean	Mo. Max	Year	Daily Max	Date	Precip ≥0.10 in.	Max Temp ≥90°F	Min Temp ≤32°F
Jan	0.85	6.75	1916	2.45	1/27/16	9.7	39.3	1949	15.0	1/5/13	2	0	30
Feb	0.68	2.44	1948	1.05	2/20/15	7.3	36.4	1982	19.0	2/4/82	2	0	26
Mar	1.01	4.11	1973	2.25	3/30/16	9.7	36.0	1973	18.0	3/30/16	3	0	24
Apr	0.86	4.64	1915	2.00	4/12/75	5.1	33.6	1958	20.0	4/12/75	2	0	13
May	1.13	4.47	1929	1.80	5/21/29	0.8	17.0	1917	12.0	5/2/78	3	0	2
Jun	1.12	5.57	1913	2.51	6/10/13	0	---	---	---	---	3	1	0
Jul	3.18	7.98	1919	2.47	7/31/68	0	---	---	---	---	8	1	0
Aug	3.93	11.18	1952	2.26	8/1/51	0	---	---	---	---	9	0	0
Sept	1.63	5.79	1941	2.21	9/22/29	0.1	6.0	1913	6.0	9/25/13	4	0	0
Oct	1.52	6.77	1957	3.48	10/5/11	1.7	20.0	1984	9.0	10/31/72	3	0	7
Nov	0.96	6.60	1978	1.77	11/25/78	5.0	26.2	1931	14.0	11/22/31	2	0	22
Dec	0.96	3.21	1984	1.60	12/6/78	11.4	41.3	1967	22.0	12/6/78	3	0	30
Annual	17.83	30.34	1941	3.48	10/5/11	50.8	112.8	1984	22.0	12/6/78	43	2	154

[a]Latitude 35° 32′ north, longitude 106° 19′ west; elevation 2249 m.
[b]Means based on standard 30-year period: 1951-1980.
[c]Metric conversions: 1 in. = 2.5 cm; °F = 9/5 °C + 32.
[d]Includes liquid water equivalent of frozen precipitation.

Table G-46. Climatological Summary for 1985

Month	Temperature (°F)[a]						
	Means			Extremes			
	Mean Max	Mean Min	Avg	High	Date	Low	Date
Jan	36.9	16.4	26.7	47	19	−3	31
Feb	41.4	17.4	29.4	57	17	−9	1
Mar	49.1	27.4	38.3	62	24	10	31
Apr	62.0	34.8	48.4	74	15	22	1
May	67.3	42.9	55.1	78	28,29	27	14
Jun	78.6	50.9	64.8	87	4 dates	40	5
Jul	81.7	54.4	68.0	92	5-7	48	3
Aug	79.3	53.3	66.3	85	6,23,30	48	13
Sept	69.1	44.0	56.6	83	1	25	30
Oct	60.9	37.0	49.0	72	6	29	5
Nov	49.4	27.1	38.2	65	5	9	20
Dec	43.8	20.0	31.9	53	21	5	13
Annual	60.1	35.6	47.8	92	7/5-7	−9	2/1

Month	Precipitation(in.)[a]						Number of Days		
	Rain[a]			Snow					
	Total	Daily Max	Date	Total	Daily Max	Date	Precip ≥0.10 in.	Max Temp ≥90°F	Min Temp ≤32°F
Jan	0.57	0.36	8	14.3	5.3	8	1	0	31
Feb	0.87	0.39	23	13.5	5.5	23	3	0	27
Mar	3.17	1.33	12	28.3	11.0	12	6	0	22
Apr	3.10	1.45	28	4.0	2.0	26	7	0	11
May	2.24	0.40	21	0	0	—	8	0	2
Jun	1.89	0.58	24	0	0	—	5	0	0
Jul	2.97	0.81	29	0	0	—	7	4	0
Aug	3.98	1.76	10	0	0	—	9	0	0
Sept	2.80	0.92	20	0	0	—	6	0	1
Oct	2.97	1.01	10	0	0	—	7	0	4
Nov	0.57	0.16	17	5.9	2.8	17	2	0	25
Dec	0.44	0.35	10	10.5	10.0	10	1	0	31
Annual	25.57	1.76	8/10	76.5	11.0	3/12	62	4	154

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

Table G-47. Weather Highlights of 1985

January	Cool. Mean temperature = 26.7°F (Normal = 29.1°F). Mean high temperature = 36.9°F (Normal = 39.7°F). SMDL on the 31st: −3°F.
February	Cool and snowy. Mean temperature = 29.4°F (Normal = 32.2°F). Mean low temperature = 17.4 (Normal = 21.5°F). Snowfall = 13.5 in. (Normal = 7.3 in.). SMDL on the 2nd: −9°F. SMDL on the 5th: 0°F. SMDP on the 23rd: 0.39 in. SMDS on the 23rd: 5.5 in.
March	Very wet and snowy. Precipitation = 3.17 in. (Normal = 1.01 in.). 3rd wettest March on record (most was 4.11 in. in 1973). Snowfall = 28.3 in. (Normal = 9.7 in.). SMDP on the 12th: 1.33 in. SMDS on the 12th: 11.0 in. Strong winds with blowing dust on 27th and 28th: peak winds of 61 and 57 mph, respectively. TMDL on the 31st: 10°F.
April	Warm and very wet. Mean temperature = 48.4°F (Normal = 45.6°F). Mean high temperature = 62.0°F (Normal = 57.6°F). Precipitation = 3.10 in. (Normal = 0.86 in.). 5th wettest April on record (most was 4.64 in. in 1915). Strong winds on 4th, 18th, and 25th: peak winds at 59, 58, and 51 mph, respectively. SMDP on the 28th: 1.45 in.
May	Wet. Precipitation = 2.24 in. (Normal = 1.13 in.). Strong winds with peak gusts ≥ 50 mph on 10th, 11th, 12th, and 31st. SMDL on the 14th: 27°F. (Late hard freeze.)
Spring 1985 (March-May)	Precipitation = 8.51 in. (Normal = 3.00 in.). 2nd wettest spring on record (most was 9.97 in. in 1915).
June	Wetter than normal. Precipitation = 1.89 in. (Normal = 1.12 in.). SMDH on the 7th: 87°F. TMDH on the 8th: 87°F. Intense lightning causes power outage in Los Alamos County on 18th. Strong winds cause power outage in Los Alamos County on 19th. Strong winds with peak gusts of 56 mph on 25th. SMDL on the 27th: 46°F. TMDL on the 28th: 45°F.

Table G-47 (cont)

July	Near normal temperatures and precipitation. SMDH on the 6th: 92°F. SMDH on the 7th: 92°F. SMDH on the 8th: 90°F.
August	Near normal temperatures and precipitation. Strong thunderstorms on 10th: intense lightning causes power outage, heavy rains occur. A total of 2.72 in. fell at East Gate.
September	Cool and wet. Mean temperture = 56.6°F (Normal = 60.2°F). 3rd coldest September on record (coldest was 56.2°F in 1965). Mean low temperature = 44.0°F (Normal = 48.4°F). Precipitation = 2.80 in. (Normal = 1.63 in.). Tornado in Albuquerque on 20th. TMDL on the 23rd: 33°F. SMDL on the 30th: 25°F. (Early hard freeze.)
October	Wet. Precipitation = 2.97 in. (Normal = 1.52 in.).
November	Dry. Precipitation = 0.57 in. (Normal = 0.96 in.). SMDS on the 30th: 2.0 in.
December	Mild days and dry. Mean high temperature = 43.8°F (Normal = 41.3°F). Snowstorm on 10th. SMDS on the 10th: 10.0 in. TMDH on the 22nd: 52°F.
Annual	1985 mean temperature = 47.8°F (Normal = 48.1°F). 1985 precipitation = 25.57 in. (Normal = 17.83 in.). Wettest year since 1969 when 25.67 in. fell. 1985 snowfall = 76.5 in. (Normal = 50.8 in.). 1984-1985 seasonal snowfall = 121.5 in. Second snowiest winter on record (snowiest was 1957-1958 with 123.6 in.). 1985 growing season was second shortest on record: May 15-September 29 (138 consecutive days with no temperature below 28°F)—previous record was 125 days in 1983.

Table G-48. Bandelier National Atmospheric Deposition Program Station Sampling Results-Concentration

Week	Precip. (in.)	Concentrations (μEquiv/ℓ) Ca	Mg	K	Na	NH_4	NO_3	Cl	SO_4	PO_4	pH	Conductivity (μMhos/cm)	Ion Balance (μ Equiv/ℓ) Anions	Cations
1984														
8/14-21	0.11	19.96	15.87	1.28	19.57	9.42	26.73	9.59	44.97	<0.09	4.58	16.00	77.10	82.70
8/21-28	1.20	4.39	0.99	0.20	0.87	6.65	20.00	2.26	21.86	<0.09	4.61	14.00	41.00	40.60
8/28-9/4	0.00[a]	—	—	—	—	—	—	—	—	—	—	—	—	—
9/4-11	trace[a]	4.84	2.30	0.20	1.00	0.00	1.73	2.54	<2.00	<0.09	5.63	2.30	5.10	11.20
9/11-18	0.09	53.19	11.76	5.29	14.53	9.98	41.53	15.51	50.17	0.22	4.95	19.20	100.80	112.50
9/18-25	0.10	38.62	11.92	5.40	11.70	18.85	41.72	10.15	57.25	<0.09	4.47	19.50	102.50	101.30
9/25-10/2	0.49	7.53	2.63	0.46	3.48	8.87	10.00	1.97	16.68	<0.09	5.13	6.10	27.30	29.90
10/2-9	0.57	3.29	2.30	0.23	3.26	1.66	5.19	1.69	5.62	0.16	5.65	2.70	11.80	14.50
10/9-16	1.07	5.39	1.64	0.54	3.00	3.33	10.0	2.82	12.70	<0.09	4.94	5.40	24.00	21.50
10/16-23	0.93	8.53	2.47	1.56	5.00	3.88	11.73	5.36	12.28	0.25	4.81	5.50	27.70	22.20
10/23-30	0.22	6.79	6.83	2.84	10.26	4.43	3.85	6.77	10.41	0.41	5.15	3.90	20.80	32.70
10/30-11/6	0.00[a]	—	—	—	—	—	—	—	—	—	—	—	—	—
11/6-13	trace[a]	4.14	3.04	0.31	2.00	3.33	1.15	2.26	<2.00	0.22	—	0.20	4.50	14.40
11/13-20	0.06	48.85	47.45	7.57	72.20	2.77	34.03	20.02	64.75	<0.09	5.62	20.70	113.40	179.10
11/20-27	0.28	5.94	3.70	1.10	6.18	6.65	7.69	3.10	16.66	<0.09	4.75	4.90	26.30	25.90
11/27-12/4	0.12	15.52	5.76	3.15	10.87	6.10	21.54	4.79	28.73	<0.09	4.78	8.00	51.70	43.30
12/4-11	0.06	18.56	13.40	2.97	17.01	6.65	20.19	8.18	16.45	<0.09	5.19	8.60	41.60	59.30
12/11-18	1.55	2.25	0.58	2.61	4.18	0.00	5.58	2.54	8.33	<0.09	4.75	3.30	15.60	14.10
12/18-26	0.08	19.96	12.01	10.79	16.44	6.65	25.00	15.79	32.48	0.32	4.42	11.90	69.60	69.50
12/26-1/2	0.88	8.83	1.48	0.95	2.48	17.18	9.61	1.41	27.48	<0.09	4.74	8.90	37.00	39.10
1985														
1/2-15	0.52	3.04	1.40	0.26	1.70	0.00	8.46	1.13	12.28	<0.09	4.75	6.20	20.60	15.90
1/15-22	0.00[a]	—	—	—	—	—	—	—	—	—	—	—	—	—
1/22-29	0.15	4.79	4.52	0.51	5.96	<1.10	9.81	2.26	13.12	<0.09	4.85	5.90	23.70	19.70
1/29-2/5	0.24	3.44	1.15	0.49	2.39	<1.10	18.46	2.54	9.78	<0.09	4.70	7.60	27.90	21.50
2/5-12	0.08	3.19	1.40	1.87	1.74	5.54	11.92	3.67	16.86	<0.09	4.84	9.00	30.60	22.50
2/12-19	0.00[a]	—	—	—	—	—	—	—	—	—	—	—	—	—
2/19-26	0.84	8.23	2.55	1.87	4.18	<1.10	12.11	4.51	10.62	<0.09	4.84	6.10	25.30	20.00
2/26-3/5	trace[a]	<0.44	<0.12	<0.08	<0.13	<1.10	<0.40	1.13	<2.00	<0.09	—	—	2.40	5.20
3/5-12	1.92	1.15	0.58	0.20	0.83	8.87	5.77	1.97	14.57	<0.09	4.80	5.60	21.40	20.10
3/12-19	0.76	6.74	1.73	0.79	1.30	7.21	8.65	1.97	18.74	<0.09	4.75	8.20	28.00	29.30
3/19-26	0.26	13.42	3.04	1.30	2.96	<1.10	1.35	3.38	22.28	0.25	4.85	6.90	27.10	29.00
3/26-4/2	0.65	24.05	3.45	0.97	5.13	4.99	12.31	4.51	29.56	<0.09	5.02	8.40	44.50	43.40
4/2-9	trace[a]	2.79	2.14	0.20	2.04	4.99	1.35	2.54	<0.60	<0.09	—	—	4.00	14.80
4/9-16	0.02[a]	61.58	16.12	0.82	8.39	<3.30	38.26	7.33	28.73	<0.30	—	—	68.30	94.00
4/16-23	0.43	47.55	5.02	2.15	4.05	7.21	13.27	5.36	26.44	<0.09	5.10	8.80	43.00	66.30
4/23-30	2.60	8.58	1.56	0.33	1.74	<1.10	5.58	1.97	7.49	<0.09	5.27	3.90	14.20	15.90
4/30-5/7	0.43	8.68	1.73	0.54	1.65	5.54	15.96	1.97	17.07	<0.09	4.65	8.50	32.50	28.60
5/7-14	0.05	59.68	10.28	5.58	11.83	18.29	26.15	14.38	74.53	0.25	4.47	24.30	111.10	107.90
5/14-21	0.34	29.34	6.09	1.38	5.00	14.97	42.11	6.20	36.23	<0.09	4.72	14.70	77.80	71.60
5/21-28	0.35	14.37	3.54	1.61	5.48	20.51	37.30	7.61	37.89	<0.09	4.50	18.50	76.90	79.40
5/28-6/4	0.13	68.96	7.15	5.24	5.26	29.93	42.11	9.59	69.95	<0.09	4.83	18.70	115.00	119.70
6/4-11	0.12	36.03	7.15	3.09	8.13	11.09	26.53	9.87	32.69	<0.09	4.83	10.10	64.90	68.70
6/11-18	0.43	42.51	5.92	2.97	3.13	17.18	36.34	4.23	25.61	<0.09	5.02	9.70	60.40	73.00
6/18-25	0.52	27.45	4.28	2.99	2.83	21.62	30.00	5.08	35.81	<0.09	4.74	12.90	66.10	65.50
6/25-7/2	trace[a]	1.30	0.99	0.28	1.74	<1.10	<0.40	2.26	<2.00	0.47	—	—	3.30	7.70
7/2-9	trace[a]	6.74	1.56	1.02	1.83	<1.10	<0.40	2.26	3.54	<0.09	—	—	6.10	14.50
7/9-16	0.45	8.43	1.56	1.10	1.26	6.65	11.92	3.67	9.58	<0.09	4.23	10.40	23.30	25.50
7/16-23	0.81	42.76	5.51	1.25	6.44	18.85	38.26	7.90	44.97	0.16	4.67	15.00	85.10	83.90
7/23-30	0.46	5.79	2.71	0.33	1.35	7.76	22.30	2.54	25.61	<0.09	4.92	14.60	46.90	45.50
7/30-8/6	0.47	19.61	4.03	3.12	7.18	<1.10	15.96	8.18	13.53	0.73	4.79	6.70	35.80	34.60

[a]Volume of sample was too small for analysis of all or some constituents.

Table G-49. Bandelier National Atmospheric Deposition Program Station Sampling Results-Deposition

Week	Precip (in.)	Deposition (μ Equiv/m^2)[a]								
		Ca	Mg	K	Na	NH_4	NO_3	Cl	SO_4	PO_4
1984										
8/14-21	0.11	56.89	45.23	3.58	55.67	26.61	75.95	27.36	127.62	
8/21-28	1.20	133.23	29.61	6.14	26.53	201.77	607.21	68.53	663.71	
8/28-9/4	0.00									
9/4-11	trace	3.49	1.64	0.26	0.87		1.35	1.97		
9/11-18	0.09	119.76	26.32	12.02	32.62	22.17	93.45	34.97	112.84	0.63
9/18-25	0.10	94.81	29.61	13.30	28.71	46.56	102.48	24.82	140.74	
9/25-10/2	0.49	94.81	32.89	5.88	43.93	111.42	125.56	24.82	211.94	
10/2-9	0.57	47.90	33.72	3.32	47.41	24.39	75.76	24.54	82.03	2.21
10/9-16	1.07	146.71	44.41	14.58	81.77	90.35	271.88	76.71	345.39	
10/16-23	0.93	200.60	58.39	36.57	117.44	91.46	275.73	126.07	288.76	6.00
10/23-30	0.22	37.92	37.83	15.86	56.98	24.39	21.34	37.51	57.88	2.21
10/30-11/6	0.00									
11/6-13	trace	2.99	2.47	0.26	1.30	2.22	0.77	1.69		0.32
11/13-20	0.06	70.36	68.26	11.00	104.39	3.88	49.22	28.77	93.48	
11/20-27	0.28	42.42	26.32	7.93	43.93	47.12	54.80	22.00	118.67	
11/27-12/4	0.12	48.90	18.09	9.97	34.36	19.40	68.26	15.23	90.98	
12/4-11	0.06	25.95	18.91	4.09	23.92	9.42	28.26	11.56	23.11	
12/11-18	1.55	88.32	23.03	102.81	164.41		219.77	100.12	328.11	
12/18-26	0.08	38.92	23.03	20.97	32.19	12.75	48.84	30.74	63.29	0.63
12/26-1/2	0.88	197.60	32.89	21.23	55.24	384.15	214.97	31.59	614.58	
1985										
1/2-5	0.52	39.92	18.09	3.02	22.18		110.75	14.67	160.93	
1/15-22	0.00									
1/22-29	0.15	17.96	17.27	1.79	22.18		36.73	8.46	49.13	
1/29-2/5	0.24	20.46	6.58	2.81	14.35		110.37	15.23	58.50	
2/5-12	0.08	6.49	3.29	3.84	3.48	11.64	24.80	7.61	35.18	
2/12-19	0.00									
2/19-26	0.84	176.15	54.28	39.90	89.17		259.19	96.45	227.14	
2/26-3/5	trace						0.85			
3/5-12	1.92	55.89	27.96	9.97	40.45	431.82	280.92	96.17	709.72	
3/12-19	0.76	129.74	33.72	15.35	25.35	139.14	166.90	38.07	361.42	
3/19-26	0.26	90.32	20.56	8.70	20.01		9.04	22.84	149.69	1.58
3/26-4/2	0.65	349.21	56.74	15.86	83.95	82.04	201.70	73.89	484.67	
4/2-9	trace	2.00	1.64	0.26	1.30	3.88	0.96	1.97		
4/9-16	0.02	24.95	6.58	0.26	3.48		15.57	2.82	11.66	
4/16-23	0.43	551.90	58.39	25.06	46.97	83.70	154.01	62.33	306.87	
4/23-30	2.60	567.86	103.62	21.99	115.26		368.79	130.58	495.91	
4/30-5/7	0.43	95.31	18.91	5.88	18.27	60.42	174.78	21.72	186.95	
5/7-14	0.05	75.35	13.16	6.91	14.79	23.28	32.88	18.05	93.89	0.32
5/14-21	0.34	253.49	52.63	12.02	43.06	129.16	364.17	53.59	313.33	
5/21-28	0.35	127.74	31.25	14.32	48.71	182.37	331.68	67.69	336.85	
5/28-6/4	0.13	233.53	23.85	17.65	17.83	101.44	142.48	32.43	236.71	
6/4-11	0.12	108.78	21.38	9.46	24.36	33.26	80.18	29.90	98.68	
6/11-18	0.43	460.08	64.14	31.97	33.93	185.70	393.02	45.69	276.89	
6/18-25	0.52	363.27	56.74	39.64	37.41	286.03	396.86	67.12	473.63	
6/25-7/2	trace	1.00	0.82	0.26	1.30			1.69		0.32
7/2-9	trace	4.99	0.82	0.77	1.30			1.69	2.71	
7/9-16	0.45	97.31	18.09	12.79	14.35	76.50	137.29	42.30	110.34	
7/16-23	0.81	879.74	113.49	25.83	132.33	387.47	787.19	162.45	924.99	3.16
7/23-30	0.46	68.36	32.07	3.84	15.66	91.46	262.46	29.90	301.46	
7/30-8/6	0.47	235.03	48.52	37.34	86.12		191.32	98.15	162.18	8.84

[a]Blank value indicates that amount of constituent was below analytical limit of detection.

Table G-50. Results of Samples Taken Below the Los Alamos Meson Physics Facility's (TA-53) Lagoons

Analysis	Units	1985 Sampling Month	Sampling Station 1	2	3	4	5	6	7	8
			Sediments							
^{7}Be	pCi/g	July	193 ± 20	2190 ± 220	1690 ± 170	1560 ± 170	102 ± 12	2.7 ± 1.0	0.5 ± 0.8	0.9 ± 0.4
^{7}Be	pCi/g	December	NA	115 ± 12	332 ± 34	359 ± 37	NA	NA	NA	NA
^{57}Co	pCi/g	July	56 ± 5.7	1180 ± 119	666 ± 67	993 ± 100	49 ± 5.0	2.4 ± 0.3	0.3 ± 0.1	0.06 ± 0.02
^{57}Co	pCi/g	December	NA	132 ± 13	444 ± 45	207 ± 21	NA	NA	NA	NA
^{134}Cs	pCi/g	July	160 ± 16	1680 ± 169	715 ± 72	713 ± 72	457 ± 0.7	7.4 ± 0.3	2.6 ± 0.3	0.2 ± 0.1
^{134}Cs	pCi/g	December	NA	244 ± 25	1150 ± 116	1200 ± 121	NA	NA	NA	NA
^{3}H	10^{-4} µCi/mℓ	July	5.1 ± 0.5	4.9 ± 0.5	4.4 ± 0.4	4.0 ± 0.4	0.18 ± 0.02	0.04 ± 0.02	0.001 ± 0.003	0.02 ± 0.01
^{3}H	10^{-4} µCi/mℓ	December	NA	0.18 ± 0.002	0.12 ± 0.001	0.14 ± 0.01	NA	NA	NA	NA
^{54}Mn	pCi/g	July	66 ± 6.7	448 ± 45	338 ± 34	552 ± 56	45 ± 4.5	2.5 ± 0.3	0.51 ± 0.09	0.06 ± 0.03
^{54}Mn	pCi/g	December	NA	165 ± 17	357 ± 36	376 ± 38	NA	NA	NA	NA
^{22}Na	pCi/g	July	7.1 ± 0.8	8.2 ± 0.9	3.5 ± 0.5	4.3 ± 0.6	3.7 ± 0.4	1.4 ± 0.2	0.32 ± 0.08	0.01 ± 0.03
^{22}Na	pCi/g	December	NA	0.92 ± 0.16	1.8 ± 0.3	2.9 ± 0.4	NA	NA	NA	NA
^{83}Rb	pCi/g	July	108 ± 11	322 ± 32	139 ± 14	108 ± 11	1.8 ± 1.0	−0.006 ± 0.120	0.2 ± 0.2	0.06 ± 0.05
^{83}Rb	pCi/g	December	NA	27 ± 3	106 ± 11	99 ± 10	NA	NA	NA	NA
			Water							
^{7}Be	10^{-6} µCi/mℓ	July	20 ± 3	10 ± 1	1.0 ± 0.3	Dry	Dry	Dry	Dry	Dry
^{7}Be	10^{-6} µCi/mℓ	December	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
^{57}Co	10^{-6} µCi/mℓ	July	5.2 ± 0.5	7.0 ± 0.7	0.006 ± 0.02	Dry	Dry	Dry	Dry	Dry
^{57}Co	10^{-6} µCi/mℓ	December	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
^{134}Cs	10^{-6} µCi/mℓ	July	6.6 ± 0.7	2.3 ± 0.2	0.04 ± 0.03	Dry	Dry	Dry	Dry	Dry
^{134}Cs	10^{-6} µCi/mℓ	December	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
^{3}H	10^{-6} µCi/mℓ	July	4.9 ± 0.5	Dry	4.4 ± 0.4	Dry	Dry	Dry	Dry	0.034 ± 0.005
^{3}H	10^{-6} µCi/mℓ	December	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
^{54}Mn	10^{-6} µCi/mℓ	July	5.6 ± 0.6	7.2 ± 0.7	0.09 ± 0.03	Dry	Dry	Dry	Dry	Dry
^{54}Mn	10^{-6} µCi/mℓ	December	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
^{22}Na	10^{-6} µCi/mℓ	July	4.1 ± 0.04	4.8 ± 0.5	−0.001 ± 0.020	Dry	Dry	Dry	Dry	Dry
^{22}Na	10^{-6} µCi/mℓ	December	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
^{83}Rb	10^{-6} µCi/mℓ	July	9.7 ± 1.0	5.5 ± 0.6	0.04 ± 0.05	Dry	Dry	Dry	Dry	Dry
^{83}Rb	10^{-6} µCi/mℓ	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry

[a]No samples taken.

Table G-51. Most Recent Available Data on Environmental Samples from Fenton Hill Geothermal Site

Location[a]	As		B		Cd		F		Li	
	Date	Concentration (μg/g)	Date	Concentration (μg/g)	Date	Concentration (μg/g)	Date	Concentration (μg/g)	Date	Concentration (μg/g)
Roots (Bank)										
100 m[b]	Fall 1982	1.8	Fall 1982	29	Spring 1982	740	Fall 1983	8.1	Fall 1983	4.4
200 m	Fall 1982	1.6	Fall 1982	37	Spring 1982	200	Fall 1983	31	Fall 1983	13
400 m	Fall 1982	1.6	Fall 1982	30	Spring 1982	120	Fall 1983	20	Fall 1983	5.7
1000 m	Fall 1982	0.9	Fall 1982	34	Spring 1982	250	Fall 1983	16	Fall 1983	6.7
Roots (Channel)										
100 m	Fall 1982	8.5	Fall 1982	114	Spring 1982	260	Fall 1983	16	Fall 1983	5.0
200 m	Fall 1982	7.0	Fall 1982	139	Spring 1982	220	Fall 1983	25	Fall 1983	4.0
400 m	Fall 1982	9.3	Fall 1982	130	Spring 1982	270	Fall 1983	22	Fall 1983	10
1000 m	Fall 1982	1.5	Fall 1982	30	Spring 1982	280	Fall 1983	10	Fall 1983	2.1
Lower Canyon	Fall 1982	0.6	Fall 1982	32	Spring 1982	350	Fall 1983	40	Fall 1983	15
Foliage (Bank)										
100 m	Fall 1982	0.02	Fall 1982	11	Spring 1982	28	Fall 1983	0.5	Fall 1983	0.3
200 m	Fall 1982	0.03	Fall 1982	13	Spring 1982	43	Fall 1983	1.9	Fall 1983	0.6
400 m	Fall 1982	0.08	Fall 1982	32	Spring 1982	19	Fall 1983	1.0	Fall 1983	1.3
1000 m	Fall 1982	0.10	Fall 1982	9	Spring 1982	22	Fall 1983	3.0	Fall 1983	0.3
Foliage (Channel)										
100 m	Fall 1982	0.2	Fall 1982	188	Spring 1982	44	Fall 1983	1.2	Fall 1983	17
200 m	Fall 1982	0.2	Fall 1982	434	Spring 1982	31	Fall 1983	3.3	Fall 1983	66
400 m	Fall 1982	0.04	Fall 1982	110	Spring 1982	65	Fall 1983	2.9	Fall 1983	28
1000 m	Fall 1982	0.08	Fall 1982	12	Spring 1982	38	Fall 1983	1.9	Fall 1983	5.1
Lower Canyon	Fall 1982	0.1	Fall 1982	13	Spring 1982	44	Fall 1983	3.4	Fall 1983	8.9
Soil (Bank)										
100 m	Fall 1982	3.1	Fall 1982	14	Spring 1982	80	Fall 1983	98	Fall 1983	15
200 m	Fall 1982	3.1	Fall 1982	23	Spring 1982	160	Fall 1983	71	Fall 1983	30
400 m	Fall 1982	3.9	Fall 1982	17	Spring 1982	80	Fall 1983	100	Fall 1983	18
1000 m	Fall 1982	5.4	Fall 1982	31	Spring 1982	510	Fall 1983	120	Fall 1983	26
Soil (Channel)										
100 m	Fall 1982	12	Fall 1982	49	Spring 1982	210	Fall 1983	135	Fall 1983	28
200 m	Fall 1982	17	Fall 1982	104	Spring 1982	440	Fall 1983	115	Fall 1983	38
400 m	Fall 1982	12	Fall 1982	54	Spring 1982	220	Fall 1983	81	Fall 1983	43
1000 m	Fall 1982	2.9	Fall 1982	18	Spring 1982	210	Fall 1983	100	Fall 1983	30
Lower Canyon	Fall 1982	2.8	Fall 1982	15	Spring 1982	140	Fall 1983	120	Fall 1983	51

[a]One sample per location.
[b]Distance downstream channel from Fenton Hill Geothermal Site.

GLOSSARY

alpha particle	A charged particle (identical to the helium nucleus) composed of two protons and two neutrons that is emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
activation products	In nuclear reactors and some high energy research facilities, neutrons and other subatomic particles that are being generated can produce radioactive species through interaction with materials such as air, construction materials, or impurities in cooling water. These "activation products" are usually distinguished, for reporting purposes, from "fission products."
background radiation	Ionizing radiation from sources other than the Laboratory. It 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; and radiation from medical diagnostic procedures.
beta particle	A 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 or less.
Concentration Guide (CG)	The concentration of a radionuclide in air or water that results in a whole body or organ dose in the 50th year of exposure equal ot the Department of Energy's Radiation Protection Standard for external and internal exposures. This dose is calculated assuming the air is continuously inhaled or the water is the sole source of liquid nourishment for 50 years.
Controlled Area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
cosmic radiation	High energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
curie (Ci)	A special unit of radioactivity. One curie equals 3.70×10^{10} nuclear transformations per second.
dose	A term denoting the quantity of radiation energy absorbed.
dose, absorbed	The energy imparted to matter by ionizing radiation per unit mass of irradiated material. (The unit of absorbed dose is the rad.)

dose, equivalent	A term used in radiation protection that expresses all types of radiation (alpha, beta, and so on) on a commom 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.)
dose, maximum boundary	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 for 100% of the time (full occupancy) and does not take into account shielding (for example, by buildings).
dose, maximum individual	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.
dose, population	The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem (for example, if 1000 people each received a radiation dose of 1 rem, their population dose would be 1000 person-rem.
dose, whole body	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).
exposure	A measure of the ionization produced in air by x or gamma radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
fission products	Those atoms created through the splitting of larger atoms into smaller ones, accompanied by release of energy.
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 (microwaves, visible light, radiowaves, etc.) have 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.

ground water	A subsurface body of water in the zone of saturation.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$), after three half-lives, one-eigth ($1/2 \times 1/2 \times 1/2$), and so on.
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.
Laboratory	Los Alamos National Laboratory.
Maximum Contaminant Level (MCL)	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-III). The MCLs are specified by the Environmental Protection Agency.
mrem	Millirem (10^{-3} rem). See rem definition.
perched water	A ground water body above an impermeable layer that is separated from an underlying main body of ground water by an unsaturated zone.
person-rem	The unit of population dose, it expresses the sum of radiation exposures received by a population. For example, two persons each with a 0.5 rem exposure have received 1 person-rem. Also, 500 people each with an exposure of 0.002 rem have received 1 person-rem.
rad	A special 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.
Radiation Protection Standard	A standard for external and internal exposure to radioactivity as defined in Department of Energy Order 5480.1A, Chapter XI (see Appendix A and Table A-II in this report).
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.

roentgen (R)	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.
terrestrial radiation	Radiation emitted by naturally occurring radionuclides, such as ^{40}K, the natural decay chains ^{235}U, ^{238}U, or ^{232}Th, or from cosmic-ray induced radionuclides in the soil.
thermoluminescent dosimeter (TLD)	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.
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.
tuff	Rock of compacted volcanic ash and dust.
Uncontrolled Area	An area beyond the boundaries of a Controlled Area (see definition of "Controlled Area" in this Glossary).
uranium, depleted	Uranium consisting primarily of ^{238}U and having less than 0.72 wt% ^{235}U. Except in rare cases occurring in nature, depleted uranium is manmade.
uranium, total	The amount of uranium in a sample assuming the uranium has the isotopic content of uranium in nature (99.27 wt% ^{238}U 0.72 wt% ^{235}U, 0.0057 wt% ^{234}U).
Working Level Month (WLM)	A unit of exposure to ^{222}Rn and its decay products. A Working Level (WL) is any combination of the short-lived ^{222}Rn decay products in 1 liter 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 one WL. Cumulative exposure is measured in Working Level Months, which is 170 WL-hours.

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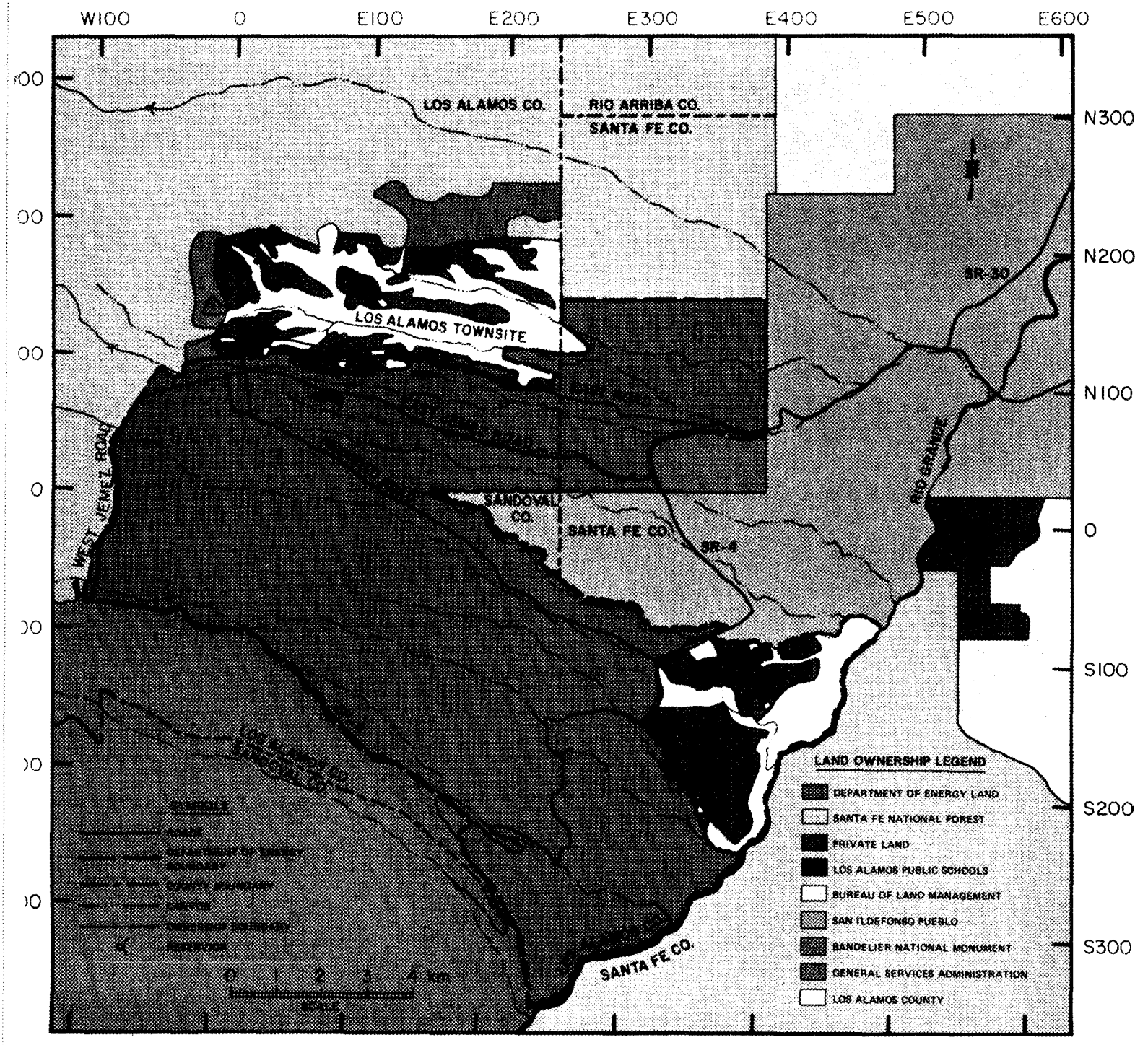

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