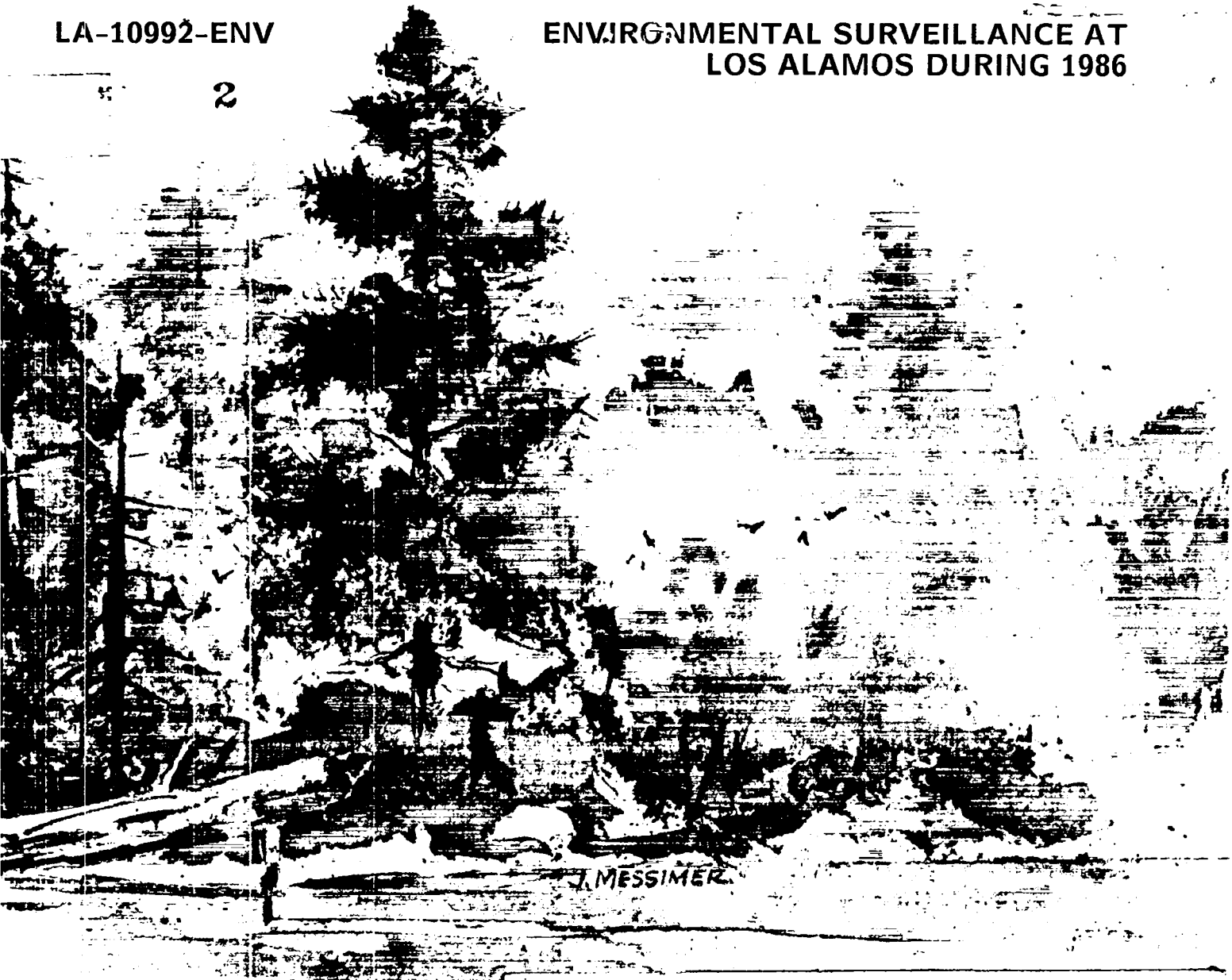
LA-10992-ENV

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1986



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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.

LA-10992-ENV

UC-41
Issued: April 1987

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1986

Environmental Surveillance Group

LOS ALAMOS NATIONAL LABORATORY
3 9338 00098 9367

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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FOREWORD

Suggestions on How to Read this Report

This report addresses both lay people 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. Lay Person 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. Lay Person with Comprehensive Interest. Follow directions for the "Lay Person 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 details are 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. Scientists 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. Scientists 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 details are in the text and appendixes.

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ACKNOWLEDGEMENTS

This report was compiled by the Environmental Surveillance Group (HSE-8) of the Laboratory's Health, Safety, and Environment Division. Personnel in HSE8 include:

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Daniel Talley
Gail Tierney
Michael Trujillo
Donald Van Etten
Robert Vocke
Ralph Ward
James White

Kathy Derouin and Gloria Brito did the word processing and assembly of this report in a very professional manner. Environmental data were provided by the following groups in the Laboratory's Health, Safety, and Environmental Division: Radiation Protection (HSE-1), Industrial Hygiene (HSE-5), Waste Management (HSE-7), Health and Environmental Chemistry (HSE-9), Accelerator Health Protection (HSE-11), and Environmental Sciences (HSE-12).

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ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1986

by

ENVIRONMENTAL SURVEILLANCE GROUP

ABSTRACT

This report describes the environmental surveillance program conducted by Los Alamos National Laboratory during 1986. Routine monitoring for radiation and radioactive or chemical materials 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 potentially undesirable trends. Results and interpretation of data for 1986 cover: external penetrating radiation; quantities of airborne emissions and liquid effluents; concentrations of chemicals and radionuclides in ambient air, surface and ground waters, municipal water supply, soils and sediments, and foodstuffs; and environmental compliance. Comparisons with appropriate standards, regulations, and background levels provide the basis for concluding that environmental effects from Laboratory operations are insignificant and do not impact the public, Laboratory employees, or the environment.

I. EXECUTIVE SUMMARY

A. Monitoring Operations

The Laboratory maintains an ongoing environmental surveillance program as required by US Department of Energy (DOE) Orders 5480.1A ("Environmental Protection, Safety, and Health Protection Programs," August 1981) and 5484.1 ("Environmental Protection, Safety, and Health Protection Information Reporting Requirements," February 1981). The surveillance program maintains routine monitoring for radiation, radioactive materials, and chemical substances on the Laboratory site and in the surrounding region. These activities document compliance with appropriate standards, identify trends, provide information for the public, and contribute to general environmental knowledge. More detailed, supplemental environmental studies are carried out to determine the extent of the potential problems, to provide the basis for any specific remedial actions, and provide further information on surrounding environments. The monitoring program also supports the Laboratory's policy to protect the public, employees, and environment from harm that could be caused by Laboratory activities and to reduce 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 normal 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 25 000 analyses for chemical and radiochemical constituents were carried out for routine and special environmental samples during 1986. Resulting data were used for comparisons with standards and background levels for dose calculations and for interpretation of the relative risks associated with Laboratory operations.

B. Estimated Doses and Risks from Radiation Exposure

1. Radiation Doses. Estimated individual 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's Radiation Protection Standard (RPS). The RPS is

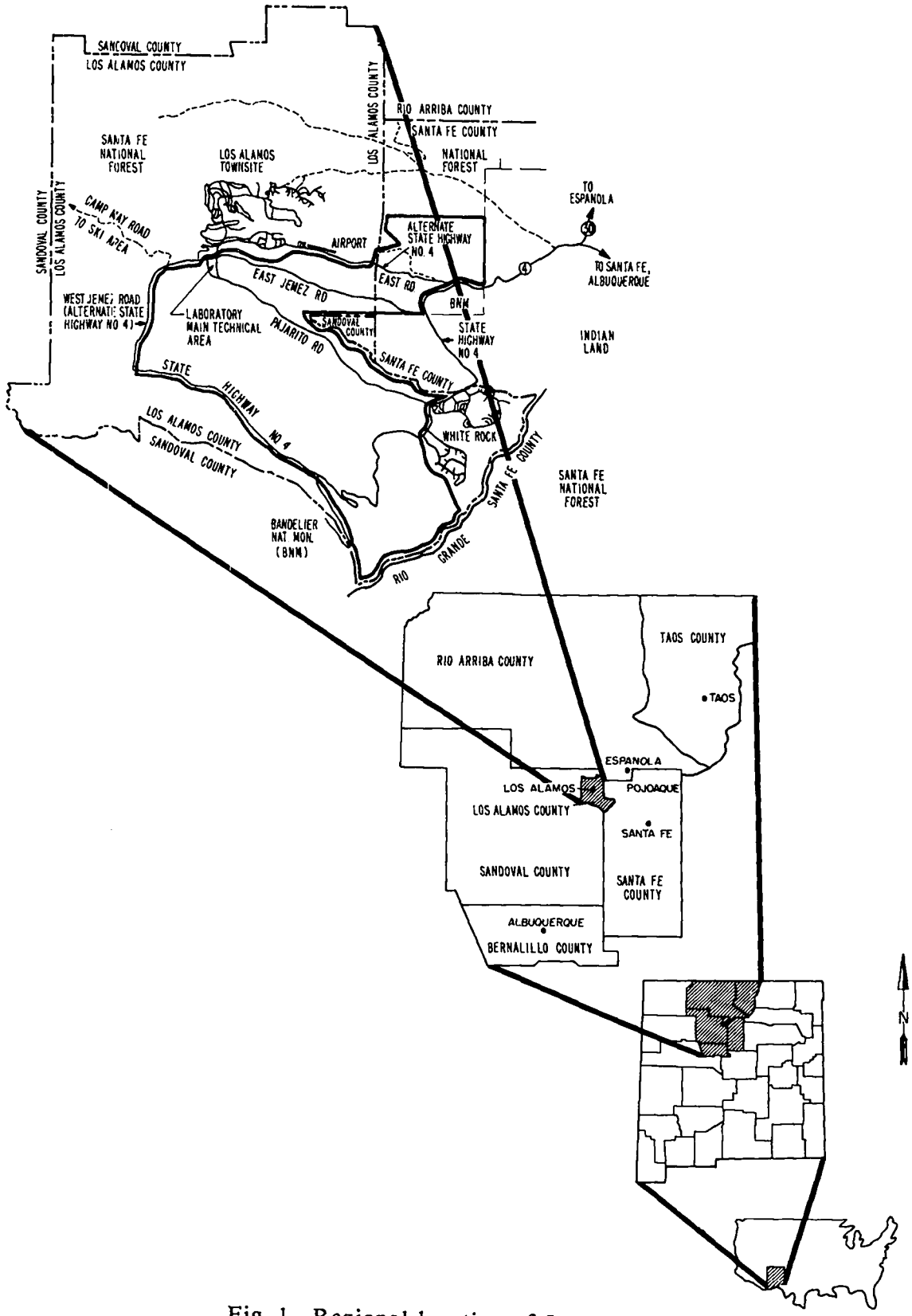

Fig. 1. Regional location of Los Alamos.

Table 1. Number of Sampling Locations

Typing 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.

for doses from exposures excluding contributions from natural background, fallout, and radioactive consumer products. Estimated doses are those believed to be potential 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 to 100 mrem/yr (effective dose) from all exposure pathways. In addition, exposure via the air pathway is further limited to 25 mrem/yr (whole body) in accordance with requirements of the US Environmental Protection Agency (EPA) (Appendix A). In 1986 the estimated maximum individual dose was 11.5 mrem, 46% of the EPA's 25-mrem air emission standard. 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 9% of the 127 mrem from background radioactivity in Los Alamos in 1986.

2. Risk Estimates. Estimates of the added risk of cancer were calculated to provide a perspective for comparing the significance of radiation exposures. Incremental cancer risk to residents of Los Alamos townsite due to 1986 Laboratory operations was estimated to be 1 chance in 77 000 000 (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 (ICRP 1977).

The Laboratory's potential contribution to cancer risk is small when compared with overall cancer risks. The overall lifetime risk in the United States of contracting some from 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

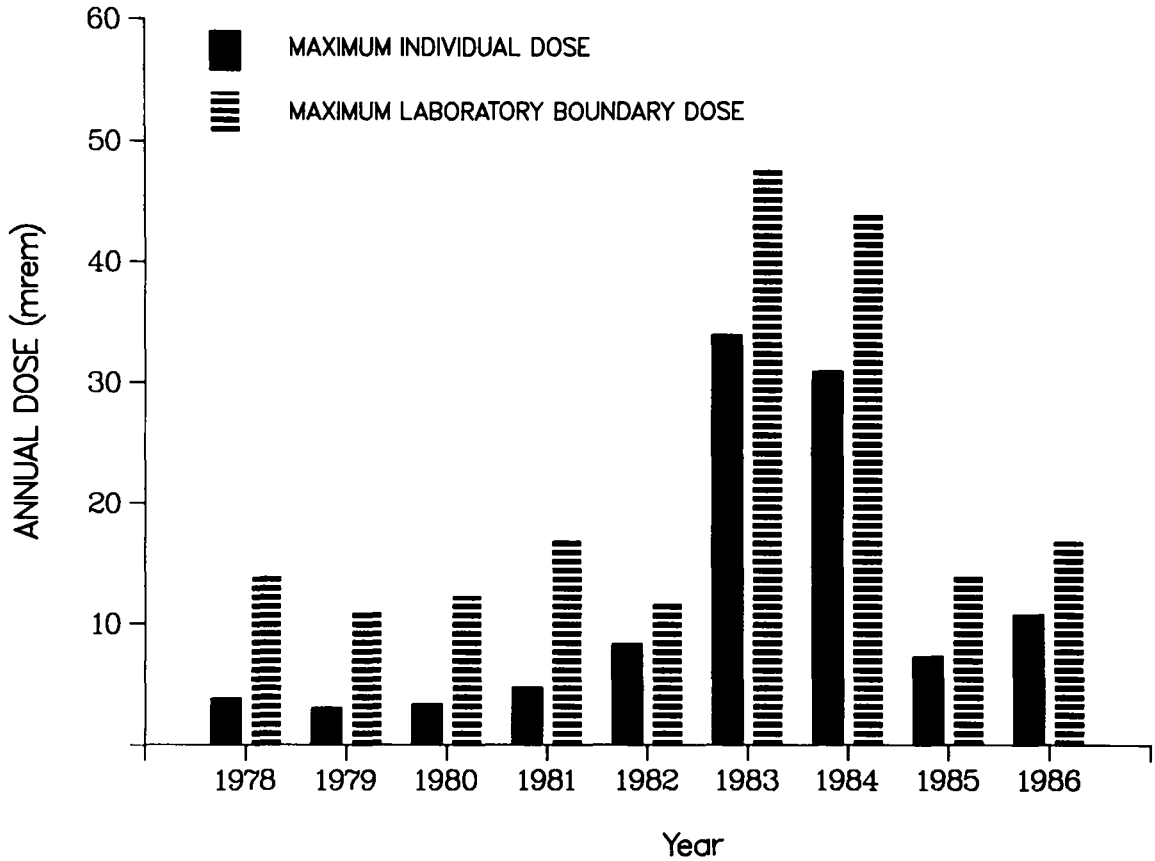

Fig. 2. Summary of estimated maximum individual and maximum Laboratory boundary doses (excluding contributions from cosmic, terrestrial, and medical diagnostic sources) from Laboratory operations.

particle contributions from cosmic, terrestrial, and manmade sources) in the Los Alamos area are monitored with thermoluminescent dosimeters (TLDs) at 147 locations.

The TLD network monitoring radiation from airborne activation products released by the LAMPF measured 18 ± 3 mrem/yr (excludes background radiation from cosmic and terrestrial sources). This measured external radiation level was used to calculate radiation dose by taking into account shielding by buildings and self-shielding by the body. The value measured in 1986 is slightly higher than the measured 11 ± 2 mrem/yr obtained in 1985 (Fig. 2). The increase is probably caused by differences in weather patterns between the two years rather than differences in LAMPF operations, because airborne emissions from LAMPF decreased in 1986 (Table 3).

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. Some measurements at onsite stations were above background levels, as expected, reflecting ongoing research activities at the Laboratory. In addition, three perimeter stations had slightly elevated values during one or more of the three calendar quarters. The reason for these elevated values is not known. *In*

Table 2. Added Individual Lifetime Cancer Mortality Risks Attributable to 1986 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	0.13	1 in 77,000,000
White Rock Area	0.09	1 in 110,000,000
Natural Radiation		
Cosmic, Terrestrial, Self-Irradiation and Radon Exposure[a]		
Los Alamos Townsite	127	1 in 26,000[b]
White Rock Area	117	1 in in 27,000[b]
Medical X-Rays (Diagnostic Procedures)		
Average Whole Body Exposure	92	1 in 110,000

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[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.

situ spectral measurements are planned to try to determine the cause.

D. Air Monitoring

Airborne radioactive emissions were monitored at 87 release points at the Laboratory. In general, airborne radioactive emissions declined from 1985 (Table 3). This was principally due to a slight decrease in releases of air activation products from the LAMPF. Changes in operation resulted in these reduced emissions from LAMPF.

Ambient air is routinely sampled for tritium, uranium, plutonium, americium, and gross beta activity at 26 sampling stations. Measurements of radioactivity in the air are compared with concentration guides based upon the DOE's RPS. These guides are concentrations of radioactivity in air breathed continuously throughout the year that result in effective doses equal to DOE's RPS of 100 mrem/yr for offsite areas (Derived Concentration Guides for Uncontrolled Areas) and to the occupational RPS (see Appendix A) for onsite areas (Concentration Guides for Controlled Areas). Hereafter they are called guides for onsite and offsite areas.

Only the tritium air concentrations showed any measurable impact from radionuclides due to Laboratory operations. Annual average concentrations of tritium remained much less than 0.1% of DOE's guides at all stations and posed no environmental or health problems in 1986. Annual

Table 3. Comparison of 1985 and 1986 Radioactive Releases from the Laboratory

Airborne Emissions

Radionuclide	Units	Activity Released 1985	Activity Released 1986	Ratio 1986:1985
^{3}H	Ci	8 638	10 700	1.2
^{32}P	μCi	53	70	1.3
^{41}Ar	Ci	390	276	0.7
^{131}I	μCi	146	38	0.3
Uranium	μCi	728	847	1.2
Plutonium	μCi	213	207	1.0
Gaseous Mixed Activation Products	Ci	126 079	112 000	0.9
Mixed Fission Products	μCi	1 230	2 570	2.1
Particulate/Vapor Activation Products	Ci	0.2	0.1	0.5
Total	Ci	135 107	122 976	0.9

Liquid Effluents

Radionuclide	Activity Released (mCi) 1985	Activity Released (mCi) 1986	Ratio 1986:1985
^{3}H	76 850.0	89 710.0	1.2
$^{89,90}Sr$	10.3	9.9	1.0
^{137}Cs	<0.1	18.0	---
^{234}U	0.6	2.4	4.1
$^{238,239,240}Pu$	9.7	5.1	0.5
^{241}Am	5.5	3.2	0.6
Other	271.0	1 166.7	4.3
Total	77 147.1	90 915.3	1.2

average concentrations of longer-lived radionuclides in air were also less than 0.1% of the guides during 1986.

On April 26, 1986, an accident occurred at the fourth unit of the Chernobyl Nuclear Power Station in the U.S.S.R. As a result of this accident, large amounts of fission products were ejected into the atmosphere. These fission products were detected by the Laboratory's air monitoring network in the weeks following the accident. However, potential doses received from this accident were locally low, <0.1% of DOE's RPS for the general public.

E. Water, Soil, and Sediment Monitoring

Liquid effluents containing low levels of radioactivity were routinely released from one waste treatment plant and one sanitary sewage lagoon system. Concentrations at all discharge points were well below the DOE's concentration guides for onsite areas. The only major trend has an increase in tritium discharge from the TA-53 lagoons (Table 3). Discharge generally increased at the lagoons due to increased concentrations of radionuclides in the lagoon waters.

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 contained radioactivity in concentrations that are above natural terrestrial and worldwide fallout levels. These concentrations are minute fractions (<0.1%) of DOE's guides for onsite areas. These onsite waters are not a source of industrial, agricultural, or municipal water supplies. The radiochemical quality of water from regional, perimeter, and onsite areas that receive or received no direct discharge showed no significant effects from Laboratory releases.

The potable water supply met all applicable EPA radiochemical and chemical standards. Lack of hydrologic connection to the deep ground water aquifer was confirmed by lack of radioactive or chemical contamination in municipal water supply sources.

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. Onsite areas within Pueblo, Los Alamos, and Mortandad canyons all had concentrations of radioactivty on sediments at levels slightly higher than 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 above-background 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 pre-1964 effluents) and upper Los Alamos Canyon (from 1952 to current treated effluents) have 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 11 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. Leachate extracts (following EPA guidelines) from the surface contamination indicate the presence of no constituents in excess of EPA criteria for hazardous waste determination.

F. Foodstuffs Monitoring

Most fruits, vegetable, fish, bee, and honey samples from regional locations showed no radioactivity distinguishable from that attributable to natural sources or worldwide fallout. Some produce samples from onsite locations had slightly elevated tritium concentrations. These levels were 2% or less of DOE's guides for tritium in water (there are no concentration guides for produce).

G. Unplanned Release

During 1986, there were four unplanned airborne releases of radioactive or hazardous material: three involving tritium and one involving hydrochloric acid (HCl). All releases were small and resulted in radiation doses or air concentrations that were fractions of regulatory guidelines.

1. July 22 Tritium Release at TA-33. On July 22, 1986, approximately 1700 Ci of tritium were released at TA-33. Air samples collected from five air samplers in areas downwind from the release found no detectable increase in tritiated water. The chemical form of the release was elemental hydrogen gas; hence the organ receiving the largest dose was the lung. Calculations from meteorological modeling of the release indicated that the dose to the maximum exposed individual would be less than 0.01 mrem (lung). The calculated maximum dose from this unplanned release is less than 0.01% of EPA's air emission standard of 75 mrem/yr to a member of the public.

2. October 30-31 Tritium Release at TA-33. An estimated 633 Ci of tritium were released at TA-33 over a 23-hour period on October 30-31, 1986. The released material was conservatively assumed to be in the form of tritiated water. The estimated maximum individual dose was 0.05 mrem (whole body). This dose is 0.2% of the EPA's air emission standard of 25 mrem/yr. Samples were collected at five stations of the airborne radioactivity monitoring network and analyzed for tritium. The tritium concentrations were less than 0.5% of DOE's concentration guide for offsite areas.

3. November 14 Tritium Release at TA-33. On November 14, 1986, 11.5 Ci of elemental tritium were released at TA-33. For elemental tritium, the organ receiving the highest dose is the lung. The maximum lung dose to a member of the public was calculated to be less than 0.01 mrem. This dose is less than 0.01% of EPA's air emission standard of 75 mrem/yr (organ dose). Air samples from five environmental monitoring stations all indicated that atmospheric levels of tritiated water were less than 0.5% of the DOE's concentration guide for offsite areas.

4. December 8 HCl Release at TA-3. A cylinder containing a mixture of 5% hydrogen chloride (HCl) and 95% helium developed a leak during the morning of December 8, 1986, at TA-3. The maximum amount of HCl released was estimated to be 600 g. Based on this release amount, maximum air concentrations occurred onsite (outside the building where the cylinder was taken) and were estimated to be 0.06 parts per million (ppm) using an atmospheric dispersion model and the wind conditions during the release. Although there is no environmental exposure

limit for HCl, the maximum concentration is a small percentage of the occupational exposure limit, 5 ppm.

H. Environmental Compliance Activities

1. **Resource Conservation and Recovery Act.** The Resource Conservation and Recovery Act (RCRA) regulates hazardous wastes from generation to ultimate disposal. The EPA has transferred full authority (with the exception of the Hazardous and Solid Waste Amendment of 1984) for administering RCRA to New Mexico's Environmental Improvement Division (EID). In 1986, the Laboratory had numerous interactions with EID and prepared documentation to comply with RCRA requirements. The Laboratory has revised RCRA Parts A and B permit applications, originally submitted in 1985. The latest revisions were submitted November 1986.

2. **Clean Water Act.** Regulations under the Clean Water Act set water quality standards and effluent limitations. The Laboratory's two primary programs to comply with the Clean Water Act are the National Pollutant Discharge Elimination System (NPDES) and the Spill Prevention Control and Countermeasure (SPCC) program.

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 March 1991. The Laboratory was in compliance with the NPDES permit in about 93% and 98% of the samples collected at sanitary and industrial waste discharges, respectively. Chronically noncompliant, sanitary discharge outfalls are being upgraded under an EPA/DOE Federal Facility Compliance Agreement.

Another NPDES permit authorizes liquid effluent discharge from the Fenton Hill Geothermal Project. The permit for a single outfall was issued to regulate the discharge of mineral-laden water from the recycle loop of the geothermal wells.

The SPCC program provides for prevention and cleanup of spills and requires preparation of a SPCC Plan. The laboratory assembled a formal SPCC Plan that will be adopted and implemented in 1987.

3. **National Environmental Policy Act.** The Laboratory Environmental Review Committee reviews environmental documentation required by National Environmental Policy Act legislation as well as identifies other environmental items of concern to the Laboratory. An Environmental Evaluations Coordinator helps prepare required DOE documentation and identify other items requiring committee attention. Documentation usually consists of Action Description Memorandums (brief environmental evaluations) or Environmental Assessments (more detailed evaluations). During 1986, the committee approved 33 Action Description Memorandums, 4 Environmental Assessments, and 2 Environmental Remarks and forwarded this documentation to DOE.

4. **Clean Air Act.** During 1986, 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 state standards are more stringent. Over 70 asbestos removal jobs involved the disposal of 250 m^3 ($1000/ft^3$) of asbestos. Permits were issued by the state for two beryllium machine shops. All beryllium shops met emission performance requirements.

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 quality of the water met EPA's National Interim Primary Drinking Water Standards (40 CFR 141) in 1986.

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's Environmental Evaluation Coordination and Quality Assurance programs provide protection as mandated by law for the hundreds of archaeological and historical resources located on Laboratory land. Pursuant to federal regulations implementing Section 106 of the National Historic Preservation Act of 1966, as amended, clearance for construction where no resource will be affected and mitigation of unavoidable adverse effects from Laboratory activity is determined in consultation with New Mexico's State Historical Preservation Office. Archaeologists performed 32 cultural resource surveys during 1986.

8. Comprehensive Environmental Response, Compensation, and Liability Act. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 mandated clean up of toxic and hazardous contaminants at closed and abandoned hazardous waste sites. The Superfund Amendments and Reauthorization Act (SARA) of 1986, extensively amended CERCLA. Laboratory compliance activities at hazardous waste sites are part of DOE's Albuquerque Operations Office's Comprehensive Environmental Assessment and Response Program (CEARP). The program is evaluating all areas at the Laboratory for possible contamination.

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 PCB wastes at its Chemical Waste Landfill and burn PCB contaminated wastes at its Controlled Air Incinerator (99.9999% combustion efficiency). The Laboratory is in compliance with EPA's permit conditions for authorizing onsite disposal of PCB contaminated wastes.

II. INTRODUCTION TO THE 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 3 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

Fig. 3. Topography of the Los Alamos area.

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 (Fig. 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

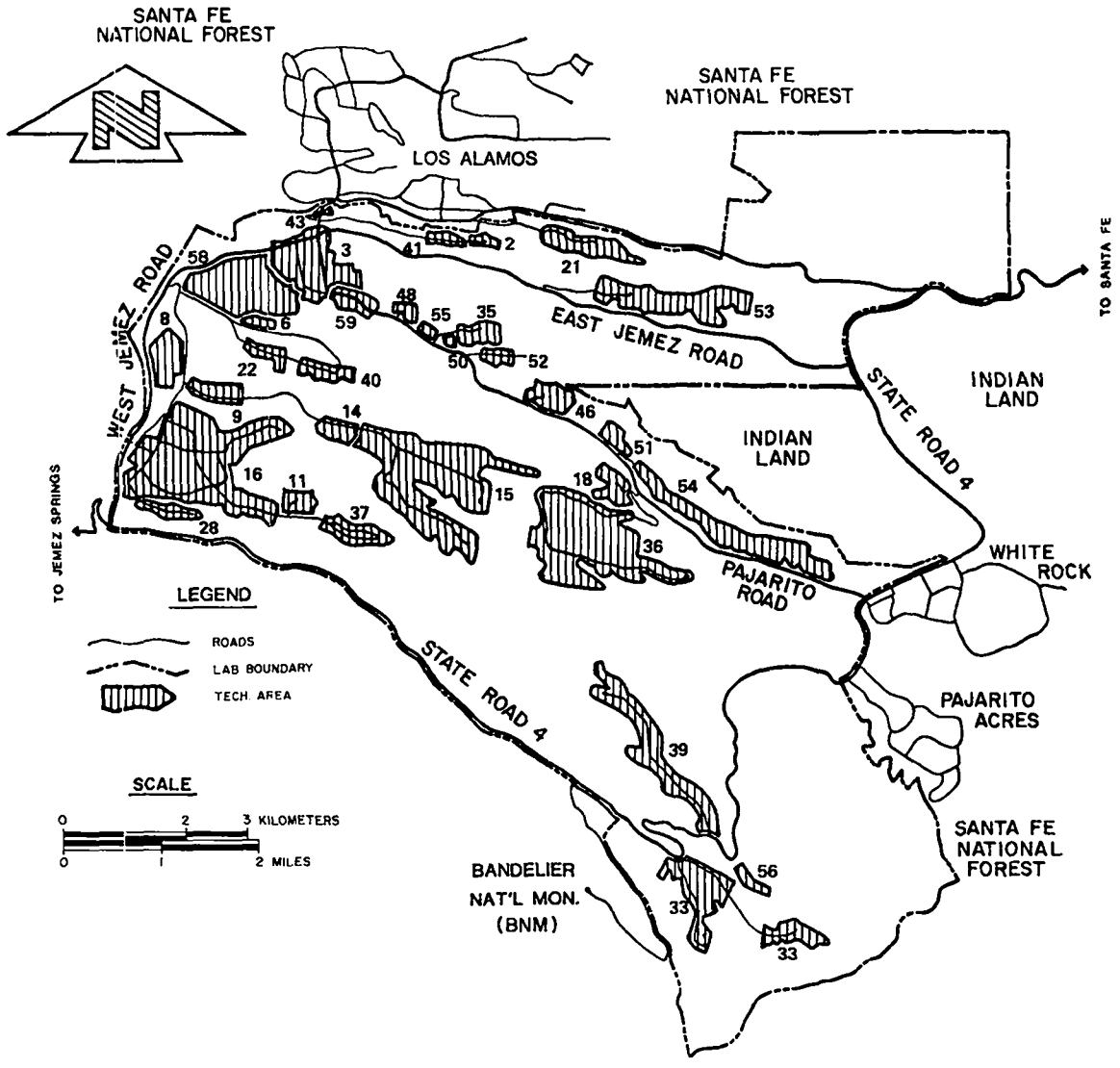

Fig. 4. Technical areas (TAs) of Los Alamos National Laboratory in relation to surrounding landholdings.

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 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 archaeological 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 found in Bandelier Tuff (Fig. 5). Ashfall, ashfall pumice, and rhyolite tuff from 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 m (260 ft) toward the east above the Rio Grande. It is deposited as as 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 overlap 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 sediments of the Tesuque Formation (Fig. 5),

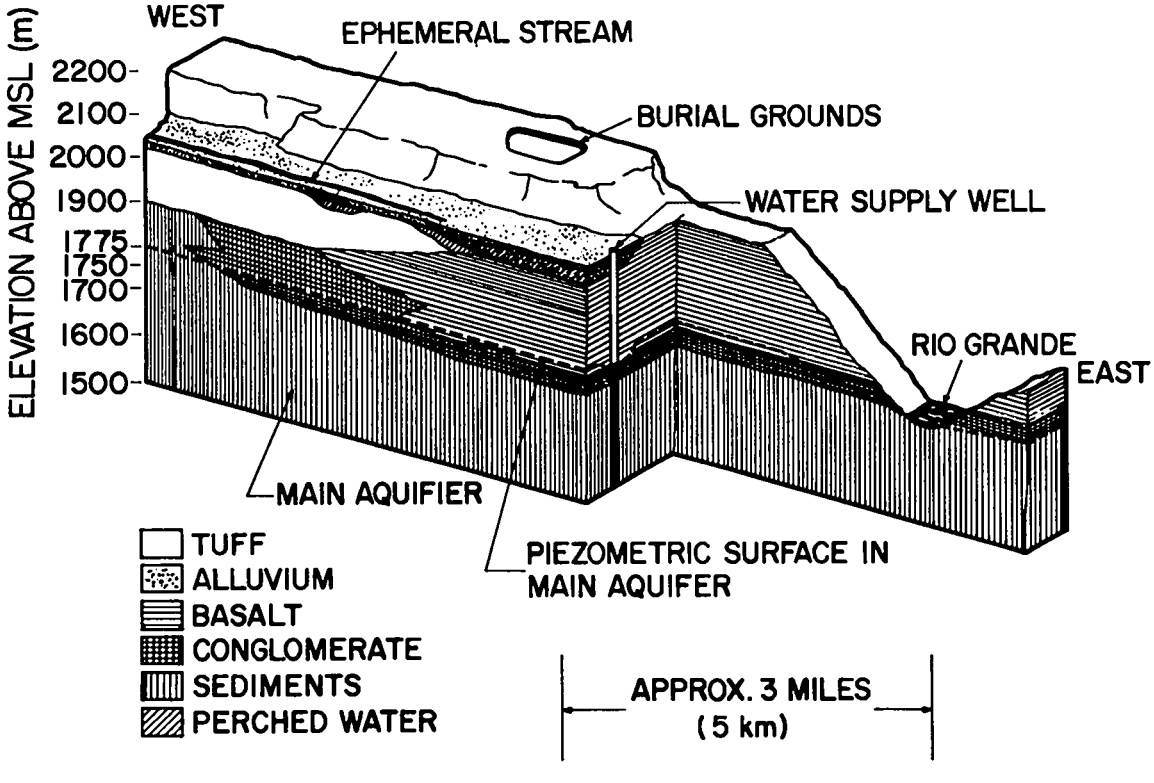

Fig. 5. Conceptual illustration of geologic-hydrologic relationships in Los Alamos area.

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).

Groundwater occurs in three modes in the Los Alamos area: (1) water in shallow alluvium in canyons, (2) perched water (a groundwater body above an impermeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the main aquifer of the Los Alamos area (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 groundwater 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 of 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 and perched waters by about 110 to 190 m (350 to 620 ft) of dry tuff and volcanic sediments. Thus, there is little 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 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 groundwater 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 x 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. However, in 1986, July and August were drier than average, and June, 1986, produced a record rainfall for the month. 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. January-February precipitation in 1986 was about average, whereas October-December precipitation was nearly twice average.

Summers are generally sunny with moderate 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 day. Winter temperatures typically range from about -9 to -4°C (15 to 25°F) during the night and from -11 to 10°C (30 to 50°F) during the day. Occasionally, temperatures drop to near -18°C (0°F) or below. The winter of 1985-1986 was the second warmest on record. During October, 1986, record cold and snow occurred. 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. The year 1986 followed normal patterns in wind.

Historically, no tornadoes have been reported to have touched down in Los Alamos County. However, strong dust devils can produce strong winds up to 35 m/sec (75 mph) at isolated spots in the county, especially at lower elevations. Strong winds with gusts exceeding 30 m/sec (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, whereas 1.3-cm (0.5-in.) diameter hailstones are 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, the potential increases for exposure to higher 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 inversion, restricting atmospheric dispersion. Air flow channeling by terrain features also reduces nighttime dispersion. Poor atmospheric dispersion

conditions frequently exist 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 1986 population of approximately 18 250 (based on the 1980 census adjusted for 1986). 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 11 400. The White Rock area (including the residential areas of White Rock, La Senda, and Pajarito Acres) has about 6780 residents. About one-third of those employed in Los Alamos commute from other counties. Population estimates for 1986 place about 180 000 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 1983, 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 supports 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 people can best live in balance with nature while enjoying the benefits of technology. Park resources are available to individuals and organizations outside of the Laboratory to facilitate self-supported research on these subjects deemed compatible with the Laboratory programmatic mission (DOE 1979).

A Final Environmental Impact Statement (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. 1986 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	---	---	---	---	---	---	1 100	---	356
NNE	---	---	---	548	--	525	1 677.	1 742	214
NE	1	---	---	---	307	14 549	978	1 108	3 758
ENE	---	---	---	1 681	1 515	2 353	2 538	1 151	2 236
E	---	---	72	22	482	992	603	---	1 440
ESE	---	---	---	---	---	253	20 058	1 046	1 448
SE	---	---	6 780	---	---	---	46 370	2 117	7
SSE	---	---	---	---	---	---	369	3 767	82
S	---	---	---	50	---	210	406	4 589	---
SSW	---	---	---	20	---	540	133	5 446	22 136
SW	---	---	---	---	---	---	208	2 748	---
WSW	---	---	---	---	---	208	207	1 682	137
W	---	---	---	---	---	---	---	108	87
WNW	---	1 440	6 556	---	---	---	---	---	2 037
NW	---	525	1 727	---	---	---	---	1 393	---
NNW	---	580	581	---	---	---	---	62	60

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[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 townsite 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 178 118.

III. RADIATION DOSES

Some incremental radiation doses--above those received from natural background, resuspended 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 11.5 mrem or 46% of EPA's air emission standard of 25 mrem/yr. This estimate is based on boundary dose measurements of airborne radiation from the linear particle accelerator at the Los Alamos Meson Physics Facility. Other minor exposure pathways may result in several mrem/yr doses to the public.

No significant exposure pathways are believed to exist for radioactivity released in treated liquid waste discharges. Most released radionuclides are retained in alluvial sediments within Laboratory boundaries. A small faction is transported offsite in stream channel sediments during heavy runoff. Radionuclide concentrations in these sediments, however, are only slightly above natural background levels. Other minor pathways include direct radiation and foodstuffs.

The total population, whole-body does attributable to Laboratory operations received by the population living within 80 km (50 mi) of the Laboratory was conservatively estimated to be 2.3 person-rem during 1986. This is about 0.01% of the 20 000 person-rem dose received by the same population from natural radiation sources and 0.01% of the 16 000 person-rem dose received from diagnostic medical procedures. About 90% of this dose, 2.1 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 background radiation and 0.1% of the 1700 person-rem from diagnostic medical and dental procedures.

In 1986, the same average, added risk to cancer mortality to Los Alamos town site residents was 1 chance in 77 000 000 due to radiation from this year's Laboratory operations; this is much less than 1 chance in 26 000 from background radiation. The EPA has estimated average lifetime risk for overall cancer incidence as 1 chance in 4 and for cancer mortality as 1 chance in 5.

A. Background

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 RPS 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 federal EPA regulations

(40 CFR 61), whole-body doses received via the air pathway alone are limited to 25 mrem/yr and individual organ doses are limited to 75 mrem/yr via this pathway. The principal pathway of exposure at Los Alamos has been via release of radionuclides into the air resulting in external radiation doses to the whole body. 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 treated liquid effluents, food chains, and direct exposure to external penetrating radiation. Exposure to radioactive materials or radiation in the environment was 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 to low for instrumental measurements.

Doses were calculated from measured or derived exposures using models based on the recommendations of the International Commission of 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 the offsite location where the highest dose rate occurs and where there is a person present (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 dose and the maximum individual dose over the past 9 years are summarized in Fig. 2. Over 95% of each of these doses resulted from airborne emissions of activation products from the Los Alamos Meson Physics Facility (LAMPF).

All internal radiation doses (via inhalation or ingestion) are 50-year commitments (Appendix D). This is the total dose received from intake of a radionuclide for 50 years following intake.

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 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

Table 5. Summary of Annual, Whole-Body[a] Doses Due to 1986 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	18 ± 3 mrem	11.5 mrem	0.13 mrem	0.09 mrem	2.3 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	--	46%	0.5%	0.4%	--
Background	127 mrem	127 mrem	127 mrem	117 mrem	20 000 person-rem
% of Background	14%	9%	0.1%	0.08%	0.01%

[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 with no correction for shielding. 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 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.

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 vary each year depending on factors such as snow cover and the solar cycle (see Sec. IV.A). In 1986, estimates were 127 mrem at Los Alamos and 117 mrem at White Rock.

These estimates are based on measured external radiation background levels of 120 mrem (Los Alamos) and 110 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 (60 mrem at Los Alamos and 58 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 (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 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 Work Level Month (WLM)/yr (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 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. Dose to Individuals from External Penetrating Radiation (from Airborne Emissions). The thermoluminescent dosimeter network at the Laboratory boundary north of LAMPF indicated a 18 mrem increment above cosmic and terrestrial background radiation during 1986 (Sec. IV). 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 18 mrem increment translates to an estimated 11.5 mrem whole-body dose to an individual living along State Road 4 north of LAMPF (Table G-1). The 11.5 mrem is 46% of EPA's air emission standard of 25 mrem/yr for a member of the public (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.

A maximum onsite dose to a member of the public from external penetrating radiation from all Laboratory airborne emissions was estimated using a Gaussian dispersion meteorological model (Slade 1968), to be 0.001 mrem (whole body), less than 0.005% of the EPA's 25 mrem air emission 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 town site attributable to Laboratory operations was 0.13 mrem (whole body). The corresponding dose to White Rock residents was 0.09 mrem (whole body). The doses are 0.5% and 0.4%, respectively, of EPA's 25 mrem air emission standard. They were estimated using an air dispersal model, measured stack releases (Table G-2), and 1986 meteorological data. These doses were dominated by external radiation from airborne releases at LAMPF.

3. 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 the EPA air emission standards for whole body doses, 25 mrem/yr, and the limit for a single organ dose, 75 mrem/yr (Appendix A).

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

The inhalation dose that was the highest percentage of the EPA's air emission standard was 0.29 mrem to the bone surface; this is 0.4% of the 75 mrem/yr standard for dose to any organ from the air pathway.

Emissions of air activation products from LAMPF resulted in negligible inhalation exposures.

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.

4. Modeled Doses from Airborne Emissions. For compliance with 40 CFR Part 61, Subpart H, the federal EPA requires that radiation doses be determined with the computer cod AIRDOS-EPA (EPA 1985A). The AIRDOS-EPA code was run with 1986 meteorology data and radioactive missions data given in Table G-2. As expected, over 99% of the maximum individual dose resulted from external exposure to the air activation products from LAMPF. The maximum individual whole-body dose as determined by AIRDOS-EPA was 10.4 mrem corrected to include shielding due to presence in buildings (20% reduction). This dose, which would occur in the area just north of LAMPF, is 41% of the EPA's air emission standard of 25 mrem/yr (whole body). This dose is within the 95% confidence range of the maximum individual dose determined from TLD monitoring of 11.5 mrem/yr, which was estimated for the same location.

The maximum individual organ dose was calculated by AIRDOS-EPA to be 11 mrem to the lung, or 15% of EPA's air emission standard for 75 mrem/yr to any organ. This dose would also occur in the area just north of LAMPF. Of the 11 mrem, approximately 91% is due to external penetrating radiation from LAMPF air emissions, and 9% from other Laboratory emissions.

5. Doses from Direct Penetrating Radiation. No direct penetrating radiation from Laboratory operations was detected by TLD monitoring in offsite areas. The only offsite TLD measurements showing any effect from Laboratory operations were those taken north of LAMPF. These were due to airborne emissions and are discussed above in Section 2. Onsite TLD measurements of external penetrating radiation reflected laboratory operations and do not represent potential exposure to the public except in the vicinity of 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 1986 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 1986, there was less than 1 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 60 mrem. This reflects

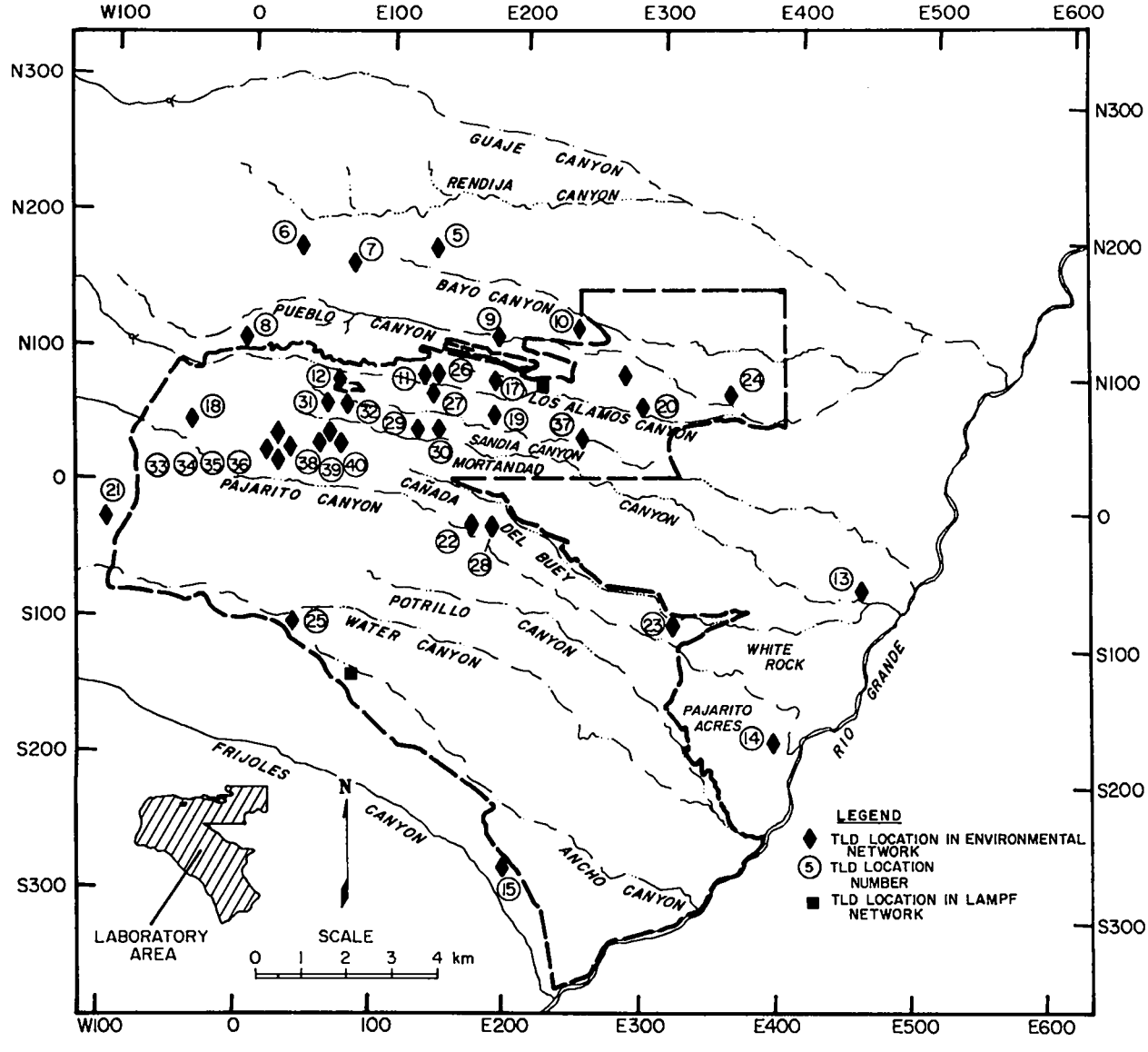

Fig. 6. Thermoluminescent dosimeter (TLD) locations on or near the Laboratory site.

direct radiation from a localized accumulation of ^{137}Cs on sediments transported from treated effluent released from TA-21 prior to 1964 (Gunderson 1983). No one resides near this location.

6. Doses to Individuals from Treated Liquid Effluents. Treated liquid effluents do not flow beyond the Laboratory boundary but are retained in alluvium of the receiving canyons (Sec. VI). These treated 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 with radiological data from Acid, Pueblo, and Los Alamos canyons (ESG 1981) indicate a minor 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 could potentially result in a maximum 50-year dose commitment of 0.0013 mrem to the bone.

7. Doses to Individuals from Ingestion of Foodstuffs. Data from sampling of produce, fish and honey during 1986 (Section VII) were used to estimate doses caused from eating these foodstuffs. All calculated doses are 0.15% or less of the DOE's 100 mrem/yr standard (Appendix A).

Fruit and vegetable samples were analyzed for six radionuclides (^{3}H, ^{90}Sr, total uranium, ^{238}Pu, and $^{239,240}Pu$). Maximum committed 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 0.03 mrem and a 50-year dose equivalent to bone surface of 0.1 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, because of the low radionuclide concentrations, and the limited access to these foodstuffs.

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. The ^{90}Sr levels were distinguishable from background and are believed to be a result of worldwide fallout. Strontium concentrations vary from year to year; in 1986, ^{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 0.03 mrem, which is 0.03% of DOE's 100 mrem standard (DOE 1985A). Maximum organ dose is 0.14 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 0.15 mrem, which is 0.15% of DOE's 100 mrem standard

8. Whole-Body Population Doses. The 1986 population whole-body dose attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory is calculated to be 2.3 person-rem. This dose is 0.01% of the 20 000 person-rem exposure from natural background radiation (whole body) and 0.01% of the 16 000 person-rem exposure from medical radiation (Table 6).

Table 6. Estimated Whole-Body, Population Doses During 1986

Exposure Mechanism	Los Alamos County (person-rem) (18 300 persons)	80-km Region (person-rem[a]) (178 000 persons)
Airborne Tritium	0.03	0.03
Airborne ^{11}C, ^{13}N, ^{15}O, ^{41}Ar	2.06	2.31
Total Due to Laboratory Releases	2.09	2.34
Total Due to Natural Sources of Radiation[b]	2300	20 000
Average Due to Airline Travel [~0.22 mrem/h at 9 km (NCRP 1975B)]	27	--[c]
Diagnostic Medical Exposure [~92 mrem/yr per person (NRC 1980)]	1700	16000

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[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 structuures, 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.

The population dose from Laboratory operations was calculated from measured radionuclide emission rates (Table G-2), atmospheric model using measured meteorological data for 1986, and population data based on the 1980 Bureau of Census count adjusted to 1986 (Table 4 and Appendix D).

The population 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 means annual dose of 92 mrem per capita. The population distribution in Table 4 was used in both these calculations to obtain the total population dose.

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

Population centers outside of Los Alamos County are farther away, so dispersion, dilution, and decaying transit (particularly for ^{11}C, ^{13}N, ^{14}O, ^{15}O, and ^{41}Ar) reduce their contribution to dose to less than 10% of the total. The population dose to residents outside of Los Alamos County and within 80 km (50 mi) of the Laboratory is 0.001% 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 Risk. 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 radiation, and have such a high probability of overestimating the actual risk as to be of only marginal value, if any, for purposes of realistic risk-benefit evaluation."

Low-LET radiation, which includes gamma rays, is the principal type of environmental radiation resulting from Laboratory operations. Estimated doses from high-LET radiation, such as neutron or alpha particle radiation, are less than 3% of estimated low-LET radiation doses. Consequently, risk estimates in this report may overestimate the true risks.

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 1986, persons living in Los Alamos and White Rock received an average of 127 and 117 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 1986 was 1 chance in 79 000 in Los Alamos and 1 chance in 86 000 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 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 1 Working Level Month (WLM) exposure over a year would give an age-average 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 WML (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 radiations 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 1986 Laboratory activities were 0.13 mrem and 0.09 mrem, respectively. These doses are estimated to add lifetime risks of about 1 chance in 77 000 000 in Los Alamos and 1 chance in 110 000 000 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 of cancer (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 0.35 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 homes. The EPA has estimated the annual whole body dose to individuals from global fallout to be 4.4 mrem Klement 1972).

IV. MEASUREMENT OF EXTERNAL PENETRATING RADIATION

Levels of external penetrating radiation--excluding X and gamma rays and charged particle contributions from cosmic terrestrial, and manmade sources--are monitored in the Los Alamos area with thermoluminescent dosimeters. No measurement for regional locations showed any statistically discernible increase in radiation levels for 1986. 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 18 ± 3 mrem in 1986. This is an increase from the 1985 measurement of 11 ± 2 mrem. Some onsite measurements were above background levels, as expected, reflecting research activities and waste management operations at the Laboratory.

A. Background

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 decay 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 mixture and snow cover (NCRP 1975B). There are also fluctuations because of different soil and rock types in the area (ESG 1978).

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 Espanola to 2.7 km 91.7 mi) at Fenton Hill, resulting in a corresponding range between 45 and 90 mrem/yr for the cosmic component. Also, the 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. Therefore, in order to measure contributions to external radiation due to operation of the Los Alamos Meson Physics Facility (LAMPF), arrays of 48 thermoluminescent dosimeters (TLDs) each have been deployed near LAMPF and in background areas.

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 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 Espanola, Pojoaque, and Santa Fe, along with the Fenton Hill Site 30 km west of Los Alamos. The offsite perimeter group consists off 12 stations within 4 km of the boundary. Within the Laboratory boundary, 24 locations 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 1985 and 1986 (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 for medical diagnostic procedures (NRC 1980). The DOE's RPS is 100 mrem/yr, effective dose received from all pathways, and the dose received via air is restricted in EPA's standard of 25 mrem/yr (whole body) (Appendix A). These values are in addition to normal background, consumer products, and medical sources. The standard applies to locations of maximum probable exposure to an individual in an offsite, uncontrolled area.

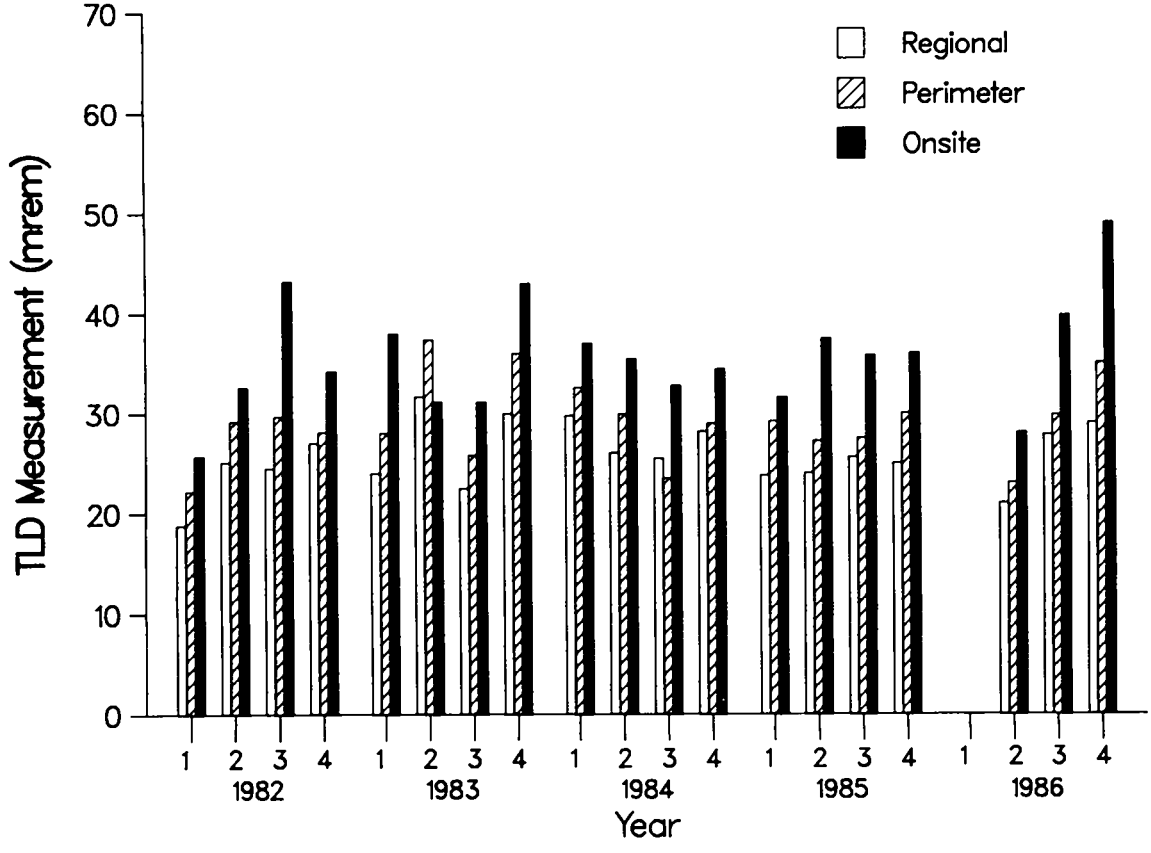

Fig. 7. Thermoluminescent dosimeter (TLD) measurements (includes contributions from cosmic, terrestrial, and Laboratory radiation sources).

At the end of the first calendar quarter the results from the Waste Areas and Environmental TLD Networks for that quarter were rendered unusable because of mishandling of the dosimeters. The loss of the first calendar quarter of data makes it necessary to estimate the total dose for the calendar year for these two networks using data from the other three quarters. Based on one regional station for which data exist for all four quarters, the estimate yields 106 mrem/yr instead of the measured 104 mrem/yr. The difference is less than the uncertainty of the measurement. For one onsite station on Frijoles Mesa, the first quarter measurement from the LAMPF Network can be used as a check of the estimate, since the LAMPF background array is physically close to he Frijoles Mesa onsite station of the Environmental Network. Substituting that value for the missing first quarter yields 118 mrem/yr instead of the estimated 116 mrem/yr. Again, the difference is less than the uncertainty of the measurement. For regional and perimeter stations in the Environmental Network the estimates based on the last three calendar quarters are probably valid, as they are for the inactive waste management areas of the Waste Areas Network. However, for the active waste management site (Area G) and for onsite stations near research facilities where programmatic activities during the first calendar quarter may have resulted in radiation levels higher or lower than in the other three quarters, the estimates could be in error by several millirem for the year.

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

This network monitors external radiation from airborne activation products (gases, particles, and vapors) released by LAMPF, TA-53. The prevailing winds are from the south and southwest (Sec. 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 TLDs at the 24 sites are changed each calendar quarter or sooner, if LAMPF's operating schedule dictates (start-up or shutdown of the accelerator for extended periods midway in a calendar quarter). The radiation measurement (above background) for this network was 18 $\pm$ 3 mrem for 1986. 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). This year's measurement is about 1.6 times the value measured in 1985 (Fig. 2). The increase is probably caused by differences in weather patterns for the two years rather than from increased releases from LAMPF, because airborne activation products decreased by a factor of 0.9 between 1985 and 1986 (Table 3).

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. Active and inactive waste areas are monitored for external penetrating radiation with arrays of TLDs (Table 7). Averages at all sites but Area X were higher than average perimeter values. However, the ranges at most sites were similar to

the range of values found at perimeter and regional stations. The extremes at Area G, the active radioactive waste area, and Area T, an inactive waste area, have been noted in previous years.

Table 7. Doses (mrem) Measured by TLDs at Onsite Waste Areas During 1986

Area	Number of TLDs	Mean	Minimum	Maximum
A	5	129	121	147
B	14	128	117	141
C	10	128	116	140
E	4	129	123	131
F	4	126	118	135
G	27	160	131	227
T	7	173	131	304
U	4	128	123	132
V	4	130	121	134
W	3	124	107	133
X	1	112	---	---

V. AIR MONITORING

Airborne radioactive emissions were monitored at 87 stacks within the Laboratory. The largest airborne release was 112 000 Ci of short-lived (2 to 20 min half-lives) air activation products from the Los Alamos Meson Physics Facility (LAMPF). Ambient air is routinely sampled at several locations onsite, along the Laboratory perimeter, and in distant areas that serve as regional background stations. Ambient air concentrations of tritium, uranium, plutonium, americium, and gross beta are measured. The highest measured and annual average concentrations of these radionuclides were less than 0.1% of concentrations that exceed DOE's guides. The accident at Chernobyl-4 in the U.S.S.R. on April 26, 1986, caused a slight increase in atmospheric concentrations of fission products in ambient air.

A. Radionuclides in Ambient Air

1. Background. The ambient-air sampling network for radionuclides consists of 26 continuously operating air sampling stations (see Appendix B). Regional monitoring stations, 28 to 44 km (18 to 28 mi) from the Laboratory, are located at Espanola, Pojoaque, and Santa Fe. The results from these stations are used as reference points for determining regional background levels of airborne radionuclides. The 11 perimeter stations are within 4 km (2.5 mi) of the Laboratory boundary; 12 onsite stations are within the Laboratory boundary (Fig. 8, Table G-4). One onsite station was moved from TA-39 to TA-2 after the first quarter of 1986 in order to more effectively monitor radionuclides in ambient air.

Natural and resuspended radionuclide concentrations in ambient air vary and affect measurements made with the Laboratory's air sampling program. Worldwide background airborne radionuclides are largely composed of resuspended fallout from past atmospheric nuclear weapons tests, natural constituents from the decay chains of thorium and uranium, 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 ambient air are summarized in Table G-5 and are useful in interpreting the air sampling data.

Particulate matter in the atmosphere is primarily caused by the resuspension of soil, which is dependent upon the current meteorological conditions. Windy, dry days can increase the soil resuspension, whereas precipitation (rain or snow) can wash out particulate matter in the atmosphere. Consequently, there are often large daily and seasonal fluctuations in airborne radioactivity concentrations caused by changing weather conditions.

2. Airborne Emissions. The Laboratory monitors radioactive airborne emissions that are discharged from 87 stacks onsite. These

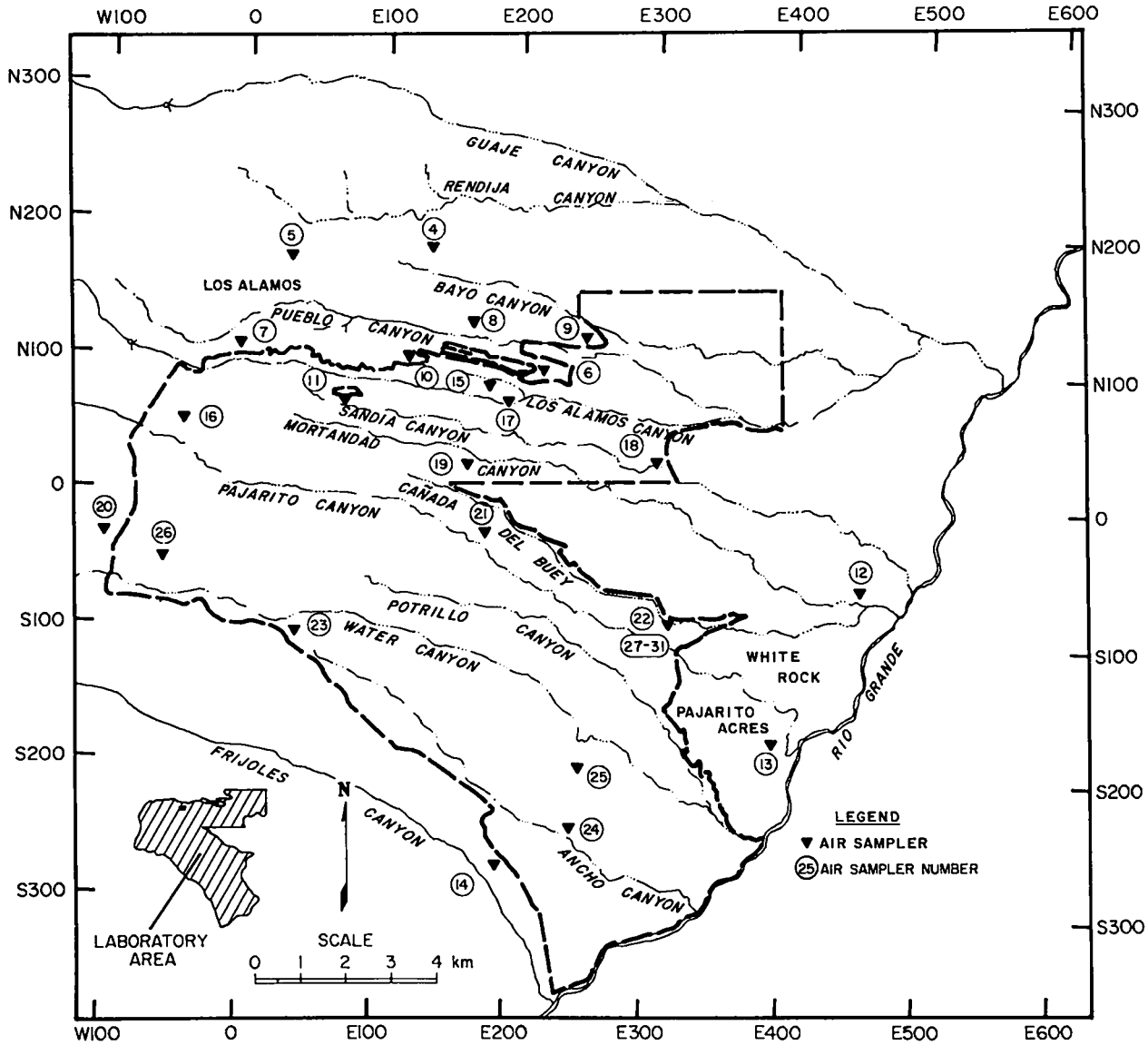

Fig. 8. Air sampler locations on and near the Laboratory site.

emissions consist primarily of treated exhausts from gloveboxes, experimental facilities, operational facilities (such as liquid waste treatment plants), a nuclear research reactor, and a linear particle accelerator at the Los Alamos Meson Physics Facility (LAMPF). The emissions receive appropriate treatment prior to discharge, such as filtration for particulates, catalytic conversion and adsorption for activation gases. Quantities of airborne radioactivity released depend on the kind of research activities and can vary markedly from year to year (Figs. 9-11).

During 1986, the most significant releases were from LAMPF (Table G-2). The amount released for the entire year was 112 000 Ci

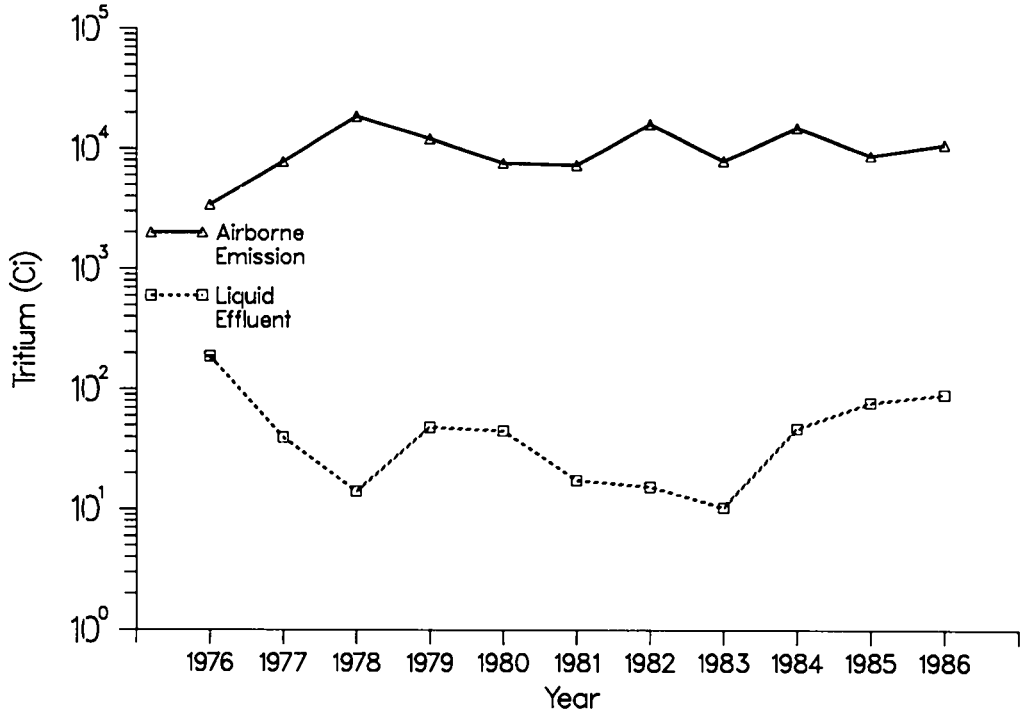

Fig. 9. Summary of tritium releases (airborne emissions and liquid effluents).

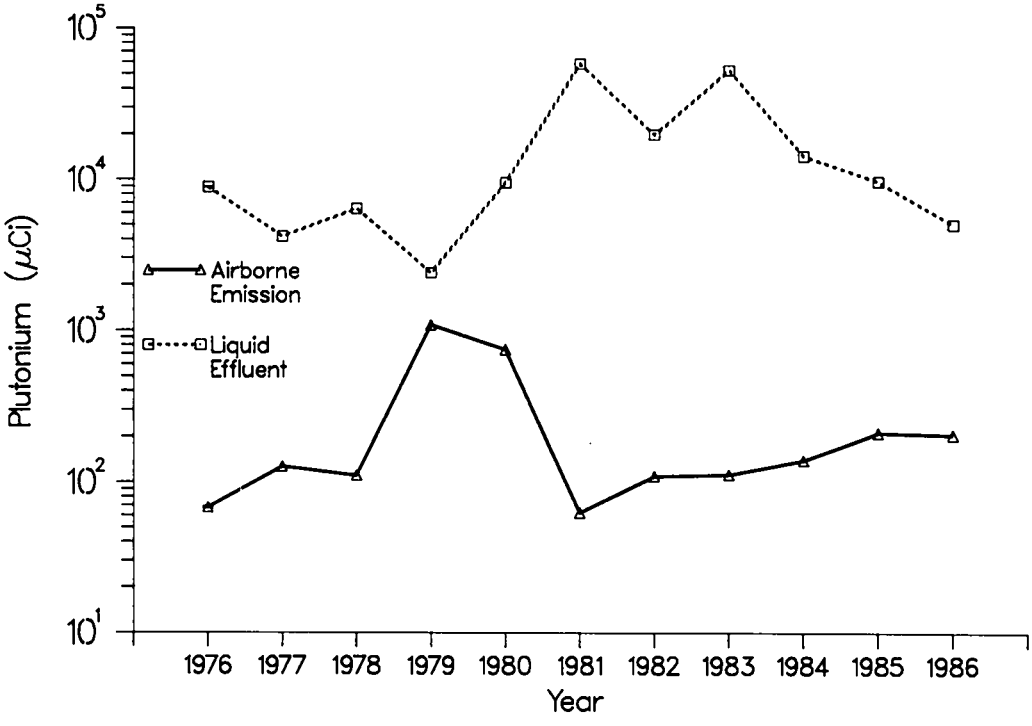

Fig. 10. Summary of plutonium releases (airborne emissions and liquid effluents).

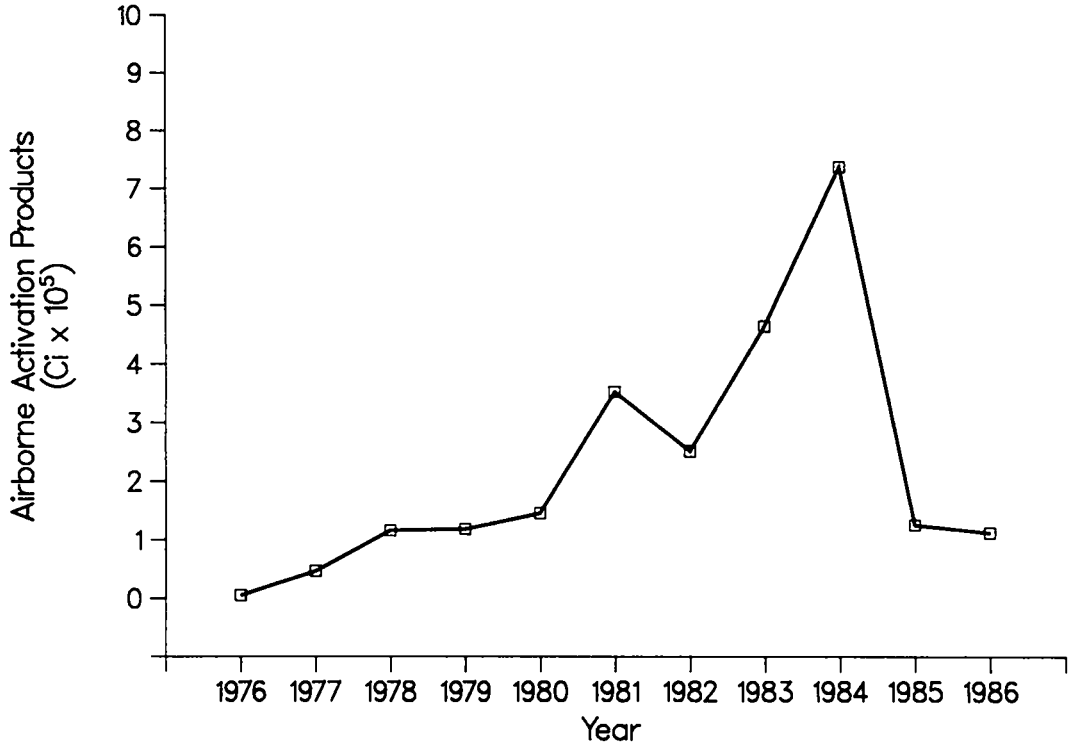

Fig. 11. Airborne activation product emissions (^{11}C, ^{13}N, ^{14}Ar, ^{192}Au, ^{195}Hg) from the Los Alamos Meson Physics Facility (TA-53).

of air activation products (gases, particulates, and vapors). The principal airborne activation products (half-lives in parentheses) were ^{11}C (20 min), ^{13}N (10 min), ^{14}O (71 sec), ^{15}O (123 sec), ^{41}Ar (1.83), ^{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 minutes. Therefore, the radioactivity from LAMPF emissions declines very rapidly.

Airborne tritium emissions increased from 8638 Ci in 1985 to 10 700 Ci in 1986 (Table 3). This was principally due to increases in tritium releases at TA-33 and TA-55.

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 188 kg (414 lb) of depleted uranium were used in such experiments in 1986 (Table G-6). This mass contains about 0.09 Ci of radioactivity principally from ^{238}U and ^{234}U. Most of the debris from these experiments is deposited on the ground in the vicinity of the firing sites. Limited experimental data indicate 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 the natural abundance of uranium resuspended in dust particles originating from the earth's crust.

3. Chernobyl Fallout Monitoring. On April 26, 1986, at the Chernobyl Nuclear Power Station in the U.S.S.R., the fourth unit had a rapid power excursion. This led to an

expansion of the fission products in the fuel and cladding, which burst the fuel. Subsequent interactions with the coolant resulted in a steam explosion, which was followed by a hydrogen explosion. The estimated amount of fission products released ranged from 2 to 6% of the core inventory.

Supplemental air sampling was initiated April 28 through June 2, 1986. Daily samples were taken at the Occupational Health Laboratory (OH-1) during this period and analyzed for alpha and beta activity. These samples were counted after only a 5-hour delay. Due to this short delay period, the gross-beta concentrations increased sharply compared with earlier and later results in the year. This artifact results from counting of short-lived radon and thoron daughter products (Fig. 12). Starting on April 30, 1986, all samples were analyzed for radioiodine (^{131}I) (Fig. 13).

The ratio of gross alpha and beta concentrations was evaluated during this supplemental air sampling period. Prior to the arrival of the Chernobyl fission products, the ratio was less than 2. On May 11, 1986, the ratio increased above 2 and the maximum ratio occurred on May 12, 1986. For the rest of May, the ratio stayed above 2.

Radioiodine appeared on May 8, 1986 with the peak concentration occurring on May 11, 1986. The maximum concentration was 0.2 pCi/m^3, 0.05% of DOE's concentration guide (400 pCi/m^3 for offsite areas). By the end of May the ^{131}I concentrations were nearly back to normal levels.

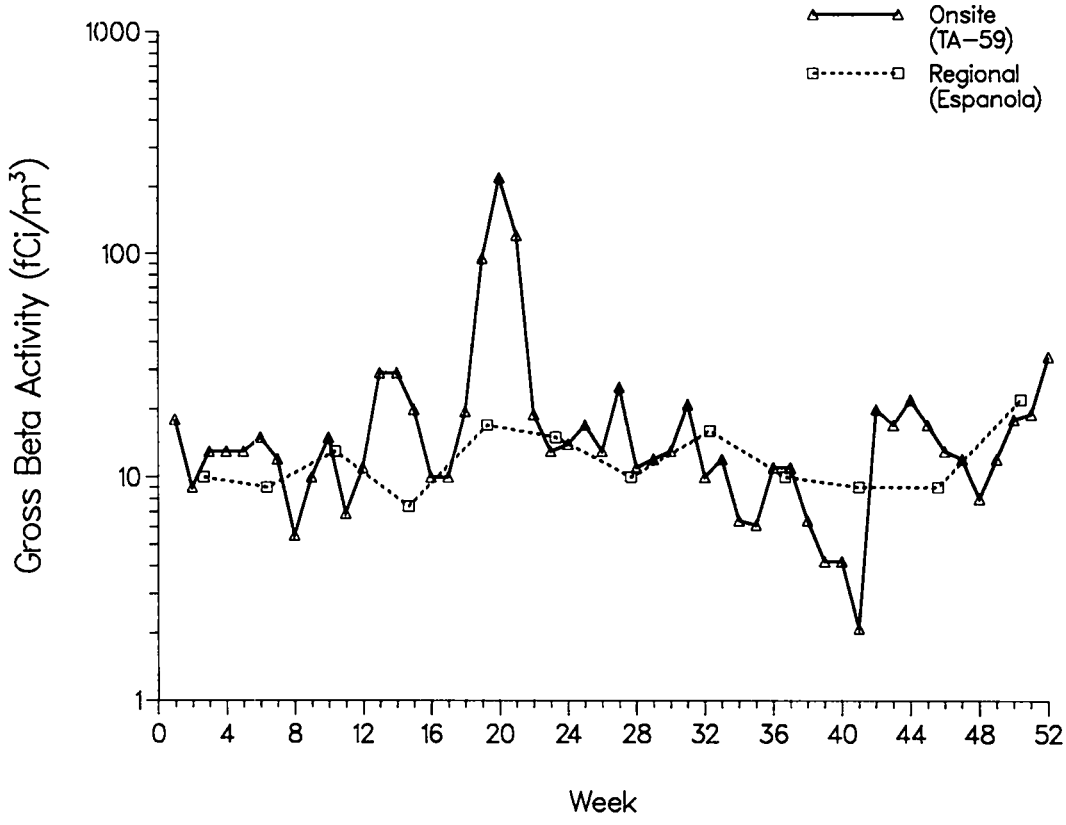

Fig. 12. Atmospheric gross beta activity at a regional (background) station and an onsite station during 1986.

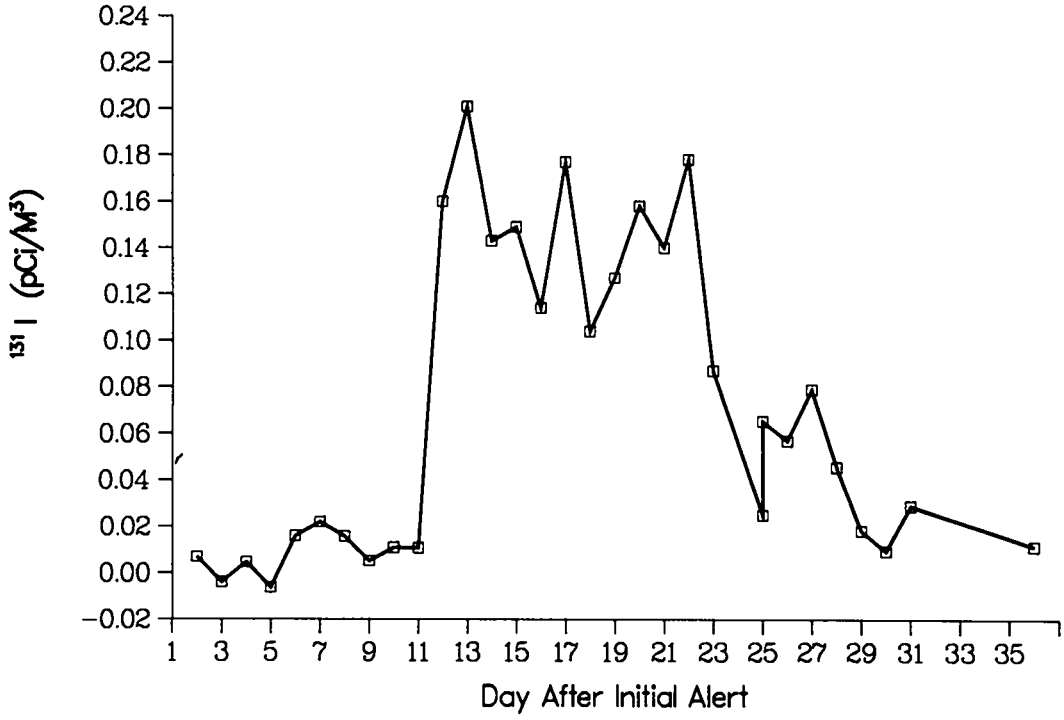

Fig. 13. Iodine-131 in ambient air at TA-59.

4. Gross Beta Radioactivity. Gross beta analyses help in evaluating general radiological air quality. Figure 12 shows gross beta concentrations at a regional sampling location (Espanola, Station 1) about 30 km (20 mi) from the Laboratory and at an onsite sampling location (TA-59, OH-1). The apparent increase in gross beta activity for weeks 16-19 is an artifact reflecting the change from weekly to daily sampling in response to the Soviet Reactor accident at Chernobyl as discussed above. Thus, the results for this period of time are not comparable with results from the rest of the year.

5. Tritium. In 1986, the onsite annual mean (12.5 x 10^{-12} μCi/mL was slightly, but significantly ($p<0.05$), higher than the regional (5.0 x 10^{-12} μCi/mL) and perimeter (6.5 x 10^{-12} μCi/mL) means. There was no statistical difference between the regional and perimeter annual means (Table G-7). This reflects the minor impact of Laboratory operations in offsite areas. The TA-54 (Station 22) and TA-33 (Station 24) annual means of 27.8 x 10^{-12} and 31.3 x 10^{-12} μCi/mL, respectively, were the two highest annual means measured in 1986. Both of these stations are located within the Laboratory boundary near areas of tritium disposal or of operational use. These tritium concentrations are <0.01% of DOE's concentration guide for tritium in air in onsite areas (Appendix A).

6. Plutonium and Americium. Of the 103 samples analyzed for ^{238}Pu in air during 1986, five were above the minimum detectable limit of 2.0 x 10^{-18} μCi/mL. All five samples were collected onsite. The highest concentration occurred at TA-54 (70.1 ± 4.8 x 10^{-18} μCi/mL) and represents 0.004% of the

DOE's concentration guide for ^{238}Pu in offsite areas, 2 x 10^{-12} μCi/mL (Appendix A). The results of the ^{238}Pu analyses are not tabulated in this report because of the large number of results below the minimum detectable activity.

The 1986 annual means for $^{239,240}Pu$ concentrations in air for the regional (1.5 x 10^{-18} μCi/mL), perimeter (1.7 x 10^{-18} μCi/mL), and onsite (2.8 x 10^{-18} μCi/mL) stations were <0.01% of the concentration guides for onsite or offsite areas (Appendix A). Measured concentrations of ^{241}Am were all 0.1% of the concentration guides. The detailed results are in Tables G-8 and G-9.

7. **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 1986 annual mean of the regional stations (60 pg/m^3) was statistically greater ($p<0.05$) than the perimeter (26 pg/m^3) and onsite (26 pg/m^3) stations (G-10). All measured annual means were <0.1% of the concentration guides for uranium in onsite and offsite areas (Appendix A).

B. Nonradioactive Chemicals in Ambient Air

1. Air Quality

a. Bandelier Air Quality Monitoring Station. 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 air quality measurements for the first two quarters of 1986 are summarized in Table 8. During these two

Table 8. Ambient Air Quality Measurements[a]

	TSP (24-h avg)	SO_2 (1-h avg)	O_3 (1-h avg)
First Quarter 1986			
Mean	14	b	36
Range	6.3-32	b	9.1-58
% Data Capture	100	96	95
Second Quarter 1986			
Mean	18	b	43
Range	6.2-39	b	20.8-76
% Data Capture	100	96	96

[a]All concentration measurement are expressed in ppb except for TSP measurements, which are in micrograms per cubic meter.
[b]Below minimum detectable limits.

quarters, between 95.3 and 100.0% data capture was achieved for total suspended particulates (TSP), sulfur dioxide, and ozone. The station has had four independent audits, and it met the stringent EPA quality assurance (QA) requirements for Prevention of Significant Deterioration air quality monitoring.

Except for ozone, the measurements were well below the state and federal Ambient Air Quality Standards. The New Mexico standard for ozone of 60 ppb, hourly average, was exceeded during 1986. The cause of the exceedance is most likely due to distant urban sources rather than to sources within Los Alamos County. The county is not a major source of precursor pollutants, which through chemical transformations produce high ozone levels.

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

c. Particulate Air Quality Measurements. Measurements of 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 New Mexico's Environmental Improvement Division (NMEID). 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 state and federal ambient air quality standards were met in both Los Alamos and White Rock (Table 9). The seasonally averaged TSP concentrations were slightly higher in the spring (Table 10), which is the windiest season of the year. For the first two quarters (winter and spring seasons), the seasonal averages were lower at the Bandelier air quality monitoring site than at the two state monitoring sites. This is likely due to the lack of dust generating activities (motor vehicle traffic and soil disturbance) at the Bandelier site. Measurements are not made for the 7- and 30-day average state standards. Based upon the 24-hour averaged data, these standards are probably also met.

2. Beryllium Operations. Beryllium machining operations are located in shop 4 at TA-3-39, in shop 13 at TA-3-102, and the beryllium shop at TA-35-213. Beryllium machining, which is done in shop 13, takes place intermittently, 10s of days per year. A new beryllium processing facility to be located at TA-3-141 is planned to begin operation in 1987. 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. The air pollution control systems have >99.9% particulate removal efficiencies.

Stack emission tests, using EPA and NMEID approved methods, were performed for each of the beryllium machining shops during 1986. These tests showed that the measured maximum emissions were far below the emission limits specified in the air quality permits issued by the NMEID (Table G-11). Routine stack-gas sampling for beryllium particulates at shop 4 was discontinued at the end of February 1986.

3. Steam Plants and Power Plant. Fuel consumption and emission estimates for the

Table 9. 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]		44[c] (60)[d]	50[c] (60)[d]
State[b]	150		
Federal			
Primary	260		
Secondary	150		
7-day average[b]	110		
30-day average[b]	90		
Annual Geometric Mean		18	20
Primary	75		
Secondary	60		

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

Table 10. Particulate Air Quality, Seasonal Averages ($\mu g/m^3$)

	Winter	Spring	Summer	Fall
Los Alamos	19	22	20	22
White Rock	24	27	19	22

steam plants and the TA-3 power plant are reported in Table G-12. The NO_x emissions from the TA-3 power plant were estimated based upon boiler exhaust gas measurements. Exhaust gas measurements also indicated that SO_x levels exhaust gases were below minimum detectable levels. Emission factors from EPA were used in making the other emission estimates (EPA 1984). Approximately, half to three quarters of the emissions come from the TA-3 power plant. The change in emissions from 1985 to 1986 reflects the change in fuel consumption. The Western Area steam plant, used as a standby plant, was not operated during 1985.

4. Motor Vehicle Emissions. Estimates of air pollutant emissions associated with the operation of the motor vehicle fleet are reported in Table 11. There was a large reduction in emissions from 1985 to 1986. This large reduction was caused by large changes

Table 11. Estimate of Air Pollutant Emissions Associated With the Operation of the Vehicle Fleet (1000 kg)

	1985	1986	Incremental % Change
Fuel Storage Evaporative Losses	6.2	4.8	-29.9
Hydrocarbons	16.6	10.4	-59.4
Carbon Monoxide	202.3	120.2	-68.3
Nitrogen Oxides	23.6	11.9	-98.0
Sulfur Oxides	2.2	1.4	-57.8
Particulates			
Exhaust	1.0	0.6	-61.0
Tire Wear	1.4	1.3	-10.7

in vehicle miles travelled for heavy duty diesel powered trucks, in fuel usage, in emission factors by vehicle age and class, and in vehicle age distribution. 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 (EPA 1981, EPA 1984). Fuel storage evaporative losses were estimated based upon the fuel usage.

5. Asphalt Plant. Annual production figures and estimates of the particulate emissions from the asphalt concrete plant are found in Table 12. The particulate emissions from the plant are low and substantially decreased from 1985 to 1986 because of the decrease in production. The substantial decrease in production was caused by the purchasing of 68% of the total asphalt used from an outside vendor. A multicyclone and a wet scrubber are used to clean the exhaust gas stream before it is released into the atmosphere. The particulate emission estimate was based upon stack testing data (Kramer 1977) and production data.

6. Burning and Detonation of Explosives. During 1986, a total of 19 936 kg (20 tons) of high-explosive wastes were disposed of by open burning at the TA-16 burn ground. Estimates of emissions resulting from this burning are reported in Table 13. The emissions were 7.8% lower than those for 1985. These estimates were made by using data

Table 12. Asphalt Plant Particulate Emissions

Year	Production (tons/yer)	Emissions (lb/year)	Incremental % Change from 1985
1985	24 659	820	---
1986	6 980	232	-71.7

Table 13. Estimated Air Pollutant Emissions from the Open Burning of Waste Explosives (kg)

Pollutant	1985	1986
Oxides of Nitrogen	653.0	602.1
Particulates	389.2	358.9
Carbon Monoxide	168.7	155.5
Hydrocarbons	2.2	2.0

from experimental work carried out by Mason and Hanger - Silas Co., Inc. (MHSM 1976).

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. Uranium emissions decreased 59.2% and lead emissions decreased 40.6% from 1985. There were no beryllium emissions during 1985.

Estimates of average concentrations of these toxic metals downwind from the detonations are reported in Table G-6. Applicable standards are also presented in this table. Estimated concentrations were less than 0.01% 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 1986 experiments.

7. Lead Pouring Facility. Pan Am Work Services operates a lead pouring facility for producing lead castings that is located at TA-3-38. Approximately 4500 kg (10 000 lb) of lead were estimated to have been poured during 1986. The estimated 1986 annual lead emissions from this facility were 2.0 kg (4.4 lb). The emission estimates were based upon the amounts of lead poured and an EPA emission factor for lead casting operations (EPA 1984).

Both federal and state ambient air quality standards for lead are 1.5 $\mu g/m^3$ averaged over a calendar quarter. Air dispersion procedures recommended by the EPA (EPA 1977, 1986) were used to estimate the maximum quarterly average lead concentrations caused by emissions from the lead pouring facility. These procedures provide conservative concentration estimates. The maximum quarterly concentration for 1986 was estimated to be 0.03 $\mu g/m^3$, 2% of the standard.

VI. WATER, SOILS, AND SEDIMENTS MONITORING

Surface and ground waters, soils, and sediments were sampled and analyzed to monitor dispersion of radionuclides and chemicals from Laboratory operations. Radionuclide and chemical concentrations of water from areas where there has been no direct release of treated effluents evidenced no observable effects due to Laboratory operations. The chemical quality of surface waters from areas with no discharge varied with seasonal fluctuations. Water in onsite areas where treated effluent has been released contained radionuclides below DOE's concentration guides. The quality of water in these release areas reflected some impact of Laboratory operations, but these waters are confined within the Laboratory and are not a source of municipal, industrial, or agricultural water supply. Special samples were collected for analyses of metals and organics from regional, perimeter, and onsite stations. Several anomalies occurred and were tagged for additional study.

Most regional and perimeter soil and sediment stations contained radioactivity at or near background levels. Concentrations that did exceed background were low and not considered significant. Sediments from areas where treated discharges have been released contained radionuclides in excess of background. A study in lower Los Alamos Canyon indicated most uranium in sediments was depleted (i.e., not natural) uranium with a small amount of natural uranium. Sediments from regional reservoirs on the Rio Chama and Rio Grande reflect plutonium concentrations in worldwide fallout.

A. Effluent Quality

In the past, treated liquid effluents containing low levels of radioactivity have been 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-13, G-14, and Figs. 9, 10, and 14). In 1986, there were no releases from TA-21.

Radionuclide concentrations in treated effluents from the larger radioactive liquid waste treatment plant (TA-50) were well below DOE's concentration guides for onsite areas (Table G-13). Volume of discharge and total activity release from TA-50 in 1986 was about the same as for TA-50 and TA-21 in 1985. Effluents are discharged into a normally dry stream channel in Mortandad Canyon where surface flow has not passed beyond the Laboratory's boundary since before the plant began operation in 1963.

Radionuclide concentrations found in the TA-53 lagoon effluent in 1986 were higher than in 1985. The source of the radioactivity was activated water from the beam-stop cooling systems. Radionuclide discharge from the lagoons increased in 1986 by a factor of 2.6. This was due to the higher concentrations of radionuclides, particularly tritium, in lagoon waters even though the volume of discharge declined from 1985 to 1986. However, all radionuclide concentrations were well below DOE's concentration guides for onsite areas (Table G-14). Although tritium

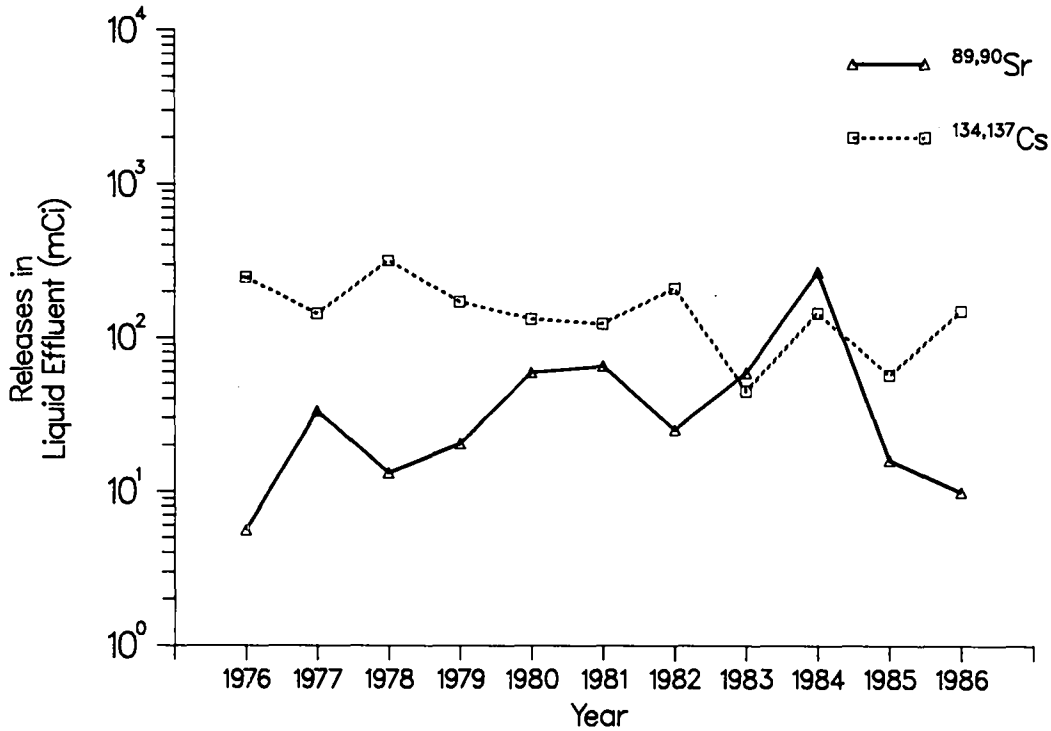

Fig. 14. Summary of strontium and cesium liquid effluent releases.

discharge increased in 1986, activity released of tritium remained within the range of previous years (Fig. 9). The discharge from the lagoons sinks into alluvium of Los Alamos Canyon within the Laboratory's boundary.

B. Radiochemical and Chemical Quality of Surface and Ground Water

1. Background. Surface and ground waters from regional, perimeter, and onsite stations are monitored to provide routine surveillance of Laboratory operations (Figs. 15 and 16, Table G-15). 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

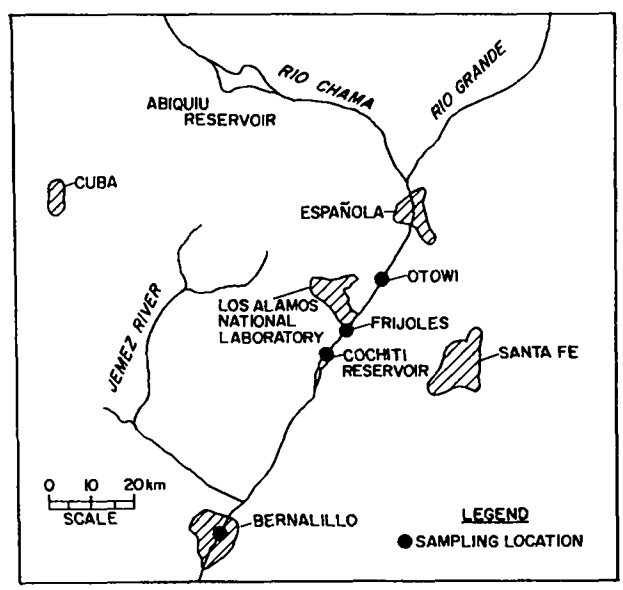

Fig. 15. Regional surface water, sediment, and soil sampling locations.

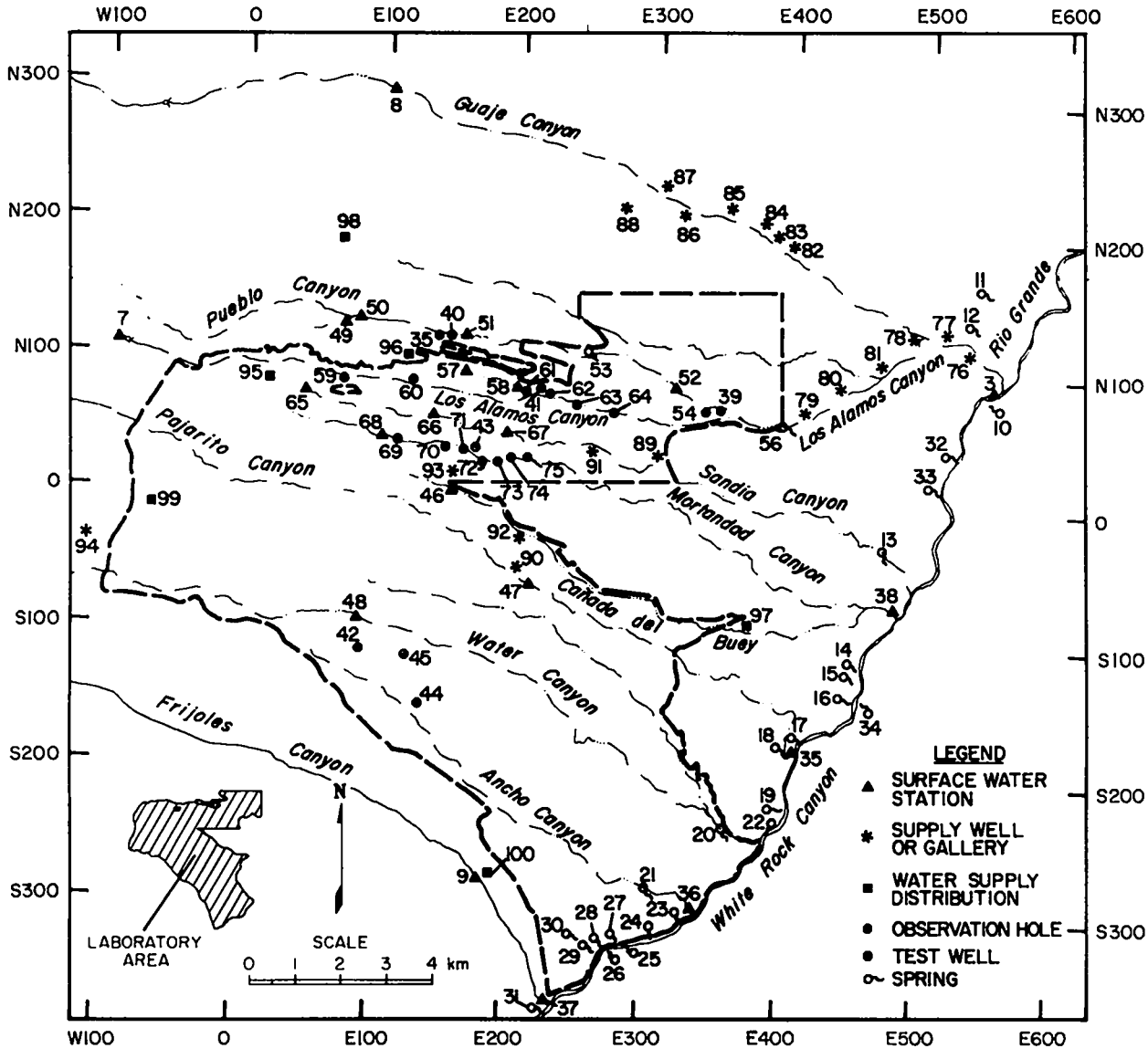

Fig. 16. Surface and ground water sampling locations on and near the Laboratory site.

DOE's Radiation Protection Standard (RPS) (Appendix A). Offsite regional and perimeter stations are subject to an RPS of 100 mrem/yr, whereas onsite stations are subject to an occupational RPS of 5000 mrem. 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 subsequent sections).

Routine chemical analyses of water samples have been carried out for many constituents over a number of years. Although water from which these samples are taken is not a source of municipal or industrial water

supply, results of these analyses are compared with EPA drinking water standards as these are the most restrictive related to water use. In 1986, a select number of regional, perimeter, and onsite stations were sampled, and a number of analyses for additional chemical and organic compounds were performed.

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. 15). The six sampling 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, 1909-1985) 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 1985 (October 1984 to September 1985) ranged from 11 m^3/sec (386 ft^3/sec) in October to 351 m^3/sec (12,400 ft^3/sec) in May (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 1985 ranged from 1.4 m^3/sec (50 ft^3/sec) in August to 111 m^3/sec (3920 ft^3/sec) in May.

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 water year 1985, the discharge ranged from 0.28 m^3/sec (10 ft^3/sec) in December to 129 m^3/sec (4540 ft^3/sec) in July. 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 upstream 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 February and August 1986. Cesium, plutonium, tritium, and total uranium activity levels in these waters were low (Tables 14 and G-17). Samples collected downgradient from the Laboratory showed no effect from the Laboratory's operation. Results from 1986 exhibited no significant differences from 1985. Maximum concentrations of radioactivity in regional surface water samples were well below DOE's concentration guides for offsite areas.

b. Chemical Analyses. Surface water samples from regional stations were collected in February 1986. Maximum concentrations in regional water samples were well below drinking water standards (Tables 15 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 with variations in discharges at the various stations. This is normal and no inference can be made that the water quality at these stations is deteriorating.

Table 14. Maximum Concentrations of Radioactivity in Surface and Groundwaters 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)
Analytical Limits of Detection		40	0.009	0.03	0.7	1.0
Offsite Stations (Uncontrolled Areas)						
Derived Concentration Guide (DCG) for Uncontrolled Areas[b]		3000	400	300	2000	800
Regional	6	38 (34)[c]	0.028 (0.015)	0.028 (0.013)	1.3 (0.4)	5.0 (1.0)
Perimeter						
Adjacent	7	58 (38)	0.019 (0.015)	0.036 (0.027)	3.5 (0.6)	13 (1.0)
White Rock	24	110 (57)	0.018 (0.012)	0.037 (0.015)	1.4 (0.4)	16 (1.0)
Offsite Station Group Summary:						
Maximum Concentration		110	0.028	0.028	3.5	16
Maximum Concentration as % DCG for Uncontrolled Areas		4	<1	<1	<1	2
Onsite Stations (Controlled Areas)						
Concentration Guide (CG) for Controlled Areas[b]		400 000	100 000	100 000	100 000	60 000
Noneffluent Areas						
Groundwater (Main Aquifer)	6	73 (30)	0.016 (0.015)	0.016 (0.012)	1.4 (0.4)	3.0 (1.0)
Surface Water	3	52 (33)	0.012 (0.011)	0.013 (0.010)	1.7 (0.4)	4.0 (1.0)
Pajarito Canyon	3	-10 (64)	0.016 (0.026)	0.021(0.020)	1.2 (0.8)	3.7 (0.8)

Table 14 (cont)

	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)
Effluent Areas						
Acid-Pueblo Canyon	8	53 (36)	0.031 (0.017)	0.220 (0.005)	5.2 (0.7)	4.0 (1.0)
DP-Los Alamos Canyon	8	59 (35)	0.067 (0.019)	0.180 (0.029)	7.2 (0.9)	3.0 (1.0)
Sandia Canyon	3	18 (33)	0.012 (0.018)	0.015 (0.009)	2.9 (0.5)	12.0 (1.0)
Mortandad Canyon	7	72 (34)	0.961 (0.066)	3.82 (0.165)	1300 (100)	12.0 (1.0)
Onsite Group Summary:						
Maximum Concentration		72	0.961	3.82	1300	12
Maximum Concentration as % CG for Controlled Areas		<1	<1	<1	1	<1

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[a]One or two analyses from each station.
[b]See Appendix A.
[c]Counting uncertainty in parentheses.

Table 15. Maximum Chemical Concentrations in Surface and Groundwaters

	Number of Stations	mg/L				
		CL	F	NO_3 (as N)	TDS	pH
EPA Drinking Water Standard[a]	--	250	2.0	10	500	6.5-8.5
Offsite Stations						
Regional Stations	6	67	0.8	1.1	308	8.2
Perimeter Stations						
Adjacent	6	9	0.5	1.9	197	7.9
White Rock Canyon	21	53	1.4	7.0	468	8.4
Summary: Offsite Stations						
Maximum Concentration		67	1.4	7.0	468	8.4
Maximum Concentration as Per Cent of Standard		33	70	70	94	--
Onsite Stations						
Noneffluent Areas						
Groundwater	6	38	0.7	6.4	268	8.6
Surface Water	3	101	1.0	0.8	454	8.6
Pajarito Canyon	3	40	0.6	1.3	438	8.0
Effluent Release Areas						
Acid-Pueblo Canyon	7	138	1.0	12	357	8.1
DP-Los Alamos Canyon	8	133	5.5	2.8	391	8.1
Sandia Canyon	3	165	12	2.2	583	7.5
Mortandad Canyon	7	32	4.0	106	1071	8.6
Summary: Onsite Stations						
Maximum Concentration		165	12	106	1071	8.6
Maximum Concentration as Per Cent of Standard		66	600	1060	214	--

[a]EPA (1976, 1979B).

3. Perimeter Stations. Perimeter stations within 4 km (2.5 mi) 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 20 springs, 3 streams, and a sanitary effluent release (Fig. 16 and Tables G-15).

Los Alamos Reservoir in upper Los Alamos Canyon on the flanks of the mountains, west of Los Alamos, has a capacity of 51 000 m^3 (41 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 Laboratory, 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 x 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 Cemetary. The stream and reservoir are also used for recreation.

The water lines 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 Pan Am World Services. Diversion for irrigation is usually from May through October.

Surface flow in Frijoles Canyon was sampled at Bandelier National Monument Headquarters. Flow in the canyon is from spring discharge in the upper reach of the canyon. Flow decreases as the stream 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, whereas Indian and Sacred springs are west of the river in lower Los Alamos Canyon. These springs discharge from faults in the siltstones and sandstones of the Tesuque Formation and from 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 run-off in the Rio Grande in 1986 was stored in Cochiti Reservoir. In September, when the springs were sampled, three 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 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.

Detailed results of radiochemical and chemical analyses of samples collected from

the perimeter stations are shown in Tables G-18 through G-23.

a. Radiochemical Analyses. Cesium, plutonium, tritium, and total uranium activity for samples collected at perimeter stations were low and well below DOE's concentration guides for offsite areas (Table 14).

b. Chemical Analyses. Maximum chemical concentrations (chloride, fluoride, nitrate, total dissolved solids, and pH) in samples from the perimeter stations were within drinking water standards (Table 15). Concentrations in water samples from the 20 springs and 3 streams in White Rock Canyon were also within drinking water standards.

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

a. 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 TD-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 effects that the Laboratory's operation may have on water quality in the main aquifer.

Surface water samples are collected in Canada del Buey and Pajarito and Water canyons downstream from technical areas to monitor the quality of run-off from these sites.

Three shallow observation wells were drilled in 1985 and cased through the alluvium [thickness about 4 m (12 ft)] in Pajarito Canyon (Fig. 16 and Table G-16). Water in the alluvium is perched on the underlying tuff and is recharged through storm run-off. The observation wells were constructed to determine if technical areas in the canyon or adjacent mesas were affecting the quality of shallow groundwater (Tables 14, 15, and G-24).

Radiochemical concentrations from groundwater (test and observation wells in Pajarito Canyon) and surface water sources showed no effects of laboratory operations (Tables 14, G-24, and G-25). Concentrations of cesium and plutonium were at or below limits of detection. Concentrations of all radionuclides were well below DOE's concentration guides for onsite areas.

Chemical quality of groundwater 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. The effect, if any, was small, probably as the result of seasonal fluctuations.

Maximum concentrations of five chemical constituents in the onsite surface and groundwater samples were within drinking water standards (Tables 15, G-26, and G-27).

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 run-off. Three observation wells in the alluvium of Pueblo Canyon were not used as part of the 1986 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 is sampled from Test Well 1A, in lower Pueblo Canyon, and Basalt Springs, further eastward in lower Los Alamos Canyon. Recharge to the perched aquifer in the basalt occurs 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. Treated 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 run-off from snowmelt and rainfall. Stream flow from this impoundment into the canyon is intermittent, dependent on precipitation to cause run-off to reach the laboratory boundary at State Road 4.

Infiltration to treated effluents and natural run-off maintains a shallow body of water in the alluvium of Los Alamos Canyon. Water levels are highest in late spring from snowmelt run-off and late summer from thundershowers. Water levels decline during the winter and early summer as natural storm run-off is at a minimum. Sampling stations consist of two surface water stations in DP Canyon and six observation wells completed into alluvium [about 66 m (20 ft) thick] in Los Alamos Canyon (Table G-15).

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. Treated 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 wells 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 contains 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. 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 begin in 1960. Since that time, there has been no surface flow beyond the Laboratory's boundary because the small drainage area in the upper part of the canyon results in limited run-off and a thick section of unsaturated alluvium in the lower canyon allows rapid infiltration and storage of run-off when it does occur. 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-28), DP-Los Alamos (Table G-29), Mortandad (Table G-30), and Sandia (Table G-31) canyons all contained surface and shallow groundwaters with measurable amounts of radioactivity. Radioactivity is well below DOE's concentration guides for onsite areas (Table 14). Radionuclide concentrations from treated effluents decreased downgradient in the canyon due to dilution with surface and shallow groundwater and with their adsorption on alluvial sediments. Surface and shallow ground waters in these canyons are 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 extend beyond Laboratory boundaries and reach the Rio Grande. In Mortandad Canyon there has been no surface run-off 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 treated effluents were released into the canyon (Purtymun 1983).

Relatively high concentrations of chlorides, nitrates, and total dissolved solids have resulted from effluents released into the canyons (Tables G-32 through G-35). Relatively high fluoride and nitrate concentrations were found in waters from Mortandad Canyon, which receives the largest volume of industrial effluents (Purtymun 1977). Though the concentrations of some chemical constituents in the waters in these canyons were high when compared with drinking water standards (Table 15), these onsite waters are not a source of municipal, industrial, or agricultural supply.

Maximum chemical concentrations occurred in water samples taken near treated effluent outfalls (Table G-32 through G-35). 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 run-off to Laboratory boundaries recorded in Mortandad Canyon since 1960, when observations began.

5. Transport of Radionuclides in Surface Run-Off. The major transport of radionuclides from canyons that have received or are now receiving treated low-level radioactive effluents is by surface run-off (solution and sediments). Radionuclides in the effluents become absorbed or attached to

sediment particles in the stream channels. Concentrations of radioactivity in the alluvium is highest near the treated effluent outfall and decreases in concentration downgradient in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and surface run-off.

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

Samples of run-off 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 a residue on the filter. The solution was analyzed for ^{238}Pu, ^{239,240}Pu, and total uranium, and suspended sediments were analyzed for ^{238}Pu and ^{239,240}Pu.

Samples of summer run-off were collected in Los Alamos Canyon at State Road 4 (SR4) and at the Rio Grande. Also sampled at SR-4 was Pueblo Canyon, which is tributay to Los Alamos Canyon, and Pajarito Canyon (Fig. 17 and Table G-36).

Summer run-off at the gaging station in Los Alamos Canyon at State Road 4 during 1986 occurred for about a 48-day period from June 7 to July 24, 1986. During this period, about 5000 m^3 (175 000 ft^3) of runoff passed the station. Surface flow reached the Rio Grande at Otowi during the period June 24 through July 6. An estimated 40 m^3 (1400 ft^3) of flow reached the river. One sample was collected from Pueblo Canyon at its confluence with Los Alamos Canyon. The ^{238}Pu in solution in samples collected at the three sampling stations was below background. Trace amounts of ^{239,240}Pu were

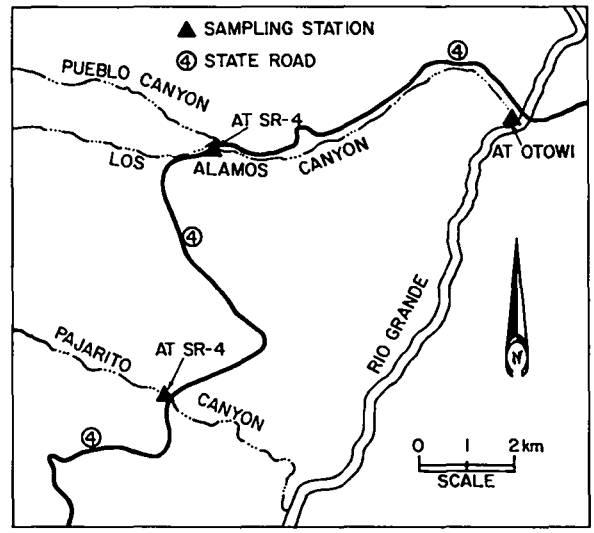

Fig. 17. Locations of surface run-off sampling stations at State Road 4 (SR-4).

found in solution, but were below background (Table 16).

Suspended sediments collected in Los Alamos Canyon at SR-4 contained ^{238}Pu and ^{239,240}Pu in concentrations slightly above background, whereas at Otowi, the ^{239,240}Pu in sediments were slightly below background. Los Alamos Canyon west of SR-4 received treated, low-level radioactive effluents. The plutonium concentrations in the suspended sediments were low and were dispersed anddiluted by storm run-off before they reached the Rio Grande.

Snowmelt samples were also collected in Pajarito Canyon near SR-4, where about 3000 m^3 (106 000 ft^3) run-off passed the gaging station. The run-off (in solution and suspended sediments) contained only background concentrations of plutonium (Tables 16 and G-36).

In lower Mortandad Canyon just below Well MCO-7 (Fig. 15), three sediment basins were constructed. The upper part of the canyon receives treated, low-level radioactive effluents from the treatment plant

Table 16. Average Plutonium Concentrations in Summer Run-off in Effluent Receiving Canyons

	Number of Analyses	Solution		Suspended Sediments	
		^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Los Alamos Canyon at State Road 4	11	−0.002 (0.011)[a]	0.005 (0.008)	0.239 (0.173)	1.57 (0.88)
Pueblo Canyon at State Road 4	1	0.004 (0.007)	0.004 (0.008)	−0.022 (0.016)	0.000 (0.21)
Los Alamos Canyon at Rio Grande	4	−0.004 (0.011)	0.013 (0.011)	0.104 (0.055)	1.53 (1.34)
Pajarito Canyon at State Road 4	8	−0.002 (0.011)	0.009 (0.012)	−0.055 (0.081)	0.290 (0.451)
Mortandad Canyon at Retention Ponds Near MCO-7	2	--	--	6.88 (2.07)	20.2 (7.71)
Regional and Local Background[b]	--	0.005	0.036	0.026	0.740
Limits of Detection	--	0.009	0.03	0.003	0.002

[a]Standard deviation is contained in parentheses.
[b]Solution surface water, Rio Grande, and Rio Chama, 1986 (12 analyses $\bar{x}$ + s).
Suspended Sediments Pajarito Canyon, 1986 (8 analyses $\bar{x}$ + s).

at TA-50. The total capacity of the three basins is about 40 000 m^3 (~133 000 ft^3). The capacity is estimated to retain a 50-yr run-off event. Two run-off events into the upper basin in June were sampled for radionuclides (Table G-36). The average plutonium in solution and in suspended sediments were above background indicating run-off transport from the upper canyon (Table 16).

6. Special Chemical Analyses of Water From Perimeter and Onsite Stations. Additional chemical analyses were performed on waters from 2 perimeter and 12 onsite stations as further evaluation of the quality of water in these areas. The analyses were performed for 22 different chemical constituents, 17 constituents that have limits for use as municipal supply and 5 other miscellaneous chemicals (Tables G-37 through G-39, and Fig. 16). Although water from the stations is not a source of municipal or industrial water supply, the results of the analyses are compared with USEPA Drinking Water Standards as these standards are the most restrictive related to water use.

Fluorides in waters from stations in DP-Los Alamos, Sandia, and Mortandad canyons and nitrates in water from stations in Acid-Pueblo and Mortandad Canyons exceeded the primary standards (Tables 17 and G-37). Iron, manganese, and total dissolved solids in exceeded secondary standards waters from stations in Acid-Pueblo, Sandia, and Mortandad canyons (Table G-38). These canyons have received or/are now receiving industrial effluent. The five miscellaneous chemicals from the 14 stations were low (Table G-39).

7. Volatile Organics in Water from Selected Regional, Perimeter, and Onsite Stations. Volatile organics are considered by the EPA to be priority pollutants in liquid discharges (40 CFR 122.21). Volatile organic analyses were performed on waters from one regional, two perimeter, and six onsite stations. The samples were analyzed for six volatile compounds. These compounds, method of analyses, and limits of detection are found in Appendix C. Of nine stations, only one station in Sandia Canyon, SCS-3, contained water with a volatile organic. Water at SCS-3 contained methylene chloride at 11 μg/L. The canyon receives sanitary effluents and cooling water from a power plant and also drains an area of a asphalt mix plant, motor pool, and associated shops. The other sampling station below these facilities did not contain any volatile compounds. The concentration of the methylene chloride is slightly above EPA's toxic criterion of 10 μg/L for aquatic life.

8. Semivolatile Organics in Waters From Selected Regional, Perimeter, and Onsite Stations. Analyses for EPA, priority-pollutant semivolatile organics were performed on waters from one regional, two perimeter, and six onsite stations. The samples were analyzed for 57 semivolatile compounds (Appendix C). All of the waters contained the compound bis(2-ethylhexyl)phthalate. Other phthalate compounds in waters from some stations are di-n-butylphthalate and diethylphthalate. These compounds are derived from various types of plastics or processes involved with plastics. Contamination of water with plastics can occur during the sampling process or during laboratory analyses and thus does not imply that a water source contains a phthalate compound. Further analyses will be carried out in 1987 to clarify this point.

The regional sample from the Rio Grande at Otowi contained two phthalates and an aromatic hydrocarbon, pyrene. The concentrations were low, near the limits of detection (Table 18).

Table 17. Analyses of Water from Perimeter and Onsite Stations Compared with Drinking Water Standards

Stations Exceeding Standards	Parameter	mg/L Concentration	mg/L Standard	Concentration as Percent of Standard
		Exceeded Primary Drinking Water Standards[a]		
DPS-4	F	5.5	2.0	275
LAO-1	F	2.4	2.0	120
LAO-4	F	2.4	2.0	120
SCS-1	F	12	2.0	600
MCO-4	F	4.0	2.0	200
Pueblo 1	N	10	10	100
TW-1A	N	12	10	120
MCO-4	N	90	10	900
MCO-7	N	74	10	740
		Exceeded Secondary Drinking Water Standards[b]		
SCS-3	Fe	0.43	0.3	143
MCO-4	Fe	0.43	0.3	143
Pueblo 3	Mn	0.15	0.05	300
MCGS-1	Mn	0.05	0.05	100
SCS-3	TDS	583	500	117
MCO-4	TDS	944	500	189
MCO-7	TDS	854	500	171

[a]USEPA 1976.
[b]USEPA 1979.

Note: See Tables G-37 through G-39 for complete listing of perimeter and onsite stations sampled, analyses, and analytical results.

Table 18. Organics in Regional, Perimeter, and Onsite Waters

	Compounds Detected[a]	Limits of Detection (µg/L)	Concentration (µg/L)	Standard[b] (µg/L)	Concentration as Percent of Standard
Regional					
Rio Grande at Otowi	Bis (2-ethylexyl) phthalate	10	5	940	<1
	Di-N-butylphthalate	10	2	940	<1
	Pyrene	1	3.5	--	--
Perimeter					
Los Alamos Reservoir	Bis (2-ethylexyl) phthalate	1.0	14	940	1
	Di-N-butylphthalate	2.0	4	940	<1
	Hexachlorobutadiene	1.0	1100	90	1200
Frijoles Canyon	Bis (2-ethylhexyl) phthalate	1.0	23	940	2
Onsite Noneffluent Area					
Test Well TW-1	4-Chlorophenylphenylether	3.0	4	360	1
	Di-N-butylphthalate	1.0	2	940	<1
	Bis (2-ethylhexyl) phthalate	1.0	7	940	<1
Test Well DT-5A	Bis (2-ethylhexyl) phthalate	1.0	32	940	3
Onsite Effluent Areas					
Acid-Pueblo Canyon Test Well TW-1A	Bis (2-ethylhexyl) phthalate	1.0	4	940	<1

Table 18 (cont)

	Compounds Detected[a]	Limits of Detection (µg/L)	Concentration (µg/L)	Standard[b] (µg/L)	Concentration as Percent of Standard
Basalt Springs	Bis (2-ethylhexyl) phthalate	1.0	4	940	<1
Sandia Canyon					
SCS-1	Diethylphthalate	2.0	9	940	<1
	Di-N-butylphthalate	1.0	6	940	<1
	By (2-ethylhexyl) phthalate	1.0	18	940	2
	Naphthalene	1.0	12	2,300	<1
	Fluoranthene	1.0	4	4,000	<1
	2,6-Dinitrotoluene	5.0	20	330	6
SCS-2	Bis (2-ethylhexyl) phthalate	1.0	4	940	<1
	2,4-Dinitrotoluene	1.0	250	330	75

---

[a]Samples were analyzed for 57 semivolatile compounds. These compounds, methods of analyses, and the limits of detection is found in Appendix C.
[b]Toxic Standard for Aquatic Life (EPA 1986).
Note: Collected January 23 and 24, 1986.

Waters from the perimeter stations at Los Alamos Reservoir and Frijoles Canyon contained phthalates. The sample from Los Alamos Reservoir also had a high concentration of hexachlorobutadiene. The concentration of 1100 μg/L exceeded the EPA's toxic criteria aquatic life by 1200%. This compound is a solvent, used as a hydraulic or transfer fluid. The compound was confirmed in two columns but not with the Gas Chromotograph Mass Spectrophotometry (GCMS) scan. The lack of confirmation in the GCMS scan may indicate the compound is not present in the water. Water in the reservoir contains only run-off from the mountain slopes and from a spring in the canyon to the west, and does not receive run-off from areas of Laboratory or community activities.

The water from the onsite station test well TW-1 contained two phthalates and the compound 4-chlorophenyphenylether, which is an oil or solvent probably associated with the operation of the pump. The concentrations were low, <4 μg/L. Water from test well TD-5A also contained a phthalate.

Waters from the onsite test well TW-1A and Basalt Springs contained phthalates and no other compounds (Table 18). Other water samples from onsite in Sandia Canyon contained phthalates as well as other organic compounds. The compounds other than the phthalates are related to use of oils or solvents. Sandia Canyon receives sanitary effluents and cooling water from the power plant and also drains an area of a asphalt mix plant, motor pool, and associated shops. The concentrations of the compounds were below EPA's toxic criteria for aquatic life.

C. Radioactivity in Soils and Sediments

1. Background Levels of Radioactivity in Soils and Sediments. Samples were routinely collected and analyzed for radionuclides from regional stations from 1978 through 1985 (Purtymun 1986c). They 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 (Table 19). Average concentrations plus twice the standard deviation were used to establish the upper limits of the background concentrations. The number of analyses used to establish background levels ranged from 15 (^{90}Sr) to 40 (^{137}Cs) for soils and (^{90}Sr) to 30 (^{137}Cs and plutonium) for sediments. Samples were collected from five regional soil stations and four regional sediments stations. Background concentrations may be exceeded slightly by 1986 surveillance results due to slight changes in instrument background or a slight modification of analytical procedures. See Appendix B for description of methods for collection of soil and sediment samples.

2. Regional Soils and Sediments. Regional soils and sediment samples were collected in the same general locations as the regional water samples (Figs. 15, 18, and 19). Additional regional sediment samples were collected along the Rio Grande from Otowi Bridge to Cochiti Reservoir (Fig. 19). The locations are listed in Table G-40 and the detailed results of radiochemical analyses of the regional soils and sediments are in Table G-41.

In 1986, soil samples were collected from seven stations and analyzed for six types of radioactivity (Table 19). Cesium and plutonium concentrations were below background levels. Total uranium and gross gamma concentrations at one station were slightly above background levels. The tritiated moisture content of three soil samples exceeded background concentrations (maximum equal to 150 x 10^{-6} μCi/mL). These three stations were resampled and ranged from 0.4 to 3.9 x 10^{-6} μCi/mL or a

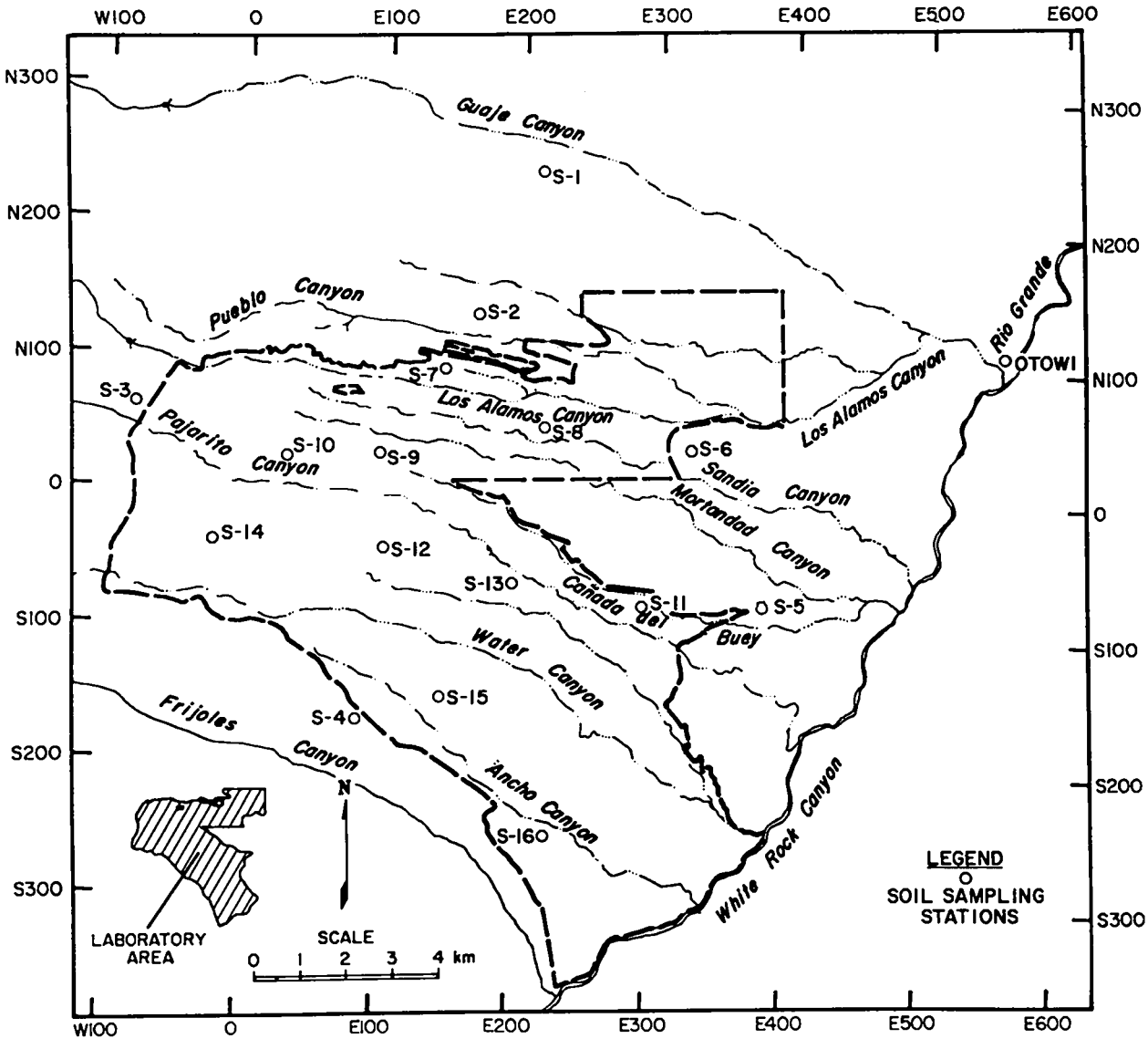

Fig. 18. Soil sampling stations on and near the Laboratory site.

factor of 40 lower than the first set of samples. The second set of samples contained no concentrations exceeding background. The high values in the earlier samples are believed to be attributable to contamination during sample preparation.

In 1986, sediments were collected from nine regional stations and analyzed for five types of radioactivity (Table 19). Only the maximum concentration off $^{239,240}Pu$ in one sample was slightly above background.

3. Perimeter Soil and Sediments. Six perimeter soil stations were sampled within 4 km (2.5 mi) of the Laboratory. Eighteen sediment stations near the Laboratory boundary

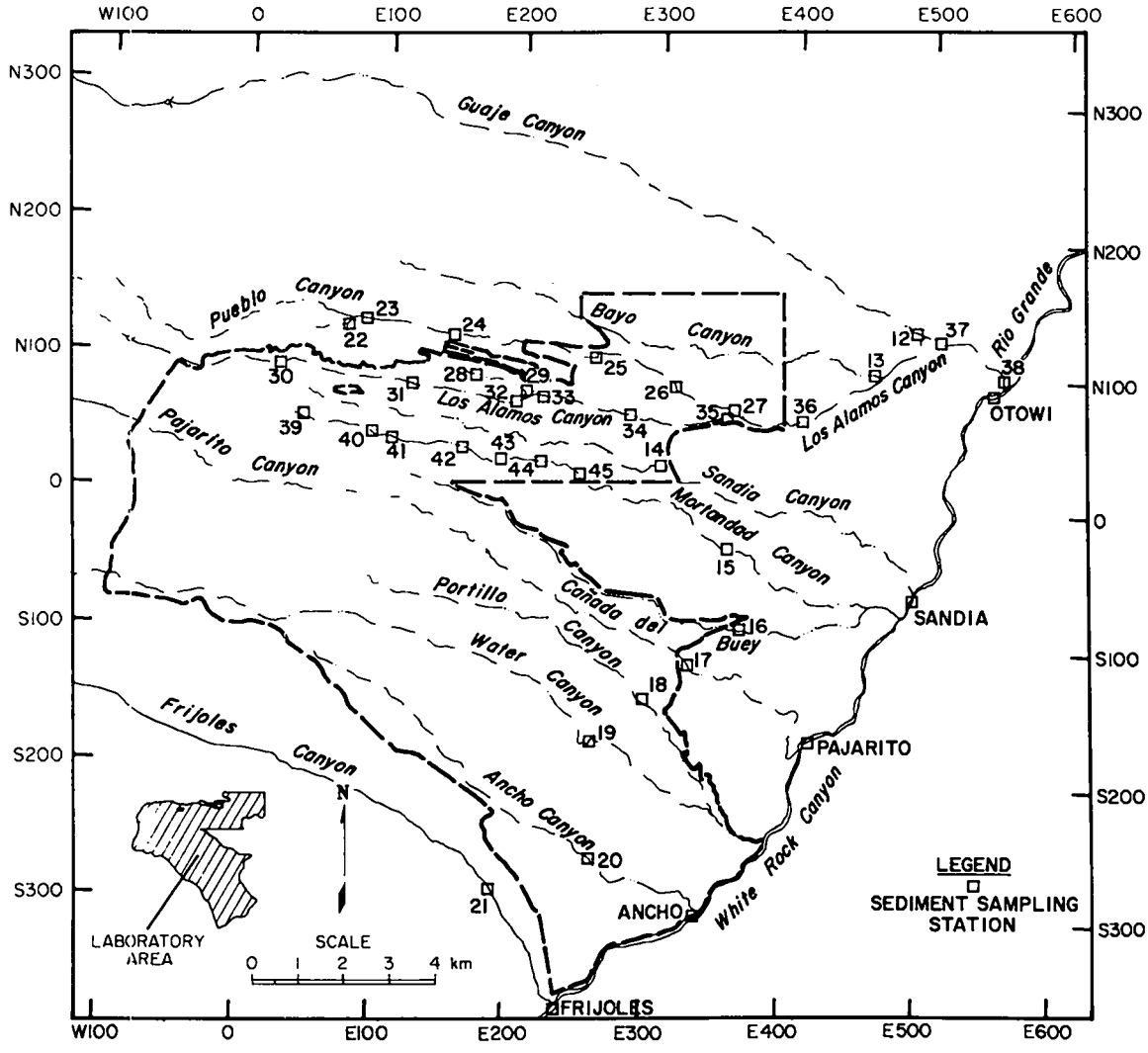

Fig. 19. Sediment sampling locations on and near the Laboratory site.

and in intermittent streams that cross the Pajarito Plateau were sampled (Fig. 18). Sediment stations in Acid-Pueblo and DP-Los Alamos canyons at SR-4 and at the Rio Grande were sampled in addition to onsite sediments in disposal canyons (Fig. 19). The perimeter soil and sediment sampling stations are listed in Table G-40 and detailed analytical results are found in Table G-42.

Analyses of the perimeter soil samples indicated that background concentrations were slightly exceeded in 1986 for ^{137}Cs (one sample), $^{239,240}Pu$ (one sample), total uranium (two samples), and gross gamma (three samples (Table 16). Uranium and gross gamma reflect naturally occurring radiation in soil and sediments.

Analyses of sediments from the 18 perimeter stations indicated that concentrations were below background levels (Table 19).

Table 19. Maximum Concentrations of Radioactivity in Soils and Sediments from Regional, Perimeter, and Onsite Stations

	Number of Stations	^{3}H (10^{-6} µCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total U (µg/g)
Analytical Limits of Detection	--	0.7	---	0.1	0.03
Soil					
Background (1978-1985)[a]	--	7.1	0.68	1.18	3.5
Regional Stations	7	6.4 (0)[b]	---	0.71 (0)	4.3 (1)
Perimeter Stations	6	4.3 (0)	---	1.9 (1)	5.9 (2)
Onsite Stations	10	16 (2)	---	0.56 (0)	4.6 (7)
Sediments					
Background (1978-1985)[a]	---	---	1.15	0.52	4.8
Regional Stations	9	---	---	0.28 (0)	4.4 (0)
Perimeter Stations	18	---	---	0.21 (0)	3.6 (0)
Onsite Station, Effluent Release Areas					
Acid-Pueblo Canyon	6	---	0.59 (0)	0.83 (0)	3.4 (0)
DP-Los Alamos Canyon	11	---	1.6 (2)	11 (6)	3.2 (0)
Mortandad Canyon	7	---	4.8 (3)	64 (5)	5.9 (1)

---

[a] $\bar{x}$ + 2s of a number of background analyses for soils and bed sediments (Purtymun 1986).

[b] Number in parentheses indicates number of stations exceeding background concentrations.

Table 19 (cont)

	Number of Stations	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (Counts/min/g)
Analytical Limits of Detection	---	0.003	0.002	0.1
Soil				
Background (1978-1985)[a]	---	0.005	0.036	6.6
Regional Stations	7	0.002 (0)[b]	0.017 (0)	6.9 (0)
Perimeter Stations	6	0.005 (0)	0.054 (1)	11 (4)
Onsite Stations	10	0.003 (0)	0.063 (1)	8.3 (3)
Sediments				
Background (1978-1985)[a]	---	0.002	0.011	8.1
Regional Stations	9	0.002 (0)	0.013 (1)	5.2 (0)
Perimeter Stations	18	0.002 (0)	0.006 (0)	4.8 (0)
Onsite Station, Effluent Release Areas				
Acid-Pueblo Canyon	6	0.063 (1)	10.1 (4)	6.3 (0)
DP-Los Alamos Canyon	11	0.299 (8)	0.507 (9)	10.2 (2)
Mortandad Canyon	7	11.1 (6)	50.6 (7)	8.3 (3)

---

[a] $\bar{x}$ + 2s of a number of background analyses for soils and bed sediments (Purtymun 1986).

[b] Number in parentheses indicates number of stations exceeding background concentrations.

4. Onsite Soils and Sediments. Onsite soil samples were collected from 10 stations within the Laboratory boundaries. Onsite sediments were collected from 24 stations within treated liquid effluent release areas (Table G-40, Figs. 18 and 19).

The maximum ^{137}Cs and ^{238}Pu concentrations in the 10 soil samples were below regional background levels (Tables G-43 and G-44). The concentration of $^{239,240}Pu$ at one station (near TA-55, Plutonium Facility) was above background (Tables 19 and G-44). The ^{3}H concentrations from soil at two stations (one near TA-33, Tritium Facility) were above background. The uranium background concentration was exceeded at seven stations, and gross gamma background activity was exceeded a three stations. Uranium and gross gamma are low and do not reflect contamination from laboratory operations but rather variation in natural radioactivity in the soil minerals.

Three canyons have or are now receiving treated, low-level radioactive effluents. The concentrations of radionuclides in these canyons, Acid-Pueblo, DP-Los Alamos, and Mortandad canyons, exceed regional background levels. In general, the concentrations decrease downgradient in the sediments as the radionuclides are dispersed and mixed with uncontaminated sediments (Tables G-43 and G-44). The radionuclides in these canyons reflect the low-level radioactive effluents released from the treatment plants. The concentrations are low, most are within the Laboratory boundaries, and pose no health or environment problems.

5. Sediments in Regional Reservoirs. Reservoir sediments were collected from Abiquiu Reservoir on the Rio Chama (Fig. 20) and Rio Grande Reservoir on the Rio Grande in southern Colorado. Three sediment samples were collected at each reservoir. Four sediment samples were collected from Cochiti Reservoir on the Rio Grande south of Los Alamos (Fig. 20). The samples were analyzed for ^{238}Pu and $^{239,240}Pu$ using 1 kg (2 lb) samples (100 times the usual mass used for analyses) of regular sediments. These large samples increase the sensitivity of the plutonium analyses, which is necessary to effectively evaluate background plutonium concentrations in fallout from atmospheric tests.

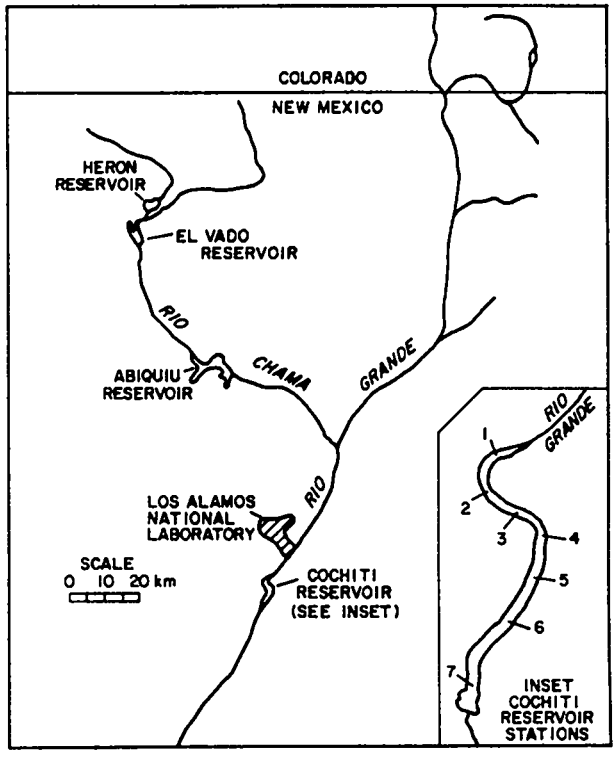

Fig. 20. Special regional sediment sampling locations.

The average ^{238}Pu concentrations ranged from 0.0003 pCi/g to 0.0012 pCi/g; $^{239,240}Pu$ concentrations were slightly higher, ranging from 0.0075 pCi/g to 0.0212 pCi/g (Table 20). The distribution of plutonium was similar to samples collected in previous years (1979, 1982, 1984, and 1985). Analyses of the current and previous years' data revealed significantly higher levels ($p<0.05$) of plutonium in Cochiti and Rio Grande reservoirs

Table 20. Plutonium in Reservoir Sediment Samples (pCi/g)

Reservoir	No. of Analyses	Average Concentration ^{238}Pu	Average Concentration $^{239,240}Pu$
Rio Grande	3	0.0009 (0.0011)[a]	0.0177 (0.0184)
Abiquiu	3	0.0003 (0.0001)	0.0075 (0.0017)
Cochiti	4	0.0012 (0.0005)	0.0212 (0.0061)

[a]Standard deviation in parentheses.

than in Abiquiu reservoir. Sediments in Cochiti and Rio Grande reservoirs contained a higher fraction of finer particles and organic materials than sediments from Abiquiu. These features enhance the capacity of the sediment to adsorb plutonium and other metal ions. The difference does not appear to be attributable to Laboratory operations. Rio Grande Reservoir is upstream from the Laboratory. In addition, the ratios of $^{239,240}Pu$ to ^{238}Pu in the Cochiti sediments does not differ significantly from the ratio characteristic of worldwide fallout, about the same as found in sediment at Abiquiu and Rio Grande reservoirs. The plutonium concentrations in sediments from the three reservoirs are low, within the range of worldwide fallout and are not a health or environmental concern.

6. Distribution of Depleted Uranium in Lower Los Alamos Canyon. Storm run-off has transported radioactivity in solution (trace amounts), in suspended sediments, and bedload from effluent release areas in upper Pueblo Canyon. Samples were collected at five sections starting about 2 km (1 mi) below the junction of Pueblo and Los Alamos canyons and then at intervals of about 1 km (0.6 mi) apart, with the last section in Los Alamos Canyon just above its confluence with the Rio Grande (Fig. 18). In 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 per section were submitted for analyses (Table 21). The samples were collected using a soil ring sampler, 9 cm in diameter, driven into the sediments about 10 cm.

The active channel carries snowmelt run-off and small events from summer storms. These events 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 run-off occurring in the active channel can reach the Rio Grande. The inactive channel above the active channel will carry run-off from summer storms 1 to 6 times annually, whereas overflow to the bank will occur once or twice every two years.

The sediment samples were analyzed for gross $^{235}U/^{238}U$ alpha count activity ratios to evaluate presence of natural or depleted uranium (uranium from which ^{235}U has been extracted). This ratio for natural uranium

Table 21. Distribution of Depleted Uranium in Sediments of Lower Los Alamos Canyon

	$^{235}U/^{238}U$	Remarks
Active Channel		
Section 1	0.0062 (0.0006)[a]	
Section 2	0.0030 (0.0003)	Depleted U
Section 3	--	
Section 4	0.0063 (0.0006)	
Section 5	0.0029 (0.0003)	Depleted U
Inactive Channel		
Section 1	0.0060 (0.0006)	
Section 2	0.0058 (0.0006)	Depleted U
Section 3	0.0033 (0.0004)	Depleted U
Section 4	0.0015 (0.0002)	Depleted U
Section 5	0.0021 (0.0002)	Depleted U
Bank		
Section 1	0.0042 (0.0004)	Depleted U
Section 2	0.0033 (0.0003)	Depleted U
Section 3	0.0042 (0.0004)	Depleted U
Section 4	--	
Section 5	0.0045 (0.0005)	Depleted U

[a]Counting uncertainty in parentheses.

has a range of about 0.0065 to 0.0079; any ratio below 0.0065 is assumed to be depleted uranium (Table 21). The ratios indicate that the uranium in the active channel at sections 1 and 4 and in the inactive channel at section 1 is a mixture of natural and depleted uranium. Depleted uranium is found in the remainder of the sections in the active and inactive channels, and banks. The depleted uranium is not a health hazard (Sec. III) or an environmental problem.

7. Radionuclide Transport in Sediments and Run-Off of an Active Radioactive Waste Management Area (Area G). Radionuclides transported by surface run-off have an affinity for attachment to sediment particles by ion exchange or adsorption. Thus, radionuclides in surface run-off tend to concentrate in sediments. Nine sampling stations were established in 1982 outside the perimeter fence at Area G (TA-54) to monitor possible transport of radionuclides by storm run-off from the waste storage and disposal area (Fig. 21).

Cesium and gross gamma radioactivity in sediments from the nine stations were below background levels (Table 22). Uranium at station 8 was slightly elevated when compared to background. The ^{238}Pu concentration at stations 6 through 9 and the $^{239,240}Pu$ concentrations at stations 6 and 7 were above background levels. The concentrations

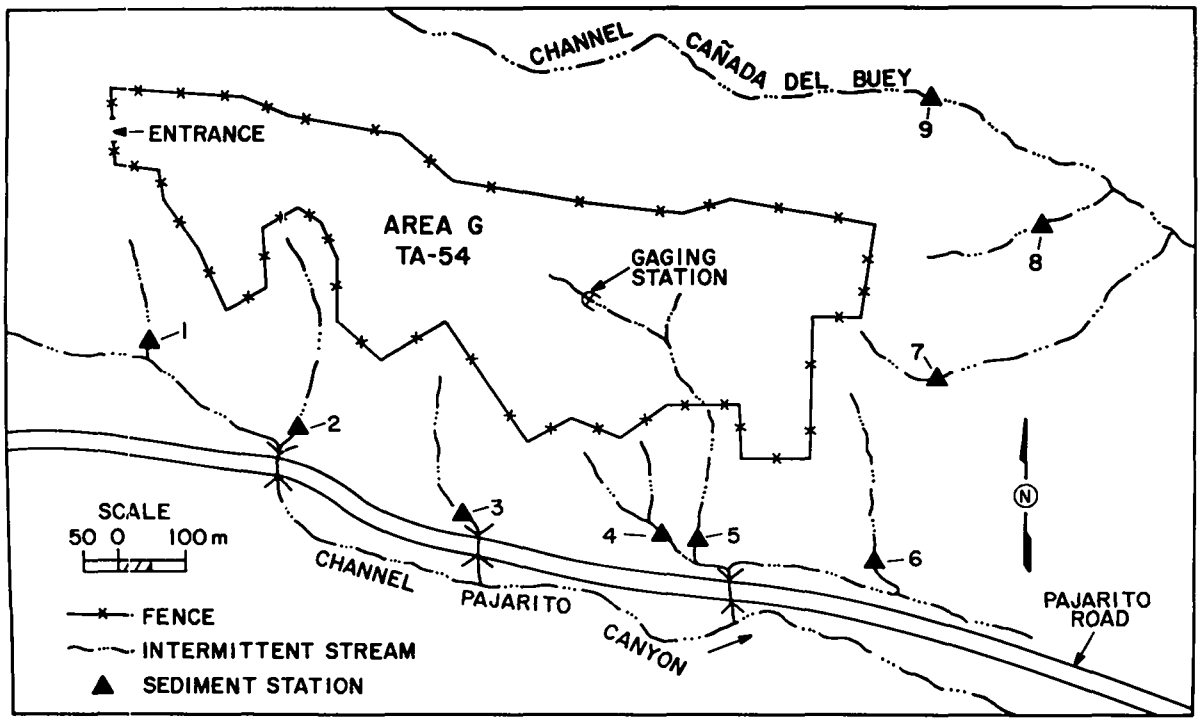

Fig. 21. Surface water gaging station in Area G (TA-54) and sediment sampling stations adjacent to Area G.

are low and do not pose any health or environmental problems. The presence of the plutonium in the sediment indicates that there is transport of surface contamination.

Two run-off samples were collected and analyzed for radionuclides in solution and plutonium in suspended sediments (Table 22). The event of 6/9/86 carried a trace of ^{238}Pu in solution while tritium was slightly above background for both events. The event of 6/26/86 also carried low amounts of ^{238}Pu in the suspended sediments.

Table 22. Radiochemical Analyses of Sediments and Run-off, Area G, TA-54

Station	Sediments, October 21, 1986				
	^{137}Cs (pCi/g)	Total U (g/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (Counts/min/g)
1	0.22 (0.6)[a]	2.7 (0.3)	0.001 (0.001)	0.002 (0.001)	-3.5 (0.7)
2	0.44 (0.11)	2.7 (0.3)	0.003 (0.001)	0.004 (0.002)	-4.3 (0.7)
3	0.08 (0.08)	2.1 (0.2)	0.003 (0.002)	0.003 (0.002)	-5.4 (0.8)
4	0.16 (0.17)	2.4 (0.3)	0.002 (0.001)	0.009 (0.002)	-1.9 (0.6)
5	0.09 (0.07)	1.9 (0.2)	0.002 (0.001)	0.008 (0.002)	-3.7 (0.7)
6	0.04 (0.06)	1.5 (0.2)	0.010 (0.001)	0.048 (0.005)	-5.9 (0.8)
7	0.09 (0.07)	1.5 (0.2)	0.091 (0.007)	0.051 (0.005)	-4.6 (0.7)
8	0.26 (0.09)	4.6 (0.5)	0.027 (0.004)	0.022 (0.003)	0.0 (0.6)
9	0.11 (0.07)	1.8 (0.2)	0.015 (0.002)	0.006 (0.001)	-5.9 (0.8)
Back-ground[b]	1.18	3.5	0.005	0.036	7.1
Limits of Detection	0.1	0.7	0.003	0.002	0.1

Table 22 (cont)

Date	In Run-off Solution					
	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/mL)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{9} µCi/mL)	Gross Gamma (counts/min/L)
6/9/86	2.2 (0.5)	−46 (28)	0.7 (0.3)	0.031 (0.04)	−0.005 (0.016)	−120 (60)
6/26/86	3.0 (0.5)	−91 (22)	0.3 (0.1)	−0.004 (0.04)	0.004 (0.012)	−70 (100)
Back-ground[c]	1.0	26	3.1	0.022	0.018	243
Limits of Detection	0.7	40	1	0.009	0.03	50

Table 22 (cont)

Suspended Sediments in Run-off		
Date	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
6/9/86	0.021 (0.003)	0.109 (0.008)
6/26/86	0.346 (0.050)	0.197 (0.036)
Back-ground[d]	0.026	0.741
Limits of Detection	0.003	0.002

[a]Counting uncertainties in parentheses.
[b]$\bar{x}$ + 2s (Purtymun 1986).
[c]Surface Water Rio Grande and Rio Chama, 1986 (12 analyses; $\bar{x}$ + s).
[d]Suspended Sediments Pajarito Canyon, 1986 (8 analyses; $\bar{x}$ + s).

VII. FOODSTUFFS MONITORING

Most produce, fish, and honey samples collected near the Laboratory showed no influence from Laboratory operations. Onsite and perimeter samples contained slightly elevated levels of tritium and other radionuclides. Concentrations of radionuclides in foodstuffs contributed only a minute fraction of the Laboratory's contribution to individual and population doses received by the public.

A. Background

Produce, garden soil, fish, and honey have been routinely sampled to monitor for potential radioactivity from Laboratory operations. Produce and honey collected in the Espanola Valley and fish collected at Abiquiu Reservoir are not affected by Laboratory operations (Fig. 22). 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 foodstuffs sampling program.

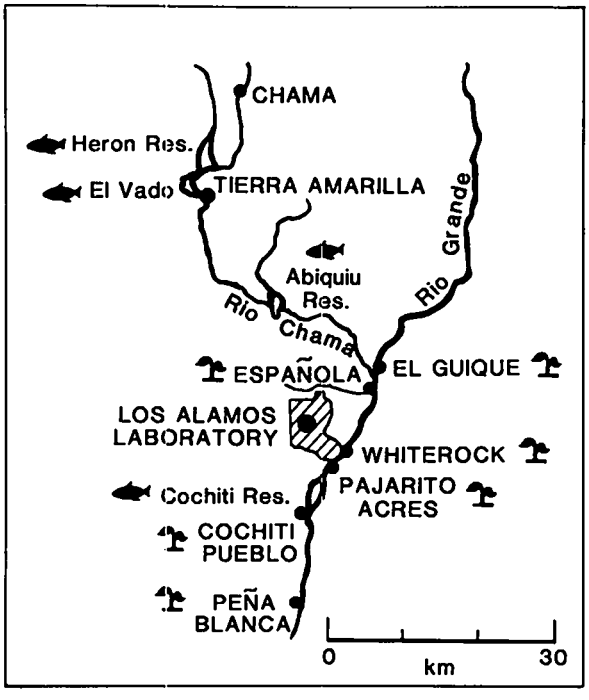

Fig. 22. Fish and produce sampling locations.

B. Produce

Data in Table G-45 summarize produce sample results for ^{3}H (in tritiated water), ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and total uranium. Sampling and preparation methods are described in Appendix B.

Concentrations of ^{90}Sr, $^{239,240}Pu$, and total uranium in produce from regional, perimeter, and onsite sampling locations were statistically indistinguishable (one-way analysis of variance at the 95% confidence level).

Plutonium-238 concentrations were slightly elevated in onsite produce. These levels were only significantly higher than the levels in produce from perimeter stations in Los Alamos and White Rock. However, produce grown in offsite locations did not exhibit statistically different levels among themselves.

Significantly higher levels of ^{3}H were found in onsite produce than in the other sites. The Laboratory releases tritium (Table 3), and samples from onsite locations reflect these releases. During 1986, the Laboratory released nearly 11,000 Ci of tritium. Perimeter locales did exhibit slightly elevated levels

of tritium in produce, but these levels were statistically indistinguishable from levels found in regional produce.

Elevated radionuclide levels in onsite samples is probably the result of laboratory operations. However, onsite produce are not a regular component of the diet of either Laboratory employees or the general public. The Laboratory contribution to doses received in produce consumption pose no threat to the health and safety of the general public (Sec. III).

C. Fish

Fish were sampled in two reservoirs (Fig. 22). Abiquiu Reservoir is upstream from the Laboratory on the Rio Chama and serves as a background sampling location. Cochiti Reservoir could potentially be affected by Laboratory operations because it is downstream from the Laboratory on the Rio Grande. Sampling procedures are described in Appendix B. Edible tissue was radiochemically analyzed within fish species for ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and total uranium.

Results for fish are presented in Table G-46. For ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and uranium no statistical differences were apparent (two-factor analysis of variance, 95% confidence level) between the upstream and downstream samples. Thus, significantly higher concentrations of plutonium in Cochiti sediments (Table 20) were not reflected in the food chain. In some previous years, higher levels of ^{137}Cs had been observed in fish upstream. As in previous years, uranium levels within species exhibited distinct patterns. Body burdens in bottom-feeding catfish tended to be higher than those found in crappie. Levels of ^{90}Sr in fish were significantly higher in upstream samples, reflecting increased global fallout at higher elevations.

The data indicate that Laboratory operations do not result in significant doses received by the general public consuming fish from Cochiti Reservoir (Sec. III).

D. Honey

The honey bee hive locations are listed in Table G-47 and shown on the map in Figure 23. The most recent data are shown in Table G-48. The radionuclide data show essentially the same patterns as in previous years, although concentrations are generally elevated. Uranium concentrations are elevated at DP Canyon, and certain activation products are elevated at TA-53 (LAMPF). There are somewhat elevated radiocesium concentrations in the hive at the TA-50 outfall. Tritium concentrations are elevated at all onsite hives. These results reflect activities that are ongoing at the Laboratory. There are several high results from the hives at regional stations which do not reflect Laboratory operations. These results may be artifacts of counting statistics. Most results onsite and offsite were within the counting uncertainty of the analytical systems.

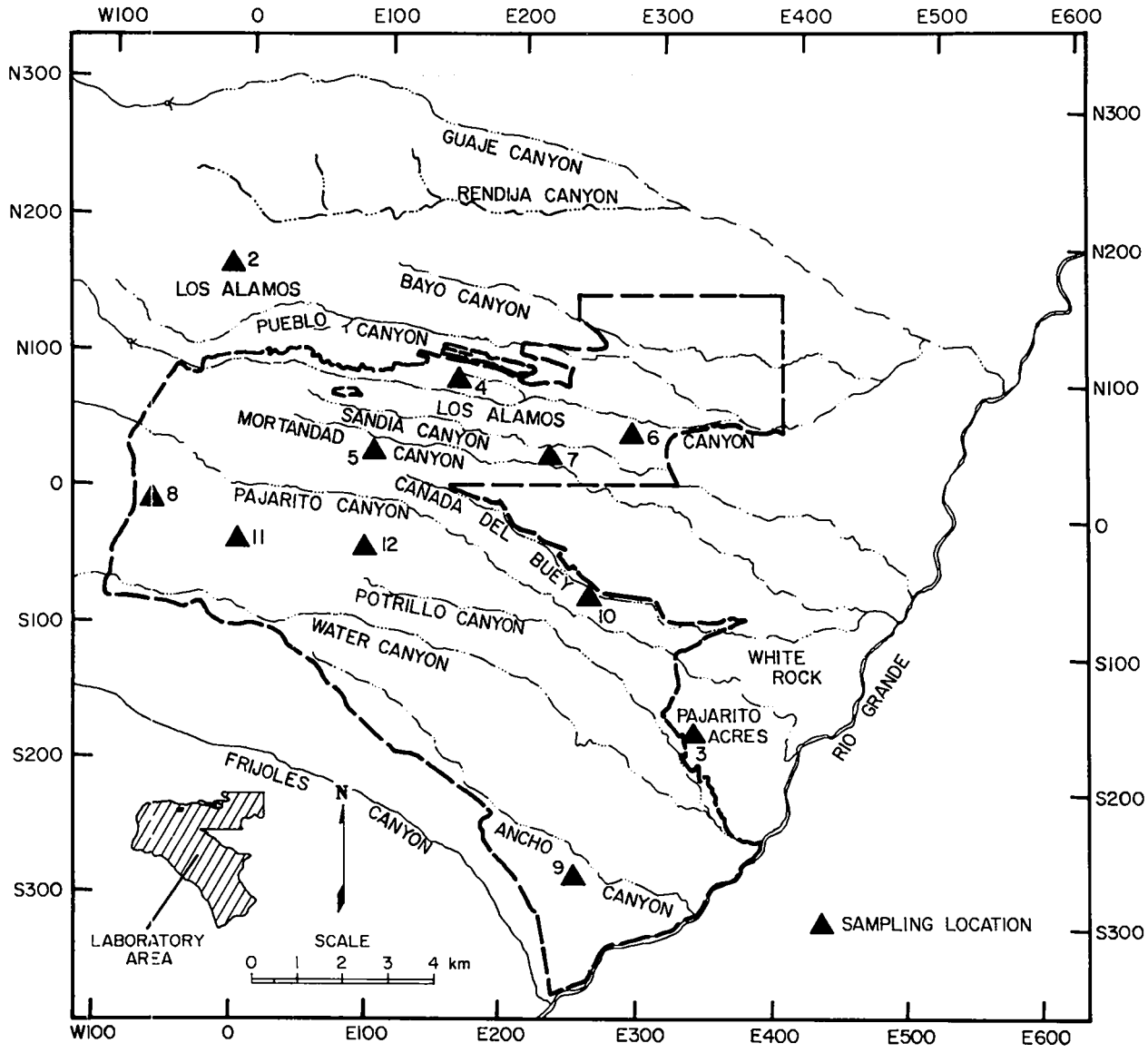

Fig. 23. Locations of beehives.

VIII. ENVIRONMENTAL COMPLIANCE

In accordance with the policy of the Department of Energy, the Laboratory complies with federal and state environmental requirements. These requirements address handling, transport, release, and disposal of hazardous materials as well as protection of ecological, archaeological, historical, atmospheric, and aquatic resources. The Laboratory is currently 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 treated liquid discharge permit limits in 93% 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 1986. A total of 72 asbestos removal jobs were carried out by Laboratory contractors during the year, and appropriate notification was provided to state regulators. Concentrations of constituents in the drinking water distribution system remained within federal water supply standards, although a few constituents exceeded limits at the wellhead. The Laboratory carried out two mitigation actions at cultural sites. During 1986, 38 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) mandates 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 to reduce hazardous waste volume and toxicity and to minimize land disposal of hazardous waste. Major requirements under HSWA that impact waste handling at the Laboratory are presented in Table 23.

The EPA granted New Mexico interim RCRA authorization on September 30, 1983, transferring regulatory control of hazardous wastes from EPA to the state's Environmental Improvement Division (NMEID). State authority for hazardous waste regulation is the New Mexico State Hazardous Waste Act and Hazardous Waste Management Regulation (HWMR). Although NMEID received final authorization in January, 1985, it has not yet obtained authorization for implementing the 1984 RCRA amendments. An amendment to the state's Hazardous Waste Act is being presented to the 1987 state legislature to pave the way for the authorization.

The Laboratory produces a wide variety of hazardous wastes. Discarded laboratory chemicals include a number 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

Table 23. 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:

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

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 explosive-contaminated sludges that are thermally treated onsite.

2. **Permit Application.** The Los Alamos Area Office of DOE has submitted both Part A and Part B applications under RCRA and the New Mexico Hazardous Waste Act for the Laboratory (Table 24). The original Part A was submitted in 1980, but a revised Part A application was submitted in 1986 to respond to changes in waste handling, comments from NMEID, and changes in regulations. In 1984, EPA and NMEID requested submission of DOE's RCRA Part B application. A formal Part B application was submitted on May 1, 1986, although drafts had been reviewed previously. On May 29, 1986, the NMEID issued a Notice of Deficiency (NOD) and, on October 14, 1985, a Notice of

Table 24. Environmental Permits Under Which the Laboratory Operated in 1986

Type	Permitted Activity	Issue Date	Expiration Date	Administering Agency
RCRA Hazardous Waste Facility	Hazardous Waste Handling	Revised Application Submitted November 1986	...	NMEID[a]
PCB	Disposal of PCBs	June 5, 1980	...	EPA[b]
PCB Oil	Incineration of PCB Oils	May 21, 1984	...	EPA
NPDES-Los Alamos	Discharge of Industrial and Sanitary Liquid Effluents	March 1, 1986	March 1, 1991	EPA
NPDES-Fenton Hill	Discharge of Industrial and Sanitary Liquid Effluents	October 15, 1983[c]	...	EPA
Ground Water Discharge Plan-Feton 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	NMEID
Open Burning	Burning of TA-22-1	January 17, 1985	...	NMEID
Open Burning	Burning of TA-16-525	November 22, 1985	...	NMEID

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

Violation (NOV) resulting from the administrative review of the Part B. A response was submitted to the NMEID for the NOD on July 2, 1986. Response to the NOV was submitted November 13, 1986. The DOE submitted revised Parts A and B in November 1986. The revised applications are currently under review by NMEID.

Landfilling of hazardous wastes was discontinued in 1985, and existing landfills will be closed under interim authority after the NMEID approves closure plans, which have been submitted. Storage facilities holding wastes for less than 90 days need not obtain a Part B permit. All facilities listed in Table G-49 as having interim status, but not included in the Part B Application, must be closed before the Part B is approved.

3. 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. They are therefore subject to RCRA regulation. A groundwater monitoring waiver application for both Area L and Area G was submitted to the NMEID 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 a May 7, 1985, 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 (Sec. IX.C). New Mexico's EID stated on November 5, 1985, that DOE and the Laboratory had demonstrated that there was 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 help 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. Quarterly reports of the pore gas sampling and perched water analysis have been submitted to the EID.

Table G-49 lists several storage areas and one thermal treatment area currently under interim status but for which a Part B permit is not being sought. Area 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. Areas 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 has been closed to waste detonation and converted to experimental detonations. Any scrap generated will be handled at other detonation sites included in the Part B application. Closure plans for these facilities have been submitted to NMEID.

A controlled air incinerator with interim status for treating hazardous waste is located at TA-50-37. A trial burn was conducted in October 1986. The raw data were submitted to the NMEID in December 1986 and a final report for the test burn will be submitted on or before March 8, 1987. These data and report will support the laboratory's application for a hazardous waste permit for this facility.

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 EPA's Extraction Procedure (EP) toxicity limit for barium. Information on Area P was submitted to the NMEID and a closure/post-closure

plan submitted on November 25, 1985. Disposal of wastes at Area P has been discontinued. A more detailed waste-site closure plan and a design package have been put together and are in the draft stages. This will be submitted to the NMEID in 1987.

An inventory of underground storage tanks was submitted to the NMEID on May 5, 1986, in accordance with the Hazardous and Solid Waste Amendments. A total of 105 tanks may be regulated under Subtitle I of RCRA. Leak testing was conducted on 27 petroleum tanks. About half of the tanks were found to be leaking and required corrective action. The major leaks have been corrected.

In January, 1986, EPA/NMEID conducted a joint hazardous waste compliance inspection. No major violations were noted. The EPA was the lead agency for this inspection.

A complete listing of interactions between the NMEID, DOE, and the Laboratory in 1986 is given in Table G-50.

B. Clean Water Act

1. Laboratory Liquid Waste 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 establishes 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 24). Both permits are issued and enforced by EPA Region VI, Dallas, Texas. However, through a federal/state agreement and grant, NMEID performs compliance monitoring and reporting as agents for EPA.

The NPDES permit in effect for the Laboratory in 1986 (NM0028355) was reissued March 1, 1986, and expires March 1, 1991 (the prior permit was to expire September 9, 1986, and was supplanted upon the Laboratory's reapplication early in 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 seven categories of wastewater effluent (Table G-51).

Weekly sampling results are tabulated in a Discharge Monitoring Report (DMR) and submitted through DOE to EPA and NMEID on a monthly basis. Deviations from NPDES permit limitations are also explained separately to EPA and NMEID with the monthly DMR submittal (Tables G-52 through G-54). During 1986, 93% and 97.5% of monitoring analyses complied with NPDES limits at sanitary and industrial outfalls, respectively (Fig. 24).

2. Federal Facility Compliance Agreement. On June 19, 1986, a meeting was held with EPA and DOE's Los Alamos Area Office (LAAO) to negotiate a second-round Federal Facility Compliance Agreement (FFCA). On July 18, 1986, the FFCA was signed by DOE/LAAO and became effective. The FFCA contains interim effluent limitations and a schedule of compliance for several outfalls and outfall categories that had experienced frequent noncompliance with the NPDES permit limitations (Tables G-55 and G-56). Throughout 1986, required FFCA quarterly progress reports reflected that the Laboratory was well ahead of schedule in meeting final compliance milestones, with the exception of corrective actions on outfall 06S at TA-41, which were delayed due to construction contract negotiations.

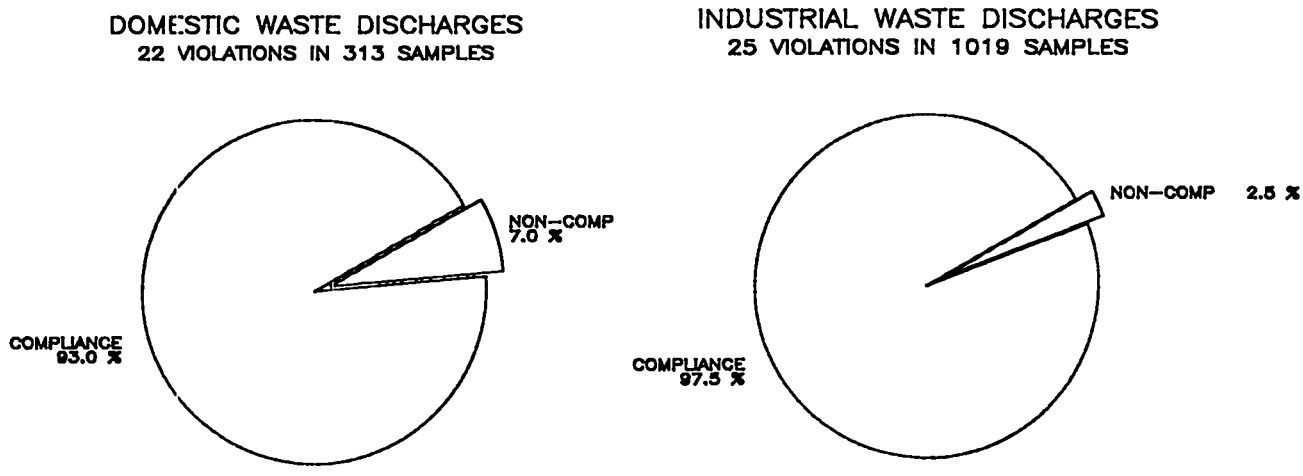

Fig. 24. 1986 Summary of Clean Water Act Compliance, NPDES Permit NM0028353.

3. **Clean Water Act Audits.** The EPA conducted two audits under the Clean Water Act during 1986 (Table 25). An EPA Compliance Evaluation Inspection (CEI) was conducted on March 10, 1986, in conjunction with NMEID representation; and a compliance inspection reviewed the status of FFCA subject NPDES outfalls on June 19, 1986.

On May 15, 1986, a tour of NPDES outfalls was conducted for the U.S. Department of Interior, Bureau of Indian Affairs (Albuquerque Area Office), and the Pueblo de San Ildefonso. Both parties were interested in the recent NPDES permit reissuance and the number of NPDES outfalls that potentially discharge treated effluents into drainages that cross pueblo lands.

4. **Administrative Order.** On February 12, 1985, EPA Region VI issued an Administrative Order (AO) to DOE regarding NPDES Permit NM0028355. The AO was based on self-monitoring reports submitted by the Laboratory that identified a number of individual parameter violations occurring at outfalls during 1984.

The 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, 07S, 08S, 10S, and 11S.

On February 10, 1986, a letter from DOE to EPA detailed the corrective actions that had been completed on outfall 09S. On October 15, 1986, EPA issued notice to DOE that, based on the previously submitted information, the AO was closed.

5. **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 24). The NPDES permit NM0028576 was issued October 15, 1979, with an expiration date of June 30, 1983. Although the Laboratory applied for permit

Table 25. Environmental Appraisals Conducted at the Laboratory in 1986

Day	Purpose	Performing Agency
January 28-29	Hazardous Waste Management Inspection	New Mexico's Environmental Improvement Division (EID) and U.S. Environmental Protection Agency (EPA)
January 27-31	Review of Environmental Monitoring Program	Albuquerque Operations Office U.S. Department of Energy (ALO/DOE)
January 27-29	Reconnaissance Survey of Zia Motor Pool	Laboratory'sEnvironmental Surveillance Group, HSE-8
March 10	NPDES Compliance Evaluation Inspection	EPA and EID
May 1	Inspection of Air Pollution Compliance	EPA and EID
June 19	Compliance Inspection Federal Facility Compliance Agreement	EPA
October 27	Evaluation of RCRA Permit	EID

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 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, OCD approved the discharge plan (GW-31) for the Fenton Hill Geothermal Project (Table 24). The discharge plan approval is for a period of 5 years, and the 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 1987 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 date. There was approximately 17 000 m^3 (4 500 000 gal) of discharge from the geothermal loop to the pond during 1986.
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 1986.

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

6. Spill Prevention Control and Countermeasure (SPCC) Plan. During 1986, the Laboratory continued to prepare a Comprehensive Spill Prevention Control and Countermeasure (SPCC) Plan and Compliance Recommendation Report (CRR) for the Laboratory. Final drafts of the two documents were completed on September 30, 1986. Both documents are pending further technical and administrative review, and are expected to be formally adopted early in 1987.

The SPCC Plan addresses facilities improvements (e.g., dikes, berms, or other secondary spill containment measures), operational procedures, and mechanisms for reporting of hazardous substances and oil spills to the appropriate managerial and regulatory authorities. The CRR evaluates each Laboratory Technical Area and makes 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.

During 1985 and 1986, surveys and inventories of regulated substances were conducted at all of the Laboratory's Technical Areas. Regulated substances inventoried (in decreasing order of quantity) include: dielectric oils in drums; acids and bases in tanks; photographic chemicals in shipping containers and plastic vats; and toxic chemicals (approximately 210 compounds).

Although the SPCC Plan is pending formal adoption early in 1987, conceptual engineering design work was initiated during September, 1986, for 20 sites identified in the SPCC Plan as requiring corrective actions to prevent spills. Conceptual engineering designs will be available early in 1987, and will guide further detailed designs and construction of spill control and prevention structures.

C. National Environmental Policy Act (NEPA)

The National Environmental Policy Act of 1969 (NEPA) requires that proposed federal actions be evaluated for their potential environmental impacts. The DOE's 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 any further NEPA documentation. Further documentation is carried out at the request of DOE and may consist of either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). The Laboratory Environmental Review Committee (LERC) reviews

NEPA documentation. A Laboratory Environmental Evaluation Coordinator assists project personnel to prepare the appropriate documentation and present it to the committee.

The LERC approved 2 Environmental Remarks, 33 ADMs, and 3 EAs in 1986. An additional EA was forwarded to DOE without formal LERC review. Table G-57 tabulates these documents by Laboratory Technical Area.

D. Clean Air Act

1. Federal Regulations

a. National Emissions Standards for Hazardous Air Pollutants (NESHAPS). This regulation sets reporting, emissions control, disposal, stack testing, and other requirements for specified operations involving hazardous air pollutants. New Mexico EID has responsibility for administering these regulations. Currently, the following air pollutants are listed under NESHAPS: radionuclides, asbestos, benzene, beryllium, inorganic arsenic, mercury, and vinyl chloride. Laboratory operations that could be regulated by NESHAPS include asbestos removal, primarily from heating, air conditioning and ventilation systems, beryllium machining, and radionuclide handling.

Under the authority of the Clean Air Act, EPA has promulgated regulations for control of airborne radionuclide 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 (Sec. III). Further discussion is presented in Appendix A. In late 1986, DOE and the Laboratory submitted to EPA an application for an air emissions permit for construction and operation of the proposed Ground Test Accelerator facility at TA-53. Parts of the application are still under review.

Notification, emission control, and disposal requirements for operations involving the removal of friable asbestos are specified under the NESHAPS regulations. This year the NMEID required asbestos disposal certification forms be filled out and sent to them for each large asbestos removal job and an annual one for all small renovation jobs. Six forms, including the annual notification for the small jobs, were completed and sent to the NMEID. Asbestos wastes are disposed of at TA-54.

Asbestos materials were widely used in buildings constructed prior to the early 1970s. These materials are being replaced by safer materials such as fiberglass insulation and are removed from buildings prior to their demolition. During 1986, 72 asbestos jobs involved the removal of 1476 m (4844ft) of asbestos materials on pipe and 187 m^2 (2010 ft^2) on other facility components. This required disposal of 282 m^3 (9962 ft^3) of asbestos contaminated wastes. Except for one removal by a DOE contractor, these removals were done by the Pan Am World Services. Ninety percent of the asbestos removal jobs, including 49.1% of the length of asbestos removed from pipe and 9.8% of the volume of asbestos removed from other facility components, involved small renovation jobs that require no job-specific notification to the state.

The NESHAPS includes notification, emission limit, and stack performance testing requirements for beryllium machine shops. Permits were issued by New Mexico's EID for two beryllium machine shops. Three

beryllium machine shops, including one permitted in December, 1985, passed their stack performance tests during 1986.

b. National Ambient Air Quality Standards. Federal and state Ambient Air Quality Standards are shown in Table 26. Based upon available monitoring data and modeling, there has not been an exceedance of federal nor state Ambient Air Quality Standards caused by Laboratory sources (Sec. V). Pollutants emitted by Laboratory sources 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, the lead pouring facility, chemical usage, the burning and detonation of high explosives, and the burning of potentially high-explosive contaminated wastes (Sec. V).

c. Prevention of Significant Deterioration (PSD). The 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 the construction of any new major stationary source or major modification located near a Class I Area, such as Bandelier National Monument's Wilderness Area. The DOE and Laboratory have not been subject to PSD.

d. New Source Performance Standards (NSPS). The NSPS applies to 72 source categories. Its provisions include emission standards, notification, and emission testing procedures and reporting and emission monitoring requirements. The DOE and Laboratory have not been subject to NSPS. A proposed solid-waste-fired-boiler would easily meet NSPS for incinerators.

2. State Regulations

a. New Mexico Air Quality Control Regulation (NMAQCR) 201. The NMAQCR 201 sets ambient air quality standards discussed above.

b. NMAQCR 301. NMAQCR 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. The DOE and Laboratory are permitted to burn waste explosives and explosive contaminated wastes. The burning of waste explosives is done at the TA-16 burn ground. The burning of potentially, high explosive, contaminated wastes is done at the TA-16 open incinerator. Because of requirements under RCRA, this year a burn permit was submitted and issued for the TA-16 open incinerator. The permit must be renewed during 1987.

There are plans to replace the open incinerator with an enclosed incinerator with two-stage combustion. The enclosed incinerator has been purchases and it is planned to be delivered and installed during 1987. Complete combustion would occur within the two-stage incinerator. An air pollution health and regulatory compliance review was completed for the planned incinerator. The estimated ambient air pollutant concentrations are not a health concern. Estimated emissions are too low to require either a permit or registration.

c. NMAQCR 401. The NMAQCR 401 controls smoke and visible emissions. No Laboratory source was subject to this regulation during 1986.

Table 26. 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	0.10	0.14	
	3 hour[a]	ppm			0.5
Total Suspended Particulates	Annual Geometric Mean	ug/m^3	60	75	60
	30 days	ug/m^3	90		
	7 days	ug/m^3	110		
	24 hour[a]	ug/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	ug/m^3	1.5	1.5	1.5

Table 26 (cont)

Pollutant	Averaging Time	Units	New Mexico	Federal Primary	Federal Secondary
Beryllium	30 days	ug/m^3	0.01		
Asbestos	30 days	ug/m^3	0.01		
Heavy Metals (Total Combined)	30 days	ug/m^3	10		
Non-Methane Hydrocarbons	3 hour	ppm	0.19		

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[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.

d. NMAQCR 501. The NMAQCR 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 Pan Am World Services is subject to this regulation. This plant is old, subject to leaking, and is inspected semiannually. During one of the two inspections that took place during 1986, leaks causing fugitive emissions were discovered. Pan Am repaired the leaks.

The asphalt plant meets the stack emission standard for particulates as specified in this regulation. The plant, which has a 75 ton/h capacity, is required to meet an emission limit of 35 lb particulates per hour. A stack test of the asphalt plant in 1977 indicated an average emission rate of 1.8 lb/h and a maximum rate of 2.2 lb/h over 3 tests (Kramer 1977). Although the plant is old and not required to meet NSPS stack-emission limits for asphalt plants, it meets these standards (Kramer 1977).

e. NMAQCR 604. The NMAQCR 604 requires gas burning equipment built prior to January 10, 12973 to meet an emission standard for 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 potential to operate at heat inputs that exceed the 10^{12} Btu\yr\unit but have not operated beyond this limit. Thus, these boilers have not been subject to the requirements of this regulation. In 1986, the power plant's boilers, numbered 1, 2, and 3, consumed 0.5, 0.7, and 0.1 x 10^{12} Btu of natural gas, respectively.

Because the power plant has the potential to be subject to this regulation, the DOE and Laboratory are required by NMEID to submit an annual fuel consumption report for the plant. This report for 1986 was submitted to NMEID during January 1987.

The TA-3 power plant meets the emission standard under NMAQCR 604, although it is not required to do so. The emission standard is equivalent to a flue gas concentration of 248 ppm. The TA-3 boilers meet the standard with measured flue gas concentrations of between 14 and 22 ppm. These concentrations are between 6-9% of the equivalent standard, respectively.

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

When new Laboratory air pollutant emission sources or modifications to existing sources are planned, an air pollution health and regulatory compliance review is carried out. This review evaluates the need for air pollution controls and operating procedures for maintaining low ambient air pollutant concentrations. Also, this review evaluates the steps to be followed to comply with state and federal air pollution regulations. As part of the permitting process, NMEID reviews new or modified sources for compliance with all state and federal air pollution regulations.

Under the existing regulation, three permits were issued by the NMEID during 1986. They were issued for the following hazardous air pollutant emission sources: the beryllium machine shops located at TA-3-39 and TA-3-102 and a beryllium-uranium oxide processing facility planned for TA-3-141. Beryllium operation planned for TA-3-141 have been modified requiring amendment to the permit.

As required by NMAQCR 702, stack tests for the Laboratory's three beryllium machine

shops were completed during 1986, including one located at TA-35-213 that was permitted during 1985. The stack emissions were all at least one to two orders of magnitude lower than the emission limits specified in the permit conditions.

g. Other Regulations. The NMAQCR 703 requires registration of any stationary source that emits more than 2000 lb per year of any contaminant. Several Laboratory sources have been registered (TA-3 power plant and the steam plants), but no sources required registration during 1986. The NMAQCR 707 is New Mexico's PSD regulation. Requirements of this regulation were previously discussed under the PSD section. The NMAQCR 750 adopts the Federal NSPS regulations, which were previously discussed. The NMAQCR 751 adopts the federal NESHAPS regulations, which were previously discussed.

3. Operational Improvements. Operational improvements that took place during 1986 included asphalt plant repairs and installation of air pollution controls for new sources, as discussed above.

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

1. Background. The federal Safe Drinking Water Act (42 U.S.C. 300 (f) 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 NMEID. During 1986, chemical quality reports regarding trihalomethane and inorganic chemical concentrations in the Laboratory's water supply were submitted to New Mexico's EIB pursuant to NMEID regulations. Municipal and industrial water supply for the Laboratory met EIB regulations.

The main aquifer is the only aquifer in the area capable of municipal and industrial water supply (Sec. II). Water from the Laboratory and community is supplied from 17 deep wells in 3 well fields and 1 gallery. The well fields are on Pajarito Plateau and in canyons east of the Laboratory (Fig. 25). The gallery is west of the Laboratory on the flanks of the mountains. Production from the wells and gallery for 1986 was 5.8×10^9 L (1.5×10^9 gal).

The Los Alamos well field is composed of five producing wells and one standby well. 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 (8869 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. During 1986, Well G-5 was down for repairs and was not sampled. Wells in the field range in depth from 463 to 610 m (1520 to 2000 ft). Movement in water in the upper 430 m (1410 ft) of the aquifer

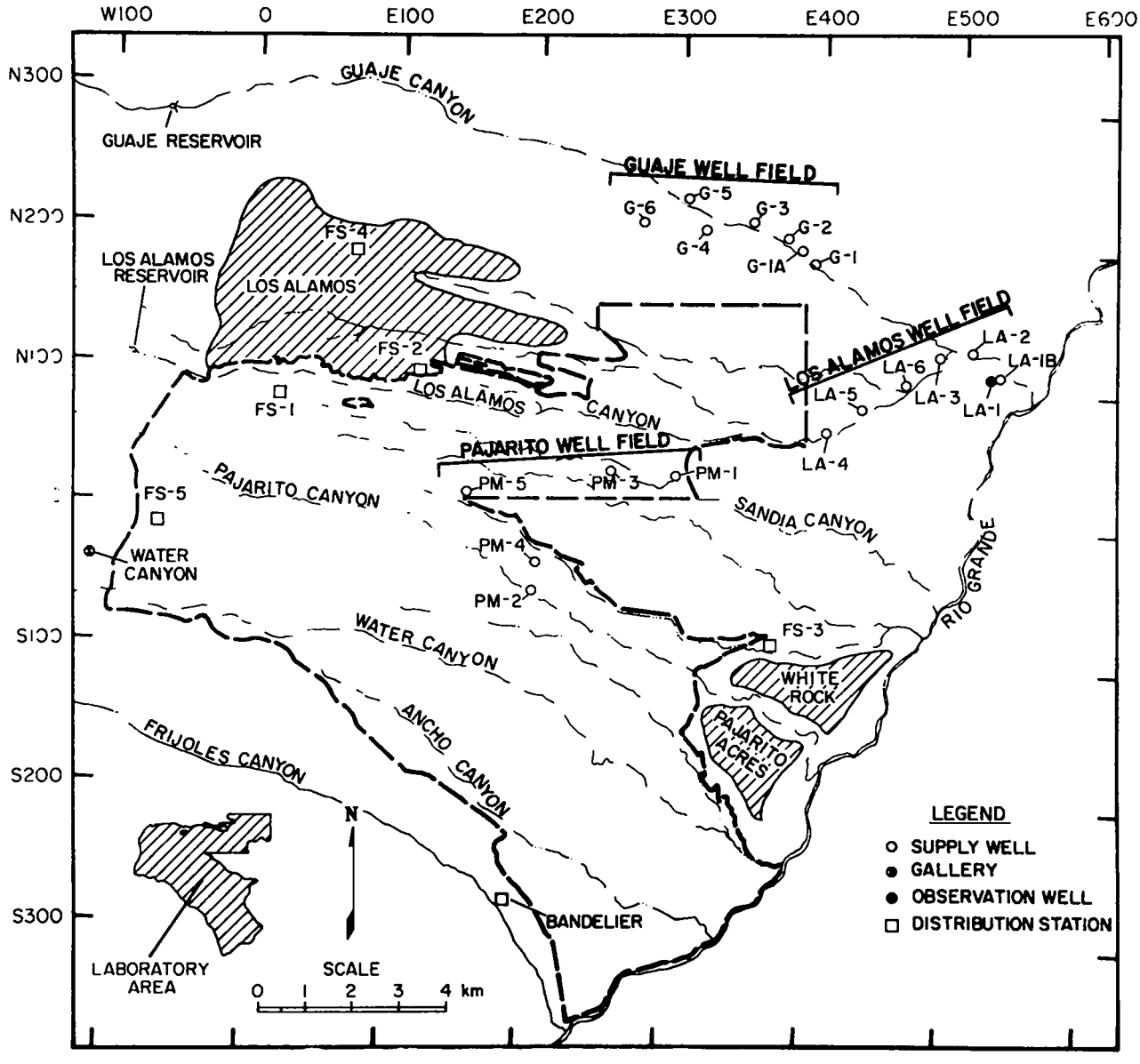

Fig. 25. Locations of reservoirs, well fields, supply wells, and gallery water supply.

is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

The Pajarito well field is composed of five wells. Well PM-4 was down for repairs during a part of 1986 and was not sampled. 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 from 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 1986 the well produced about 22 x 10^6 L (5.8 x 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 listed 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). Although 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 in compliance with the EPA's National Interim Primary Drinking Water Standards (Tables 27, G-58, and G-59).

3. Chemical Quality of Municipal and Industrial Water Supply. Water from most wells and the distribution systems complied with EPA's primary and secondary standards (Tables 28 and G-60 through G-62). Maximum concentrations of fluoride from Well LA-1B were at or above primary standards (Table 28). However, mixing in the distribution system reduced concentrations to acceptable levels. The fluoride occurs naturally in the aquifer.

The quality of water from the wells varied with local conditions within the same aquifer (Tables G-60 through G-62). 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 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 1986.

G. Archaeological and Historical Protection

Laboratory lands contain about 500 known archaeological and historical sites. Protection of cultural resources is mandated by numerous laws and regulations, including the National Historic Preservation Act of 1066 (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.

Table 27. Maximum Concentrations of Radioactivity in Municipal Water Supply, Well and Distribution System

	Number of Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µ/L)	^{238}Pu (10^{-9} µCi/mL)
Analytical Limits of Detection	--	0.7	40	1.0	0.009
Maximum Contamination Level (MCL)[a]	--	20	200	1800[b]	15
Wells	16	0.1	165	5.1	0.021
	--	(<1%)[c]	(82%)	(<1%)	(<1%)
Distribution System (Los Alamos)	6	1.4	5.9	7.0	0.025
	--	(7%)	(30%)	(<1%)	(<1%)
Distribution System (Fenton Hill)	1	1.6	61	1.0	−0.004
	--	(8%)	(30%)	(<1%)	(<1%)

Table 27 (cont)

	Number of Stations	239,240 Pu (10^{-9} µCi/mL)	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Analytical Limits of Detection	--	0.03	3	3	50
Maximum Contaminant Level (MCL)[a]	--	15	15[d]	--	--
Wells	16	0.012	11	1.9	360
	--	(<1%)	(73%)	--	--
Distribution System (Los Alamos)	6	0.022	3.0	5.6	60
	--	(<1%)	(20%)	--	--
Distribution System (Fenton Hill)	1	0.032	3.0	5.4	20
	--	(<1%)	(20%)	--	--

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[a]EPA (1976).

[b]Level recommended by International Commission on Radiological Protection.

[c]Percentage of EPA's MCL.

[d]Environmental Protection Agency's Maximum contaminant Level (MCL) for gross alpha is 15 x 10^{-9} µCi/mL. However, gross alpha results in the system that exceed EPA's limit of 5 x 10^{-9} µCi/mL require isotopic analysis to determine radium content.

Table 28. Maximum Chemical Concentrations in Water Supply and Distribution Systems (results in mg/L)

Inorganic Chemical Contaminant	Standards	Supply: Well and Gallery	Supply: Per Cent of Standard	Distribution: Los Alamos Bandelier TA-57	Distribution: Per Cent of Standard
Primary[a]					
Ag	0.05	<0.001	<2	<0.001	<2
As	0.05	0.039	78	0.017	34
Ba	1.0	0.104	10	0.057	6
Cd	0.01	0.0004	4	0.0005	5
Cr	0.05	0.024	48	0.011	22
F	2.0	3.3	165	0.8	40
Hg	0.002	<0.0002	<10	<0.0002	<10
NO_3(N)	10	1.7	17	0.3	3
Pb	0.05	0.009	18	<0.002	4
Se	0.01	<0.003	<30	<0.003	<30
Secondary[b]					
Cl	250	17	7	8	3
Cu	1.0	0.019	2	0.023	2
Fe	0.3	0.049	16	0.020	7
Mn	0.05	<0.001	<2	<0.001	<2
SO_4	250	40	16	114	46
Zn	5.0	0.03	<1	0.14	3
TDS	500	456	91	234	47
pH	6.5 - 8.5	8.5	100	8.3	98

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

The Laboratory Environmental Evaluation Coordinator oversees management and protection of cultural resources.

The Laboratory's archaeologists survey construction sites in advance to determine the presence or absence of cultural resources. During 1986, the Laboratory conducted 32 cultural resource surveys, monitored construction at 3 sites, had permanent protective fencing erected at 1 site, and undertook adverse impact mitigation at 2 sites. Archaeologists and botanists continued data analysis of artifacts salvaged from historic Romero Cabin complex. A historic cabin, the Pond Cabin, was given emergency stabilization, and grates were placed over two unique cavates to provide protection from vandalism.

Pursuant to federal regulations implementing Section 106 of the National Historic Preservation Act of 1966, as amended, clearance for construction and mitigation of unavoidable adverse impact to cultural resources is determined in consultation with the New Mexico State Historical Preservation Office and, if necessary, by the Advisory

Council on Historic Preservation. The State Historical Preservation Office was consulted concerning potential impact to six projects; the Advisory Council was consulted concerning one of these projects.

H. Threatened/Endangered Species and Floodplains/Wetlands Protection

The DOE and Laboratory must comply with the Endangered Species Act of 1973, as amended, 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. No floodplain/wetlands notifications were published in 1986. The Laboratory's biologists surveyed 12 proposed construction sites for potential impact. They identified no endangered or rare animal or plant species at these sites. The Laboratory also conducted a biological assessment of potential threat to a local peregrine falcon (*Falco peregrinus anatum*) aerie from one proposed project; this project was later sited elsewhere. The peregrine is an endangered species as listed by the federal government. Information concerning local threatened and endangered plant species was transmitted to Bandelier National Monument.

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

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 mandated cleanup of toxic and hazardous contaminants at closed and abandoned hazardous waste sites. On October 17, 1986, President Reagan signed into law the Superfund Amendments and Reauthorization Act (SARA) of 1986, Pub. L. No. 99-499. Major goals of SARA include a faster pace of cleanup standards, with an emphasis on achieving remedies that permanently and significantly reduce the mobility, toxicity, or volume of wastes. The SARA significantly expands the powers and responsibilities of EPA. The 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 CERCLA-related action at hazardous waste sites at the Laboratory are being addressed under the Comprehensive Environmental Assessment and Response Program (CEARP) begun by DOE's Albuquerque Operations Office in 1984.

J. Toxic Substances 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 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 parts per million (ppm) and above. At the Laboratory, materials with >500 ppm PCBs are transported offsite for incineration.

During 1986, the Laboratory continued to inventory and mark PCB articles such as transformers and capacitors. The Laboratory's in-service inventory of PCB-contaminated transformers (>500 ppm PCB), PCB transformers (>50 but <500 ppm PCB), and PCB capacitors includes 141, 144, and 3678 units, respectively, as of July 1, 1986. A visual inspection of PCB transformers was conducted at least quarterly during 1986, and inspection records maintained pursuant to the regulations.

The DOE and 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 24). The approval requires semiannual reporting to EPA regarding the type and weight of disposed PCB articles, and monitoring information regarding chemical quality of storm water runoff and natural springs in the area. The cumulative weights of specific types of PCB articles, which were disposed at TA-54 during 1986, are listed in Table 29.

Table 29. Quantities (kg) of PCB Contaminated Articles Discarded at TA-54 in 1986[a]

PCB Article(s)	Shaft C11	Shaft C12	Pit 29	Pit 32
Transformer Carcases			1 436	4 268
Absorbed PCB Oil (<500 ppm)	453			45
Rags/Dirt (drummed)	3 377			793
Empty Drums			62	
Asphalt/dirt				45
(noncontainerized)			5 987	422 571
Capacitors				3 622
Generators				1 361
Power Supply			866	5 542
PCB Clean-Up Drum		587		
PCB Contaminated Equipment			4 082	
Misc			2 054	3 221
Total	3 830	587	10 405	445 550
Grand Total	462 172			

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

K. Engineering Quality Assurance

The Laboratory has a Quality Assurance program (Facilities 1983) for engineering, construction, modification, installation, and maintenance of DOE 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 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 DOE's program division, the DOE's Albuquerque Operations, and Los Alamos Area Offices, the Laboratory's operating group(s), the Laboratory's Facility Engineering Division, design contractor, inspection organization, and construction contractor. Each proposed project is reviewed by personnel from the Environmental Surveillance Group (HSE-8) to ensure environmental integrity is maintained.

IX. ENVIRONMENTAL SUPPORT ACTIVITIES

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

A. Meterological Monitoring (B. Bowen, J. Dewart, W. Olsen, I. Chen, and C. Bender)

1. Weather Summary. Los Alamos received heavy precipitation for the second consecutive year, with over 24 in. (60 cm) of water equivalent falling during 1986. Record rainfall of 5.7 in. (14.5 cm) fell in June, while only 0.01 in. (0.03 cm) fell during January. Snowfall, unlike the previous several years, was near normal. There were also large departures from normals in temperature throughout the year. January became the warmest on record. Mild weather continued through February, making the winter of 1985-1986 (December-February) the second warmest on record. Unusually warm weather returned in March. Arctic air made an early arrival in October, giving Los Alamos record cold and snow. The year as a whole had above-normal temperatures (Fig. 26, Tables G-63 through G-65).

A persistent high-pressure system centered over the southwestern United States brought record warm temperatures and very little precipitation during January. The month became the warmest January on record, with a mean temperature of 37.6°F (4.2°C), 8.5°F (4.7°C) above the normal. The daily high temperature for the month averaged 51.1°F (4.2°C), almost 11.5°F (6.4°C) above the normal. Record temperatures were set on 5 days during the last two weeks of the month, including 60°F (15.6°C) on the 19th. Precipitation was scant at 0.01 in. (0.03 cm), the lowest total for a January except for 1928, when no precipitation was recorded. Likewise, snowfall was only 0.2 in., the least since 1928 when none fell. The warm weather extended into February, with a mean temperature of 36.0°F (2.2°C), nearly 4°F (2.2°C) above normal. Several high temperatures records were set on the 18th and 19th, with the 68°F (20°C) on the 19th setting a record for the highest in February and for so early in the season. Several storms dropped heavy snow on Los Alamos on the 6-7th and on the 9th. The total snowfall for the month was 19 in. (48 cm), nearly 3 times the normal. The winter of 1985-1986 (December-February) became the second warmest on record, only slightly cooler than the winter of 1980-1981.

A strong high-pressure system over the southwest once again dominated the Los Alamos weather during March. High temperatures for the month averaged 57.1°F (13.9°C), almost 8.5°F (4.7°C) above normal. High temperature records were set or tied on 12 days during the month. The mercury reached 60°F (16°C) or higher on 17 days and 70°F (21°C) or higher on 4 days. The 71°F (22°C) on the 27th also tied the record for highest temperature in the month of March. Several storms moved through New Mexico during the month, including one that caused a peak wind of 69 mph (101 km/hr)

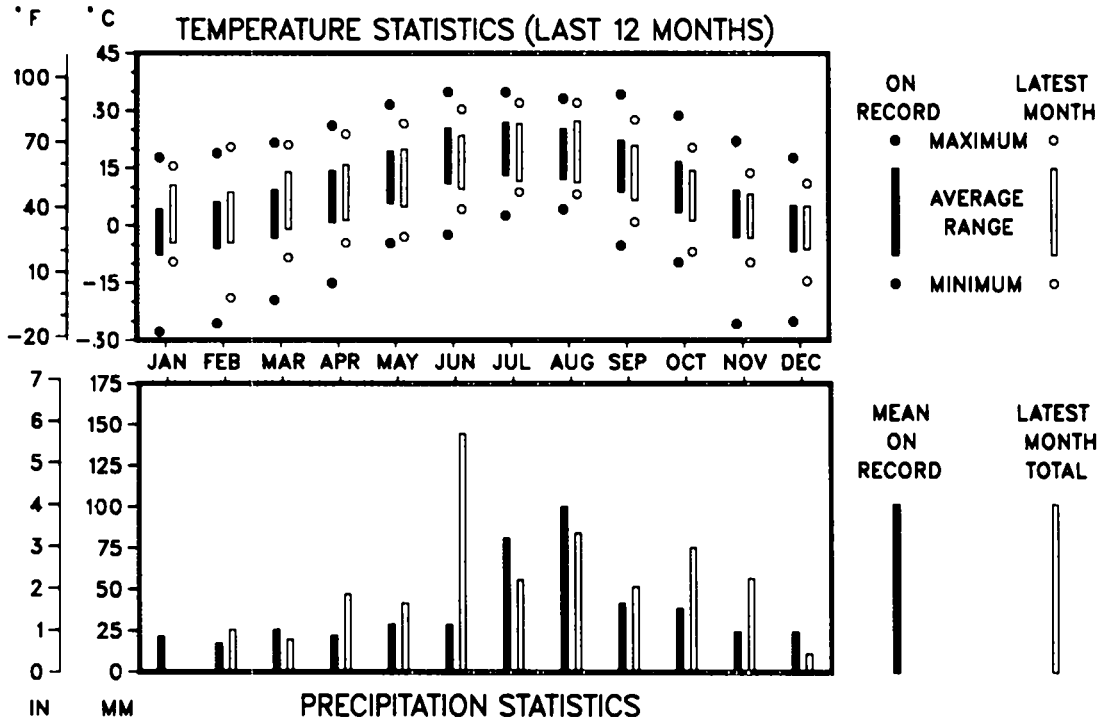


Fig. 26. Summary of 1986 weather in Los Alamos (data from Occupational Health Laboratory, OHL, TA-59.

to occur on the 9th. The strong high pressure system gave way to a stormy April, with 1.85 in. (4.7 cm) of precipitation falling during the month. Weather was uneventful during May, except for 2.0 in. (5.1 cm) of snowfall on the 17th.

Record wet weather occurred in June, as a strong high pressure system that caused a severe drought in the southeastern U.S. helped to stall storms over New Mexico. A total of 5.67 in. (14.4 cm) of rain fell during the month, edging out the previous record for June set in 1913. Strong thunderstorms produced heavy rains of 1.58 in. (4.01 cm) and hail on the 3rd. This was the second largest daily rainfall in June on record. Funnel clouds were also reported in Santa Fe on this day. Another 1.60 in. (4.06 cm) of rain fell on the 23rd-26th along with very cool temperatures. High temperatures only reached 57°F (13.9°C) and 61°F (16.1°C) on the 24th and 25th, respectively.

Rainfall was less than normal during the normally wettest months of July and August. Daytime temperatures were quite warm in August, with record high temperatures set on the 17th through 20th, including 90°F (32.2°C) on the 19th and 20. Temperatures changed to below normal during September, averaging over 4°F (2°C) below the normal. The low temperature dipped on 34°F (1.7°C) on the 11th, setting a daily record. A storm on the 24th and 25th produced several inches of snow in the Jemez Mountains while a few snow flakes were mixed with the rain at Los Alamos. The temperature reached only 49°F (9.4°C) for a high on the 24th.

Stormy and cold weather prevailed into October. A unusually strong storm for so early in the season brought 1.70 in. (4.31 cm)

of water equivalent on the 10th through 12th. As a surge of Arctic air plunged into New Mexico on the 11th, rain changed to snow. A total of 7 in. (18 cm) of powdery snow fell on the 11th and 12th. Record low temperatures were set for the dates of the 11th through 13th. The 21°F (-6.1°C) on the 12th and the 20°F (-6.7°C) on the 13th were also record lows for so early in the season. The high temperature of 28°F (-2.2°C) on the 12th also set a record for the lowest high temperature for so early in the season. Strong thunderstorms on the 20th produced heavy rains and hail, while there were reports of funnel clouds in Albuquerque. The precipitation of nearly 3 in. (7.6 cm) was twice the normal for October.

The wet weather continued into November, with much of the precipitation falling as rain. Precipitation totaled 2.23 in. (5.66 cm) during the month, over twice the normal. It was a quiet December, with light precipitation and snowfall.

2. Wind Roses. The 1986 surface wind speed and direction measured from sites at Los Alamos are plotted in wind roses for day, night, and total hours (Figs. 27 through 29). 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/s (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 sties.

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 11% at TA-50 to 18% at East Gate. Nearly 50% of winds at all sites were less than 2.5 m/s (5.5 mph).

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 fre-quency of SE through S winds during the day at OHL, TA-50, and East Gate (Fig. 26). Upslope winds are generally light, less than 2.5 m/s (5.5 mph). In contrast, winds are predominantly SSW and S 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 regional-scale winds by the valley contributes to the high frequency of SSW and S winds and to 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 WNW are evident at TA-59 and TA-50, respectively, while the drainage wind at Area G is evenly distributed from the WNW through the NNW. Note the predominance of winds from the N, probably because of channeling down the Rio Grande Valley. A nighttime maximum off N winds is also seen at East Gate. Another maximum of SSW and southwesterly winds is evident at East Gate because of

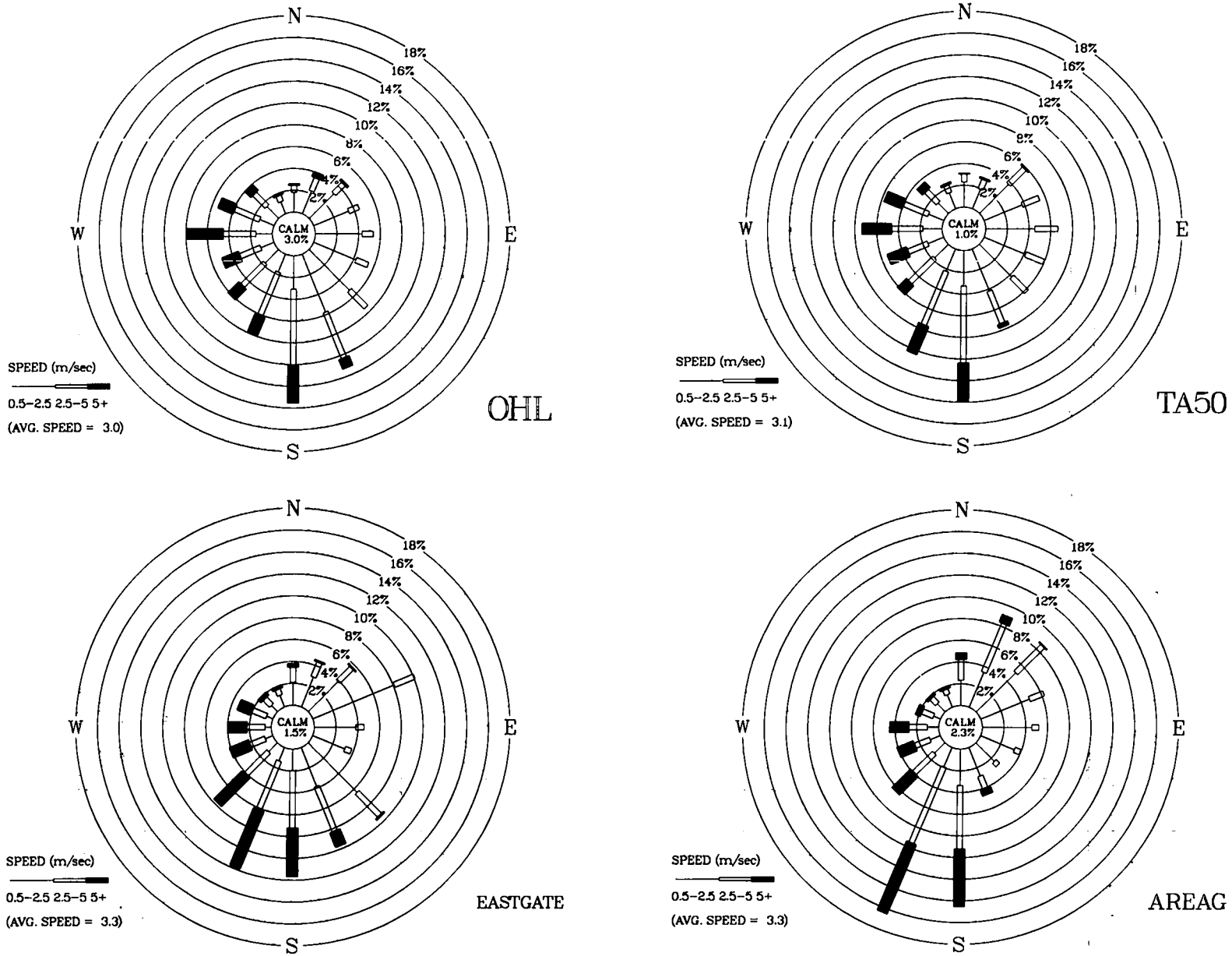


Fig. 27. Daytime wind roses at Laboratory stations during 1986.

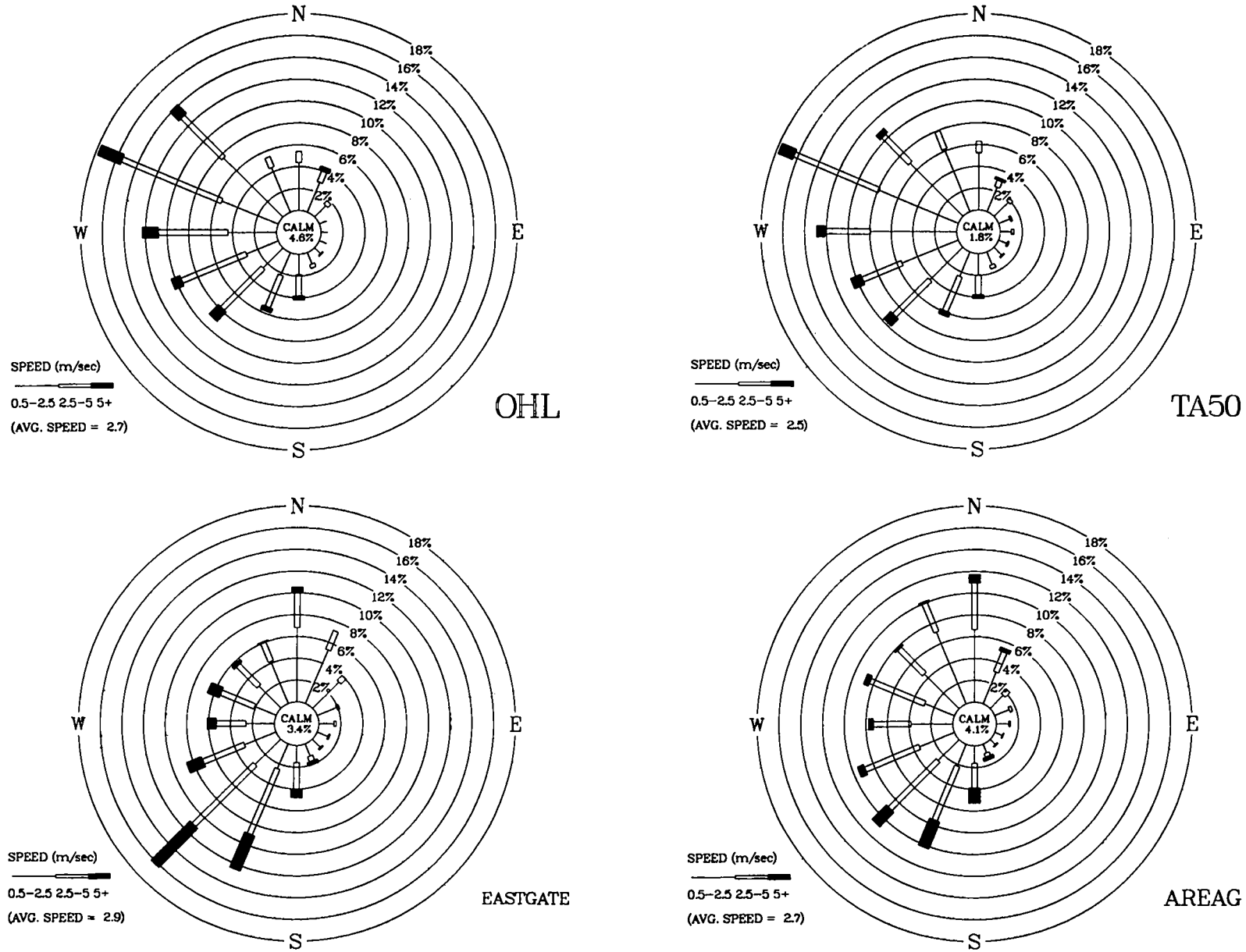


Fig. 28. Nighttime wind roses at Laboratory stations during 1986.

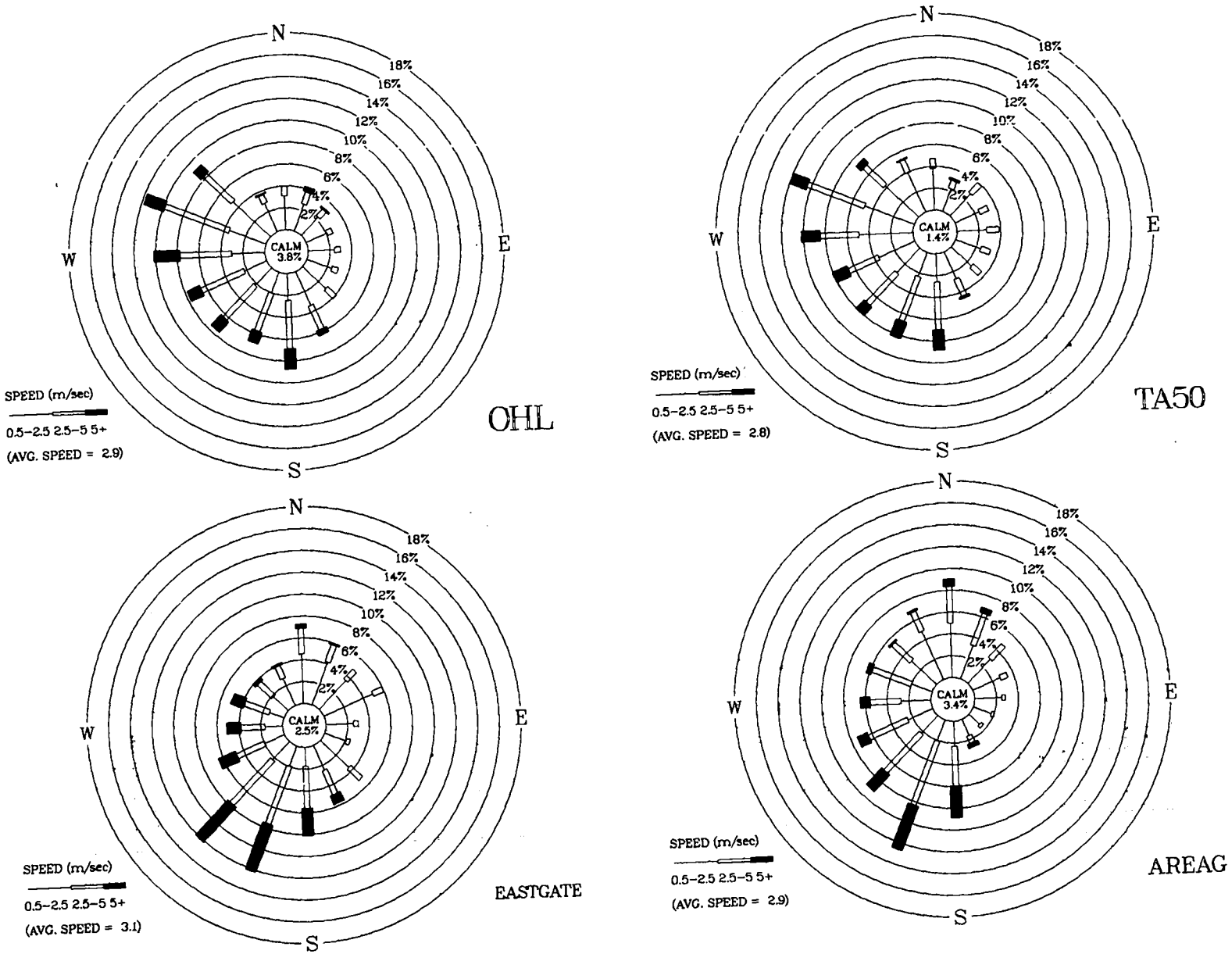
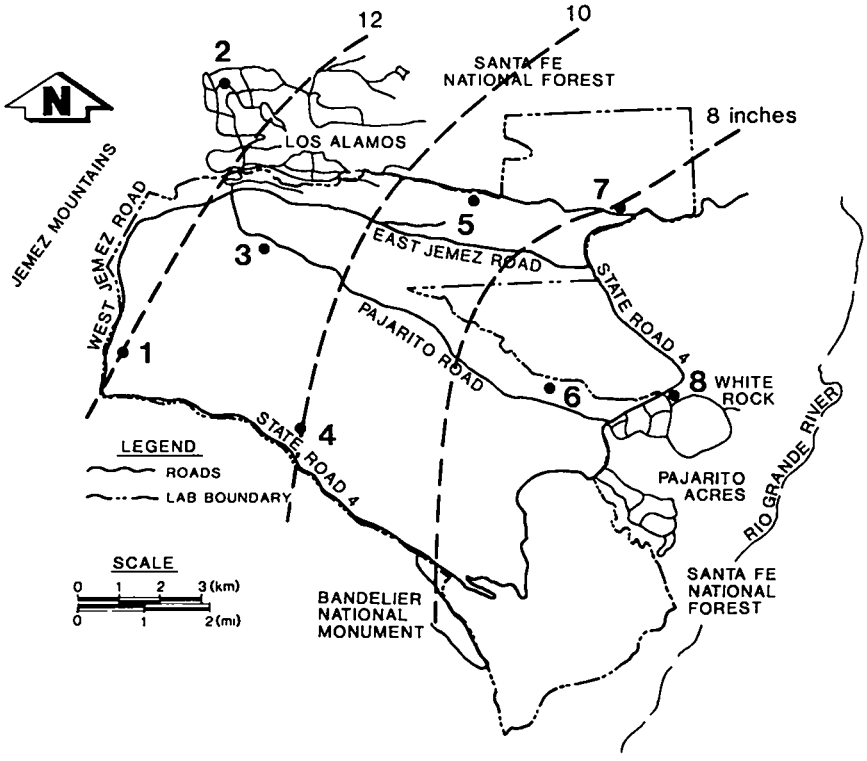
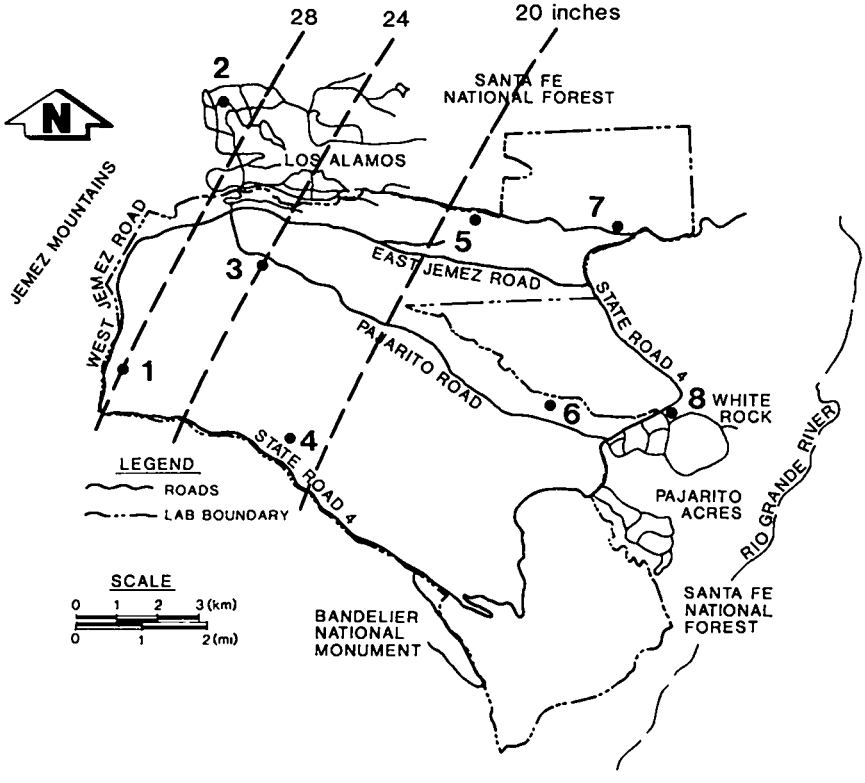


Fig. 29. Cumulative wind roses at Laboratory stations in 1986.



1986 SUMMER RAINFALL



1986 TOTAL RAINFALL

Fig. 30. Summer (June-August) and annual rainfall during 1986 (inches).

channeling. Downslope winds are less frequent at East Gate than at the other sites.

3. Precipitation Summary. Precipitation in Los Alamos County was heavy during 1986, with as much as 30 in. (75 cm) falling in the North Community. Figure 30 shows analyses of rainfall for the summer season (June-August) and the entire year. Record rainfall amounts in June, ranging from 3.2 in. (8.25 cm) in White Rock to 7.5 in. (19 cm) in the North Community, were responsible for producing large rainfall amounts in the summer. Stormy weather in the spring and autumn helped to push the 1986 precipitation totals to 6 to 8 in. (15 to 20 cm) above normal over the Los Alamos area. Note that the precipitation generally occurs in the northwestern part of Los Alamos County, adjacent to some high peaks of the Jemez Mountains.

B. Comprehensive Environmental Assessment and Response Program (CEARP) (R. Vocke, J. Ahlquist, N. Becker, R. Ferenbaugh, R. Gonzales, M. Martz, B. Perkins, K. Rea, L. Scholl, and A. Stoker)

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. LANL is providing programmatic guidance/management and technical support to AL for CEARP implementation at AL installations.

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 Resources 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), Phase II (Confirmation and Evaluation), Phase III (Technological Assessment), Phase IV (Remedial Action) and Phase V (Compliance and Verification). These phases parallel EPA's and DOE's CERCLA compliance plans.

During 1986, the Phase I reports for Kansas City Plant, Mound, Pantex Plant, Rocky Flats Plant, and Sandia National Laboratories-Livermore were released to the EPA and appropriate states. The Phase I reports for LANL Sandia-Albuquerque and Pinellas will be released during 1987. Phase II Monitoring Plan development and site characterization, as appropriate, will proceed at all eight AL installations during 1987, The Phase IIa Installation Generic Monitoring Plans (IGMPs), which are being prepared for each DOE-AL installation, are being tiered to the Phase IIa Generic Monitoring Plan (CGMP), which was prepared during 1986. The Phase II Site-Specific Monitoring Plans (SSMPs), which will be prepared for

each AL installation, will be tiered to the appropriate IGMP.

The working draft Phase I report for LANL was reviewed by the Laboratory and the Los Alamos Area Office during 1986. After additional review (DOE/AL and Headquarters) the LANL Phase I report will be released to the State of New Mexico and EPA. The Phase II IGMP will be ready for LANL review during March 1987. The SSMPs for TA-21 and TA-33 were initiated during the last quarter of 1986 and will be ready for LANL review during the second quarter of 1987.

Results from the 1986 Phase IIA reconnaissance activities (i.e., geophysical investigations at Area F, Sandia Canyon, Pajarito Site, and Area N; and chemical characterization of areas potentially contaminated from the old TA-22 plating outfalls, and potentially contaminated areas of upper Sandia canyon at TA-3) are in various stages of completion.

C. Vadose Zone Characterization at Area L and Area G (D. McInroy)

The Resource Conservation and Recovery Act (RCRA) requires that hazardous waste disposal facilities such as Los Alamos National Laboratory either (1) perform groundwater monitoring or (2) obtain a waiver of groundwater monitoring. To evaluate wheth er or not DOE and the Laboratory can obtain such a 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 No. 001007) issued by New Mexico's Environmental Improvement Division (EID) on May 7, 1985, under the New Mexico Hazardous Waste Management Act.

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 contamination migration from these two waste disposal areas. Figure 31 shows the approximate locations of the 25 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); (2) core and pore gas distribution with neutron probe and soil psychrometer installations.

Sampling was conducted in accordance with EPA procedures (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-cm (6-5/8 in.) OD 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 3-m (10-ft) section of core, two representative samples were taken--one for volatile organic analyses and one for inorganic analyses, respectively.

The DOE and Laboratory have been responding to the Compliance Order/Schedule by providing the EID with results of pore gas analyses, perched water analyses, and surface impoundment investigations. The DOE and Laboratory submitted the results of tuff soil physical properties to EID on 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 by March 31, 1987.

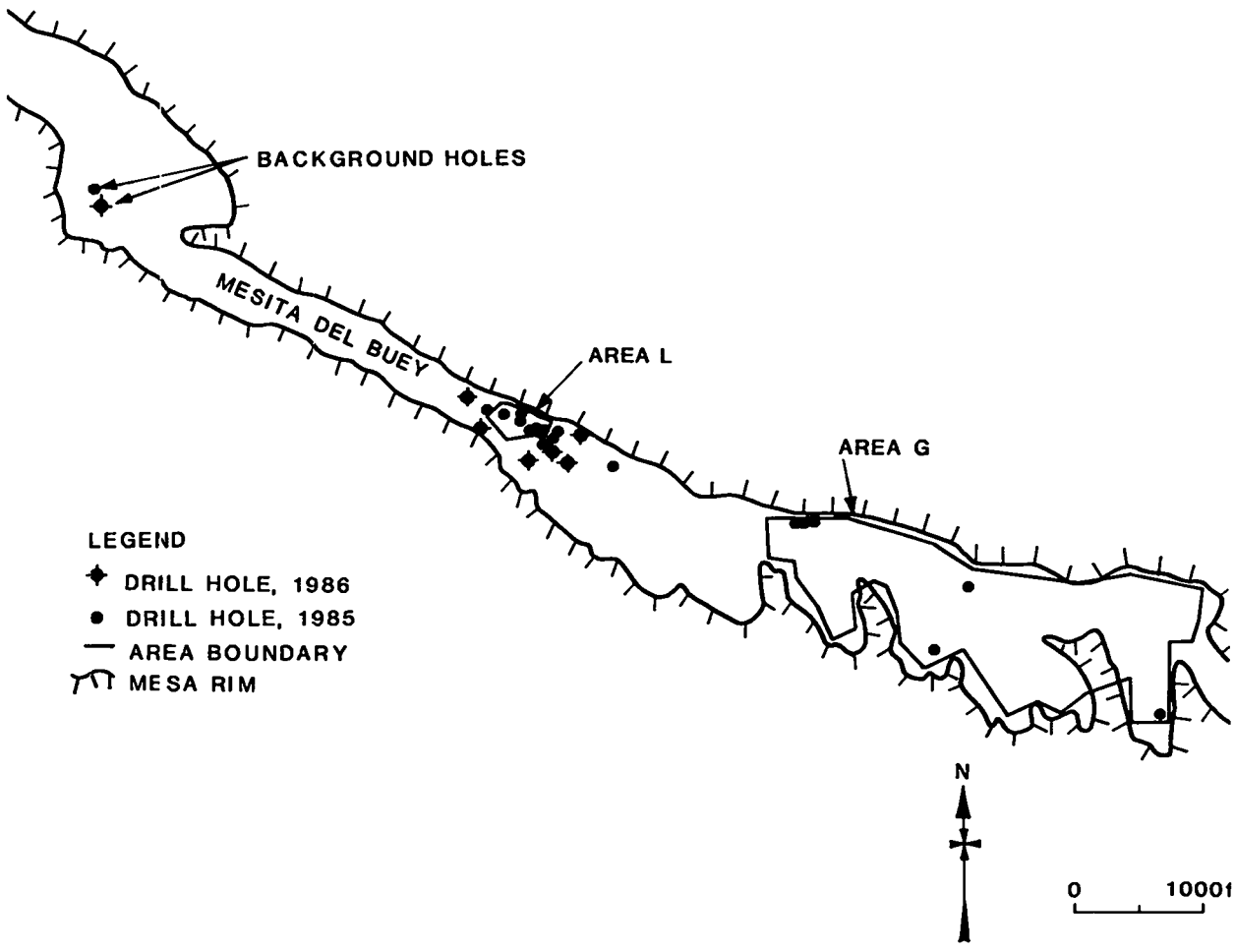


Fig. 31. Locations of drill holes for vadose zone characterization at Areas G and L.

D. Use of Floristic Surveys in Magnetometer Studies for Detecting Former Burial Sites (N. Becker and T. Foxx)

The DOE/AL's Comprehensive Environmental Assessment and Response Program (CEARP) provides information for compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Accordingly, Los Alamos National Laboratory is investigating areas of former hazardous and toxic waste disposal.

Former waste disposal Area F was used during 1946 for disposal of unsalvageable objects. The location of the pits was not established with survey markers until nearly 20 years after the pits were closed, and the area was not fenced until 1963. Therefore, it can be assumed that the fenced locations are approximate and that burial sites may exist outside of fenced areas. Because exact locations are unknown and the areas to be surveyed are large, magnetic surveys have been conducted to locate former burial sites. Floristic composition was combined with magnetics to better define suspect areas and to delineate former sites of waste burial.

Before the establishment of Los Alamos National Laboratory, homesteads dotted the mesa tops. The homesteads were condemned

in 1940 to make way for the Manhattan Project. Many of the former waste burial sites were located in areas cleared for homesteading. At Area F, which was decommissioned in 1946, the nearby homestead field has remained fallow for 46 years and the waste burial sites for over 40 years. Successional patterns have resulted in a mosaic of vegetation types throughout the site. Examination of the floristic patterns in aerial photographs and on-site reconnaissance revealed historic archaeological features such as a homestead trash depository and an old road, as well as suspect areas for waste burial.

Soil conditions were indicative of former usage. Soils undisturbed since the condemnation of the homestead had a soil crust of lichens and mosses, whereas areas disturbed by waste burial activities were devoid of soil crusts. Vegetative patterns were also important. Areas that had remained fallow since condemnation of the homestead had a cover of wormwood, bitterweed, and various grasses. Areas disturbed by waste burial activities had a cover of sweet clover, false tarragon, and other disturbed soil species.

After ground reconnaissance of the floristic composition and definition of suspect areas, a magnetic field survey was performed with a Geometrics G826 Proton Precision Magnetometer. Magnetic anomalies of considerable magnitude were found to coincide in all instances with suspect areas identified during the floristic survey. One suspect area, which produced a magnetic anomaly but was not identified by the floristic study, was within an old roadbed with compacted soils and devoid of vegetation.

At the Laboratory, burial areas that have remained fallow for a number of years may be defined by patterns in floristic composition. Patterns in vegetation can be a useful guide in geophysical surveys such as magnetics and in reconnaissance activities.

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

The 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 (28 mi) west of Los Alamos on the southern edge of the Valles Caldera. The hot dry rock energy concept involves drilling two deep holes, connecting these holes by hydraulic fracturing, and bringing the thermal energy to the surface by circulating water through the system. Environmental monitoring is performed adjacent to the site to assess any impacts of the geothermal operations.

The chemical quality of surface and ground water in the vicinity of TA-57 (Fig. 32) 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). The samples were collected in December 1985.

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 30). The predominate ions are (1) sodium and chloride, (2) calcium and bicarbonate, (3) calcium and sulfate, and (4) sodium and bicarbonate. Groundwater stations (five mineral and hot springs, one well, and five springs) are also grouped according to predominate ions. These ions are (1) sodium and chloride, (2) calcium and bicarbonate, and (3) sodium and bicarbonate (Table 30).

There was no significant change in the chemical quality of surface and ground water at the individual stations in December,

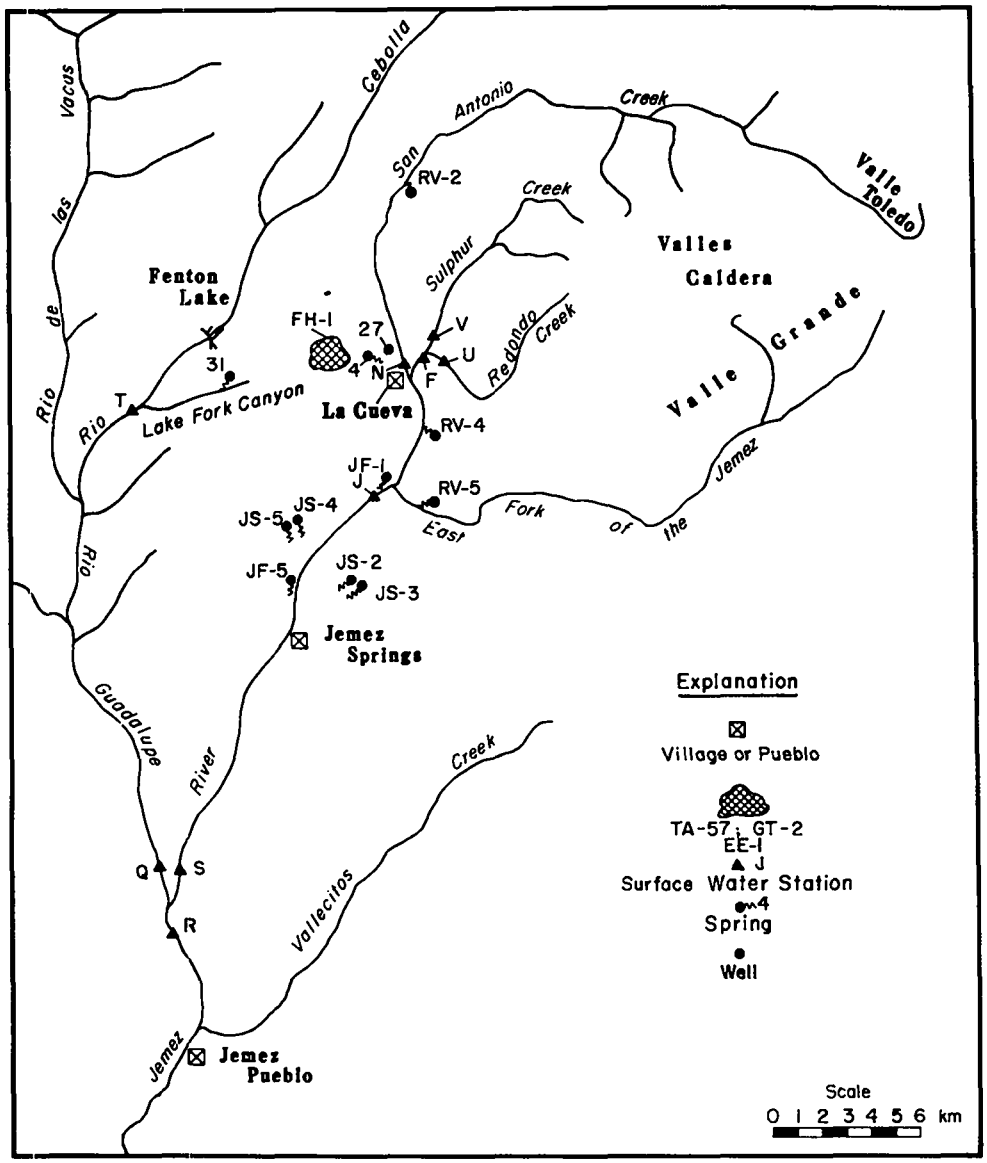


Fig. 32. Sampling stations for surface and ground water near the Fenton Hill Site (TA-57).

1985, when compared with the previous years' chemical analyses. The slight variations that have occurred are caused by normal seasonal variations.

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 samples are analyzed for arsenic, boron, cadmium, fluoride, and lithium. The sampling locations are 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 at its junction with Lake Fork Canyon. The discharge from the pond is drilling fluids or waters

Table 30. Quality of Surface and Groundwaters at Fenton Hill Geothermal Site
(concentrations in mg/L)
December 1985[a]

Surface Water

	Na	Cl	TDS
Sodium Chloride			
Redondo Creek (U)	8	10	78
Jemez River (R)	52	88	364
Jemez River (S)	73	96	376

	Na	HCO_3	TDS
Calcium Bicarbonate			
San Antonio Creek (N)	12	58	124
Rio Cebolla (T)	21	70	71
Rio Guadalupe (Q)	43	172	200
Lake Fork 1 (LF-1)	15	49	111
Lake Fork 2 (LF-2)	17	66	127
Lake Fork 3 (LF-3)	11	52	115
Lake Fork 4 (LF-4)	14	64	160

	Ca	SO_4	TDS
Calcium Sulfate			
Sulphur Creek (V)	41	220	404
Sulphur Creek (F)	20	110	221

	Na	HCO_3	TDS
Sodium Bicarbonate			
Jemez River (J)	15	56	16

Groundwater

	Na	Cl	TDS
Sodium Chloride			
Loc. JF-1 (Hot Spr)	159	71	1670
Loc. JF-5 (Hot Spr)	302	6600	3146

	Ca	HCO_3	TDS
Calcium Bicarbonate			
FH-1 (Supply Well)	34	109	228
Loc. 39 (Spr)	16	38	111

	Na	HNO_3	TDS
Sodium Bicarbonate			
JS-2, 3 (Spr)	16	77	146
JS-4, 5 (Spr)	15	73	165
Loc. 4 (Spr)	30	123	224
Loc. 31 (Spr)	11	52	122
RV-2 (Hot Spr)	22	45	162
RV-4 (Hot Spr)	52	107	221
RV-5 (Hot Spr)	19	73	128

[a]See Fig. 32 for sampling locations. One sample taken at each location.

used in the circulation loop of the geothermal system. The discharge of the effluents is restricted so that all effluents infiltrate in to the alluvium of the dry canyon within 150 m of the effluent outfall.

The most recent vegetation and soil data are shown in Table G-66. Since last year's surveillance report, the only new data are 1986 data for fluoride and the 1985 data for lithium in foliage and roots. The data are quite variable but generally do not seem to represent a great change from previous years. The data for lithium in foliage and roots and fluoride in foliage still seem to indicate a decrease in concentration with progression down the stream channel, a trend that was apparent in previous years' data. This trend is not as obvious in the data for soil from the stream channel.

F. Storm Water Run-off Sampling (L. Soholt, K. Jacobsen, and F. Brown)

In September, 1984, the EPA promulgated regulations that could require NPDES permitting of some of the Laboratory's outfalls that receive storm water run-off from conveyance systems, e.g., channels or culverts. The application must contain results of analyses from runoff samples that the Laboratory has reason to believe contain non-coventional, priority pollutants in concentrations in excess of 10 micrograms per liter (100 micrograms per liter for some pollutants). During August and September, runoff samples were obtained once each at 17 outfalls around the Laboratory. Samples were collected in TA-3 (7 stations), TA-21 (3), TA-35 (3), TA-50 (1), TA-53 (2), and TA-59 (1). Samples were analyzed for approximately 30 inorganic pollutants and 145 organic pollutants.

The majority of organic pollutants occurred at levels below the minimum limits of detection by the analytical methods used. However, methylene chloride was detected in two samples from TA-35 and from TA-50, exceeding 8 micrograms per liter in one sample. Fluoranthene and phenol were also detected in one sample from TA-35. These three organics are found with a frequency of >10% of urban runoff (EPA 1983). None of these detected pollutants exceeded EPA's criteria for reporting in the NPDES permit application. Levels of chloroform exceeded these criteria in one sample from TA-35 and one from TA-59. General phenolic levels were at or above the EPA reporting criteria in all but one sample (Table 31). Oil and grease were present in three samples from TA-3 at levels near the reporting criteria.

As expected, inorganic pollutants were commonly detected in storm water run-off (Table 31). Most metals and anions for which we analyzed exceeded reporting criteria in one or more samples. For several elements, the analytical level of detection exceeded the reporting criteria. It is possible that in these cases levels exceeded reporting criteria, but this cannot be determined from the data. Aluminum and iron were the most abundant metals in run-off. This probably reflects their natural abundance in the geosphere.

G. Underground Storage Tanks (J. White)

Subtitle I of the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act has broadened the scope of underground tank regulation. Previously, only Subtitle C or RCRA regulated those underground tanks that contained hazardous waste. Subtitle I now brings underground tanks that contain regulated substances under RCRA regulation. Along with the requirement for EPA to promulgate specific regulations, several major provisions have been included in this new program. Among them are: the requirement to notify

Table 31. Summary of Occurrence of Inorganic, Oil and Grease, and Phenol Pollutants in Run-off Samples From 17 Storm Water Outfalls

Frequency of Detected Occurrence				
17	11-16	5-10	1-4	0
Aluminum	Chromium	Arsenic	Antimony	Bromide
Barium	Lead	Fluoride	Beryllium	Cyanide
Chloride	Nitrate		Boron	Mercury
Copper	Phenols		Cadmium	Molybdenum
Iron	Titanium		Cobalt	Selenium
Magnesium			Nickel	Silver
Manganese			Nitrate	Tin
Sulfate			Oil & Grease	
Zinc			Thallium	

for existing tanks; the provision granting EPA authority to inspect the test tanks, and to enforce regulatory requirements through the use of administrative orders, injunctions or civil penalties; the provision subjecting tanks controlled by the federal government to Subtitle I; and the requirement to satisfy statutory standards for new tanks.

In response to these requirements, an inventory of underground storage tanks was taken and the results submitted to New Mexico's EID. Leak testing was also conducted on 27 of the 105 tanks found to be subject to Subtitle I. The results of this testing indicated several leaking tanks. Corrective action has been performed on the major leaks. Further mitigation will be implemented as the need is identified in development of a tank management plan. An underground storage tank management program is currently being developed that will provide background information, descriptions of the tank population and associated regulatory requirements, a leak detection program, and a software package to facilitate data manipulation.

H. PCB Inventory at the Laboratory (R. Bohn)

In order to comply with federal, state, and Laboratory environmental regulations, the Laboratory's Environmental Surveillance Group (HSE-8) coordinated a Laboratory-wide program to inventory and label polychlorinated biphenyls (PCBs).

A PCB "hotline" was installed and operated by HSE-8 personnel to record any messages or questions regarding PCB contaminated items owned or operated by any user group throughout the Laboratory. Each division appointed a "PCB representative" whose responsibilities included notifying HSE-8, through the established "PCB hotline," of any equipment owned or operated by the representative's division that contained or was suspected to contain PCBs.

Once notified of equipment containing or suspected of containing PCBs, HSE-8 samples the equipment and submits these samples to the Laboratory's Health and Environmental Chemistry Group (HSE-9) for PCB analysis. Once completed, the analytical results along

with other information on sample origin (i.e. the location and type of equipment) are entered on the HSE-8 computer data base for inventory. The equipment is then labeled either as containing PCBs (in concentrations found present) or as containing no PCBs.

The HSE-8 computer data base contains data on 931 samples analyzed for PCBs in 1986.

I. Survey of Sediments in Major Stream Channels for Toxic and Hazardous Waste (W. Purtymun and M. Maes)

Treated industrial and sanitary effluents from the Laboratory are released into the canyons that traverse the Pajarito Plateau. The volume of effluents is not great enough to maintain surface flow off Laboratory lands. Flow is depleted by evapotranspiration and infiltration into the alluvium. Some inorganic and organic compounds in the effluents have an affinity for attachment to the sediments by ion exchange or adsorption. These sediments are subject to transport with storm runoff. The presence of inorganic and organic compounds in the sediment of the intermittent stream channel could indicate potential for transport of contaminants offsite.

A survey to determine if there has been major transport of organic or inorganic contamination from the Laboratory was made by collecting sediment from 10 canyons that cross the Laboratory and 4 canyons near or adjacent to the Laboratory (Fig. 15). Two of the offsite canyons (Guaje and Frijoles canyons) could be considered as background data as they do not drain the Laboratory. The other two (Bayo and Pueblo canyons) drain former Laboratory areas. The sediment samples were leached and the leachate was analyzed for metals, pesticides, herbicides, and volatile organics. In all, 14 samples were taken and 55 analyses performed on each. Methods for preparation of the sample and analyses are outlined by the EPA (1985).

1. Metals. The sediments from the 14 stations (canyon crossings at State Road 4, except for Frijoles at Park Headquarters) were analyzed for 13 metals and anions as well as pH. Eight of the constituents (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) have limits set for EPA toxic concentrations. Sediment concentrations were below detectable limits and well below the toxic limits as described by the EPA. The remaining six constituents (nickel, beryllium, cyanide, sulfate, nitrate, and pH) have no EPA limits but were analyzed to provide additional information. The concentrations of beryllium and nickel were below detectable limits. Nickel at 9.5 mg/L (detectable limits 0.05 mg/L) was reported from sediments taken from Fence Canyon at State Road 4. This canyon drains a small area which contain some firing sites. The nickel could be from the firing sites. Sulfate concentrations ranged from 1.1 to 1.9 mg/L in sediments from all stations. The concentrations are background, within the range found at the control stations in Guaje and Frijoles Canyon. Nitrate concentrations ranged from <0.2 to 1.0 mg/L and are within the same range as background. The pH of the samples varied considerably, from 5.1 to 7.6. The two background canyons contained sediments with pH 5.1 and 7.5, at the extremes of the range of measurements. Hence, the variations are probably related to normal variation among canyons. Variation could be related to frequency of runoff in each canyon, particle size distribution, or the makeup of the soils from which drainage occurs.

2. Pesticides and Herbicides. Pesticides analyses (lindane, endrin, methorychlor, and

toxaphene) were performed on sediments from the 14 stations. The results were below detectable limits and well below the maximum EPA toxic concentrations.

Herbicide analyses [2,4-D and silvex (2,4,5-TP)] were performed on sediments from the 14 station. The results were below the detection limits and well below the maximum EPA toxic concentrations.

3. Volatile Organics. The sediments from the 14 stations were analyzed for 36 EPA priority pollutant, volatile organic compounds. Detection limits ranged from 2 to 50 μg/kg (ppb). Of the 36 organic compounds, only two were identified in the sediments. The compound 1,1,2,2,-tetrachloroethane was detected in sediments from Canada del Buey (12 μg/kg), Pajarito (6 μg/kg), Potrillo (7 μg/kg), and Water (6 μg/kg) canyons. The concentrations are only slightly above the detection limits of 5 μg/kg. A similar compound 1,1,1,2,-tetrachloroethane was also found in sediments from Canada del Buey (9 μg/kg) and Water (6 μg/kg) canyons. This compound's detection limit is 2 μg/kg. Both compounds are used as solvents, degreasers, paint removers, varnishes and lacquers in photographic film, organic syntheses, solvents, insecticides, fumigants, and weed killers. Although the concentrations are low, additional investigations will be conducted.

J. Rate of Sedimentation in Sandia Canyon Based on Carbon-14 (W. Purtymun and M. Maes)

Surface flow into upper Sandia Canyon drains from the TA-3 shops, buildings, asphalt plant, and parking lots. In addition to runoff, waste water is released from the sanitary treatment plant and the power plant into the upper part of the canyon. Immediately east of TA-3, the canyon is cut into a moderately welded to a welded tuff. Through this section the canyon is narrow, and the gradient of the channel is steep. About a quarter of the canyon bottom widens, and the gradient of the channel decreases as the canyon is cut and underlain by a moderately welded tuff. The channel meanders through this section forming a marsh with grasses, cattails, and a few willows.

To create additional parking area for TA-3, plans were developed to fill the narrow part of the canyon with building debris and carry the runoff and effluents through a culvert into the upper part of the marsh. An investigation was performed in the upper part of the marsh to determine the thickness of the sediments and if the sediments could take the weight of the culvert and building debris. A backhoe dug through the sediments into the top of the tuff. The hole penetrated sands and gravels underlain by silts and plastic clays which would allow compaction and settling that would damage the culvert. The culvert was relocated to the north of the channel cut into the underlain by the tuff. The bearing capacity of the tuff will handle the weight of the culvert and the debris deposited on top of or around the culvert.

The sediments in the marsh were about 4.3 m (14 ft) deep. The upper part of the sediments consisted of sands and gravels grading downward into silts and clay. There was a gradual increase in the carbonaceous material with increased depth. The carbon apparently was derived from decomposition of plant material. The presence of the organic material in the sediments presented a means of determining the age of the carbon, and, thus, the rate of deposition.

Three samples of carbonaceous sediments were collected and sent to a contractor laboratory for age dating by use of the half-life of carbon-114. The dating was based on a determination of the amount of carbon-14

and its Libby half-life of 5568 yrs. The age of the carbon in the sediments in years before the present increased downward from <185 yrs at a depth of 1 m (3 ft), 940 yrs at a depth of 2 m (8 ft), and 2530 yrs at a depth of 3.6 m (12 ft).

The rate of sedimentation increased about 9 cm (0.3 ft)/100 yr near the base of the sediments to about 49 cm (1.6 ft)/100 yr near the surface of the sediments. The average rate of sedimentation has been about 15 cm (0.5 ft)/100 yr for the 4.3 m (14 ft) of sediments in the canyon.

Mortandad Canyon, the next canyon to the south, is similar to Sandia Canyon. The upper reach is narrow with a steep gradient cut into a welded to moderately welded tuff. In the midreach, the canyon widens and the steam channel gradient decreases, braiding out on the canyon floor. The canyon is underlain by a moderately welded tuff. The canyon receives low-level radioactive effluent from the treatment plant at TA-50. Runoff and effluent are not sufficient to form marsh-like conditions in the canyon. Casual observations indicate that sedimentation is taking place in the midreach of the canyon. The sediments range from 7.5 to 10.5 m (25 to 35 ft) in thickness in the middle section of the canyon.

Runoff in both canyons has scoured the channels down into the moderately welded tuff. Changes in channel gradient caused by possible tectonic adjustments of the Pajarito Plateau or an increase in runoff (precipitation) causing increased down cutting of the moderately welded to welded tuff in the narrow part of both canyons. Either of these changes would result in increased sediment deposition in the sections of the canyons cut into the moderately welded tuff.

K. National Atmospheric Deposition Program (NADP) Network Station (D. Nochumson and M. Trujillo)

Group HSE-8 operates a wet deposition station that is part of the NADP Network. The station is located at the Bandelier National Monument. Composite precipitation samples are collected on a weekly basis. The samples are initially weighed and analyzed for pH and conductivity before being sent out for the analysis of ionic species. Summary statistics of the data for the four latest complete quarters are presented in Table G-67.

The magnitude of the ionic species deposition was generally highest in the third quarter of 1985 and lowest during the first quarter of 1986. The amount of precipitation was also lowest during the first quarter of 1986. The amount of deposition is quite variable. This variation reflects the variability in the cleanliness in the atmosphere that storm clouds have contacted. The ions in the rainwater are from both nearby and distant, manmade, and natural sources. High nitrate and sulfate levels are most likely caused by manmade sources (motor vehicles, copper smelters, and power plants).

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. All but one of the weekly samples where enough precipitation was present to measure field pH, had pH's below 5.6, which indicates contributions from acidic species other than carbon dioxide.

L. Preoperational and Faunal Surveys (W. Wenzel, J. Kent, J. Salazar, and K. Jacobsen)

Three preoperational surveys were conducted during 1986 to fulfill DOE Order 5480.1a. These surveys establish the baseline radioecological status for the Nuclear Materials Storage Facility at TA-55, Tritium Processing Facility at TA-16, and the Weapons Neutron Research Facility at TA-53. Ecological, soil, and radiochemical data from the preoperational surveys were entered into files on the Los Alamos Central Computing Facility. Permanent metal signs were fabricated and placed at each preoperational sampling site for long-term reference.

Small mammal surveys were conducted at the preoperational survey sites and at sites in Sandia Canyon, Canyon del Buey, Ancho Canyon, and Potrillo Canyon. The specimens were prepared for deposit in the Museum of Southwestern Biology at the University of New Mexico. Bird surveys were completed on these sites to complement the small mammal studies.

A long-term ecological research study area was established in lower Mortandad Canyon and on the two mesas above the canyon. Winter and breeding bird inventories were made for the ponderosa pine, pinyon-juniper, and riparian canyon sites. The data were analyzed and submitted to the Cornell University ornithological survey.

M. BIOTRAN Modeling Program (W. Wenzel and A. Gallegos)

During 1986 BIOTRAN model development focused on expansion of the ground and surface water modules to complete the hydrological cycle portions. The surface hydrology of the Department of Agriculture's SPUR model was combined with BIOTRAN to develop the capability to simulate intermittent flow for area canyons coupled with groundwater recharge of perched aquifers. A water mass balance approach was used for the Los Alamos mesa, canyon, and groundwater watersheds.

Input data from Mortandad Canyon hydrology were simulated using the watershed strategy for the upper portion of the canyon. Particle size and radionuclide distributions from Mortandad Canyon studies were used to estimate sediment fractionation as particles moved down the surface of the watershed. The alluvial aquifer was simulated as a series of irregular trapezoids where water was moved form one trapezoid to the next as it filled using a modified Bernouli equation. The algorithms for the trapezoid mass balance integration were complicated by the irregular shape of the alluvial aquifer in Mortandad Canyon. In addition, the canyon stream can be considered perennial below TA-48, and average annual flows were input for the two major outfalls from TAs-50, and -48. Work is currently focused on simulating the winter ice sheet, which usually extends from the TA-50 outfall to the Laboratory boundary in lower Mortandad Canyon.

The BIOTRAN development phase is currently centered on strengthening the input and verifying the code using available experimental data. The coupling of the BIOTRAN plant community models with the hydrological models has given the group a high resolution simulation capability. This effort was necessary because evapotranspiration far exceeds precipitation in the southwest. BIOTRAN can now specify the plant community on each watershed lateral and simulate the movement of water and particles above and below ground in a mass-balance fashion. Calibration of the models will require soil and rock weathering rates, near surface water flow measurements, and storm event parameters for calibrating the overland transport with subsurface water movement in the watershed.

N. Environmental Studies of TA-49 (W. Purtymun and A. Stoker)

Hydronuclear experiments were conducted in underground shafts at the Los Alamos National Laboratory in an area known as TA-49 in 1959-1961. Area TA-49 is located on Frijoles Mesa in the southwest corner of the Laboratory between TA-28 and TA-33 (Fig. 4). These experiments involved a combination of conventional (chemical) high explosives, usually in a nuclear weapon configuration, and fissile material whose quantity was reduced far below the amount required for a nuclear explosion. Between January, 1960, and August, 1961, a total of 35 hydronuclear experiments and 9 related equation-of-state and criticality experiments, all involving some fissile material, were conducted. Other experiments involving high explosives, but no fissile materials, were conducted starting in October, 1959, and extending through the same period.

The hydronuclear experiments and directly related operations deposited various residuals and wastes in the immediate vicinity of TA-49. A total of about 41 kg (90 lb) of plutonium, 93 kg (200 lb) of enriched uranium, 82 kg (180 lb) of depleted uranium, and 15 kg (33 lb) of beryllium was utilized. These materials were dispersed in the bottoms of the shafts by detonation of the conventional (chemical) high explosives.

Some plutonium contamination was measured at the surface in one experimental area in December, 1960, and was traced to cuttings from a shaft drilled during October and November. Plutonium had apparently been dispersed through fractures in the tuff by the detonation of an experiment in an adjacent, experimental shaft. All surface soil contamination ascertainable by standard procedures and instruments of the time was cleaned up and placed back in the shaft from which it originated.

Routine monitoring has not shown any migration of contaminants from TA-49. All monitoring of ground water in the main aquifer, surface water runoff, and sediments will be continued as part of the routine annual environmental surveillance program carried out by Group HSE-8. These results will continue to be reported in the annual environmental monitoring reports. Supplementary onsite monitoring results will be included in the periodic reports prepared for the Interim Waste Management Program or CEARP reports as appropriate.

Preliminary, summary information on TA-49 will be included in the CEARP Phase 1, Installation Assessment document for Los Alamos, which is expected to be released in 1987. A detailed plan for field investigation of TA-49 will be prepared during 1987 under the auspices of the CEARP. This will result in a CEARP Phase 2, Confirmation, Site-Specific Monitoring Plan (Ref. CEARP Generic Monitoring Plan). The Site-Specific Monitoring Plan will include detailed evaluation of all known existing data. This evaluation will be the basis for developing a detailed sampling plan that will meet all the guidelines required by DOE under its applicable programs and those required by EPA for a Remedial Investigation under CEARP. The Site-Specific Sampling Plan will be made available to the EPA and appropriate New Mexico agencies for information and review.

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APPENDIX A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

Throughout this report, concentrations of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, and foodstuffs are available. 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 I (Environmental Protection, Safety, and Health Protection Standards) and Chapter XI (Requirements for Radiation Protection); and DOE Order 5484.1 (Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements), Chapter III (Effluent and Environmental Monitoring Program Requirements). All of these DOE orders are being revised.

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-yr 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.[A3] Table A-1 lists currently applicable RPS 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.[A4] These DCGs represent the smallest estimated concentrations in water or air, taken in continuously for a period of 50 yrs, 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/yr 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

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

Table A-1 (cont)

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[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.

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

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

where,

RPS = 0.1 mrem/yr, the DOE Radiation Protection Standard,[A3]

BR = 8.400×10^9 mL/yr, the breathing rate for the standard person,[A6] and

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

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

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	$1x10^{-7}$	$2x10^{-3}$	$5x10^{-6}$	$1x10^{-1}$
^{7}Be	$5x10^{-8}$	$1x10^{-3}$	$1x10^{-6}$	$5x10^{-2}$
^{89}Sr	$3x10^{-10}$	$2x10^{-5}$	$3x10^{-8}$	$3x10^{-4}$
^{90}Sr[b]	$9x10^{-12}$	$1x10^{-6}$	$1x10^{-9}$	$1x10^{-5}$
^{137}Cs	$4x10^{-10}$	$3x10^{-6}$	$1x10^{-8}$	$4x10^{-4}$
^{234}U	$9x10^{-14}$	$5x10^{-7}$	$1x10^{-10}$	$1x10^{-4}$
^{235}U	$1x10^{-13}$	$6x10^{-7}$	$1x10^{-10}$	$1x10^{-4}$
^{238}U	$1x10^{-13}$	$6x10^{-7}$	$7x10^{-11}$	$2x10^{-5}$
^{238}Pu	$3x10^{-14}$	$4x10^{-7}$	$2x10^{-12}$	$1x10^{-4}$
^{239}Pu[b]	$2x10^{-14}$	$3x10^{-7}$	$2x10^{-12}$	$1x10^{-4}$
^{240}Pu	$2x10^{-14}$	$3x10^{-7}$	$2x10^{-12}$	$1x10^{-4}$
^{241}Am	$2x10^{-14}$	$6x10^{-8}$	$6x10^{-12}$	$1x10^{-4}$
	(pg/m^3)	(mg/L)	(pg/m^3)	(mg/L)
U,natural[c]	$1x10^{+5}$	$8x10^{-1}$	$2x10^{+8}$	$6x10^{+1}$

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[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 DOEs "uranium special curie" by multiplying by $3.3x10^{-13}$ μCi/pg.

DCG = RPS/(ING x DCF)

where,

RPS = 0.11 rem/yr, the DOE Radiation Protection Standard,[A3]

ING = 7.3×10^5 mL/yr, the rate of ingestion of drinking water for the standard person,[A6] and

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

Radionuclide concentrations in air and water in uncontrolled areas measured by the Laboratory' surveillance program are compared to these DCGs in this report. In addition to the 100 mrem/yr effective dose RPS,

exposures from the air pathway are also limited by the EPA's standard of 25 mrem/yr (whole body) and 75 mrem/yr (any organ) (Table A-1). To demonstrate compliance with these standards, doses from the air pathway are compared directly with the EPA dose limits in this report.

For chemical constituents in drinking water, standards have been promulgated by the EPA 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.

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 x 10^{-9} μCi/mL. Gross alpha activity (including ^{226}Ra, but excluding radon and uranium) may not exceed 15 x 10^{-9} μCi/mL.

A screening level of 5 x 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 established minimum concentrations of certain contaminants in a water extract from wastes for designation of these wastes as hazardous by reason of toxicity.[A9] 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.

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		
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}
Fc	2.0		
Hg	0.002		
NO^{3}	45		
Pb	0.05		
Se	0.01		
	Secondary Standards		
C	250		
Cu	1.0		
Fe	0.3		
Mn	0.05		
SO^{4}	250		
Zn	5.0		
TDS	500		
pH	6.5 - 8.5		

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[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.

Table A-4. Minimum Concentrations of Inorganic Contaminants for Meeting EPA's Extraction Procedure (EP) 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.

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

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

APPENDIX B
PROCEDURES FOR 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 to 400°C (752°F) for 1 h and then cooled rapidly to room temperature. This followed by annealing at 100°C (212°F) 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 can be place 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 irradiate 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 factors of 0.958 for muscle ^{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 thermoluminescent 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 the 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]

Further details are provided in the TLD quality assurance project plan.[B5]

B. Air Sampling

Samples are collected monthly at 26 continuously operating stations.[B6] Air pumps with flow rates of about 3 L/sec are used. Airborne 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 get to absorb 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) airborne radioactivity samples are collected weekly. Airborne particulate matter on each week filter is counted for gross alpha and gross beta activities, which help trace temporal variations in radionuclide concentrations in ambient air. The same measurements are made on a monthly filter from the Espanola (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 analysis.

Filters from the first composite group are ignited in platinum dishes, treated with HF-HNO_3 to dissolve silica, wet ashed with HNO_3-H_2O_2 to decompose organic residue, and treated with HNO_3-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 form the eluant solutions resulting from the plutonium separation process. The purified plutonium and americium samples are separated electrodeposited and measured for alpha-particle emission with a solid state alpha detection system. Alpha particle energy groups associated with 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 blue "indicating" gel to indicate the degree of desiccant 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 get cartridge and an aliquot of the distillate is analyzed for tritium by liquid scintillation counting. The amount of water absorbed by the silica get 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.

Further details may be found in the air sampling quality assurance project plan. [B7]

C. Water Sampling

Surface water 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 for ^{3}H, ^{137}Cs, total U, ^{238}Pu and $^{239,240}Pu$, and as well as for gross alpha, gross beta, and gross gamma activities. Water samples for chemical analyses are handled similarly.

Storm run-off 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

Further details may be found in the water sampling quality assurance project plan.[B8]

D. Soil and Sediment Sampling

Two soil sampling procedures are used. The first procedure is used to take surface composite samples. Soiled 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 undercutting the ring with a metal spatula. A second spatula is then placed on top of the ring and the sample is transferred 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 perennially flowing streams. Samples from the beds of intermittently following 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 beta activities, ^{90}Sr, total uranium, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$. Moisture distilled from soiled samples may be analyzed for ^{3}H.

Further details may be found in the soil and sediment sampling quality assurance plan.[B8]

E. Foodstuffs Sampling

Local and regional produce are sampled annually. Fish are sampled annually from reservoirs upstream and downstream from the Laboratory.

Produce and soil samples are collected from local gardens in the fall of each year.[B9] Each produce or soil sample is sealed in a labeled, plastic bag. Samples are refrigerated until preparation for chemical analysis. Produce samples are washed as if prepared for consumption and quantitative wet, dry, and ash weights are determined. Soils are split and dried at 100°C (212°F) before analysis. A complete sample bank is kept until all radiochemical analyses are completed. Water is distilled from samples using the beaker/watchglass method. This water is submitted for tritium analysis. Produce ash and dry soil are submitted for analyses of ^{90}Sr, ^{132}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$.

At each reservoir, hook and line, trot line, or gill nets are used to capture fish.[B9] 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. Ash is submitted for analysis of ^{90}Sr, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$.

Further information may be found in the foodstuffs sampling quality assurance project plan.[B10]

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 minute 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. On computer code compares measured data with expected ranges and make 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.

Further details may be found in the meteorological monitoring quality assurance project plan.[B11]

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 and 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.[B12]

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:

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

where,

c_i = concentration for sample i,
$\bar{c}$ = means of samples room 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 for 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 Health and Environmental 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 and 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.

Each number, a single sample, is assigned to a particular station and 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 is labeled with station name, sample number, date, and preservative, if added.

After the sample is collected, it is delivered to the Group HSE-9 section leader. The section leader makes out a numbered request form entitled "HSE-9 Analytical Chemical Request." The 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 "chain-of-custody" for the samples.

The analytical request form contains the following information related to ownership and sample program submitted as (1) requestor (i.e., sample collector), (2) program code, (3) sample owner (i.e., program manager); (4) date, and (5) total number of samples. The second part of the request form contains (1) sample number or numbers, (2) matrix (e.g., water), (3) types of analyses (i.e., specific radionuclide and/or chemical 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 Group HSE-9 in analytical work are presented in Appendix C.

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

Further details may be found in the quality assurance project plan for each program.[B5,B7,B8,B10,B11]

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APPENDIX C
ANALYTICAL CHEMISTRY METHODOLOGY

All analytical chemistry is provided by the Environmental and Health Chemistry 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 +5% are adequate.[C5] More precise work require mass spectrometry. Group HSE-9 acquired a VG-Instruments PLASMAQUAD Inductively Coupled Plasma Mass Spectrometer (ICPMS) in early 1986. Uranium isotopic ratios can be readily determined by environmental materials with precisions of 1-2% RSD at considerably reduced cost relative to neutron activation. Detailed procedures are under active development.

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, combustion analysis and, most recently, ICPMS. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capacities include flame, furnace, mercury cold vapor, and hydride generation, as well as flame emission spectrophotometry. The methods used and references for determination of various chemical constituents are summarized in Table C-1. The ICPMS methods are currently being developed for uranium, beryllium, and boron in environmental materials. The use of ICPMS for multielement determination in extracts from EPA Test Method 1310: Extraction Procedure Toxicity, is also under investigation. The EPA Region-6 administration granted HSE-9 limited approval for alternative test procedures for uranium in drinking water (delayed neutron assay) and for flow injection (without distillation) for chloride in drinking water and waste water.

C. Organic Constituents

Environmental water samples are analyzed by EPA or modified EPA methodology. Methods in use are supported by the use of documented spike/recovery studies, method and field blanks, matrix spikes, surrogate spikes, and blind quality control samples.

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^{-3}, 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, C12, C13, C14, C15
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, C9, C16, C17, C18, C19, C20, C21
Thermal Neutron Capture Gamma Ray	Al, B, Ca, Cd, C, Gd, H, Fe, Mg, N, P, K, Si, Na, S, Ti	C7, C22, C23, C24, C25, C26, C27, C29
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, C6, C7, C30, C31, C32, C33, C34, C35, C36, C37, C38, C51
Delayed Neutron Assay	U	C7, C8, C10, C11, C39, C40
Atomic Absorption	Sb, As, Ba, Be, Bi, Cd, Ca, Cr, Co, Cu, Ga, In, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Na, Sr, Te, Tl, Sn, Ti, V, Zn, Al	C6, C41, C43, C44, C45, C46, C47, C48, C52, C53, C54

Table C-1 (cont)

Technique	Stable Constituents Measured	References
Ion Chromatograpy	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	C6, C59, C60, C62,

EPA procedures are modified in order to take advantages of recent advances in analytical separation and analysis techniques. Volatile organics are analyzed by a modification of EPA 624 (purge and trap/gas chromatography/mass spectrometry (PT/GC/MS). Semivolatile organics are analyzed by a variety of method including 604 (phenols), 606 (phthalate esters), 608 (organochlorine pesticides and PBCs), 609 (nitroaromatics), 610 (polynuclear aromatic hydrocarbons), 612 (chlorinated hydrocarbons), and 625 (semivolatiles by GC/MS). For samples in a solid matrix, comparable methods found within EPA's document SW-846 are used with suitable modifications as needed. Manual and automated methods are being developed using neutron activation to screen oil samples for potential PCB contamination via total chlorine determination.

Instrumentation available for organic analysis include gas chromatographs with a variety of detector systems including mass spectrometry, flame ionization, and electron capture. Also available is a high pressure liquid chromatograph equipped with a UV and refractive index detection system, an infrared spectrophotometer, and a UV/visible spectrophotometer for colorimetric analyses. Methods used for sample preparation include solvent extraction, soxhlet extraction, liquid/liquid extraction, kuderna danish concentration, column separation, headspace, and purge and trap. The methods used for analyses in 1986 along with references are shown in Table C-2. Tables C-3 through C-7 show compounds determined by these methods and representative detection limits.

D. Analytical Chemistry Quality Evaluation Program

1. Introduction. Control samples are analyzed in conjunction with normal analytical

Table C-2. Method Summary (Organics)

Analyte	Matrix	Method	Technique[a]	Reference
Volatiles	air	---	GC/MS	C65
Volatiles	soil	8010	PT/GC/MS	C64 C65
		8020		C66
Volatiles	water	625	PT/GC/MS	C64
EP Toxicity	soil	1310, 8080 8150	GC/ECD	C66
PCBs	water	606	GC/ECD	C64
	soil	8080	GC/ECD	C66
	oil	IH 320	GC/ECD	C65

[a]GC - gas chromatography, PT - purge and trap, ECD - electron capture detection, and MS - mass spectrometry.

chemistry workload. Such samples consist of several general types: calibration standards, reagent blanks, process 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.[C67-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 samples 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

Table C-3. Volatiles Determined by Purge and Trap

Compound	Representative Detection Limits (μg/L)
Methylene chloride	1.0
1,1-Dichloroethane	1.0
1,1-Dichloroethene	1.0
cis-1,2-Dichloroethene	1.0
1,2-Dichloroethane	1.0
Chloroform	1.0
Bromoform	1.0
Carbon tetrachloride	1.0
Bromodichloromethane	1.0
Dibromochloromethane	1.0
Dibromomethane	1.0
4-Methyl-2-pentanone	1.0
1,1,1-Trichloroethane	1.0
1,1,2-Trichloroethane	1.0
1,2-Dichloropropane	1.0
cis-1,3-Dichloropropene	5.0
trans-1,3-Dichloropropene	5.0
1,2-Dibromo-3-chloropropane	1.0
Trichloroethene	1.0
2-chloroethylvinyl ether	5.0
1,1,2,2-Tetrachloroethane	1.0
Tetrachloroethene	1.0
Chlorobenzene	1.0
1,2-Dichlorobenzene	1.0
1,3-Dichlorobenzene	1.0
1,4-Dichlorobenzene	1.0
Benzene	1.0
Acetone	5.0
Carbon disulfide	5.0
Toluene	1.0
Ethyl benzene	1.0
Styrene	5.0
o-xylene	1.0
m-xylene/p-xylene	1.0

Column: Supelco SPB-5 60 m x 0.25 mm x 1.0 μm. Limits of detection estimated by minimum signal required to yield identifiable mass spectral scan.

Table C-4. Volatiles Determined by SW-846 Method 8010

Compound	Detection Limits (μg/kg)[a]
Bis (2-chloroethoxy) methane	--
Bis (2-chlorisopropy) ether	--
Bromobenzene	2300
Bromodichloromethane	1000
Bromoform	1000
Carbon tetrachloride	2100
Chloracetaldehyde	--
Chlorobenzene	1200
Chloroethane	--
Chloroform	1000
1-Chlorohexane	--
2-Chloroethyl vinyl ether	--
Chloromethane	--
Chlorotoluene	--
Dibromochloromethane	1000
Dibromomethane	--
1,2-Dichlorobenzene	500
1,3-Dichlorobenzene	500
1,4-Dichlorobenzene	500
Dichlorodifluoromethane	--
1,1-Dichloroethane	1000
1,2-Dichloroethane	800
1,1-Dichloroethylene	--
trans-1,2-Dichloroethylene	500
Dichloromethane	500
1,2-Dichloropropane	500
trans- 1,3-Dichloropropylene	--
1,1,2,2-Tetrachloroethane	2100
1,1,1,2-Tetrachloroethane	--
Tetrachloroethylene	2100
1,1,1-Trichloroethane	1600
1,1,2-Trichloroethane	1500
Trichloroethylene	500
Trichlorofluoromethane	--
Trichloropropane	--
Vinyl chloride	--

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

Table C-5. Volatiles Determined by SW-846 Method 8020

Compound	Detection Limits (μg/kg)[a]
Benzene	500
Chlorobenzene	1200
1,4-Dichlorobenzene	500
1,3-Dichlorobenzene	500
1,2-Dichlorobenzene	500
Toluene	500
Ethyl Benzene	800
Xylenes	--

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

^{235}U, ^{238}U, ^{228}Th, ^{230}Th, ^{232}Th, ^{226}Ra, ^{228}Ra, and ^{210}Pb. The national Bureau of Standards (NBS) provides several soil and sediment Standard Reference Materials (SRM) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{230}Pu, $^{238,240}Pu$, ^{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 "inhouse" standards are prepared by adding known quantities of liquid NBS radioactivity SRMs to blank matrix 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 of 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) x (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,

Table C-6. Volatiles Determined in Air

Compound	Representative Detection Limits (g/tube)
1,1-Dichloroethane	3.0
1,1-Dichloroethene	3.0
cis-1,2-Dichloroethene	3.0
Chloroform	3.0
Bromoform	3.0
Bromodichloromethane	3.0
Dibromochloromethane	3.0
Dibromomethane	3.0
1,1,1-Trichloroethane	3.0
1,1,2-Trichloroethane	3.0
1,2-Dichloropropane	3.0
cis-1,3-Dichloropropene	5.0
trans-1,3-Dichloroprepene	5.0
1,2-Dibromo-3-chloropropane	3.0
Trichlorethene	3.0
2-chloroethylvinyl ether	5.0
1,1,2,2-Tetrachloroethane	3.0
Tetrachloroethene	3.0
Chlorobenzene	3.0
1,2-Dichlorobenzene	3.0
1,3-Dichlorobenzene	3.0
1,4-Dichlorobenzene	3.0
Trichlorofluoromethane	5.0
Toluene	3.0
Ethyl benzene	3.0
o-xylene	3.0
m-xylene/p-xylene	3.0

Column: Supelco SPB-5 60 m x 0.25 mm x 1.0 μm.
Method: Carbon disulfide desorbtion of charcoal tubes followed by GC/MS analysis.

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 quality in the reference material to permit comparison among reference materials of similar matrix containing different concentrations of the analyte:

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

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):

Table C-7. 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 x 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.

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

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

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

These calculated values are presented in Table C-8 through C-10. 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 instances, 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:

Table C-8. Summary of HSE-9 Quality Assurance Data for Environmental Surveillance Analyses: 1-Jan-1986 to 31-Dec-1986 (Radiochemical Analyses)

Analysis	Biological Mean ± SD	(n)	Filter Mean ± SD	(n)	Silicate Mean ± SD	(n)	Water Mean ± SD	(n)
ALPHA	---		0.87 ± 0.06	(62)	---		1.06 ± 0.09	(406)
Am-241	1.26 ± 0.37	(12)	1.00 ± 0.08	(12)	0.67 ± 0.16	(9)	0.99 ± 0.12	(59)
Be-7	---		0.99 ± 0.07	(3)	---		1.01 ± 0.22	(19)
BETA	---		0.93 ± 0.10	(62)	---		0.99 ± 0.11	(406)
Co-57	---		---		---		1.06 ± 0.07	(47)
Co-60	---		1.16 ± 0.03	(3)	---		1.00 ± 0.10	(59)
Cr-51	---		---		---		0.70 ± 0.20	(7)
Cs-134	---		---		---		0.99 ± 0.13	(62)
Cs-137	0.87 ± 0.23	(18)	1.00 ± 0.07	(3)	0.96 ± 0.09	(48)	1.01 ± 0.12	(89)
GAMMA	---		---		0.95 ± 0.02	(44)	1.04 ± 0.08	(73)
H-3	---		---		---		1.08 ± 0.10	(321)
I-131	1.08 ± 0.10	(12)	---		---		---	
Mn-54	---		1.01 ± 0.08	(3)	---		1.05 ± 0.10	(50)
Na-22	---		---		---		0.98 ± 0.06	(47)
Pu-238	1.51 ± 0.44	(4)	0.90 ± 0.06	(10)	0.60	(1)	0.98 ± 0.08	(41)
Pu-239	1.02 ± 0.19	(12)	0.85 ± 0.08	(7)	1.00 ± 0.28	(25)	0.97 ± 0.07	(64)
Ra-226	---		---		---		0.92 ± 0.08	(15)
Ru-106	---		---		---		0.72 ± 0.07	(8)
Sr-90	0.93 ± 0.28	(15)	1.41 ± 0.07	(3)	0.92 ± 0.06	(3)	1.01 ± 0.10	(18)
U-234	1.19 ± 0.58	(9)	---		---		1.02 ± 0.18	(21)
U-235	---		---		---		1.08 ± 0.42	(20)
U-235/238	---		---		1.04	(2)	0.98 ± 0.04	(13)
U-238	0.93 ± 0.16	(5)	---		---		---	

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

where $\bar{X}_E$ and $\bar{X}_c$ are the experimentally determined and certified or 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-11.

Table C-9. Summary of HSE-9 Quality Assurance Date for Environmental Surveillance Analyses: 1-Jan-1986 to 31-Dec-1986 (Stable Element Analyses)

Analysis	Biological Mean ± SD	(n)	EP-TOX Mean ± SD	(n)	Filter Mean ± SD	(n)	Silicate Mean ± SD	(n)	Water Mean ± SD	(n)	Bulk Mean ± SD	(n)
Ag	---		1.06 ± 0.07	(16)	1.07	(2)	1.09	(1)	1.02 ± 0.07	(63)	---	
Al	1.04 ± 0.03	(9)	---		---		---		0.96 ± 0.21	(18)	---	
As	---		1.15 ± 0.09	(17)	1.04	(2)	0.96	(2)	1.02 ± 0.10	(61)	---	
B	---		---		---		---		1.00 ± 0.09	(21)	---	
Ba	---		1.05 ± 0.07	(15)	---		---		1.02 ± 0.17	(66)	---	
Be	---		---		1.03 ± 0.06	(74)	0.95 ± 0.08	(3)	1.13 ± 0.11	(6)	---	
Br	1.12 ± 0.07	(10)	---		---		1.40	(2)	---		---	
Ca	---		---		---		---		0.98 ± 0.06	(38)	---	
Cd	---		1.07 ± 0.09	(18)	1.00 ± 0.10	(52)	---		0.96 ± 0.07	(109)	---	
Ce	---		---		---		0.95	(1)	---		---	
Cl	0.99 ± 0.09	(11)	---		---		1.02 ± 0.01	(3)	1.01 ± 0.07	(73)	0.98 ± 0.11	(190)
Cl2	---		---		---		---		0.88 ± 0.14	(44)	---	
CN-	---		---		---		---		0.92 ± 0.07	(98)	---	
Co	---		---		---		---		1.05 ± 0.01	(4)	---	
COD	---		---		---		---		0.94 ± 0.10	(53)	---	
Conductivity	---		---		---		---		1.02 ± 0.04	(43)	---	
Cr	0.92 ± 0.11	(13)	1.09 ± 0.09	(15)	1.11	(2)	1.46	(1)	1.03 ± 0.14	(103)	---	
Cr(±6)	---		---		---		---		1.10 ± 0.06	(90)	---	
Cs	1.13 ± 0.10	(26)	---		---		0.80	(1)	---		---	
Cu	---		---		---		---		1.04 ± 0.18	(110)	---	
Eu	---		---		---		1.02	(2)	---		---	
F	1.04 ± 0.05	(11)	---		---		0.91 ± 0.08	(4)	1.05 ± 0.11	(115)	---	
Fe	1.09	(1)	---		---		1.01	(1)	1.02 ± 0.06	(103)	---	
Flash Point	---		---		---		---		---		1.00 ± 0.03	(13)
Ga	---		---		1.06		---		---		---	
Hardness	---		---		---		---		0.97 ± 0.08	(15)	---	
Heat Capacity	---		---		---		---		---		1.07 ± 0.11	(4)
Hf	---		---		---		1.05	(1)	---		---	
Hg	---		0.97 ± 0.23	(7)	---		0.82 ± 0.06	(5)	0.99 ± 0.11	(71)	---	
I	---		---		---		0.76	(1)	---		---	
K	---		---		---		0.92	(1)	1.03 ± 0.08	(35)	---	
La	---		---		---		1.35	(2)	---		---	
Li	---		---		1.01	(2)	---		1.01 ± 0.02	(9)	---	
Mg	---		---		---		---		1.01 ± 0.04	(28)	---	
Mn	1.01 ± 0.11	(9)	---		---		---		1.02 ± 0.10	(57)	---	
Mo	---		---		---		---		1.05 ± 0.04	(8)	---	
Na	0.97 ± 0.03	(10)	---		---		0.61	(1)	1.00 ± 0.04	(37)	---	
NH3-N	---		---		---		---		1.01 ± 0.06	(120)	---	
Ni	---		---		0.95	(1)	---		1.02 ± 0.08	(63)	---	
NO2-N	---		---		---		---		0.82	(2)	---	
NO3-N	---		---		---		---		1.00 ± 0.06	(108)	---	
Os	---		---		0.93	(1)	---		---		---	
P	---		---		---		---		1.03 ± 0.18	(151)	---	
Pb	---		1.03 ± 0.05	(15)	1.03 ± 0.07	(55)	---		1.02 ± 0.08	(118)	---	
pH	---		---		---		---		1.00 ± 0.01	(610)	---	
Rb	1.33	(1)	---		---		---		---		---	

Table C-9 (cont)

Analysis	Biological Mean ± SD	(n)	EP-TOX Mean ± SD	(n)	Filter Mean ± SD	(n)	Silicate Mean ± SD	(n)	Water Mean ± SD	(n)	Bulk Mean ± SD	(n)
S	1.00 ± 0.05	(209)	---		---		---				1.05 ± 0.18	(51)
Sb	---		---		---		0.98	(1)	---		---	
Sc	0.92 ± 0.03	(8)	---		1.01 ± 0.09	(10)	0.98 ± 0.05	(11)	---		---	
Se	---		1.10 ± 0.22	(4)	---		0.72	(1)	1.02 ± 0.12	(71)	---	
Si	---		---		---		---		0.91 ± 0.10	(27)	---	
Sm	---		---		---		0.91	(2)	---		---	
Sn	---		---		---		---		0.99 ± 0.01	(3)	---	
SO4	---		---		---		---		0.97 ± 0.09	(69)	---	
Sr	---		---		---		1.00	(2)	---		---	
Ta	---		---		1.02	(1)	0.96	(1)	---		---	
Total Alk.	---		---		---		---		0.98 ± 0.06	(35)	---	
TDS	---		---		---		---		1.03 ± 0.14	(33)	---	
Th	---		---		---		0.95 ± 0.06	(8)	1.03 ± 0.06	(8)	---	
Ti	1.04 ± 0.07	(8)	---		---		---		1.15 ± 0.05	(8)	---	
Tl	---		---		---		---		1.25	(2)	---	
Tm	---		---		1.09	(2)	---		---		---	
TOX	---		---		---		---		---		1.00	(2)
TSS	---		---		---		---		0.85	(1)	---	
U	1.19 ± 0.28	(34)	---		0.95 ± 0.05	(32)	1.00 ± 0.05	(167)	1.09 ± 0.28	(95)	---	
V	0.97 ± 0.12	(3)	---		---		---		---		---	
Zn	0.96	(1)	---		1.00 ± 0.14	(46)	---		1.02 ± 0.06	(103)	---	

Table C-10. Summary of HSE-9 Quality Assurance Data for Environmental Surveillance Analyses: 1-Jan-1986 to 31-Dec-1986 (Organic Analyses)

Analysis	Silicate Mean ± SD	(n)	Water Mean ± SD	(n)	Filter Mean ± SD	(n)	Bulk Mean ± SD	(n)
Acenaphthene	---		0.94	(1)	---		---	
Anthracene	---		0.98	(1)	---		---	
Aroclor 1242	---		---		---		1.10 ± 0.38	(30)
Aroclor 1254	---		---		1.46	(2)	0.98 ± 0.22	(27)
Aroclor 1254	4.41	(1)	0.91 ± 0.39	(4)	---		---	
Aroclor 1260	0.96 ± 0.18	(6)	0.98	(2)	0.90	(2)	0.92 ± 0.14	(55)
1,2-Benzanthracene	---		0.23	(1)	---		---	
Benzene	0.92 ± 0.07	(5)	---		---		---	
Benzo(g,h,i)perylene	---		0.72	(1)	---		---	
Benzo-a-pyrene	---		0.48	(1)	---		---	
Benzo-b-fluoranthene	---		0.74	(1)	---		---	
Benzo-k-fluoranthene	---		0.70	(1)	---		---	
1,12-Benzoperylene	---		0.72	(1)	---		---	
Bis(2-chloroethoxy)methane	---		0.92	(1)	---		---	
Bis(2-chloroethyl)ether	---		0.84	(1)	---		---	
Bis(2-chloroisopropyl)ether	---		1.10	(1)	---		---	
Bis(2-ethylhexyl)phthalate	---		0.81	(2)	---		---	
Bromodichloromethane	0.86 ± 0.06	(5)	---		---		---	
Bromodichloromethane	---		0.80 ± 0.07	(5)	---		---	
Bromoform	---		0.91 ± 0.08	(10)	---		---	
4-Bromophenylphenyl ether	---		1.12	(1)	---		---	
Butylbenzyl phthalate	---		1.12	(1)	---		---	
Camphene, chlorinated	---		1.54 ± 0.01	(4)	---		---	
4-Chloro-3-methylphenol	---		1.00	(1)	---		---	
Chlorobenzene	---		0.94 ± 0.05	(7)	---		---	
Chlorodibromomethane	---		0.92 ± 0.06	(6)	---		---	
Chloroform	---		1.00 ± 0.03	(4)	---		---	
2-Chloronaphthalene	---		1.01	(1)	---		---	
o-Chlorophenol	---		1.10	(1)	---		---	
2-Chlorophenol	---		1.10	(1)	---		---	
4-Chlorophenylphenyl ether	---		1.09	(1)	---		---	
Chrysene	---		0.81	(1)	---		---	
2,4-D	0.89 ± 0.05	(5)	1.77 ± 0.20	(4)	---		---	
p,p'-DDT	0.44 ± 0.07	(7)	---		---		---	
DDT	0.44 ± 0.07	(7)	---		---		---	
Di-n-butyl phthalate	---		0.81	(1)	---		---	
1,2:5,6-Dibenzanthracene	---		0.67	(1)	---		---	
Dibenzo(a,h)anthracene	---		0.67	(1)	---		---	
1,2-Dibromo-3-chloropropane	---		1.10	(2)	---		---	
Dibromochloromethane	---		0.92 ± 0.06	(6)	---		---	
1,2-Dibromoethane	---		0.85	(2)	---		---	
Dibutyl phthalate	---		0.81	(1)	---		---	
o-Dichlorobenzene (1,2)	---		1.14	(1)	---		---	

Table C-10 (cont)

Analysis	Silicate Mean ± SD	(n)	Water Mean ± SD	(n)	Filter Mean ± SD	(n)	Bulk Mean ± SD	(n)
m-Dichlorobenzene (1,3)	0.58 ± 0.05	(5)	1.61	(1)	---		---	
p-Dichlorobenzene (1,4)	---		0.23	(1)	---		---	
Dichlorobromomethane	0.86 ± 0.06	(5)	0.80 ± 0.07	(5)	---		---	
1,2-Dichloroethane	0.85 ± 0.04	(5)	0.85 ± 0.13	(4)	---		---	
trans-1,2-Dichloroethene	---		0.93	(1)	---		---	
cis-1,2-Dichloroethylene	---		1.50	(1)	---		---	
trans-1,2-Dichloroethylene	---		0.93	(1)	---		---	
2,4-Dichlorophenol	---		0.98	(1)	---		---	
1,2-Dichloropropane	---		0.92	(2)	---		---	
Diethyl phthalate	---		0.97	(1)	---		---	
Dimethyl phthalate	---		0.23	(1)	---		---	
2,4-Dimethylphenol	---		0.74	(1)	---		---	
4,6-Dinitro-o-cresol	---		1.02	(1)	---		---	
2,6-Dinitrotoluene	---		0.76	(1)	---		---	
2,4-Dinitrotoluene	---		0.90	(1)	---		---	
Endrin	0.91 ± 0.03	(7)	1.63 ± 0.05	(4)	---		---	
Ethylbenzene	---		0.87 ± 0.09	(9)	---		---	
Ethylene bromide	---		0.85	(2)	---		---	
Ethylene chloride	0.85 ± 0.04	(5)	0.85 ± 0.13	(4)	---		---	
Fluoranthene	---		0.93	(1)	---		---	
Fluorene	---		0.62	(1)	---		---	
Formaldehyde	---		1.05 ± 0.17	(7)	---		---	
Hexachloro-1,3-butadiene	---		0.97	(1)	---		---	
Hexachlorobenzene	---		0.74	(1)	---		---	
Hexachlorobutadiene	---		0.97	(1)	---		---	
Hexachloroethane	---		0.01	(1)	---		---	
Isophorone	---		1.17	(1)	---		---	
Lindane	0.96 ± 0.07	(7)	1.10 ± 0.15	(4)	---		---	
Methoxychlor	---		1.08 ± 0.15	(4)	---		---	
2-Methyl-4,6-dinitrophenol	---		1.02	(1)	---		---	
Methylchloroform	0.86 ± 0.06	(5)	0.83	(1)	---		---	
Naphthalene	---		0.79	(1)	---		---	
Nitrobenzene	---		1.01	(1)	---		---	
2-Nitrophenol	---		0.95	(1)	---		---	
4-Nitrophenol	---		1.21	(1)	---		---	
p-Nitrophenol	---		1.21	(1)	---		---	
o-Nitrophenol	---		0.95	(1)	---		---	
N-Nitrosodi-n-propylamine	---		0.06	(1)	---		---	
PCP	---		1.29	(1)	---		---	
Pentachlorophenol	---		1.29	(1)	---		---	
Phenanthrene	---		0.84	(1)	---		---	
Phenol	---		0.63	(1)	---		---	
Pyrene	---		0.59	(1)	---		---	
Silvex (2,4,5-TP)	0.84 ± 0.09	(5)	3.42 ± 0.12	(4)	---		---	
1,1,2,2-Tetrachloroethane	---		0.92 ± 0.08	(6)	---		---	
s-Tetrachloroethene	---		0.92 ± 0.08	(6)	---		---	
Tetrachloroethylene	---		0.85 ± 0.08	(4)	---		---	
Toluene	---		0.86	(2)	---		---	

Table C-10 (cont)

Analysis	Silicate Mean ± SD	(n)	Water Mean ± SD	(n)	Filter Mean ± SD	(n)	Bulk Mean ± SD	(n)
Toxaphene	---		1.54 ± 0.01	(4)	---		---	
Tribromomethane	---		0.91 ± 0.08	(10)	---		---	
1,1,1-Trichloro-2,2-bis(p-methoxyphenyl)ethane	---		1.08 ± 0.15	(4)	---		---	
1,2,4-Trichlorobenzene	---		1.50	(1)	---		---	
1,1,1-Trichloroethane	0.86 ± 0.06	(5)	0.95 ± 0.01	(4)	---		---	
1,1,2-Trichloroethane	---		0.83	(1)	---		---	
Trichloroethene	0.64 ± 0.06	(5)	---		---		---	
Trichloroethylene	0.64 ± 0.06	(5)	---		---		---	
2,4,6-Trimethylphenol	---		1.10	(1)	---		---	

Table C-11. 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^{-10} 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

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APPENDIX D

METHODS FOR DOSE CALCULATIONS

A. Introduction

Annual radiation 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, individual and population doses attributable to Laboratory activities are estimated through modeling of releases.

Dose conversion factors used for inhalation and ingestion calculations are given in Table D-1. These dose conversion factors are taken from the DOE,[D3] and 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 that is attributable to that intake.

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

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		$1.1 \times 10^{+3}$					$1.3 \times 10^{+2}$
^{235}U		$1.0 \times 10^{+3}$					$1.2 \times 10^{+2}$
^{238}U		$1.0 \times 10^{+3}$					$1.2 \times 10^{+2}$
^{238}Pu			$8.1 \times 10^{+3}$	$6.7 \times 10^{+2}$	$1.8 \times 10^{+3}$	$1.0 \times 10^{+2}$	$4.6 \times 10^{+2}$
$^{239,240}Pu$			$9.3 \times 10^{+3}$	$7.4 \times 10^{+2}$	$2.0 \times 10^{+3}$	$1.2 \times 10^{+2}$	$5.1 \times 10^{+2}$
^{241}Am			$9.3 \times 10^{+3}$	$7.4 \times 10^{+2}$	$2.0 \times 10^{+3}$	$1.2 \times 10^{+2}$	$5.2 \times 10^{+2}$

Ingestion:

Radionuclide	Bone Surface	Red Marrow	Liver	Gonads	Kidney	Lungs	Breast	Thyroid
^{3}H								
^{7}Be		4.4×10^{-3}		2.1×10^{-4}				
^{90}Sr	1.6	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	2.7×10^{-1}			1.7			
^{235}U	3.7	2.5×10^{-1}			1.6			
^{238}U	3.7	2.5×10^{-1}			1.5			
^{238}Pu	6.7	5.5×10^{-1}	1.5	8.5×10^{-2}				
$^{239,240}Pu$	7.8	5.9×10^{-1}	1.6	9.6×10^{-2}				
^{241}Am	$4.1 \times 10^{+1}$	3.1	8.5	5.2×10^{-1}				

Table D-1 (cont)

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		4.4×20^{-4}	2.0×10^{-4}	2.7×10^{-4}		1.1×10^{-4}
^{90}Sr						1.3×10^{-1}
^{137}Cs		5.2×10^{-2}	5.2×10^{-2}		5.5×1^{-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

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[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	$7.5 \times 10^{+9}$

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[a]Dose conversion factors for ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar were taken from Kocher.[D5] Dose conversion factors for the remaining radionuclides, which were not presented by Krocher, were calculated from:

$$\text{DCF } [(\text{mrem/yr})/(\mu\text{Ci/mL})] = 0.25 \times \bar{E} \times 3.2 \times 10^{+10}$$

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.

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 equivalent for each radionuclide (see Appendix A for definition of effective dose equivalent).

The dose calculated for inhalation of ^3H is increased by 50% to account for absorption through the skin.

This procedure for dose calculation conservatively assumes that a hypothetical individual is exposed to the measured air concentration continuously throughout the entire year (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 equivalent are determined at all sampling sites for each radionuclide. A final calculation estimates the total inhalation organ doses and effective dose equivalent by summing over all radionuclides.

C. Ingestion Dose

Results from foodstuff sampling (Sec. VII) are used to calculate organ doses and effective dose equivalents 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 equivalent is calculated using the effective dose equivalent conversion factor (Table D-1).

Doses are evaluated for ingestion of ^{3}H, ^{90}Sr, ^{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 ^{90}Sr, ^{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 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.

The 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 (Sec. II.E). The population data have been slightly modified (increased from 155 077 in 1980 to 178 118 persons in 1986 within 80 km [50 mi] of the boundary) to account for population changes between 1980 and 1986. These changes are extrapolated from an estimate of the 1984 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[D8]) and the source term Q. Source terms, obtained by stack measurements, are in Table G-2.

The dispersion factors were calculated from 1986 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] or calculated from Slade,[D8]

$\chi(r,\theta,t)$ = plume concentration in μCi/mL).

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]

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APPENDIX E
UNITS OF MEASUREMENT

Throughout this report the International (SI) or Metric system of measurements 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, cryogenics laboratories, a Van de Graaff 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, PH-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 in 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, 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 1986 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]	0.01	<0.1%
$^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar$	Whole Body	East Gate (Station 6)[b]	11.5	46%
$U, ^{238}Pu, ^{239,240}Pu, ^{241}Am$	Bone Surface	Arkansas Ave. (Station 5)[b]	0.29	0.4%

[a]Estimated maximum individual dose is the dose from Laboratory operations (excluding dose contributions from cosmic, terrestial, 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	$^{239,239,240}Pu$[b] (μCi)	$^{235,238}U$[c] (μCi)	Mixed Fission Products (μCi)	^{131}I (μCi)	^{41}Ar[d] (Ci)	^{32}P (μCi)	^{3}H (Ci)	Activation Products: Gaseous[e] (Ci)	Activation Products: Particulate/Vapor[f] (Ci)
TA-2					276				
TA-3	194	631	47.9	38.0			1,230		
TA-9									
TA-15									
TA-18									
TA-21	3.6	212	0.3				448		
TA-33							6,660		
TA-35	0.4						48		
TA-41							1,320		
TA-43	2.9					70			
TA-46		<0.1							
TA-48	2.8	0.6	2,500						
TA-50	2.9		20.1						
TA-53							6	112,000	0.1
TA-54	0.2								
TA-55	0.2								
Totals	207	847	2,570	38.0	276	70	10,700	112,000	0.1

[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 0.02 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. Espanola	--	73 (8)[b]
2. Pojoaque	--	104 (5)
3. Santa Fe	--	94 (7)
4. Fenton Hill	--	133 (8)
Perimeter Stations (0-4 km)--Uncontrolled Areas		
5. Barranca School	N180 E130	107 (7)
6. Arkansas Avenue	N170 E030	88 (7)
7. Cumbres School	N150 E090	118 (7)
8. 48th Street	N110 W010	129 (7)
9. LA Airport	N110 E170	119 (7)
10. Bayo Canyon	N120 E250	130 (7)
11. Exxon Station	N090 E120	145 (7)
12. Royal Crest Trailer Court	N080 E080	132 (7)
13. White Rock	S080 E420	91 (7)
14. Pajarito Acres	S210 E380	129 (7)
15. Bandelier Lookout Station	S280 E200	120 (7)
16. Pajarito Ski Area	N150 W200	123 (8)
Onsite Stations--Controlled Areas		
17. TA-21 (DP West)	N095 E140	105 (7)
18. TA-6 (Two-Mile Mesa)	N025 E030	120 (7)
19. TA-53 (LAMPF)	N070 E090	143 (7)
20. Well PM-1	N030 E305	119 (7)
21. TA-16 (S-Site)	S035 W025	132 (7)
22. Booster P-2	S030 E220	128 (7)
23. TA-54 (Area G)	S080 E290	142 (14)
24. State Hwy 4	N070 E350	198 (7)
25. Frijoles Mesa	S165 E085	116 (7)
26. TA-2 (Omega Stack)	N075 E120	137 (7)
27. TA-2 (Omega Canyon)	N085 E1210	289 (7)
28. TA-18 (Pajarito Site)	S040 E205	181 (11)
29. TA-35 (Ten Site A)	N040 E105	197 (7)
30. TA-35 (Ten Site B)	N040 E110	134 (7)
31. TA-59 (Occupational Health Lab)	N050 E040	125 (7)
32. TA-3 (Van de Graaff)	N050 E020	136 (7)
33. TA-3 (Guard Station)	N050 E020	288 (8)
34. TA-3 (Alarm Buildling)	N050 E020	260 (8)
35. TA-3 (Guard Building)	N050 E020	127 (7)
36. TA-3 (Shop)	N050 E020	104 (8)
37. Pistol Range	N040 E240	123 (7)
38. TA-55 (Plutonium Facility South)	N040 E240	135 (7)
39. TA-55 (Plutonium Facility West)	N040 E080	139 (7)
40. TA-55 (Plutonium Facility North)	N040 E080	139 (7)

[a]Based on last three calendar quarters.
[b]Estimate (95% confidence increments).

Table G-4. Location of Air Sampling Stations

Station	Latitude or N-S Coord	Longitude or E-W Coord
Regional (28-44 km)		
1. Espanola	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 Canyon	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-2	N082	E110
26. TA-16-450	S055	W070

Table G-5. Average Background Concentrations of Radioactivity in the Atmosphere

Radioactive Constituent	Units	EPA[a] 1983-1986	Laboratory[b] 1986	Uncontrolled Area Guide[c]
Gross beta	10^{-15} μCi/mL	10 ± 0	12 ± 4	9×10^3
^3H	10^{-12} μCi/mL	Not reported	5.0 ± 12.1	2×10^5
U(natural)	pg/m^3	66 ± 28	60 ± 24	1×10^5
^{238}Pu	10^{-18} μCi/mL	0.3 ± 0.5	<2[d]	3×10^4
$^{239,240}Pu$	10^{-18} μCi/mL	0.8 ± 0.9	1.5 ± 1.2	2×10^4
^{241}Am	10^{-18} μCi/mL	Not reported	3.3 ± 2.7	2×10^4

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[a]Environmental Protection Agency, "Environmental Radiation Data," Reports 33 through 45. Data are from Santa Fe, New Mexico sampling location and were taken from January 1983 through March 1986, 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 (Espanola, Pojoaque, Santa Fe) and were taken during calendar year 1986.
[c]See Appendix A. These values are presented for comparison.
[d]Minimum detectable limit.

Table G-6. Estimated Aerial Concentrations of Toxic Elements Aerosolized by Dynamic Experiments

Element	1986 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	200	10	0.02	0.008	9000[a]
Be	2.1	2	6×10^{-5}	12×10^{-5}	10[b]
Pb	97	100[c]	0.11	0.04	1500[d]

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[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-7. Atmospheric Tritiated Water Concentration for 1986

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly 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. Espanola	121.32	11	8	11.0 ± 3.0	-2.0 ± 1.0	2.5 ± 5.8	<0.1
2. Pojoaque	136.45	12	9	46.0 ± 9.0	-2.0 ± 1.0	5.0 ± 13.2	<0.1
3. Santa Fe	116.40	12	8	46.0 ± 9.0	-1.0 ± 1.0	5/9 ± 13.8	<0.1
Regional Group Summary	374.17	35	25	46.0 ± 9.0	-2.0 ± 1.0	5.0 ± 12.1	<0.1
Perimeter Stations (0-4)--Uncontrolled Areas							
4. Barranca School	132.33	12	6	11.0 ± 2.0	-0.1 ± 1.0	3.8 ± 3.4	<0.1
5. Arkansas Avenue	133.12	12	6	9.0 ± 2.0	0.4 ± 0.3	3.2 ± 2.6	<0.1
6. East Gate	139.39	12	2	20.0 ± 4.0	1.1 ± 0.2	6.8 ± 5.7	<0.1
7. 48th Street	137.79	12	5	9.0 ± 2.0	0.8 ± 0.2	3.7 ± 2.9	<0.1
8. LA Airport	134.74	12	2	18.0 ± 4.0	1.2 ± 0.3	6.3 ± 4.7	<0.1
9. Bayo STP	128.23	12	6	9.0 ± 2.0	1.1 ± 0.3	3.0 ± 2.3	<0.1
10. Exxon Station	137.86	12	2	70.0 ± 10.0	1.1 ± 0.4	10.9 ± 18.9	<0.1
11. Royal Crest	137.89	12	2	60.0 ± 10.0	1.4 ± 0.3	16.9 ± 16.6	<0.1
12. White Rock	130.41	12	6	17.0 ± 3.0	0.9 ± 0.3	4.5 ± 4.8	<0.1
13. Pajarito Acres	103.22	12	7	19.0 ± 4.0	0.3 ± 0.6	4.8 ± 6.0	<0.1
14. Bandelier	142.27	12	2	20.0 ± 4.0	1.2 ± 0.3	7.5 ± 6.0	<0.1
Perimeter Group Summary	1457.25	132	46	70.0 ± 10.0	-0.1 ± 1.0	6.5 ± 9.7	<0.1

Table G-7 (cont)

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations--pCi/m^3 (10^{-12} µCi/mL) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Onsite Stations--Controlled Areas							
15. TA-21	132.96	12	0	70.0 ± 10.0	2.5 ± 0.5	16.2 ± 19.7	<0.1
16. TA-6	138.32	12	8	15.0 ± 3.0	-1.0 ± 1.0	3.6 ± 5.1	<0.1
17. TA-53 (LAMPF)	137.21	12	2	31.0 ± 6.0	1.2 ± 0.3	9.6 ± 9.9	<0.1
18. Well PM-1	137.05	12	3	40.0 ± 8.0	1.3 ± 0.3	10.4 ± 12.8	<0.1
19. TA-52	131.06	12	1	23.0 ± 5.0	1.4 ± 0.3	9.8 ± 7.3	<0.1
20. TA-16	137.66	12	6	7.0 ± 2.0	-2.0 ± 2.0	3.1 ± 3.1	<0.1
21. Booster P-2	120.07	12	1	31.0 ± 6.0	0.7 ± 0.1	10.3 ± 9.0	<0.1
22. TA-54	128.36	12	1	50.0 ± 10.0	1.9 ± 0.4	27.8 ± 16.2	<0.1
23. TA-49	134.88	12	7	14.0 ± 3.0	-1.0 ± 0.9	2.5 ± 3.9	<0.1
24. TA-33	119.61	11	1	90.0 ± 20.0	1.8 ± 0.4	31.3 ± 26.3	<0.1
25. TA-2	72.80	7	2	60.0 ± 10.0	1.4 ± 0.3	24.7 ± 26.0	<0.1
26. TA-16-450	116.70	11	9	60.0 ± 10.0	-0.7 ± 1.0	6.3 ± 17.9	<0.1
Onsite Group Summary	1507.31	137	41	90.0 ± 20.0	-2.0 ± 2.0	12.5 ± 16.7	<0.1

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[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 = 2×10^{-6} µCi/mL.
Uncontrolled Area Derived Concentration Guide = 2×10^{-7} µCi/mL.

Table G-8. Atmospheric $^{239,240}Pu$ Concentration for 1986

Station Location[a]	Total Air Volume (m^3)	Number of Monthly 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. Espanola	98038	4	3	3.8 ± 0.9	0.2 ± 0.5	1.5 ± 1.6	<0.1
2. Pojoaque	93326	4	4	1.6 ± 0.6	0.6 ± 0.4	1.1 ± 0.4	<0.1
3. Santa Fe	77945	4	3	3.8 ± 1.0	0.7 ± 0.6	1.9 ± 1.5	<0.1
Regional Group Summary	269309	12	10	3.8 ± 1.0	0.2 ± 0.5	1.5 ± 1.2	<0.1
Perimeter Stations (0-40 km) -- Uncontrolled Areas							
4. Barranca School	88073	4	4	0.8 ± 0.2	0.0 ± 0.5	0.4 ± 0.4	<0.1
5. Arkansas Avenue	89228	4	3	15.8 ± 1.0	1.0 ± 0.6	4.9 ± 7.3	<0.1
6. East Gate	73175	4	3	4.6 ± 1.2	0.0 ± 0.5	1.8 ± 2.0	<0.1
7. 48th Street	82969	4	3	3.5 ± 1.0	0.8 ± 0.7	1.6 ± 1.3	<0.1
8. LA Airport	93782	4	2	2.8 ± 0.8	1.6 ± 0.5	2.1 ± 0.5	<0.1
9. Bayo STP	89859	4	1	4.1 ± 1.0	1.2 ± 0.3	2.4 ± 1.2	<0.1
10. Exxon Station	79254	4	1	6.8 ± 1.3	2.0 ± 0.7	3.5 ± 2.2	<0.1
11. Royal Crest	84742	4	4	1.0 ± 0.8	0.2 ± 0.4	0.5 ± 0.4	<0.1
12. White Rock	107199	4	4	1.0 ± 0.4	0.1 ± 0.4	0.5 ± 0.4	<0.1
13. Pajarito Acres	88893	4	4	0.6 ± 0.5	0.3 ± 0.4	0.5 ± 0.1	<0.1
14. Bandelier	103917	4	4	0.7 ± 0.6	0.1 ± 0.5	0.5 ± 0.3	<0.1
Perimeter Group Summary	981091	44	33	15.8 ± 1.0	0.0 ± 0.5	1.7 ± 2.6	<0.1

Table G-8 (cont)

Station Location[a]	Total Air Volume (m^3)	Number of Monthly Samples	Number of Samples <MDL[b]	Concentrations--aCi/m^3 (10^{-18} μCi/mL) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Onsite Stations -- Controlled Areas							
15. TA-21	76925	4	4	1.8 ± 0.8	0.9 ± 0.7	1.4 ± 0.4	<0.1
16. TA-6	77409	4	4	1.6 ± 0.4	0.3 ± 0.7	1.2 ± 0.6	<0.1
17. TA-53 (LAMPF)	102235	4	4	1.4 ± 0.6	0.2 ± 0.4	0.8 ± 0.6	<0.1
18. Well PM-1	103057	4	4	1.4 ± 0.3	0.1 ± 0.4	0.6 ± 0.6	<0.1
19. TA-52	90565	4	4	1.9 ± 0.7	0.0 ± 0.4	1.0 ± 0.8	<0.1
20. TA-16	100594	4	4	0.9 ± 0.4	0.3 ± 0.4	0.6 ± 0.2	<0.1
21. Booster P-2	91940	4	3	2.4 ± 0.8	0.0 ± 0.5	1.3 ± 1.0	<0.1
22. TA-54	67434	4	0	36.8 ± 3.2	7.8 ± 1.5	22.6 ± 11.9	<0.1
23. TA-49	77076	4	4	1.5 ± 1.0	0.2 ± 0.5	1.0 ± 0.6	<0.1
24. TA-33	96368	4	4	0.9 ± 0.4	0.2 ± 0.4	0.6 ± 0.4	<0.1
25. TA-2	60542	3	2	4.2 ± 1.5	0.0 ± 0.4	1.5 ± 2.3	<0.1
26. TA-16-450	83116	4	4	1.9 ± 0.8	0.2 ± 0.2	0.6 ± 0.8	<0.1
Onsite Group Summary	1 027 261	47	41	36.8 ± 3.2	0.0 ± 0.5	2.8 ± 6.9	<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/mL.
Uncontrolled Area Derived Concentrations Guide = 2×10^{-14} μCi/mL.

Table G-9. Atmospheric ^{241}Am Concentration for 1986

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	77 945	4	1	7.2 ± 1.09	0.9 ± 2.4	3.3 ± 2.7	<0.1
Perimeter Stations (0-40 km)--Uncontrolled Areas							
6. East Gate	53 818	3	0	7.5 ± 1.5	3.8 ± 1.3	5.2 ± 2.0	<0.1
8. LA Airport	93 782	4	0	7.9 ± 2.5	2.2 ± 0.9	4.5 ± 2.5	<0.1
9. Bayo STP	42 782	2	0	5.4 ± 1.5	2.8 ± 0.9	4.1 ± 1.8	<0.1
12. White Rock	107 199	4	1	5.2 ± 2.9	2.2 ± 0.9	3.3 ± 1.4	<0.1
Perimeter Grouop Summary	376 835	13	1	7.9 ± 2.5	2.2 ± 0.9	4.2 ± 1.8	<0.1
Onsite Stations--Controlled Areas							
16. TA-6	77 409	4	1	6.2 ± 1.6	0.9 ± 3.3	3.1 ± 2.3	<0.1
17. TA-53 (LAMPF)	102 235	4	1	4.1 ± 0.9	2.2 ± 1.0	3.0 ± 0.8	<0.1
20. TA-16	78 679	3	2	4.0 ± 0.9	1.2 ± 0.7	2.7 ± 1.4	<0.1
21. Booster P-2	91 940	4	1	4.3 ± 1.1	2.8 ± 0.9	3.6 ± 0.6	<0.1
22. TA-54	67 434	4	0	24 ± 2.8	9.5 ± 1.9	18.3 ± 6.4	<0.1
Onsite Group Summary	417 697	19	5	24.3 ± 2.8	0.9 ± 3.3	6.3 ± 7.0	<0.1

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[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/mL.
Uncontrolled Area Derived Concentration Guide = 2×10^{-14} µCi/mL.

Table G-10. Atmospheric Uranium Concentration for 1986

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. Espanola	98 038	4	0	71.6 ± 7.2	53.3 ± 5.3	62.6 ± 9.0	<0.1
2. Pojoaque	93 326	4	0	104.7 ± 10.5	41.0 ± 4.1	73.4 ± 27.0	<0.1
3. Santa Fe	77 945	4	0	84.3 ± 8.4	21.8 ± 2.2	45.4 ± 27.7	<0.1
Regional Group Summary	269 309	12	0	104.7 ± 10.5	21.8 ± 2.2	60.4 ± 24.0	<0.1
Perimeter Stations (0-4)--Uncontrolled Areas							
4. Barranca School	88 073	4	0	26.5 ± 2.6	12.7 ± 1.3	20.3 ± 6.5	<0.1
5. Arkansas Avenue	89 228	4	0	18.2 ± 1.8	14.0 ± 1.4	15.3 ± 2.0	<0.1
6. East Gate	73 175	4	0	38.9 ± 3.9	19.1 ± 1.9	29.2 ± 8.4	<0.1
7. 48th Street	82 969	4	0	27.5 ± 2.8	12.0 ± 1.2	20.6 ± 6.7	<0.1
8. LA Airport	93 782	4	0	41.1 ± 4.1	24.0 ± 2.4	31.5 ± 7.7	<0.1
9. Bayo STP	89 859	4	0	33.8 ± 3.4	13.1 ± 1.3	24.0 ± 9.1	<0.1
10. Exxon Station	79 254	4	0	51.1 ± 5.1	30.8 ± 3.1	40.2 ± 10.8	<0.1
11. Royal Crest	84 742	4	0	123.4 ± 12.3	18.2 ± 1.8	51.2 ± 49.4	<0.1
12. White Rock	107 199	4	0	21.6 ± 2.1	10.4 ± 1.0	16.5 ± 4.7	<0.1
13. Pajarito Acres	88 893	4	0	62.6 ± 6.3	10.7 ± 11	28.4 ± 23.6	<0.1
14. Bandelier	103 917	4	0	17.1 ± 1.7	9.0 ± 0.9	11.6 ± 3.7	<0.1
Perimeter Group Summary	981 091	44	0	123.4 ± 12.3	9.0 ± 0.9	26.2 ± 19.2	<0.1

Table G-10 (cont)

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]
Onsite Stations--Controlled Areas							
15. TA-21	76 925	4	0	48.5 ± 4.8	21.5 ± 2.2	34.8 ± 11.0	<0.1
16. TA-6	77 409	4	0	74.4 ± 7.4	21.7 ± 2.2	37.3 ± 24.9	<0.1
17. TA-53 (LAMPF)	102 235	4	0	41.5 ± 4.1	19.4 ± 1.9	30.8 ± 10.1	<0.1
18. Well PM-1	103 057	4	0	21.2 ± 2.1	13.3 ± 1.3	15.4 ± 2.8	<0.1
19. TA-52	90 565	4	0	31.6 ± 2.2	21.6 ± 2.2	26.6 ± 5.1	<0.1
20. TA-16	100 594	4	0	24.1 ± 2.4	10.9 ± 1.1	17.4 ± 5.6	<0.1
21. Booster P-2	91 940	4	0	42.0 ± 4.2	19.2 ± 1.9	26.1 ± 10.6	<0.1
22. TA-54	67 454	4	0	92.5 ± 9.2	32.9 ± 3.3	61.6 ± 27.8	<0.1
23. TA-49	77 076	4	0	35.5 ± 3.5	12.7 ± 1.3	20.7 ± 10.1	<0.1
24. TA-33	96 368	4	0	23.9 ± 2.4	7.9 ± 0.8	14.5 ± 6.8	<0.1
25. TA-2	47 720	2	0	22.8 ± 2.3	16.5 ± 1.7	19.6 ± 4.4	<0.1
26. TA-16-450	83 116	4	0	12.3 ± 1.2	3.5 ± 0.4	9.3 ± 3.9	<0.1
Onsite Group Summary	1 016 439	46	0	92.5 ± 9.2	3.5 ± 0.4	26.5 ± 17.9	<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-11. Beryllium Emission Tests

Location of Beryllium Shop	Beryllium Emissions: Measured Maximum 10^{-8} lb/hr	Measured Maximum 10^{-8} tons/yr	Permit Limits 10^{-8} lb/hr	Permit Limits 10^{-8} tons/yr
TA-35-213	3	3.1	40	40
TA-3-39, Shop 4	<1.3	<1.4	400	400
TA-3-102, Shop 13	<5.9	<1.1	40	7

Table G-12. 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	1985	2.3	0.4	0.1	2.8
	1986	1.8	0.4	0.1	2.3
	% Change	-21.9	0	0	-17.7
Oxides of Nitrogen	1985	18.1	19.9	5.2	43.2
	1986	15.1	19.6	5.5	40.1
	% Change	-16.8	-1.8	6.3	-7.1
Carbon Monoxide	1985	30.3	5.0	1.3	36.6
	1986	23.6	4.9	1.4	29.9
	% Change	-21.9	-1.8	6.4	-18.2
Hydrocarbons	1985	1.3	0.8	0.2	2.3
	1986	1.0	0.8	0.2	2.0
	% Change	-22.1	0	0	-12.3
Fuel Consumption	1985	1670	314	81	2065
	1986	1313	310	87	1710
	% Change	-21.4	-1.1	7.1	-17.2

Table G-13. Quality of Effluent from the TA-50 Liquid Radioactive Waste Treatment Plan for 1986[a]

Radionuclide	Activity Released (mCi)	Mean Concentration (μCi/mL)	Mean as % DOE's CG[b]
^{3}H	7250	2.4×10^{-3}	2.4
^{89}Be	9.2	3.0×10^{-7}	0.1
^{90}Sr	0.69	3.2×10^{-8}	0.3
^{137}Cs	18	5.9×10^{-7}	0.1
^{234}U	2.4	8.0×10^{-8}	0.1
^{238}Pu	1.5	4.9×10^{-8}	<0.1
$^{239,230}Pu$	3.6	1.2×10^{-7}	0.1
^{241}Am	3.2	1.1×10^{-7}	0.1

Nonradioactive Constituents	Mean Concentration (mg/L)
Cd[c]	5.7×10^{-4}
Ca	140
Cl	170
Total Cr[c]	2.9×10^{-2}
Cu[c]	0.36
F	18
Hg[c]	2.2×10^{-3}
Mg	0.55
Na	850
Pb[c]	1.0×10^{-2}
Zn[c]	0.16
CN	0.26
COD	180
NO_3-N	410
PO_4	0.29
TDS	3780
pH[c]	7.6 - 12.7

Total Effluent Volume = 3.0×10^{7} L

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[a]As reported on DOE forms F-5821.1.
[b]Department of Energy's Concentration Guide for Controlled Areas (Appendix A).
[c]Constituents regulated by National Pollutant Discharge Elimination System permit.

Table G-14. Quality of Effluent from the Los Alamos Meson Physics Facilities (TA-53) Lagoons

Radionuclide	Activity Released (mCi)	Mean Concentration (Ci/mL)	Mean as % DOE's CG[a]
^{3}H	17210	$3.1E \times 10^{-3}$	3.1
^{7}Be	831	$1.5E \times 10^{-4}$	0.3
^{22}Na	142	$2.5E \times 10^{-5}$	2.5
^{54}Mn	18.9	$3.4E \times 10^{-6}$	0.1
^{57}Co	50.2	$8.8E \times 10^{-6}$	<0.1
^{60}Co	3.6	$6.4E \times 10^{-7}$	0.1
^{134}Cs	131	$2.3E \times 10^{-5}$	7.7

Total Effluent Volume = 5.6×10^{6} L

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[a]Department of Energy's Concentration Guide for Controlled Areas (Appendix A).

Table G-15. Location of Surface and Groundwater 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	30°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	E530	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
Group III				
Spring 1	N040	E520	32	SWR
Spring 2	N015	E505	33	SWR

Table G-15 (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
White Rock Canyon				
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
Canada 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-15 (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-15 (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

[a]Federal surface water sampling locations in Fig. 15; Perimeter, White Rock Canyon, Onsite, and Effluent Release Area sampling locations in Fig. 16.
[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. Radiochemical Quality of Surface Water from Regional Stations

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Rio Chama at Chamita[a]	1.3 (0.4)[b]	-41 (37)	0.3 (0.2)	0.000 (0.010)	0.005 (0.010)	95 (60)
Rio Chama at Chamita[c]	-0.6 (0.4)	-57 (30)	2.0 (1.0)	0.000 (0.010)	0.026 (0.012)	-300 (100)
Rio Grande at Embudo	1.0 (0.4)	-30 (32)	0.7 (0.7)	0.018 (0.015)	0.000 (0.010)	60 (60)
Rio Grande at Embudo	-0.2 (0.4)	10 (31)	2.0 (1.0)	0.000 (0.010)	-0.004 (0.008)	-300 (100)
Rio Grande at Otowi	0.5 (0.4)	23 (35)	0.3 (0.2)	-0.004 (0.008)	0.000 (0.010)	20 (60)
Rio Grande at Otowi	-0.7 (0.4)	38 (34)	5.0 (1.0)	0.024 (0.019)	0.009 (0.012)	-200 (100)
Rio Grande at Cochiti	0.8 (0.4)	17 (42)	2.5 (0.5)	0.028 (0.020)	0.009 (0.011)	40 (60)
Rio Grande at Cochiti	0.6 (0.4)	-5 (34)	2.0 (1.0)	-0.008 (0.010)	-0.008 (0.008)	400 (100)
Rio Grande at Bernalillo	0.6 (0.4)	-45 (46)	2.7 (0.5)	-0.014 (0.011)	-0.009 (0.007)	90 (60)
Rio Grande at Bernalillo	-0.2 (0.4)	-27 (32)	2.0 (1.0)	-0.018 (0.013)	0.028 (0.013)	-150 (100)
Jemez River at Jemez	0.6 (0.4)	0 (40)	0.4 (0.2)	0.025 (0.015)	0.015 (0.011)	-5 (60)
Jemez River at Jemez	0.8 (0.4)	37 (32)	2.0 (1.0)	0.023 (0.023)	0.006 (0.013)	-350 (100)
No. of Analyses	12	12	12	12	12	12
Average	0.4	-7	1.8	0.006	0.006	-50
S	0.6	33	1.3	0.016	0.012	215
Minimum	-0.7 (0.4)	-57 (30)	0.3 (0.2)	-0.018 (0.013)	-0.009 (0.007)	-350 (100)
Maximum	1.3 (0.4)	38 (34)	5.0 (1.0)	0.028 (0.015)	0.028 (0.013)	400 (100)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]February 1986.
[b]Counting uncertainties in parentheses.
[c]August 1986.

Table G-17. Chemical Quality of Surface Water from Regional Stations

Station	(Chemical Concentrations in mg/L)															Conductivity (mS/m)
	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hardness	pH	
Rio Chama at Chamita	11	39	7.1	2.0	15	0	85	<0.1	74	3	0.2	0.3	213	120	8.0	32
Rio Grande de Embudo	22	27	5.0	2.4	13	0	82	<0.1	33	4	0.4	0.5	159	85	8.0	24
Rio Grande at Otowi	14	37	6.6	2.2	15	0	88	<0.1	58	4	0.3	0.3	195	104	8.0	30
Rio Grande at Cochiti	16	36	1.2	2.7	19	0	103	<0.1	42	5	0.4	0.5	199	111	8.2	31
Rio Grande at Bernalillo	15	38	6.8	2.9	19	0	105	<0.1	46	6	0.4	0.7	206	108	8.0	28
Jemez River at Jemez	36	38	4.1	8.8	51	0	133	<0.1	13	67	0.8	1.1	308	108	8.0	50
Summary																
No. of Analyses	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Average	19	36	5.1	3.5	22	-	99	<0.1	44	15	0.4	0.6	213	106	8.0	32
S	9	4	2.2	2.6	14	-	19	--	21	26	0.2	0.3	50	12	<0.1	9
Minimum	11	27	1.2	2.0	13	-	82	--	13	3	0.2	0.3	159	85	8.0	24
Maximum	22	39	7.1	8.8	51	0	133	--	74	67	0.8	1.1	308	120	8.2	50

Table G-18. Radiochemical Quality of Surface and Groundwaters from Perimeter Stations, 1986

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Los Alamos Reservoir[a]	2.1 (0.5)[b]	-33 (36)	1.0 (1.0)	-0.006 (0.013)	0.012 (0.020)	-300 (100)
Guaje Reservoir[a]	2.4 (0.5)	-14 (29)	1.0 (1.0)	0.014 (0.010)	0.019 (0.013)	-350 (100)
Frijoles Canyon[c]	0.2 (0.4)	58 (38)	--	0.005 (0.013)	-0.010 (0.007)	-5 (60)
Frijoles Canyon[a]	0.4 (0.4)	-37 (38)	1.0 (1.0)	0.000 (0.010)	0.004 (0.011)	-15 (100)
La Mesita Spring[c]	0.3 (0.4)	37 (48)	13 (1.0)	-0.008 (0.015)	-0.004 (0.004)	-5 (60)
La Mesita Springs[a]	0.4 (0.4)	-50 (35)	10 (0.1)	-0.005 (0.005)	0.010 (0.012)	-75 (100)
Indian Springs[c]	1.4 (0.4)	50 (48)	2.5 (0.5)	-0.005 (0.013)	0.010 (0.012)	-20 (60)
Indian Springs[a]	0.1 (0.4)	-46 (37)	5.0 (0.1)	-0.012 (0.021)	0.036 (0.027)	-200 (100)
Sacred Springs[c]	0.4 (0.4)	45 (36)	3.5 (0.6)	0.019 (0.015)	0.010 (0.010)	--
Sacred Springs[a]	3.5 (0.6)	19 (32)	2.0 (0.1)	0.014 (0.012)	0.019 (0.009)	-75 (100)
Summary						
No. of Analyses	10	10	9	10	10	9
Average	1.1	3	4.3	0.002	0.011	-176
S	1.2	43	4.3	0.011	0.013	130
Minimum	0.1 (0.4)	-50 (35)	1.0 (1.0)	-0.012 (0.021)	-0.010 (0.007)	-350 (100)
Maximum	3.5 (0.6)	58 (38)	13 (1.0)	0.019 (0.015)	0.036 (0.077)	-5 (60)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]September
[b]Counting uncertainty in parentheses.
[c]February

Table G-19. Radiochemical Quality of Surface Waters from White Rock Canyon, October 1986

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Group I						
Sandia Spring	0.6 (0.4)[a]	-48 (39)	4 (1)	-0.008 (0.011)	0.004 (0.009)	200 (100)
Spring 3	0.4 (0.4)	27 (47)	4 (1)	0.011 (0.008)	0.000 (0.010)	450 (200)
Spring 3A	0.0 (0.4)	8 (37)	4 (1)	0.000 (0.010)	0.000 (0.010)	450 (100)
Spring 3AA	0.4 (0.4)	110 (57)	5 (1)	-0.004 (0.007)	0.004 (0.008)	-150 (100)
Spring 4	0.4 (0.4)	-46 (44)	4 (1)	0.004 (0.009)	0.037 (0.015)	300 (100)
Spring 4A	-0.1 (0.4)	25 (46)	4 (1)	0.009 (0.019)	0.004 (0.010)	200 (100)
Spring 5	0.6 (0.4)	-34 (39)	3 (1)	0.004 (0.010)	0.004 (0.014)	200 (100)
Spring 5AA	0.6 (0.4)	6 (52)	2 (1)	0.003 (0.008)	-0.004 (0.012)	150 (100)
Ancho Spring	1.3 (0.4)	15 (45)	2 (1)	-0.013 (0.008)	0.004 (0.010)	75 (100)
Group II						
Spring 5A	0.5 (0.4)	85 (48)	4 (1)	0.000 (0.010)	0.010 (0.015)	750 (200)
Spring 5B	0.3 (0.4)	-12 (39)	3 (1)	0.000 (0.010)	-0.004 (0.011)	-75 (100)
Spring 6	0.0 (0.4)	-43 (44)	3 (1)	0.000 (0.010)	0.000 (0.010)	800 (200)
Spring 6A	0.5 (0.4)	1 (47)	2 (1)	0.000 (0.010)	0.007 (0.010)	800 (200)
Spring 8A	-0.1 (0.4)	61 (47)	1 (1)	-0.015 (0.011)	0.005 (0.013)	-75 (100)
Spring 9	0.6 (0.4)	7 (39)	1 (1)	-0.004 (0.007)	0.000 (0.010)	75 (100)
Spring 9A	-0.1 (0.4)	-33 (46)	1 (1)	0.018 (0.012)	0.004 (0.008)	150 (100)
Doe Spring	0.3 (0.4)	53 (38)	1 (1)	0.008 (0.011)	0.019 (0.011)	-75 (100)
Group III						
Spring 1	0.8 (0.4)	34 (53)	3 (1)	0.008 (0.010)	0.004 (0.007)	75 (100)
Spring 2	0.5 (0.4)	31 (39)	4 (1)	-0.008 (0.008)	0.016 (0.014)	150 (100)
Group IV						
Spring 3B	0.4 (0.4)	25 (52)	16 (1)	-0.008 (0.015)	0.017 (0.011)	-75 (100)
Streams						
Pajarito	0.9 (0.4)	-58 (50)	9 (1)	0.005 (0.020)	0.005 (0.013)	-200 (100)
Ancho	0.9 (0.4)	81 (50)	4 (1)	-0.012 (0.010)	0.008 (0.014)	-350 (100)
Frijoles	1.4 (0.4)	-36 (39)	2 (1)	0.006 (0.023)	0.000 (0.010)	-75 (100)

Table G-19 (cont)

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Sanitary Effluent						
Mortandad	0.1 (0.4)	89 (0.4)	2 (1)	0.017 (0.018)	0.013 (0.011)	75 (100)
No. of Analyses	24	24	24	24	24	24
Average	0.5	14	4	0.001	0.006	160
S	0.4	48	3	0.009	0.009	305
Minimum	−0.1 (0.4)	−48 (39)	1 (1)	−0.015 (0.011)	−0.004 (0.012)	−150 (100)
Maximum	1.4 (0.4)	100 (57)	16 (1)	0.018 (0.012)	0.037 (0.015)	800 (200)
Limits of Detection	0.7	40	1	0.009	0.03	50

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[a]Counting uncertainty in parentheses.

Table G-20. Chemical Quality of Perimeter Stations, February 1986 (mg/L unless specified)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hardness	pH[a]	Conductivity[b]
Frijoles Canyon	53	8	2.6	1.5	9	0	46	<0.1	3	2	0.2	<0.1	114	33	7.8	11
La Mesita Spring	26	33	0.8	2.7	30	0	116	<0.1	12	6	0.4	1.9	197	84	7.9	30
Indian Spring	30	21	0.4	2.6	23	0	93	<0.1	6	4	0.5	0.4	194	55	7.8	19
Sacred Spring	42	26	2.0	2.3	21	0	100	<0.1	5	9	0.5	0.5	172	69	7.8	24
Summary																
No. of Analyses	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Average	38	22	1.4	2.3	21	--	89	--	6	5	0.4	<0.7	169	60	7.8	21
S	12	10	1.0	0.5	9	--	30	--	4	3	0.1	0.8	38	22	<0.1	8
Minimum	26	8	0.4	1.5	9	--	46	--	3	2	0.2	<0.1	114	33	7.8	11
Maximum	53	33	2.6	2.7	30	0	116	<0.1	12	9	0.5	1.9	197	84	7.9	30

[a]Standard units.
[b]mS/m.

Table G-21. Primary Water Quality of Springs and Streams in White Rock Canyon (mg/L)

Station	Ag	As	Ba	Cd	Cr	F	N	Pb	Se
Group I									
Sandia Spring	<0.05	<0.05	<0.05	<0.01	<0.05	0.7	0.3	<0.05	<0.01
Spring 3	<0.05	<0.05	<0.05	<0.01	0.05	0.6	0.7	<0.05	0.01
Spring 3A	<0.05	<0.05	<0.05	<0.01	0.05	0.6	0.6	<0.05	<0.01
Spring 3AA	<0.05	<0.05	<0.05	<0.01	<0.05	0.7	0.7	<0.05	<0.01
Spring 4	<0.05	<0.05	<0.05	<0.01	0.05	0.7	1.4	<0.05	<0.01
Spring 4A	<0.05	<0.05	<0.05	<0.01	0.06	0.7	1.1	<0.05	<0.01
Spring 5	<0.05	<0.05	<0.05	<0.01	0.06	0.6	0.5	<0.05	<0.01
Spring 5AA	<0.05	<0.05	<0.05	<0.01	0.06	0.6	0.2	<0.05	<0.01
Ancho Spring	<0.05	<0.05	<0.05	<0.01	0.06	0.5	0.3	<0.05	0.01
Group II									
Spring 5A	<0.05	<0.05	<0.05	<0.01	0.06	0.5	0.4	<0.05	<0.01
Spring 5B	<0.05	<0.05	0.06	<0.01	<0.05	0.5	7.0	<0.05	<0.01
Spring 6	<0.05	<0.05	<0.05	<0.01	0.06	0.5	0.4	<0.05	0.03
Spring 6A	<0.05	<0.05	<0.05	<0.01	0.06	0.4	0.4	<0.05	0.01
Spring 8A	<0.05	<0.05	<0.05	<0.01	<0.05	0.5	0.9	<0.05	<0.01
Spring 9	<0.05	<0.05	<0.05	<0.01	<0.05	0.6	0.2	<0.05	<0.01
Spring 9A	<0.05	<0.05	<0.05	<0.01	<0.05	0.5	<0.1	<0.05	0.02
Doe Spring	<0.05	<0.05	<0.05	<0.01	<0.05	0.7	<0.1	<0.05	<0.01
Group III									
Spring 1	<0.05	<0.05	0.05	<0.01	<0.05	1.0	0.1	<0.05	<0.01
Spring 2	<0.05	<0.05	<0.05	<0.01	<0.05	1.4	0.8	<0.05	<0.01
Group IV									
Spring 3B	<0.05	<0.05	0.06	<0.01	<0.05	0.7	1.6	<0.05	<0.01
Streams									
Pajarito	<0.05	<0.05	0.05	<0.01	<0.05	0.6	0.7	<0.05	<0.01
Ancho	<0.05	<0.05	<0.05	<0.01	<0.05	0.4	<0.1	<0.05	<0.01
Frijoles	<0.05	<0.05	<0.05	<0.01	<0.05	0.5	0.4	<0.05	<0.01

Table G-21 (cont)

Station	Ag	As	Ba	Cd	Cr	F	N	Pb	Se
Sanitary Effluent									
Mortandad	<0.05	<0.05	<0.05	<0.01	<0.05	0.5	1.0	<0.05	<0.01
Maximum	<0.05	<0.05	0.06	<0.01	0.06	1.4	7.0	<0.05	0.03
Maximum % of Standard	<100	<100	6	<100	120	70	70	<100	300
USEPA Standard	0.05	0.05	1.0	0.01	0.05	2.0	10	0.05	0.01

Table G-22. Secondary Water Quality of Springs and Streams in White Rock Canyon (mg/L)

Station	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Group I								
Sandia Spring	6	<0.05	0.2	<0.05	7	<0.05	179	8.1
Spring 3	4	<0.05	0.2	<0.05	6	<0.05	150	8.2
Spring 3A	4	<0.05	0.2	<0.05	6	<0.05	148	8.2
Spring 3AA	3	<0.05	0.2	<0.05	4	<0.05	135	7.4
Spring 4	8	<0.05	0.2	<0.05	9	<0.05	161	7.7
Spring 4A	7	<0.05	0.2	<0.05	8	<0.05	178	8.0
Spring 5	6	<0.05	0.2	<0.05	6	<0.05	154	7.7
Spring 5AA	6	<0.05	0.3	0.08	5	<0.05	182	7.4
Ancho Spring	4	<0.05	0.2	<0.05	7	0.08	130	7.5
Group II								
Spring 5A	7	<0.05	0.2	<0.05	15	<0.05	187	7.7
Spring 5B	1	<0.05	0.1	<0.05	18	<0.05	200	7.8
Spring 6	3	<0.05	0.3	<0.05	5	<0.05	146	7.8
Spring 6A	2	<0.05	0.3	<0.05	2	<0.05	131	7.6
Spring 8A	4	<0.05	<0.1	<0.05	4	<0.05	137	8.2
Spring 9	2	<0.05	<0.1	<0.05	2	<0.05	139	8.1
Spring 9A	2	<0.05	<0.1	0.05	3	<0.05	126	7.8
Doe Spring	4	<0.05	0.2	<0.05	5	<0.05	137	7.8
Group III								
Spring 1	5	<0.05	0.2	<0.05	9	<0.05	162	8.0
Spring 2	5	<0.05	0.2	<0.05	12	<0.05	198	8.4
Group IV								
Spring 3B	6	<0.05	0.2	<0.05	10	<0.05	395	7.9
Streams								
Pajarito	6	<0.05	0.1	<0.05	7	<0.05	167	8.3
Ancho	4	<0.05	0.2	<0.05	4	<0.05	123	8.6
Frijoles	4	<0.05	0.6	<0.05	7	<0.05	110	7.9

Table G-22 (cont)

Station	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Sanitary Effluent								
Mortandad		<0.05	0.2	<0.05	34	<0.05	468	8.2
Maximum	53	<0.05	0.6	0.05	34	<0.05	468	---
Maximum % of Standard	21	5	200	<100	14	<1	94	---
USEPA Standard	250	1.0	0.3	0.05	250	5.0	500	6.5-8.5

Table G-23. Miscellaneous Water Quality of Springs and Streams in White Rock Canyon (mg/L)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hardness	Conductivity (mS/m)
Group I										
Sandia Spring	51	38	2.5	2.6	16	0	121	<1	104	26
Spring 3	61	21	1.6	3.0	15	0	78	<1	60	18
Spring 3A	48	21	1.7	2.9	15	0	78	<1	62	18
Spring 3AA	42	19	0.4	4.0	18	0	78	<1	59	17
Spring 4	52	23	4.3	2.7	14	0	79	<1	74	22
Spring 4A	83	22	4.5	2.2	12	0	78	<1	83	19
Spring 5	65	20	4.5	2.4	12	0	77	<1	73	18
Spring 5AA	62	34	6.0	2.5	14	0	126	<1	112	28
Ancho Spring	71	13	2.9	1.9	10	0	57	<1	56	13
Group II										
Spring 5A	49	28	3.5	3.3	22	0	116	<1	97	28
Spring 5B	75	29	6.5	3.5	11	0	78	<1	101	30
Spring 6	71	14	3.3	2.0	11	0	66	<1	49	15
Spring 6A	75	9	2.8	2.3	17	0	55	<1	48	12
Spring 8A	56	10	2.6	1.8	12	0	57	<1	40	12
Spring 9	72	11	2.9	1.5	12	0	59	<1	51	12
Spring 9A	68	11	2.8	1.5	11	0	54	<1	49	12
Doe Spring	64	12	3.2	1.5	12	0	62	<1	50	13
Group III										
Spring 1	36	19	1.2	2.2	33	0	107	<1	55	24
Spring 2	33	23	1.2	1.2	61	1.9	168	<1	63	36
Group IV										
Spring 3B	57	25	1.9	4.8	134	0	308	<1	71	65

Table G-23 (cont)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hardness	Conductivity (mS/m)
Streams										
Pajarito	65	21	4.3	2.6	14	0	84	<1	70	20
Ancho	65	13	3.1	1.6	11	4.8	61	<1	47	13
Frijoles	52	10	3.0	2.2	9	0	46	8.7	42	11
Sanitary Effluent										
Mortandad	125	33	11	18	60	0	210	9.1	115	71

Table G-24. Radiochemical Quality of Surface and Groundwaters from Onsite Stations

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Test Well 1[a]	10.6 (0.4)	−92 (32)	1.0 (0.2)	−0.008 (0.017)	−0.004 (0.007)	15 (60)
Test Well 1[b]	0.9 (0.4)	−38 (29)	3.0 (1.0)	−0.012 (0.011)	0.016 (0.012)	−150 (100)
Test Well 2[a]	0.4 (0.4)	73 (30)	0.0 (0.1)	−0.005 (0.010)	0.009 (0.009)	−150 (70)
Test Well 2[b]	1.4 (0.4)	−16 (31)	3.0 (1.0)	0.000 (0.010)	−0.004 (0.009)	−200 (100)
Test Well 3[a]	0.0 (0.4)	5 (28)	0.0 (0.1)	−0.004 (0.007)	0.008 (0.008)	−150 (70)
Test Well 3[b]	1.4 (0.4)	−17 (32)	3.0 (1.0)	−0.012 (0.007)	0.008 (0.010)	−300 (100)
Test Well DT-5A[a]	−0.1 (0.4)	−45 (27)	0.1 (0.1)	0.000 (0.010)	−0.012 (0.008)	−120 (60)
Test Well DT-5A[b]	--	--	2.0 (1.0)	--	--	--
Test Well 8[a]	1.0 (0.4)	−38 (34)	0.1 (0.1)	0.016 (0.015)	0.000 (0.010)	−120 (70)
Test Well 8[b]	0.7 (0.4)	−39 (37)	1.0 (1.0)	0.008 (0.011)	0.004 (0.009)	−75 (100)
Test Well DT-10[a]	−0.2 (0.4)	−78 (32)	0.0 (0.1)	0.004 (0.015)	0.013 (0.010)	−160 (70)
Test Well DT-10[b]	1.7 (0.4)	22 (32)	1.0 (1.0)	0.004 (0.011)	0.008 (0.008)	−200 (100)
Canada del Buey[a]	1.6 (0.4)	14 (24)	0.0 (0.1)	0.000 (0.010)	0.011 (0.011)	−140 (70)
Canada del Buey[b]	1.7 (0.4)	15 (28)	1.0 (1.0)	0.012 (0.011)	0.012 (0.007)	−300 (100)
Pajarito Canyon[a]	1.4 (0.4)	52 (33)	1.1 (0.2)	0.006 (0.023)	0.000 (0.010)	−95 (60)
Pajarito Canyon[b]	1.1 (0.4)	−29 (38)	4.0 (1.0)	0.000 (0.010)	0.000 (0.010)	75 (100)
Water at Beta Hole[a]	0.8 (0.4)	−2 (37)	0.1 (0.1)	−0.009 (0.009)	−0.004 (0.004)	−20 (70)
Water at Beta Hole[b]	1.1 (0.4)	−11 (27)	1.0 (1.0)	0.010 (0.021)	−0.005 (0.005)	−150 (100)

Table G-24 (cont)

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
No. of Analyses	17	17	18	17	17	17
Average	0.9	−13	1.1	0.001	0.004	−120
S	0.6	42	1.3	0.008	0.008	100
Minimum	−0.2 (0.4)	−92 (32)	0.0 (0.1)	−0.012 (0.007)	−0.012 (0.008)	−300 (100)
Maximum	1.7 (0.4)	73 (30)	4.0 (1.0)	0.016 (0.015)	0.016 (0.012)	75 (100)
Limits of Detection	0.7	40	1	0.009	0.03	50

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[a]February 1986.
[b]Counting uncertainty in parentheses.
[c]September 1986.

Table G-25. Radiochemical Quality of Groundwater in Pajarito Canyon

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Well PCO-1[a]	−1.4 (0.8)[b]	−17 (61)	0.0 (0.2)	0.016 (0.020)	0.021 (0.020)	−30 (120)
Well PCO-1[c]	0.8 (0.8)	−28 (72)	1.0 (0.6)	−0.010 (0.025)	0.005 (0.033)	−90 (120)
Well PCO-2 (Dry)[a]						
Well PCO-2[c]	0.8 (0.4)	−38 (56)	2.5 (0.6)	0.006 (0.029)	−0.011 (0.027)	−140 (120)
Well PCO-3[a]	1.2 (0.8)	−44 (70)	0.5 (0.6)	0.012 (0.020)	0.015 (0.020)	−40 (120)
Well PCO-3[c]	0.9 (0.8)	−10 (64)	3.7 (0.8)	−0.027 (0.034)	−0.005 (0.016)	−120 (120)
No. of Analyses	5	5	5	5	5	5
Average	0.5	−27	1.5	−0.001	0.005	−84
S	1.0	14	1.5	0.018	0.013	48
Minimum	−1.4 (0.8)	−44 (70)	0.0 (0.2)	−0.027 (0.031)	−0.011 (0.027)	−140 (120)
Maximum	1.2 (0.8)	−10 (64)	3.7 (0.8)	0.016 (0.020)	0.021 (0.020)	−30 (120)

[a]March 1986.
[b]Counting uncertainty in parentheses.
[c]June 1986.

Table G-26. Chemical Quality of Onsite Ground or Surface Water, February and March 1986 (mg/L unless specified)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hardness	pH[a]	Conductivity[b]
Test Well 1	50	46	9.5	3.7	14	0	92	<0.1	22	38	0.7	6.4	268	144	8.0	39
Test Well 2	19	13	3.2	1.2	10	0	63	<0.1	<1	2	0.4	0.1	76	47	8.1	13
Test Well 3	13	15	4.8	2.2	13	0	76	<0.1	2	4	0.3	<0.1	96	58	8.0	16
Test Well DT-5A	69	7	2.4	1.8	11	0	42	<0.1	1	2	0.6	3.9	130	35	7.7	12
Test Well 8	35	12	3.2	2.0	11	0	67	<0.1	2	2	0.2	0.2	113	43	8.3	13
Test Well DT-10	35	14	3.6	1.4	12	0	72	<0.1	1	2	0.3	0.2	108	47	8.6	15
Canada del Buey	30	9	2.1	2.5	18	0	30	<0.1	5	20	1.0	0.8	113	30	8.6	15
Pajarito Canyon	35	82	16	4.8	62	0	239	<0.1	11	101	0.2	<0.1	454	260	7.7	80
Water at Beta Hole	30	10	3.3	3.0	19	0	59	<0.1	7	8	0.2	0.1	107	39	7.7	16
Summary																
No. of Analyses	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Average	35	23	5.3	2.5	19	--	82	--	<5.8	20	0.4	<1.3	163	78	8.1	24
S	16	25	4.6	1.2	16	--	62	--	>7.0	33	0.3	>2.3	122	76	0.4	22
Minimum	13	7	2.1	1.2	10	--	30	--	<1	2	0.2	<0.1	76	30	7.7	12
Maximum	50	82	16	4.8	62	0	239	<0.1	22	101	1.0	6.4	454	260	8.6	39

[a]Standard units.
[b]mS/m.

Table G-27. Chemical Quality of Groundwater in Pajarito Canyon (mg/L unless specified)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hardness	pH[a]	Conductivity[b]
PCO-1[c]	26	18	5	4	28	0	93	<0.2	8	22	0.3	0.3	170	88	7.4	26
PCO-2[d]	27	19	6	4	26	0	82	<0.2	9	27	0.2	1.3	188	74	7.5	28
PCO-2 (Dry)[c]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCO-2[d]	27	21	6	4	21	0	82	<0.2	8	25	0.2	0.8	175	75	7.4	26
PCO-3[c]	34	87	18	3	41	0	287	<0.2	9	40	0.6	<0.1	438	302	8.0	66
PCO-3[d]	30	55	12	4	32	0	212	<0.2	19	24	0.5	0.9	350	183	7.8	52
Summary																
No. of Analyses	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Average	29	40	9	4	30	--	151	--	11	27	0.4	0.7	264	144	7.6	40
S	3	30	6	<1	8	--	94	--	5	7	0.2	0.5	123	99	0.3	18
Minimum	26	18	5	3	21	--	82	--	8	22	0.2	<0.1	170	74	8.4	26
Maximum	34	87	18	4	41	0	287	<0.2	19	40	0.6	1.3	438	302	8.0	66

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[a]Standard units.
[b]mS/m.
[c]March 1986.
[d]June 1986.

Table G-28. Radiochemical Quality of Surface and Groundwaters from Acid-Pueblo Canyon

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Acid Weir[a]	0.9 (0.4)[b]	-57 (28)	0.1 (0.1)	0.004 (0.014)	0.220 (0.035)	-140 (70)
Acid Weir[c]	4.6 (0.6)	46 (37)	4.0 (1.0)	0.019 (0.020)	0.005 (0.011)	-200 (100)
Pueblo 1[a]	1.9 (0.4)	-50 (33)	0.1 (0.1)	0.000 (0.020)	0.026 (0.012)	-100 (60)
Pueblo 1[c]	0.4 (0.4)	-40 (31)	2.0 (1.0)	0.031 (0.017)	0.004 (0.012)	0 (100)
Pueblo 2[a]	0.6 (0.4)	61 (33)	0.0 (0.1)	0.004 (0.013)	0.000 (0.010)	-120 (70)
Pueblo 2[c]	1.1 (0.4)	-86 (34)	1.0 (1.0)	0.004 (0.012)	0.044 (0.018)	75 (100)
Pueblo 3[a]	0.4 (0.4)	6 (33)	0.1 (0.1)	0.004 (0.011)	0.017 (0.010)	-75 (60)
Pueblo 3[c]	3.2 (0.5)	-43 (28)	2.0 (1.0)	0.000 (0.010)	0.059 (0.021)	75 (100)
Hamilton Bend Springs (Dry)[a]	---	---	---	---	---	---
Hamilton Bend Springs[c]	1.0 (0.4)	-69 (37)	1.0 (1.0)	0.020 (0.029)	0.020 (0.020)	150 (100)
Test Well 1A[a]	0.3 (0.4)	19 (26)	0.1 (0.1)	-0.004 (0.005)	0.004 (0.008)	-75 (60)
Test Well 1A[c]	0.5 (0.4)	17 (36)	3.0 (1.0)	0.024 (0.017)	0.019 (0.012)	-75 (100)
Test Well 2A[a]	5.2 (0.7)	-40 (30)	0.1 (0.1)	0.005 (0.010)	-0.005 (0.005)	-75 (70)
Test Well 2A[c]	1.0 (0.4)	32 (30)	3.0 (1.0)	-0.010 (0.014)	0.000 (0.010)	-150 (100)
Basalt Spring[a]	0.9 (0.4)	50 (48)	1.1 (0.2)	-0.010 (0.014)	0.000 (0.010)	---
Basalt Spring[c]	2.3 (0.5)	53 (36)	1.0 (1.0)	0.009 (0.014)	0.017 (0.016)	-75 (100)
No. of Analyses	15	15	15	15	15	14
Average	1.6	-7	1.2	0.007	0.029	-60
S	1.6	50	1.3	0.012	0.056	100
Minimum	0.3 (0.4)	-86 (34)	0.1 (0.1)	-0.010 (0.014)	-0.005 (0.005)	-200 (100)
Maximum	5.2 (0.7)	53 (36)	4.0 (1.0)	0.031 (0.017)	0.220 (0.035)	150 (100)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]February 1986.
[b]Counting uncertainties in parentheses.
[c]September 1986.

Table G-29. Radiochemical Quality of Ground and Surface Waters from DP-Los Alamos Canyon

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
DPS-1[a]	1.2 (0.4)[b]	59 (35)	0.5 (0.2)	0.067 (0.019)	0.180 (0.029)	-30 (60)
DPS-1[c]	0.6 (0.4)	12 (35)	1.0 (1.0)	0.013 (0.013)	0.060 (0.017)	75 (100)
DPS-4[a]	4.5 (0.6)	-38 (30)	0.7 (0.2)	0.012 (0.012)	0.058 (0.018)	-40 (60)
DPS-4[c]	2.1 (0.5)	-29 (36)	1.0 (1.0)	0.012 (0.011)	0.037 (0.012)	0 (100)
LAO-C[a]	0.8 (0.4)	28 (33)	0.0 (0.1)	0.000 (0.010)	0.005 (0.013)	-5 (60)
LAO-C[c]	1.2 (0.4)	-6 (31)	2.0 (1.0)	0.005 (0.008)	0.000 (0.010)	0 (100)
LAO-1[a]	5.2 (0.7)	5 (31)	1.1 (0.2)	0.008 (0.010)	0.016 (0.011)	-20 (60)
LAO-1[c]	0.7 (0.4)	-10 (52)	1.0 (1.0)	0.008 (0.014)	0.004 (0.004)	-150 (100)
LAO-2[a]	7.2 (0.9)	-12 (27)	0.2 (0.1)	0.008 (0.014)	0.008 (0.010)	15 (60)
LAO-2[c]	3.1 (0.5)	26 (34)	2.0 (1.0)	0.004 (0.007)	0.004 (0.011)	0 (100)
LAO-3[a]	5.9 (0.7)	-85 (31)	3.8 (0.6)	0.000 (0.010)	0.014 (0.012)	-5 (60)
LAO-3[c]	3.2 (0.5)	-45 (34)	2.0 (1.0)	-0.008 (0.015)	0.024 (0.014)	-150 (100)
LAO-4[a]	3.5 (0.5)	-13 (23)	0.5 (0.2)	-0.014 (0.017)	0.014 (0.014)	-60 (60)
LAO-4[c]	3.6 (0.6)	---	3.0 (1.0)	0.000 (0.010)	0.000 (0.010)	-75 (100)
LAO-4.5[a]	3.1 (0.5)	36 (32)	0.4 (0.2)	-0.008 (0.006)	0.017 (0.010)	15 (60)
LAO-4.5[c]	2.9 (0.5)	-6 (36)	3.0 (1.0)	0.011 (0.011)	0.028 (0.016)	75 (100)
Summary						
No. of Analyses	16	15	16	16	16	16
Average	3.0	-5	1.4	0.007	0.020	-23
S	1.9	36	1.1	0.018	0.044	63
Minimum	0.6 (0.4)	-85 (31)	0.0 (0.1)	-0.014 (0.017)	0.000 (0.010)	-150 (100)
Maximum	7.2 (0.9)	59 (35)	3.0 (1.0)	0.067 (0.019)	0.180 (0.029)	75 (100)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]February 1986.
[b]Counting uncertainties in parentheses.
[c]September 1986.

Table G-30. Radiochemical Quality of Surface and Groundwater from Mortandad Canyon

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
GS-1[a]	18 (2.0)[b]	−17 (2.7)	0.2 (0.2)	0.211 (0.029)	1.06 (0.069)	−80 (70)
GS-1[c]	140 (2.0)	−51 (44)	2.0 (1.0)	0.259 (0.036)	1.09 (0.079)	150 (100)
MCO-3[a]	21 (2.0)	32 (32)	0.2 (0.2)	0.961 (0.066)	3.82 (0.165)	−110 (70)
MCO-3[c]	14 (10)	58 (54)	4.0 (1.0)	---	---	320 (150)
MCO-4[a]	560 (60)	−6 (33)	9.7 (1.0)	0.198 (0.030)	0.651 (0.054)	140 (70)
MCO-4[c]	810 (80)	23 (38)	6.0 (1.0)	0.309 (0.038)	1.55 (0.093)	150 (100)
MCO-5[a]	1300 (100)	−25 (30)	8.7 (0.9)	0.397 (0.044)	1.01 (0.069)	310 (80)
MCO-5[c]	660 (70)	68 (55)	2.0 (1.0)	0.231 (0.031)	0.910 (0.065)	300 (100)
MCO-6[a]	720 (70)	−31 (27)	9.2 (0.9)	0.226 (0.034)	0.869 (0.066)	170 (70)
MCO-6[c]	620 (60)	4 (44)	12.0 (1.0)	0.134 (0.027)	0.359 (0.041)	150 (100)
MCO-7[a]	500 (50)	72 (34)	4.7 (0.5)	0.038 (0.017)	0.105 (0.023)	0 (60)
MCO-7[c]	760 (80)	−30 (33)	3.0 (1.0)	0.043 (0.015)	0.032 (0.014)	−75 (100)
MCO-7.5[a]	530 (50)	41 (29)	6.6 (0.6)	0.040 (0.020)	0.081 (0.019)	−80 (70)
MCO-7.5[c]	760 (80)	−30 (33)	5.0 (1.0)	0.045 (0.023)	0.051 (0.022)	−150 (100)
Summary						
No. of Analyses	14	14	14	13	13	14
Average	510	8	5.2	0.238	0.891	28
S	396	41	3.7	0.245	1.01	156
Minimum	18 (2.0)	−51 (44)	0.2 (0.2)	0.038 (0.017)	0.032 (0.014)	−750 (100)
Maximum	1300 (100)	72 (34)	12.0 (1.0)	0.961 (0.066)	3.82 (0.165)	310 (100)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]March 1986.
[b]Counting uncertainties in parentheses.
[c]September 1986.

Table G-31. Radiochemical Quality of Surface Water from Sandia Canyon

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
SCS-1[a]	0.9 (0.4)[b]	-25 (37)	0.9 (0.2)	0.012 (0.018)	0.012 (0.011)	-80 (60)
SCS-1[c]	1.3 (0.4)	-8 (26)	12.0 (1.0)	0.000 (0.010)	-0.008 (0.006)	75 (100)
SCS-2[a]	2.3 (0.5)	-57 (27)	0.4 (0.2)	0.012 (0.012)	0.004 (0.007)	-30 (60)
SCS-2[c]	2.9 (0.5)	-44 (36)	4.0 (1.0)	-0.014 (0.009)	0.007 (0.009)	0 (100)
SCS-3[a]	2.6 (0.5)	18 (33)	0.5 (0.2)	0.008 (0.009)	0.015 (0.009)	7 (60)
SCS-3[c]	1.9 (0.5)	-3 (31)	1.0 (1.0)	0.000 (0.010)	0.004 (0.011)	-75 (100)
Summary						
No. of Analyses	6	6	6	6	6	6
Average	2.0	-20	3.1	0.003	0.006	-17
S	0.8	28	4.6	0.010	0.008	58
Minimum	2.9 (0.5)	18 (33)	12.0 (1.0)	0.012 (0.018)	0.015 (0.009)	75 (100)
Maximum	0.9 (0.4)	-57 (27)	0.4 (0.2)	-0.014 (0.009)	-0.008 (0.006)	-79 (66)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]February 1986.
[b]Counting uncertainties in parentheses.
[c]September 1986.

Table G-32. Chemical Quality of Ground and Surface Waters from Acid-Pueblo Canyons, February 1986 (mg/L) unless specified)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard-ness	pH	Conduc-tivity
Acid Weir	19	24	3.2	5.4	88	0	32	0.4	8	138	0.4	1.3	326	70	6.8	63
Pueblo 1	61	20	3.0	11	78	0	66	8.8	30	68	0.9	10	357	57	7.6	54
Pueblo 2	66	15	2.3	12	85	0	99	1.0	31	53	1.0	3.3	346	42	7.2	55
Pueblo 3	51	21	3.2	11	79	0	147	0.7	27	63	0.7	1.4	349	57	7.3	56
Hamilton Bend Sharing (Dry)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Test Well 1A	48	28	7.5	7.7	75	0	111	1.0	31	60	1.0	12	351	92	7.9	54
Test Well 2A	66	23	4.6	3.5	19	0	62	0.4	1	40	0.4	0.8	125	72	8.1	26
Basalt Spring	38	25	6.6	3.4	15	0	80	<0.1	18	13	0.6	2.3	178	82	8.0	26
Summary																
No. of Analyses	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Average	50	22	4.3	7.7	63	0	85	<1.8	21	62	0.7	4.4	290	67	7.6	48
S	17	4	2.0	3.7	32	--	38	>3.1	12	38	0.3	4.6	97	17	0.5	15
Minimum	19	15	2.3	3.4	15	--	32	<0.1	1	13	0.4	0.8	125	42	6.8	26
Maximum	66	28	7.5	12	88	--	147	8.8	31	138	1.0	12	357	92	8.1	63

Table G-33. Chemical Water Quality of Ground or Surface Waters in DP-Los Alamos Canyon, February 1986 (mg/L unless specified)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hardness	pH[a]	Conductivity[b]
DPS-1	14	20	1.7	4.2	92	0	72	0.1	7	133	0.7	0.5	301	49	7.8	54
DPS-4	23	19	2.1	15	121	0	120	0.4	34	118	5.5	2.2	391	51	8.1	71
LAO-C	30	18	4.1	3.4	52	0	48	<0.1	11	90	0.9	0.3	231	62	7.4	40
LAO-1	35	20	3.5	14	68	0	106	0.2	26	50	2.4	2.5	283	63	7.6	45
LAO-2	40	18	3.4	14	66	0	106	0.2	24	48	3.1	2.2	279	57	7.2	46
LAO-3	40	19	3.5	14	66	0	104	0.2	28	49	2.4	2.8	295	52	7.4	46
LAO-4	34	13	4.1	4.8	42	0	88	<0.1	11	30	0.8	0.2	177	47	7.4	30
LAO-4.5	35	14	4.2	4.9	43	0	89	<0.1	12	32	0.9	<0.1	196	50	7.5	30
Summary																
No. of Analyses	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Average	31	18	3.3	9.2	69	0	92	<0.2	19	69	2.1	<1.4	269	54	7.6	45
S	9	3	0.9	5.3	27	--	23	>0.1	10	40	1.7	>1.2	68	6	0.3	13
Minimum	14	13	1.7	3.4	42	--	48	<0.1	7	30	0.7	<0.1	177	47	7.2	30
Maximum	40	20	4.2	15	121	--	120	0.4	34	133	5.5	2.8	391	63	8.1	54

[a]Standard units.
[b]mS/m.

Table G-34. Chemical Quality of Ground and Surface Waters in Mortandad Canyon, March 1986 (mg/L unless specified)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hardness	pH[a]	Conductivity[b]
GS-1	58	12	2.6	4.8	27	3.2	74	<0.1	4	5	0.7	3.9	166	39	8.5	21
MCO-3	59	12	2.5	5.4	29	3.7	75	0.2	3	6	3.4	3.9	175	41	8.6	22
MCO-4	18	14	2.6	11	294	0	236	0.3	44	29	4.0	90	944	47	7.7	138
MCO-5	17	15	2.9	10	318	0	242	1.0	53	29	4.0	106	1071	48	7.7	164
MCO-6	22	15	2.8	10	308	0	239	0.4	52	29	2.9	102	1037	47	7.8	158
MCO-7	27	22	5.1	5.3	236	0	221	<0.1	41	32	2.0	74	854	69	7.4	124
MCO-7.5	25	22	5.2	5.5	240	0	226	<0.1	41	32	2.7	74	850	70	7.4	128
Summary																
No. of Analyses	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Average	32	16	3.4	7.4	207	1.0	188	<0.3	34	23	2.8	65	728	52	7.9	108
S	18	4	1.2	2.8	127	1.7	78	>0.3	22	12	1.2	43	390	13	0.5	61
Minimum	17	12	2.5	4.8	27	0	7.4	<0.1	3	5	0.7	3.9	166	39	7.4	21
Maximum	59	22	5.2	11	318	3.7	242	1.0	53	32	4.0	106	1071	70	8.6	164

[a]Standard units.
[b]mS/m.

Table G-35. Chemical Quality of Ground and Surface Waters in Sandia Canyon, February 1986 (mg/L unless specified)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hardness	pH[a]	Conductivity[b]
SCS-1	130	23	4.9	11	71	0	48	2.3	26	94	12	2.2	419	70	7.3	59
SCS-2	82	28	5.1	13	141	0	101	2.7	65	154	1.7	1.8	575	64	7.5	90
SCS-3	84	28	5.2	13	138	0	102	2.9	78	165	1.6	2.0	583	84	7.5	89
Summary																
No. of Analyses	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	99	26	5.1	12	117	0	84	2.6	56	138	5.1	2.0	526	73	7.4	79
S	27	3	0.2	1	40	--	31	0.3	27	38	6.0	0.2	92	10	0.1	18
Minimum	82	23	4.9	11	71	--	48	2.3	26	94	1.6	1.8	419	64	7.3	59
Maximum	130	28	5.2	13	141	--	102	2.9	78	165	12	2.2	583	84	7.5	90

[a]Standard units.
[b]mS/m.

Table G-36. Radiochemical Analyses of Summer Run-off in Los Alamos, Pueblo, Pajarito, and Mortandad Canyons

Station	Date	Solution: ^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Los Alamos Canyon at State Road 4	6-9	1.8 (0.4)[a]	20 (32)	2.2 (0.3)	-0.009 (0.010)	0.013 (0.012)	-90 (60)
	6-26	2.9 (0.5)	-51 (32)	0.2 (0.1)	0.005 (0.009)	-0.005 (0.009)	-75 (100)
	6-27	1.6 (0.5)	292 (50)	0.2 (0.1)	-0.009 (0.013)	0.004 (0.014)	-75 (100)
	6-30	3.8 (0.6)	-48 (17)	0.3 (0.1)	-0.016 (0.012)	0.016 (0.014)	-75 (100)
	7-2	3.0 (0.5)	13 (32)	0.2 (0.1)	0.004 (0.007)	0.004 (0.009)	-75 (100)
	7-7	2.0 (0.5)	-59 (33)	0.2 (0.1)	-0.012 (0.007)	0.016 (0.010)	-150 (100)
	7-10	2.5 (0.5)	32 (31)	0.1 (0.1)	0.025 (0.012)	0.004 (0.009)	-580 (200)
	7-14	3.2 (0.6)	-30 (32)	0.1 (0.1)	-0.004 (0.007)	0.004 (0.008)	-450 (100)
	7-16	3.1 (0.6)	-39 (33)	---	-0.010 (0.010)	0.005 (0.014)	-150 (100)
	7-21	3.0 (0.5)	-2 (37)	---	0.000 (0.010)	-0.011 (0.011)	150 (100)
	11-6	---	---	---	0.000 (0.010)	0.005 (0.010)	---
Mean		2.7	13	0.4	-0.002	0.005	-157
S		0.7	103	0.7	0.011	0.008	208
Pueblo Canyon at State Road 4	7-2	1.8 (0.5)	-18 (39)	0.3 (0.1)	0.004 (0.007)	0.004 (0.008)	0 (100)
Los Alamos Canyon at Rio Grande	6-26	2.4 (0.5)	-66 (34)	0.2 (0.1)	-0.020 (0.014)	0.010 (0.012)	-150 (100)
	6-27	2.4 (0.5)	-3 (31)	0.2 (0.1)	0.004 (0.015)	0.013 (0.022)	0 (100)
	6-30	2.9 (0.5)	-31 (29)	0.2 (0.1)	-0.004 (0.014)	0.027 (0.016)	-150 (100)
	7-2	1.7 (0.5)	61 (38)	0.4 (0.1)	0.004 (0.012)	0.000 (0.010)	-150 (100)
Mean		2.3 (0.5)	-10	0.2	-0.004	0.013	-112
S		0.5	54	0.1	0.211	0.011	75

Table G-36 (cont)

Station	Date	Solution					
		^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Pajarito Canyon	6-26	4.0 (0.6)	3 (32)	0.2 (0.1)	0.004 (0.009)	0.027 (0.013)	0 (100)
	6-30	4.4 (0.6)	211 (44)	3.8 (0.4)	0.000 (0.010	-0.008 (0.006)	-75 (100)
	7-2	1.3 (0.5)	-22 (34)	1.0 (1.0)	0.014 (0.015)	0.021 (0.012)	-75 (100)
	7-7	2.5 (0.5)	70 (34)	1.0 (1.0)	0.005 (0.009)	0.016 (0.009)	-300 (100)
	7-10	1.9 (0.5)	-33 (32)	1.0 (1.0)	0.000 (0.010)	0.004 (0.007)	-350 (100)
	7-14	2.3 (0.5)	48 (19)	1.0 (1.0)	-0.015 (0.009)	0.008 (0.009)	-580 (200)
	7-16	2.3 (0.5)	5 (31)	1.0 (1.0)	-0.022 (0.013)	0.004 (0.008)	75 (100)
	7-21	2.1 (0.5)	53 (40)	1.0 (1.0)	-0.004 (0.013)	-0.004 (0.001)	-100 (200)
Mean		2.6	42	1.2	-0.002	0.009	-175
S		1.1	78	1.1	0.011	0.012	215
Mortandad Canyon	6-10	23 (2)	-26 (28)	---	---	---	-150 (100)
at Sediment Pond	6-26	23 (2)	-35 (12)	0.6 (0.1)	0.037 (0.019)	0.089 (0.022)	0 (100)
Mean		23	-35	---	---	---	-75
s		0	12	---	---	---	106

Table G-36 (cont)

Station	Date	Suspended Sediments ^{238}Pu (pCi/g)	Suspended Sediments $^{239,240}Pu$ (pCi/g)
Los Alamos Canyon at State Road 4	6-9	0.149 (0.010)	0.334 (0.98)
	6-26	0.145 (0.013)	1.90 (0.093
	6-27	0.113 (0.013)	1.66 (0.080)
	6-30	0.147 (0.018)	2.00 (0.097)
	7-2	0.045 (0.005)	0.265 (0.016)
	7-7	0.135 (0.030)	1.08 (0.084)
	7-10	0.588 (0.019)	2.08 (0.186)
	7-14	0.425 (0.131)	2.23 (0.259)
	7-16	0.254 (0.036)	1.23 (0.085)
	7-21	0.392 (0.076)	2.89 (0.221)
Mean		0.239	1.57
S		0.173	0.838
Pueblo Canyon at State Road 4	7-2	-0.022 (0.016)	0.000 (0.021)
Los Alamos Canyon at Rio Grande	6-26	0.159 (0.013)	3.42 (0.153)
	6-27	0.073 (0.008)	1.17 (0.060)
	6-30	0.042 (0.006)	0.257 (0.017)
	7-2	0.142 (0.04)	1.26 (0.057)
Mean		0.104	1.53
S		0.055	1.34

Table G-36 (cont)

Station	Date	Suspended Sediments ^{238}Pu (pCi/g)	Suspended Sediments $^{239,240}Pu$ (pCi/g)
Pajarito Canyon	6-26	−0.024 (0.022)	0.082 (0.033)
at State Road 4	6-30	−0.010 (0.018)	0.005 (0.018)
	7-2	0.009 (0.003)	1.36 (0.060)
	7-7	0.020 (0.003)	0.135 (0.008)
	7-10	−0.121 (0.134)	0.161 (0.099)
	7-14	−0.206 (0.546)	0.413 (0.652)
	7-16	−0.108 (0.132)	0.162 (0.143)
	7-21	0.000 (0.068)	0.000 (0.067)
Mean		−0.055	0.290
S		0.081	0.451
Mortandad Canyon	6-10	8.34 (0.500)	25.7 (1.30)
at Retention Pond	6-26	5.41 (0.350)	14.8 (0.8)
Near MCO-7			
Mean		6.88	20.2
S		2.07	7.71

Table G-37. Chemical Analyses for Primary Chemicals in Water from Perimeter and Onsite Areas, January 1986, (mg/L)

	As	Ba	Cd	Cr	F	Hg	N	Pb	Se
Perimeter									
Los Alamos Reservoir	<0.002	0.08	<0.001	0.004	<0.1	<0.0001	0.3	<0.001	0.004
Frijoles Canyon	<0.002	0.06	<0.001	0.004	0.2	<0.0001	<0.1	0.002	0.004
Maximum	<0.002	0.08	<0.001	0.004	0.2	<0.0001	0.3	0.002	0.004
Maximum as % of Standard	<4	8	<10	8	10	<5	3	4	40
Onsite									
Effluent Release Areas									
Acid-Pueblo Canyon									
Pueblo 1	0.019	0.06	<0.001	0.007	0.9	<0.0001	10	0.004	<0.002
Pueblo 3	0.017	0.06	<0.001	0.018	0.7	<0.0001	1.4	0.009	<0.002
Basalt Spring	<0.002	0.06	<0.001	0.006	0.6	<0.0001	2.3	<0.001	0.003
DP-Los Alamos Canyon									
DPS-4	<0.002	0.08	<0.001	0.011	5.5	<0.0001	2.2	0.005	0.004
LAO-1	0.007	0.07	<0.001	0.005	2.4	<0.0001	2.5	0.009	0.004
LAO-3	<0.002	0.15	<0.001	0.005	2.4	<0.0001	2.8	0.001	0.004
LA-4.5	<0.002	0.08	<0.001	0.004	0.9	<0.0001	<0.1	<0.001	<0.002
Sandia Canyon									
SCS-1	0.009	0.07	<0.001	0.023	12.0	<0.0001	2.2	0.006	0.004
SCS-3	0.009	0.05	<0.001	0.014	1.6	<0.0001	2.0	0.003	0.004

Table G-37 (cont)

	As	Ba	Cd	Cr	F	Hg	N	Pb	Se
Mortandad Canyon									
MCGS-1	<0.002	0.06	<0.001	<0.005	0.7	<0.0001	3.9	0.001	0.004
MCO-4	<0.002	0.08	<0.001	<0.005	4.0	<0.0001	90	0.004	0.008
MCO-7	<0.002	0.12	<0.001	<0.005	2.0	<0.0001	74	0.001	0.005
Maximum	0.019	0.15	<0.001	0.023	12.0	<0.0001	90	0.009	0.008
Maximum as % of Standard	38	15	<10	46	600	<5	900	18	80
USEPA Maximum Primary Standards (municipal supply)	0.05	1.0	0.01	0.05	2.0	0.002	10	0.05	0.01

Table G-38. Chemical Quality for Secondary Chemicals in Water from Perimeter and Onsite Areas (January 1986)

	Secondary Quality (concentrations in mg/L)							
	Cl	Cu	Fe	Mn	SO_4	TDS	Zn	pH
Perimeter								
Los Alamos Reservoir	3	0.002	0.115	0.005	10	95	0.01	7.0
Frijoles Canyon	2	0.003	0.115	0.012	3	114	0.01	7.8
Maximum	3	0.003	0.115	0.012	10	114	0.01	7.8
Maximum as % of Standards	1	<1	38	24	4	23	<1	---
Onsite								
Effluent Release Areas								
Acid-Pueblo Canyon								
Pueblo 1	68	0.013	0.050	0.041	30	357	0.04	7.6
Pueblo 3	63	0.017	0.170	0.148	27	349	0.11	7.3
Basalt Springs	13	<0.001	0.020	0.016	18	178	0.01	8.0
DP-Los Alamos Canyon								
DPS-4	118	0.010	0.011	0.006	34	391	0.02	8.1
LAO-1	50	0.003	0.055	<0.005	26	283	0.02	7.6
LAO-3	49	0.010	0.014	0.008	28	295	0.04	7.4
LAO-4.5	32	0.030	0.023	0.011	12	196	0.04	7.5
Sandia Canyon								
SCS-1	94	0.079	0.245	0.039	26	419	0.16	7.3
SCS-3	165	0.035	0.434	0.026	78	583	0.12	7.5
Mortandad Canyon								
MCGS-1	5	0.010	0.169	0.050	4	166	0.04	8.5
MCO-4	29	0.093	0.428	0.008	44	944	0.05	7.7
MCO-7	32	0.063	0.020	0.022	41	854	0.08	7.4
Maximum	165	0.093	0.434	0.148	78	944	0.16	8.5
Maximum as % of Standard	66	9	145	296	31	189	3	--
USEPA Maximum Secondary Standards (municipal supply)	250	1.0	0.3	0.05	250	500	5.0	6.5-8.5

Table G-39. Quality for Miscellaneous Chemicals in Water from Perimeter and Onsite Areas (January 1986)

	Miscellaneous Quality (concentrations in mg/L)				
	B	Be	COD	Li	TSS
Perimeter					
Los Alamos Reservoir	<0.03	<0.001	20	<0.005	9
Frijoles Canyon	<0.03	<0.001	20	0.014	8
Onsite					
Effluent Release Areas					
Acid-Pueblo Canyon					
Pueblo 1	0.25	<0.001	57	0.029	6
Pueblo 3	0.23	<0.001	49	0.031	17
Basalt Springs	<0.03	<0.001	16	0.018	335
DP-Los Alamos Canyon					
DPS-4	<0.03	<0.001	59	0.034	327
LAO-1	0.07	<0.001	36	0.017	16
LAO-3	0.03	<0.001	51	0.016	1320
LAO-4.5	<0.03	<0.001	36	<0.005	3
Sandia Canyon					
SCS-1	0.16	<0.001	63	0.038	134
SCS-3	0.18	<0.001	39	0.048	17
Mortandad Canyon					
MCGS-1	<0.03	<0.001	24	0.022	9
MCO-4	0.18	<0.001	44	<0.005	56
MCO-7	0.13	<0.001	47	<0.005	1410

Table G-40. 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
Canada 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-40 (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	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)	S055	E385	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
Potrillo 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 in Figs. 16 and 19; sediment sampling locations in Figs. 16 and 20.

Table G-41. Radiochemical Analyses of Regional Soils and Sediments

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (Counts/min/g)
Soils						
Chamita[a]	6.4 (0.8)[b]	0.25 (0.08)	1.7 (0.2)	0.001 (0.001)	0.003 (0.001)	1.2 (0.30)
Embudo[a]	0.8 (0.4)	0.69 (0.13)	2.4 (0.2)	0.001 (0.002)	0.017 (0.003)	3.7 (0.50)
Otowi[a]	4.5 (0.6)	0.71 (0.13)	4.3 (0.4)	0.002 (0.002)	0.016 (0.003)	6.9 (0.80)
Near Santa Cruz Lake[a]	1.1 (0.4)	0.48 (0.10)	3.3 (0.3)	0.000 (0.000)	0.014 (0.002)	5.0 (0.60)
Cochiti[a]	2.8 (0.5)	0.60 (0.12)	3.0 (0.3)	0.000 (0.001)	0.014 (0.003)	5.2 (0.60)
Bernalillo[a]	2.0 (0.5)	0.22 (0.08)	1.3 (0.2)	0.001 (0.001)	0.002 (0.001)	1.0 (0.30)
Jemez[a]	3.9 (0.5)	0.16 (0.07)	1.8 (0.2)	0.000 (0.001)	0.004 (0.002)	2.7 (0.40)
Summary						
No. of Analyses	7	7	7	7	7	7
Average	3.1	0.44	2.5	0.001	0.010	3.7
S	2.0	0.23	1.0	0.001	0.007	2.2
Minimum	0.8 (0.4)	0.16 (0.07)	1.3 (0.2)	0.000 (0.000)	0.002 (0.001)	1.0 (0.30)
Maximum	6.4 (0.8)	0.71 (0.13)	4.3 (0.4)	0.002 (0.002)	0.017 (0.003)	6.9 (0.80)
Sediments						
Rio Chama at Chamita[a]	---	0.23 (0.09)	2.3 (0.2)	−0.001 (0.001)	0.001 (0.001)	1.9 (0.30)
Rio Grande at Embudo[a]	---	0.05 (0.06)	2.8 (0.3)	0.000 (0.002)	0.003 (0.001)	3.1 (0.40)
Rio Grande at Otowi[a]	---	0.09 (0.07)	4.4 (0.4)	0.001 (0.001)	0.003 (0.001)	5.2 (0.40)
Rio Grande at Sandia[c]	---	0.17 (0.07)	2.9 (0.3)	0.000 (0.001)	0.002 (0.001)	−5.4 (0.80)
Rio Grande at Pajarito[c]	---	0.20 (0.10)	3.0 (0.3)	0.002 (0.002)	0.002 (0.002)	−4.1 (0.80)
Rio Grande at Ancho[c]	---	0.13 (0.07)	2.5 (0.2)	−0.002 (0.001)	0.002 (0.002)	−4.8 (0.80)
Rio Grande at Frijoles[c]	---	0.28 (0.10)	3.6 (0.4)	0.001 (0.001)	0.009 (0.002)	4.7 (0.60)
Rio Grande at Bernalillo[a]	---	0.15 (0.10)	2.9 (0.3)	0.002 (0.002)	0.013 (0.003)	3.0 (0.40)
Jemez River at Jemez[a]	---	0.00 (0.05)	1.9 (0.2)	0.001 (0.001)	0.002 (0.001)	4.1 (0.50)

Table G-41 (cont)

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (Counts/min/g)
Summary						
No. of Analyses	---	9	9	9	9	9
Average	---	0.14	2.9	0.000	0.004	1.4
S	---	0.09	0.7	0.001	0.004	3.7
Minimum	---	0.00 (0.05)	1.9 (0.2)	−0.001 (0.001)	0.001 (0.001)	−5.4 (0.80)
Maximum	---	0.28 (0.10)	4.4 (0.4)	0.002 (0.002)	0.013 (0.003)	5.2 (0.40)
Limits of Detection	0.7	0.1	0.03	0.003	0.002	0.1

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[a]February 1986.
[b]Counting uncertainties within parentheses.
[c]October 1986.

Table G-42. Radiochemical Analyses of Perimeter Soils and Sediments

Location	^{3}H (10^{-6} µCi/g)	^{137}Cs (pCi/g)	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (Counts/min/g)
Perimeter Soils[a]						
Sportsmans Club	1.5 (0.4)[b]	0.17 (0.07)	5.1 (0.5)	0.000 (0.002)	0.013 (0.003)	7.7 (0.90)
North Mesa	2.1 (0.5)	0.01 (0.06)	4.0 (0.4)	0.003 (0.002)	0.006 (0.002)	6.1 (0.70
TA-8	2.0 (0.4)	1.9 (0.32)	3.2 (0.3)	0.005 (0.002)	0.054 (0.005)	5.9 (0.70)
TA-49	1.2 (0.4)	0.10 (0.07)	3.8 (0.4)	0.000 (0.001)	0.002 (0.001)	7.4 (0.90)
White Rock (East)	2.8 (0.5)	0.35 (0.09)	4.3 (0.4)	0.001 (0.001)	0.005 (0.002)	7.9 (0.90)
Tsankawi	4.3 (0.6)	0.83 (0.15)	5.9 (0.6)	0.005 (0.002)	0.017 (0.003)	11 (1.0)
Summary						
No. of Analyses	6	6	6	6	6	6
Average	2.3	0.56	4.4	0.002	0.016	7.7
S	1.1	0.72	1.0	0.002	0.019	1.8
Minimum	1.2 (0.4)	0.01 (0.06)	3.2 (0.3)	0.000 (0.002)	0.002 (0.001)	6.1 (0.70)
Maximum	4.3 (0.6)	1.9 (0.32)	5.9 (0.6)	0.005 (0.002)	0.054 (0.005)	11 (1.0)
Perimeter Sediments[a]						
Guaje at SR-4	--	0.04 (0.07)	2.4 (0.2)	0.000 (0.000)	0.005 (0.002)	2.9 (0.40)
Bayo at SR-4	--	0.05 (0.06)	2.9 (0.3)	−0.001 (0.001)	0.001 (0.001)	2.9 (0.40)
Sandia at SR-4	--	0.10 (0.07)	2.0 (0.2)	−0.001 (0.001)	0.000 (0.000)	3.1 (0.40)
Mortandad at SR-4	--	−0.04 (0.05)	2.3 (0.2)	0.002 (0.001)	0.002 (0.001)	4.0 (0.50)
Canada del Buey at SR-4	--	0.07 (0.07)	1.7 (0.2)	0.000 (0.000)	0.002 (0.001)	2.2 (0.40)
Pajarito at SR-4	--	0.21 (0.06)	2.1 (0.2)	0.001 (0.001)	0.006 (0.002)	2.5 (0.40)
Potrillo at SR-4	--	0.00 (0.06)	3.6 (0.4)	0.000 (0.001)	0.004 (0.001)	4.8 (0.60)
Water at SR-4	--	--	1.7 (0.3)	0.002 (0.001)	0.004 (0.001)	3.3 (0.40)
Ancho at SR-4	--	0.10 (0.05)	1.4 (0.2)	0.002 (0.001)	0.001 (0.001)	1.9 (0.30)
Frijoles at Bandelier	--	0.04 (0.06)	1.7 (0.2)	0.000 (0.002)	0.003 (0.001)	1.18 (0.30)
Sandia at Rio Grande[c]	--	0.06 (0.07)	2.5 (0.3)	0.001 (0.001)	0.002 (0.001)	−5.0 (0.90)
Canada del Ancha at Rio Grande[c]	--	0.09 (0.07)	1.0 (0.2)	0.000 (0.001)	0.001 (0.001)	−10 (1.0)

Table G-42 (cont)

Location	^{3}H (10^{-6} µCi/g)	^{137}Cs (pCi/g)	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (Counts/min/g)
Mortandad at Rio Grande[c]	--	0.04 (0.07)	1.7 (0.2)	-0.001 (0.001)	0.001 (0.001)	-8.0 (1.0)
Pajarito at Rio Grande[c]	--	0.10 (0.07)	2.0 (0.2)	0.001 (0.002)	0.003 (0.001)	-7.4 (1.0)
Water at Rio Grande[c]	--	0.14 (0.08)	1.6 (0.2)	0.000 (0.001)	0.001 (0.061)	-8.4 (1.0)
Ancho at Rio Grande[c]	--	0.11 (0.07)	1.1 (0.21)	-0.001 (0.001)	0.002 (0.001)	-8.4 (1.0)
Chaquihui at Rio Grande[c]	--	0.27 (0.07)	3.1 (0.2)	-0.001 (0.001)	0.001 (0.001)	-6.0 (0.9)
Frijoles at Rio Grande[c]	--	0.15 (0.07)	2.7 (0.3)	0.000 (0.001)	0.005 (0.002)	-4.0 (0.7)
Summary						
No. of Analyses		17	18	18	18	18
Average		0.09	2.1	0.000	0.002	-1.6
S		0.08	0.7	0.001	0.002	5.4
Minimum		-0.04 (0.05)	1.0 (0.2)	-0.001 (0.001)	0.000 (0.000)	-10 (1.0)
Maximum		0.21 (0.06)	3.6 (0.4)	0.002 (0.001)	0.006 (0.002)	4.8 (0.60)
Limits of Detection	0.7	0.1	0.3	0.003	0.002	0.1

[a]March 1986.
[b]Counting uncertainties in parentheses.
[c]October 1986.

Table G-43. Suburanic and Gross Gamma Radiochemical Analyses of Onsite Soils and Sediments

Location	^{3}H (10^{-6} µCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Gross Gamma (Counts/min/g)
Onsite Soils[a]				
TA-21	4.1 (0.6)[b]	---	0.07 (0.06)	5.8 (0.70)
East of TA-53	8.7 (1.0)	---	0.23 (0.08)	6.7 (0.80)
TA-50	4.9 (0.7)	---	0.19 (0.08)	6.3 (0.70)
Two-Mile Mesa	2.8 (0.5)	---	0.03 (0.06)	5.4 (0.60)
East of TA-54	8.1 (0.9)	---	0.13 (0.09)	8.3 (0.90)
R-Site Road East	4.2 (0.6)	---	0.19 (0.06)	6.3 (0.70)
Potrillo Drive	3.5 (0.5)	---	0.38 (0.09)	5.2 (0.60)
S-Site	3.7 (0.6)	---	0.22 (0.08)	5.6 (0.70)
Near DT-9	1.8 (0.4)	---	0.56 (0.11)	6.3 (0.70)
Near TA-33	16 (2.0)	---	-0.11 (0.05)	7.1 (0.80)
Summary				
No. of Analyses	10	---	10	10
Minimum	1.8 (0.4)	---	-0.11 (0.05)	5.2 (0.60)
Maximum	16 (2.0)	---	0.56 (0.11)	8.3 (0.90)
Average	5.8	---	0.19	6.3
S	4.2	---	0.18	0.92
Sediments: Effluents[c]				
Release Area, Acid-Pueblo Canyon				
Acid Weir	---	0.59 (0.05)	0.83 (0.15)	6.3 (0.70)
Pueblo 1	---	-0.08 (0.07)	0.16 (0.08)	3.4 (0.50)
Pueblo 2	---	0.11 (0.07)	0.04 (0.04)	5.2 (0.60)
Hamilton Bend Spring	---	0.12 (0.08)	0.23 (0.07)	5.4 (0.70)
Pueblo 3	---	-0.02 (0.08)	0.14 (0.07)	2.3 (0.40)
Pueblo at SR-4	---	0.00 (0.06)	0.01 (0.07)	2.2 (0.40)

Table G-43 (cont)

Location	^{3}H (10^{-6} µCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Gross Gamma (Counts/min/g)
Summary				
No. of Analyses	---	6	6	6
Minimum	---	−0.08 (0.07)	0.01 (0.07)	2.2 (0.40)
Maximum	---	0.59 (0.05)	0.83 (0.15)	6.3 (0.70)
Average	---	0.12	0.24	4.1
S	---	0.24	0.30	1.7
Sediments: Effluent[c]				
Release Area, DP-Los Alamos Canyon				
DP Canyon at DPS-1	---	1.2 (0.10)	1.0 (0.18)	4.7 (0.60)
DP Canyon at DPS-4	---	1.6 (0.10)	11 (1.6)	10.2 (1.0)
Los Alamos at Bridge	---	−0.02 (0.04)	−0.06 (0.06)	2.1 (0.40)
Los Alamos at LAO-1	---	0.02 (0.04)	2.2 (0.34)	2.8 (0.40)
Los Alamos at GS-1	---	0.48 (0.09)	3.7 (0.57)	7.7 (0.90)
Los Alamos at LAO-3	---	0.44 (0.08)	5.2 (0.79)	3.4 (0.50)
Los Alamos at LAO-4.5	---	0.58 (0.10)	8.3 (1.2)	9.3 (1.0)
Los Alamos at SR-4	---	0.39 (0.09)	2.5 (0.39)	4.7 (0.60)
Los Alamos at Totavi	---	0.07 (0.05)	0.23 (0.07)	2.8 (0.40)
Los Alamos at LA-2	---	0.09 (0.05)	0.02 (0.05)	3.3 (0.40)
Los Alamos at Otowi	---	0.01 (0.07)	0.15 (0.06)	2.6 (0.40)
Summary				
No. of Analyses	---	11	11	11
Minimum	---	−0.02 (0.04)	−0.06 (0.06)	2.1 (0.40)
Maximum	---	1.6 (0.10)	11 (1.6)	10.2 (1.0)
Average	---	0.44	3.1	4.8
S	---	0.53	3.7	2.9

Table G-43 (cont)

Location	^{3}H (10^{-6} µCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Gross Gamma (Counts/min/g)
Sediments: Effluent[a]				
Release Area, Mortandad Canyon				
Mortandad at CMR	---	0.03 (0.05)	0.04 (0.06)	2.6 (0.40)
Mortandad West of GS-1	---	0.03 (0.04)	0.09 (0.07)	2.6 (0.40)
Mortandad at GS-1	---	1.6 (0.10)	26 (3.9)	83 (9.0)
Mortandad at MCO-5	---	4.8 (0.20)	64 (9.5)	79 (8.0)
Mortandad at MCO-7	---	2.0 (0.10)	32 (4.8)	38 (4.0)
Mortandad at MCO-9	---	0.11 (0.08)	0.72 (0.13)	7.4 (0.80)
Mortandad at MCO-13	---	0.15 (0.07)	1.1 (0.20)	5.5 (0.70)
Summary				
No. of Analyses	---	7	7	7
Minimum	---	0.03 (0.04)	0.04 (0.06)	2.6 (0.40)
Maximum	---	4.8 (0.20)	64 (9.5)	83 (9.0)
Average	---	1.2	18	31
S	---	1.8	24	36

[a]March 1986.
[b]Counting uncertainties in parentheses.
[c]February 1986.

Table G-44. Uranium and Transuranic Radiochemical Analyses of Onsite Soils and Sediments

Location	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)
Onsite Soils[a]				
TA-21	3.9 (0.4)[b]	0.003 (0.002)	0.006 (0.002)	---
East of TA-53	3.8 (0.4)	0.002 (0.002)	0.014 (0.003)	---
TA-50	3.8 (0.4)	0.002 (0.001)	0.063 (0.005)	---
Two-Mile Mesa	3.5 (0.4)	0.000 (0.000)	0.008 (0.002)	---
East of TA-54	4.6 (0.5)	0.001 (0.001)	0.001 (0.001)	---
R-Site Road East	3.9 (0.4)	0.002 (0.001)	0.041 (0.004)	---
Potrillo Drive	4.5 (0.5)	-0.001 (0.001)	0.010 (0.002)	---
S-Site	3.7 (0.4)	0.000 (0.001)	0.011 (0.003)	---
Near DT-9	4.5 (0.5)	0.003 (0.002)	0.012 (0.002)	---
Near TA-33	3.6 (0.4)	0.000 (0.001)	0.004 (0.002)	---
Summary				
No. of Analyses	10	10	10	---
Average	4.0	0.001	0.017	---
S	0.4	0.001	0.020	---
Minimum	3.5 (0.4)	-0.001 (0.001)	0.001 (0.001)	---
Maximum	4.6 (0.5)	0.003 (0.002)	0.063 (0.005)	---
Sediments: Effluent[c] Release Area, Acid-Pueblo Canyon				
Acid Weir	2.9 (0.3)	0.063 (0.007)	10.1 (0.303)	2.64 (0.411)
Pueblo 1	1.8 (0.2)	0.002 (0.001)	0.004 (0.001)	0.221 (0.104)
Pueblo 2	3.4 (0.3)	0.000 (0.002)	0.177 (0.012)	-0.150 (0.049)
Hamilton Bend Spring	3.2 (0.3)	0.002 (0.002)	0.297 (0.017)	-0.141 (0.067)
Pueblo 3	1.7 (0.2)	0.001 (0.001)	0.005 (0.002)	-0.066 (0.094)
Pueblo at SR-4	1.4 (0.2)	0.002 (0.001)	0.433 (0.021)	0.023 (0.081)

Table G-44 (cont)

Location	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)
Summary				
No. of Analyses	6	6	6	6
Average	2.4	0.012	1.84	0.421
S	0.9	0.025	4.05	1.09
Minimum	1.4 (0.2)	0.000 (0.002)	0.004 (0.001)	-0.150 (0.049)
Maximum	3.4 (0.3)	0.063 (0.007)	10.1 (0.303)	2.64 (0.411)
Sediments: Effluent[c] Release Area, DP-Los Alamos Canyon				
DP Canyon at DPS-1	2.5 (0.3)	0.025 (0.004)	0.082 (0.007)	0.120 (0.074)
DP Canyon at DPS-4	1.6 (0.2)	0.106 (0.007)	0.346 (0.017)	0.576 (0.134)
Los Alamos at Bridge	1.8 (0.2)	-0.001 (0.001)	0.001 (0.001)	0.134 (0.083)
Los Alamos at LAO-1	1.4 (0.2)	0.000 (0.001)	0.071 (0.006)	-0.009 (0.078)
Los Alamos at GS-1	3.2 (0.3)	0.299 (0.015)	0.507 (0.022)	-0.026 (0.085)
Los Alamos at LAO-3	1.3 (0.2)	0.052 (0.005)	0.192 (0.012)	0.162 (0.080)
Los Alamos at LAO-4.5	2.3 (0.3)	0.068 (0.006)	0.260 (0.014)	0.299 (0.110)
Los Alamos at SR-4	2.1 (0.2)	0.062 (0.006)	0.230 (0.013)	0.243 (0.084)
Los Alamos at Totavi	2.6 (0.3)	0.003 (0.001)	0.118 (0.008)	0.051 (0.098)
Los Alamos at LA-2	2.8 (0.3)	0.003 (0.002)	0.072 (0.007)	-0.217 (0.081)
Los Alamos at Otowi	2.5 (0.3)	0.000 (0.001)	0.001 (0.001)	-0.004 (0.098)
Summary				
No. of Analyses	11	11	11	11
Average	2.2	0.056	0.171	0.121
S	0.6	0.088	0.156	0.206
Minimum	1.4 (0.2)	-0.001 (0.001)	0.001 (0.001)	-0.217 (0.081)
Maximum	3.2 (0.3)	0.299 (0.015)	0.507 (0.022)	0.576 (0.134)

Table G-44 (cont)

Location	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)
Sediments: Effluent[a]				
Release Area, Mortandad Canyon				
Mortandad at CMR	1.8 (0.2)	0.137 (0.010)	0.019 (0.003)	-0.198 (0.080)
Mortandad West of GS-1	1.8 (0.2)	0.058 (0.006)	0.045 (0.005)	-0.040 (0.082)
Mortandad at GS-1	5.9 (0.6)	11.1 (0.620)	50.6 (2.00)	49.9 (7.50)
Mortandad at MCO-5	1.8 (0.2)	7.44 (0.340)	29.7 (1.20)	40.7 (6.12)
Mortandad at MCO-7	1.8 (0.2)	4.12 (0.166)	16.8 (0.5140)	18.6 (2.80)
Mortandad at MCO-9	3.8 (0.4)	0.000 (0.002)	0.023 (0.004)	0.019 (0.084)
Mortandad at MCO-13	2.9 (0.3)	0.005 (0.001)	0.035 (0.003)	-0.037 (0.018)
Summary				
No. of Analyses	7	7	7	7
Minimum	1.8 (0.2)	0.000 (0.002)	0.019 (0.003)	-0.198 (0.080)
Maximum	5.9 (0.6)	11.1 (0.620)	50.6 (2.00)	49.9 (7.50)
Average	2.8	3.27	13.9	15.6
S	1.6	4.50	19.8	21.6

---

[a]March 1986.
[b]Counting uncertainty in parentheses.
[c]February 1986.

Table G-45. Radionuclides in Local and Regional Produce

	^{3}H (pCi/mL)	^{90}Sr (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)
Cochiti/Santo Domingo					
N	8	8	8	8	8
Mean	1.2	5.5	1.6	8	10
Std. Dev.	1.0	4.1	16	6	30
Minimum	0.0 (0.4)	0.3 (0.3)	-2.0 (13)	0 (1)	-14 (932)
Maximum	2.4 (0.5)	11 (2.4)	2.0 (40)	17 (7)	78 (11)
Espanola Valley					
N	6	6	6	6	6
Mean	0.2	4.7	1.4	3	7
Std. Dev.	0.3	4.0	4.1	6	8
Minimum	-0.2 (0.4)	1.2 (0.3)	-2.9 (14)	-4 (2)	-1 (2)
Maximum	0.5 (0.4)	11 (2.4)	6.5 (5.2)	9 (4)	20 (10)
Los Alamos/White Rock					
N	8	8	8	8	8
Mean	2.6	7.5	1.7	-0.4	-0.9
Std. Dev.	5.9	6.6	1.3	4	0.7
Minimum	-0.4 (0.4)	1.0 (0.3)	0.5 (3.6)	-10 (9)	-7 (9)
Maximum	17 (2.0)	20 (1.6)	4.6 (18)	4 (4)	2 (7)
Onsite					
N	7	7	7	7	7
Mean	13	7.1	5.6	20	200
Std. Dev.	16	3.7	6.8	20	550
Minimum	0.8 (0.4)	2.4 (0.6)	-0.9 (3.6)	1 (3)	2 (3)
Maximum	47 (5.0)	13 (1.1)	16 (13)	56 (11)	1470 (73)
Minimum Detectable Limit	0.7	--	2	20	10

[a]Counting uncertainties within parenthesis.

Table G-46. Radionuclides in Fish

	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
CATFISH					
Abiquiu					
N	7	7	7	5	5
Mean	51	-37	6.8	1	4
Std. Dev.	23	37	3.7	3	4
Minimum	32 (2)[a]	-81 (33)	2.3 (0.2)	-2 (7)	0 (6)
Maximum	95 (2)	49 (37)	11 (1)	4 (7)	9 (6)
Cochiti					
N	8	8	8	5	5
Mean	18	-22	8.7	1	2
Std. Dev.	5	28	3.7	2	4
Minimum	11 (1)	-75 (61)	3.2 (0.3)	-1 (2)	0 (5)
Maximum	26 (2)	1.9 (17)	15 (2)	3 (5)	10 (7)
CRAPPIE					
Abiquiu					
N	16	16	16	5	5
Mean	76	-38	1.7	3	6
Std. Dev.	14	57	0.57	10	5
Minimum	47 (3)	-140 (57)	0.69 (0.1)	-12 (15)	-3 (6)
Maximum	96 (3)	46	2.7 (0.3)	12 (9)	10 (9)

Table G-46 (cont)

	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
Cochiti					
N	10	10	10	5	5
Mean	52	-26	1.6	4	9
Std. Dev.	8	37	0.25	7	7
Minimum	36 (3)	-79 (45)	1.2 (0.1)	-3 +(9)	2 (4)
Maximum	65 (3)	47 (10)	2.0 (0.2)	15 (8)	21 (10)
Minimum Detectable Limit	--	10	3	30	20

[a]Counting uncertainties in parenthesis.

Table G-47. Locations of Beehives

Stations	N-S Coordinate	E-W Coordinate
Regional Stations (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 (Upper Mortandad Canyon)	N040	E080
6. TA-53 (LAMPF)	N070	E090
7. Lower Mortandad Canyon	N020	E220
8. TA-8 (Anchor Site W)	S020	W080
9. TA-33 (HP-Site)	S245	E225
10. TA-54 (Area G)	S080	E90
11. TA-9 (Anchor Site E)	S045	E010
12. TA-15 (R-Site)	S040	E100

Table G-48. Selected Radionuclides in Local and Regional Honey[a]

	Chimayo	San Pedro	Northern Los Alamos	Pajarito Acres	Lower Mortandad	TA-8	TA-9	TA-15	TA-21	TA-33	TA-50	TA-53
^{3}H (pCi/L)[b]	9	60	860	9	10	59	13	26	6200	67	73	7600
^{7}Be (pCi/L)	1430	-550	--	-140	41	1830	130	1920	1130	1710	-422	1040
^{57}Co (pCi/L)	68	65	00	217	101	13	69	107	160	60	16	92
^{134}Cs (pCi/L)[b]	58	58	127	63	33	1	75	76	37	73	46	58
^{137}Cs (pCi/L)	488	509	--	4	88	24	61	5	24	-52	73	62
^{54}Mn (pCi/L)	76	72	--	99	93	54	73	77	53	118	52	3
^{22}Na (pCi/L)	55	58	--	46	43	57	111	47	49	106	64	49
^{83}Rb (pCi/L)	215	197	--	139	146	187	132	180	115	194	192	207
Uranium (ng/g)[b]	3.2	0.7	0.8	0.4	1.3	1.3	0.5	1.6	2.8	0.8	0.8	2.0

[a]Density of honey was about 1860 g/L.
[b]Data from 1985.

Table G-49. 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	Yes	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-50. 1986 RCRA Interactions Among the Laboratory, Environmental Protection Agency (EPA), and New Mexico's Environmental Improvement Division (EID)

January, 1986	Joint EPA/EID inspection of the treatment, storage, and disposal facility. The EPA was the lead agency.
February, 1986	A revised Part A/B of the RCRA permit application was submitted to the EID. As a result of the Hazardous and Solid Waste Amendments of 1984, Area L was closed to disposal of hazardous waste in November 1985. All reference to the Area L land disposal facility in either the Part A or Part B was removed. This required the submittal of a revised closure plan for Area L disposal while the closure plan for Area L treatment and storage remain in the Part B.
March, 1986	Submitted report on TA-54 tuff soil physical properties required by Compliance Order/Schedule (Docker No. 001007).
April 2, 1986	Submitted 1985 Biennial Report to the EID listing hazardous wastes handled at LANL and shipped offsite.
April 7, 1986	Submitted information to the EPA for the 1986 National Survey of Hazardous Waste Facilities.
May 5, 1986	Submitted the Underground Storage Tank (UST) notification to the EID.
May 29, 1986	Received Notice of Deficiency (NOD) letter from the EID requiring additional information for the RCRA Part B submittal.
July 2, 1986	Responded to NOD letter of 5/29/86 with submittal of requested information.
August, 1986	Quarterly Submittal: March 1986 Observation Well Data from Canyons Adjacent to Mesita del Buey Waste Disposal Areas.
August 8, 1986	The controlled air incinerator (CAI) located at TA-54-37 was found by the EID to be eligible for interim status.
September 4-8, 1986	A trial burn was conducted at the CAI to determine destructibility of hazardous waste.
September 5, 1986	A Underground Storage Tank inventory revising the May 5, 1986, inventory was submitted to the EID.
October, 1986	Quarterly Submittal: Results of March and April 1986 Pore Gas Sampling Conducted at Technical Area 54 Waste Disposal Areas L and G.
October 14, 1986	Received Notice of Violation (NOV) letter from the EID.

Table G-50 (cont)

November 13, 1986	Responded to 10/14/86 NOV with a submittal.
November 1986	Quarterly Submittal: June 1986 Observation Well Data From Canyons Adjacent to Mesita del Buey Waste Disposal Areas.
November, 1986	Results of Area L surface Impoundment Characterization.
November, 1986	Area L closure/post closure plan revised to include Area H and submitted to the EID.
December 5, 1986	Raw data from the September 1986 trial burn were submitted to the EID.

Table G-51. 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)
SS	Sanitary Wastes	11	Biochemical Oxygen Demand, Flow, pH, Total Suspended Solids, Fecal Coliform Bacteria, (variable frequency, from 3 per month to quarterly)

Table G-52. NPDES Permit Effluent Quality Monitoring of Sanitary Sewage Treatment Outfalls

Discharge Location	Permit Parameters	Number of Deviations	Range of Deviation
TA-3	BOD[a]	4	48.9 to 63.3
	TSS[b]	0	--
	Fecal Coliforms[c]	7	4060.0 to 353,000
	pH[d]	0	--
TA-8	BOD	0	--
	TSS (90)	1	155.4
	pH	0	--
TA-9	BOD	0	--
	TSS	0	--
	pH	0	--
TA-16	BOD	0	--
	TSS	2	47.6 to 83.0
	pH	0	--
TA-18	BOD	0	--
	TSS (90)	1	128.0
	pH	2	5.8 to 9.2
TA-21	BOD	0	--
	TSS	0	--
	pH	0	--
TA-35	BOD	1	49.0
	TSS (90)	0	--
	pH	0	--
TA-41	BOD	1	59.2
	TSS	0	--
	Fecal Coliforms	0	--
	pH	0	--
TA-46	BOD	0	--
	TSS	0	--
	pH	1	5.0
TA-48	BOD	0	--
	TSS	0	--
	pH	0	--

Table G-52 (cont)

Discharge Location	Permit Parameters	Number of Deviations	Range of Deviation
TA-53	BOD	0	--
	TSS (90)	1	313.0
	pH	2	9.1 to 10.0

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[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 1000 organisms/100 mL (20-day average) and 2000 organisms/100 mL (7-day average).
[d]Range of permit pH limits is >6.0 and <9.0 standard units.

Table G-53. 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-54. 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	11.4	1
Treated Cooling Water	30	TSS	0	---	0
		Free Cl	6	0.8 to 10.6	6
		P	0	---	0
		pH	0	---	0
Noncontact Cooling Water	29	pH	1	9.5	1
Radioactive Waste Treatment Plant	2	COD[c]	6	180.2 to 787.33	1
		TSS	0	---	0
		Cd	0	---	0
		Cr	0	---	0
		Cu	0	---	0
		Fe	0	---	0
		Pb	0	---	0
		Hg	0	---	0
		Zn	0	---	0
		pH	7	9.4 to 12.8	1
High Explosives	20	COD	0	178.2 to 1067.0	2
		TSS	2	49.0 to 1368.0	1
		pH	0	---	0
Photo Wastes	13	CN	0	---	0
		Ag	0	---	0
		TSS	0	---	0
		pH	1	5.6	1

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[a]Limits set by the NPDES permit are presented in Table G-40.
[b]Total Suspended Solids.
[c]Chemical Oxygen Demand.

Table G-55. Schedule and Status of Upgrading the Laboratory's Sanitary Waste Outfalls

Outfalls	Date	Status
01A		
Final design complete	August 1986	Completed
Advertisement of construction contract	September 1986	Completed
Award of construction contract	October 1986	Completed
Construction completion	December 1986	Completed
In compliance with final limits	January 1987	Completed
03A		
Final design complete	August 1986	Completed
Advertisement of construction contract	September 1986	Completed
Award of construction contract	October 1986	Completed
Construction completion	December 1986	Completed
In compliance with final limits	January 1987	Completed
05A		
Final design complete	September 1986	Completed
Advertisement of construction contract	October	Completed
Award of construction contract	November 1986	Completed
Construction completion	May 1987	--
In compliance with final limits	June 1987	--
01S		
Final design complete	Completed	Completed
Advertisement of construction contract	Completed	Completed
Award of construction contract	July 1986	Completed
Construction completion	May 1987	--
In compliance with final limits	August 1987	--
04S		
Final design complete	January 1987	Completed
Advertisement of construction contract	February 1987	--
Award of construction contract	March 1987	--
Construction complete	December 1987	--
In compliance with final limits	January 1988	--
05S		
Final design complete	Completed	Completed
Advertisement of construction contract	Completed	Completed
Award of construction contract	July 1986	Completed
Construction completion	January 1988	--
In compliance with final limits	May 1988	--
06S		
Final design complete	Completed	Completed
Advertisement of construction contract	July 1986	Completed
Award of construction contract	August 1986	--
Construction completion	August 1987	--
In compliance with final limits	September 1987	--

Table G-55 (cont)

Outfalls	Date	Status
10S		
Final design complete	Completed	Completed
Advertisement of construction contract	Completed	Completed
Award of construction contract	Completed	Completed
Construction completion	Completed	Completed
In compliance with final limits	September 1986	Completed
11S		
Final design complete	Completed	Completed
Advertisement of construction contract	Completed	Completed
Award of construction contract	July 1986	Completed
Construction complete	November 1986	Completed
In compliance with final limits	January 1987	Completed

Table G-56. Federal Facility Compliance Agreement Interim Compliance Limits and Complaince Schedule

Effluent Characteristic	Discharge Limitation Daily Avg. (lb/day)	Daily Avg. (mg/L)	7-Day Avg. (mg/L)
Industrial Outfalls			
Outfall 01A (Power Plant)			
Flow (MGD)[a]	N/A	N/A	N/A
Total Suspended Solids (TSS)	N/A	30	100
Free Available Chlorine	N/A	1.0	5.0
Outfall 03A (Treated Cooling Water)			
Flow (MGD)[a]	N/A	N/A	N/A
Total Suspended Solids (TSS)	N/A	30	100
Free Available Chlorine	N/A	1.0	5.0
Total Phosphorous	N/A	5	5
Outfall 05A (High Explosive)			
Flow (MGD)[a]	N/A	N/A	N/A
Chemical Oxygen Demand (load)	N/A	1000	2000
Total Suspended Solids (TSS)	N/A	60	90
Sanitary Waste Water Outfalls			
Outfall 01S (Located at TA-3)			
Flow (MGD)[a]	N/A	N/A	N/A
Biochemical Oxygen Demand (BOD_5)	225.2	70	105
Total Suspended Solids (TSS)	225.2	55	105
Fecal Coliform	N/A	10,000	200,000
Outfall 04S (Located at TA-18)			
Flow (MGD)[a]	N/A	N/A	N/A
Biochemical Oxygen Demand (BOD)	10	60	95
Total Suspended Solids (TSS)	10	70	125
Outfall 05S (Located at TA-21)			
Flow (MGD)[a]	N/A	N/A	N/A
Biochemical Oxygen Demand (BOD_5)	6.8	60	95
Total Suspended Solids (TSS)	7.3	60	100

Table G-56 (cont)

Effluent Characteristic	Discharge Limitation		
	Daily Avg. (lb/day)	Daily Avg. (mg/L)	7-Day Avg. (mg/L)
Outfall 06S (Located at TA-41)			
Flow (MGD)[a]	N/A	N/A	N/A
Biochemical Oxygen Demand (BOD_5)	11.4	55	60
Total Suspended Solids (TSS)	6.2	30	45
Fecal Coliform Bacteria	N/A	20,000	100,000
Outfall 10S (Located at TA-35)			
Flow (MGD)[a]	N/A	N/A	N/A
Biochemical Oxygen Demand (BOD_5)	23.2	115	185
Total Suspended Solids (TSS)	26.1	130	170
Outfall 11S (Located at TA-8)			
Flow (MGD)[a]	N/A	N/A	N/A
Biochemical Oxygen Demand (BOD_5)	N/A	60	95
Total Suspended Solids (TSS)	N/A	70	125

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[a]Flow must be monitored and reported.
Note: The pH shall not be less than 6.0 nor greater than 9.0.

Table G-57. Environmental Documentation Approved by the Laboratory Environmental Review Committee in 1986

Environmental Remarks

Laboratory-Wide

- 345-kV Power Line, PNM OJO Line Extension, Document No. 86-10
- Summer of Applied Geophysical Experience (SAGE), Document No. 86-18

Action Description Memorandums

Laboratory-Wide

- Airport Fire Station, LJ 8458, Document No. 86-13
- Replacement of Transformers Containing PCB Fluids, FY 1986, LJ 8061, Document No. 86-07
- Safeguards and Security Upgrade, Phase II, LJ 8176, Document No. 86-16
- Sanitary Landfill, Canada del Buey, Document No. 86-21
- Sanitary Wastewater Systems Consolidation, LJ 8165, Document No. 86-02
- Scientific Shallow Hole Core Drilling at Sulfur Springs, Document No. 86-17
- Utilities Restoration, FY 1985, LJs 6300, 7666, 7667, 8031, Document No. 86-28

TA-3

- Center for Nonlinear Studies, LJ 8547, Document No. 86-40
- Computational Physics Building, LJ 7954, Document No. 86-41
- Ion Beam Materials Laboratory, LJ 7367, Document No. 86-20
- Selected Rubble Landfill, Sandia Canyon, Document No. 86-14
- Semiconductor Processing Laboratory, ADM Document No. 86-12
- Strategic Defense Design Laboratory, LJ 8195, Document No. 86-8195

Table G-57 (cont)

TA-16

- S-Site Data Communications Project, LJ 8494, Document No. 86-19
- Weapons Subsystem Relocation, LJ 6919, Document No. 86-01

TA-21

- Decommissioning of Enriched Uranium Processing Facility, Buildings 3 and 4 South, Document No. 86-42
- Transuranic Expansion Program, Document No. 86-08

TA-33

- Very Long Baseline Array Radio Telescope Antenna, Document No. 86-15

TA-35

- Cold Support Office Building, LJ 8158, Document No. 86-30
- Confinement Physics Research Facility, LJ 8555, Document No. 86-36
- Laser Physics Facility, Document No. 86-38

TA-36

- Independent Management Activities Program (also TA-66), Document No. 86-25
- Independent Management Activities Program revision (also TA-66), Document No. 86-25rev
- Large Bore Gun and Sled Track Ranges, LJ 8134, Document No. 86-11

TA-43

- Outdoor Bioaerosol Experiments, rev., Document No. 86-31

Table G-57 (cont)

TA-48

- Radiochemical Data Wing for Diagnostics, LJ 8130, Document No. 86-32

TA-52

- Ultra High Temperature Reactor Experiment (UHTREX) Decommissioning, Document No. 86-37

TA-53

- Ground Test Accelerator (GTA) 1, LJ 8401
- High Resolution Atomic Beam Facility, LJ 7927, Document No. 86-06
- Large Cherenkov Detector, LJ 8498, Document No. 86-35
- Nucleon Physics Laboratory Improvements, LJ 8180, Document No. 86-33
- Support Building for Ground Test Facilities (GTA), Document No. 86-22

TA-55

- Category I Automated Vault at PF-4, Document No. 86-09

TA-66

- Independent Management Activities Program (also TA-36), Document No. 86-25
- Independent Management Activities Program revised (also TA-36, Document No. 86-25rev

Environmental Assessments

Laboratory-Wide

- Transuranic (TRU) Waste Inventory Work-Off Plan, Draft, Document No. 86-34 (Transmitted to DOE at their request without formal LERC review; the LERC will review this EA when DOE requests a final document.)

Table G-57 (cont)

TA-16

- Solid-Waste-Fired Boiler Facility, LJ 7415, Document No. 86-03

TA-53

- Accelerator Test Stand Upgrade, rev (GTA-2), Document 86-04
- Ground Test Accelerator (GTA) 1 and 2, Document No. 86-24

Table G-58. Radiochemical Analyses of Water from Municipal Supply and Distribution System (February 1986)

Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{249,240}Pu$ (10^{-9} µCi/mL)
Los Alamos Field					
Well LA-1B	−1.0 (0.4)	−76 (31)	5.1 (0.6)	0.016 (0.015)	−0.012 (0.007)
Well LA-2	−0.9 (0.4)	−22 (27)	1.8 (0.4)	0.009 (0.013)	−0.004 (0.008)
Well LA-3	−0.1 (0.4)	−5 (36)	0.5 (0.2)	−0.012 (0.012)	−0.008 (0.006)
Well LA-4	−0.8 (0.4)	−62 (31)	0.2 (0.2)	−0.008 (0.013)	−0.004 (0.009)
Well LA-5	−1.0 (0.4)	16 (30)	1.0 (0.1)	0.021 (0.014)	0.000 (0.010)
Guaje Field					
Well G-1	−0.6 (0.4)	−43 (31)	0.2 (0.2)	−0.004 (0.013)	−0.004 (0.010)
Well G-1A	−0.4 (0.4)	41 (38)	0.2 (0.2)	−0.009 (0.011)	0.000 (0.010)
Well G-2	−0.8 (0.4)	2 (31)	0.2 (0.2)	−0.004 (0.009)	0.000 (0.010)
Well G-3	−0.5 (0.4)	−34 (32)	0.3 (0.2)	−0.008 (0.008)	0.000 (0.010)
Well G-4	0.1 (0.4)	40 (36)	0.3 (0.2)	−0.006 (0.014)	0.006 (0.006)
Well G-6	−0.6 (0.4)	54 (43)	0.2 (0.2)	−0.004 (0.010)	0.004 (0.009)
Pajarito Field					
Well PM-1	-0.2 (0.4)	13 (35)	0.8 (0.2)	−0.012 (0.009)	0.012 (0.012)
Well PM-2	−1.1 (0.4)	8 (36)	0.1 (0.1)	−0.005 (0.012)	0.005 (0.009)
Well PM-3	−0.6 (0.4)	29 (43)	0.2 (0.1)	0.008 (0.012)	0.004 (0.009)
Well PM-5	−0.6 (0.4)	−25 (37)	0.4 (0.2)	0.005 (0.014)	0.005 (0.008)

Table G-58 (cont)

Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{249,240}Pu$ (10^{-9} µCi/mL)
Gallery (Water Canyon)	−0.8 (0.4)	165 (48)	0.3 (0.2)	−0.008 (0.006)	0.004 (0.007)
Supply Summary					
No. of Analyses	16	16	16	16	16
Average	−0.6	6	0.7	−0.001	0.001
S	0.3	56	1.2	0.010	0.006
Minimum	−0.8 (0.4)	−76 (31)	0.1 (0.1)	0.012 (0.009)	−0.012 (0.007)
Maximum	0.1 (0.4)	165 (48)	5.1 (0.6)	0.021 (0.014)	0.012 (0.012)
Distribution					
Fire Station 1	−0.3 (0.4)	37 (48)	0.2 (0.2)	0.025 (0.018)	−0.004 (0.012)
Fire Station 1	−0.6 (0.4)	−24 (37)	7.0 (1.0)	−0.022 (0.012)	0.018 (0.011)
Fire Station 2	−0.8 (0.4)	−78 (35)	0.4 (0.2)	−0.004 (0.004)	0.000 (0.010)
Fire Station 2	−0.6 (0.4)	0 (32)	2.0 (1.0)	0.009 (0.018)	−0.005 (0.008)
Fire Station 3	−0.7 (0.4)	0 (32)	0.8 (0.7)	0.000 (0.010)	0.008 (0.010)
Fire Station 3	−0.4 (0.4)	−27 (37)	1.0 (1.0)	0.009 (0.013)	0.018 (0.017)
Fire Station 4	−0.1 (0.4)	11 (42)	0.6 (0.2)	0.000 (0.010)	0.000 (0.010)
Fire Station 4	0.1 (0.4)	−9 (35)	1.0 (1.0)	−0.008 (0.002)	0.022 (0.013)
Fire Station 5	−0.4 (0.4)	−6 (38)	0.5 (0.2)	−0.004 (0.008)	0.009 (0.009)
Fire Station 5	0.5 (0.4)	−32 (32)	4.0 (1.0)	0.015 (0.012)	0.000 (0.010)
Bandelier Nat. Mon.	−0.1 (0.4)	26 (38)	0.4 (0.2)	0.020 (0.020)	0.010 (0.012)
Bandelier Nat. Mon.	1.4 (0.4)	59 (39)	1.0 (1.0)	−0.005 (0.010)	−0.005 (0.014)

Table G-58 (cont)

Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{249,240}Pu$ (10^{-9} µCi/mL)
Distribution Summary					
No. of Analyses	12	12	12	12	12
Average	−0.2	−4	1.6	0.003	0.006
S	0.6	36	2.0	0.013	0.010
Minimum	−0.8 (0.4)	−78 (35)	0.2 (0.2)	−0.022 (0.012)	−0.005 (0.005)
Maximum	1.4 (0.4)	59 (39)	7.0 (1.0)	0.025 (0.018)	0.022 (0.013)
Fenton Hill (TA-57)	1.6 (0.4)	56 (46)	1.0 (1.0)	−0.009 (0.009)	0.032 (0.017)
Fenton Hill (TA-57)	−0.3 (0.4)	61 (44)	0.8 (0.2)	−0.004 (0.011)	−0.004 (0.007)
Standby Well (not part of Water Supply) Well LA-6	−0.7 (0.4)	54 (38)	3.4 (0.5)	0.004 (0.011)	−0.004 (0.006)
USEPA Maximum Concentration[a]	20	200	1800[c]	15	15
Limits of Detection	0.7	40	1	0.009	0.03

[a]Counting uncertainties in parentheses.
[b]Reference (USEPA 1976).
[c]Level recommended by International Commission on Radiological Protection.

Table G-59. Gross Radioactivity in Water from Municipal Supply and Distribution Systems (February 1986)

Stations	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Los Alamos Field			
Well LA-1B	11 (3.0)[a]	1.6 (0.5)	150 (70)
Well LA-2	1.8 (0.8)	−1.2 (0.5)	360 (80)
Well LA-3	2.0 (0.8)	0.0 (0.4)	360 (80)
Well LA-4	0.0 (0.5)	0.1 (0.5)	200 (70)
Well LA-5	0.3 (0.4)	0.5 (0.4)	75 (60)
Guaje Field			
Well G-1	0.1 (0.4)	1.1 (0.5)	150 (70)
Well G-1A	1.4 (0.6)	1.8 (0.5)	60 (60)
Well G-2	2.9 (1.0)	0.3 (0.5)	190 (70)
Well G-3	2.3 (0.8)	−0.1 (0.4)	190 (70)
Well G-4	0.7 (0.7)	0.2 (0.5)	325 (80)
Well G-6	2.6 (1.0)	1.0 (0.5)	150 (70)
Pajarito Field			
Well PM-1	2.0 (0.9)	1.9 (0.5)	110 (70)
Well PM-2	1.4 (0.6)	−0.8 (0.4)	350 (80)
Well PM-3	1.7 (0.8)	0.7 (0.5)	160 (70)
Well PM-5	3.0 (0.9)	0.6 (0.4)	175 (70)

Table G-59 (cont)

Stations	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Gallery (Water Canyon)	0.7 (0.4)	−0.4 (0.4)	90 (60)
Supply Summary			
No. of Analyses	16	16	16
Average	2.1	0.5	190
S	2.6	0.9	101
Minimum	0.0 (0.5)	−0.8 (0.4)	60 (60)
Maximum	11 (3.0)	1.9 (0.5)	360 (80)
Distribution			
Fire Station 1	0.8 (0.5)	−0.6 (0.4)	50 (60)
Fire Station 1	0.0 (1.0)	3.2 (0.8)	−650 (200)
Fire Station 2	0.3 (0.5)	−0.6 (0.4)	15 (60)
Fire Station 2	2.0 (1.0)	4.7 (0.9)	−300 (100)
Fire Station 3	0.6 (0.7)	0.6 (0.5)	60 (60)
Fire Station 3	2.0 (1.0)	3.8 (0.8)	−75 (100)
Fire Station 4	1.6 (0.6)	−0.3 (0.4)	20 (60)
Fire Station 4	0.0 (1.0)	5.6 (0.9)	−150 (100)
Fire Station 5	1.6 (0.6)	1.3 (0.4)	0 (60)
Fire Station 5	0.3 (0.9)	3.1 (0.7)	−220 (100)
Bandelier Nat. Mon.	0.6 (0.5)	−0.8 (0.4)	30 (60)
Bandelier Nat. Mon.	3.0 (0.8)	2.0 (0.4)	−300 (100)

Table G-59 (cont)

Stations	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Distribution Summary			
No. of Analyses	12	12	12
Average	1.1	1.9	-125
S	1.0	2.1	210
Minimum	0.0 (1.0)	-0.8 (0.4)	-650 (200)
Maximum	3.0 (0.8)	5.6 (0.9)	60 (60)
Fenton Hill (TA-57)	1.2 (0.7)	5.4 (0.7)	-150 (100)
Fenton Hill (TA-57)	3.0 (1.0)	2.3 (0.6)	20 (60)
Standby Well (not part of Water Supply) Well LA-6	4.0 (1.0)	-1.0 (0.4)	150 (70)
USEPA Maximum Concentration[a]	15	--	--
Limits of Detection			

[a]Counting uncertainties in parentheses.

[b] The Environmental Protection Agency MCL for gross alpha is 15 x 10^{-9} µCi/mL; however gross alpha in the distribution system that exceeds 5 x 10^{-9} µCi/mL requires isotope analyses of radium content.

Table G-60. Primary Chemical Quality for Water Supply and Distribution System, February 1986 (mg/L)

Stations	Ag	As	Ba	Cd	Cr
Supply					
Los Alamos Field					
Well 1B	<0.001	0.039	0.067	<0.0002	0.024
Well 2	<0.001	0.012	0.104	<0.0002	<0.005
Well 3	<0.001	0.004	0.066	<0.0002	0.008
Well 4	<0.001	0.003	0.030	<0.0002	<0.005
Well 5	<0.001	0.004	0.091	<0.0002	<0.005
Guaje Field					
Well G-1	<0.001	0.005	0.060	<0.0002	<0.005
Well G-1A	<0.001	0.012	0.047	<0.0002	0.005
Well G-2	<0.001	0.013	0.074	<0.0002	0.006
Well G-3	<0.001	0.005	0.017	<0.0002	<0.005
Well G-4	<0.001	<0.002	0.028	<0.0002	<0.005
Well G-6	<0.001	<0.002	0.012	0.0003	<0.005
Pajarito Field					
Well PM-1	<0.001	<0.002	0.069	<0.0002	<0.005
Well PM-2	<0.001	<0.002	0.026	<0.0002	0.006
Well PM-3	<0.001	<0.002	0.049	0.0004	<0.005
Well PM-4	Pump Put				
Well PM-5	<0.001	<0.002	0.028	<0.0002	0.007
Gallery (Water Canyon)	<0.001	<0.002	0.014	<0.0002	<0.005
Supply Summary					
No. of Analyses	16	16	16	16	16
Average	--	<0.007	0.049	<0.002	<0.007
S	--	0.009	0.028	0.001	0.005
Minimum	--	<0.002	0.012	<0.0002	<0.005
Maximum	<0.001	0.039	0.104	0.0004	0.024

Table G-60 (cont)

Stations	Ag	As	Ba	Cd	Cr
Distribution					
Fire Station 1	<0.001	<0.002	0.026	<0.0002	<0.005
Fire Station 2	<0.001	0.017	0.033	<0.0002	0.011
Fire Station 3	<0.001	0.002	0.047	<0.0002	<0.005
Fire Station 4	<0.001	0.017	0.034	<0.0002	0.007
Fire Station 5	<0.001	0.002	0.025	0.0005	<0.005
Bandelier National Monument	<0.001	<0.002	0.021	<0.0002	<0.005
Distribution Summary					
No. of Analyses	6	6	6	6	6
Average	--	<0.007	0.031	<0.0003	<0.006
S	--	0.008	0.009	0.001	0.002
Minimum	--	<0.002	0.021	<0.0002	<0.005
Maximum	<0.001	0.017	0.047	0.0005	0.011
Fenton Hill (TA-57)	<0.001	<0.002	0.057	<0.0002	<0.005
Standby Well (not part of Water Supply) Well LA-6	<0.001	0.246	0.026	<0.0002	0.030
USEPA and NMEID Primary Maximum Concentration Levels [a]	--	0.05	1.0	0.01	0.05

[a]Reference (USEPA 1976).

Table G-60 (cont)

Stations	F	Hg	N	Pb	Se
Supply					
Los Alamos Field					
Well 1B	3.3	<0.0002	0.6	0.003	<0.003
Well 2	1.0	<0.0002	0.7	<0.002	<0.003
Well 3	0.6	<0.0002	0.6	<0.002	<0.003
Well 4	0.4	<0.0002	0.6	<0.002	<0.003
Well 5	0.4	<0.0002	0.6	<0.002	<0.003
Guaje Field					
Well G-1	0.4	<0.0002	0.6	<0.002	<0.003
Well G-1A	0.5	<0.0002	0.7	0.009	<0.003
Well G-2	0.7	<0.0002	0.6	0.002	<0.003
Well G-3	0.4	<0.0002	0.7	<0.002	<0.003
Well G-4	0.3	<0.0002	0.8	<0.002	<0.003
Well G-6	0.4	<0.0002	1.7	<0.002	<0.003
Pajarito Field					
Well PM-1	0.3	<0.0002	1.5	<0.002	<0.003
Well PM-2	0.2	<0.0002	0.2	0.003	<0.003
Well PM-3	0.3	<0.0002	0.6	<0.002	<0.003
Well PM-5	0.3	<0.0002	0.4	0.003	<0.003
Gallery (Gallery)	0.1	<0.0002	0.4	<0.002	<0.003
Supply Summary					
No. of Analyses	16	16	16	16	16
Average	0.6	--	0.7	<0.003	--
S	0.8	--	0.4	0.002	--
Minimum	0.1	--	0.2	<0.002	--
Maximum	3.3	<0.0002	1.7	0.009	<0.003

Table G-60 (cont)

Stations	F	Hg	N	Pb	Se
Distribution					
Fire Station 1	0.3	<0.0002	0.4	<0.002	<0.003
Fire Station 2	0.6	<0.0002	0.6	<0.002	<0.003
Fire Station 3	0.8	<0.0002	0.6	<0.002	<0.003
Fire Station 4	0.6	<0.0002	0.6	<0.002	<0.003
Fire Station 5	0.3	<0.0002	0.5	<0.002	<0.003
Bandelier National Monument	0.2	<0.0002	0.4	<0.002	<0.003
Distribution Summary					
No. of Analyses	6	6	6	6	6
Average	0.5	--	0.5	--	--
S	0.2	--	0.1	--	--
Minimum	0.2	--	0.4	--	--
Maximum	0.8	<0.0002	0.6	<0.002	<0.003
Fenton Hill (TA-57)	0.1	<0.0002	0.3	<0.002	<0.003
Standby Well (not part of Water Supply) Well LA-6	2.8	<0.0002	0.7	<0.002	<0.003
USEPA and NMEID Primary Maximum Concentration Levels [a]	2.0	0.002	10	0.05	0.01

[a]Reference (USEPA 1976).

Table G-61. Secondary Chemical Quality for Water Supply, February 1986 (mg/L)

Stations	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH[a]
Supply								
Los Alamos Field								
Well 1B	17	0.007	0.006	<0.001	40	<0.01	456	8.2
Well 2	4	<0.005	0.004	<0.001	9	<0.01	144	8.5
Well 3	3	<0.005	0.004	<0.001	7	<0.01	135	8.3
Well 4	2	0.019	0.004	<0.001	4	<0.01	115	8.3
Well 5	2	<0.005	0.006	<0.001	4	0.02	251	8.3
Guaje Field								
Well G-1	3	<0.005	0.004	<0.001	4	<0.01	166	8.3
Well G-1A	2	<0.005	0.004	<0.001	4	<0.01	170	8.3
Well G-2	3	<0.005	0.004	<0.001	4	<0.01	174	8.3
Well G-3	3	0.015	0.005	<0.001	4	<0.01	135	8.3
Well G-4	3	0.008	0.006	<0.001	4	<0.01	147	8.2
Well G-6	3	<0.005	0.005	<0.001	4	<0.01	159	8.0
Pajarito Field								
Well PM-1	3	<0.005	0.004	<0.001	3	<0.01	213	8.2
Well PM-2	2	<0.005	<0.001	<0.001	2	0.02	139	8.1
Well PM-3	7	<0.005	0.004	<0.001	6	<0.01	227	8.2
Well PM-5	2	0.007	0.005	<0.001	2	0.03	156	8.0
Gallery (Water Canyon)	1	0.064	0.049	<0.001	2	<0.01	91	7.9
Supply Summary								
No. of Analyses	16	16	16	16	16	16	16	16
Average	4	<0.011	<0.007	--	7	<0.01	180	8.2
S	4	>0.015	>0.011	--	9	>0.01	84	0.2
Minimium	1	<0.005	<0.001	--	2	<0.01	91	7.9
Maximum	17	0.019	0.049	<0.001	40	0.03	456	8.5

Table G-61 (cont)

Stations	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH[a]
Distribution								
Fire Station 1	3	<0.005	0.006	<0.001	3	0.05	170	8.1
Fire Station 2	4	<0.005	0.020	<0.001	5	<0.01	172	8.3
Fire Station 3	8	0.017	0.006	<0.001	6	<0.01	234	8.1
Fire Station 4	4	0.008	0.018	<0.001	5	<0.01	177	8.3
Fire Station 5	2	<0.005	0.011	<0.001	2	0.05	151	8.1
Bandelier Nat. Mon.	3	0.023	0.013	<0.001	2	0.10	149	8.2
Distribution Summary								
No. of Analyses	6	6	6	6	6	6	6	6
Average	4	<0.011	0.012	--	4	<0.04	176	8.2
S	2	>0.008	0.006	--	2	>0.04	31	0.1
Minimum	2	<0.005	0.006	--	2	<0.01	149	8.1
Maximum	8	0.023	0.020	<0.001	6	0.10	234	8.3
Fenton Hill (TA-57)	6	<0.005	0.012	<0.001	114	0.14	220	8.1
Standby Well (not part of Water Supply) Well LA-6	4	<0.005	0.061	<0.001	8	<0.01	133	8.8
USEPA Secondary Maximum Contaminate Levels[b]	250	1.0	0.3	0.05	250	5.0	500	6.5-8.5

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[a]Standard units.
[b]Reference: USEPA 1979.

Table G-62. Miscellaneous Chemical Analyses, February 1986 (mg/L)

Stations	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hardness	Conductivity (ms/m)
Los Alamos Field										
Well LA-1B	36	8	0.4	2.7	173	0	302	<0.1	31	72
Well LA-2	28	8	<0.1	1.3	39	1.7	93	<0.1	21	22
Well LA-3	28	12	0.3	1.6	30	0	84	<0.1	33	19
Well LA-4	36	13	0.2	2.4	18	0	66	<0.1	34	15
Well LA-5	37	10	<0.1	1.6	24	0	70	<0.1	26	15
Guaje Field										
Well G-1	78	12	0.6	3.1	21	0	73	<0.1	32	16
Well G-1A	70	10	0.5	2.9	25	0	75	<0.1	31	16
Well G-2	71	12	0.7	2.9	27	0	82	<0.1	34	18
Well G-3	55	14	1.9	2.1	17	0	73	<0.1	45	16
Well G-4	52	17	2.9	2.0	13	0	73	<0.1	52	16
Well G-6	54	17	2.7	2.4	14	0	75	<0.1	51	17
Pajarito Field										
Well PM-1	64	26	6.1	3.6	20	0	118	<0.1	82	27
Well PM-2	72	9	2.8	1.8	10	0	52	<0.1	36	11
Well PM-3	84	24	7.8	3.7	18	0	119	<0.1	88	26
Well PM-5	85	10	3.2	2.1	12	0	60	<0.1	35	13
Gallery (Water Canyon)	40	7	3.1	1.6	6		39	<0.1	28	8
Distribution										
Fire Station 1	84	11	3.1	2.1	13	0	63	<0.1	39	13
Fire Station 2	62	12	7.2	2.5	29	0	88	<0.1	33	19
Fire Station 3	85	25	7.5	3.7	18	0	116	<0.1	86	28
Fire Station 4	63	12	1.2	2.5	27	0	83	<0.1	36	18

Table G-62 (cont)

Stations	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hard-ness	Conduc-tivity (ms/m)
Fire Station 5	78	10	3.0	2.1	11	0	57	<0.1	38	12
Bandelier Nat. Mon.	75	11	2.8	2.0	11	0	57	<0.1	38	12
Fenton Hill (TA-57)	11	36	3.6	4.4	13	0	111	<0.1	95	28
Standby Well (not part of Water Supply) Well LA-6	35	3	0.6	1.0	87	8.7	170	<0.1	14	36

Table G-63. Climatological Survey (1911-1986) for Los Alamos New Mexico[a] Means[b] and Extremes of Temperature and Precipitation

	Temperature(°F)[c]										
	Means			Extremes							
Month	Mean Max	Mean Min	Mean	High Monthly Mean	Year	Low Monthly Mean	Year	High Daily Max	Date	Low Daily Min	Date
Jan	39.7	18.5	29.1	37.6	1986	20.9	1930	64	1/12/81	-18	1/19/76
Feb	43.0	21.5	32.2	37.4	1934	23.0	1939	69	2/25/86	-14	2/1/51
Mar	48.7	26.5	37.6	45.8	1972	32.1	1948	71	3/27/86[d]	-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	5/1/76[d]
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	6/22/81[d]	-18	1/13/63

Table G-63 (cont)

	Precipitation (in.)[c]										Mean Number of Days		
	Rain[e]					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	1/12/76	10.7	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	5.67	1986	2.51	6/10/13	0	---	---	---	---	3	0	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
Season							123.6	1957-1958					

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[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]Most recent data.
[e]Includes liquid water equivalent of frozen precipitation.

Table G-64. Climatological Summary for 1986

	Temperature (^{o}F)[a]						
	Means			Extremes			
Month	Mean Max	Mean Min	Avg	High	Date	Low	Date
Jan	51.1	24.1	37.6	60	19	15	5
Feb	47.8	24.1	36.0	69	25	-2	10
Mar	57.1	30.4	43.8	71	27	17	20
Apr	60.5	34.7	47.6	75	30	24	14,18
May	68.0	41.2	54.6	80	20	27	8
Jun	74.5	49.5	62.0	87	16	40	10
Jul	79.9	53.3	66.6	90	30	48	17,24
Aug	81.3	52.6	67.0	90	19,20	47	30
Sept	69.8	44.2	57.0	82	5,6	34	30
Oct	58.0	34.7	46.4	69	5,8	20	13
Nov	47.1	26.6	36.8	57	17	15	13
Dec	41.2	21.1	31.2	52	3	6	11
Annual	61.5	36.4	49.0	90	7/30 7/19-20	-2	2/10

Table G-64 (cont)

	Precipitation (in.)[a]						Number of Days		
	Rain[a]			Snow					
Month	Total	Daily Max	Date	Total	Daily Max	Date	Precip ≥0.10 in.	Max Temp ≥90°F	Min Temp ≤32°F
Jan	0.01	0.01	7	0.2	0.2	7	0	0	31
Feb	1.01	0.46	7	19.0	8.0	7	3	0	22
Mar	0.78	0.37	18	7.2	4.0	18	1	0	19
Apr	1.85	0.56	26	2.7	2.5	19	5	0	12
May	1.64	0.48	17	2.0	2.0	1	5	0	5
Jun	5.67	1.58	3	0	0	--	9	0	0
Jul	2.19	0.41	16	0	0	--	8	1	0
Aug	3.31	0.72	25	0	0	--	10	2	0
Sept	2.03	0.82	13	1	1	24,25	4	0	0
Oct	2.96	0.79	10	7.0	4.5	12	5	0	9
Nov	2.23	0.51	2	5.9	3.5	23	6	0	26
Dec	0.44	0.19	6	5.2	1.0	8,24	1	0	31
Annual	24.12	1.58	6/3	49.2	8.0	2/7	57	3	155

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

Table G-65. Weather Highlights of 1986

January	Very warm and dry. Mean temperature = 37.6°F (Normal = 29.1°F) Warmest January or record (previous warmest was 37.5° in. 1953). Mean maximum temperature=51.1°F (Normal = 39.7°F). Highest mean maximum temperature for January (previous highest was 49.1°F). Very dry: 0.01 in precipitation (Normal = 0.85 in). Least precipitation for January since 1928 when none fell. Only 0.2 in. snow (Normal = 9.7 in.). Least snow for January since 1928 when none fell. SMDH on the 19th: 60°F. SMDH on the 23rd: 57°F. SMDH on the 28th: 59°F. SMDH on the 29th: 57°F. SMDH on the 30th: 59°F.
February	Snowy and mild. Mean temperature = 36.0°F (Normal = 32.2°F). Mean May temperature 47.8°F (Normal = 43.0°F. Snowfall = 19.0 in. (Normal = 7.3 in.). SMDP on the 7th: 0.46 in. SMDS on the 7th: 8.0 in. SMDP on the 9th: 0.22 in. SMDS on the 9th: 6.5 in. TMDH on the 18th: 60°F. SMDH on the 19th: 68°F (Also highest for February - previous: 66°F, and highest for so early in the year. 2/24/36). SMDH on the 20th: 69°F (Also highest for February set previous day;) highest for so early in the year. SMDH on the 21st: 68°F Strong winds with peak gusts > 50 mph on 13th and 16th.
Winter 1985-1986 (December-February)	2nd warmest winter on record: mean temperature =35.2°F. (Warmest winter on record: 35.3°F: 1980-1981)
March	Very warm. Mean temperature = 43.8°F (Normal = 37.6°F). Mean maximum temperature = 57.1°F (Normal = 48.7°F). SMDH on the 1st: 64°F. TMDH on the 2nd: 64°F. SMDH on the 5th: 65°F. TMDH on the 7th: 65°F. SMDH on the 8th: 63°F. Very windy on 9th: 69 mph peak gust. SMDH on the 23rd: 70°F (Also warmest for so early in season). SMDH on the 24th: 66°F.

Table G-65 (cont)

	TMDH on the 25th: 67°F. SMDH on the 27th: 71°F (Also tied for highest in March; previous: 3/26/71 and 3/20/46). TMDH on the 29th: 70°F. TMDH on the 31st: 69°F.
April	Wet and mild. Precipitation = 1.85 in. (Normal = 0.86 in.). SMDS on 19th: 2.5 in. Strong winds with peak gusts > 50 mph on the 13th, 17th and 23rd.
May	Late snowfall of 2.0 in. on the 17th.
June	Record precipitation and cool. Precipitation = 5.67 in. (Normal = 1.12 in.) Wettest June on record (previous: 5.57 in. in 1913) Also wettest month since November 1, 1978 when 6.60 in. fell. Mean temperature = 62.0°F (Normal = 65.1°F). SMDP on the 3rd: 1.58 in. Also second highest daily rainfall on record for June; highest: 2.51 in. on 6/10/13. Strong thunderstorms on the 3rd produce heavy rains and hail. Funnel clouds reported in Santa Fe area. Very cool on 24th and 25th with March temperatures of 57 and 61°F, respectively. SMDP on the 25: 0.61 in.
July	Drier and cooler than normal. TMDL on the 17th: 48°F.
August	Warm day temperatures. Mean maximum temperature = 81.3°F (Normal = 77.4°F) SMDH on the 17th: 88°F. SMDH on the 18th: 89°F. SMDH on the 19th: 90°F. SMDH on the 20th: 90°F. Hazy on the 24th and 25th.
September	Cool. Mean minimum temperature = 44.2°F (Normal = 48.4°F). SMDL on the 11th: 35°F. Very cool on the 24th with high temperature only 49°F. Some wet snow on the 24th and 25th.

Table G-65 (cont)

October	Wet, snowy, and cold. Mean temperature = 46.4°F (Normal = 50.3°F). Precipitation = 2.96 in. (Normal = 1.52 in.). Snowfall = 7.0 in. (Normal = 1.7in.). A storm gives record snowfall and cold on 11th - 13th. SMDL on the 11th: 26°F. SMDP on the 11th: 0.61 in. SMDS on the 11th: 2.5 in. SMDL on the 12th: 21°F (High temperature only 28°F on 12th; lowest for so early in season) SMDL on the 13th: 20°F (Also lowest temperature for so early in season) Haze on the 30th and 31st.
November	Wet. Precipitation = 2.23 in. (Normal = 0.96 in.). SMDP on the 1st: 0.49 in. SMDP on the 4th: 0.27 in.
December	Near normal temperatures. Dry = 0.44 in. precipitation
Annual	1986 mean temperature = 49.0°F (Normal = 48.1°F) 1986 precipitation = 24.12 in. (Normal = 17.83 in.). Second consecutive year with precipitation > 24 in. 1986 snowfall = 49.0 in. (Normal = 50.8 in).

Key for Abbreviations:

SMDH: Set Maximum Daily High Temperature Record
TMDH: Tied Maximum Daily High Temperature Record
SMDL: Set Minimum Daily Low Temperature Record
TMDL: Tied Minimum Daily Low Temperature Record
SMDP: Set Maximum Daily Precipitation Record
SMDS: Set Maximum Daily Snowfall Record

Table G-66. Most Recent Available Data (μg/g) on Environmental Samples from Fenton Hill Geothermal Site

Location[a]	As	B	Cd	F	Li
Roots (Bank)					
100 m[b]	1.8	29	180	33	6.5
200 m	1.6	37	100	32	8.2
400 m	1.6	30	170	18	7.2
1000 m	0.9	34	---	31	6.0
Roots (Channel)					
100 m	8.5	114	200	49	11
200 m	7.0	139	530	51	19
400 m	9.3	130	260	39	10
1000 m	1.5	30	330	12	5.1
Lower Canyon	0.6	32	320	37	4.6
Foliage (Bank)					
100 m	0.02	11	<20	0.9	0.8
200 m	0.03	13	28	2.0	0.6
400 m	0.08	32	47	3.8	0.5
1000 m	0.10	9	55	2.8	0.5
Foliage (Channel)					
100 m	0.2	188	120	6.4	12
200 m	0.2	434	53	7.3	57
400 m	0.04	110	83	4.0	4.8
1000 m	0.08	12	---	4.3	2.6
Lower Canyon	0.1	13	49	1.8	1.0
Soil (Bank)					
100 m	3.1	14	80	79	15
200 m	3.1	23	160	140	30
400 m	3.9	17	80	99	18
1000 m	5.4	31	510	160	26
Soil (Channel)					
100 m	12	49	210	260	28
200 m	17	104	440	240	38
400 m	12	54	220	150	43
1000 m	2.9	18	210	130	30
Lower Canyon	2.8	15	140	300	51

[a]One sample per location.
[b]Distance downstream channel from Fenton Hill Geothermal Site.

Table G-67. Wet Deposition in $\mu g/m^2$ (Unless Specified)[a]

Parameter	Third Quarter 1985	Fourth Quarter 1985	First Quarter 1986	Second Quarter 1986
Precipitation (in.)	0.5 (0.0-1.74)	0.52 (0.0-6.04)	0.14 (0.0-1.11)	0.40 (0.0-1.3)
Field pH	4.76 (4.23-4.92)	4.82 (4.49-5.33)	4.78 (4.71-4.85)	5.05 (4.66-6.80)
Calcium	161.5 (5.0-879.7)	39.9 (0.5-152.7)	29.4 (0.5-139.2)	186.9 (0.5-713.6)
Magnesium	29.7 (0.8-113.5)	9.9 (0.0-46.9)	7.4 (0.0-44.4)	29.8 (0.0-93.8)
Potassium	16.2 (0.8-47.0)	2.9 (0.2-10.5)	2.1 (0.0-12.3)	9.6 (0.0-45.0)
Sodium	33.2 (1.3-132.2)	12.5 (0.9-60.4)	8.1 (0.4-41.8)	29.4 (1.3-86.6)
Ammonium	158.4 (67.1-387.5)	69.1 (6.1-181.3)	32.5 (0.6-93.7)	140.4 (31.0-359.8)
Nitrate	256.7 (6.2-787.2)	55.5 (10.2-267.3)	116.1 (9.8-417.4)	228.5 (0.8-545.9)
Chloride	53.4 (1.7-162.4)	8.2 1.1-29.6)	12.8 (1.1-55.6)	34.3 (1.1-85.7)
Sulfate	258.4 (2.7-925.0)	119.2 (4.0-646.8)	73.4 (0.8-211.3)	269.8 (5.6-802.2)
Phosphate	2.46 (0.00-8.84)	1.90 (0.00-13.00)	0.47 (0.32-0.63)	5.53 (0.63-10.4)

[a]Mean; range in parenthesis.

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 diagostic procedures.
beta particle	A charged particle (identical to the electron) that is emitted during decay of certain radioactivity 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 to 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, effective	The hypothetical whole body dose that would give the same risk of cancer mortality and/or serious genetic disorder as a given exposure, that may be limited to just a few organs. The effective dose equivalent is equal to the sum of individual organ doses each weighted by degree of risk that the organ dose carries. For example, a 100 mrem dose to the lung, which has a weighting factor of 0.112, gives an effective dose equivalent to (100 x 0.12 =) 12 mrem.
dose, equivalent	A term used in radiation protection that expresses all types of radiation (alpha, beta, and so on) on a common scale for calculating the effective absorbed dose. It is the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the rem.)
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 reontgen).
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.
groundwater	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 x 1/2), after three half-lives, one-eighth (1/2 x 1/2 x 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 groundwater body above an impermeable layer that is separated from an underlying main body of groundwater by an unsaturated zone.
person-rem	The unit of population dose, 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 years 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 users 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 radioactivity 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. W 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 x 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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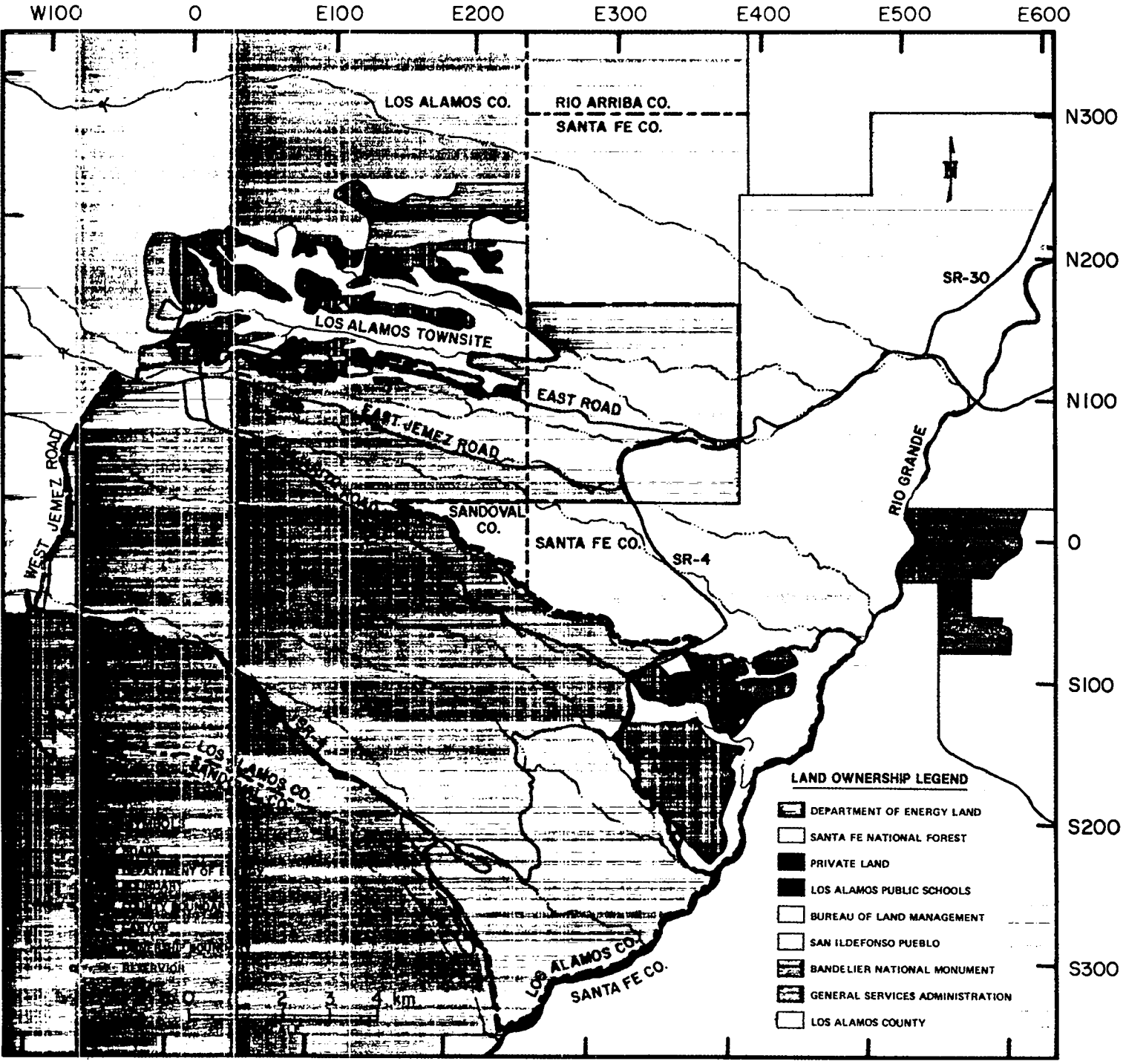

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