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Environmental Surveillance at Los Alamos during 1990

8038

Los Alamos
NATIONAL LABORATORY

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

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Environmental Surveillance at Los Alamos during 1990

Environmental Protection Group

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Department of Energy
Albuquerque Operations
Los Alamos Area Office
Los Alamos, New Mexico 87544

JAN 0 5 1992

To the Reader:

Enclosed is your copy of the Environmental Surveillance Report for the Los Alamos National Laboratory (the Laboratory). This report summarizes the Laboratory's 1990 environmental monitoring and compliance activities. These activities are carried out in order to ensure compliance with environmental standards, to identify at early stages any undesirable environmental trends, and to inform the public about the magnitude of potential health and environmental effects of the Laboratory's operations. This is the latest in a continuing series of environmental surveillance reports published annually by the Laboratory.

The report was prepared by members of the Laboratory's Health, Safety, and Environment Division. Since this is an annual report for an ongoing program, we would appreciate your comments or suggestions for improving both the report and the program. If you are not currently on the mailing list for this report, or if personnel changes in your organization have resulted in a need for us to update our mailing list for next year's report, please contact Karl J. Twombly of the Environment, Safety, and Health Branch at the address provided above, or by telephone at (505) 667-5288. I hope you will find this document useful and informative.

Sincerely,

Jerry L. Bellows
Area Manager

Enclosure

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1990

ENVIRONMENTAL PROTECTION GROUP

ABSTRACT

This report describes the environmental surveillance program conducted by Los Alamos National Laboratory during 1990. 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 1990 cover external penetrating radiation; quantities of airborne emissions and effluents; concentrations of chemicals and radionuclides in ambient air, surface waters and groundwaters, 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 small and do not pose a threat to the public, Laboratory employees, or the environment.

FOREWORD

Suggestions on How to Read This Report

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

1. Lay Person with Limited Interest. Read Section I, the Compliance 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 in the back of the report describes pertinent terms and acronyms..

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 Section I, the Compliance 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 Section I, the Compliance Summary, which describes the Laboratory's environmental programs and summarizes environmental data for this year. Read each major subdivision of this report. Further details are in the text and appendixes.

For further information about this report, contact the Los Alamos National Laboratory's Environmental Protection Group (HSE-8):

Environmental Protection Group (HSE-8)
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, NM 87545
Attn: Dr. Larry Hoffman
Mail Stop K490
Commercial Telephone: (505) 667-4715
Federal Telephone System: 843-4715

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This report was compiled by Larry Hoffman and Karen Lyncoln (Benchmark Environmental Corporation) with contributions from members of the Environmental Protection Group (HSE-8) in the Laboratory's Health, Safety, and Environment Division. Personnel in HSE-8 during 1990 include the following:

Ken Hargis, Group Leader
Roger Ferenbaugh, Deputy Group Leader
Michael Alexander
Alice Barr
Naomi Becker
Kathryn Bennett
Roy Bohn
Brent Bowen
Thomas Buhl
Michael Burkheimer
Jeff Carmichael
Juan Corpion
Jean Dewart
Craig Eberhart
Brenda Edeskuty
Malcolm Ennis
Teralene Foxx
Philip Fresquez
Bruce Gallaher
Vince Garcia
Doris Garvey
Anthony Grieggs
Tim Haarmann
Belinda Harrigan
Joan Harris
Larry Hoffman
Chris Holmes
Keith Jacobsen
Carla Jacquez
David Jardine
Pat Kennedy
David Kraig
Beverly Larson
Suzanne Lester
Consuelo Lujan
Eddie Lujan
Daniel Macdonell
Max Maes
Ernestine Martinez
Sally Martinez
Ellen McGehee
David McInroy
Steven McLin
Raul Morales
Joan Morrison
David Nochumson
Charles Nylander
William Olsen
Vivian Pearson
Ann Pendergrass
Margaret Powers
William Purtymun
Steven Rae
Geraldine Rodriguez
Richard Romero
Michelle Rutherford
John Salazar
Tina Marie Sandoval
Mike Schillaci
Wayne Scoggins
Lars Soholt
Alan Stoker
Will Stolpe
Greg Stone
Beverly Talley
Daniel Talley
Janet Taylor
Donald VanEtten
James White

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I. COMPLIANCE SUMMARY

A. Monitoring Operations

The Laboratory supports an ongoing environmental surveillance program as required by U.S. Department of Energy (DOE) Orders 5400.1 ("General Environmental Protection Program," November 1988) and 5484.1 ("Environmental Protection, Safety, and Health Protection Information Reporting Requirements," February 1981). The surveillance program includes routine monitoring for radiation, radioactive materials, and hazardous 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. The environmental program also includes an assessment of the Laboratory's impact on the surrounding environment. Detailed, supplemental environmental studies also are carried out to determine the extent of potential problems, to provide a basis for any remedial actions, and to gather further information on the surrounding environment. The monitoring program 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, as well as airborne releases of nonradioactive compounds from many Laboratory operations.

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

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

Samples of air particles and gases, water, soils, sediments, and foodstuffs are routinely collected at these stations for subsequent analyses (Table I-1). External penetrating radiation from cosmic, terrestrial, and Laboratory sources is also measured.

Additional samples are collected and analyzed to gain information about particular events, such as major surface runoff events, nonroutine releases, or special studies. More than 25 000 analyses for chemical and radiochemical constituents were carried out for environmental surveillance during 1990. Resulting data were used for dose calculations, for comparisons with standards and background levels, and for interpretation of the relative risks associated with Laboratory operations.

Comprehensive information about monitoring activities, environmental regulatory standards, and methods and procedures for acquiring, analyzing, and recording data is presented in Appendices A–F; detailed environmental data tables are given in Appendix G. Results are discussed in the body of the report.

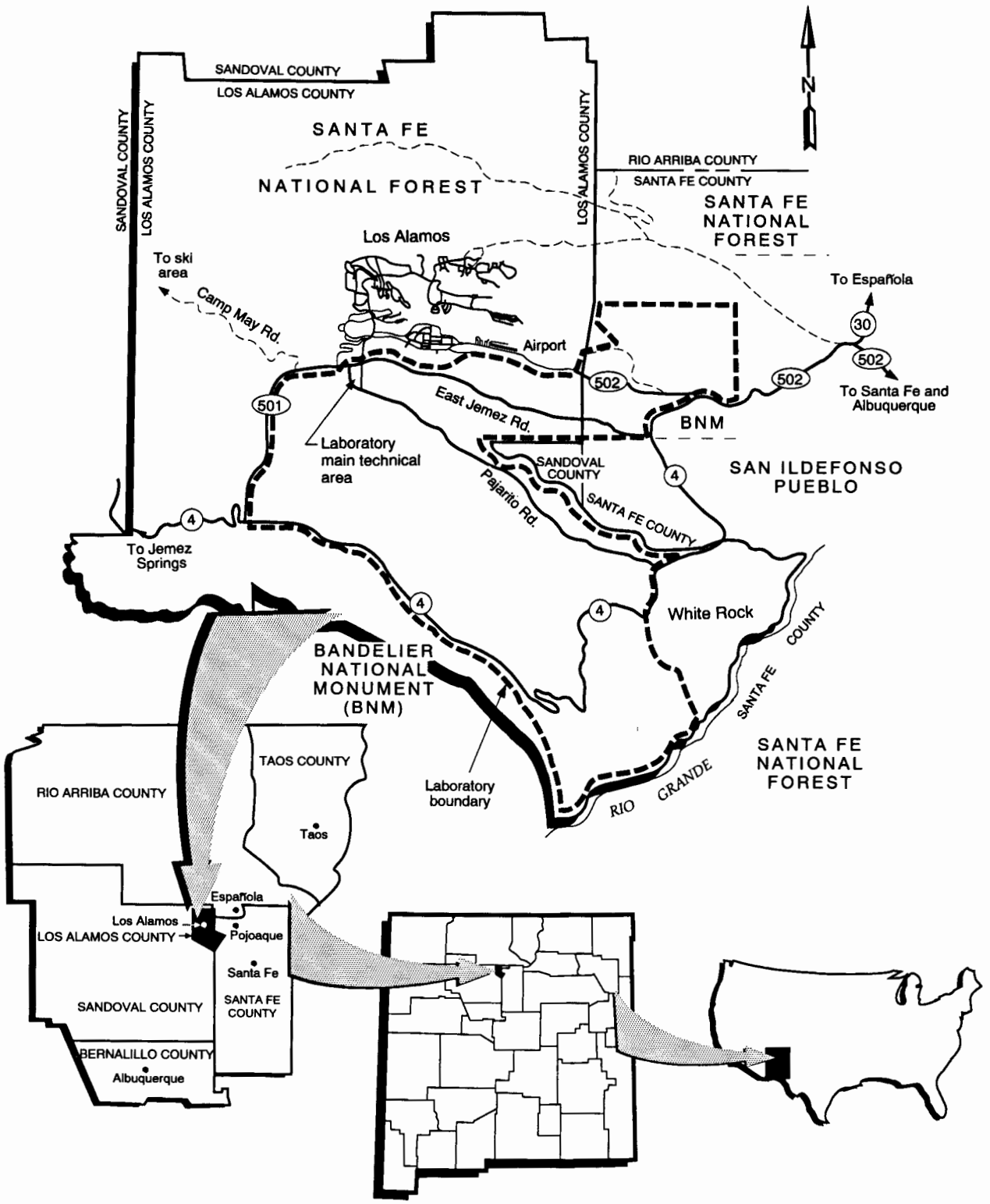


Fig 1. Regional location of Los Alamos.

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

Type of Monitoring	Regional	Perimeter	On-Site
External radiation	4	12	139
Air	3	13	12
Surface and ground waters[a]	6	32	37
Soils and sediments	16	16	34
Foodstuffs	10	8	11

[a]Samples from an additional 22 stations for the water supply and 33 special surface water and groundwater stations related to the Fenton Hill Geothermal Program were also collected and analyzed as part of the monitoring program.

B. Estimated Doses and Risks from Radiation Exposure

1. Radiation Doses. In this report, estimated individual radiation doses to the public attributable to Laboratory operations are compared with applicable standards. Doses are expressed as percentages of DOE's public dose limit (PDL). The PDL excludes exposures from natural background, fallout, and radioactive consumer products. Estimated doses are 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 before 1985 (Fig. 2). These doses have principally resulted from external radiation from the Laboratory's airborne releases. In 1989, DOE issued Order 5400.5, which finalized its 1985 interim guideline lowering the PDL to 100 mrem/yr (effective dose equivalent) from all exposure pathways. In addition, exposure via the air was further limited to 10 mrem/yr (effective dose equivalent) in accordance with requirements of the U.S. Environmental Protection Agency (EPA) (Appendix A).

In 1990, the estimated maximum individual effective dose was 3.1 mrem, or 3.1% of DOE's 100 mrem/yr standard for all pathways. It is 31% of EPA's 10 mrem/yr standard for the air alone (Table G-1). 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 effective dose attributable to background radiation. The highest estimated dose caused from Laboratory operations was about 1% of the 337 mrem received from background radioactivity in Los Alamos during 1990. No data on first quarter CY 91 sampling is available.

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 caused by 1990 Laboratory operations was estimated to be 1 chance in 21 000 000 (Table I-2). This risk is <0.5% of the 1 chance in 8 000 for cancer from natural background radiation and the 1 chance in 43 000 for cancer from medical radiation.

The 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 form of cancer is 1 chance in 4. The lifetime risk of cancer mortality is 1 chance in 5. No analysis of first quarter 1991 data is available.

C. External Penetrating Radiation

Levels of external penetrating radiation (including x and gamma rays and charged particle contributions from cosmic, terrestrial, and manmade sources) in the Los Alamos area are monitored with thermoluminescent dosimeters (TLDs) at 155 locations.

The TLD network for monitoring radiation from airborne activation products released by LAMPF measured about 6±3 mrem for 1990 (excluding background radiation from cosmic and terrestrial sources). This is less than that measured in 1989, reflecting a 20% decrease in the release of airborne radioactivity from LAMPF.

Radiation levels (including natural background radiation from cosmic and terrestrial sources) are also measured at regional, perimeter, and on-site locations in the environmental TLD network. Some measurements at on-site stations were above background levels, as expected, reflecting ongoing research activities at, or past releases from, Laboratory facilities.

D. Air Monitoring

1. Radioactive Air Emissions. Airborne radioactive emissions were monitored at 88 release points at the Laboratory. Total radioactive airborne emissions decreased substantially from those in 1989 (Table I-3). This was primarily due to a 20% decrease in releases of airborne activation products from LAMPF. The total curies released throughout the Laboratory also decreased 20%.

Ambient air is routinely sampled for tritium, uranium, plutonium, americium, and gross beta activity. Measurements of radioactivity in the air are compared with DOE's derived concentration guides. These guides are concentrations of radioactivity in air that, if breathed continuously throughout the year, would result in effective doses equal to DOE's PDLs of 100 mrem/yr for persons in off-site areas (derived concentration guides for uncontrolled areas) and to the occupational radiation protection standards (see Appendix A) for persons in on-site areas (derived air concentrations for controlled areas). Hereafter, they are called guides for on- and off-site areas.

Tritium was the primary radionuclide with air concentrations that showed levels indicating any measurable impact from radionuclide releases caused by Laboratory operations. Annual average concentrations of tritium continued to be much less than 0.1% of DOE's guides at all stations and posed no

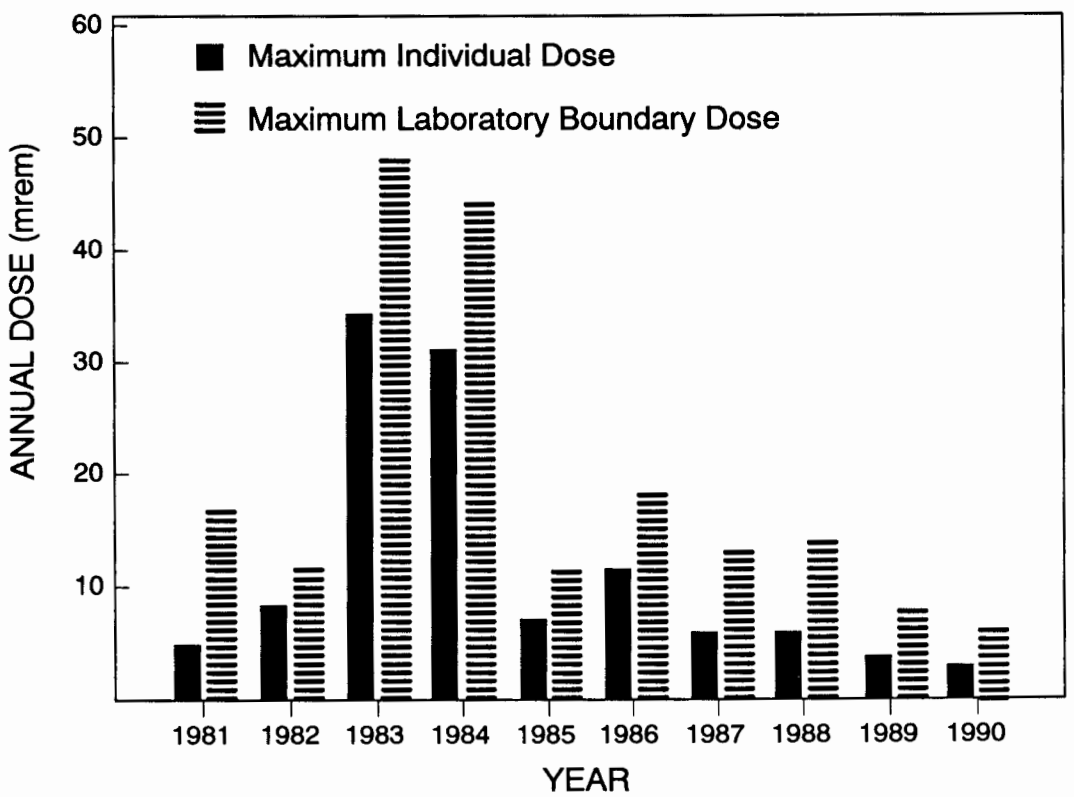


Fig. 2. Summary of estimated maximum individual and maximum Laboratory boundary doses from Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources).

Table I-2. Added Individual Lifetime Cancer Mortality Risks Attributable to 1990 Radiation Exposure

Exposure Source	Incremental Effective Dose Equivalent Used in Risk Estimate (mrem)	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.11	1 in 21 000 000
White Rock area	0.15	1 in 15 000 000
Natural Radiation		
Cosmic, terrestrial, self-irradiation, and radon exposure[a]		
Los Alamos	337	1 in 8 000[b]
White Rock	337	1 in 8 000
Medical X Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in 43 000

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

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

environmental or health problems in 1990. Annual average concentrations of all other radionuclides in air during 1990 were also much less than 0.1% of the guides. No analysis of first quarter CY 91 sampling is available.

2. Nonradioactive Air Emissions. During 1990, Johnson Controls World Services removed approximately 540 linear feet of friable asbestos and 960 linear feet of potentially friable asbestos from piping. Approximately 70 360 square feet of friable asbestos and 6 280 square feet of potentially friable asbestos were removed from other components. The Laboratory inspects asbestos removal operations on a routine basis and coordinates corrective action on identified problems.

Asbestos wastes potentially contaminated with radionuclides are disposed of at TA-54 in accordance with required disposal practices. Nonradioactive asbestos is disposed of off-site in a certified landfill. Eight disposal certifications, including the annual notification for asbestos disposal during small jobs, were submitted to New Mexico Environmental Improvement Division (NMEID) during 1990. Also submitted were nine notifications of asbestos removal, including the annual notification for small renovation jobs. In 1990, 0.2% of the asbestos removed from pipe and other facility components involved small renovation jobs that required no job-specific notification to the State; the rest required job-specific notification.

E. Water, Soil, and Sediment Monitoring

Surface waters and groundwaters are monitored to detect potential dispersion of radionuclides and

Table I-3. Comparison of 1989 and 1990 Releases of Radionuclides from Laboratory Operations[a]

Airborne Emissions

Radionuclide	Units	Activity Released 1989	Activity Released 1990	Ratio 1990:1989
^{3}H	Ci	14 440	6 400	0.6
^{32}P	μCi	18	9	0.5
^{41}Ar	Ci	222	160	0.7
Uranium	μCi	394	240	0.6
Plutonium	μCi	45	26	0.6
Gaseous mixed activation products	Ci	156 000	123 400	0.8
Mixed fission products	μCi	435 000	1 085	<0.1
Particulate/vapor activation products	Ci	0.1	0.08	0.7
Spallation Products	Ci	—	2	—
Rounded Total	Ci	170 000	131 000	0.8

Liquid Effluents

Radionuclide	Activity Released (mCi) 1989	Activity Released (mCi) 1990	Ratio 1990:1989
^{3}H	41 000	12 000	0.3
$^{82,85,89,90}Sr$	119.1	253	2.1
^{137}Cs	39	21	0.5
^{234}U	0.5	0.07	0.03
$^{238,239,240}Pu$	2.6	0.8	0.3
^{241}Am	4.1	2.7	0.7
Other	828.6	574.6	0.7
Rounded Total	42 000	13 000	0.3

[a]Detailed data are presented in Table G-2 for airborne emissions, and Table VI-1 for liquid effluents.

hazardous chemicals from Laboratory operations. Only the surface waters and shallow groundwaters in on-site liquid effluent release areas contained radioactivity in concentrations that were above natural terrestrial and worldwide fallout levels. These waters are not a source of industrial, agricultural, or municipal water supplies. The quality of water from regional, perimeter, and on-site areas that have received no direct discharge showed no significant effects from Laboratory releases. Samples from test wells and water supply wells continued to show no radioactive or chemical contamination in the deep aquifer that occurs 180 to 360 m (600 to 1 200 ft) beneath the Pajarito Plateau.

Liquid effluents containing low levels of radioactivity are routinely released from one waste treatment plant and one sanitary sewage lagoon system. The dominant change from 1989 was a decrease in tritium discharges (Table I-3). The LAMPF lagoons were modified during 1989, resulting in no discharge in 1990.

Measurements of radioactivity in samples of soils and sediments provide data on less direct pathways of exposure. These measurements are useful for understanding hydrological transport of radioactivity in intermittent stream channels near low-level radioactive waste management areas. On-site areas within Pueblo, Los Alamos, and Mortandad Canyons all had concentrations of radioactivity in sediments at levels higher than those attributable to natural terrestrial sources or worldwide fallout. Cesium, plutonium, and strontium in Mortandad Canyon result from effluents from a liquid waste treatment plant. No runoff or sediment transport has occurred beyond the Laboratory boundary in Mortandad Canyon since effluent release into the canyon started. However, some radioactivity in sediments in Pueblo Canyon (from pre-1964 effluents) and Los Alamos Canyon (from post-1952 treated effluents) has been transported to the Rio Grande. Theoretical estimates, confirmed by measurements, show that the incremental effect on Rio Grande sediments is a very small percentage of the background concentrations attributable to worldwide fallout in soils and sediments.

Surface runoff has transported some low-level contamination from the active waste disposal area and several of the inactive areas into controlled-access canyons. Analyses for extracting toxic metals from surface sediments indicate that no constituents in excess of EPA criteria for determining hazardous waste are present in these canyons.

F. Foodstuffs Monitoring

Most fruit, vegetable, fish, bee, and honey samples from regional and perimeter locations showed no radioactivity distinguishable from that attributable to natural sources or worldwide fallout. Some produce, bee, and honey samples from on-site locations had elevated tritium concentrations at levels <1% of DOE's guides for tritium in water (there are no concentration guides for produce). No analysis of first quarter CY 91 data is available.

G. Environmental Compliance Activities

1. Resource Conservation and Recovery Act. This act regulates hazardous wastes, from generation to ultimate disposal. The EPA has given full authority for administering the Resource Conservation and Recovery Act (RCRA) with the exception of the Hazardous and Solid Waste Amendments (HSWA) of 1984 to the NMEID. In 1990 and the first quarter of 1991, the Laboratory had numerous interactions with NMEID and prepared the necessary documentation to comply with RCRA requirements. NMEID had the lead in one compliance inspection during 1990 and issued one Notice of Violation (NOV). The HSWA Module of the RCRA permit was written by EPA and issued on March 8, 1990. The Laboratory appealed the permit because of its belief that neither EPA nor NMEID has authority to monitor radionuclides. No decision on the appeal has been rendered; the permit is currently in effect. The State received authorization from EPA for regulating mixed waste on July 25, 1990. A Part A application was submitted to the NMEID by January 25, 1991. Interactions relating to RCRA issues for CY 90 and the first quarter of CY 91 are presented in Table I-4.

a. **RCRA Compliance Inspection.** In March 1990, the EPA and NMEID conducted a joint hazardous waste compliance inspection. Nine violations were noted and an NOV was issued by the NMEID in June 1990. Eight of the violations were administrative; one involved characterization of an active waste unit. Within the 90-day period allowed for corrective actions, the unit was fully characterized and cleaned out. The NMEID was the lead agency for the RCRA portion of this inspection; the EPA was responsible for the evaluation of the Land Disposal Restriction requirements (HSWA provision). No compliance inspections were conducted in the first quarter of CY 91.

b. **Underground Storage Tanks.** The majority of underground storage tanks (USTs) at the Laboratory was installed in the 1940s. Six USTs in need of upgrades were removed from the ground during 1990. Four 30 000-gallon diesel tanks (TA-16-543, 544, 545, and 546) were removed from the yard at the TA-16 steam plant. These tanks were replaced with one 150 000-gallon above ground tank. A 4 000-gallon gasoline tank (TA-16-197) was removed and replaced with a state-of-the-art 10 000-

Table I-4. Resource Conservation and Recovery Act Interactions among the Laboratory, the U.S. Environmental Protection Agency, and New Mexico's Environmental Department[a] in 1990 and First Quarter of 1991

January 24, 1990	LANL is visited by EPA and NMEID for a joint inspection of the UST Program.
January 26, 1990	The Laboratory submitted the 1989 Federal Hazardous Waste Activities report to DOE EPA/NMEID.
February 12, 1990	LANL receives approved closure plan for TA-16 Surface Impoundment from NMEID.
March 5, 1990	The NMEID/EPA conducted the annual RCRA compliance inspection of LANL on March 5 - 9, 1990. Several minor violations were noted in the closeout.
March 8, 1990	The EPA issues the HSWA portion of the hazardous waste permit. Becomes module VIII of the permit. Effective date - April 23, 1990. Portions appealed (Rad monitoring).
March 16, 1990	The Laboratory submitted the 1989 Hazardous Waste and Waste Minimization Report to DOE to send to NMEID/EPA.
May 4, 1990	The Laboratory received a notice of findings for January's UST inspection. Two minor violations were noted.
June 18, 1990	The Laboratory received a Notice of Violation (NOV) for the findings of March 5, 1990 NMEID/EPA annual RCRA compliance inspection.
July 5, 1990	LANL, DOE submit 1990-1991 invoice/registration and payment for USTs.
July 20, 1990	LANL, DOE submit a written response to the June 18, 1990 RCRA NOV.
July 31, 1990	NMEID acknowledges receipt of the response to the RCRA NOV and recognizes that all cited violations have been addressed. The NOV action will be formally closed when information on the closure of a mixed waste tank is submitted to the State.
August 24, 1990	LANL, DOE submit written notification to NMEID regarding three USTs that failed tightness tests.
September 18, 1990	LANL submits final Closure Report for the TA-16 Surface Impoundment to NMEID. A copy was also sent to EPA Region VI.
September 19, 1990	Met with NMEID to discuss classified waste, mixed waste Part A, permit modification request, and ER Program approach to closure of RCRA units.
September 26, 1990	Again met with State on permit modification request.
October 2, 1990	LANL, DOE submit information of TA-53 tank cited in the June 18 RCRA NOV.
October 3, 1990	LANL, DOE submit written notification to NMEID regarding two USTs that failed tightness tests.

Table I-4 (Cont)

October 10, 1990	LANL, DOE call NMEID to satisfy a 24 hr. notification requirement. The notification was for a release from UST at TA-55.
October 16, 1990	LANL, DOE submit written notification to NMEID of a UST being ruptured at TA-55 by a backhoe.
November 2, 1990	DOE submits Class 1 modification to the RCRA Permit to clarify information regarding radioactive waste.
November 7, 1990	LANL sends written notification to NMEID UST Bureau regarding the removal and replacement of tank at TA-16 Service Station.
November 28, 1990	LANL sends written status report to NMEID UST Bureau regarding UST removal at TA-55. This was the final report required by Part XII of the NM UST regulations.
November 28, 1990	LANL sends written notification to NMEID UST Bureau notifying them that the Laboratory plans on removing several USTs during FY91. This notification must be received 30 days prior to construction.
December 12, 1990	NMEID issues letter stating the Attachment I reports submitted to them can be in the form if summary reports if all the records are available for their review.
December 14, 1990	NMEID issues NOV stating that summary reports have not been submitted on time
December 20, 1990	DOE/LANL have meeting with NMEID explaining a misunderstanding on the submittal of the reports (i.e., LANL awaiting the letter from the NMEID - issued on 12/12/90)
December 29, 1990	DOE issues letter drafted by HSE-8 bringing into question proposed solid waste management regulations. At issue were proposals to potentially restrict low level radioactive wastes, conflict with the ER program, and unfair restrictions on government facilities seeking variances from the regulations.
January 8, 1991	NMEID issues letter withdrawing the 12/14/90 NOV agreeing there was some justification for misunderstanding. However, the required reports are to be submitted by the deadline in the NOV letter.
January 11, 1991	DOE/LANL (HSE-13 and HSE-8) and NMED meet to discuss proposed approach to SWMU, including RCRA, closures.
January 16, 1991	LANL submits the required reports (first 3 quarters) and a fourth as per Permit Attachment I.
January 18, 1991	DOE, LANL, and NMEID meet to discuss concerns with the draft changes to the solid waste regulations.
January 25, 1991	LANL/DOE submit Part A application for continued operation of mixed waste units to NMEID within required 6 months of EPA delegation of mixed waste authority to NMEID.

Table I-4 (Cont)

February 5, 1991	Discussed with NMED/UST Program about obtaining copies of the New Mexico UST Regulations. LANL was told that they had run out of copies of the regulations. Additional copies have been ordered from the printer and LANL will receive copies of the regulations in due course.
February 20, 1991	NMED contacted by phone. The State has now adopted the latest RCRA Subtitle C regulations. The regulations should become effective in the State around March 3, 1991. NMED noted, that due to the current State Statutory requirements for Hazardous Waste Permit modifications, a Class 1 Permit modification must be public noticed by NMED even though the federal regulations do not require a public notice.
March 12, 1991	Boyd Hamilton of NMED contacted by phone. The newly adopted State regulations will come into effect on March 13, 1991. He promised to send out a copy of the regulations ASAP.

[a]New Mexico Environmental Improvement Division (NMEID) became the New Mexico Environmental Department (NMED) in March 1991.

gallon, double-walled tank with an automated leak detection system and spill and overflow protection. The final tank removed was a 550 gallon diesel tank located at TA-55 (TA-55-15). This tank has not yet been replaced. It will be replaced with a vaulted tank during 1991. Laboratory policy is to remove underground storage tanks when user groups determine that the tanks are no longer needed and as funding permits. No USTs were removed or replaced during the first quarter of CY 91.

c. **Hundred-year Floodplain Study.** Under existing HSWA permit requirements, the EPA stipulates that regulated facilities must delineate all 100-year floodplain elevations within their boundaries. At Los Alamos these floodplains are located within ungaged watersheds that drain approximately 43 square miles on the Pajarito Plateau. These floodplains were mapped using a combined graphic information system and computer modeling (GIS-HEC) approach. These maps are maintained on file by the Facilities Engineering Planning Group (ENG-2) and satisfy the RCRA/HSWA permit condition requiring floodplain definition.

2. Clean Water Act. Regulations under the Clean Water Act (CWA) set water quality standards and effluent limitations. The two primary programs at the Laboratory established to comply with the Clean Water Act are the NPDES program and the Spill Prevention Control and Countermeasure (SPCC) program.

The CWA, under the National Pollutant Discharge Elimination System (NPDES), requires permits for nonradioactive constituents at all point-source discharges. A single NPDES permit for the Laboratory authorizes effluent discharges from 128 industrial outfalls and nine sanitary sewage treatment outfalls. The permit expires in March 1991. The Laboratory submitted a reapplication in September 1990. The existing permit has been extended until review and approval of the new permit to complete, probably in October 1991. The Laboratory was in compliance with the NPDES permit in 96.8% of the analyses done on samples at sanitary waste discharges and 97.8% at the industrial waste discharges in CY 90. In the first quarter of CY 91, NPDES industrial waste discharges exhibited eight violations out of 481 samples analyzed. Noncompliant discharges are being addressed under an EPA/DOE Federal Facility Compliance Agreement. For example, the Sanitary Wastewater Systems Consolidation project will eliminate NPDES violations

by construction of a new, centralized sanitary wastewater treatment plant at TA-46. In addition, NPDES corrective activities are listed in DOE's "Environmental Restoration and Waste Management Five-Year Plan" (DOE 1989).

Another NPDES permit authorizes liquid effluent discharge from the Fenton Hill Geothermal Project. The permit is for a single outfall and was issued to regulate the discharge of mineral-laden water from the recycle loop of the geothermal wells. No discharges occurred from this outfall in 1990 or the first quarter of 1991.

The Laboratory has an SPCC Plan, as required by the CWA implemented by 40 CFR 112. The plan is implemented by providing secondary containment for large tanks and other containers to control accidental oil spills and prevent them from entering a watercourse. The plan also provides for spill control and cleanup training. Approximately 32 major containment structures are presently in use at the Laboratory for spill control. During 1990, construction was completed on four containment structures. Eight chemical storage lockers were purchased by HSE-8 for use at various sites. The SPCC Plan also serves as a Best Management Practice under 40 CFR 125 for control of materials other than oil.

3. National Environmental Policy Act. In accordance with the National Environmental Policy Act (NEPA) of 1969, federal agencies must consider the potential environmental impacts of proposed activities during the planning stage so that decisions reflect environmental values as well as cost and mission. Proposed activities at the Laboratory are reviewed by HSE-8 staff to identify those that could adversely impact the human environment, including environmentally sensitive areas in need of special protection, such as archaeological resources, floodplains, wetlands and the habitat of threatened or endangered species. Staff provides DOE with information on potential environmental impacts of proposed activities, including the results of surveys of environmentally sensitive areas. No action can go beyond the planning stage, nor can reasonable alternatives be precluded, until DOE approves the NEPA documentation for that action.

The basic, brief information document used for NEPA compliance in past years was an Action Description Memorandum (ADM); beginning in April 1990, a different format containing similar information, called a DOE Environmental Checklist (DEC) was required. Using information in the ADM or DEC, DOE approves a proposed activity as having clearly insignificant environmental impacts (categorically excluded) or requires that an Environmental Assessment (EA) be prepared to evaluate in greater detail whether significant adverse environmental impacts could occur. Following an EA, DOE either issues a Finding of No Significant Impact (FONSI) or, if the analysis indicates potentially significant impacts can occur, prepares an Environmental Impact Statement.

In 1990, one ADM, 82 DECs, and five EAs were submitted. Based on the DECs, 48 activities were approved as categorical exclusions, 13 were to be further examined in EAs, and no decision has been made by the end of 1990 on the remaining 20 DECs and one ADM. Decisions are also pending on the five EAs.

During the first quarter of CY 91, 15 new DECs on proposed projects were submitted to DOE. No decisions on any of these DECs were received during the first quarter. During the first quarter, 11 DECs submitted to DOE during CY90 were approved as categorical exclusions, one was approved as a memo-to-file, and decisions are still pending on the remaining eight.

Also during the first quarter of CY 91, five EAs were submitted to DOE. Decisions on these EAs had not been received by the end of the quarter. Of the five EAs submitted during 1990, a FONSI was signed for the Weapons Engineering Tritium Facility. The remaining EAs are still in the review and revision process.

4. Federal Clean Air Act and New Mexico Air Quality Control Act. Nonradioactive regulations under these acts set ambient air quality standards, require the permitting of new sources, and set acceptable emission limits. The air quality and meteorological program at the Laboratory includes monitoring to ensure that ambient air quality standards are met, reviewing all new and modified sources to determine whether air permits or construction approvals are required, and providing air modeling support for permit applications and other programs. During 1990,

all of the Laboratory's existing operations remained in compliance with all federal and state air quality regulations for nonradioactive emissions:

- Monitoring revealed no violations of ambient air quality standards.
- All construction projects at the Laboratory were reviewed and air emissions were estimated to determine whether air permits or construction approvals were required.
- Air quality impacts were modeled for EAs, Safety Analysis Reports, air quality permit applications, and unplanned releases.

No data on first quarter CY 91 sampling is available.

Amendments to the Clean Air Act adopted in November of 1990 may require additional air monitoring programs to be established at the Laboratory. The Laboratory will track new regulations written to implement the act, determine their effects on Laboratory operations, and implement programs as needed.

The EPA regulates radioactive air emissions from DOE facilities under the Clean Air Act. For 1990 the Laboratory remained in compliance with the EPA standard that limits the effective dose equivalent to a member of the public from airborne radioactive emissions to less than 10 mrem/year. However, the Laboratory cannot yet demonstrate compliance with all of EPA's radioactive emission monitoring requirements. Discussions between LANL, DOE, and EPA to identify areas of noncompliance and to develop a program to bring the emission monitoring into compliance with the regulations will be initiated in CY 91.

5. Safe Drinking Water Act. Municipal and industrial water supply for the Laboratory and community is from 16 deep wells owned by DOE. The wells range in depth from 265 to 942 m (869 to 3 090 ft) and one gallery (collection system fed by springs). In 1990 and the first quarter of 1991, the chemical quality of the water met federal and state primary and secondary drinking water standards (NMEIB 1988, EPA 1989).

6. Federal Insecticide, Fungicide, and Rodenticide Act. This act regulates the manufacturing of pesticides, with requirements on registration, labeling, packaging, enforcement, record keeping, distribution, worker protection, certification, experimental use, and tolerances in foods and feeds. An annual inspection conducted in 1990 by the U.S. Department of Agriculture found no deficiencies in the Laboratory's pesticide application program or certified application equipment. No inspections were performed in the first quarter of CY 91.

7. National Historic Preservation Act. As required by Sec. 106 of the National Historic Preservation Act of 1966, which was implemented by 36 CFR 800, "Protection of Historic Properties," Laboratory activities are evaluated in consultation with the State Historic Preservation Officer (SHPO) for possible effects to cultural or historic resources. During 1990, Laboratory archaeologists evaluated 355 undertakings (an undertaking is an activity that has the potential to affect a cultural/historic resource), conducted 37 field surveys, recorded 18 archaeological sites, and submitted four survey reports for SHPO review. As a result of Laboratory activities, adverse impacts to two archaeological sites were mitigated through site excavation.

Forty-eight activities and 205 excavation permits were reviewed during January–March 1991; none required reports to the State Historic Preservation Office. Excavation of one site, being conducted under an approved mitigation plan, resulted in several interesting finds, including portions of a human burial and a kiva. The burial was removed for nondestructive examination by University of New Mexico experts after consultation with the local Indian Tribe and will be reburied on site.

8. Endangered/Threatened/Protected 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." Compliance under NEPA requires review of projects for potential environmental impact on critical habitats, floodplains, and wetlands.

Laboratory activities during 1990 to comply with these requirements were in three categories: (1) thirteen endangered species surveys were completed; (2) bird censuses were continued and sensitive habitats were monitored to provide base line monitoring of sensitive or potentially sensitive species; and (3) all wetlands greater than one acre within the Laboratory boundaries were mapped.

Forty-eight activities were reviewed during January–March 1991 for possible impacts on threatened and endangered species. None required surveys beyond a brief field reconnaissance. Plans were developed for field work to begin in April/May including surveys of sites for proposed projects, additional characterization of wetlands, and continued monitoring of the impacts of the construction of the Sanitary Wastewater Systems Consolidation on Sandia Canyon and Cañada del Buey.

9. Comprehensive Environmental Response, Compensation, and Liability Act. Cleanup of toxic and hazardous contaminants at closed and abandoned hazardous waste sites was mandated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Superfund Amendments and Reauthorization Act (SARA) of 1986 extensively amended CERCLA. Investigations and any required remedial actions at Los Alamos will be carried out under RCRA as part of DOE's Environmental Restoration Program, which requires evaluation of all areas at the Laboratory for possible contamination (Sec. IX.K).

a. Emergency Planning and Community Right-to-Know Act. Title III Sec. 313 of SARA exempts DOE facilities from reporting requirements. However, it is DOE policy that this exemption not be exercised and that the Laboratory report its releases under the remaining provisions of Sec. 313. Even without the DOE exemption, all research operations at the Laboratory are exempt under other provisions of the regulation. Only pilot plants and specialty chemical production facilities at the Laboratory are not covered by this exemption and must report their releases. As a result, the Plutonium Processing Facility is the only operation at the Laboratory that is covered by Sec. 313. The only regulated chemical that is used at the Plutonium Processing Facility in amounts greater than the Sec. 313 reporting thresholds is nitric acid.

The Laboratory submitted the required Sec. 313 report to EPA in July of 1990. This report covered the releases of nitric acid during 1989. About 47 500 pounds of nitric acid were used for plutonium processing with releases to the air of approximately 1 000 lb. The amount of nitric acid released to the atmosphere was calculated using data obtained from a study that measured the air emissions from the facility. The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in the wastewater treatment operations. Only the air releases required reporting in 1989. Data on releases for CY 90 will be reported under Sec. 313 in July 1991.

10. Toxic Substances Control Act. This act regulates the manufacture, processing, distribution, use, storage, and labeling of all chemical substances, including polychlorinated biphenyls (PCBs). The Laboratory has EPA authorization to dispose of PCB-contaminated equipment and soil at its low-level radioactive waste landfill (Area G). However, most PCB-containing or -contaminated materials have been sent offsite to EPA-approved disposal facilities.

Efforts continued toward the replacement, reclassification, and disposal of PCB equipment at the Laboratory. During 1990, the following PCB waste was sent off-site for disposal: 62 395 kg (137 555 lb) liquid PCB oil that included 50-499 ppm oil; 10 751 kg (23 701 lb) contaminated debris; 3 338 kg (7 360 lb) contaminated water; 45 148 kg (99 533 lb) from 17 transformers; and 47 901 kg (105 603 lb) from 558 capacitors. In addition, 5 039 kg (11 109 lb) of PCB-contaminated soil, debris, and equipment were disposed of at TA-54, Area G. Of the 31 PCB transformers being retrofilled within the last two years, nine were reclassified to non–PCB status at the end of 1990, two more are expected to be reclassified in the first quarter of 1991, and another six by the end of 1991. Eleven of the 31 transformers are being retrofilled with silicone oil and the rest with perchloroethylene. No audits or inspections of the Laboratory's PCB activities were conducted by the EPA, NMEID, or DOE in 1990.

H. Compliance Agreements

1. Federal Facility Compliance Agreement and Administrative Order. The EPA, Region 6, issued a revised Federal Facility Compliance Agreement (FFCA), Docket No. VI-90-1240 to DOE/LAAO on July 12, 1990. The revised FFCA provided interim effluent limits and compliance schedules for Outfalls 04S, 05S, 09S, and 10S. Interim effluent limits and schedules of compliance for Outfalls 05S and 10S were added to the existing FFCA. DOE/LAAO did not sign the FFCA until January 8, 1991 and therefore the FFCA did not become effective during 1990.

On July 19, 1990, EPA Region 6 served an Administrative Order (AO), Docket No. VI-90-1263, on the University of California. This AO contains the same interim limits and schedules for compliance as the FFCA issued to DOE/LAAO on July 12, 1990. This AO became effective in July, 1990.

On December 19, 1990 EPA Region 6 served an AO, Docket No. VI-91-067 on Los Alamos National Laboratory. This AO listed 13 violations of the Laboratory's NPDES permit during August to November 1990 and required the Laboratory to take corrective actions necessary to eliminate and prevent recurrence of the effluent violations cited. In addition, the Laboratory was required to submit a report detailing the specific actions. For any corrective actions exceeding 30 days a plan for elimination and prevention of the listed violations was required to be submitted to EPA. In 1991 LANL prepared and submitted a response to EPA, including corrective actions taken and proposed schedules necessary to achieve compliance with the AO.

2. Environmental Oversight and Monitoring Agreement. The Environmental Oversight and Monitoring Agreement between DOE and the State of New Mexico requires that the Laboratory prepare the following studies:

- Waste Minimization Plan
- Source Reduction Study
- Waste Characterization Plan
- Background Characterization Studies
- Environmental Monitoring and Review Documents
- Information on Environmental Releases & Emissions
- DOE Compliance Assessments
- NEPA Documents

The State will receive financial and technical support for activities in environmental oversight, monitoring, access and emergency response to ensure compliance with regulations and standards at the Laboratory.

This agreement, originally signed by DOE and the State in October 1990, is being renegotiated, and it is unclear when the agreement will become active.

I. Unplanned Releases

1. Airborne Radionuclide Releases. *Tritium Release at TA-41.* On May 17, 1990, approximately 2 000 Ci (74 000 GBq) of tritium was released from TA-41. Measurements indicated that approximately 15% of the tritium was in the form of tritiated water, and 85% was in the form of tritium gas. The resulting doses to members of the public were estimated using current meteorological conditions. The maximum effective dose was estimated to be 0.5 mrem, which is 0.5% of the DOE's PDL of 100 mrem/yr from all pathways, and 5% of the 10 mrem/yr radiation limit for the air from DOE facilities.

Airborne Tritium Release at TA-41. On February 1, 1991, 2 800 Ci of elemental tritium were released at TA-41. Less than 0.1% of the tritium was present as tritiated water. The effective dose equivalent (50-year dose commitment) to a member of the public was calculated to be 0.03 mrem. This dose occurred 7 km east of TA-41, where Los Alamos Canyon opens out onto State Route 4. The dose estimate conservatively assumed that 1% of the tritium was oxidized before reaching the receptor location. The dose is 0.03% of DOE's PDL of 100 mrem/year from all pathways, and 0.3% of the EPA's 10 mrem/year limit for the air pathway.

2. Airborne Nonradiological Release. *Leaking ClF_3 Gas Cylinder.* On July 17, 1990, a small cylinder containing chlorine trifluoride (ClF_3) was found to be leaking at TA-46. The Waste Management Group (HSE-7) Hazardous Materials (HAZMAT) Team

responded to the incident and moved the leaking cylinder to TA-54, Area J. The cylinder was punctured and vented the following day. The Hazardous and Solid Waste Section of HSE-8 has determined that although the cylinder was being used as a product when the leakage was detected, the ClF_3 became a hazardous waste when it was moved to TA-54, Area J. Nevertheless, the leaking gas cylinder posed an imminent and substantial danger to human health and the environment and the manner in which the incident was resolved was consistent with current EPA policy.

No releases were reported in the first quarter of 1991.

3. Liquid Releases. *Sulfuric Acid Release at TA-3 Power Plant.* During May 19, 20, and 21, 1990, sulfuric acid accidentally was released from the acid storage tank at the TA-3 power plant. This acid flowed into the neutralization tank at the power plant causing three separate periods during which the pH of the discharge from the neutralization tank to Sandia Canyon exceeded NPDES limits. These exceedances were reported to the NMEID within 24 hours as required by paragraph G of the Laboratory's NPDES Permit, which requires immediate reporting of any noncompliance that may endanger health or the environment. Response to the acid releases included neutralization of the flow in Sandia Canyon with soda ash, plugging of the overflow at the neutralization tank, and preparation of new procedures for operation of the neutralization system. An investigation of the release has been completed, and findings of the investigation are being implemented by the Laboratory and Johnson Controls World Services. This acid release represents a violation of the CWA. The Laboratory is planning a new system for neutralization at the power plant and is increasing oversight of power plant operations.

Other violations of the CWA. HSE-8 was involved in three incidents involving the discharge of an oily sheen near the University House at TA-3. Discharges were noted on October 5 and 20, 1990 and November 1, 1990. Personnel from HSE-8 collected samples, supervised cleanup at the site, prepared written reports to the EPA and the NMEID, and reported the incidents verbally to EPA and NMEID as required by the CWA and New Mexico Water Quality Control Commission regulations. Staff participated in a task force to identify and eliminate all sources of oil responsible for the oily sheen. This outfall, storm water discharge associated with industrial activity, will be permitted by new storm water regulations promulgated by EPA on October 31, 1990.

A release occurred at TA-16, Building 340, involving the spill of compressor fluid through an NPDES-permitted outfall on December 12, 1990. Personnel from HSE-8 collected samples, supervised cleanup at the site, prepared required written reports to EPA and NMEID, and reported the incidents verbally to EPA and NMEID as required by the CWA and New Mexico Water Quality Control Commission Regulations.

Notice of Violation. On January 18, 1991, the NMED issued a Notice of Violation of the NPDES permit to the Laboratory concerning the reporting of the following discharges:

- Potable water from an eye wash/safety shower at TA-54, Area G, where a pipe froze and burst sometime during the period from December 22, 1990, through January 1, 1991; and

- Steam condensate from an emergency pipe line repair at TA-43, Building 1, which discharged from December 20, 1990, through January 17, 1991.

The Department of Energy voluntarily submitted a Corrective Action Report to the NMED which listed the actions being taken to improve communication between operating groups and HSE-8 concerning notification of existing or potential liquid releases and to insure timely reporting to the regulatory agencies.

J. Waste Minimization

The Waste Management group prepared a "Waste Minimization and Pollution Prevention Awareness Program Plan," as per DOE Orders 5400.1, 5820.2A, and 5400.3. The plan will remain in final draft form until policy guidelines on waste minimization and pollution prevention awareness are finalized by senior management at the Laboratory.

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, north central New Mexico, approximately 100 km (60 mi) north northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe (Fig. 1). The 111 km^2 (43 mi^2) Laboratory site and adjacent communities are situated on Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west oriented canyons cut by intermittent streams (Fig. 3). Mesa tops range in elevation from approximately 2 400 m (7 800 ft) on the flank of the Jemez Mountains to about 1 900 m (6 200 ft) at their eastern termination above the Rio Grande Valley.

The Department of Energy (DOE) controls the area within Laboratory boundaries and has the option to completely restrict access.

B. Land Use

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

Laboratory land is used for building sites, experimental areas, waste disposal locations, roads, and utility rights-of-way (see Laboratory Technical Areas, Fig. 4 and Appendix F). However, these uses account for only a small part of the total land area. Most land provides isolation for security and safety and is a reserve for future structure locations.

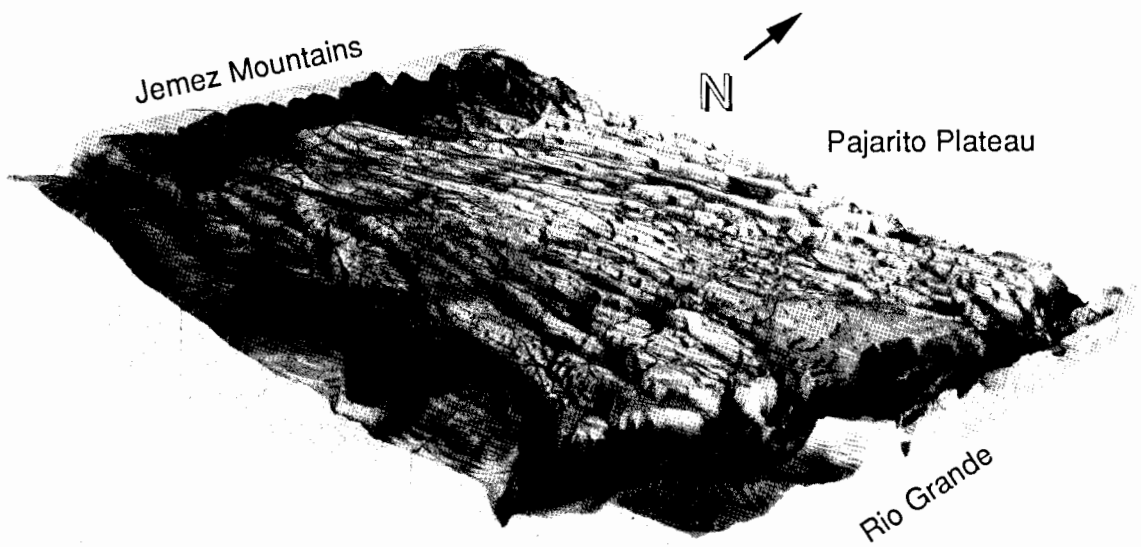


Fig. 3. Topography of the Los Alamos Area.

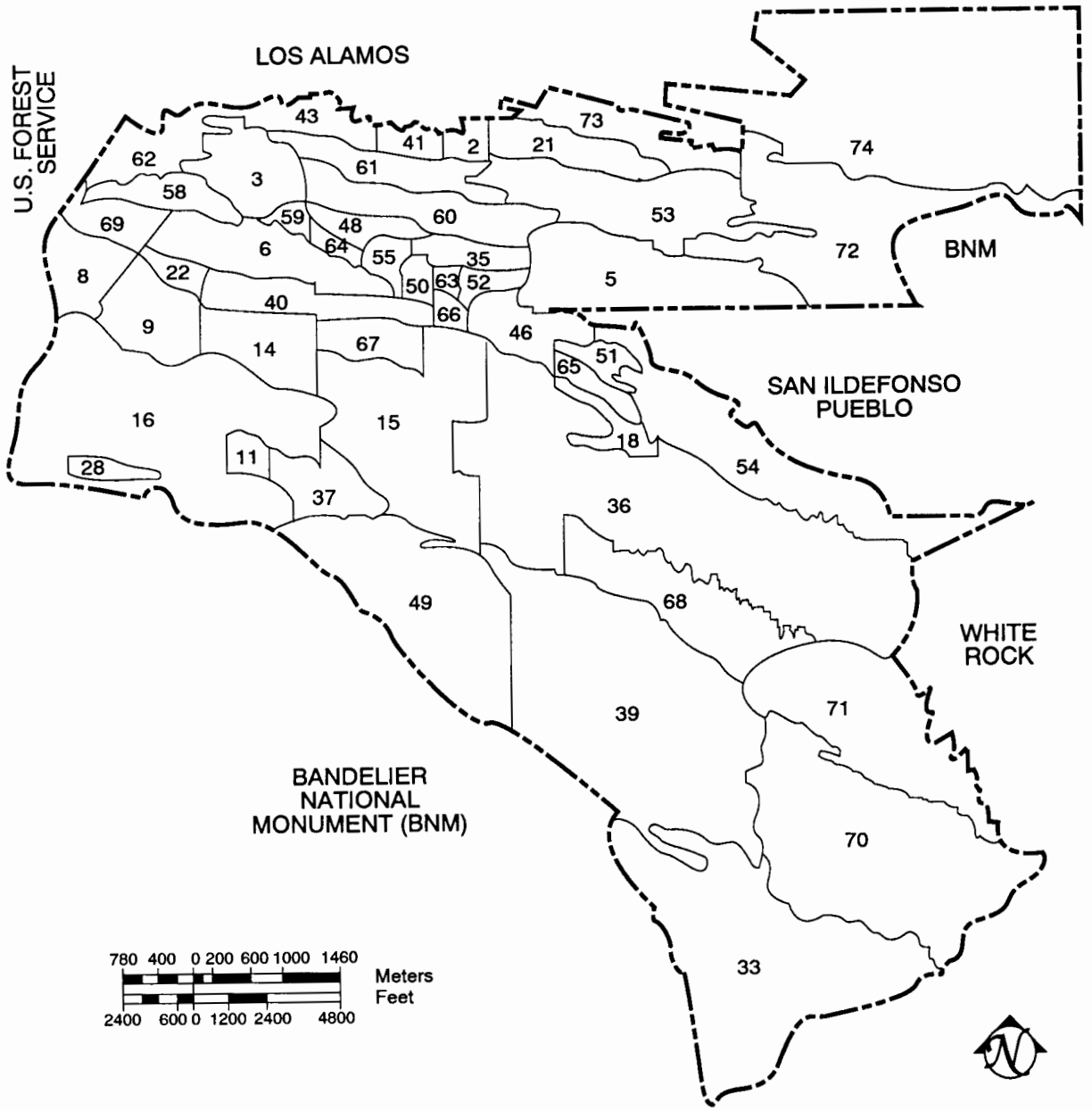
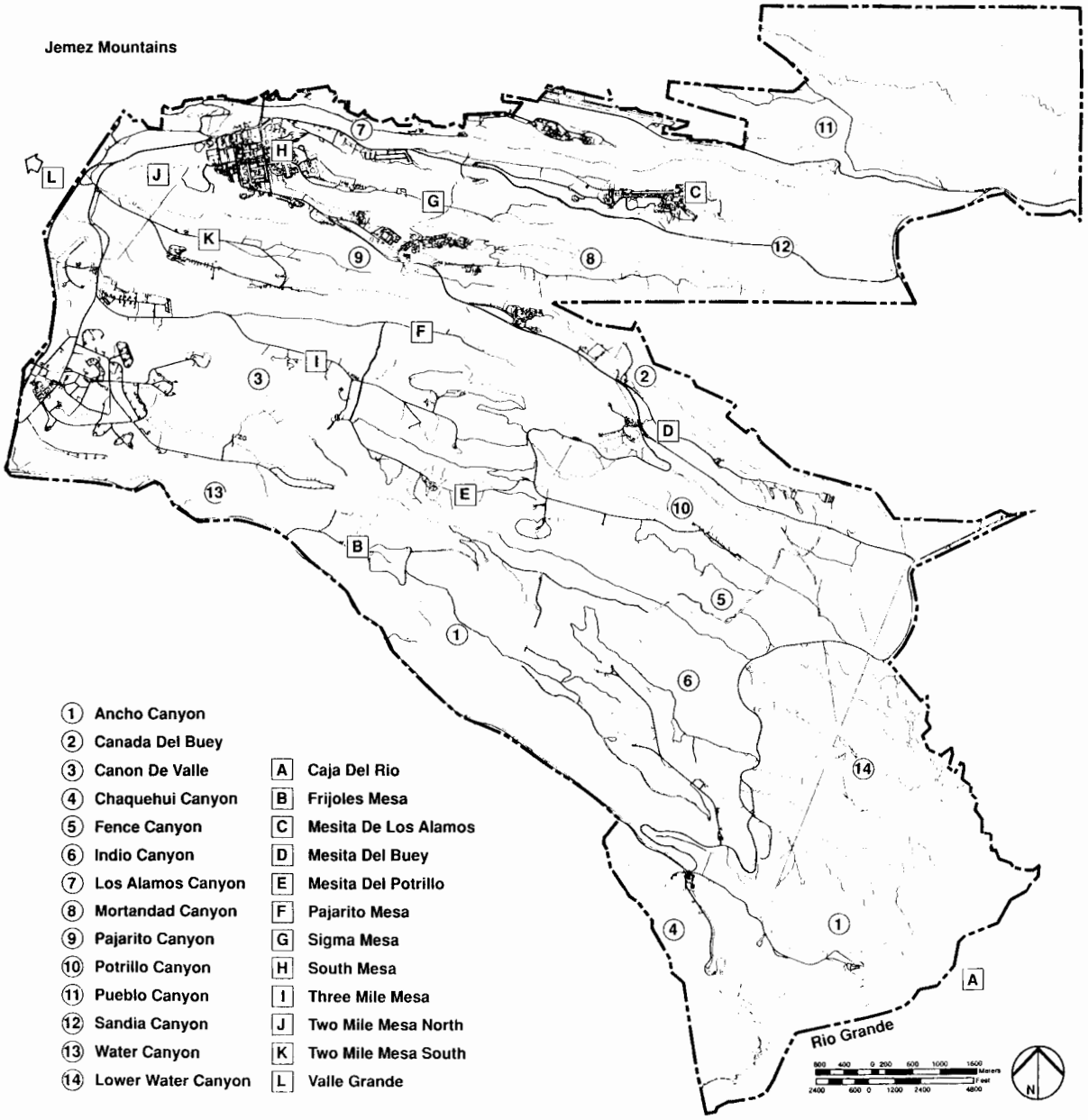


Fig. 4. Technical areas (TAs) of Los Alamos National Laboratory.

Limited access by the public is allowed in certain areas of the Laboratory reservation. An area north of Ancho Canyon (Fig. 5) between the Rio Grande and State Road 4 is open to hikers, rafters, and hunters, but woodcutting and vehicles are prohibited. Portions of Mortandad and Pueblo Canyons are also open to the public. An archaeological site (Otowi Tract), northwest of State Road 502 near the White Rock Y, is open to the public subject to restrictions of cultural resource protection regulations.



General Site Description

1990 Los Alamos National Laboratory Site Development Plan

Fig. 5 Major Canyons and Mesas.

C. Geology-Hydrology

Most of the finger-like mesas in the Laboratory area are found in Bandelier Tuff (Fig. 6). Ash fall, ash fall pumice, and rhyolite tuff form the surface of Pajarito Plateau. The tuff, ranging from nonwelded to welded, is over 300 m (1 000 ft) thick in the western part of the plateau and thins to about 80 m (260 ft) eastward above the Rio Grande. It was deposited as a result of a major eruption of a volcano in the Jemez Mountains about 1.1 to 1.4 million years ago.

The tuffs overlap onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation (Fig. 6) in the central and eastern edge along the Rio Grande. Chino Mesa basalts interfinger with the conglomerate along the river. These formations overlay the sediments of the Tesuque Formation, which extends across the Rio Grande Valley and is in excess of 1 000 m (3 300 ft) thick.

Los Alamos area surface water occurs primarily as intermittent streams. Springs on the 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 in some drainages. Effluents from sanitary sewage, industrial waste treatment plants, and cooling-tower blowdown are released into some canyons at rates sufficient to maintain surface flows for varying distances.

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 separates it from the underlying

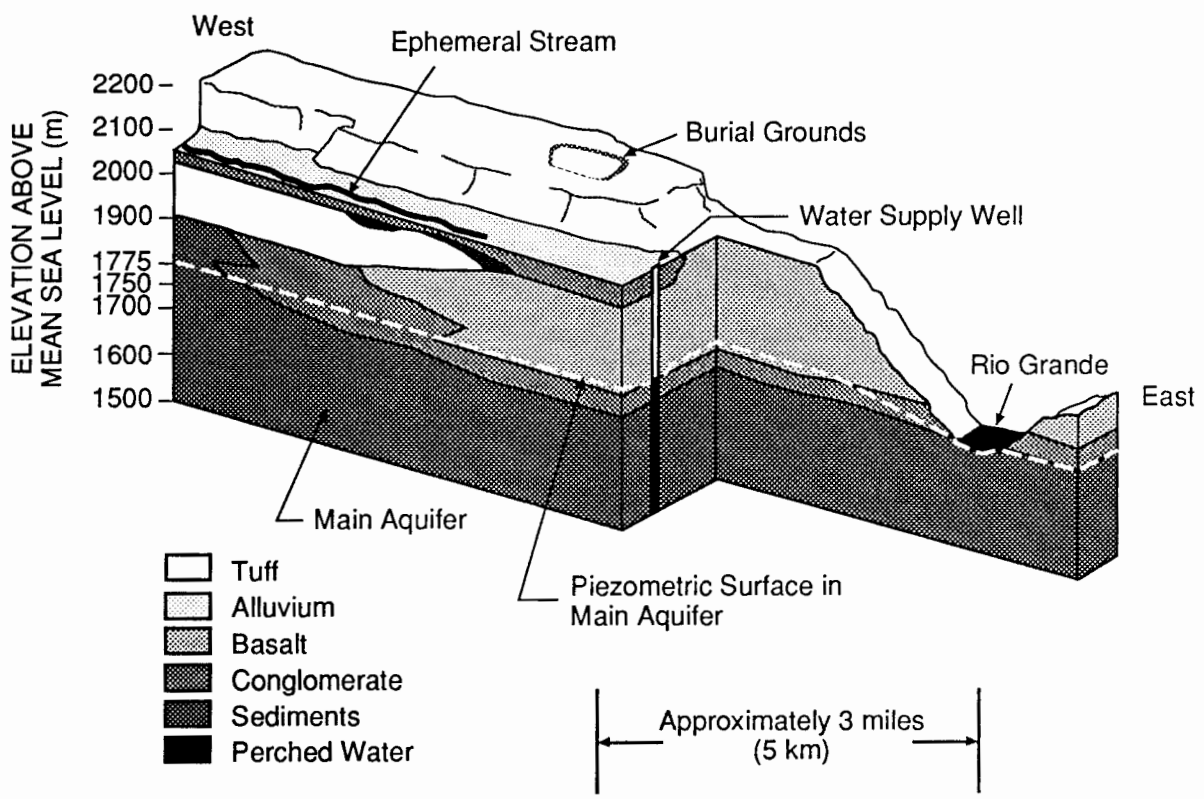


Fig. 6. Conceptual illustration of geologic-hydrologic relationship in Los Alamos area.

main body of groundwater by an unsaturated zone), and (3) the main aquifer of the Los Alamos area.

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 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 down gradient within the alluvium. As water in the alluvium moves down gradient, it is depleted by evapotranspiration and movement into underlying volcanics (Purtymun 1977).

Perched water occurs in conglomerate and basalts beneath the alluvium in a limited area about 37 m (120 ft) deep in the midreach of Pueblo Canyon and in a second area about 45 to 60 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. 6) and has one discharge point at Basalt Spring 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 (1 200 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). 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 contribute to the recharge of the aquifer through the 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 18.5 km (11.5 mi) reach of the river in White Rock Canyon between Otowi Bridge and the mouth of Rito de Frijoles receives an estimated 5.3 to 6.8 $\times$ 10^6 m^3 (4 300 to 5 500 ac-ft) annually from the aquifer.

D. Climatology

Los Alamos has a semiarid, temperate mountain climate. Average annual precipitation is nearly 47 cm (19 in.). Precipitation was normal during 1990. Thirty-six percent of the annual precipitation normally occurs during July and August from thundershowers. Winter precipitation falls primarily as snow, with accumulations of about 150 cm (59 in.) annually. Snowfall was below normal during 1990, with only 109 cm (43 in.). This was the least annual snowfall since 1981.

Summers are generally sunny with moderate, warm days and cool nights. Maximum daily temperatures are usually below 32°C (90°F). The temperature reached or exceeded 32°C (90°F) seven times during the summer of 1990, including six in June. It was the warmest June on record. Brief afternoon and evening thundershowers are common, especially in July and August. A heavy thunderstorm dropped 4.2 cm (1.64 in.) of rain in one hour at East Gate on August 21. High altitude, light winds, clear skies, and dry atmosphere allow night temperatures to drop below 15°C (59°F) after even the warmest day. Winter temperatures typically range from about −9°C to −4°C (15°F to 25°F) during the night and from −1°C to 10°C (30°F to 50°F) during the day. Occasionally, temperatures drop to −18°C (0°F) or below. Temperatures dipped to -23°C (-10°F) on December 23 and 24, the coldest since December 1978 when it reached −25°C (−13°F). The month became the coldest December on record. Many winter days are clear with light winds, so strong sunshine can make conditions comfortable even when air temperatures are cold.

Snowstorms with accumulations exceeding 10 cm (4 in.) are common in Los Alamos. Some storms can be associated with strong winds, frigid air, and dangerous wind chills. The year's largest snow storm struck January 18, when 30.5 cm (12.0 in.) of snow fell.

Unusually little snowfall fell during the end of winter ending in 1990; only 9.4 in. (or 35% of normal) fell from February through April.

Because of complex terrain, surface winds in Los Alamos often vary greatly with time of day and location. With light, large-scale winds and clear skies, daytime winds are predominantly south to south-southwest as winds flow up the Rio Grand Valley. Thermally driven upslope winds from the southeast and east are also common toward the Jemez Mountains. At night, a shallow drainage wind often flows from the west and northwest high on the Pajarito Plateau. Nighttime winds become more parallel to the Valley (south-southwest and north-northeast) both above the drainage winds over the Western Plateau (about 30-40 m [~100-130 ft) above ground level [AGL]) and at the surface toward the Valley. Predominant winds are west to west-northwesterly at the west end of the Plateau to south southwesterly at the east end. Winds during 1990 followed normal patterns.

Historically, no tornadoes have been reported to have touched down in Los Alamos County. Strong dust devils can produce winds up to 34 m/s (75 mph) at isolated spots in the County, especially at lower elevations. Strong winds with gusts exceeding 27 m/s (60 mph) are common and widespread during the spring. A storm on January 29 caused strong winds with a peak gust of 22 m/s (71 mph).

Lightning is common over the Pajarito Plateau. There are 58 thunderstorm days during an average year, with most occurring during the summer. There were 68 thunderstorm days reported during 1990. 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; 1.3 cm-(0.5 in.-) diameter hailstones are less common. A severe hailstorm dropped golf-ball- and some baseball-sized hail at White Rock on July 20, causing $9 million of damage to homes, motor vehicles, and other property.

The irregular terrain at Los Alamos affects the atmospheric turbulence and dispersion, sometimes favorably and sometimes unfavorably. Enhanced dispersion promotes greater dilution of contaminants released into the atmosphere. The complex terrain and forests create an aerodynamically rough surface, forcing increased horizontal and vertical dispersion. Dispersion generally decreases at lower elevations where the terrain becomes smoother and less vegetated. The frequent clear skies and light, large-scale winds cause good vertical, daytime dispersion, especially during the warm season. Strong daytime heating during the summer can force vertical mixing up to 1–2 km (3 000–6 000 ft) AGL, but the generally light winds are limited in diluting contaminants horizontally.

Clear skies and light winds have a negative effect on nighttime dispersion, causing strong, shallow surface inversions to form. These inversions can severely restrict near-surface vertical and horizontal dispersion. Inversions are especially strong during the winter. Shallow drainage winds can fill lower areas with cold air, thereby creating deeper inversions, common toward the valley (White Rock) on clear nights with light winds. Canyons can also limit dispersion by channeling air flow. Strong, large-scale inversions during the winter can limit vertical mixing to under 1 km (3 000 ft) AGL.

Dispersion is generally greatest during the spring when winds are strongest. However, deep vertical mixing is greatest during the summer. Low-level dispersion is generally the least during summer and autumn when winds are light. Even though low-level, winter dispersion is generally greater, intense surface inversions can cause least-dispersive conditions during the night and early morning.

The frequencies of atmospheric dispersive capability are 52% unstable (stability classes *A–C*), 21% neutral (*D*), and 27% stable (*E–F*) during the winter at TA-59. The frequencies are 44%, 22%, and 34%, respectively, during the summer. These stability category frequencies are based on measured vertical wind variations. Stability generally increases (becomes less dispersive) toward the valley.

E. Population Distribution

Los Alamos County has an estimated 1990 population of approximately 18 200 (based on the 1990 U.S. Census, adjusted to July 1, 1990). Two residential and related commercial areas exist in the County (Fig. 1).

The Los Alamos townsite (the original area of development, now including residential areas known as Eastern Area, 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 6 800 residents. About one-third of the people employed in Los Alamos commute from other counties. Population estimates for 1990 place about 213 000 persons within an 80 km (50 mi) radius of Los Alamos (Table II-1).

F. Programs at Los Alamos National Laboratory

The Laboratory is administered by the University of California for the DOE. The Laboratory's environmental program, conducted by HSE-8, is part of a continuing investigation and documentation program.

Since its inception in 1943, the Laboratory's primary mission has been nuclear weapons research and development. Programs include weapons development, magnetic and inertial fusion, nuclear fission, and nuclear safeguards and security. There is also basic

Table II-1. 1990 Population within 80 km of Los Alamos[a]

	Distance from TA-53 (km)								
Direction	**1–2**	**2–4**	**4–8**	**8–15**	**15–20**	**20–30**	**30–40**	**40–60**	**60–80**
N	1	0	0	0	0	0	1 136	0	368
NNE	0	0	0	565	0	542	1 730	1 797	221
NE	1	0	0	0	317	15 352	1 009	1 135	3 846
ENE	0	0	0	1 940	1 563	2 716	2 729	1 187	2 214
E	0	0	83	25	556	1 145	696	0	1 402
ESE	0	0	0	0	0	293	23 151	1 067	1 476
SE	0	0	6 757	0	0	0	53 520	2 443	8
SSE	0	0	0	0	0	0	426	4 347	95
S	0	0	0	50	0	318	614	6 775	0
SSW	0	0	0	20	0	817	201	8 238	33 485
SW	0	0	0	0	0	0	315	4 157	0
WSW	0	0	0	0	0	315	313	2 545	207
W	0	0	0	0	0	0	0	164	132
WNW	0	1 435	6 535	0	0	0	0	0	3 081
NW	0	523	1 721	0	0	0	0	1 438	0
NNW	0	578	579	0	0	0	0	64	62
1990 Pop. Distribution	2	2 536	15 675	2 600	2 436	21 497	85 838	35 357	46 597

[a]Total population within 80 km of Los Alamos is 213 000.

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. Major research programs in elementary particle physics are carried out at the Laboratory's linear proton accelerator. 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 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 more detailed information on the environment of the Los Alamos area.

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 effective dose equivalent to a member of the public was about 3.1 mrem (0.031 mSv) from all pathways, which is 3.1% of the DOE's public dose limit of 100 mrem/yr (1 mSv/yr)(all pathways). This dose is principally due to airborne emissions from the linear particle accelerator at the Los Alamos Meson Physics Facility.

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 fraction is transported off-site in stream channel sediments during heavy runoff. Radionuclide concentrations in these sediments, however, are only slightly above background levels. Other minor pathways include direct radiation and ingestion of foodstuffs.

The collective effective dose equivalent attributable to Laboratory operations received by the population living within 80 km (50 mi) of the Laboratory was conservatively estimated to be 3.1 person-rem (0.031 person-Sv) during 1990. This is <0.01% of the 70 000 person-rem (700 person-Sv) collective effective dose equivalent received by the same population from natural radiation sources and 0.03% of the 11 000 person-rem (110 person-Sv) collective effective dose equivalent received from diagnostic medical procedures. Over 70% of the dose contributed by Laboratory operations, 2.2 person-rem (0.022 person-Sv), was received by persons living in Los Alamos County. This dose is 0.04% of the 6 100 person-rem (61 person-Sv) received by the population of Los Alamos County from background radiation and 0.2% of the 1 000 person-rem (10 person-Sv) from diagnostic medical and dental procedures.

In 1990, the average added risk of cancer mortality to Los Alamos townsite residents was 1 chance in 21 000 000 from radiation released by the year's Laboratory operations; this is much less than the 1 chance in 8 000 from background radiation. The Environmental Protection Agency (EPA) has estimated average lifetime risk for overall cancer incidence as 1 chance in 4 and for cancer mortality, 1 chance in 5.

To evaluate compliance with EPA's regulation 40 CFR Part 61, Subpart H, the maximum doses from airborne emissions from 1990 Laboratory operations were calculated by the EPA-approved computer modeling programs CAP-88. The maximum individual effective dose equivalent was 8.1 mrem (0.081 mSv). This was 81% of EPA's radiation limit of 10 mrem (0.1 mSv) from the air pathway. This 8.1 mrem (0.081 mSv) dose is higher than the 3.1 mrem (0.031 mSv) maximum effective dose equivalent cited above because exposure was modeled rather than based on thermoluminescent dosimeter measurements taken in the area of maximum exposure. CAP-88 tends to overestimate radiation doses in the complex terrain around Los Alamos because it does not take into account dilution of airborne radionuclides by terrain-induced turbulence.

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.

The Department of Energy's (DOE's) public dose limit (PDL) limits the effective dose equivalent for a member of the public to 100 mrem/yr (1 mSv/yr) for all pathways of exposure (DOE 1990a). The effective dose equivalent is the hypothetical whole-body dose that carries the same risk of cancer or genetic disorders as a given dose to a particular organ (see Glossary). Using this dose allows direct comparison of exposures to different organs.

In accordance with EPA regulations (40 CFR 61) governing radiation doses from the air pathway to members of the public, the effective dose equivalent from airborne radioactive releases at DOE facilities is limited to 10 mrem/yr (0.1 mSv/yr). This new radiation limit under this regulation became effective for 1990 LANL operations when 40 CFR 61 was revised in December, 1989 and January, 1990. The previous radiation limit was 25 mrem/yr (0.25 mSv/yr) (whole-body) and 75 mrem/yr (0.75 mSv/yr) (any organ). The principal pathway of exposure at Los Alamos has been through release of radionuclides into the air, resulting in external radiation doses to the whole body. Other pathways contribute finite but negligible doses. A 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 airborne and waterborne contaminants, of contaminants in foodstuffs, and of external penetrating radiation. Theoretical dose calculations based on atmospheric dispersion modeling were made for other airborne emissions present at levels too low to measure.

Doses were calculated from measured or derived exposures using models based on the recommendations of the International Commission on Radiological Protection (ICRP) (Appendix D). These doses are summarized in Table III-1 for the most important exposure categories:

- *Maximum Boundary Dose, or "Fence-Post" Dose Rate.* This is the estimated maximum effective dose to a hypothetical individual present at the point on the Laboratory boundary where the highest dose rate occurs. This dose does not take into account shielding or occupancy and does not mean that an individual actually receives this dose.
- *Maximum Individual Dose.* This is the estimated maximum effective dose to an individual actually residing in the off-site location where the highest dose rate occurs. It includes corrections for shielding (for example, for being inside a building) and occupancy (the fraction of the year that the person is in the area).
- *Average Dose.* This is the estimated average dose to residents of Los Alamos and White Rock.
- *Collective Effective Dose Equivalent.* This is an estimate of the total effective dose (in person-rem) received by the population within an 80 km (50 mi) radius of the Laboratory.

The maximum boundary dose and the maximum individual dose over the past 10 years are summarized in Fig. 2. Each year, more than 95% of the dose resulted from airborne emissions of activation products from LAMPF.

All internal radiation doses (through inhalation or ingestion) are 50-year dose 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 limit 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, not only to minimize doses to the public but also to limit releases of radioactive materials to the environment. Ambient monitoring described in this report documents the effectiveness of these controls.

Table III-1. Summary of Annual Effective Dose Equivalents Attributable to 1990 Laboratory Operations

	Maximum Dose at Laboratory Boundary[a]	Maximum Dose to an Individual[b]	Average Dose to Nearby Residents		Collective Dose to Population within 80 km of the Laboratory
			Los Alamos	White Rock	
Dose	6 ± 3 mrem	3.1 mrem	0.11 mrem	0.15 mrem	3.1 person-rem
Location	Boundary north of TA-53	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
DOE Public Dose Limit	—	100 mrem	100 mrem	100 mrem	—
Percentage of Public Dose Limit	—	3.1%	0.11%	0.15%	—
Background	337 mrem	337 mrem	337 mrem	337 mrem	70 000 person-rem
Percentage of background	2%	1%	0.03%	0.04%	0.004%

[a]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. Calculation of boundary dose assumes that the individual would be at the Laboratory boundary continuously (24 hours/day, 365 days/year).

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

B. Estimate of Radiation Doses

1. Total Maximum Individual Dose to a Member of the Public from 1990 Laboratory Operations. The maximum individual effective dose equivalent to a member of the public from 1990 Laboratory operations is estimated to be 3.1 mrem/yr (0.031 mSv/yr). This is the total effective dose equivalent from all pathways. This dose is 3.1% of the DOE's PDL of 100 mrem/yr (1 mSv/yr) effective dose equivalent from all pathways.

The dose occurred at East Gate (the Laboratory boundary northeast of LAMPF) and was primarily due to external penetrating radiation from air activation products released by the LAMPF accelerator. The dose is based on environmental measurement data discussed below. Table III-2 summarizes the maximum individual effective dose equivalent and associated organ doses.

The average effective dose to residents in Los Alamos townsite attributable to Laboratory operations in 1990 was 0.11 mrem (0.0011 mSv). The corresponding dose to White Rock residents was 0.15 mrem (0.0015 mSv). The doses are approximately 1% of EPA's 10 mrem/yr (0.1 mSv/yr)air pathway standard. They were estimated using the CAP-88 models, measured stack releases (Table G-2), and 1990 meteorological data.

2. Doses from Natural Background Radiation and Medical and Dental Radiation. Effective dose equivalents from natural background and from medical and dental uses of radiation are estimated so that we may provide a comparison with doses resulting from Laboratory operations. Doses from global fallout are only a small fraction of total background doses (<0.3%, NCRP 1987a) and are not considered further here. Exposure to natural background radiation results principally in whole-body doses and in localized doses to the lung and other organs. These doses are divided into those resulting from exposure to radon and its decay products that mainly affect the lung and those from nonradon sources that mainly affect the whole body.

Estimates of background radiation are based on a recent comprehensive report by the National Council on Radiation Protection and Measurements (NCRP 1987a). The 1987 NCRP report uses 20% shielding by structures for high-energy cosmic radiation and 30% self-shielding by the body for terrestrial radiation.

Table III-2. Maximum Individual Dose from Laboratory Operations during 1990

	Laboratory Operations (mrem/yr)	DOE Public Dose Limit (mrem/yr)	Percentage of PDL
Effective Dose Equivalent	3.1	100	3.1
Organ			
Breast	3.3	*	*
Lung	2.7	*	*
Red marrow	2.8	*	*
Bone surface	3.1	*	*
Thyroid	3.3	*	*
Testes	3.6	*	*
Ovaries	2.4	*	*

*Maximum doses to organs are presented for reference only. The previous DOE Radiation Protection Standard limited the radiation dose to individual organs to 5 000 mrem/yr. This standard has been superceded by DOE Order 5400.5 which limits radiation doses to organs through the effective dose equivalent concept.

Whole-body external dose is incurred from exposure to cosmic rays and to external terrestrial radiation from naturally occurring radioactivity in the earth's surface and from global fallout. Effective dose equivalents from internal radiation are due to radionuclides deposited in the body through inhalation or ingestion.

Nonradon effective dose equivalents from background radiation vary each year depending on factors such as snow cover and the solar cycle (NCRP 1975b). Estimates of background radiation from nonradon sources are based on measured external radiation background levels of 116 mrem (1.16 mSv) in Los Alamos and 120 mrem (1.2 mSv) in White Rock caused by irradiation from charged particles, x rays, and gamma rays. Please note that these estimates did not include measurements taken at two monitoring locations (Section IV). These uncorrected measured doses were adjusted for shielding by reducing the cosmic ray component (60 mrem [0.6 mSv] at Los Alamos and 52 mrem [0.52 mSv] at White Rock) by 20% to allow for shielding by structures and by reducing the terrestrial component (56 mrem [0.56 mSv] at Los Alamos and 68 mrem [0.68 mSv] at White Rock) by 30% to allow for self-shielding by the body (NCRP 1987a). To these estimates, based on measurements, were added 10 mrem (0.1 mSv) at Los Alamos and 8 mrem (0.08 mSv) at White Rock from neutron cosmic radiation (20% shielding assumed) and 40 mrem (0.4 mSv) from internal radiation (NCRP 1987a). The estimated whole body dose from background, nonradon radiation is 137 mrem (1.37 mSv) at both Los Alamos and White Rock.

In addition to these nonradon doses, a second component of background radiation is dose to the lung from inhalation of ^{222}Rn and its decay products. The ^{222}Rn is produced by decay of ^{226}Ra, a member of the uranium series, which is naturally present in construction materials in buildings and in the underlying soil. The effective dose equivalent from exposure to background ^{222}Rn and its decay products is taken to be 200 mrem/yr (2 mSv/yr) (NCRP 1987a). This background estimate may be revised if a nationwide study of background levels of ^{222}Rn and its decay products in homes is undertaken, as recommended by the NCRP (1984, 1987a).

The total effective dose equivalent to residents is 337 mrem/yr (3.37 mSv/yr) at Los Alamos and White Rock (Table III-1), or 137 mrem/yr (1.37 mSv/yr) from nonradon sources and 200 mrem/yr (2 mSv/yr) from radon.

Medical and dental radiation in the United States accounts for an average effective dose equivalent, per person, of 53 mrem/yr (0.53 mSv/yr) (NCRP 1987a). This estimate includes doses from both x rays and radiopharmaceuticals.

3. Doses to Individuals from External Penetrating Radiation from Airborne Emissions. The thermoluminescent dosimeter (TLD) network at the Laboratory boundary north of LAMPF indicated a 6.3 mrem (0.063 mSv) increment above cosmic and terrestrial background radiation during 1990 (Sec. IV). This increment is attributable to emission of air activation products from LAMPF. Based on estimates of 30% shielding inside buildings (NRC 1977, NCRP 1987a), 30% self-shielding (NCRP 1987a), and 100% occupancy, this 6.3 mrem (0.063 mSv) increment translates to an estimated 3.1 mrem (0.031 mSv) whole-body dose to an individual living along State Road 502, northeast of LAMPF (Table G-1). This location has been the area where the highest boundary and individual doses have been measured since dosimeter monitoring began.

Because this dose is from external penetrating radiation, the 3.1 mrem (0.031 mSv) whole-body dose is numerically equal to the effective dose equivalent. The 3.1 mrem (0.031 mSv) effective dose is 31% of EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr), and 3.1% of DOE's PDL of 100 mrem/yr (1 mSv/yr) (Appendix A).

4. Doses to Individuals from Inhalation of Airborne Emissions. The maximum individual effective doses attributable to inhalation of airborne emissions (Table G-1) are below the EPA air pathway standard of 10 mrem/yr (1 mSv/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 by assuming that natural radioactivity and worldwide fallout were represented by data from the three regional sampling stations at Española, Pojoaque, and Santa Fe. Doses were calculated using the procedures described in Appendix D.

The highest effective dose equivalent was 0.09 mrem (0.0009 mSv), or 0.1% of the DOE's PDL of 100

mrem/yr (1 mSv/yr), and 0.9% of the EPAs 10 mrem/yr (0.1 mSv/yr) standard for dose from the air pathway. Emissions of air activation products from LAMPF resulted in negligible inhalation exposures.

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

5. Modeled Doses from Airborne Emissions for Compliance with 40 CFR 61, Subpart H. The EPA requires that radiation doses be determined with the CAP-88 computer codes AIRDOS2 to demonstrate compliance with 40 CFR 61, and RADRISK (40 CFR 61). The CAP-88 codes were run with 1990 meteorological data, radioactive emissions data (given in Table G-2), and RADRISK dose conversion factors. As expected, more than 98% of the maximum individual dose resulted from external exposure to air activation products from LAMPF. The maximum individual effective dose equivalent, as determined by CAP-88, was 8.1 mrem (0.081 mSv), corrected to include shielding by buildings (30% reduction). The calculation also took into account the chemical form of the radionuclide, such as whether tritium was present as tritiated water or tritium gas (see Appendix D). The 8.1 mrem (0.081 mSv) maximum dose, which would occur in the area just northeast of LAMPF, is 81% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr) (effective dose equivalent).

The Laboratory is currently reviewing its airborne radioactive effluent monitoring program to determine compliance status with EPA's stack monitoring requirements in 40 CFR 61.93. An inventory of radionuclide use at each LANL facility is currently being conducted. This information will be used to identify which stacks at LANL require effluent monitoring under the EPA regulations.

See Appendix D for additional information on modeling doses under 40 CFR 61.

6. Doses from Direct Penetrating Radiation. No direct penetrating radiation from Laboratory operations was detected by TLD monitoring in off-site areas. The only off-site TLD measurements showing any effect from Laboratory operations were those taken north of LAMPF. These were due to airborne emissions, as discussed above. On-site TLD measurements of external penetrating radiation reflected Laboratory operations and did not represent potential exposure to the public. During previous years, a potential 2 to 3 mrem/yr (0.02 to 0.03 mSv/yr) dose to the public occurred to members of the public using the DOE-controlled road passing by TA-18. This potential dose did not exist during 1990 because of curtailed operations at TA-18.

The on-site TLD station (Station 24, Fig. 7) near the northeastern Laboratory boundary recorded an above-background dose of about 27 mrem (0.27 mSv). This dose reflects direct radiation from a localized accumulation of ^{137}Cs on sediments transported from TA-21 before 1964. No one resides near this location at this time.

TLD stations at White Rock (Station 12) and at Shell (Station 10) had anomalous readings during 1990. As will be discussed in Section IV, these readings were investigated with a field survey, which included identifying what radionuclides caused the elevated reading. The elevated readings were observed at these stations while the surveys were conducted. Elevated levels of naturally occurring radioactivity, particularly ^{214}Bi and ^{214}Pb, were observed at both locations. These radionuclides were identified by collecting *in-situ* gamma spectra at each location with a high-purity germanium detector. These radionuclides are naturally occurring and are not associated with any LANL operation.

7. Doses to Individuals from Treated Effluents. At this time, discharged, treated effluents do not flow beyond the Laboratory boundary but are retained in the alluvium of the receiving canyons (Sec. VI). These treated effluents are monitored at point of discharge; their behavior in the alluvium of the canyons below outfalls has been studied and is monitored annually (Hakonson 1976a, 1976b; Purtymun 1971, 1974a; Sec. VI).

Small quantities of radioactive contaminants transported during periods of heavy runoff have been measured in canyon sediments beyond the Laboratory boundary in Los Alamos Canyon (Fig. 5). Calculations made with radiological data from Acid-Pueblo and Los Alamos canyons (ESG 1981) indicate a minor exposure

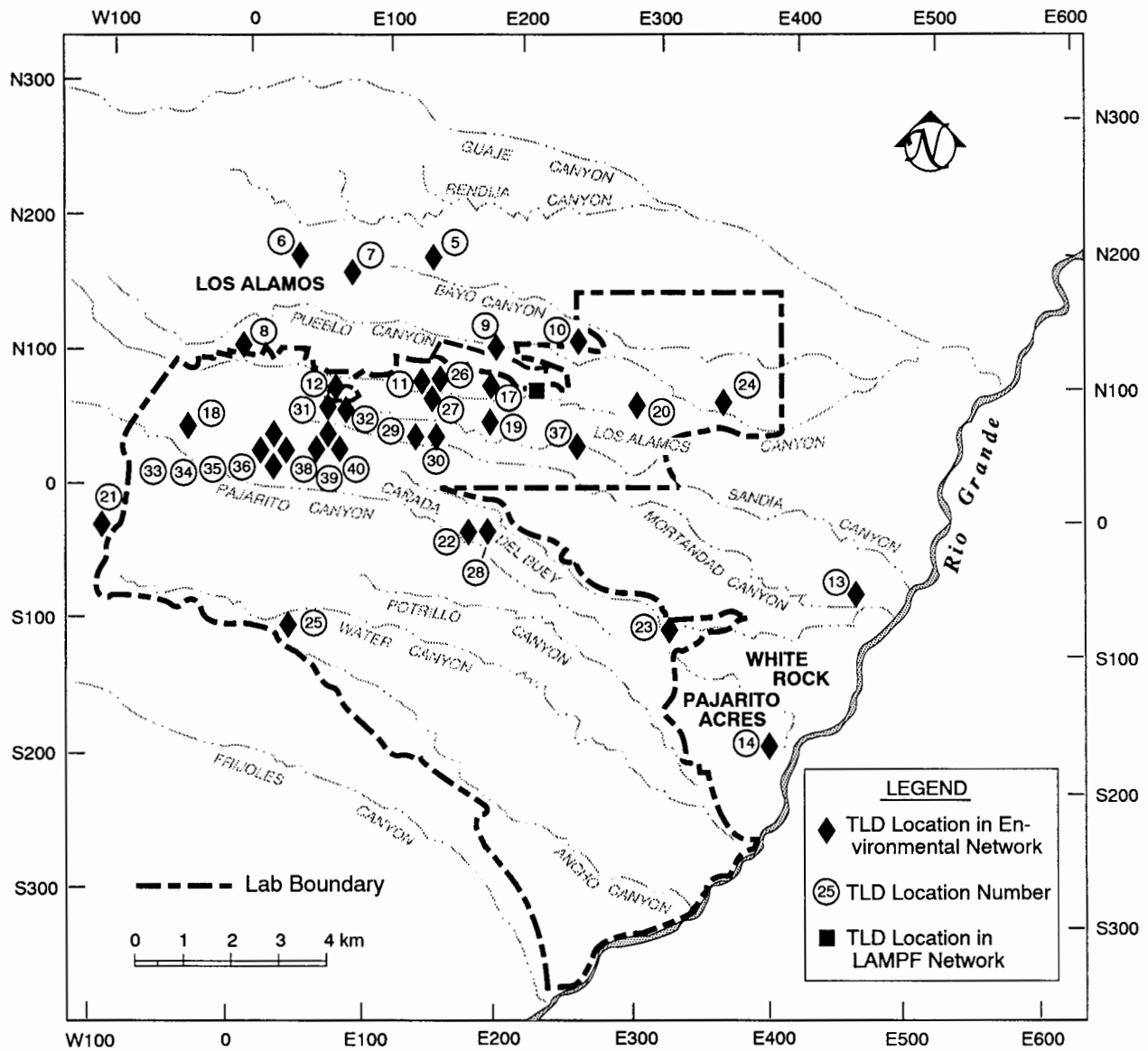


Fig. 7. Thermoluminescent dosimeter (TLD) locations on or near the Laboratory site.

pathway to man from these canyon sediments (eating liver from a steer that drinks water from and grazes in lower Los Alamos Canyon). This pathway could potentially result in a maximum committed effective dose equivalent of 0.1 mrem (0.001 mSv).

8. Doses to Individuals from Ingestion of Foodstuffs. Data from sampling of produce, fish, and honey during 1990 (Sec. VII) were used to estimate doses received from eating these foodstuffs. All calculated effective dose equivalents are 0.1% of DOE's 100 mrem/yr (1 mSv/yr)standard (Appendix A).

Fruit and vegetable samples were analyzed for six radionuclides (^{3}H, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$). The maximum committed effective dose equivalent that would result from ingesting one-fourth of an annual consumption of fruits and vegetables (160 kg) from an off-site location was 0.13 mrem (0.0013 mSv). This dose is 0.1% of the DOE's PDL for protecting members of the public (Appendix A).

Ingestion of produce collected on-site is not a significant exposure pathway because of the small amount of edible material, low radionuclide concentrations, and limited access to these foodstuffs.

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, are compared with concentrations in fish taken from Abiquiu Reservoir upstream. The maximum effective dose equivalent to an individual eating 21 kg of fish from Cochiti Reservoir is 0.04 mrem (0.0004 mSv), which is <0.1% of DOE's 100 mrem/yr (1 mSv/yr) standard (DOE 1990a). Maximum organ dose is 0.08 mrem (0.0008 mSv) to bone surface.

Trace amounts of radionuclides were found on site 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 0.06 mrem (0.0006 mSv), which is 0.06% of DOE's 100 mrem/yr (1 mSv/yr) standard.

9. Collective Effective Dose Equivalents. The 1990 population collective effective dose equivalent attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory was calculated to be 3.1 person-rem (0.031 person-Sv). This dose is <0.1% of the 70 000 person-rem (700 person-Sv) exposure from natural background radiation and <0.1% of the 11 000 person-rem (110 person-Sv) exposure from medical radiation (Table III-3).

The collective dose from Laboratory operations was calculated from measured radionuclide emission rates (Table G-2), atmospheric modeling using measured meteorological data for 1990, and population data based on the Bureau of Census count (Table II-1 and Appendix D).

The collective dose from natural background radiation was calculated using the background radiation levels given above. For the population living within the 80 km radius of the Laboratory, the dose from medical and dental radiation was calculated using a mean annual dose of 53 mrem (0.53 mSv) per capita. The population distribution in Table II-1 was used in both these calculations to obtain the total collective dose.

Also shown in Table III-3 is the collective effective dose equivalent in Los Alamos County from Laboratory operations, natural background radiation, and medical and dental radiation. Approximately 70% of the total collective dose from Laboratory operations is to Los Alamos County residents. This dose is <0.1% of the collective effective dose equivalent from background and 0.2% of the collective dose from medical and dental radiation, respectively.

Table III-3. Estimated Collective Effective Dose Equivalents during 1990 (person-rem [person-Sv])

Exposure Mechanism	Los Alamos County (18 200 persons)	80 km Region (213 000 persons)[a]
Total caused by Laboratory releases	2.2 (0.022)	3.1 (0.031)
Natural background		
Nonradon[b]	2 500 (25)	27 000 (270)
Radon	3 600 (36)	43 000 (430)
Total caused by natural sources of radiation	6 100 (61)	70 000 (700)
Diagnostic medical exposures (~53 mrem/yr/person)[c]	1 000 (10)	11 000 (110)

[a]Includes doses reported for Los Alamos County.

[b]Calculations are based on TLD measurements. They include a 20% reduction in cosmic radiation from shielding by structures and a 30% reduction in terrestrial radiation from self-shielding by the body (NCRP 1987a).

[c]NCRP (1987a).

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 NCRP (1975a) has warned that "risk estimates for radiogenic cancers at low doses and low dose rates derived on the basis of linear (proportional) extrapolation from the rising portions of the dose incidence curve at high doses and high dose rates . . . cannot be expected to provide realistic estimates of the actual risks from low-level, low-LET radiation, and have such a high probability of overestimating the actual risk as to be of only marginal value, if any, for purposes of realistic risk-benefit evaluation."

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

Risk estimates used here are based on two recent reports by the National Research Council's Committee on the Biological Effects of Ionizing Radiation (BEIR IV 1988, BEIR V 1990). These reports incorporate the results of the most current research and update risk estimates in previous surveillance reports that were based on the work of the ICRP. The procedures used in this report for the risk estimates are described in more detail in Appendix D.

2. Risk from Natural Background Radiation and Medical and Dental Radiation. During 1990, persons living in Los Alamos and White Rock received an average effective dose equivalent of 137 mrem (1.37 mSv) of nonradon radiation (principally to the whole body) from natural sources (including cosmic, terrestrial, and self-irradiation sources, with allowances for shielding and cosmic neutron exposure). Thus, the added cancer mortality risk attributable to natural, whole-body radiation in 1990 was 1 chance in 16 000 in Los Alamos and White Rock.

Natural background radiation also includes exposure to the lung from ^{222}Rn and its decay products (see above) in addition to exposure to whole-body radiation. This exposure to the lung also carries a chance of cancer mortality because of natural radiation sources that were not included in the estimate for whole-body radiation. For the background effective dose equivalent of 200 mrem/yr (2 mSv/yr), the added risk because of exposure to natural ^{222}Rn and its decay products is 1 chance in 14 000.

The total cancer mortality risk from natural background radiation is 1 chance in 8 000 for Los Alamos and White Rock residents (Table I-2). The additional risk of cancer mortality from exposure to medical and dental radiation is 1 chance in 43 000.

3. Risk from Laboratory Operations. The risks calculated above from natural background radiation and medical and dental radiation can be compared with the incremental risk caused by radiation from Laboratory operations. The average doses to individuals in Los Alamos and White Rock because of 1990 Laboratory activities were 0.11 and 0.15 mrem (0.0011 and 0.0015 mSv), respectively. These doses are estimated to add lifetime risks of about 1 chance in 21 000 000 in Los Alamos and 1 chance in 15 000 000 in White Rock to an individual's risk of cancer mortality (Table I-2). These risks are <0.1% of the risk attributed to exposure to natural background radiation or to medical and dental radiation.

For Americans, the average lifetime risk is a 1-in-4 chance of contracting cancer and a 1-in-5 chance of dying of cancer (EPA 1979). The Los Alamos incremental risk attributable to Laboratory operations is equivalent to the additional exposure from cosmic rays a person would get from flying in a commercial jet aircraft for 30 minutes at an altitude of 9 100 m (30 000 ft) (NCRP 1987b). The exposure from Laboratory operations to Los Alamos County residents is well within variations in exposure of these people to natural cosmic and terrestrial sources and global fallout. For example, the amount of snow cover and variability of the solar sunspot cycle can explain a 10 mrem (0.1 mSv) difference from year to year (NCRP 1975b).

IV. MEASUREMENT OF EXTERNAL PENETRATING RADIATION

Levels of external penetrating radiation (including x and gamma rays and charged-particle contributions from cosmic, terrestrial, and manmade sources) are monitored in the Los Alamos area with thermoluminescent dosimeters (TLDs). 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). These TLDs showed an above-background radiation measurement of about 6 ± 3 mrem in 1990, less than the dose measured in 1989. Some on-site 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 the decay of ^{40}K and of radionuclides 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 from 15% to 25% at any location because of changes in soil moisture and snow cover (NCRP 1975b). There is also spatial variation because of different topographies and soil and rock types from area to 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, regional locations range in elevation from about 1.7 km (1.1 mi) at Española to 2.7 km (1.7 mi) at Fenton Hill, resulting in a corresponding range between 45 and 90 mrem/yr for the cosmic component. This component can vary ±5% because of solar modulations (NCRP 1975b).

Fluctuations in natural background ionizing radiation make it difficult to detect an 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, to measure contributions to external radiation from the operation of the Los Alamos Meson Physics Facility (LAMPF), arrays with 48 TLDs (12 stations, 4 TLDs per station) for each array have been deployed near LAMPF and in background areas.

B. Environmental TLD Network

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

The environmental network consists of 40 stations divided into 3 groups. The regional group consists of four locations, 28 to 44 km (17 to 27 mi) from the Laboratory boundary in the neighboring communities of Española, Pojoaque, and Santa Fe, as well as at the Fenton Hill Site 30 km (19 mi) west of Los Alamos. The off-site perimeter group consists of 12 stations within 4 km (2.5 mi) of the boundary (Fig. 7). Within the Laboratory, the on-site group is composed of 24 locations (Fig. 7). Details of the methodology for this network are found in Appendix B.

Annual averages for the groups were generally higher in 1990 than in 1989 (Fig. 8), close to the

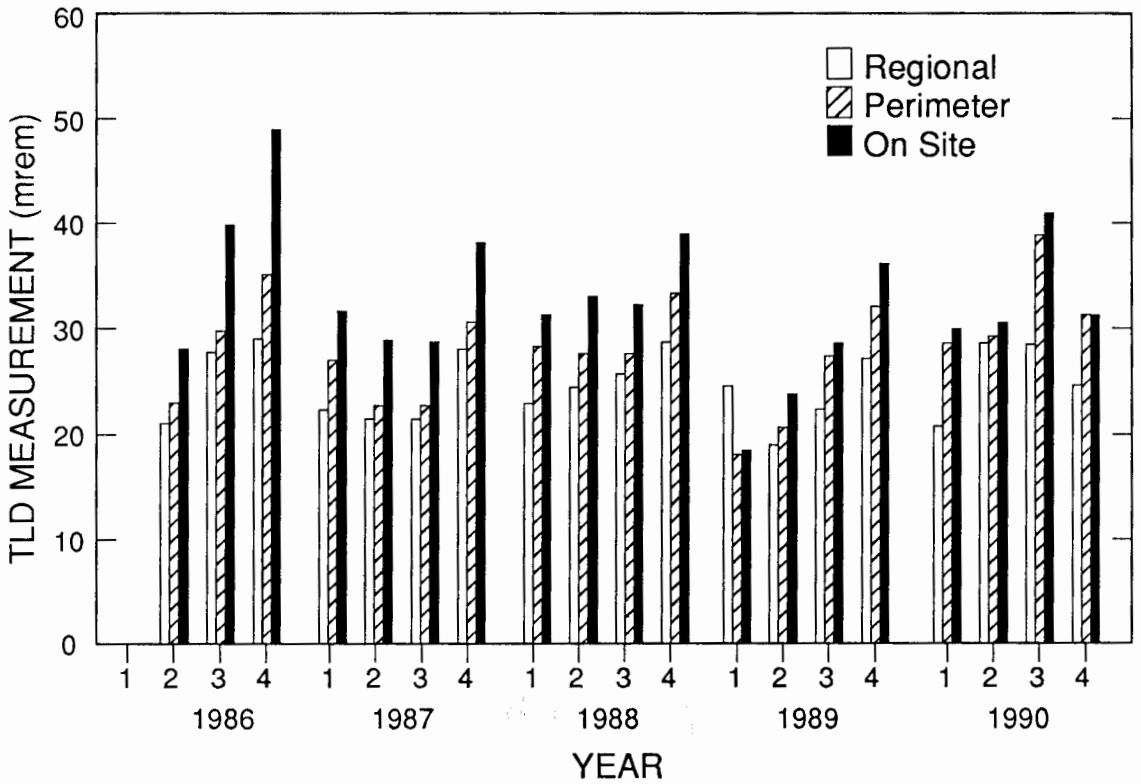


Fig. 8. Thermoluminescent dosimeter (TLD) measurements (including contributions from cosmic, terrestrial, and Laboratory radiation sources).

averages observed in 1988 and consistent with the variability in natural background observed at these stations. An increase in the TLD reading was noted in two stations resulting from a change at the beginning of 1990 at several monitoring locations within each station. The increase was determined by independent measurement to be from an increase in natural terrestrial exposure (see Section IX, M.2.). Regional and perimeter stations showed no statistically discernible increase in radiation levels attributable to Laboratory operations (Table G-3). Annual measurements at off-site stations ranged from 89 to 180 mrem.

Some comparisons provide a useful perspective for evaluating these measurements. For instance, the average person in the United States receives about 53 mrem/yr of radiation from medical diagnostic procedures (NCRP 1987a). The DOE's public dose limit (PDL) is 100-mrem/yr effective dose received from all pathways, and the dose received by air is restricted by EPA's (effective dose) standard of 10 mrem/yr (Appendix A). These values are in addition to those from normal background, consumer products, and medical sources. The standards apply to locations of maximum probable exposure to an individual in an off-site, uncontrolled area.

C. TLD Network at LAMPF

This network monitors external radiation from airborne activation products (gases, particles, and

Table IV-1. Doses Measured by TLDs at On-Site Waste Disposal Areas during 1990

Area	Number of TLDs	Doses (mrem) Mean	Minimum	Maximum
A	5	115	107	119
B	14	124	112	134
C	10	133	119	160
E	4	129	117	145
F	4	114	106	118
G	27	162	127	404
T	7	139	114	256
U	4	133	123	145
V	4	116	111	123
W	2	118	116	120
X	1	97	—	—
AB	10	114	105	122

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 (0.5 mi) of canyon rim. Twelve background TLD sites are about 9 km (5.5 mi) from the facility along a canyon rim near the southern boundary of the Laboratory (Fig. 7). This background location is not influenced by any Laboratory external radiation sources.

The TLDs at the 24 sites are changed each calendar quarter or more often if LAMPF's operating schedule indicates the need (start-up or shutdown of the accelerator for extended periods midway in a calendar quarter). The radiation measurement (above background) for this network was about 6 ± 3 mrem for 1990. This value was obtained by subtracting the annual measurement taken at the background sites from the annual measurement taken at the Laboratory's boundary north of LAMPF (Appendix B). The value measured this year is less than that measured in 1989 (Fig. 2). The annual emissions of mixed activation products from LAMPF also decreased (Table I-3) and is reflected in the boundary measurements.

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

This network of 92 locations monitors radiation levels at one active and 11 inactive low-level radioactive waste management areas. These waste management areas are controlled-access areas and thus are not accessible to the general public. Active and inactive waste areas are monitored for external penetrating radiation with arrays of TLDs (Table IV-1). Averages at all sites were higher than the average for the perimeter network. However, the range of values at most sites largely overlapped those found at perimeter and regional stations (Tables IV-1 and G-3). The extremes at Area G (the active radioactive waste area) and Area T (an inactive waste area) have been noted in previous years. These data reflect the results of past and present radioactive waste management activities.

V. AIR MONITORING

Airborne radioactive emissions were monitored at 88 Laboratory release points. The largest airborne release was 123 400 Ci (4 565 800 GBq) of short-lived (2- to 20-minute half-lives) air activation products from the Los Alamos Meson Physics Facility during its operation from May 26 through October 26, 1990. A significant decrease was observed for all airborne radionuclide effluents released in 1990 compared to 1989.

Air is routinely sampled at several locations on-site, along the Laboratory perimeter, and in distant areas that serve as regional background stations. Atmospheric concentrations of tritium, uranium, plutonium, americium, and gross beta are measured. The highest measured annual average concentrations of these radioactive materials were less than 0.1% of the concentrations that would cause DOE's public dose limits to be exceeded.

A. Airborne Radioactivity

1. Introduction. The sampling network for ambient airborne radioactivity consists of 28 continuously operating air sampling stations (see Appendix B for a complete description of sampling procedures). The regional monitoring stations, 28 to 44 km (18 to 28 mi) from the Laboratory, are located at Española, Pojoaque, and Santa Fe (Table G-4). The data from these stations are used as reference points for determining regional background levels of atmospheric radioactivity. The 13 perimeter stations are within 4 km (2.5 mi) of the Laboratory boundary. Three perimeter stations were added in 1990, up from ten in 1989. Twelve on-site stations are within the Laboratory boundary (Fig. 9, Table G-4).

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

Particulate matter in the atmosphere is primarily caused by the resuspension of soil that is dependent on 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 meteorological conditions.

2. Airborne Emissions. Radioactive airborne emissions are monitored at 88 Laboratory discharge locations. These emissions consist primarily of filtered exhausts from glove boxes, experimental facilities, operational facilities (such as liquid waste treatment plants), a nuclear research reactor, and a linear particle accelerator at the Los Alamos Meson Physics Facility (LAMPF). The emissions receive appropriate treatment before discharge, such as filtration for particulate matter and catalytic conversion and adsorption for activation gases. The quantities of airborne radioactivity released depend on the type of research activities and can vary markedly from year to year (Figs. 10–12).

During 1990, the most significant releases were from LAMPF. The amount released for the entire year was 123 400 Ci (4 565 800 GBq) of air activation products (gases, particles, and vapors) (Tables I-3 and G-2). This emission was about 80% of that in 1989, but

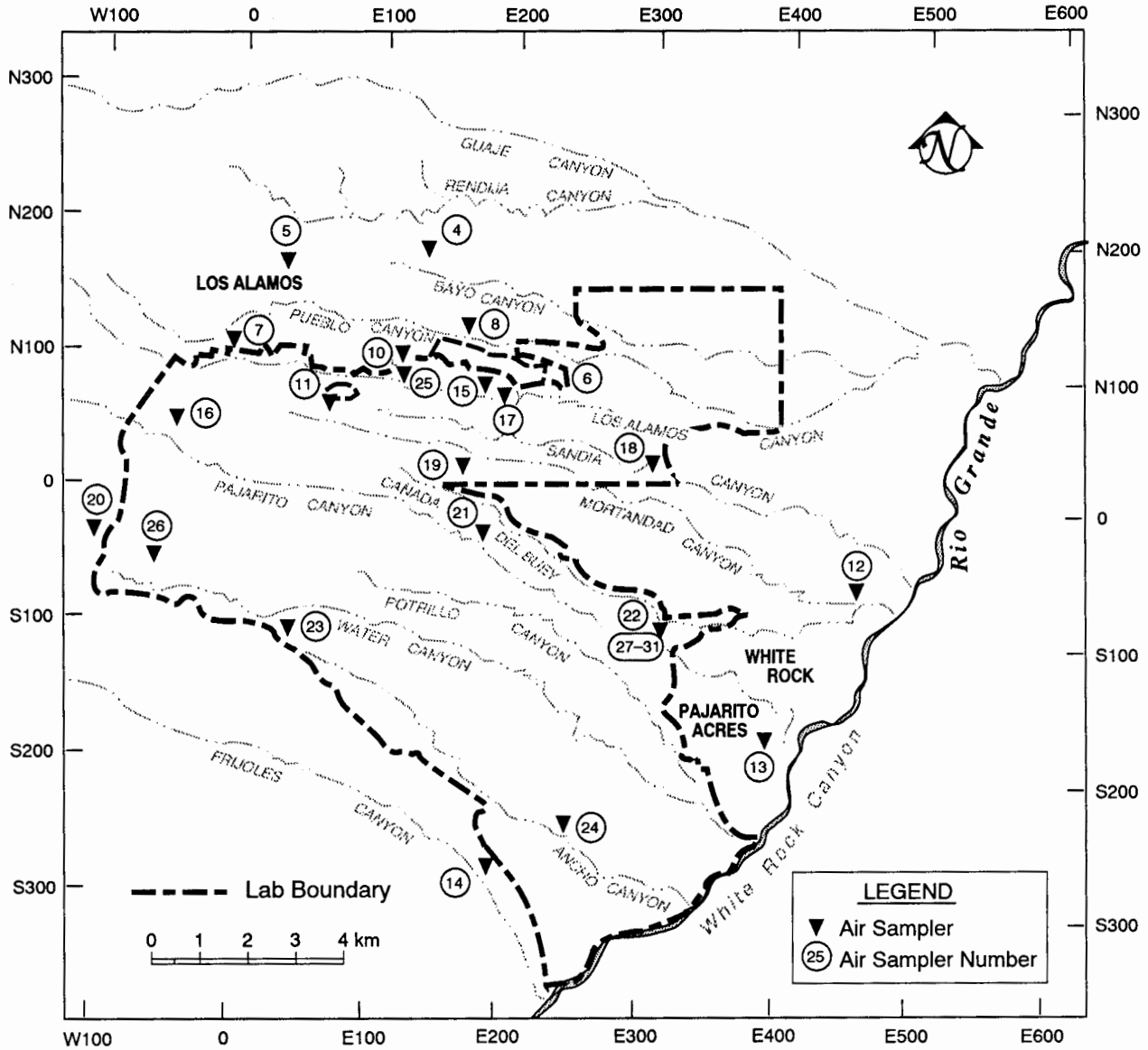


Fig. 9. Locations on or near the Laboratory site for sampling airborne radionuclides.

was within the range of variation seen over the last few years (Fig. 12). The principal airborne activation products (half-lives in parentheses) were ^{11}C (20 min), ^{13}N (10 min), ^{14}O (71 s), ^{15}O (123 s), ^{41}Ar (1.83 h), ^{192}Au (4.1 h), and ^{195}Hg (9.5 h). A list of selected nuclides and their half-lives is given in Table G-6. More than 95% of the radioactivity was from the ^{11}C, ^{13}N, ^{14}O, and ^{15}O radioisotopes, whose radioactivity declines very rapidly over time.

Airborne tritium emissions decreased to 60% of the 14 400 Ci (532 800 GBq) released in 1989 to 6 400 Ci (236 800 GBq) released in 1990 (Table I-3). Mixed fission products decreased in 1990, returning to levels observed prior to the 1989 unplanned release from TA-48 (1 150 μCi in 1988, 435 000 μCi (16 GBq) in 1989, and 1 085 μCi (40 MBq) in 1990). Spallation product releases were observed for the first time in 1990 at TA-48 [2 Ci (37 000 GBq)]. Spallation products include As-72, As-73, As-74, Se-75, and Br-77.

In addition to releases from facilities, some depleted uranium (uranium consisting primarily of

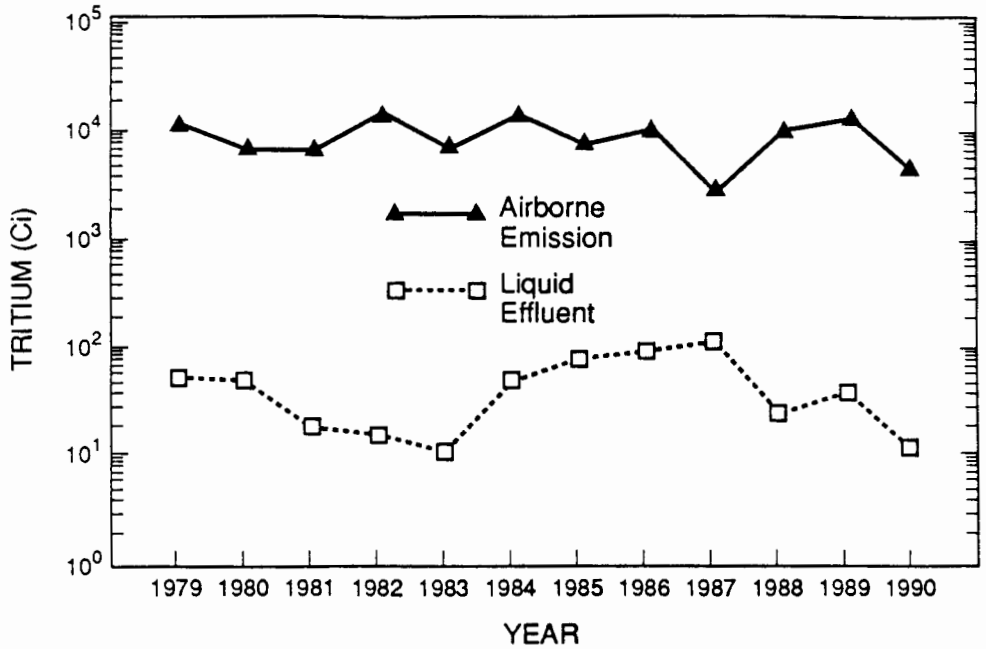


Fig. 10. Summary of tritium releases (airborne emissions and liquid effluents).

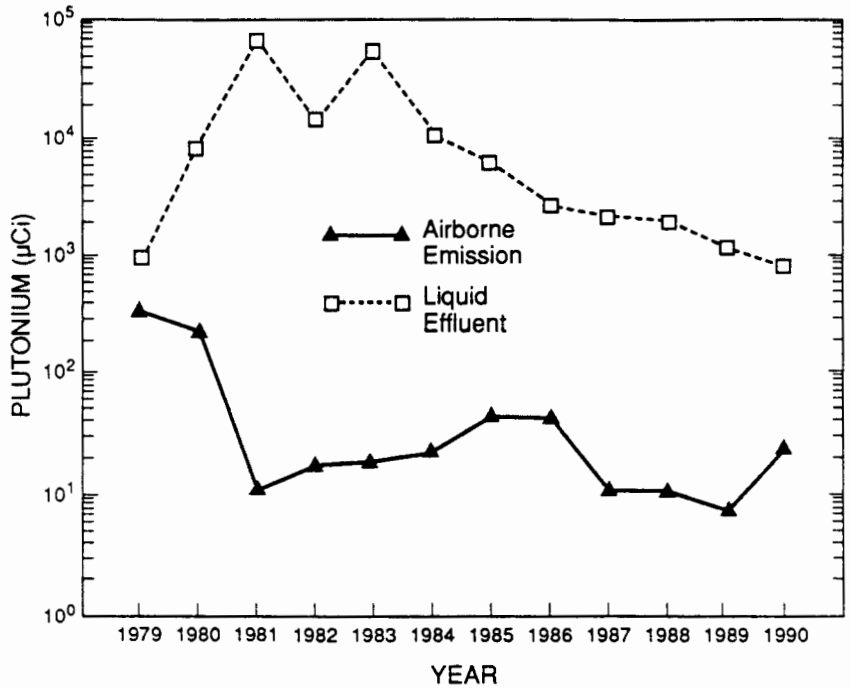


Fig. 11. Summary of plutonium releases (airborne emissions and liquid effluents).

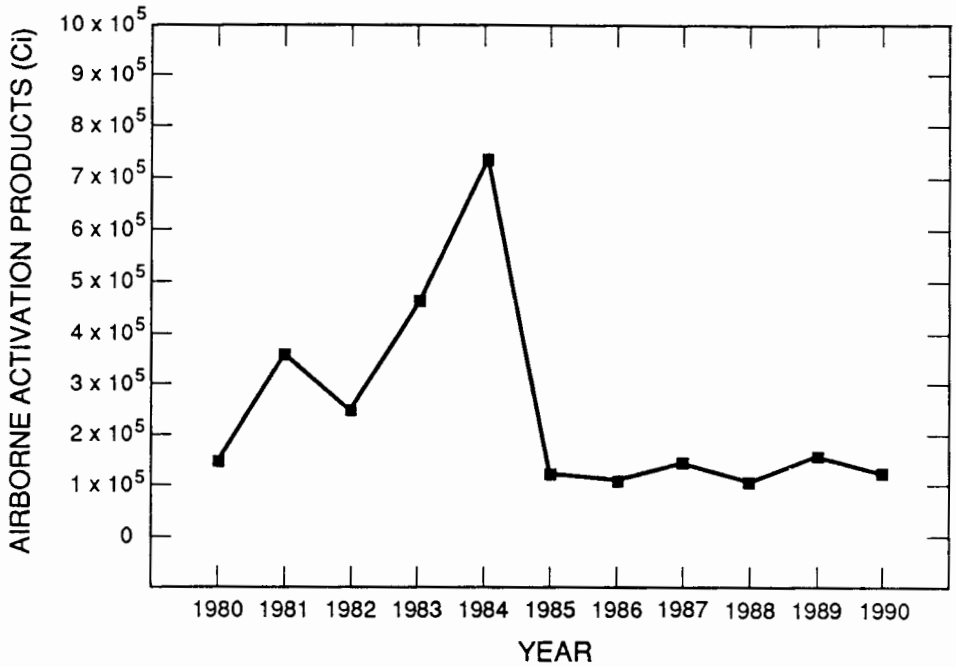


Fig. 12. Airborne activation product emissions (principally, ^{10}C, ^{11}C, ^{12}N, ^{16}N, ^{14}O, ^{15}O, ^{41}Ar) from LAMPF, the Los Alamos Meson Physics Facility (TA-53).

^{238}U) is dispersed by experiments that use conventional high explosives. About 52.1 kg (115 lb) of depleted uranium was used in such experiments in 1990 (Table G-7). This mass contains about 0.02 Ci (740 MBq) of radioactivity. Most of the debris from these experiments is deposited on the ground in the vicinity of the firing sites. Limited experimental data show that no more than about 10% of the depleted uranium becomes airborne (Dahl 1977). Dispersion calculations indicate that resulting airborne concentrations are in the same range as that for concentrations attributable to the natural abundance of uranium that is resuspended in dust particles originating from the earth's crust.

The EPA limits radiation doses from airborne radioactive emissions to 10 mrem/yr according to regulations under the auspices of NESHAP (National Emission Standards for Hazardous Air Pollutants, EPA 1989c). As discussed in Sec. III, the maximum individual doses caused by Laboratory operations during 1990, which principally resulted from releases of air activation products from LAMPF, were estimated to be 8.1 mrem to the whole body. These doses were 81% of the EPA limit of 10 mrem/yr.

3. Gross Beta Radioactivity. Gross beta analyses help in evaluating general radiological air quality. Figure 13 shows gross beta concentrations at a regional sampling location (Española, Station 1), about 30 km from the Laboratory, and at an on-site sampling location (TA-59, Building OH-1).

4. Tritium. In 1990, the regional mean (0.5×10^{-12} μCi/mL) was statistically significantly lower than the perimeter annual mean (4.1×10^{-12} μCi/mL) and the on-site annual mean (5.3×10^{-12} μCi/mL) (Table G-8). This difference reflects the slight impact of Laboratory operations. The TA-54 (Station 22) annual mean of 16.4×10^{-12} μCi/mL was the highest annual mean observed in 1990. The highest concentration observed in any month was also at TA-54 (48.2×10^{-12} μCi/mL). This station is located within the Laboratory boundary in an area where ^{3}H-contaminated waste is disposed.

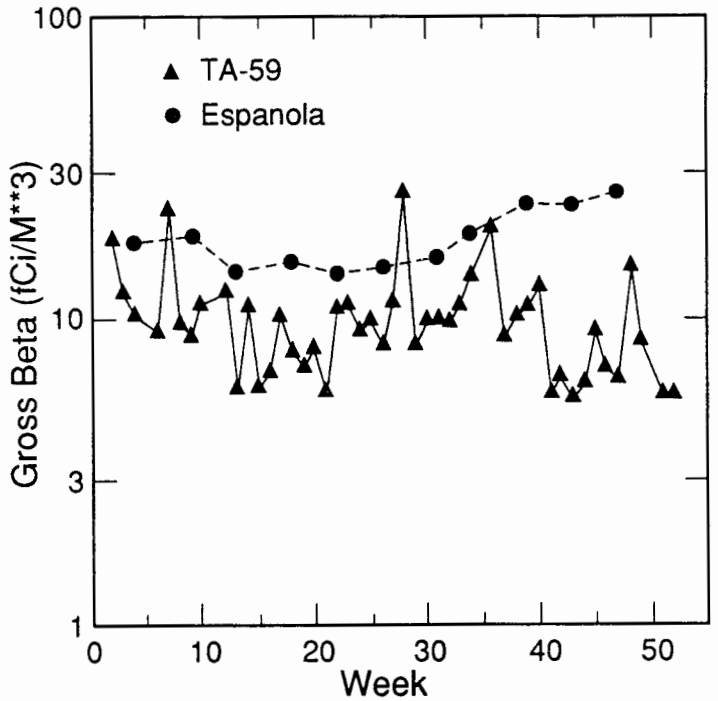


Fig. 13. Atmospheric gross beta activity at a regional (background) station and an on-site station during 1990.

These tritium concentrations are <0.1% of the concentration guides for tritium in air, based on DOE's derived air concentrations for controlled areas (Appendix A).

5. Plutonium and Americium. Of the 104 air sample analyses performed in 1990 for ^{238}Pu, only three were above the minimum detectable limit of 4×10^{-18} μCi/mL. The highest concentration occurred at Barranca School (4.2 [1.1] $\times 10^{-18}$ μCi/mL) and represents <0.1% of the DOE's derived air concentration guides for ^{238}Pu in uncontrolled areas, or 2×10^{-14} μCi/mL (Appendix A). The results of the ^{238}Pu analyses are presented in Table G-9.

The 1990 annual means for ^{239,240}Pu concentrations in air for the regional (0.9×10^{-18} μCi/mL), perimeter (3.2×10^{-18} μCi/mL), and on-site (1.8×10^{-18} μCi/mL) stations were all less than 0.1% of the derived air concentration guides for controlled or uncontrolled areas (Appendix A). The maximum concentration was observed at the 48th Street Station (13 [1.8] $\times 10^{-18}$ μCi/ml). The concentration was 0.1% of the derived air concentration guide for uncontrolled areas.

Measured concentrations of ^{241}Am were all less than 0.1% of the derived air concentration guides for controlled and uncontrolled areas (Appendix A).

Detailed results are given in Tables G-9, G-10, and G-11.

6. Uranium. Because uranium is a naturally occurring radionuclide in soil, it is found in airborne soil particles that have been resuspended by wind or mechanical forces (for example, vehicle or construction activity). As a result, uranium concentrations in air are heavily dependent on the immediate environment of the air sampling station. Stations with relatively higher annual averages or maximums are in dusty areas, where heavier accumulation of dust on filters results in increased amounts of natural uranium in the samples.

The 1990 annual means for uranium concentrations in air for regional, perimeter, and on-site stations were

114 pg/m^3, 38 pg/m^3, and 42 pg/m^3, respectively (Table G-12). All measured annual means were <0.1% of the concentration guides for uranium in controlled and uncontrolled areas (Appendix A). No effects attributable to Laboratory operations were observed.

B. Nonradioactive Chemicals in Ambient Air

1. Acid Precipitation. The Laboratory operates a wet deposition monitoring station located at Bandelier National Monument (Sec IX.E). This station is part of the National Atmospheric Deposition Program (NADP) network. The NADP is an independently operated network of monitoring stations located throughout the United States that are designed to measure regional deposition rates. The samples are collected following standardized procedures and chemically characterized by the NADP Central Analytical Laboratory.

2. Ambient Air Monitoring. Because the Los Alamos area is remote from large metropolitan areas and major sources of air pollution, extensive monitoring for nonradioactive air pollutants has not been conducted. In 1990, the Laboratory operated an ambient air monitoring station south of TA-49 and adjacent to Bandelier National Monument. Data have been collected for ozone, PM_{10}, nitrogen dioxide, and sulfur dioxide. The data and appropriate standards are summarized in Table V-1. Table G-13 presents data on beryllium concentrations.

3. Toxic Air Pollutant Sampling Program. During 1990, the Laboratory designed a short-term, intensive toxic air pollutant sampling program. This program was designed to address the complex terrain and meteorology of the area, the low levels of airborne chemical emissions from the Laboratory operations, and potential interferences from Los Alamos community emissions. Three classes of target chemicals were addressed in the plan: inorganic acids, metals, and organic vapors. These chemical classes are representative of the types of emissions from the Laboratory. Five sampling locations have been identified as sites for air samplers. Four were chosen to be downwind of major Laboratory emission sources; one is upwind of all Laboratory areas. This study will be conducted early in 1991. It will provide a detailed and comprehensive evaluation of the impact of the Laboratory's chemical emissions on ambient air quality. These data will be used to guide any future air quality studies.

Table V-1. Comparison of Bandelier Site Measured Values with Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary	Measured Concentrations
Sulfur dioxide	Annual arithmetic mean	ppm	0.02	0.03		
	24 hours[a]	ppm	0.10	0.14		
	3 hours[a]	ppm			0.05	
PM_{10}	Annual arithmetic mean	μg/m^3		50	50	14[a]
	24 hours	μg/m^3		150	150	22[a]
Ozone	1 hour	ppm	0.06	0.12	0.12	
Nitrogen dioxide	Annual arithmetic mean	ppm	0.05	0.053	0.053	
	24 hours[a]	ppm	0.10			

[a]Sampler began operation in second quarter of 1990; values based on data for second, third, and fourth quarters of 1990.

VI. WATER, SOIL, AND SEDIMENT MONITORING

Surface waters and groundwaters, soils, and sediments were sampled and analyzed to monitor dispersion of radionuclides and chemicals from Laboratory operations. Radionuclide and chemical concentrations in water from areas where there has been no direct release of treated effluents evidenced no observable effects caused by Laboratory operations. The chemical quality of surface waters from areas with no effluent release varied with seasonal fluctuations. The quality of water and sediments in and downstream from the release areas reflected some impact from Laboratory operations, but these waters are not a source of municipal, industrial, or agricultural water supply. All concentrations in water sampled outside the Laboratory boundary were less than 7% of Department of Energy's guides.

Most regional and perimeter soil and sediment stations contained radioactivity at or near background levels. Concentrations that did exceed background were low and were principally associated with sediments from areas where, historically, untreated and treated discharges have been released. Concentrations of plutonium in sediments from regional reservoirs on the Rio Chama and Rio Grande reflected worldwide fallout.

A. Groundwater Protection Management Program

Groundwater resource management and protection at Los Alamos is focused on the main aquifer underlying the region (see Sec. II.C of this report: "Geology-Hydrology"). The aquifer has been of paramount importance to Los Alamos since the days of the post-World War II Manhattan Engineering District when the Atomic Energy Commission (AEC) needed to develop a reliable water supply. The U. S. Geological Survey (USGS) was extensively involved in overseeing and conducting various studies for development of groundwater supplies starting in 1945-46. Studies specifically aimed at protecting and monitoring groundwater quality were initiated as joint efforts between the AEC, the Los Alamos Scientific Laboratory and the USGS in about 1949.

The long and comprehensive record of data indicates that DOE operations at the Los Alamos National Laboratory have not resulted in any contamination of the main aquifer. The controlled development and production of the water supply have not resulted in any significant depletion of the resource as there is no widespread major decline of the piezometric surface of the aquifer. Drawdowns are localized in the vicinity of the production wells; nearly complete recoveries are observed when wells are shut down for routine maintenance.

The early groundwater management efforts evolved with the growth of the Laboratory to become the current Groundwater Protection Management Program that addresses environmental monitoring, resource management, aquifer protection, and geohydrologic investigations. Essentially all of the action elements required by Department of Energy (DOE) Order 5400.1 as part of the Groundwater Protection Management Program have been functioning at the Laboratory for varying lengths of time. Formal documentation for the program, the "Groundwater Protection Management Program Plan," was prepared by HSE-8 of the Laboratory and issued by the Los Alamos Area Office of the DOE in April 1990. Several hundred reports and articles document the program elements and the data germane to groundwater and the related Los Alamos environmental setting.

The groundwater quality monitoring described in this report is the current evolution of the program that was initiated by the U.S. Geological Survey for the AEC in 1949. Groundwater monitoring of the main aquifer at Los Alamos was implemented as an integral part of the comprehensive monitoring of shallow alluvial groundwater in canyons, surface water, soils, and

sediments. These other media are indicators of potentials for groundwater contamination and document the range of possible pathways. Appendix B of this report summarizes the sampling methodology; and Appendix C summarizes analytical chemistry methodology. Each of the appendices provides references to more detailed quality assurance documentation. This section includes brief descriptions of groups or types of sampling locations. Data on both radiochemical and nonradiological analyses are summarized in this section; and references to detailed data tables in Appendix G are provided.

Groundwater resource monitoring routinely documents conditions of the water supply wells and the main aquifer as part of the overall Groundwater Protection Management Program. This information is documented in an annual series of reports providing detailed records of pumping and water-level measurements. The most recent report in this series is entitled "Water Supply at Los Alamos During 1988," (Purtymun, 1989c). A brief summary of water production in 1990 is included in Sec. VIII.E.6.

B. Effluent Quality

In recent years, treated 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 Los Alamos Meson Physics Facility (LAMPF) at TA-53 (Tables I-3 and VI-1 and Figs. 10, 11, 14). In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon. In 1990, there were no releases from the TA-21 plant or the TA-53 total retention lagoons.

Effluent-associated radionuclides do exist off-site in Pueblo and Los Alamos Canyons (Fig. 5). As detailed in subsequent sections, concentrations of radionuclides in water generally decrease from the point of discharge. The concentrations of radionuclides in all off-site waters are less than 7% of DOE's guides. Thus, these

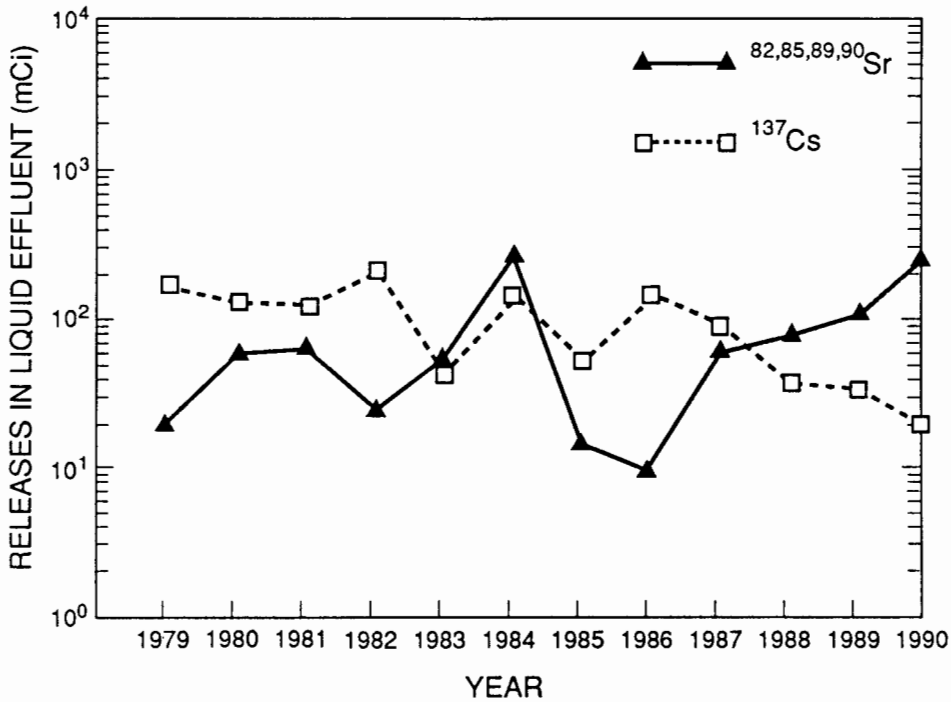


Fig. 14. Summary of strontium and cesium liquid effluent releases.

Table VI-1. Quality of Effluent Released from the TA-50 Radioactive Liquid-Waste Treatment Plant in 1990

Radionuclide	Activity Released[a] (mCi)	Mean Concentration (μCi/mL)
^{3}H	12 000	5.9×10^{-4}
^{54}Mn	1.3	6.2×10^{-8}
$^{56,57,58,60}Co$	11.9	5.6×10^{-7}
^{75}Se	53	2.5×10^{-6}
$^{83,84}Rb$	508	2.4×10^{-5}
$^{82,85,89,90}Sr$	253	1.2×10^{-5}
^{88}Y	0.4	1.9×10^{-8}
^{137}Cs	12.5	5.9×10^{-6}
^{234}U	0.07	3.4×10^{-9}
^{238}Pu	0.2	9.9×10^{-9}
$^{239,240}Pu$	0.6	2.7×10^{-8}
^{241}Am	2.7	1.3×10^{-7}
Total	12 852	

Nonradioactive Constituents	Mean Concentration (mg/L)
Cd[b]	4.3×10^{-4}
Ca	241
Cl	97
Total Cr[b]	2.5×10^{-2}
Cu[b]	0.2
F	11
Hg[b]	3.6×10^{-4}
Mg	6.3
Na	591
Pb[b]	2.1×10^{-2}
Zn[b]	0.1
CN	0.2
COD	33
NO_3-N	297
PO_4	0.2
TDS	2 550
pH[b]	7.1 – 7.8

Total effluent volume = 2.11×10^{7} L.

[a]As reported on DOE form F-5821.1.

[b]Constituents regulated by the NPDES permit.

above-background measurements do not exceed any regulatory or guideline levels established to protect the general public and the environment.

Total activity released in 1990 (about 13 Ci) was one-third of that released in 1989 (about 42 Ci, Table I-3). The decrease resulted because no effluent was discharged from the TA-53 lagoons. The elimination of discharges was the result of modifications to the TA-53 lagoons to separate sanitary and industrial waste waters. Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon, where surface flow has not passed beyond the Laboratory's boundary since the plant began operation in 1963 (Table VI-1).

C. Radiochemical and Chemical Quality of Surface Water and Groundwater

1. Background. Surface waters and groundwaters from regional, perimeter, and on-site stations are monitored to provide routine surveillance of Laboratory operations (Figs. 15 and 16, Table G-14). Concentrations of radionuclides in environmental water samples, whether within the DOE site boundary or off-site, are compared with derived concentration guides (DCGs) for ingested water calculated from DOE's public dose limits (Appendix A). Derived concentration guides do not account for accumulating mechanisms that may exist in environmental pathways. Consequently, other media such as sediments, soils, and foodstuffs are also monitored (see subsequent sections).

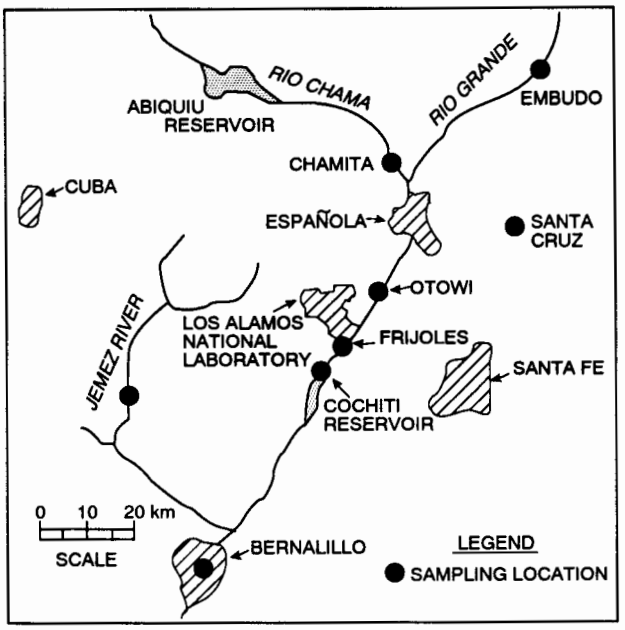


Fig. 15. Regional surface water, sediment, and soil sampling locations.

Concentrations of radioactivity in samples of water from the water supply wells completed in the Los Alamos main aquifer are compared to New Mexico Environmental Improvement Division (NMEID) and Environmental Protection Agency (EPA) drinking water standards or to the DOE derived concentration guides applicable to DOE drinking water systems, which are more restrictive in a few cases (see Appendix A).

Routine chemical analyses of water samples have been carried out for many constituents over a number of years. Although surface water and shallow groundwater are not sources of municipal or industrial water supplies, results of these analyses are compared with NMEID and EPA drinking water standards (maximum concentration levels [MCLs]), as these are the most restrictive related to potential water use.

2. Regional Stations. Regional surface water samples were collected within 75 km (47 mi) of the Laboratory from six stations on the Rio Grande, Rio Chama, and Jemez River (Fig. 15). The six water sampling stations were located at USGS gaging stations. These waters provided baseline data for radiochemical and chemical analyses in areas beyond the Laboratory boundary. Stations on the Rio Grande were at Embudo, Otowi, Cochiti, and Bernalillo.

The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 37 000 km^2 (14 300 mi^2) in southern Colorado and northern New Mexico. Discharge for the periods of record (1895–1905 and 1909–1989) has ranged from a minimum of 1.7 m^3/s (60 ft^3/s) in 1902 to 691 m^3/s (24 400 ft^3/s) in 1920. The discharge for water year 1989 (October 1988 through September 1989) ranged from 8.4 m^3/s (298 ft^3/s) in September to 115 m^3/s (4070 ft^3/s) in April (USGS 1990).

The Rio Chama is a tributary to the Rio Grande upstream from Los Alamos (Fig. 15). At Chamita on the Rio Chama, the drainage area above the station is 8 143 km^2 (3 143 mi^2) in northern New Mexico, together with a small area in southern Colorado. Since

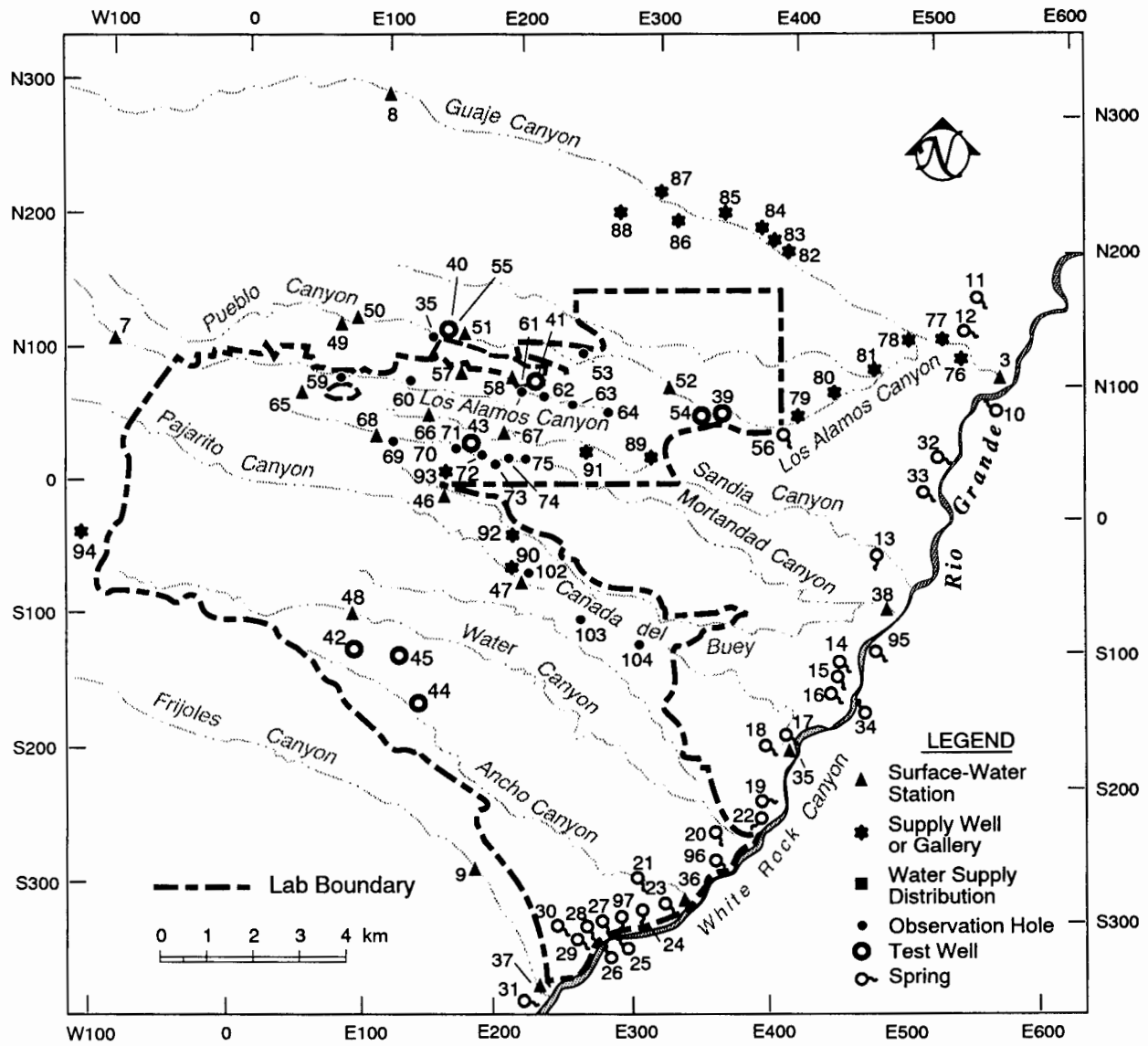


Fig. 16. Surface water and groundwater sampling locations on and near the Laboratory site.

1971, some flow has resulted from transmountain diversion water from the San Juan drainage. Flow at the Chamita gage is governed by release from several reservoirs. Discharge at Chamita during water year 1990 ranged from 1 m^3/s (35 ft^3/s) in June to 69.3 m^3/s (2 450 ft^3/s) in April.

The station at Jemez on the Jemez River drains an area of the Jemez Mountains west of Los Alamos. The Fenton Hill Hot Dry Rock Geothermal Facility (TA-57) is located within this drainage. The drainage area is small, about 1 220 km^2 (471 mi^2). During water year 1989, discharge ranged from 0.34 m^3/s (12 ft^3/s) in June and July to 11.9 m^3/s (422 ft^3/s) in March. The river is a tributary to the Rio Grande downstream from Los Alamos.

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

a. Radiochemical Analyses. Surface water samples from regional stations were collected in April 1990. Tritium, cesium, plutonium, and total uranium activity levels in these waters were low (Tables VI-2 and G-15). Samples collected downstream on the Rio Grande from the Laboratory showed no effect from the Laboratory's operation. Sampling results in 1990 exhibited no major differences from those in 1989. Maximum concentrations of radioactivity in regional surface water samples were well below DOE's DCGs for public dose.

b. Chemical Analyses. Surface water samples from regional stations were collected in April 1990. Maximum concentrations in regional water samples were well below drinking water standards (Tables VI-3 and G-16). There were some variations from previous years' results. These fluctuations are caused by chemical changes that occur with variations in discharges at the sampling stations. This is normal, and no inference can be made that the water quality at these stations is deteriorating.

3. Perimeter Stations. Perimeter stations within 4 km (2.5 mi) of Los Alamos included surface water stations at Los Alamos Reservoir, Guaje Canyon, Frijoles Canyon, and three springs (La Mesita, Indian, and Sacred Springs). Other perimeter stations were in White Rock Canyon along the Rio Grande just east of the Laboratory. Included in this group were stations at 22 springs, four streams, and a sanitary effluent release area (Fig. 16 and Table G-14).

Los Alamos Reservoir, in upper Los Alamos Canyon on the flanks of the mountains west of Los Alamos, has a capacity of 51 000 m^3 (41 ac-ft) and a drainage area of 17 km^2 (6.4 mi^2) above the intake. The reservoir is used for storage and recreation. Water flows by gravity through about 10 km (6.4 mi) of water lines for irrigation of lawns and shrubs at the Laboratory's Health Research Laboratory (TA-43), the Los Alamos High School, and the University of New Mexico's Los Alamos Branch.

The station in Guaje Canyon is below Guaje Reservoir, which is located in upper Guaje Canyon and has a capacity of 900 m^3 (0.7 ac-ft) and a drainage area above the intake of about 14 km^2 (5.6 mi^2). The reservoir is used for diversion rather than storage, as flow in the canyon is maintained by perennial springs. Water flows by gravity through 9.0 km (5.6 mi) of water lines for irrigation of lawns and shrubs at Los Alamos Middle School and Guaje Pines Cemetery. The stream and reservoir are also used for recreation.

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 Johnson Controls World Services. Diversion for irrigation is usually from May through October.

Surface water 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 monument headquarters is about 45 km^2 (17 mi^2) (Purtymun 1980a).

La Mesita Spring 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 seepage areas. Total discharge at each spring is probably less than 1 L/s (0.3 gal./s).

Perimeter stations in White Rock Canyon are composed of four groups of springs. The springs discharge from the main aquifer. Three groups (I, II, and III) have similar, aquifer-related chemical quality. Water from these springs is from 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.

Four streams that flow into the Rio Grande were also sampled. Streams in Pajarito, Water, 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 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-17 through G-21.

a. Radiochemical Analyses. Measurements of tritium, cesium, plutonium activity, and total uranium

Table VI-2. Maximum Concentrations of Radioactivity in Surface Waters and Groundwaters from Off- and On-Site Stations

	Number of Stations Sampled	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)
Analytical Limits of Detection		0.7	40	1.0	0.1	0.1
Off-Site Stations (Uncontrolled Areas)						
Derived concentration guide (DCG)[a]		2 000	3 000	800	40	30
Regional	6	0.4 (0.3)[b]	42 (63)	3.1 (0.2)	0.013 (0.015)	0.012 (0.007)
Perimeter						
Adjacent	6	0.5 (0.3)	205 (136)	18.8 (2.7)	0.013 (0.010)	0.009 (0.009)
White Rock	24	0.6 (0.3)	167 (84)	31 (3.1)	0.069 (0.019)	0.021 (0.013)
Off-Site Stations Group Summary						
Maximum concentration		0.6 (0.3)	205 (136)	31 (3.1)	0.069 (0.019)	0.021 (0.013)
Maximum concentration as a percentage of DCG		0.03	6.8	3.9	<0.17	<0.07
On-Site Stations (Controlled Areas)						
Noneffluent Release Areas						
Ground water (main aquifer)	5	0.5 (0.3)	209 (98)	0.6 (0.1)	0.028 (0.013)	0.028 (0.015)
Surface water	3	0.3 (0.3)	127 (88)	0.2 (0.1)	0.008 (0.012)	0.118 (0.031)
Observation wells (Pajarito Canyon)	3	0.1 (0.3)	132 (97)	1.2 (0.2)	0.027 (0.012)	0.027 (0.014)
Effluent Release Areas						
Acid-Pueblo canyons	6	0.4 (0.3)	162 (96)	2.5 (0.1)	0.009 (0.015)	0.360 (0.044)
DP—Los Alamos canyons	8	35 (4.0)	122 (95)	6.6 (0.7)	0.036 (0.019)	0.393 (0.050)
Sandia Canyon	3	0.4 (0.3)	35 (63)	1.1 (0.1)	0.029 (0.016)	0.012 (0.012)
Mortandad Canyon	7	190 (20)	288[c] (110)	4.8 (0.1)	0.705 (0.058)	2.65 (0.137)
On-Site Stations Group Summary						
Maximum concentration		190 (20)	288[c] (110)	4.8 (0.1)	0.705 (0.058)	2.65 (0.137)
Maximum concentration as a percentage of DCG		9.5	9.6	0.6	1.8	8.8

[a]See Appendix A.

[b]Counting uncertainties are in parentheses.

[c]This concentration was measured in water on site. The water is confined within the Laboratory boundary.

Table VI-3. Maximum Chemical Concentrations in Surface Waters and Groundwaters from Regional and Perimeter Stations (mg/L)

	Number of Stations	Ca	Na	Cl	F	NO_3-N	TDS[a]
Regional Stations							
Rio Chama	1	61	31	7	0.3	0	366
Rio Grande	4	51	50	22	0.5	0.3	356
Jemez River	1	40	35	28	0.6	<0.1	336
Perimeter Stations							
Surface water	3	12	10	57	0.2	4.9	164
Springs	3	44	38	13	0.5	8.2	746
White Rock Canyon							
Group I	8	47	31	6	0.7	1.3	226
Group II	11	31	29	4.1	0.5	1.2	254
Group III	2	37	83	5.9	1.2	0.9	308
Group IV	1	28	140	4	0.7	2.8	328
Streams	4	42	16.5	4.6	0.5	0.8	198
Sanitary effluent	1	40	92	35	0.5	7.3	400
Drinking Water Standard[b]							
(for comparison)		—	—	250	4.0	10	500

[a]Total dissolved solids.
[b]NMEIB (1988) and EPA (1989).

in samples collected at perimeter stations were low, well below DOE's DCGs for public exposure (Tables VI-2, G-17, and G-19).

b. Chemical Analyses. Maximum chemical concentrations in samples from the perimeter stations are shown in Tables VI-3, G-18, G-20 and G-21. Chemical concentrations in water samples from 22 springs and four streams in White Rock Canyon varied slightly but showed no major changes from concentrations recorded for the previous year (Table G-20). Additional measurements of trace metals were initiated in 1990 on these samples, results are presented in Table G-21). Even though none of these waters are used for water supply, maximum concentrations were below standards that apply to drinking water.

4. On-Site Stations. On-site sampling stations are grouped by location in (1) noneffluent release areas and (2) effluent release areas (areas that receive, or have received, treated industrial or sanitary effluents) (Fig. 16, Table G-14).

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

Test Wells 1 and 2 are in the lower and middle reaches of Pueblo Canyon. Depths to the top of the main aquifer are 181 m and 231 m (594 ft and 758 ft), respectively. The pumps in Test Wells 1 and 2 were down for repairs in 1990, and water from the wells was not sampled. Test Well 3 in the midreach of Los Alamos Canyon has a depth of 228 m (748 ft) to the top of the main aquifer. Test Wells DT-5A, DT-9, and DT-10 are at the southern edge of the Laboratory. Depths to the top of the main aquifer are 359 m, 306 m, and

332 m (1 180 ft, 1 006 ft, and 1 090 ft), respectively. Test Well 8 is in the midreach of Mortandad Canyon. The top of the main aquifer here lies about 295 m (968 ft) below the surface.

These test wells are constructed to seal out all water above the main aquifer. The wells are used to monitor for potential effects that the Laboratory's operation may have on water quality in the main aquifer.

Surface water samples are collected in Cañada del Buey and in Pajarito and Water Canyons downstream from technical areas to monitor the quality of runoff 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-14). Water in the alluvium is perched on the underlying tuff and is recharged through storm runoff. The observation wells were constructed to determine if technical areas in the canyon or adjacent mesas were affecting the quality of shallow groundwater.

Radiochemical concentrations from surface water and groundwater sources showed no effects from Laboratory operations (Tables VI-2 and G-22). Concentrations of tritium, cesium, and plutonium were at or below limits of detection.

Chemical quality of groundwater from the test wells into the main aquifer reflected local conditions of the aquifer around the well (Tables VI-4 and G-23). Quality of surface water and water in observation wells in Pajarito Canyon varied slightly. The effect, if any, was small and probably was the result of natural seasonal fluctuations.

b. Effluent Release Areas. On-site effluent release areas are in canyons that receive, or have received, treated industrial or sanitary effluents. These include DP-Los Alamos, Sandia, and Mortandad Canyons. Also included is Acid-Pueblo Canyon, which is a former on-site release area for industrial effluents. Acid and a portion of Pueblo Canyon (Fig. 5) are now on Los Alamos County land to a point about 1 190 m (3 900 ft) west of the Los Alamos-Santa Fe County Line (Fig. 16). Acid-Pueblo Canyon received untreated and treated industrial effluent, that contained residual radionuclides from 1944 to 1964 (ESG 1981). The canyon also receives treated sanitary effluent from Los Alamos County Bayo sewage treatment plant in the middle reach of Pueblo Canyon. Increased discharge of sanitary effluent from the County treatment plant in 1990 resulted in perennial flow in the lower reach of Pueblo Canyon and flow into Los Alamos Canyon during most months of the year. During the peak irrigating season (mid-June through early August), the reduction in treatment plant discharge because of effluent diversion for golf course irrigation and higher evapotranspiration eliminated flow into Los Alamos Canyon.

Table VI-4. Maximum Chemical Concentrations in Surface Waters and Groundwaters from On-Site Stations (mg/L)

	Number of Stations Sampled	Ca	Na	Cl	F	NO_3-N	TDS
Ground Water (main aquifer)	5	23	14	3	0.4	0.6	422
Surface Water	3	25	33	39	0.7	0.9	288
Observation Wells (Pajarito Canyon)	3	20	36	19	0.01	0.4	612
Drinking Water Standard[a] (for comparison)		—	—	250	4.0	10	500

[a]NMEIB (1988) and EPA (1989).

Water occurs seasonally in the alluvium, depending on the volume of surface flow from sanitary effluents and storm runoff. Hamilton Bend Spring, which in the past discharged from alluvium in the lower reach of Pueblo Canyon, was dry all of the year in 1990 because there was no discharge from the Los Alamos County Pueblo sewage treatment plant. The primary sampling stations are surface water stations at Acid Weir, Pueblo 1, Pueblo 2, and Pueblo 3 (Table G-14). Two other sampling stations are located in the middle reach (Test Well 2A) and lower reach (Test Well 1A) of Pueblo Canyon. Test Well 2A (drilled to a depth of 40.5 m [133 ft]) penetrates the alluvium and Bandelier Tuff and is completed into the Puye Conglomerate. Aquifer tests indicate that the perched aquifer is of limited extent. Measurements of water levels over a period of time indicate that the perched aquifer is hydrologically connected to the stream in Pueblo Canyon. Perched water in the basaltic rocks is sampled from Test Well 1A and Basalt Spring further eastward in lower Los Alamos Canyon. Recharge to the perched aquifer in the basalt occurs near Hamilton Bend Spring. Travel time for water from the recharge area near Hamilton Bend Spring to Test Well 1A is estimated to be 1 to 2 months, with another 2 to 3 months required to reach Basalt Spring.

DP-Los Alamos Canyon has received treated industrial effluents, which contain some radionuclides and some sanitary effluent from treatment plants at TA-21. Treated industrial effluents were released into the canyon between 1952 and 1984. In the upper reaches of Los Alamos Canyon (above station LAO-1), there were occasional releases of cooling water from the research reactor at TA-2. Los Alamos Canyon has also received discharge in previous years from the lagoons at LAMPF (TA-53). On the flanks of the mountains, Los Alamos Reservoir impounds runoff from snowmelt and rainfall. Stream flow from this impoundment into the canyon is intermittent, dependent on precipitation to cause runoff to reach the Laboratory boundary at State Road 4.

Infiltration of treated effluents and natural runoff from the stream channel maintains a shallow body of water in the alluvium of Los Alamos Canyon. Water levels are highest in late spring from snowmelt runoff and in late summer from thundershowers. Water levels decline during the winter and early summer, when storm runoff is at a minimum. Sampling stations consist of two surface water stations in DP Canyon and six observation wells completed into the alluvium in Los Alamos Canyon (Table G-14).

Sandia Canyon has a small drainage area that heads on Pajarito Plateau at TA-3. The canyon receives cooling tower blowdown from the TA-3 power plant and treated sanitary effluents from TA-3. Treated effluents from the TA-3 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 indicate that no perched water is in the alluvium in this area. Three surface water sampling stations in the reach of the canyon contain perennial flow (Table G-14).

Mortandad Canyon has a small drainage area that also heads at TA-3. 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, 1983). The top of the main aquifer is about 290 m (950 ft) below the perched aquifer. Hydrologic studies in the canyon began in 1960. Since that time, there has been no surface water flow beyond the Laboratory's boundary because the small drainage area in the upper part of the canyon results in limited runoff and because a thick section of unsaturated alluvium in the lower canyon allows rapid infiltration and storage of runoff when it does occur. Monitoring stations that were sampled in the canyon this year consist of one surface water station, Gaging Station 1 (GS-1) and six observation wells in the shallow alluvial aquifer. At times, wells in the lower reach of the canyon are dry.

An additional special set of water samples was collected from selected existing observation wells and adjacent new ones installed in Pueblo, Los Alamos, and Mortandad Canyons under conditions of the Laboratory's Resource Conservation and Recovery Act/Hazardous & Solid Waste Amendment permit

issued by the EPA in March, 1990. Results of this special study are summarized in Section IX. G of this report.

Acid-Pueblo, DP-Los Alamos, Sandia, and Mortandad Canyons all contain surface water and shallow groundwater with measurable amounts of radioactivity (Tables VI-2 and G-24). Radionuclide concentrations from treated effluents decreased down gradient in the canyon because of dilution and adsorption of radionuclides on alluvial sediments. Surface water and shallow groundwater in these canyons are not a source of municipal, industrial, or agricultural water supply. Only during periods of heavy precipitation or snowmelt would waters from DP-Los Alamos or Sandia Canyons extend beyond Laboratory boundaries and reach the Rio Grande. The increased flow from the County-operated Bayo sanitary sewage treatment plant this year resulted in flow in Pueblo Canyon across the DOE property and into lower Los Alamos Canyon most days of all months except June and July. In Mortandad Canyon, there has been no surface runoff to or across the Laboratory's boundary since hydrologic studies were initiated in 1960. This was three years before the treatment plant at TA-50 began releasing treated effluents into the canyon (Purtymun 1983).

Long-term trends of radionuclide concentrations in surface water in Pueblo Canyon (a former release area) is depicted in Fig. 17. These measurements were made on samples collected at Station Pueblo 3 (No. 52 on Fig. 16) which is a short distance upstream of the confluence of Pueblo and Los Alamos Canyons. In general there has been a decrease in Plutonium (238 and 239 total) over the three and a half decades, to the point where most recent measurements are below detection limits. The tritium concentrations peaked in 1982 and have decreased over the last ten years to values typically observed in regional surface waters and very near the detection limit of the methods of analysis.

Long-term trends of radionuclide concentrations in shallow alluvial groundwater in Mortandad Canyon (current release area) is depicted in Figure 18. The samples are from observation Well MCO-6, about midway down the reach of the canyon that has been affected by effluents from the radioactive liquid waste treatment plant at TA-50. The plutonium (238 and 239 total) concentrations are relatively constant, fluctuating up and down in response to variations in the treatment plant effluent and storm runoff water that causes some dilution in the shallow alluvial water. The tritium concentration has fluctuated almost in direct response to the average annual concentration of tritium in the TA-50 effluent, with a time lag of about one year.

Maximum chemical concentrations occurred in water samples taken near treated effluent outfalls (Tables VI-5 and G-25). Chemical quality of the water generally shows lower concentrations of effluent-related chemical constituents downstream from the outfalls. High nitrate concentrations were found in waters from Mortandad Canyon which receives the largest volume of industrial effluents (Purtymun 1977). Additional measurements of trace metals were initiated in 1990 on these samples; results are presented in Table G-26. Although the concentrations of some chemical constituents in the waters of these canyons were elevated above natural background (because of industrial and sanitary effluents), the concentrations do not cause concern because these on-site surface waters and shallow groundwaters are not sources of municipal, industrial, or agricultural water supply. Surface water flows from Acid-Pueblo and DP-Los Alamos Canyons reach the Rio Grande only during spring snowmelt or heavy summer thunderstorms. No surface runoff to or beyond the Laboratory boundary has been recorded in Mortandad Canyon since 1960 when observations began.

5. Water Supply Wells. The main aquifer is the only aquifer in the area capable of municipal and industrial water supply (Sec. II). Water for the Laboratory and community is supplied from 16 deep wells in three well fields. The well fields are on the Pajarito Plateau and in canyons east of the Laboratory (Fig. 19). Seven test wells are also completed into the main aquifer. Monitoring of these production and test wells provides an extensive coverage of the main aquifer in terms of the capability to detect any effect of Laboratory operations on the water quality.

The Los Alamos well field comprises four producing wells. Wells LA-6, LA-4, and LA-1 were not used in 1990, and their pump houses were demolished in 1990 as the initial steps in phasing out of the Los Alamos well field. Most of the wells in the field had reached the limit of economically useful production (Purtymun 1988c) and anticipated highway construction scheduled to start in 1991 will require discontinuance of the transmission line. Wells in the field range in depth from 265 m to 610 m (870 ft to 2 000 ft).

Table VI-5. Maximun Chemical Concentrations in Water from On-Site Effluent Release Areas (mg/L)

	Number of Stations	Ca	Na	Cl	F	NO_3-N	TDS
Acid-Pueblo Canyon	6	47	156	174	1.0	10.6	548
DP–Los Alamos Canyon	8	32	142	96	1.3	0.7	882
Sandia Canyon	3	27	138	55	0.6	8.9	400
Mortandad Canyon	7	64	229	31	1.9	86.2	982
Drinking water standard[a] (for comparison)		—	—	250	4.0	10	500

[a]NMEIB (1988) and EPA (1989).

Movement of water in the upper 411 m (1 350 ft) of the main aquifer in this area is eastward at about 6 m/yr (20 ft/yr) (Purtymun 1984).

The Guaje well field is composed of seven producing wells. Wells in this field range in depth from 463 m to 610 m (1 520 ft to 2 000 ft). Movement of water in the upper 430 m (1 410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

The Pajarito well field is composed of five wells ranging in depth from 701 m to 942 m (2 300 ft to 3 090 ft). Movement of water in the upper 535 m (1 750 ft) of the aquifer is eastward at 29 m/yr (95 ft/yr). Water for drinking and industrial use is also obtained from a well at the Laboratory's experimental geothermal site (Fenton Hill, TA-57) about 45 km (28 mi) west of Los Alamos. The well is about 133 m (436 ft) deep, completed in volcanics.

Two new water supply wells were completed in 1990. These are the first wells in a new field designated as the Otowi well field. A summary of the drilling, casing, and test pumping is provided in Sec. IX.H. Sampling of the distribution system to confirm compliance with Federal and State drinking water standards in the distribution system is discussed in Sec. VIII.E.

a. Radioactivity in the Water Supply Wells. The maximum radioactivity concentrations found in the water supply wells and gallery are shown in Tables VI-6 and G-27. Analyses of water from each of the wells showed that concentrations of radioactivity with the exception of one ^{137}Cs measurement were below the drinking water regulatory levels applicable to DOE drinking water systems. The cesium measurement for Well LA-2 was about twice the DCG (Table VI-6 and G-27) but is believed to be a statistical outlier as it is about twice the standard deviation of the measurement and was not confirmed by the gross gamma measurement of the sample. Water in the distribution system was in compliance with drinking water regulations (see Sec. VIII.E).

A special sample was collected for analysis of plutonium isotopes by unique extra-low-level mass spectrometric measurement facilities available in the Isotope Geochemistry Group (INC-7) at Los Alamos National Laboratory. The sample was collected from one of the newly drilled production wells, Otowi 4 near the end of the aquifer pumping test on April 4, 1990. The large volume sample (approximately 200 L) of the chemically separated and traced plutonium was analyzed by state-of-the-art thermal ionization mass spectrometry. The results showed less than 0.00008 pCi/L of ^{239}Pu, with the limit being constrained by the value of the method blanks. This detection limit is about 1 000 times smaller than levels detected in routine radiochemical methods at LANL, which have a detection limit of about 0.1 pCi/L for $^{239\text{-}240}Pu$. This analyses pushed the detection limits down by a factor of 1 000 below any previous measurements. No evidence of the presence of any plutonium was found. These results further confirm that operation of the Laboratory over the years has had no effect on the main

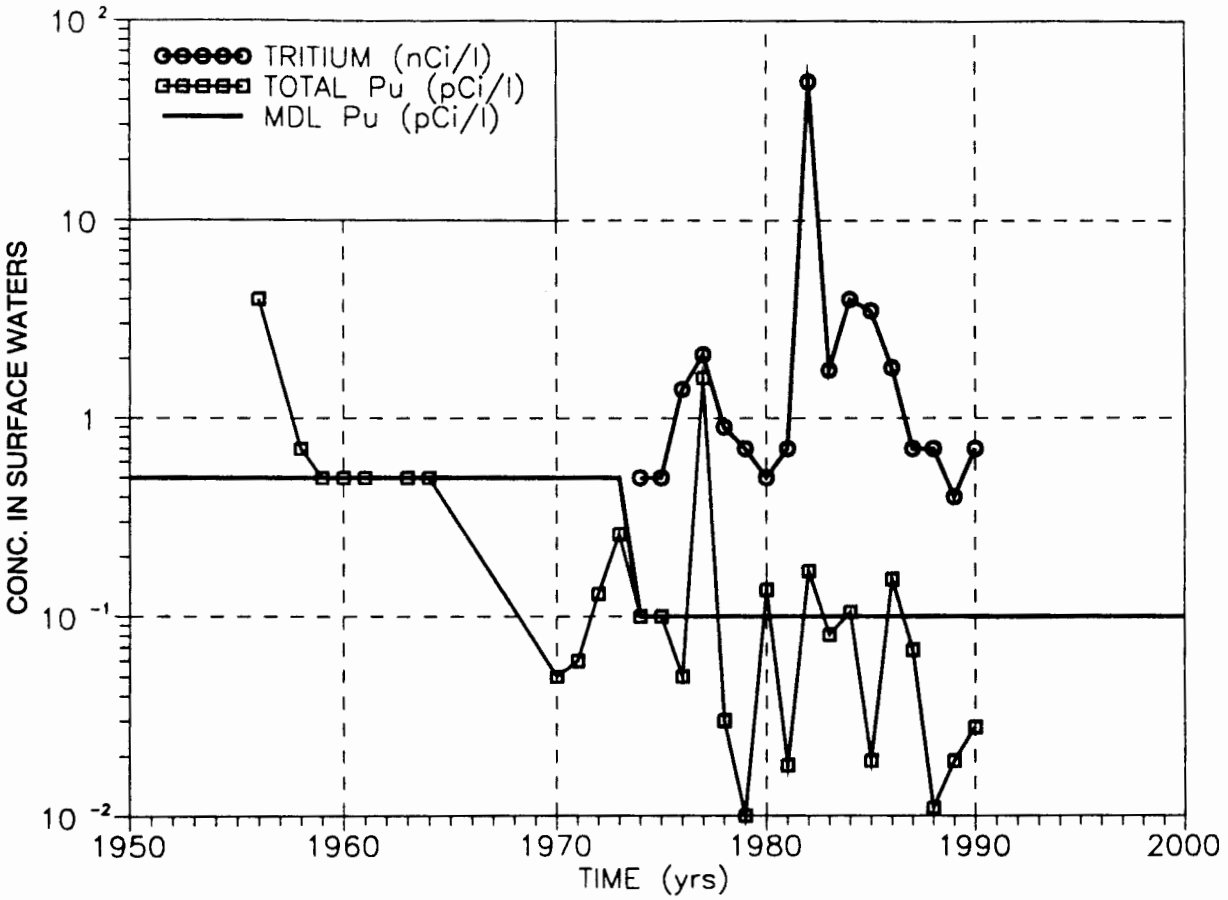


Fig 17. Pueblo-3, Tritium and Plutonium concentrations.

aquifer. The new production well Otowi 4 in particular is almost directly downgradient from TA-21, where solid and liquid wastes containing plutonium were disposed on the mesa tops in years past.

The long-term trends of the water quality in the main aquifer are simple to summarize: no measurements of radionuclides above detection limits (other than an occasional analytical statistical outlier) have been made on water samples from the production wells or test wells that reach the main aquifer. There is no indication that any contamination of the main aquifer has occurred as a result of Laboratory operations.

b. Chemical Quality of the Water Supply Wells. The chemical quality of water from wells is within EPA's primary and secondary standards (Tables VI-7, G-28, and G-29). Two wells, LA-2 and LA-5, had pH values (8.6) slightly exceeding the standard (8.5) for drinking water systems. All other parameters for all of the wells were within standards applicable to the distribution system.

The quality of water from the wells varied with local conditions within the same aquifer (Tables G-28 and G-29). Water quality depends on well depth,

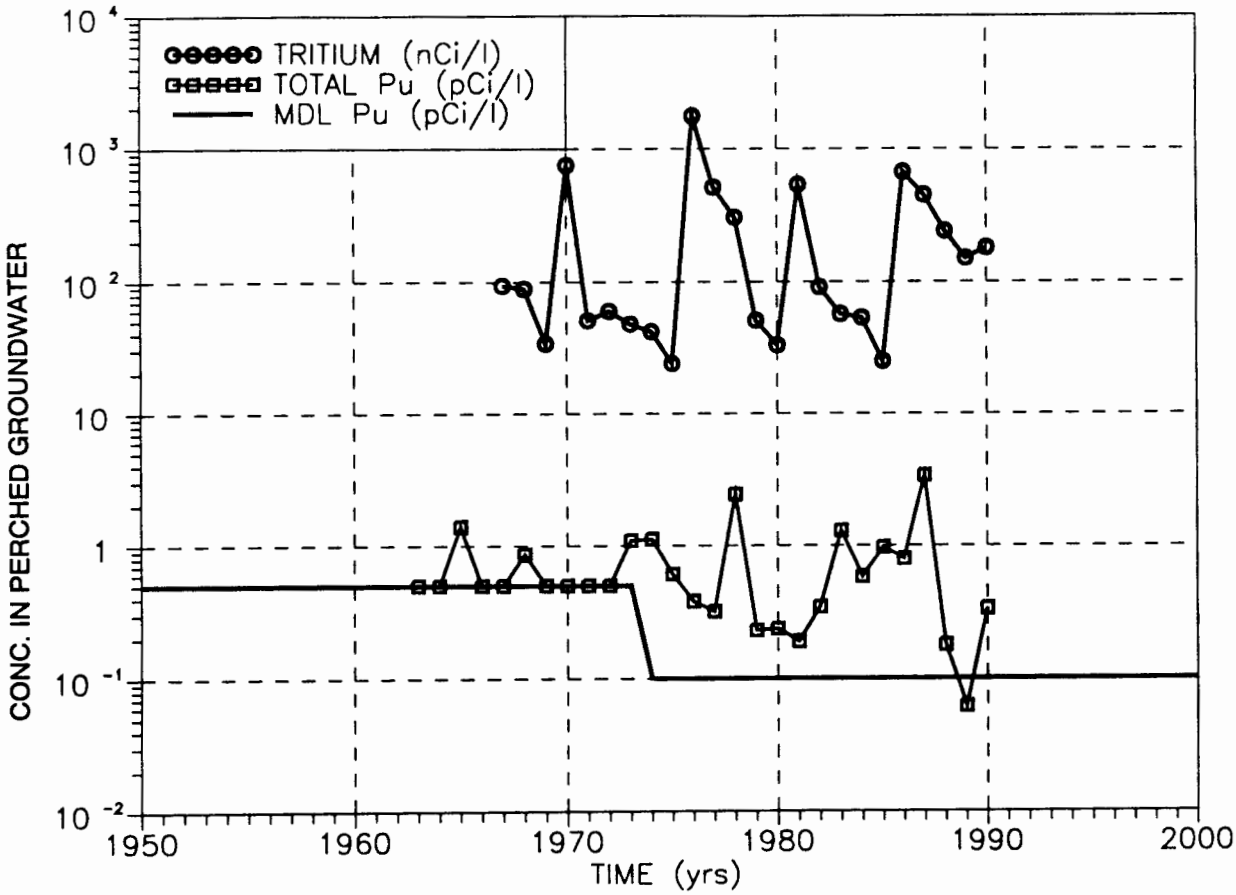


Fig. 18. MCO-6, Tritium and Plutonium concentrations.

lithology of the aquifer adjacent to the well, and yield from beds within the aquifer.

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

Natural surface runoff occurs in two modes: (1) spring snowmelt runoff occurs over a long period of time (days) at a low discharge rate and sediment load; (2) summer runoff from thunderstorms occurs over a short period of time (hours) at a high discharge rate and sediment load. In 1990, increased effluent flow from the Los Alamos County Bayo sanitary sewage treatment plant resulted in flow through the lower part of Pueblo Canyon and into Los Alamos Canyon during most of the year. This flow transported some of the contaminated sediments out of Pueblo Canyon and into

Table VI-6. Maximum Concentrations of Radioactivity in Water from Supply Wells and the Distribution System

	Number of Stations Sampled	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)
Analytical limits of detection		0.7	40	1.0	0.1	0.1	3	3
Maximum contaminant level (MCL)[a]		20[a]	120[b]	32[b]	1.6[b]	1.2[b]	15[a]	50[a]
Maximum Concentration in Supply wells (Los Alamos)	16	0.8	263	5.6	0.047	0.031	3	39
Maximum Concentration as Percent of MCL[c]		4	219	17	2.9	2.6	20	78

[a]Maximum Contaminant Level (MCL), used for comparison only, see Appendix A; NMEIB (1988) and EPA (1989).

[b]DOE Derived Concentration Guide applicable to DOE Drinking Water Systems, used for comparison only, (see Appendix A).

[c]The regulations are applicable to water in the distribution system but are used for comparison only in the case of individual supply wells.

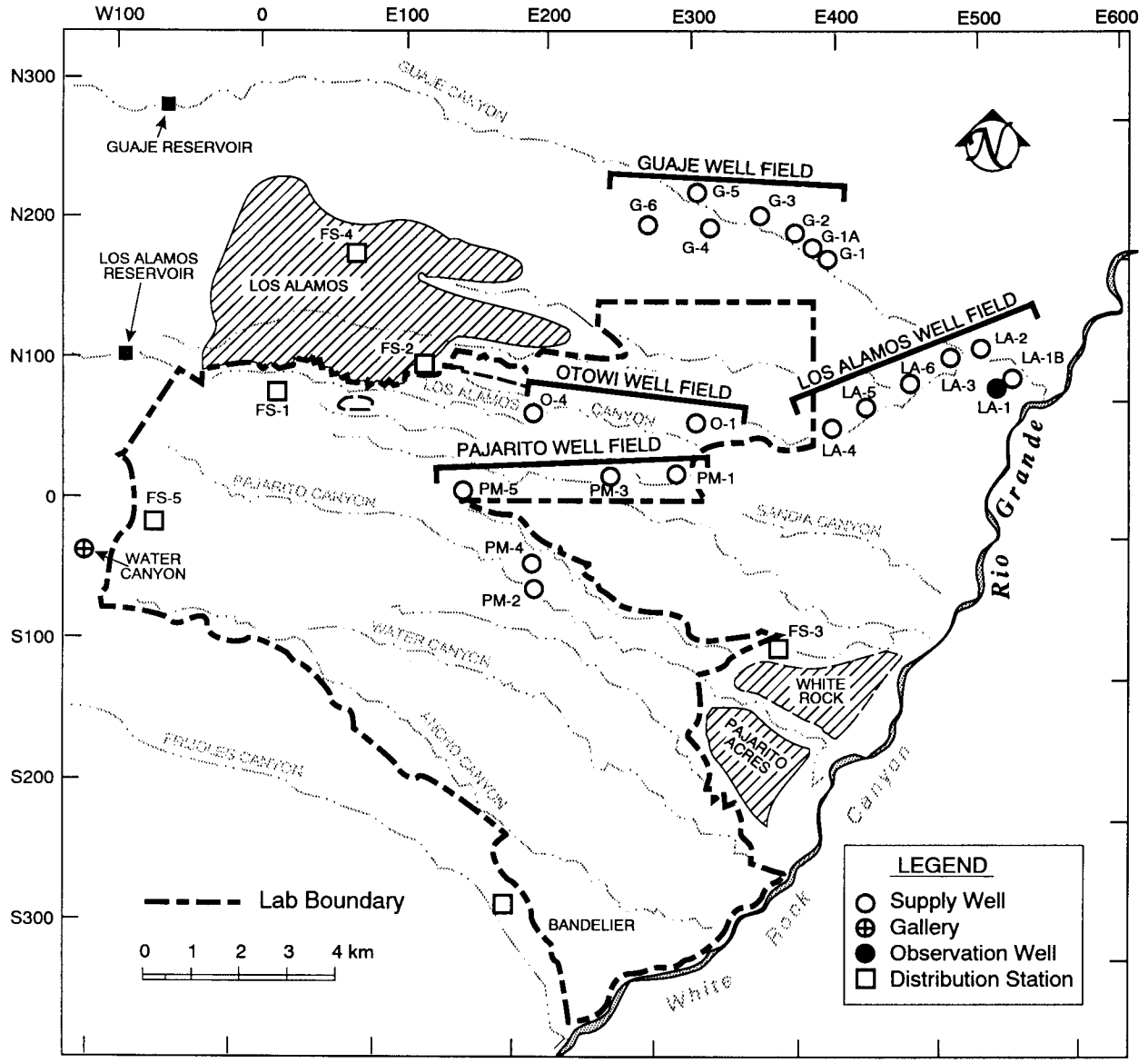


Fig. 19. Locations of reservoirs, well fields, supply wells, and gallery water supply.

the lower reach of Los Alamos Canyon. This effluent-induced flow from Pueblo Canyon entered Los Alamos Canyon on most days except for the period from about mid-June to early August, and typically extended to a location between Wells LA-6 and LA-2 in Los Alamos Canyon (Fig. 19).

Nine samples of runoff collected from this Pueblo Canyon flow near where the canyons join at State Road 502 were analyzed for radioactivity in solution and suspended sediments (Fig. 17). These runoff samples contained above-background amounts of cesium, strontium, and plutonium in solution (Table G-30) as expected from the residuals of historic releases into Pueblo Canyon (see Sec. VI.C.4.b. above). Concentrations of plutonium on the suspended sediments were above background levels (Table G-30 and Table VI-8). (Radioactivity in solution refers to the filtrate that passes through a 0.45-μm-pore-size filter; radioactivity in suspended sediments refers to the residue retained by the filter.)

Table VI-7. Maximum Chemical Concentrations in Water from Supply Wells

	Standard[a]	Supply Wells	Percentage of Standard
Number of Stations		16	
Chemical Constituents (mg/L)			
Primary			
Ag	0.05	0.001	<2
As	0.05	0.041	82
Ba	1.0	0.088	9
Cd	0.01	0.001	10
Cr	0.05	0.028	56
F	4.0	3.2	80
Hg	0.002	<0.0002	<10
NO_3 (N)	10	0.1	1
Pb	0.05	0.027	54
Se	0.01	0.001	<10
Secondary			
Cl	250	15	6
Cu	1.0	0.100	10
Fe	0.3	0.069	2.3
Mn	0.05	0.005	10
SO_4	250	53	21
Zn	5.0	0.237	<5
TDS	500	388	78
pH	6.8–8.5	8.6	101

[a]Maximum Contaminant Levels (MCL) for primary and secondary drinking water standards (NMEIB [1989] and EPA [1989]) are given for comparison only (see Appendix A).

A special study, "Transport of Plutonium in Snowmelt Run-Off," (Purtymun 1990a) was completed and published in 1990. This study reported and interpreted data from measurements of snowmelt runoff from seven events occurring between 1975 and 1986 in Pueblo and Los Alamos Canyons. The major conclusions include the finding that most plutonium moved by runoff in these canyons and reaching the Rio Grande is transported with sediments at the mouth of Los Alamos Canyon about 57% with suspended sediments and 40% with bed sediments. A total of about 600 μCi of plutonium was carried to the Rio Grande by five of the seven studied events.

Results of that special study were combined with the current measurements described above for the effluent-supported runoff in Pueblo Canyon during 1990 as the basis for estimating transport of plutonium into Los Alamos Canyon. The estimate of plutonium transported in solution and on suspended sediments from Pueblo into Los Alamos Canyon is presented in Table VI-8. By comparison with the spring snowmelt runoff we estimate that bed load sediments probably carried two to three times as much plutonium as the dissolved and suspended sediment components. Thus the total amount of plutonium transported from Pueblo into Los Alamos Canyon could be as much as 4 000 μCi. The approximate total of 1 010 μCi carried in solution and suspended sediment is about 20 times the amount carried from Pueblo into Los Alamos Canyon during four spring runoffs measured in 1975, 1979,

Table VI-8. Plutonium Transport in Runoff from Pueblo Canyon into Los Alamos Canyon

Sample Date 1990	^{239}Pu Dissolved 10^{-9}µCi/mL	^{239}Pu Suspended pCi/g	Suspended Sediment (g/L)	Total Pu[a] (pCi/L)	Estimated Flow[b] (MGD)	Assumed Days of Flow	Estimated Transport[c] (µCi)
March 2	0.025	1.56	0.78	1.33	0.49	61	150.68
March 13	0.024	5.02	0.50	2.59	0.49	11	52.74
March 26	0.010	4.11	2.20	9.14	0.49	13	220.02
April 9	0.024	4.67	0.59	2.84	0.35	14	52.43
April 20	0.007	1.12	0.92	1.09	0.29	11	13.18
June 1	0.024	–[d]	–[d]	0.18[d]	0.18	42	5.18
July 19[e]					0[e]	66	0.00
August 7	0.032	3.68	0.96	3.58	0.16	72	157.53
November 15	0.076	3.18	0.87	2.87	0.43	29	135.02
December 5	0.093	31.10	0.06	2.02	0.64	46	224.29
						Total	1 011

[a] Total Plutonium including both ^{238}Pu and ^{239}Pu in solution and on suspended sediments (Table G-25).

[b] Estimated flow at the point where Pueblo Canyon flows under State Road 502 and joins Los Alamos Canyon. Flow was estimated on the basis of reported average daily discharge from the Los Alamos County Bayo sewage treatment plant multiplied by a visually estimated fraction of flow reaching the State Road.

[c] Estimated transport of total Plutonium in solution and on suspended sediments. Bed load was not measured, but based on comparison with snowmelt runoff studies (Purtymun 1990a), can be estimated as transporting two to three times as much plutonium as carried in solution and on suspended sediments.

[d] Mass of sediment not recorded in laboratory analysis; Pu analysis was for total sample.

[e] This date of observation is approximate midpoint of period when flow past the State Road ceased or was very small. For purpose of estimating transport, the entire period from 6/1/90 through 8/7/90 was considered to have no flow.

1985, and 1986. If estimated bed sediments are also considered, the effluent-created runoff during 1990 probably carried about 18 to 25 times as much plutonium as the four spring runoffs.

The increased transport of contaminated sediments from Pueblo Canyon is not expected to have any significant effect on the concentrations of plutonium on sediments in Lower Los Alamos Canyon. This is because the concentrations on sediments in Pueblo and Lower Los Alamos Canyons have been similar for many years (ESG 1981). However, there is an estimated inventory of about 400 mCi of plutonium in lower Pueblo Canyon, which is about 10 to 15 times the <30 mCi in DP and Los Alamos Canyons. Thus, there may be an increase in the total inventory in Lower Los Alamos Canyon because of the increased input from Pueblo Canyon. However, the steady input from Pueblo Canyon is comparable to amounts moved into Lower Los Alamos Canyon from the upper portions of Los Alamos Canyon. For example, the special snowmelt study (Purtymun 1990b) measured input from the upper part of Los Alamos Canyon as ranging from 83 to 3 574 μCi during eight events between 1973 and 1986, and averaging about 1 400 μCi a year. Summer thunderstorm runoff or long periods of snowmelt runoff periodically move accumulated sediments from Lower Los Alamos Canyon into the Rio Grande (e.g., ESG 1981, Lane 1985). Thus, there is not likely to be any significant change in the total inventory in Lower Los Alamos Canyon. The effluent-induced flow will slightly increase the rate at which contaminated sediments from historic discharges in Acid-Pueblo Canyon are moved into and through Los Alamos Canyon to the Rio Grande. The impacts on the Rio Grande and Cochiti will probably be small in comparison with worldwide fallout as discussed in Sec. VI.D.4, "Sediments in Regional Reservoirs."

7. Organic Analyses of Surface Water and Groundwater. Surface water and groundwater samples for organic analyses were collected from the onsite group of sampling locations (Table G-14, Fig. 16) including five deep groundwater locations, three surface water sources, one perched water source in Pueblo Canyon, the three shallow groundwater locations in Pajarito Canyon, five of the water supply wells in the Los Alamos field, the two newly drilled wells in the Otowi field, and the six perimeter sampling locations including three surface and three groundwater sources. All samples were analyzed for 68 volatile compounds, 71 semivolatile compounds, 19 pesticide compounds, two herbicide compounds, and four polychlorinated biphenyl (PCB) compounds (Table G-31). The limits of quantification (LOQs) for these compounds are given in Appendix C. Of the 3 975 possible positive results, four were found at levels above the LOQ. Only those compounds that exceeded the LOQs are discussed and shown in Table VI-9.

a. Volatile Compounds. Water samples from the 25 stations were analyzed for 68 target volatile compounds (Table G-31). No target compounds were found at levels above the LOQs.

b. Semivolatile Compounds. Water from the 25 stations was analyzed for 71 semivolatile compounds (Table G-31). The plasticizer bis(2-ethylhexyl) phthalate was found in three of the samples (Table VI-9) but the same material was found in blanks and is attributed to laboratory contamination.

c. Pesticides. Water from 25 stations was analyzed for 19 pesticide compounds (Table G-31). None were found at levels exceeding the LOQ.

d. Herbicides. Water from 25 stations was analyzed for four herbicide compounds; none were found at levels exceeding the LOQ.

e. PCBs. Water from 25 stations was analyzed for four PCB compounds; none exceeded the LOQ except for one PCB compound (Aroclor 1260) at 0.5 micrograms/L in the Guaje sample.

D. Radioactivity in Soils and Sediments

1. Background Levels of Radioactivity in Soils and Sediments. Soil and sediment samples from regional stations routinely collected and analyzed for radionuclides from 1974 through 1986 were used to establish statistical limits for background levels of ^{3}H, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$ in northern New Mexico soils and sediments (Table VI-9) (Purtymun 1987a). The average of the concentration levels in these samples plus twice the standard deviation was used to establish the upper limits of background concentrations. In 1990, samples were collected from seven regional soil stations and 11

Table VI-9. Water and Soil Samples that Exceeded the LOQs for Volatile and Semivolatile Organic Compounds

Station	Compound	Concentration (µg/L)	LOQ (µg/L)
WATER SAMPLES			
Semivolatile Organic Compounds			
Guaje Canyon	Bis(2-ethylhexyl)phthalate	28.5 ± 8.6	10
Indian Spring	Bis(2-ethylhexyl)phthalate	26.6 ± 8	10
Otowi-4	Bis(2-ethylhexyl)phthalate	32 ± 10	10
PCB Organic Compounds			
Guaje	Aroclor 1260	0.48 ± 0.1	0.4
SEDIMENT SAMPLES			
Volatile Organic Compounds			
Rio Chama	Dichlorodifluoromethane	11.5 ± 3.5[a]	10
Otowi	Dichlorodifluoromethane	10.4 ± 3.5[a]	10
Semivolatile Organic Compounds			
Rio Chama	Di-N-Butylphthalate	1 900 ± 570[a]	330
Embudo	Di-N-Butylphthalate	2 500 ± 750[a]	330
Otowi	Di-N-Butylphthalate	1 900 ± 570[a]	330
Santa Cruz	Di-N-Butylphthalate	2 100 ± 630[a]	330
Bernalillo	Di-N-Butylphthalate	400 ± 120[a]	330
Frijoles	Di-N-Butylphthalate	3 700 ± 1 100[a]	330

[a]Also found in blanks at similar levels.

regional sediment stations (Table G-32), and concentrations of radionuclides in samples from these regional stations were measured. Results of the analyses are presented in Tables VI-10 and G-33. See Appendix B for a description of methods for collecting soil and sediment samples.

2. Perimeter Soils and Sediments. Samples are normally collected from six soil stations within 4 km (2.5 mi) of the Laboratory perimeter. A procedural error resulted in loss of these samples in 1990. Samples were collected from 10 sediment stations near the Laboratory boundary and at the confluence of eight major canyons with the Rio Grande in White Rock Canyon (Figs. 20 and 21). Perimeter soil and sediment sampling stations are listed in Table G-32, and detailed analytical results are given in Table G-34 for radiochemical and Table G-35 for metals.

a. Radiochemical Analyses of Sediments. Analyses of sediment samples from the perimeter stations indicated that concentrations of radionuclides

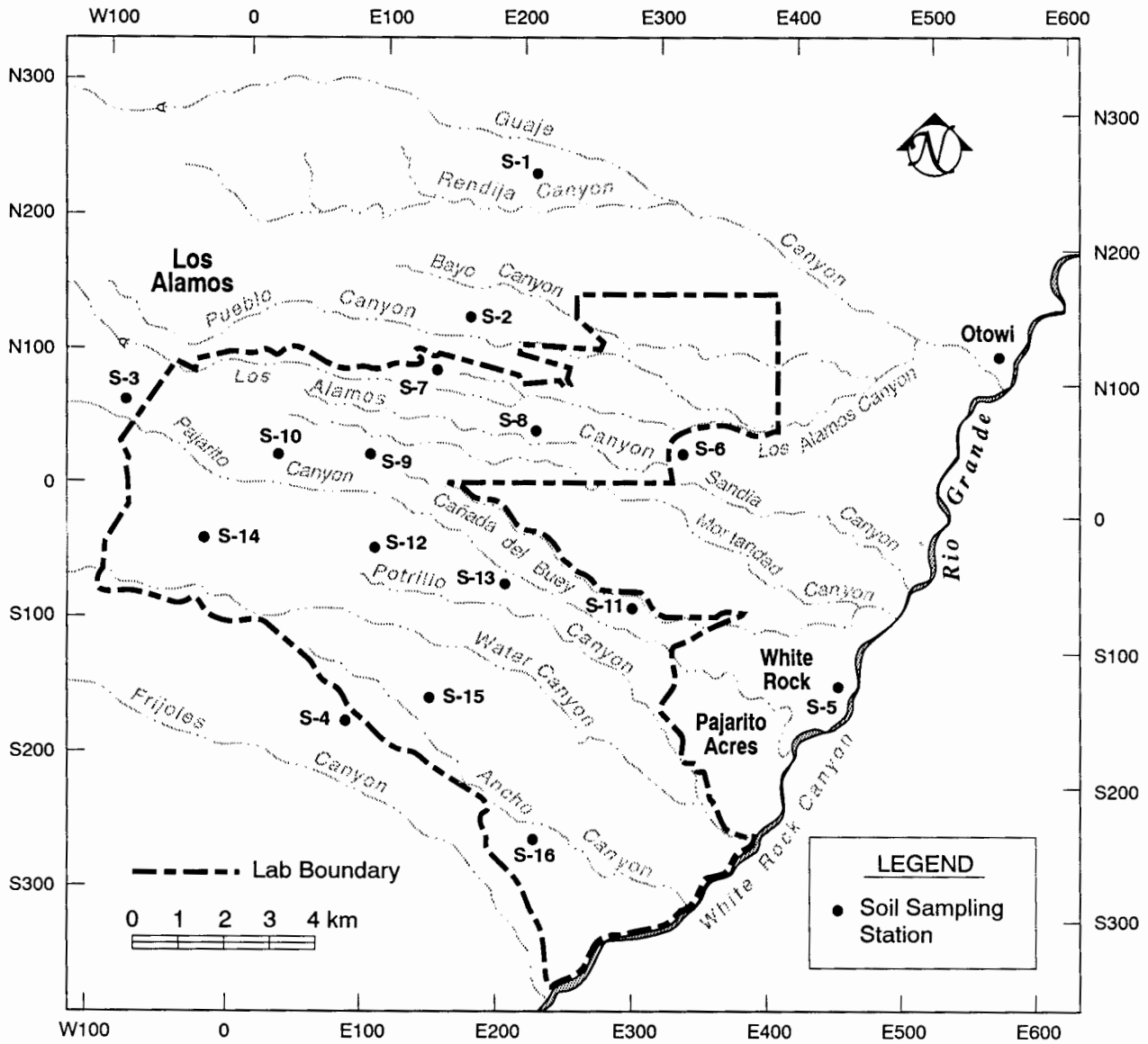


Fig. 20. Soil sampling locations on or near the Laboratory site.

were below statistically established regional background levels (Table VI-10) except for two ^{137}Cs, one total uranium, one ^{238}Pu, and two $^{239-240}Pu$ samples.

b. Inorganic Analyses of Sediments. Samples of the 10 perimeter station sediments were analyzed for metals listed under the Extraction Procedure (EP) Toxicity criteria for hazardous waste to determine if there might be any such contaminants found in canyon sediments leaving the Laboratory boundary. Analytical laboratory methodology is described in Appendix C. None of the analyses exceeded or even approached the threshold criteria. (Table G-35).

c. Organic Analyses of Sediments. Samples of bed sediments were collected from the 12 perimeter sediment stations, two effluent release area stations, and seven regional sediment stations, and were analyzed for 68 volatile compounds, 71 semivolatile compounds, 19 pesticide compounds, two herbicide compounds, and four PCBs (Table G-39). Analytical laboratory methodology is described in Appendix C. Only those compounds with concentrations that exceeded the LOQs are discussed (Table VI-9).

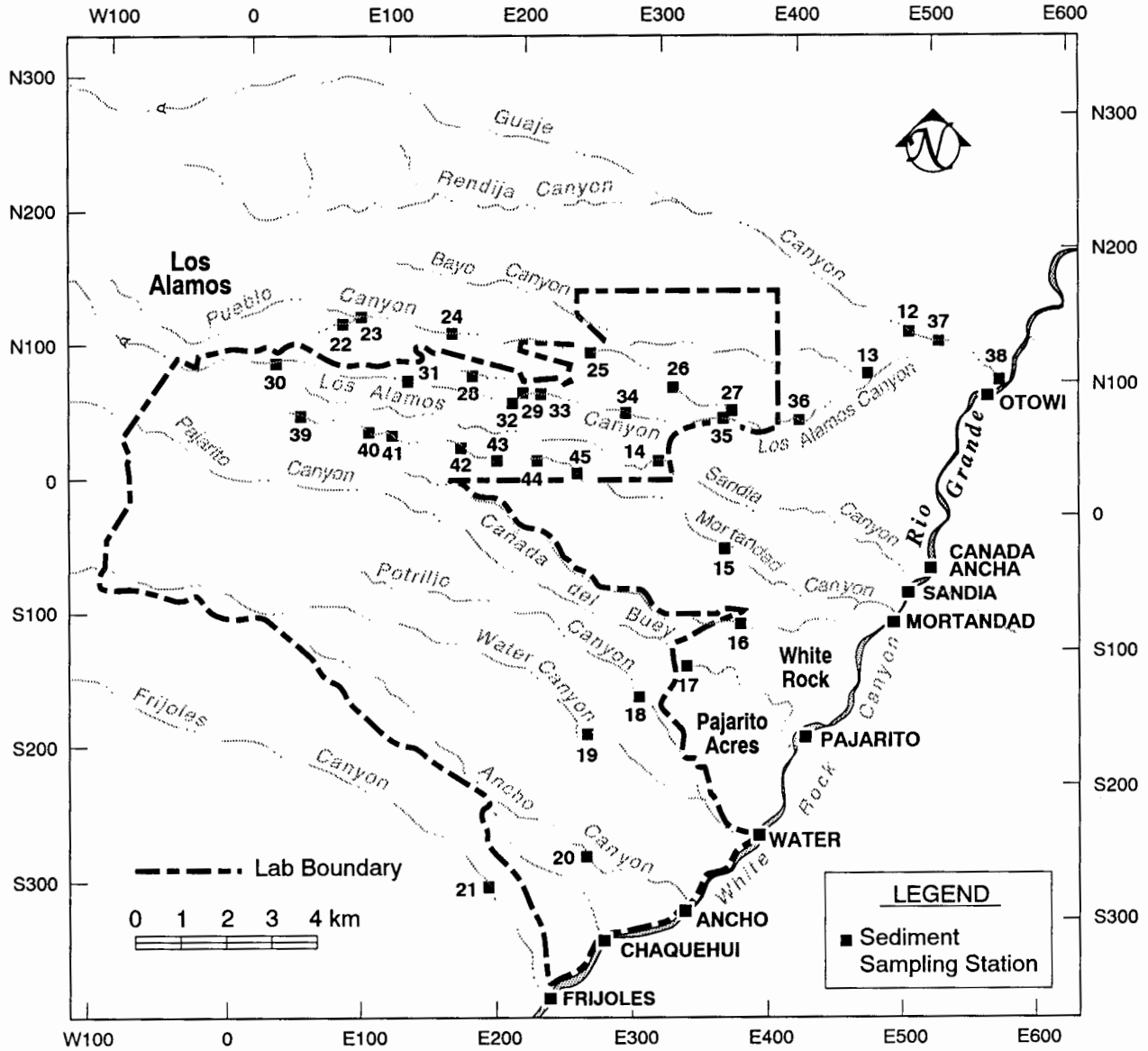


Fig. 21. Sediment sampling locations on and near the Laboratory site.

(1) Volatile Compounds. Samples of sediments from the 21 stations were analyzed for 68 volatile compounds; two were reported at levels above the LOQs (Table VI-9 and Table G-39).

(2) Semivolatile Compounds. Samples of sediments from the 21 stations were analyzed for 71 semivolatile compounds. Only six stations had analyses positive for these compounds, and only one compound was reported at levels similar to those found in the blank for the method (Table VI-9 and Table G-39).

(3) Pesticide, Herbicide, and PCB Compounds. Sediments from the 21 stations were analyzed for 19 pesticide compounds, two herbicide compounds, and four PCBs. All analyses gave results below LOQs (Table G-39).

3. On-Site Soils and Sediments. Soil samples were collected from 10 stations within Laboratory boundaries, and on-site sediment samples were collected from 24 stations within areas that have received treated effluent (Table G-32, Figs. 20 and 21).

Table VI-10. Maximum Concentrations of Radionuclides in Soils and Sediments

	Number of Sations Sampled	^{3}H (10^{-6} μCi/mL)	^{137}Cs (pCi/g)	Total Uranium (μg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Analytical Limits of Detection		0.7	0.1	0.3	0.002	0.002
Soils						
Background (1974—1986)[a]	5	7.2	1.09	3.4	0.005	0.025
Regional stations	7	0.8 (0)[b]	0.72 (0)	3.6 (1)	0.104 (1)	0.092 (1)
On-site stations	10	13 (1)	1.9 (2)	—	0.004 (0)	0.056 (1)
Sediments						
Background (1974—1986)[a]	10	—	0.44	4.4	0.006	0.023
Regional stations	9	0.4 (N/A)[c]	0.71 (1)	3.3 (0)	0.004 (0)	0.004 (0)
Perimeter stations	20	8.2 (N/A)[c]	0.70 (2)	5.2 (1)	0.014 (1)	0.069 (2)
On-site stations (effluent release areas)						
Acid-Pueblo Canyon	6	3.0 (N/A)[c]	0.68 (1)	4.0 (0)	0.054 (0)	5.17 (5)
DP–Los Alamos Canyon	11	—	1.43 (4)	2.8 (0)	0.028 (6)	0.15 (8)
Mortandad Canyon	7	—	27.4 (5)	5.0 (1)	7.48 (6)	16.8 (4)

[a]The $\bar{x} + 2s$ (97.5% value) of background analyses for soil and sediments (Purtymun 1987a).
[b]Numbers in parentheses indicate number of stations exceeding the 97.5% background value.
[c]No comparison period data available.

The concentrations were within the ranges observed in previous years and did not indicate any new releases (Tables VI-10 and G-36). Tritium at one on-site station (near TA-33), ^{137}Cs at two stations (TA-50 and R-Site Road), and ^{239}Pu at one station (East of TA-53) exceeded the regional background limit by factors of about 2 and are considered statistical outliers with no likely unusual releases being indicated. The location will be resampled during the next routine collection.

Three canyons (Acid-Pueblo, DP-Los Alamos, and Mortandad) contain sediments contaminated with residual radioactivity from past or present releases of effluents (see Sec. VI.C.4.b). As expected, the concentrations of radionuclides in these canyons exceed statistically established regional background levels (Table VI-10). The concentrations in sediments from Pueblo and DP-Los Alamos canyons generally decrease downhill as the radionuclides are dispersed and mixed with uncontaminated sediments (Table G-36). Some of these sediments are transported into the Rio Grande. Theoretical estimates (ESG 1981), confirmed by actual measurement (see Sec. VI.D.4), show that the incremental contribution to radioactivity in sediments from Cochiti Reservoir is a small percentage of the contribution attributable to typical regional background levels. The resultant incremental doses through food pathways (see Sec. VII.C) are well below DOE's applicable public dose limits.

The concentrations in Mortandad Canyon also decrease downgradient; however, no runoff has reached or extended past the Laboratory boundary since before the TA-50 treatment plant started operating in 1963. (See also discussion of special sampling conducted on San Ildefonso Pueblo, Sec. IX.B.)

Samples of sediments from 24 of the on-site effluent release area sediment stations were analyzed for metals listed under the EP Toxicity criteria for hazardous waste to determine if there might be any such contaminants found in effluent release areas. Analytical laboratory methodology is described in Appendix C. None of the analysis exceeded, or even approached the threshold criteria (Table G-37).

4. Sediments in Regional Reservoirs. Reservoir sediments were collected from three locations in the Abiquiu Reservoir on the Rio Chama and three locations in the Cochiti Reservoir on the Rio Grande south of Los Alamos (Fig. 22). Sediment samples were analyzed for ^{238}Pu and $^{239,240}Pu$ using 1-kg (2-lb, dry weight) samples (100 times the mass usually used for analyses). Large samples increase the sensitivity of the plutonium analyses and are necessary to effectively evaluate background plutonium concentrations for fallout from atmospheric tests. Normal sample sizes were used for analyzing for ^{3}H, ^{137}Cs, ^{90}Sr, and total uranium (Table G-38).

The cesium concentration of 0.55 +/- 0.13 pCi/g from the lower station at Cochiti slightly exceeded the statistically established background level of 0.44 pCi/g (Purtymun 1987a). The uranium concentration of 4.6 +/- 0.4 μ/g pCi/g from the middle station at Cochiti slightly exceeded the statistically established background level of 4.4 μg/g. Samples that occasionally exceed statistical limits are expected because of natural variability and do not necessarily indicate contamination. This is supported by the overall pattern of cesium and strontium concentrations in samples from the rest of the stations, all of which were below background (Table G-38).

Levels of plutonium in samples collected in 1990 were similar to plutonium levels found in samples collected in previous years, when the concentrations were consistently higher at Cochiti Reservoir than in Abiquiu Reservoir (Tables VI-11 and G-38). Sediments in Cochiti Reservoir (on the Rio Grande) contain a higher percentage of finer particles and organic materials than do sediments from Abiquiu (on the Chama). These characteristics enhance the capacity of sediment to adsorb plutonium and other metal ions. Only one of the 12 plutonium samples collected had concentrations that exceeded the statistically established background level. The sample from the upper station at Cochiti showed concentrations of 0.0307 pCi/g, to be compared with the 97.5% background level of 0.023 pCi/g (Purtymun 1987a). The average levels in both reservoirs were among the lowest observed since 1984. The isotope ratios of ^{239}Pu to ^{238}Pu were 19 in both reservoirs, essentially identical with the average of about 20 observed in northern New Mexico.

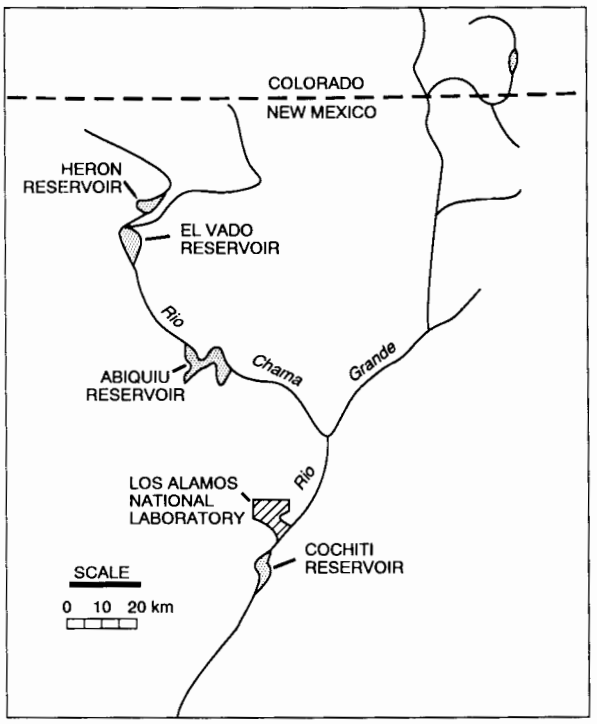


Fig. 22. Regional reservoirs for special sediment sampling.

A special study, "Plutonium Deposition and Distribution from Worldwide Fallout in Northern New Mexico and Southern Colorado," that provides a broader regional context for the reservoir sediment measurements was published in 1990 (Purtymun 1990b). This study was based on the radiochemical analyses of large samples (1 kg) of soils and sediments collected between 1979 and 1987 from locations in northern New Mexico and southern Colorado. Data on sediments from Abiquiu and Cochiti previously published in the annual environmental surveillance at Los Alamos reports are included in the larger set of data. The results of the study are summarized in Fig. 23. The conclusions of greatest significance to interpreting the current samples from Abiquiu and Cochiti reservoirs (Table VI-11) are (1) the average total plutonium concentrations in Cochiti are almost identical with the concentrations found in the Rio Grande Reservoir in Colorado, (2) all three of the reservoirs on the Rio Chama exhibit slightly lower concentrations than found in the Rio Grande Reservoir, and (3) the isotopic ratios are essentially the same, with nearly complete overlap of the statistical uncertainties for all of the soil and sediment samples. These findings are all consistent with the interpretation of the source of the plutonium at all locations being dominantly from worldwide fallout. The data from the 1990 samples (Table VI-11) fit the pattern of concentrations and isotopic ratios found by the study (Fig. 23). The Cochiti samples are very near the long-term means for concentration and isotope ratio; the Abiquiu samples were near the low end of the concentration range, but only slightly below the isotopic ratio mean.

Both the 1990 data and the special study support other observations and interpretations (ESG 1981) that the contribution of plutonium carried into the Rio Grande by runoff through Los Alamos is a small fraction of that attributable to worldwide fallout on sediments in the Rio Grande. The levels of plutonium on sediments in the Rio Grande represent a mixing of the generally higher concentrations and isotopic ratios observed on soils and sediments further north in the Rio Grande drainage and the generally lower concentrations and lower isotopic ratios found in the Chama system reservoirs and soils of New Mexico. There is no measurable increase in concentrations below Los Alamos Canyon on the Rio Grande; there is no measurable increase in isotopic ratio as would be expected if the higher-concentration, higher-ratio Los Alamos Canyon sediments (Sec. VI.C.4.b and VI.C.6) were making a large contribution.

5. Transport of Radionuclides in Sediments and Runoff from an Active Waste Management Area (TA-54). Radionuclides transported by surface runoff have an affinity for sediment particles attached by ion exchange or adsorption. Thus, radionuclides in surface runoff 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 runoff from the waste storage and disposal area (Fig. 24). The samples were collected in August 1990 (Table G-40).

a. Radioactivity. Some radionuclides are transported from the surface at Area G in suspended or bed sediments. This contamination is from the land surface and is not related to the wastes in the pits and shafts. It is residual contamination in the land surface that occurred during handling of the wastes. Tritium in soil moisture was about 5 to 10 times the background

Table VI-11. Plutonium Analyses from Reservoirs on the Rio Chama and Rio Grande (fCi/g)[a]

		^{238}Pu	$^{239,240}Pu$	Ratio ($^{239,240}Pu/^{238}Pu$)
Abiquiu Reservoir				
1984	$\bar{x}$ (*s*)	0.7 (0.4)	12.7 (6.3)	18
1985	$\bar{x}$ (*s*)	0.7 (0.5)	8.8 (0.9)	12
1986	$\bar{x}$ (*s*)	0.3 (0.1)	7.5 (1.7)	25
1987	$\bar{x}$ (*s*)	0.2 (0.1)	3.8 (3.1)	19
1988	$\bar{x}$ (*s*)	0.3 (0.2)	7.5 (2.6)	25
1989	$\bar{x}$ (*s*)	0.2 (0.6)	3.7 (0.4)	18
1990	Upper	0.1 (0.1)	0.8 (0.1)	8
	Middle	0.22 (0.06)	3.7 (0.2)	17
	Lower	0.1 (0.1)	3.4 (0.4)	34
	$\bar{x}$ (*s*)	0.14 (0.1)	2.6 (1.6)	19
Cochiti Reservoir				
1984	$\bar{x}$ (*s*)	0.7 (1.1)	19.7 (14.0)	28
1985	$\bar{x}$ (*s*)	1.6 (0.6)	24.1 (7.3)	15
1986	$\bar{x}$ (*s*)	1.2 (0.5)	21.2 (6.1)	18
1987	$\bar{x}$ (*s*)	0.8 (0.7)	17.5 (13.8)	22
1988	$\bar{x}$ (*s*)	1.7 (2.3)	21.1 (2.9)	7
1989	$\bar{x}$ (*s*)	2.5 (2.3)	49.3 (7.3)	20
1990	Upper	1.6 (0.1)	30.7 (1.1)	19
	Middle	1.1 (0.1)	22.5 (1.4)	20
	Lower	0.7 (0.1)	9.4 (0.4)	13
	$\bar{x}$ (*s*)	1.1 (0.5)	20.9 (10.7)	19
Background				
(1974–1986)[b]		6.0	23.0	

[a]Samples were collected in June 1990; counting uncertainties are in parenthesis.
[b]Purtymun (1987a).

limit in seven of the nine samples for no apparent reason. They will be resampled during the next routing monitoring. Plutonium 238 in excess of background (0.006 pCi/g) occurred at Station 2 (0.008 pCi/g). Plutonium 239 and 240 exceeded background (0.023 pCi/g) at Station 9 (0.029 pCi/g). Cesium and gross gamma were near or below background. When combined with storm runoff in Cañada del Buey or Pajarito Canyon, the concentration of radionuclides in the sediments from Area G are dispersed and are not detectable at the Laboratory boundary at State Road 4.

b. Organic Analyses of Bed Sediments. Samples of bed sediments were collected from the nine sediment statons around Area G and were analyzed for 68 volatile compounds, 71 semivolatile compounds, 19 pesticide compounds, two herbicide compounds, and four PCBs. No target compounds were detected at levels above the LOQs.

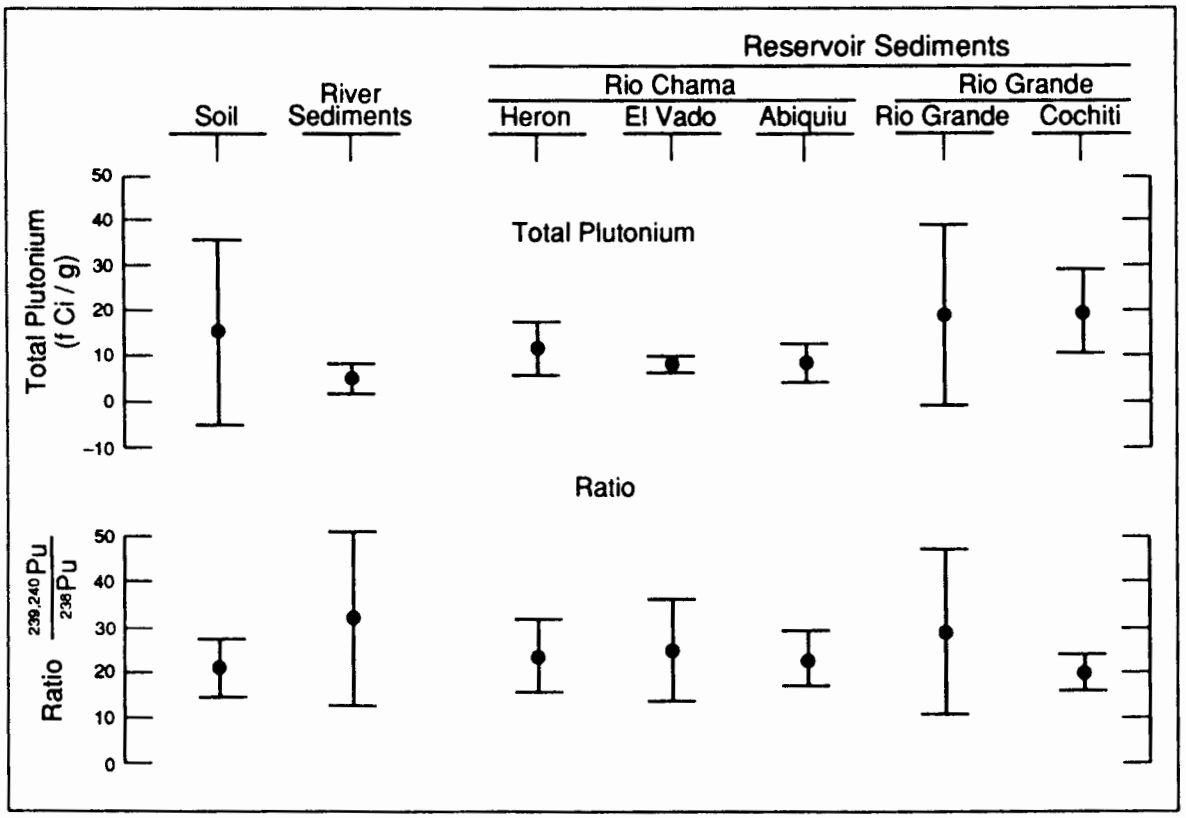


Fig. 23. Mean total Plutonium and rations of $^{239,240}Pu/^{238}Pu$, with standard deviation of soil, river and reservoir sediments (standard deviation is shown as the bar).

6. Transport of Radionuclides in Sediments from an Inactive Waste Management Area (TA-49). From 1959 to 1961, hydronuclear experiments were conducted in underground shafts at the Laboratory at TA-49. This technical area is located on Frijoles Mesa in the southwest corner of the Laboratory between TA-28 and TA-33 (Fig. 4). The experiments involved a combination of conventional (chemical) high explosives, usually in a nuclear weapons configuration. The quantity of fissile material was kept far below the amount required for a nuclear explosion (Purtymun 1987b). The underground shafts ranged in depth from 15 to 36 m (50 to 120 ft) beneath the surface of the mesa (Purtymun 1987b, ESG 1988).

Eleven stations were established in 1972 to monitor surface sediments in natural drainage from the experimental area. Another station was added in 1981 as the drainage changed (Fig. 21). Sediment samples from the 12 stations were analyzed for radiochemical and chemical constituents and for organic compounds.

Results of analyses of sediment samples for radiochemicals were compared with the statistically established levels for regional background (1977-1986 [Purtymun 1987a]) and no 1990 samples exceeded those background levels, as shown in Table G-41. Plutonium has often been found at levels exceeding background limits in previous monitoring. The plutonium reported is attributable to a surface contamination incident that occurred in 1960 (Purtymun 1987b, ESG 1988).

Sediments from the 12 stations were analyzed for chemical constituents. The results of the analyses indicated that constituents were below threshold limits for EPA's EP toxicity criteria concentrations (Table G-42). The great majority of results were below limits of analytical detection.

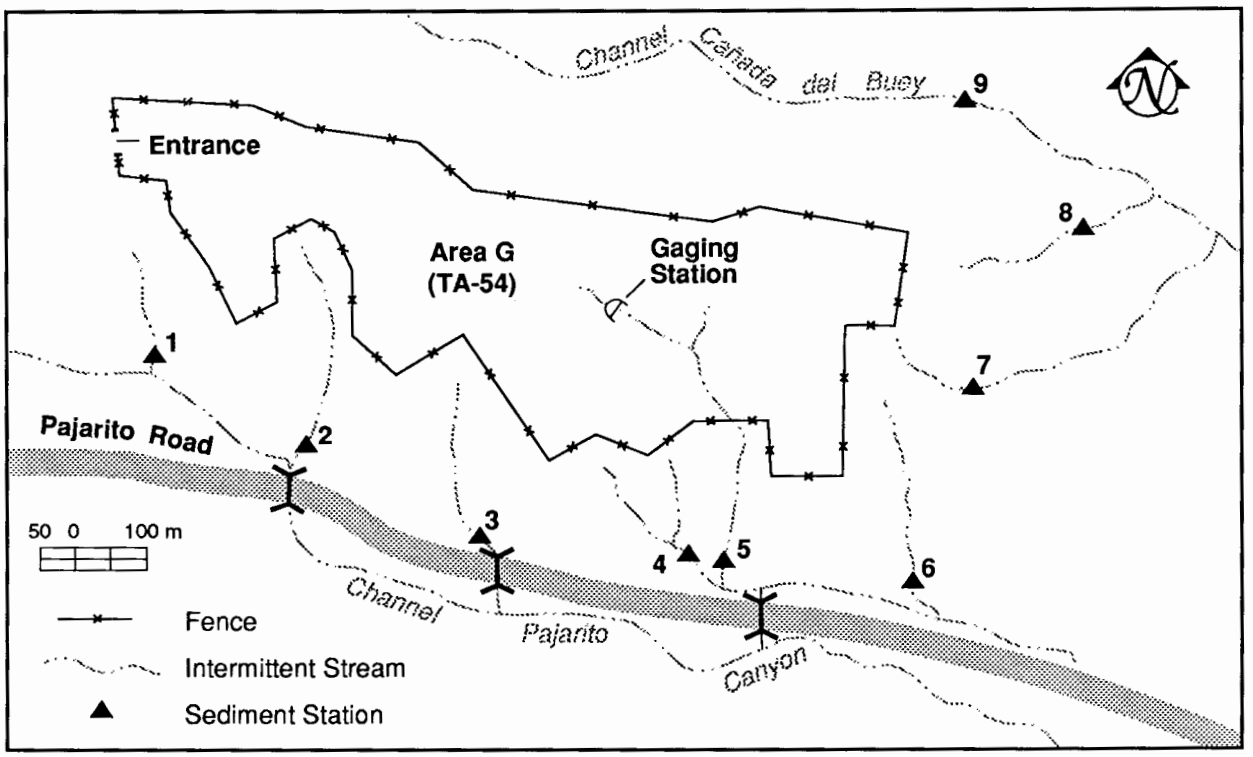


Fig. 24. Locations of sampling stations for surface runoff at TA-54.

Samples of sediments from the 12 stations were analyzed for 68 volatile organic compounds, 71 semivolatile organic compounds, 19 pesticide compounds, two herbicide compounds, and four PCB compounds (Table G-43). The LOQs for the organic compounds are given in Appendix C. All samples were analyzed for these compounds. Only one target compound was detected at levels above the LOQ: 1,2,4-trimethylbenzene at levels between 6 and 10 μg/g in 10 of the 12 samples. This suggests sample contamination during collection or analysis because of the consistent levels in all samples. This compound was not among the ones noted last year, which also showed analytical difficulties. Because of the uncertainties in the analyses, additional samples will be collected next year for organic analyses.

Three deep test wells (DT-5A, DT-9, and DT-10) were used to monitor possible movement of contaminants from the shafts to the main aquifer (Fig. 16). The depth to the main aquifer is about 360 m (1 200 ft). No water is perched in beds between the surface of the mesa and the top of the main aquifer. The chemical and radiochemical quality of water from these wells indicated no contamination from activities at TA-49 (Sec. VI.C.4.a. and Tables G-22 and G-23).

VII. FOODSTUFFS MONITORING

Concentrations of radionuclides in produce, bee, and honey samples collected from Laboratory areas were compared to radionuclides in foodstuffs collected from regional (background) areas. Also, fish (catfish and crappie) collected from a reservoir downstream from the Laboratory (Cochiti) were compared with fish collected from a reservoir upstream from the Laboratory (Abiquiu). Most radionuclides in produce, bee, and honey samples collected from Laboratory areas were not significantly different from foodstuffs collected from background sources. Tritium (^3H) levels, however, were higher in produce, bee, and honey samples collected from Laboratory areas than in foodstuffs collected from background or perimeter locations. Honey and bee samples collected from the Meson Physics Facility at TA-53 had the highest ^3H contents. Most radionuclide levels in fish collected from Cochiti Reservoir were not significantly different from fish collected from Abiquiu Reservoir. Overall, radionuclides in foodstuffs as a result of Laboratory operations contribute only a minute fraction of doses received by the public.

A. Background

Concentrations of radionuclides in foodstuffs collected from Laboratory areas are compared to levels of radionuclides in foodstuffs samples collected from regional (background) locations in an effort to monitor Laboratory operations for potential radioactive contamination. Consequently, produce, bee, and honey samples are collected on a yearly basis from Laboratory, perimeter (Los Alamos/White Rock and San Ildefonso) and regional (Española) locations. Similarly, levels of radionuclides are determined in catfish (bottom feeders) and crappie (surface feeders) collected from Abiquiu (a reservoir upstream from the Laboratory) and Cochiti (a reservoir downstream from the Laboratory). Locations of produce, fish, and beehives are shown in Figures 25 and 26 and Table G-44. Sampling procedures and data analysis can be found in Appendix B, and the radiological health significance of these data can be found in Section III.B.8.

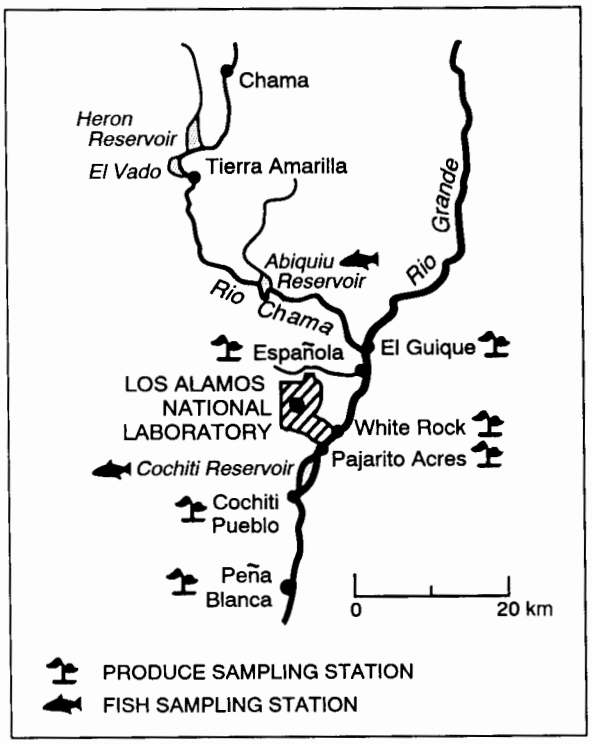


Fig. 25. Produce and fish sampling locations.

B. Produce

Concentrations of radionuclides in produce collected from on-site and off-site sources during the 1990

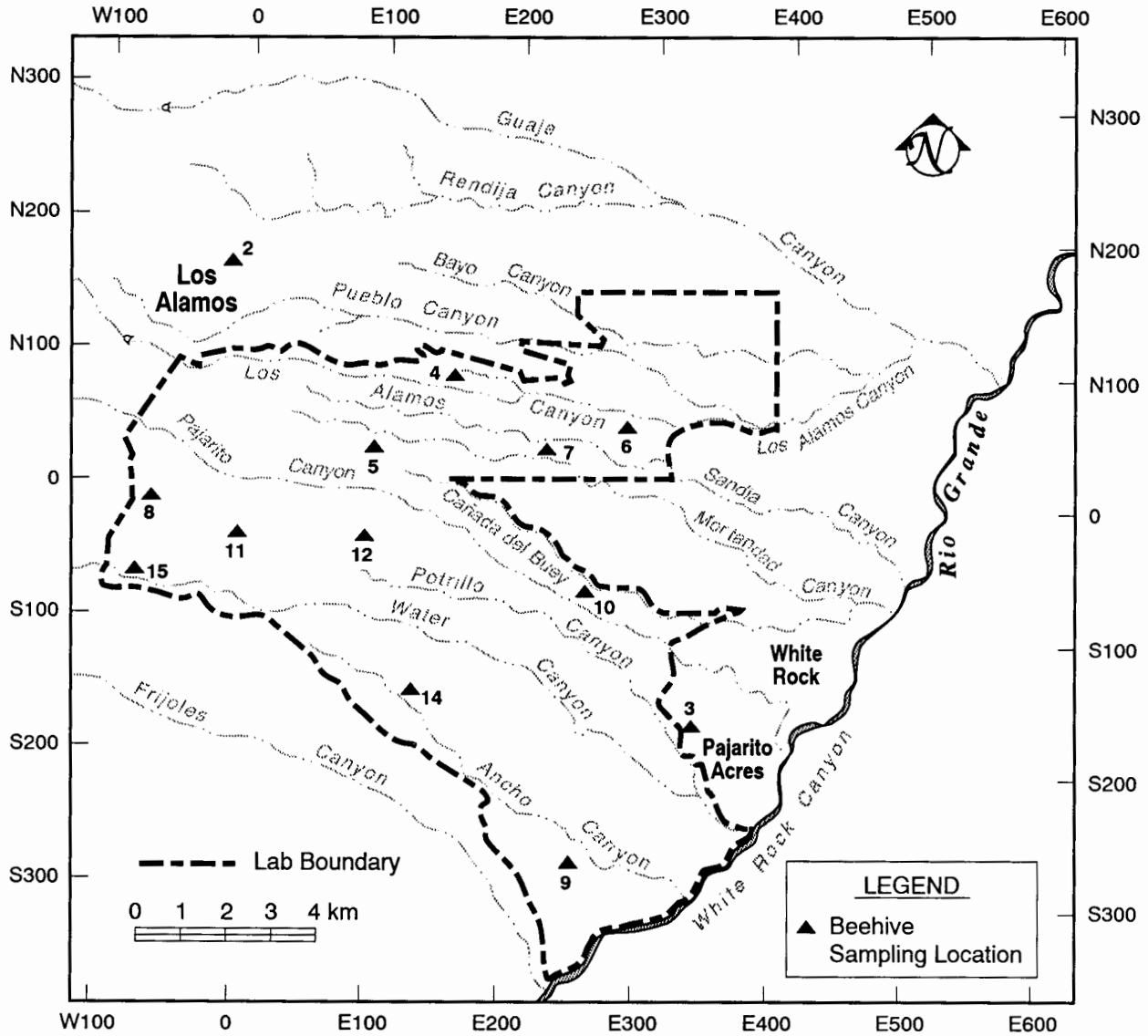


Fig. 26. Locations of beehives.

growing season can be found in Table G-45. Levels of ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$ and total uranium in produce collected from Laboratory lands were not significantly different from foodstuffs collected from perimeter or regional sampling locations. ^{3}H was the only radionuclide that was statistically significant in produce collected from Laboratory areas. The difference in ^{3}H values between on-site and off-site locations, however, was small (i.e., 1.20 pCi/mL). Laboratory contributions to doses received from produce consumption, including that from ^{3}H, pose no threat to the health and safety of the general public (Section III.B.8).

C. Fish

Crappie were not collected from Abiquiu Reservoir this past season; the low water levels at Abiquiu seemed to have inhibited crappie from reaching their spawning areas. However, levels of radionuclides in

crappie collected from Abiquiu during the years 1986 to 1989 were used to compare levels of radionuclides in crappie collected this past season from Cochiti. These data can be found in Table G-46.

Concentrations of ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$ and total uranium in catfish collected from Cochiti were not statistically significantly different from catfish collected from Abiquiu. Similarly, levels of ^{90}Sr, ^{238}Pu and $^{239,240}Pu$ in crappie collected from Cochiti were not significantly different from crappie collected from Abiquiu in past years. Levels of ^{137}Cs and total uranium in crappie collected from Cochiti were significantly higher than crappie collected over the past four years at Abiquiu. The levels of ^{137}Cs and total uranium, however, are similar to those found in catfish at Abiquiu and Cochiti, and are within the variation exhibited by crappie in previous years. As in the past, body burdens in bottom-feeding catfish had higher levels of uranium (average was 6.2 ng/dry g) than those found in crappie (3.3 ng/dry g).

Overall, the data indicate that Laboratory operations do not result in significant doses to the general public from consuming fish from Cochiti Reservoir (Section III.B.8).

D. Bees and Honey

Levels of radionuclides (^{3}H, ^{7}Be, ^{22}Na, ^{54}Mn ^{57}Co, ^{83}Rb and ^{137}Cs) as well as trace metals (Ar, Be, Cd, Cr, Fl, Pb, Hg and Se) were determined in bee and honey samples. The most recent data (1989) for bees and honey are shown in Tables G-47 through G-50.

In general, most radionuclide and trace metals were within the variation exhibited in previous years. However, some levels of radionuclides, particularly ^{3}H, were elevated at almost all collection sites within the Laboratory. Background levels of ^{3}H in honey and bees, for example, ranged from 0 to 600 ($\pm$300) pCi/L and from 200 to 300 ($\pm$300) pCi/L, respectively. Levels of ^{3}H in honey and bees collected from Laboratory lands ranged from 1 600 ($\pm$400) to 370 000 ($\pm$40 000) pCi/L and from 1 500 ($\pm$300) to 3 300 000 ($\pm$200 000) pCi/L, respectively. The highest ^{3}H levels at the Laboratory were those from the Los Alamos Meson Physics Facility at TA-53 and the Waste Disposal Site at TA-54, Area G. Honey produced by the hives around the Laboratory is not available for consumption.

VIII. ENVIRONMENTAL COMPLIANCE

In accordance with the policy of the Department of Energy, the Laboratory must comply with Federal and State environmental requirements. These requirements address handling, transport, release, and disposal of hazardous materials, as well as protection of ecological, archaeological, historic, atmospheric, and aquatic resources.

The Laboratory recently received federal and state permits for operating hazardous waste treatment and storage areas and is renewing a federal hazardous waste permit for discharge of liquid effluents. Corrective actions carried out under the federal permit are being managed by the Laboratory's Environmental Restoration Program. The Laboratory was in compliance with permit limits for treated liquid discharges in 96.8% and 97.8%, respectively, of monitored sanitary and industrial effluent outfalls. Under a Federal Facility Compliance Agreement with the Environmental Protection Agency, sanitary waste treatment facilities are being upgraded to improve compliance.

All airborne releases were well within regulatory limits during 1990. Ninety-one sources of air emissions were evaluated during 1990. All of these sources were below levels requiring an air quality permit.

Concentrations of constituents in the drinking water distribution system remained within federal water supply standards.

The Laboratory evaluated 355 activities for compliance with cultural resource requirements. During 1990, 702 actions proposed to be undertaken at the Laboratory were reviewed for the National Environmental Policy Act (NEPA) applicability and 82 documents describing new Laboratory activities were prepared to comply with NEPA.

A. Resource Conservation and Recovery Act

1. Background. The Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, mandates a comprehensive program to regulate hazardous wastes, from generation to ultimate disposal. The 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 VIII-1.

The Environmental Protection Agency (EPA) has granted RCRA authorization to New Mexico, transferring regulatory control of hazardous wastes to the State's Environmental Improvement Division (NMEID). State authority for hazardous waste regulation is the Hazardous Waste Act (HWA) and Hazardous Waste Management Regulation (HWMR). However, NMEID has not yet obtained authorization for implementing the 1984 RCRA amendments. HWMR adopted the federal codification for generating and managing hazardous waste. Although this adoption makes the State regulations more consistent with federal regulations and easier to interpret, some confusion will continue because only those federal regulations in effect on July 1, 1990, were adopted.

The Laboratory produces a wide variety of hazardous wastes. Small volumes of all chemicals listed under 40 CFR 261.33 could exist at the Laboratory as a result of ongoing research. Process wastes, such as liquid wastes from circuit board preparation and lithium hydride scrap from metal machining, are generated from ongoing manufacturing operations that support research. Although they occur in larger volumes than discarded laboratory chemicals, process wastes are few in number, they are well defined, and are not acutely

Table VIII-1. Major Regulatory Requirements of the Hazardous and Solid Waste Amendments of 1984 Impacting Waste Management at the Laboratory

The Hazardous and Solid Waste Amendments of 1984

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

toxic. High-explosive (HE) wastes include small pieces of explosives and contaminated sludges and liquids that are thermally treated on site.

On March 5, 1990, the New Mexico Legislature approved revisions to the Solid Waste Act mandating that the New Mexico Environmental Improvement Board (NMEIB) promulgate new solid waste management regulations by July 1, 1991. The Laboratory is currently operating under the Solid Waste Management Regulations (SWMR-2) promulgated by the NMEIB on April 14, 1989. As a result of SWMR-2, a notice of intent to continue to operate the TA-54, Area J administratively controlled solid waste landfill was submitted to the State on July 19, 1989. Subsequently, another notice of intent was submitted to the State on August 14, 1989, to continue to dispose asbestos at TA-54, Area G. To comply with SWMR-2, a new pit was excavated at TA-54, Area G in 1990 to monofill suspect radioactive-contaminated asbestos. Nonradioactive asbestos is currently being disposed off-site.

In addition to the TA-54 Areas G and J landfills, the Laboratory, in support of the Department of Energy (DOE) and the County of Los Alamos, provided the State with a Notice of Intent to continue to operate the Los Alamos County Municipal landfill located on East Jemez Road east of the Laboratory's salvage yard. This landfill is owned by the DOE and operated by the County. Nonhazardous, nonradioactive, and nonadministratively controlled solid wastes generated by the Laboratory are disposed at the County Landfill. These wastes comprise no greater than 38% of the total volume of solid wastes disposed at the landfill per year.

A new site on the south side of East Jemez Road across from TA-53 has been designated to replace the current municipal landfill, which is approaching design capacity. Excavation activities at this new site may begin after National Environmental Policy Act (NEPA) documentation is completed.

2. RCRA Closure Activities. The status of Laboratory hazardous waste operations to be closed under RCRA regulations is given below:

a. TA-16, Ground Burning Surface Impoundment for Burning Waste. On February 12, 1990, the Laboratory received an approved closure plan for this unit. The closure plan requires that 12 more samples be taken to confirm the absence of hazardous constituents in the soil beneath the location of the liner. Before the approved closure plan was received, the liner was removed and drummed. A trace amount of trichloroethylene (TCE) was discovered at one sample location during the required sampling. A health risk assessment was performed by the NMEID to determine if additional soil should be removed from the site. The State concluded that there were no risks associated with leaving in place the low level of TCE detected, and that the Laboratory could backfill and revegetate the area. A clean closure was achieved on this unit. The final report to the State was submitted September 19, 1990. Because clean closure was achieved at this location, no further monitoring of the site will be necessary.

b. TA-54, Waste Oil Storage Tanks. After discovering hazardous waste in six aboveground waste oil storage tanks, the Laboratory pumped and disposed of the contents as hazardous waste. The tanks were moved to Area G to make room for needed facilities at Area L. In April of 1990 the Laboratory elected to proceed with the closure of these vessels before receiving an approved closure plan. After several cleanings of the tanks, the final decontamination was accomplished in August. A final closure plan/report that reflects the actual closure process of these units will be submitted in early 1991. The process will have to be approved by the State before the disposal or salvaging of the tanks.

c. TA-35, Waste Oil Storage Pits. Closure plans for the two waste oil pits associated with buildings 85 and 125 at TA-35 were submitted in October 1988, and oral approval to proceed with closure activities was subsequently received from the State. All contents of the pits and underlying soil were removed and disposed of as hazardous waste. Sampling to verify the removal of contaminants from the area was completed in October of 1989. Preliminary results of the sampling effort revealed that the criteria for clean closure had been met. The pits were backfilled and revegetated at that time. Upon receipt of the final analytical results, it was noted that the allowed sample holding times were exceeded. Because of this problem, it was determined that the data could not be defended as correct. The closure plan is currently being modified to reflect the events of the field work that occurred and to include bore sampling to be used as the final verification of clean closure. Bore sampling was performed in December of 1990 to confirm the removal of all hazardous constituents from the area. Upon the receipt of the results of this sampling effort, a decision will be made on how this closure should proceed.

d. TA-16, Landfill at Area P. Closure and post-closure-care plans for the Area P landfill were submitted on November 25, 1985. In late 1987 these plans were modified to include standards that this unit would be subject to once the Laboratory received its RCRA permit. Since that time, the Environmental Restoration (ER) Program Office has come into existence and the Laboratory has received the HSWA amendments to the RCRA permit. Currently negotiations are under way with the State to extend the closure deadlines for this and other units that appear within the HSWA Module of the RCRA permit. An extension of the closure window would allow the ER program to incorporate the RCRA Facility Investigation/Corrective Measures Study studies into the closure process.

3. Operating Permit. An operating permit was issued by the NMEID on November 8, 1989 for RCRA-regulated hazardous waste units (Table VIII-2). A HSWA permit was issued by the EPA on March 8, 1990. Corrective actions taken under the HSWA portion of the permit will be administered by the Laboratory's Environmental Restoration Group (HSE-13), with support from HSE-8 and other groups in the Laboratory.

4. Underground Storage Tanks. Six underground storage tanks (USTs) in need of upgrades were removed from the ground during 1990. Four 30 000-

Table VIII-2. Environmental Permits under which the Laboratory Operated in 1990

Permit Type	Permitted Activity	Issue Date	Expiration Date	Administering Agency
RCRA hazardous waste facility	Hazardous waste storage, treatment, and disposal	November 1990	November 1999	NMEID
	Postclosure care	Application submitted September 1988		EPA
PCBs[a]	Disposal of PCBs at TA-54, Area G[b]	June 5, 1980	—	EPA
PCB oil	Incineration of PCB oils	May 21, 1984	—	EPA
NPDES[c], Los Alamos	Discharge of industrial and sanitary liquid effluents	Modified permit January 30, 1990	March 1, 1991	EPA
NPDES, Fenton Hill	Discharge of industrial and sanitary liquid effluents	October 15, 1983	[d]	EPA
Groundwater discharge plan, Fenton Hill	Discharge to groundwater	July 9, 1990	June 5, 1995	NMOCD[e]
Air Quality (NESHAP)[f]	Construction and operation of four beryllium facilities	December 26, 1985; March 19, 1986; September 8, 1987 April 26, 1989	—	NMEID
Open Burning	Burning of jet fuel for ordnance testing	October 6, 1989	October 6, 1990	NMEID
Open Burning	Burning of scrap wood from experiments	June 22, 1990	June 22, 1991	NMEID
NMLWD[g]	Discharge of sanitary effluents from septic tank systems into soil	[h]	—	NMEID

[a]Polychlorinated biphenyls.
[b]No incineration occurred during 1990 even though the activity was permited.
[c]National Pollutant Discharge Elimination System.
[d]Renewal pending.
[e]New Mexico Oil Conservation Division.
[f]National Emission Standards for Hazardous Air Pollutants.
[g]New Mexico Liquid Waste Disposal Regulations.
[h]Dates vary depending on individual permits.

gal. diesel tanks (TA-16-543, 544, 545, and 546) were removed from the yard at the TA-16 steam plant. These tanks were replaced with one 150 000 gallon aboveground tank. A 4 000 gallon gasoline tank (TA-16-197) was removed and replaced with a state-of-the-art 10 000 gallon, double walled tank with an automated leak detection system and spill and overfill protection. The final tank which was removed was a 550 gallon diesel tank located at TA-55 (TA-55-15). This tank has not yet been replaced. It will be replaced with a vaulted tank during 1991.

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

Table G-51 lists hazardous waste management facilities at the Laboratory. In FY 1989, the TA-40 scrap detonation pit used for destroying HE scrap was closed to waste detonation. All scrap is now handled at other detonation and open-burning sites included in the Part B permit. A closure plan for the TA-40 facility has been submitted to NMEID and is expected to be approved in 1991.

A RCRA-permitted controlled air incinerator (CAI) for treating hazardous waste is located at TA-50-37. A trial burn was conducted in October 1986. The raw data were submitted to NMEID in December 1986, and a final report for the test burn was submitted on March 5, 1987. These data and the report were used to support the Laboratory's application for a hazardous waste permit for this facility. The permit was issued in November 1989. The CAI is currently closed for upgrades and modifications to improve reliability to allow the burning of waste on a routine basis.

6. RCRA Compliance Inspection. In March 1990, the EPA and NMEID conducted a joint hazardous waste compliance inspection (Tables VIII-3 and G-52). Violations were noted and a Notice of Violation (NOV) was issued by the NMEID in June 1990. The Laboratory's response, sent to NMEID in July 1990, was found adequate by that agency in late July 1990. The NMEID was the lead agency for the RCRA portion of this inspection; the EPA was responsible for the evaluation of the Land Disposal Restriction requirements (HSWA provision).

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 of all point-source effluent discharges to the nation's waters. The NPDES permits establish specific chemical, physical, and biological criteria that an effluent must meet before it is discharged. Although most of the Laboratory's effluent is discharged to normally dry arroyos, the Laboratory is required to meet effluent limitations under the NPDES permit program.

The DOE has two NPDES permits, one covering the effluent discharges at Los Alamos and one covering the hot dry rock geothermal facility located 50 km (30 mi) west of Los Alamos at Fenton Hill (Table VIII-2). Both permits are issued and enforced by EPA Region VI in Dallas, Texas. However, through a joint federal and state agreement, NMEID acts as the agent for the EPA and performs compliance monitoring and inspections.

The NPDES permit for the Laboratory expires on March 1, 1991. An application for a new permit was submitted by the Laboratory to the EPA on September 4, 1990, in order to meet the 180 day submittal requirement before the old permit expires. The permit application included extensive flow-monitoring and sampling results completed by HSE-8 in accordance with permit application requirements. Twenty-eight outfalls were sampled and analyses were performed for more than 150 pollutants for each sample. Analytical results and flow measurements were included in the Laboratory's permit application. It is anticipated that the EPA will issue a new permit to the Laboratory with more numerous and more stringent effluent limitations

Table VIII-3. Environmental Inspections and Audits Conducted at the Laboratory in 1990

Date	Purpose	Performing Agency
March 5–9	Hazardous waste management inspection land disposal restrictions	NMEID/EPA
March	RCRA compliance inspection	NMEID
April 20	Inspection of Otowi Well discharge	NMEID
May 21	Inspection of TA-3 power plant acid release	NMEID
May 23 & 24	NPDES compliance evaluation inspection	NMEID
May 24	FIFRA inspection	U.S. Dept. of Agriculture
August 27	Inspection of Otowi Well cleanup	NMEID
October 5	Inspection of oily sheen from TA-3 storm drainage system	NMEID

during 1991. The new permit will also include requirements for biomonitoring in which an aquatic species such as a fathead minnow is introduced into wastewater effluent to determine toxicity. The Laboratory's existing permit will remain in effect until the new permit is issued by the EPA.

During 1990, the Environmental Protection Group also initiated a waste stream identification and characterization program in order to verify that each waste stream is properly monitored under the outfall category under which it is permitted. These studies consist of dye testing, interviews with user groups, and coordination with other Laboratory organizations to determine sources, concentrations, and volumes of pollutants that enter waste streams, receive treatment, and are discharged to the environment.

Two permit modification packages were submitted by the Laboratory to the EPA during 1990 that included requests for additional outfalls, deletion of outfalls, and information on changed treatment or waste stream conditions. At the present time, the Laboratory's NPDES permit for Los Alamos includes ten sanitary wastewater treatment facilities and 112 industrial outfalls. The NPDES permit for the geothermal facility at Fenton Hill includes only one industrial outfall. A summary of these outfalls is included in Table G-53.

Under the Laboratory's existing NPDES permit for Los Alamos, samples are collected on a weekly basis and results are reported each month to the EPA and NMEID. During 1990, effluent limits were exceeded nine times out of 284 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 44 times out of 1 971 samples collected from the industrial outfalls. Approximately half of these industrial exceedances were related to the surface acid release at the TA-3 power plant during May, 1990. As shown in Fig. 27 and Tables G-54–G-57, overall compliance for the sanitary and industrial discharges during 1990 was 96.8% and 97.8%, respectively. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1990.

2. Federal Facility Compliance Agreement and Administrative Order. EPA Region 6 issued a revised Federal Facility Compliance Agreement (FFCA), Docket No. VI-90-1240 to DOE/Los Alamos Area Office (LAAO) on July 12, 1990. The revised FFCA provided interim effluent limits and compliance

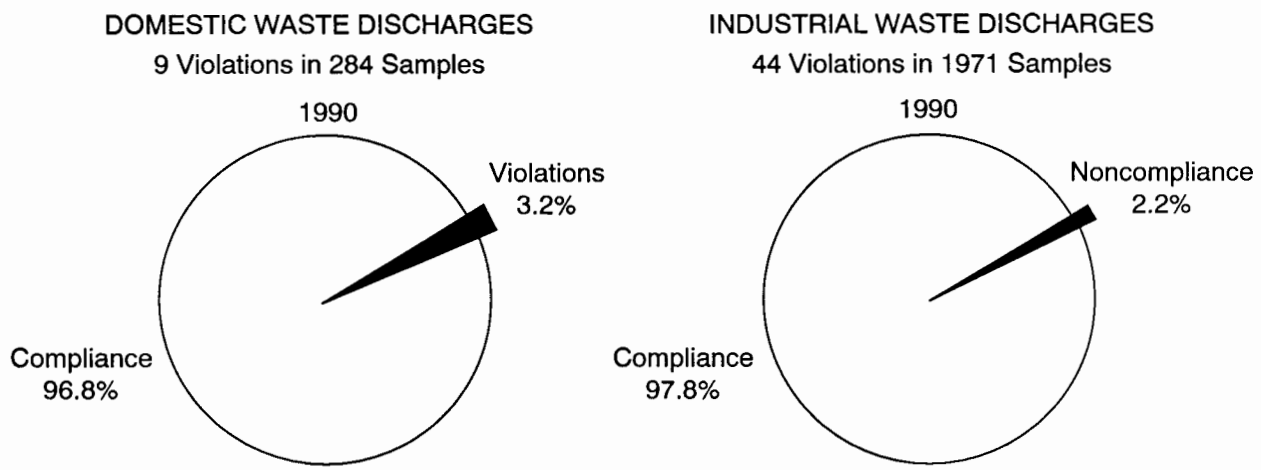


Fig. 27. Summary of Clean Water Act Compliance in 1990, NPDES Permit NM0028353.

schedules for Outfalls 04S, 05S, 09S, and 10S (Table G-58). Interim effluent limits and schedules of compliance for Outfalls 05S and 10S were added to the existing FFCA (Table G-59). DOE/LAAO did not sign the FFCA until January 8, 1991 and therefore the FFCA did not become effective during 1990.

On July 19, 1990, EPA Region 6 served an Administrative Order (AO), Docket No. VI-90-1263, on the University of California. This AO contains the same interim limits and schedules for compliance as the FFCA issued to DOE/LAAO on July 12, 1990.

On December 19, 1990 EPA Region 6 served an Administrative Order (AO), Docket No. VI-91-067 on Los Alamos National Laboratory. This AO listed 13 violations of the Laboratory's NPDES permit during August to November 1990 and required the Laboratory to take corrective actions necessary to eliminate and prevent recurrence of the effluent violations cited. In addition, the Laboratory was required to submit a report detailing the specific corrective actions. For any corrective action exceeding 30 days, EPA required LANL to submit a plan for elimination and prevention of the listed violations. In 1991, the Laboratory prepared and submitted a response to EPA, including corrective actions taken and proposed schedules necessary to achieve compliance with the AO.

3. Sanitary Wastewater Systems Consolidation Project. The purpose of this project is to eliminate violations of the Laboratory's NPDES permit by construction of a new, centralized, sanitary wastewater treatment plant at TA-46. This plant will replace the TA-3 wastewater treatment plant, which is over 30 years old, and seven smaller treatment facilities that do not consistently meet NPDES discharge requirements. The new treatment plant will also eliminate approximately 30 septic tank systems throughout the Laboratory. Completion of construction and full operation of this plant is required by July 1992 under the Laboratory's agreement (FFCA) with the EPA.

The proposed Sanitary Wastewater Systems Consolidation Project (SWSC) is designed to meet current and anticipated discharge requirements and to result in a significant savings in operating and maintenance costs. The project includes approximately 19 km (12 mi) of new gravity collection lines and five lift stations that will collect sanitary wastewater from most of the technical areas of the Laboratory. The north interceptor will be located along Pajarito Road from TA-3 to TA-46, which is the site of the new treatment plant. The south interceptor will be located along R-Site Road from TA-9 to TA-18. Two lift stations will pump wastewater from this location to the TA-46 plant.

Excess treated effluent will be discharged to Cañada del Buey under the Laboratory's NPDES permit.

The Title II plans and specifications for the SWSC Project were completed during 1990 by the consulting engineer and were approved by the Laboratory and DOE. The target date for completion of construction and start up of the new treatment plant is July 1992.

4. Compliance Evaluation Inspection. On May 23 and 24, 1990, the NMEID conducted an NPDES compliance evaluation inspection (CEI) at the Laboratory. On July 16, 1990 NMEID mailed a written report of the CEI findings to LANL and DOE. Major deficiencies cited in the inspection report concerned characterization of waste streams, operation and maintenance procedures, documentation, and record keeping.

The Laboratory's written response to the CEI was submitted to NMEID and EPA Region 6 on August 17, 1990. The Laboratory is in disagreement with a number of the findings of the CEI and provided additional information in support of its response. The response also included documentation of actions that LANL has taken and will take to correct deficiencies identified along with additional information requested by the NMEID. Corrective actions documented in the response included establishment of a waste stream identification and characterization program to verify that waste streams are properly permitted and improved operation and maintenance procedures. LANL has not received a formal response from EPA Region 6 regarding the CEI.

5. Spill Prevention Control and Countermeasure Plan. The SPCC Plan was revised in 1990 and is a comprehensive and site-specific plan for spill prevention at the Laboratory. This plan includes the regulatory requirements for oil pollution prevention under 40 CFR 112, and for best management practices under 40 CFR 125. The SPCC Plan covers containment structures and operational procedures for oil and chemical tanks to minimize a release into the environment. Appendices to the plan include reportable quantity tables for various chemicals and the mechanism for reporting these releases to the appropriate managerial and regulatory agencies. This plan complements existing administrative requirements in the Laboratory's Environmental, Health, and Safety Manual. The plan is implemented at the group level through the spill coordinator.

During 1990, construction projects were completed on four containment structures, and eight chemical storage lockers were purchased by HSE-8 for use at various sites in order to provide proper spill controls.

6. Upgrading of Septic Tank Systems. During 1990, two holding tanks systems were converted into sanitary waste treatment systems using evapotranspiration beds at TA-49. This conversion will significantly reduce the potential of an overflow from these holding tanks. In addition, a study was implemented on connecting the holding tanks at TA-54, Area L to a sanitary wastewater treatment facility. All septic systems are registered with the NMEID, in accordance with the liquid waste disposal regulations. An additional requirement for 1990 was the certification and forwarding of pumping records to the NMEID.

7. Sulfuric Acid Release from TA-3 Power Plant. During May 19, 20, and 21, 1990, sulfuric acid accidentally was released from the acid storage tank at the TA-3 power plant. This acid flowed into the neutralization tank at the power plant causing three different periods during which the pH of the discharge from the neutralization tank to Sandia Canyon exceeded NPDES limits. These exceedances were reported within 24 hours as required by paragraph G of the Laboratory's NPDES permit, which requires immediate reporting of any noncompliance that may endanger health or the environment. Response to the acid release included neutralization of the flow in Sandia Canyon with soda ash, plugging of the overflow at the neutralization tank, and preparation of new procedures for operation of the neutralization system. An investigation of the release has been completed and findings of the investigation are being implemented by the Laboratory and Johnson Controls World Services. A new pH neutralization system is being designed for the power plant.

A presentation was made on the acid release to the EPA, Region VI, on July 24, 1990, to show cause why further enforcement action was not required. EPA and the Laboratory have agreed on a settlement concerning penalties and fines associated with the acid spill that is expected to be finalized in 1991.

8. Oil Release from TA-3 Storm Drainage System. Three incidents concerning the discharge of an oily sheen from an NPDES-permitted outfall occurred near the University House at TA-3. Laboratory personnel collected samples, provided clean-up oversight, and reported incidents verbally and in writing to EPA and NMEID as required by the Clean Water Act and New Mexico Water Quality Control Commission regulations. The Laboratory formed a task force to identify and eliminate all sources of oil responsible for the oily sheen.

C. National Environmental Policy Act

1. Background. The National Environmental Policy Act (NEPA) mandates that federal agencies protect the environment while performing their missions. NEPA establishes the national policy of

- encouraging harmony between persons and their environment, and
- ensuring that planners and decision makers consider environmental values and factors of proposed actions along with technical and economic goals.

NEPA documents include the following

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

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

The issuance of Secretary of Energy Notice 15 on February 5, 1990 radically changed the DOE's requirements for compliance with NEPA. The main points of the SEN, effective on the date of issuance, are

- authority to approve NEPA documents was withdrawn to DOE Headquarters from field offices such as the Albuquerque Operations Office;
- the list of categorical exclusions, actions that do not individually or cumulatively have a significant impact on the environment and for which no further NEPA documentation need be prepared, was decreased by deleting activities similar to others covered in NEPA documentation;
- memos to file (MTF), used by DOE to document the decision that a proposed activity (not covered in a listed categorical exclusion) would not cause significant impact on the environment, was discontinued on September 30, 1990; and
- activities that do not fit one of the remaining categorical exclusions must be documented in an EA.

An expanded list of categorical exclusions is being developed but is not final yet. In the interim, EAs must be prepared on most proposed activities. Copies of EAs are submitted to affected states for review before being approved at DOE Headquarters. New regulations for implementing NEPA, including an extensive list of categorical exclusions, types of projects typically

requiring EAs, and those typically requiring EISs were proposed on November 2, 1990 (proposed 10 CFR 1021).

2. Compliance Actions. Proposed activities at the Laboratory are reviewed by HSE-8 staff to identify those that could impact the human environment. No such activity can go beyond the planning stage, nor can reasonable alternatives be precluded, until DOE approves the NEPA documentation for the action. The HSE-8 staff provides DOE with information on potential environmental impacts of proposed activities. The basic, brief information document used for NEPA compliance in past years was an action description memorandum (ADM), but beginning in April 1990, a slightly different format containing similar information, called a DOE environmental checklist (DEC) was required. Using information in the ADM or DEC, DOE approves a proposed activity as having clearly insignificant environmental impacts or requires that an EA be prepared to evaluate in greater detail whether significant adverse environmental impacts could occur. HSE-8 reviews proposed activities to identify those with potential impacts on the human environment and prepares documentation requested by DOE for compliance with NEPA. These impacts include

- emissions to air;
- liquid effluents;
- toxic, hazardous, or radioactive solid waste;
- individual doses from radioactive material;
- individual exposures to toxic or hazardous material; and
- adverse impacts on sensitive areas such as archaeological resources, floodplains, wetlands, and the habitat of threatened or endangered species.

These documents are transmitted to DOE for review and approval. This process must be completed before a proposed activity can proceed beyond the planning and design phase.

During 1990, HSE-8 reviewed 702 actions proposed to be undertaken at the Laboratory for NEPA applicability, including potential impacts on sensitive areas. Of these, 394 were reviewed through the Environment, Safety, and Health Questionnaire system, which provides detailed descriptions of proposed activities. The HSE-8 staff identified 163 projects as having possible impacts on the environment. One ADM and 81 DECs were submitted to DOE on 82 of these activities. Six were cancelled or determined to be covered in earlier NEPA documentation. The remaining 48 activities will be documented at a later date. Of the 82 ADM/DECs submitted, 48 were approved, EAs were required on 13, and no decision had been made on the remaining 21 at the end of 1990. Of the 13 required EAs, two were completed and submitted to DOE, one proposed activity was revised, and the remaining EAs are being prepared. Three additional EAs, required by DOE during 1989, were also completed and submitted. None of these EAs received approval during 1990. The level of activity summarized in the above is significantly higher than the 1989 level when seven ADMs and one EA were prepared.

3. Types of Activities Reviewed. The 82 proposed activities documented in ADM/DECs can be categorized by type of project as follows. Examples are given in parentheses.

- 8 construction projects (airport fire station, reception center addition)
- 28 waste management projects (hazardous waste oil storage facility, new sanitary landfill)
- 7 energy research projects (Line D shielding LAMPF/LANSC, scruncher support)
- 20 routine maintenance projects (elevator sprinkler addition, roof access ladder)
- 4 ongoing activity relocation projects (relocate beryllium shop, 7-in. impact tester)
- 7 other research projects (intense ion beam facility, tritium target safety study)
- 24 trailer/transportable/transportainer set-up projects, some for use as multiple units (office trailer for Area L, two office trailers for HSE-7 at TA-50)

4. Environmental Assessments. The proposed activities documented in the five EAs submitted to

DOE during 1990 are summarized below. The DOE reviews the analysis of environmental impacts for the proposed action presented in each EA.

a. Relocation of Superconducting Ceramics, Filament Winding, and Mechanical Characteristics Operations. The proposed action was to relocate the operations currently being performed in three unrelated laboratories, located in different areas of the same building, to a renovated area of the same building. No significant changes in operations were planned. The purpose of the relocation was to move the operations into areas where improved ventilation and air filtration systems would be provided and where adequate space would be available to improve the safety and efficiency of the operations.

b. New Production Reactor Modular High-Temperature Gas-Cooled Reactor Critical Experiments. As part of a research program to develop and evaluate new sources of tritium, the Idaho National Laboratory is sponsoring experiments at LANL to evaluate neutron physics parameters that could exist in the modular high-temperature gas-cooled reactor version of the new production reactor. These experiments would allow parameters such as tritium production efficiency to be quantified and would provide reactor physics data to validate the computer codes that will be used to design the new production reactor. The project involves manufacture of fuel rods, lithium targets, and filler-block absorbers, and experimentation, which includes reconfiguration of an existing reactor critical assembly, performance of experiments, and analysis of the irradiated material.

c. Weapons Engineering Tritium Facility. The Weapons Engineering Tritium Facility (WETF) was planned to retain LANL's capability of repackaging small quantities of tritium to exacting specifications. Small quantities of tritium are required for energy research and development activities and for research on nuclear weapons test devices carried out as part of LANL's mission. The WETF is an improved design proposed to replace an aging LANL facility where tritium has been repackaged for many years. The proposed action will reduce adverse environmental impacts caused by tritium repackaging by substantially reducing the amount of tritium that escapes to the environment.

d. Materials Science Laboratory. The Materials Science Laboratory is planned to modernize LANL's capabilities in the field of materials science by providing state-of-the-art materials research apparatus and proper facilities to support this equipment. The new facility will be a modern laboratory for the synthesis, processing, and characterization of new and novel materials to support programs of national interest in defense, energy, and the basic sciences.

e. Scintillation Vial Crusher. Some of the research and development projects conducted at LANL produce scintillation fluids in vials as waste from normal operations. These vials contain radioisotopes such as tritium, ^{14}C, and actinides or transuranic isotopes such as ^{238}Pu and ^{239}Pu. The scintillation fluids contain some solvents defined as hazardous waste. The scintillation vial crusher is a small (28 in. x 63 in. x 73 in.) piece of equipment designed to automatically crush vials. The fluids contained in the vials will be collected in plastic-lined drums. By operating the scintillation vial crusher, the storage space needed for this waste stream can be reduced to about 5% of that currently being used.

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

Ninety-one potential sources of air emissions were evaluated for compliance with all Federal and State air quality regulations.

1. Federal Regulations. The following federal requirements, except for radioactive emissions, have been adopted by the State of New Mexico as part of its State Implementation Plan. However, if New Mexico does not enforce these federal requirements, the EPA retains the prerogative to do so.

a. National Emission Standards for Hazardous Air Pollutants. These regulations set requirements such as reporting, construction approval, and emissions control, disposal, and stack testing for specified operations involving hazardous air pollutants. NMEID has responsibility for administering these regulations except for those governing radionuclides. Laboratory operations that are regulated by NESHAP include

radionuclide emissions, asbestos disposal and removal, and beryllium processing.

Radionuclides. The EPA has promulgated regulations for control of airborne radionuclide releases from DOE facilities (40 CFR 61, Subpart H). Since 1985, DOE and its contractors have been subject to EPA's radionuclide air emissions limits for exposure of the general public via the air pathway (DOE 1985). In its 1989 revision of this regulation, EPA required that no member of the public receive more than 10 mrem/yr (effective dose equivalent). As discussed in Section III, the maximum dose to a member of the public from 1990 LANL operations was 8.1 mrem, or 81% of the EPA limit (Sec. III).

In addition to requiring that the maximum effective dose to a member of the public from airborne radioactive emissions be less than the 10 mrem/year standard, the NESHAP regulation also prescribes detailed procedures and methods for measuring radionuclide emissions. The Laboratory, although it meets the less than 10 mrem/year standard, cannot yet demonstrate compliance with all of EPA's emission monitoring requirements. LANL and DOE will initiate discussions with EPA in 1991 to identify areas of noncompliance and to develop a program to bring the Laboratory into compliance with these regulations.

Asbestos. During 1990, Johnson Controls World Services removed approximately 540 lin ft of friable asbestos and 960 lin ft of potentially friable asbestos from piping. Approximately 70 360 sq ft of friable asbestos and 6 280 sq ft of potentially friable asbestos were removed from other components. The Laboratory inspects asbestos removal operations on a routine basis and coordinates corrective action on identified problems.

Asbestos wastes potentially contaminated with radionuclides are disposed of at TA-54 in accordance with required disposal practices. Nonradioactive asbestos is disposed of off-site in a certified landfill. Eight disposal certifications, including the annual notification for asbestos disposal during small jobs, were submitted to NMEID during 1990. Also submitted were nine notifications of asbestos removal, including the annual notification for small renovation jobs. In 1990, 0.2% of the asbestos removed from pipe and other facility components involved small renovation jobs that required no job-specific notification to the State; the rest required job-specific notification.

Beryllium. The beryllium NESHAP includes requirements for notification, emissions limits, and stack performance testing for beryllium sources. The four beryllium facilities at the Laboratory operate under State air quality permits containing these requirements. The Laboratory obtained a permit for a fifth beryllium processing operation to be located in TA-3-35; this facility has not yet been constructed.

Beryllium machining operations are located in Shop 4 at TA-3-39, in Shop 13 at TA-3-102, the beryllium Shop at TA-35-213, and the beryllium processing facility at TA-3-141. Exhaust air from each of these operations passes through air pollution control equipment before exiting from a stack. A fabric filter controls emissions from Shop 4. The other operations use high-efficiency particle-attenuation filters to control emissions, with a removal efficiency of more than 99.95%. Source tests have demonstrated that all beryllium operations meet the emission limits established by NESHAP and that emissions are so low that there is negligible impact on ambient air quality.

b. National and New Mexico Ambient Air Quality Standards. Federal and State ambient air quality standards are shown in Appendix A, Table A-3. New Mexico standards are generally more stringent than the national standards. Pollutants that are emitted by Laboratory sources include sulfur dioxide, particulate matter, carbon monoxide, nitrogen dioxide, lead, beryllium, heavy metals, and nonmethane hydrocarbons. Various operations at the Laboratory emit these pollutants. As a potential part of the Environmental Oversight and Monitoring Agreement between DOE and New Mexico, emissions of these pollutants from all sources at the Laboratory are being calculated and will be reported to the State in October of 1991. Based on monitoring data and air dispersion modeling studies, Laboratory emissions have not exceeded Federal or State standards.

c. Prevention of Significant Deterioration. These regulations have stringent requirements (preconstruction review, permitting, best available control technology for emissions, air quality increments that must not be exceeded, visibility protection

requirements, and air quality monitoring) for the construction of any new major stationary source or major modification of a source located near a Class I area, such as Bandelier National Monument's Wilderness Area. To date, DOE and the Laboratory have not been subject to these regulations.

d. New Source Performance Standards. These standards apply to 72 source categories. Its provisions include emission standards, notification, emission testing procedures and reporting, and emission monitoring requirements. The types of sources currently operating at the Laboratory have not been subject to new source performance standards (NSPS).

2. State Regulations.

a. Air Quality Control Regulation 301. The open burning of materials is regulated by Air Quality Control Regulation (AQCR) 301. Under this regulation, open burning of explosive materials is permitted when transport of these materials to other facilities may be dangerous. DOE and the Laboratory are allowed to burn waste explosives and explosive-contaminated wastes under this provision. Waste explosives are burned at the TA-16 burning ground. Other wastes, usually wood or wood products, that are potentially contaminated with small amounts of explosives are burned in a two-stage incinerator. Permits are not required for these activities. Permits are required for civil-defense-related research projects at the Laboratory that require open burning. Permits for the open burning of jet fuel for ordnance testing and for burning of wood waste from detonations were obtained during 1990 (Table VIII-2).

b. AQCR 501. Provisions of AQCR 501 set emission standards according to process rate and require the control of emissions from asphalt-processing equipment. The asphalt concrete plant operated by Johnson Controls World Services is subject to this regulation. The plant, which has a 75 000 kg/h (75 ton/h) capacity, is required to meet an emission limit of 16 kg (35 lb) of particulate matter per hour. A stack test of the asphalt plant in 1977 indicated an average emission rate of 0.8 kg/h (1.8 lb/h) and a maximum rate of 1.0 kg/h (2.2 lb/h) over three tests (Kramer 1977). Although the plant is old and is not required to, it meets NSPS stack emission limits for asphalt plants (Kramer 1977).

c. AQCR 604. Provisions of AQCR 604 require gas-burning equipment built before January 10, 1972 to meet an emission standard for NO_x of 0.3 lb/10^6 Btu when natural gas consumption exceeds 10^{12} Btu/yr/unit. The TA-3 power plant's boilers have the potential to operate at heat inputs that exceed the 10^{12} Btu/yr/unit, but they have not been operated beyond this limit. Therefore, these boilers have not been subject to this regulation. However, the TA-3 power plant meets the emission standard. The emission standard is equivalent to a flue gas concentration of 248 ppm; the measured flue gas concentrations of the TA-3 boilers ranged from 15 to 22 ppm in 1990.

d. AQCR 702. Provisions of AQCR 702 require permitting of any new or modified source of potentially harmful emissions if they exceed threshold emission rates. In the past, this regulation addressed only criteria pollutants. However, in September 1988, the NMEID adopted revisions to AQCR 702 that require new sources of toxic air pollutants that were constructed or reconstructed after December 31, 1988, to obtain air quality permits if they emit more than the specified emission rate for that chemical. More than 500 toxic air pollutants are regulated by these changes, and each chemical's specified hourly emission rate is based on its toxicity. The Laboratory makes conservative estimates of maximum hourly chemical usage and emissions for each new and modified source. These estimates are compared with the applicable AQCR 702 limits to determine if additional permits are required.

e. AQCR 752. Provisions of this regulation required a one-time registration of all sources emitting toxic air pollutants in amounts in excess of a specified annual emission limit. Complying with this regulation required the Laboratory to estimate emissions on a building-by-building basis for more than 500 chemicals. To calculate these emissions, a computerized data base has been developed that includes usage, products, and wastes for each regulated chemical. In general, air emissions are very low because the Laboratory is primarily a research facility and chemical usage is small. The limit was exceeded for only one chemical, lithium hydride, in one building, the TA-3 machine shop. This source was registered with the State. In response to the anticipated requirements of the Environmental Oversight Agreement between DOE and New Mexico, this data base is being updated.

3. Environmental Oversight and Monitoring Agreement. The Environmental Oversight and Monitoring Agreement as drafted between DOE and New Mexico requires that the Laboratory/DOE

- submit a comprehensive inventory of radionuclides, sulfur dioxide, PM-10, TSP, carbon monoxide, ozone, nitrogen dioxide, lead, beryllium, asbestos, heavy metals, nonmethane hydrocarbons, and over 600 regulated toxic air pollutants;
- provide a comprehensive materials balance of volatile organic compounds used at the Laboratory;
- perform source tests for stacks in accordance with applicable laws and regulations; and
- install continuous monitors on emission sources as required by applicable regulations.

In response to these requirements, the Laboratory is preparing a material-balance-based emission inventory for all regulated air pollutants. This inventory will be submitted to the State and will also be used to determine which stacks require testing and installation of continuous emission monitors. The Laboratory's toxic air pollutant data base, containing information on the emissions of the more than 500 toxic air pollutants regulated by New Mexico, will be updated and expanded to include the other classes of chemicals covered by the Environmental Oversight and Monitoring Agreement. It is not known when the terms of this agreement will be in place.

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

1. Background. The Laboratory conducts two separate programs to monitor the groundwater quality of the area and to meet regulatory requirements. The first program includes sampling of water supply wells and special monitoring wells under the Laboratory's long-term environmental surveillance program. These samples are collected by HSE-8 and are analyzed by the Health and Environmental Chemistry Group (HSE-9). The results of this program are reported in Sec. VI. The second program includes sampling from various points in the Laboratory and County distribution systems to ensure compliance with SDWA. Compliance samples are analyzed for organic and inorganic constituents and for radioactivity at the State Scientific Laboratory Division (SLD) in Albuquerque. SLD reports the analytical results directly to NMEID. The Johnson Controls World Services, Inc. (JCI) Environmental Laboratory also collects samples throughout the Laboratory and County distribution systems and tests them for microbiological contamination, as required under the Safe Drinking Water Act (SDWA). The JCI Environmental Laboratory is certified by SLD for microbiological testing of drinking water.

The EPA has established maximum contaminant levels for organic and inorganic constituents and radioactivity in drinking water. These standards have been adopted by the State of New Mexico and are included in the New Mexico Regulations Governing Water Supplies. NMEID has been authorized by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

During 1990, all water samples collected under the SDWA program at Los Alamos and tested by SLD in Albuquerque and by the JCI Laboratory were found to be in compliance with the maximum contaminant levels established by regulation. The following is a summary of the results of testing under the SDWA at Los Alamos.

2. Chemical Constituent Monitoring of the Water Distribution Systems. The Laboratory and County distribution systems were sampled at three locations for inorganic and volatile organic constituents during 1990 to determine compliance with SDWA parameters. Each location is representative of one of the well fields supplying the distribution system: Los Alamos Airport is representative of water quality in the Los Alamos well field; White Rock Fire Station of the Pajarito well field; and Barranca Mesa School of the Guaje well field. Samples were collected by HSE-8 and delivered to SLD in Albuquerque for analysis. All of these results were found to be in compliance with the standards. Inorganic analyses consist of the following parameters: Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, Silver, Nitrate (as N), and Fluoride. Volatile organic constituents (VOC) analyses are divided into two classes. VOC Group I consists of

Table VIII-4. Inorganic Constituents in the Water Distribution System in 1990 (mg/L)

Contaminant	Los Alamos Airport[1]	White Rock Fire Station[2]	Barranca School[3]	EPA Maximum Contaminant Level
Arsenic	0.025	<0.005	0.011	0.05
Barium	<0.1	<0.1	<0.1	1.0
Cadmium	<0.001	<0.001	<0.001	0.01
Chromium	0.019	<0.005	0.007	0.05
Lead	<0.005	<0.005	0.005	0.05
Mercury	<0.0005	<0.0005	<0.0005	0.002
Selenium	<0.005	<0.005	<0.005	0.01
Silver	<0.001	<0.001	<0.001	0.05
Nitrate (N)	0.57	0.53	0.50	10.0
Fluoride	1.57	0.35	0.62	4.0

[1]Representative of Los Alamos well field.

[2]Representative of Pajarito well field.

[3]Representative of Guaje well field.

Table VIII-5. Volatile Organic Constituents in the Water Distribution System in 1990 (μg/L)

Containment	Los Alamos Airport	White Rock Fire Station	Barranca Mesa School
VOC Group I			
Chloroform	ND	ND	0.00 T
Dibromochloromethane	0.00 T	1.40	1.20
Bromodichloromethane	ND	0.00 T	0.00 T
Bromoform	2.80 T	1.10	0.00 T
Aromatic Purgeables (6)	0.00 N	0.00 N	0.00 N
Other Group I Contaminants (47)	ND	ND	ND
VOC Group II			
1,2-Dibromoethane (EDB)	0.00 N	0.00 N	0.00 N
1,2-Dibromo-3-chloropropane (DBCP)	0.00 N	0.00 N	0.00 N

MDL = (Minimal detectable limit) 1.00 μg/L for VOC Group I.
MDL = 0.08 μg/L for VOC Group II.
ND = Not detected.
T = Trace (< detection limit).
N = None detected above detection limit.

aromatic and halogenated purgeables to determine the presence of Benzene, Carbon Tetrachloride, 1,1-Dichloroethylene, 1,2-Dichloroethane, para-Dichlorobenzene, Trichloroethane, Trichloroethylene, and Vinyl chloride plus 49 unregulated contaminants. VOC Group II consists of Ethylene Dibromide (EDB) and 1,2-Dibromo-3-chloropropane (DBCP). A summary of analytical results is included in Table VIII-4 and VIII-5.

Under the SDWA, testing for total trihalomethanes is required for the Los Alamos water supply once each quarter. During 1990, a total of 20 samples was collected by HSE-8 at five locations within the Laboratory and County distribution systems, and was delivered to SLD for analysis. Results showed concentrations below the maximum contaminant level of 0.10 mg/L for total trihalomethanes. A summary of these results is included in Table VIII-6.

3. Radiological Monitoring of the Water Distribution Systems. The water distribution systems were sampled for radioactivity at three locations during 1990. Samples were analyzed by SLD and the results showed concentrations below the maximum contaminant level for gross alpha and gross beta. A summary of these results are listed in Table VIII-7. Additional information concerning the radiological monitoring of the water supply is included in Section VI. of this report.

4. Microbiological Monitoring of the Water Distribution Systems. Each month during 1990 approximately 45 samples were collected throughout the Laboratory and County distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the distribution systems. These samples were collected by JCI Environmental Section personnel and analyzed in the JCI-certified laboratory for the presence of coliform bacteria, which is an indicator used to determine if harmful bacteria could be present. During 1990, no coliform bacteria were found. Thirty-nine of the microbiological samples (approximately 7%) collected were found to have some noncoliform bacteria present. Although the presence of noncoliform bacteria is not a violation of SDWA, it does indicate stagnant water or biofilm growth in the distribution lines. A summary of the analytical results is found in Table VIII-8.

5. Other Environmental Activities for Protection of the Water Supply System. Other programs conducted to protect the water supply system include the following:

a. Wellhead Inspection Program. A survey of water supply wells was conducted during 1990 by the JCI Environmental Section to detect any potential sources of contamination into the system. Daily inspections of the wells were also conducted by JCI Utilities to maintain pumping equipment and to identify any problem that might lead to a potential health hazard.

Table VIII-6. Total Trihalomethane Concentrations in the Water Distribution System in 1990 (mg/L)

	Quarters			
Sampling Location	**First**	**Second**	**Third**	**Fourth**
Los Alamos Airport	0.003	0.006	0.009	0.003
White Rock Fire Station	<0.004	<0.004	<0.004	<0.004
North Community Fire Station	0.005	0.003	0.002	0.002
S-Site Fire Station	<0.004	0.004	0.003	<0.004
Barranca School	<0.004	0.008	<0.004	<0.004

The EPA maximum contaminant level is 0.10 mg/L.

Table VIII-7. Radioactivity in the Water Distribution System

Analysis	Standard for Calibration	Radioactivity in Sample June 25, 1990 (pCi/L)
Los Alamos Airport		
Gross alpha[a]	^{241}Am	3.90
	Natural uranium	5.30
Gross beta[b]	^{137}Cs	3.90
	^{90}Sr, ^{90}Y	3.90
White Rock Fire Station		
Gross alpha	^{241}Am	0.40
	Natural uranium	0.60
Gross beta	^{137}Cs	4.30
	^{90}Sr, ^{90}Y	4.20
Barranca School		
Gross alpha	^{241}Am	0.50
	Natural uranium	0.60
Gross beta	^{137}Cs	3.30
	^{90}Sr, ^{90}Y	3.30

[a]The EPA gross alpha maximum contaminant level is 15 pCi/L.
[b]The EPA gross beta maximum contaminant level is 50 pCi/L.

Table VIII-8. Microbiological Testing of the Water Distribution System

Month	No. of Tests Conducted	No. of Tests Positive for Bacteria	
		Coliform	Noncoliform
January	45	0	1
February	43	0	2
March	45	0	6
April	50	0	1
May	45	0	4
June	45	0	4
July	46	0	4
August	47	0	8
September	44	0	3
October	45	0	1
November	46	0	2
December	46	0	5
Total	547	0	41

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

c. Cross-Connection Control Program. The Laboratory also maintains a cross-connection control program to ensure that a separation exists between the potable water supply and industrial or other nonpotable systems. During 1990, each of the backflow prevention devices used in separation of the potable water system was tested to ensure proper operation.

6. Water Production Records. Monthly water production records are provided to the State Engineer's Office under the water rights permit held by the DOE for the Los Alamos water system. During 1990, total production from the wells and gallery for potable and nonpotable use was 6.26×10^6 m^3 (5 070 ac-ft). This production amounts to 91.5% of the total diversion right of 6.8×10^6 m^3 (5 541 ac-ft) that is available to the DOE under its permit. Details of the performance of the water supply wells (pumpage, water levels, drawdown, and specific yield) and their operation are published in a series of separate reports, the most recent of which is "Water Supply at Los Alamos During 1990," (Stoker 1991). Two new water supply wells were completed in 1990; a summary discussion of the drilling is provided in Sec. IX.H. of this report. These wells will be connected to the water supply system and be in production once equipped with pumps, well houses, and transmission lines.

F. Federal Insecticide, Fungicide, and Rodenticide Act

This act regulates the manufacturing of pesticides, with requirements on registration, labeling, packaging, record keeping, distribution, worker protection, certification, experimental use, and tolerances in foods and feeds. Sections of this act that are applicable to the Laboratory include recommended procedures for storage and disposal and requirements for certification of applicators. The Laboratory is also regulated by the New Mexico Pest Control Act. The application, storage, disposal, and certification of these chemicals is conducted in compliance with these above governing regulations. JCI conducts the application of pesticides under the direction of the Laboratory's Pest Control Program Administrator. A Laboratory Pest Control Policy, which includes management programs for vegetation, insect, and small animals, was established in 1984 and is currently going through a formal revision by the Pest Control Oversight Committee (PCOC). The PCOC has members from ENG-6, JCI, HSE-5, and HSE-8. This committee was established to review and recommend policy changes in the overall pest management program at the Laboratory.

An annual inspection conducted by the United States Department of Agriculture found no deficiencies in the Laboratory's pesticide application program and certified application equipment.

G. National Historic Preservation Act

As required by Sec. 106 of the National Historic Preservation Act of 1966, which was implemented by 36 CFR 800, "Protection of Historic Properties," Laboratory activities are evaluated in consultation with the State Historic Preservation Officer (SHPO) for possible effects on cultural or historic resources. During 1990, Laboratory archaeologists evaluated 355 undertakings (an undertaking is an activity that has the potential to affect a cultural/historic resource), conducted 37 field surveys, recorded 18 archaeological sites, and submitted four survey reports for SHPO review.

As a result of Laboratory activities, adverse impacts to two archaeological sites were mitigated through site excavation. Laboratory of Anthropology (LA) 70029, a Late Archaic/Basketmaker II (800 B.C. - A.D. 600) lithic scatter was excavated in advance of sewer plant construction associated with the Sanitary Wastewater Systems Consolidation Project. Analysis of over 5 400 recovered artifacts is ongoing and will help answer questions concerning hunter-gatherer subsistence and the adoption of agriculture on the Pajarito Plateau.

Excavation of LA 4618, a Coalition Period (A.D. 1100-1350) nine room pueblo located at the Chemical Waste Storage Facility, was initiated. When complete,

excavation of this pueblo will help refine Coalition Period ceramic chronology and contribute to an understanding of Anasazi site abandonments.

An archaeological test excavation permit, as required by the Archaeological Resources Protection Act of 1979 and implemented by 43 CFR Part 7, was issued to Mariah Associates, archaeological contractor for the Public Service Company of New Mexico. Four sites will be tested under this permit in advance of PNM's proposed 345 KV Ojo Line Extension Project.

Inspections of artifact repositories holding DOE collections were completed as required by a new federal regulation, 36 CFR Part 79, "Curation of Federally Owned and Administered Collections." This activity included an inventory of all burial remains removed from DOE lands, which will expedite full compliance with the Native American Graves Protection and Repatriation Act passed in November, 1990.

H. Endangered/Threatened/Protected Species and Floodplains/Wetlands Protection

1. Threatened and Endangered Species. The DOE and Laboratory must comply with the Endangered Species Act of 1973 as amended. During 1990, HSE-8 reviewed 702 actions proposed to be undertaken at the Laboratory for potential impact on critical habitats. Of these, 394 were reviewed through the Environment, Safety and Health questionnaire system. The Biological Resource Evaluations Team of HSE-8 identified 13 projects (Table VIII-9) as needing surveys to determine the habitat components and to rule out the presence of critical habitats for endangered, threatened or sensitive plant or animal species either Federally or State listed.

The team identified projects needing surveys by first reviewing a literature data base compiling all habitat requirements of Federal and State endangered, threatened and candidate species. After field surveys were conducted, the habitat components of each of the surveyed sites were then compared to the habitat requirements of the organisms in question.

Both field and literature studies indicated no critical habitats for any Federal or State endangered, threatened or candidate species within the 13 proposed construction sites.

Table VIII-9. Surveys to Determine Habitat Components for Threatened and Endangered Species

White Rock Tourist Center
Meteorological Tower
Meteorological Tower
Fire Tank and Waterline Installation
Transportable for EES-14
Proposed Parking Area behind TA-48
Installation of CPM for LAMPF
Los Alamos Integrated Communications Systems
Live Firing Range Telephone Systems Upgrades
Utilities Restoration Los Alamos Canyon Wells, Lines
Norton Line Upgrade
Sanitary Wastewater Consolidation System Lines
Weapons Subsystem Laboratory

2. Monitoring of Threatened And Endangered Species. Historic nest locations of the Federally listed Peregrine falcon *(Falco peregrinus)* continued to be monitored. The historic aerie was not used during CY90 although a pair of young falcons were observed in the area.

3. Biological Surveys. As part of long-term biological monitoring studies, evaluation of raptor populations and raptor nests was continued. Birds of concern included the zone-tail hawk *(Buteo albonotatus)*, Cooper's hawk *(Accipiter cooperii)*, and Northern Goshawk *(Accipiter gentilis)*. The location of one construction project was surveyed for potential nesting of and foraging by the Cooper's hawk.

4. Floodplain/Wetland Assessments. Los Alamos National Laboratory must comply with Executive Order 11988, Floodplain Management and EO 11990, Protection of Wetlands. During 1990, 702 actions proposed to be undertaken at the Laboratory were reviewed for impact to floodplains and wetlands. All projects reviewed in 1990 were outside floodplain/wetland boundaries. The Floodplain Assessment for one project, Live Firing Range Expansion, was published in the Federal Register 55:174, September 7, 1990.

5. Wetland Studies. As part of the DOE/Laboratory RCRA permit, in coordination with the United States Fish and Wildlife Service (USFW), all wetlands greater than 1 acre within the Laboratory boundaries were mapped. The mapping was part of the USFW National Wetland Inventory (NWI). The NWI mapping used aerial mapping and a hierarchial classification based on ecological, hydrological and soil characteristics.

Although the mapping convention does identify and classify wetlands, the convention does not characterize or delineate wetlands. To understand the present state and complexity of the wetlands defined by the Fish and Wildlife Service, a characterization of selected wetlands was initiated as part of the Biological Resource Evaluations program. The purpose of the study was four-fold:

- delineate selected wetland boundaries;
- characterize the use of wetlands by reptiles, amphibians, small mammals, and birds;
- provide baseline data on which to determine future change; and
- determine present and future impacts and threats to wetlands.

A wetland characterization and delineation was done for each site in accordance with the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (EPA, 1989d). This delineation requires that three factors be present for the area to be considered a wetland: hydrology, hydric soils, and hydrophytic vegetation. All three criteria were present within the areas studied in Pajarito and Sandia Canyons. Other quantitative studies included monitoring water quality, well levels and aquatic invertebrates.

Wetlands classified as marshes in Pajarito and Sandia Canyons were selected for this first-year study. Results indicate that these wetlands provide habitats for a number of species. Quantitative information was compiled using pit traps for reptiles and amphibians and live trapping for small mammals. Observational and tracking studies were conducted for birds, large mammals and insects. Quantitative and observational data were compiled for 21 species of reptiles, amphibians and small mammals (Table VIII-10). Additionally, observations indicate that deer *(Odocoileius hemionus)*, elk *(Cervus canadensis)*, raccoon *(Pryocyon lotor)*, coyotes *(Canis latrans)* and the bobcat (*Lynx rufus*) use the wetlands for foraging and in some cases bedding. Raptor species including the American Kestrel *(Falco sparverius)* and Redtail Hawk *(Buteo jamaicensis)* use the areas for nesting and foraging. Songbirds, including the Redwing blackbird *(Agelaius phoeniceius)*, were observed nesting during the summer and flocks have been observed foraging in the winter.

Detailed information is incorporated into a report entitled "Wetland Characterization and Delineation Studies, Pajarito and Sandia Canyons," in preparation.

I. Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Reauthorization Act (SARA) of 1986 mandate cleanup of toxic and hazardous contaminants at closed and abandoned hazardous waste sites. The CERCLA/SARA-related actions for potential release sites at the Laboratory are being addressed under the DOE's Environmental Restoration Program (Sec. IV.K) in conjunction with RCRA corrective actions (Sec. VIII.A).

J. Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) (15 U.S.C. *et seq.*) establishes a list of toxic chemicals for which the manufacturing, 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 risks to human health or the environment, and controlling measures for chemicals found to pose an unreasonable risk.

The Code of Federal Regulations (40 CFR 761) contains regulations applicable to PCBs. The code applies to all persons who manufacture, process, distribute in commerce, use, or dispose of PCBs or PCB-containing 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, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to PCBs only if they are present in

Table VIII-10. Animal Species Using Wetlands in Pajarito and Sandia Canyons

Reptiles	
Cnemidophorus velox	Plateau Whiptail
Eumeces multivirgatus	Many-lined Skink
Eumeces obsoletus	Great Plains Skink
Scelophorus undulatus	Eastern Fence Lizard
Phryosoma douglasii	Short-horned Lizard
Pituophis melanoleucus	Gopher Snake
Thamnophis elegans	Wandering Garter Snake
Amphibians	
Ambystoma tigrinum	Tiger Salamander
Pseudacris triseriata	Chorus Frog
Hyla arenicolor	Canyon Treefrog
Bufo woodhousei	Woodhouse Toad
Scaphiopus multiplicatus	Southern Spadefoot
Small Mammals	
Reithrodontomy megalotis	Western Harvest Mouse
Peromyscus truei	Pinon Mouse
Peromyscus maniculatus	Deer Mouse
Peromyscus leucopus	Whitefooted mouse
Microtus montanus	Meadow Vole
Microtus longicaudus	Long-tailed Vole
Sorex vagrans	Vagrant Shrew
Tamias spp.	Chipmunk
Spermophilus variegatus	Rock Squirrel

concentrations above a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to materials whose PCB concentrations are 50 ppm and above. At the Laboratory, materials containing >500-ppm PCBs are transported off-site for treatment and disposal, and materials containing 50- to 500-ppm PCBs are incinerated off-site or disposed of at TA-54, Area G. This area has been approved by the EPA for disposal of PCB-contaminated materials.

Efforts continued toward the replacement, reclassification, and disposal of PCB equipment at the Laboratory. During 1990, the following PCB waste was sent off-site for disposal: 62 395 kg (137 555 lb) liquid PCB oil that included 50-499 ppm oil; 10 751 kg (23 701 lb) contaminated debris; 3 338 kg (7 360 lb) contaminated water; 45 148 kg (99 533 lb) from 17 transformers; and 47 901 kg (105 603 lb) from 558 capacitors. In addition, 5 039 kg (11 109 lb) of PCB-contaminated soil, debris, and equipment were disposed of at TA-54, Area G. Of the 31 PCB transformers being retrofilled within the last two years, nine were reclassified to non–PCB status at the end of 1990, two more are expected to be reclassified in the first quarter of 1991, and another six by the end of 1991. Eleven of

the 31 transformers are being retrofilled with silicone oil and the rest with perchloroethylene. No audits or inspections of the Laboratory's PCB activities were conducted by the EPA, NMEID, or DOE in 1990.

Information about the Laboratory's activities involving asbestos is presented in Sec. VIII.D.1.a.

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

Title III Sec. 313 of SARA exempts DOE facilities from reporting requirements. However, it is DOE policy that this exemption not be exercised and that the Laboratory report its releases under the remaining provisions of Sec. 313. However, all research operations at the Laboratory are also exempt under other provisions of the regulation and only pilot plants and specialty chemical production facilities at the Laboratory must report their releases. As a result, the Plutonium Processing Facility is the only operation at the Laboratory that is covered by Sec. 313. The only regulated chemical that is used at the Plutonium Processing Facility in amounts greater than the Sec. 313 reporting thresholds is nitric acid.

The Laboratory submitted the required Sec. 313 report to EPA in July of 1990. This report covered the releases of nitric acid during 1989. About 47 500 pounds of nitric acid were used for plutonium processing with releases to the air of approximately 454.55 kg (1 000 lb.) The amount of nitric acid released to the atmosphere was calculated using data obtained from a study that measured the air emissions from the facility. The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in the wastewater treatment operations. Only the air releases required reporting for 1989. Data on releases for CY 90 will be reported under Sec. 313 in July 1991.

L. Engineering Quality Assurance

The Laboratory has a quality assurance program (Engineering, 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 DOE's program division, DOE/Albuquerque Operations Office and DOE/LAAO; Laboratory operating group(s), the Facility Engineering Division; the design contractor; the inspection organization; and the construction contractor. Each proposed project is reviewed by personnel from HSE-8 to ensure that 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 in this section. Many of these activities are ongoing and provide supplementary information for surveillance and compliance activities at the Laboratory.

A. Meteorological Monitoring (Brent Bowen, Jean Dewart, Greg Stone, and William Olsen)

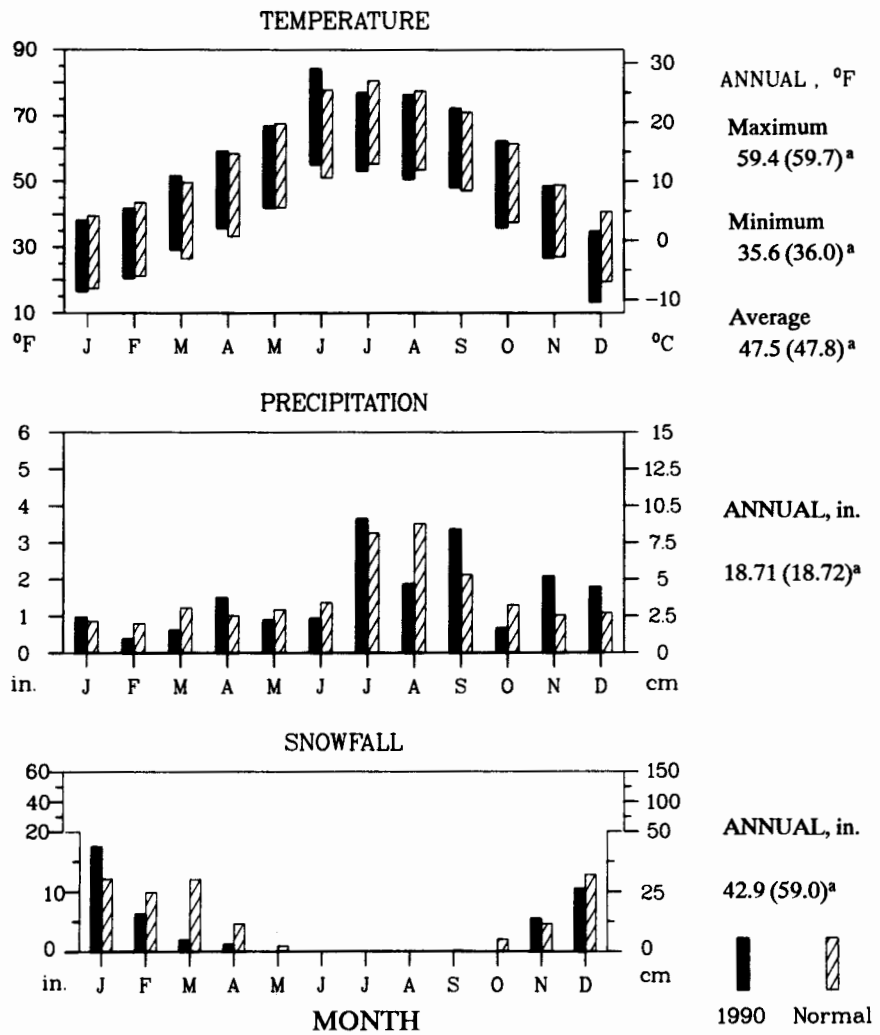
1. Weather Summary. Precipitation was normal in Los Alamos during 1990, totaling 48 cm (18.7 in.). Snowfall, however, was 25% below normal, at 109 cm (42.9 in.), the least during a year since 1981. The temperature averaged slightly below normal for the year, although there were several extreme months. A strong thunderstorm on July 20th dropped large hail on White Rock, causing extensive property damage ($9 million). The year had the warmest June and coldest December on record. The annual summary is shown in Fig. 28; other data are shown in Tables G-60 through G-63.

The year started with a snowy January, when 44 cm (17.5 in.) fell. A snowstorm on the 18th accounted for 30 cm. (12 in.). Another storm produced strong winds on the 29th, with a peak gust of 32 m/s (71 mph). The weather became dry during February and March, with precipitation at about 50% of normal during both months. Likewise, snowfall was light from February through April, totalling only 9.4 in., or 35% of normal. Record warm weather on March 21st and 22nd brought high temperatures of 65°F on both days. More record temperatures were recorded on April 14 and 28 (72° and 71°F, respectively).

A strong high-pressure system formed over the southwestern United States during June, causing record heat in Los Alamos. The month became the warmest June on record, edging out the previously warmest of 1980. Temperatures reached 90°F or higher on six days during the month, second only to the seven occurring in June of 1980. Daily temperatures tied or broke records on five days, including 93°F on the 24th, the highest recorded during 1990.

After another record high temperature of 90°F on July 1, the monsoon season got under way, with some especially intense thunderstorms. A strong thunderstorm dropped golf-ball-sized and some baseball-sized hail in White Rock on July 20. Widespread damage to homes, motor vehicles, and other property resulted in $9 million of insurance claims. Some golf-ball-sized hail was also reported in the Eastern Area of Los Alamos. Precipitation (including rainfall and melted hail) averaged 3.2 cm (1.25 in.) over White Rock, White Rock Y, and the East Gate areas. Another isolated thunderstorm dropped heavy rain of 3.1 cm (1.24 in.) at TA-59 on the 22nd. Most of the rain fell during one hour. Thunderstorm activity subsided during August, with rainfall totaling only 4.7 cm (1.87 in.), or just over 1/2 the normal amount. However, a downpour of 4.2 cm (1.64 in.) did fall at East Gate during a one-hour period on the 21st. Temperatures were quite cool during August. Low temperature records were set or tied on three dates including a 42°F reading on the 7th.

Autumn started off wet, with heavy rainfall in September of 8.6 cm (3.37 in.), 60% above normal. It was the wettest September since 1975. Daily precipitation records were set on two dates, including 2.4 cm (0.94 in.) on the 16th. The weather became dry in October with precipitation 50% below normal at 1.7 cm (0.66 in.). A record cold temperature of 26°F occurred on the ninth. November was wet with precipitation twice the normal, at 5.3 cm (2.08 in.). A strong storm dropped snow in the Jemez Mountains and heavy rain in Los Alamos at the beginning of the month. A cold



[a]Normal temperatures are in parenthesis.

Fig. 28. Summary of weather in Los Alamos (TA-59) during 1990.

front caused strong winds on the first; a modular building was damaged and several ponderosa pines were blown down near Ancho Canyon. Rainfall of 2.6 cm (1.04 in.) on the second set a record for the date. Several "Arctic blasts" gave Los Alamos its coldest December on record, besting the previous coldest in 1931. The month's average temperature was -4.4°C (24.0°F), or 3.4°C (6.1°F) below normal. A cold wave and fresh snow cover gave Los Alamos three consecutive days of below -18°C (O°F) on the 22-24th, including -23°C (-10°F) on the 23rd and 24th. The 23°C (-10°F) was the coldest temperature recorded in Los Alamos since December 1978. The cold weather caused some water pipes to burst. Several intense storms caused strong winds on the 2nd and 30th with peak gusts of 28 m/s (63 mph).

2. Wind Roses. Average wind speed and direction frequencies at four sites are plotted for daytime, nighttime, and total time (Figs. 29–31). The frequencies are presented as wind roses, which are circles with lines extending from the center representing the direction

from which the wind blows. The length of each line is proportional to the frequency at which the wind blows from the indicated direction. Each direction is 1 of 16 primary compass points (for example, N and NNE) and is centered on a 22.5° sector. Each spoke consists of different widths representing different wind speed classes. The frequency of calm winds (winds with speed less than 1 mph [0.5 m/s]) is given in the circle's center. Day and night are defined by sunrise and sunset times.

The wind roses represent winds at four sites: TA-50 (2 216 m [7 270 ft] above sea level); Bandelier (2 146 m [7 040 ft]); East Gate (2 140 m [7 019 ft]); and Area G (2 039 m [6 688 ft]). Surface winds (11-12 m above ground level) are shown for all sites, and 92 m level winds are shown for TA-50.

Surface winds at Los Alamos are generally light, with an average speed of 3 m/s (7 mph). Wind speeds greater than 5 m/s (11 mph) occur with frequencies ranging from 10% at TA-50 to 20% or so at East Gate. The southerly and southwesterly winds at East Gate tend to be stronger because the Los Alamos Canyon, located just to the south, presents less friction. Many of the strong winds occur during the spring. More than 40% of the surface winds at all sites have speeds less than 2.5 m/s (5.5 mph). The average wind speed

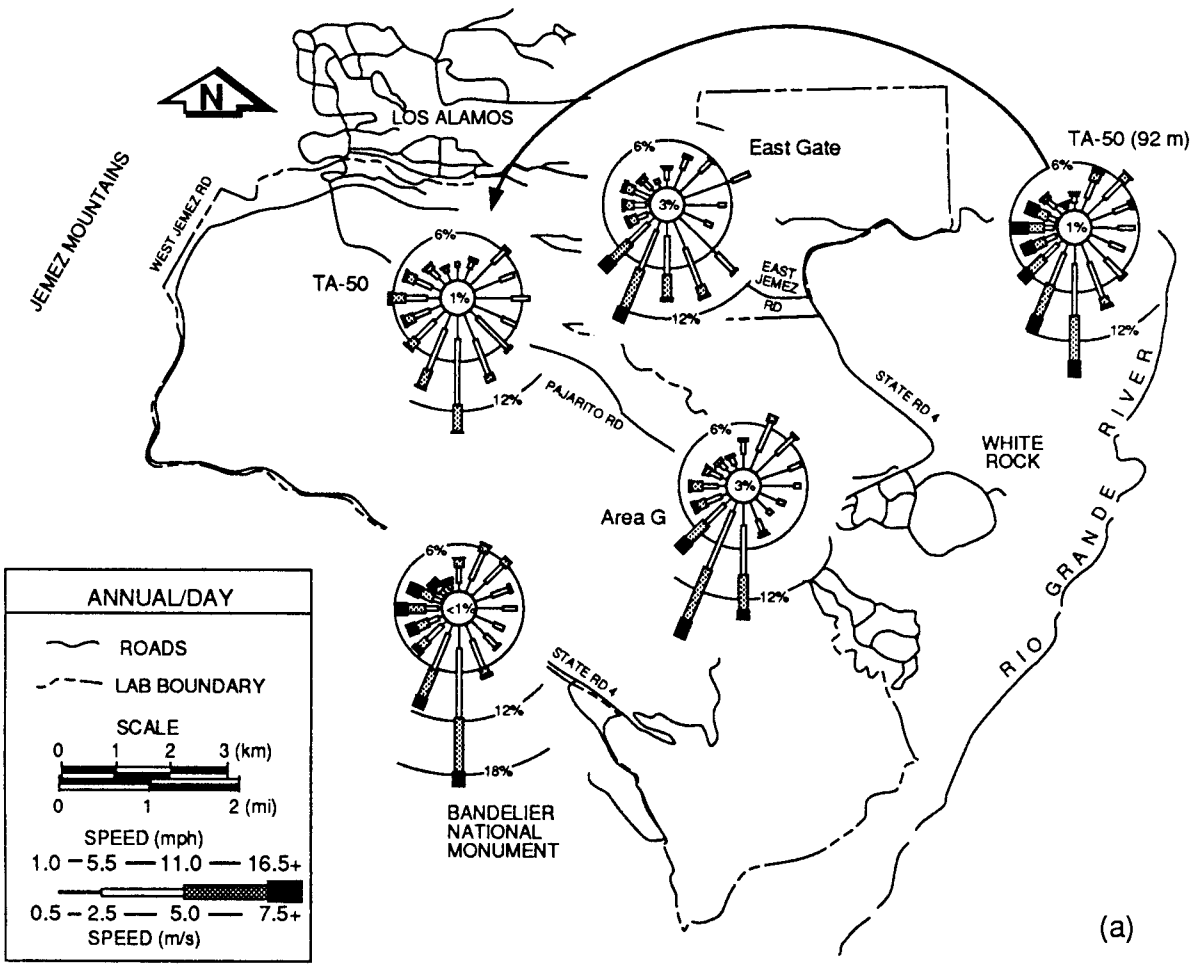


Fig. 29. Average daytime wind roses at Laboratory stations. Surface winds are represented at TA-59 (upper left) clockwise to East Gate, Area G, and Bandelier. TA-50 winds at the 92 m level are also shown.

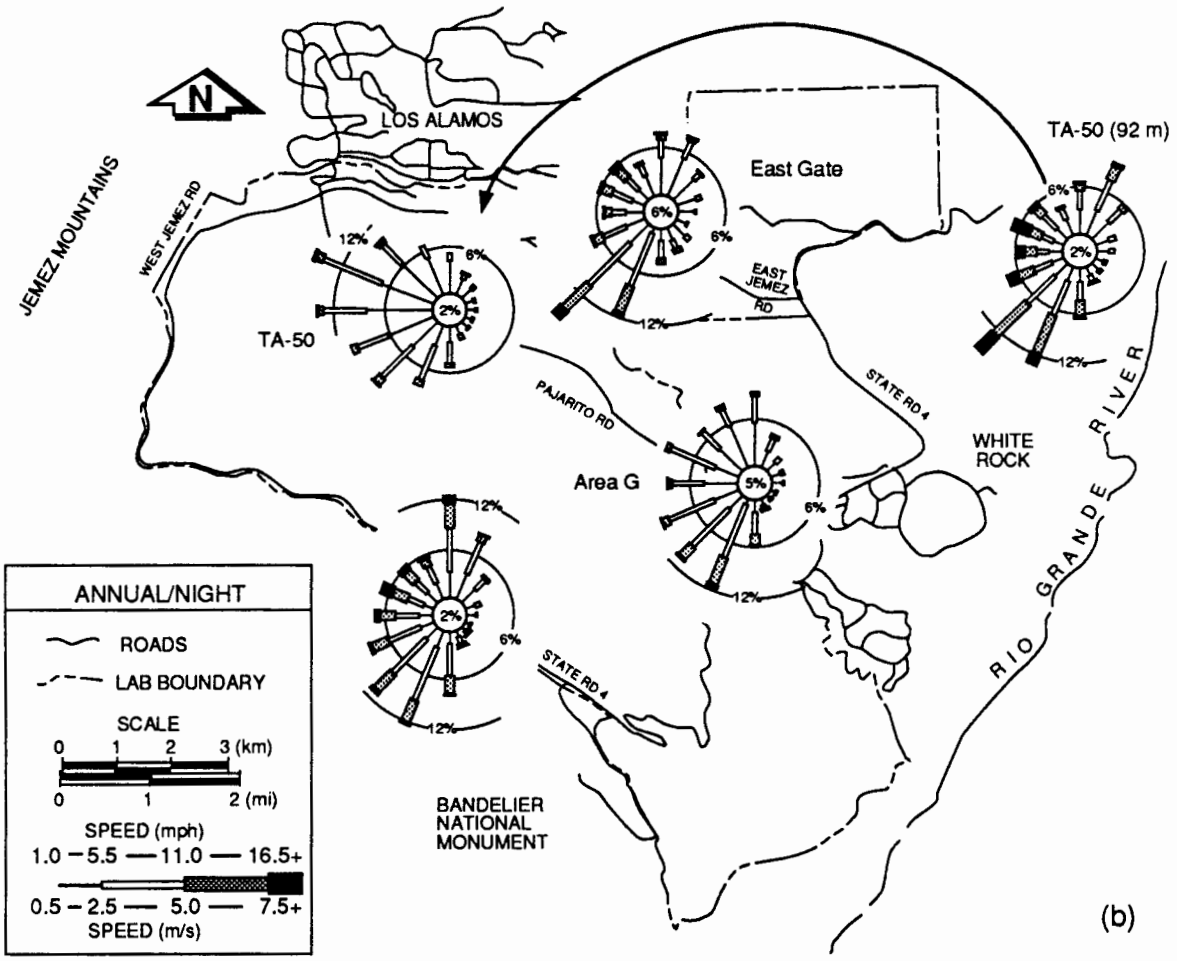


Fig. 30. Average nighttime wind roses at Laboratory stations. Surface winds are represented at TA-59 (upper left) clockwise to East Gate, Area G, and Bandelier. TA-50 winds at the 92 m level are also shown.

increases to over 4 m/s (9 mph) at the 92 m (300 ft) level at TA-50. At this higher level, winds with speeds greater than 5 m/s (11 mph) occur one-third of the time, and wind speeds less than 2.5 m/s (5.5 mph) occur almost one-third of the time.

Wind distribution varies with site, height above ground, time of day, and season, primarily because of the regional terrain. On days with sunshine and light large-scale winds, a deep, thermally driven upslope wind develops over the western part of Pajarito Plateau. Note the high frequency of southeasterly through southerly winds during the day at TA-50 (both levels) and East Gate during the year. The upslope wind is even more frequent at stations further to the west: TA-6 and TA-59 (not shown). Upslope winds are generally light: less than 2.5 m/s (5.5 mph). Winds become more southerly and south-southwesterly at lower elevations on the Plateau. The winds here are dominated by Rio Grande Valley flows. A thermally driven up-valley wind is probably responsible for most of the winds. The up-valley winds can be stronger than the upslope winds, with speeds up to 5 m/s (11 mph) or greater.

Surface winds are quite different during the night. A shallow, cold-air drainage wind often forms and flows down the plateau on clear nights when large-scale winds are light. Drainage winds are generally less than 4 m/s (9 mph) and are most apparent at TA-50 (W to NW) and less so at Area G. The nighttime TA-50 winds at 92 m (300 ft) and surface winds at other sites are dramatically different from the TA-50 surface

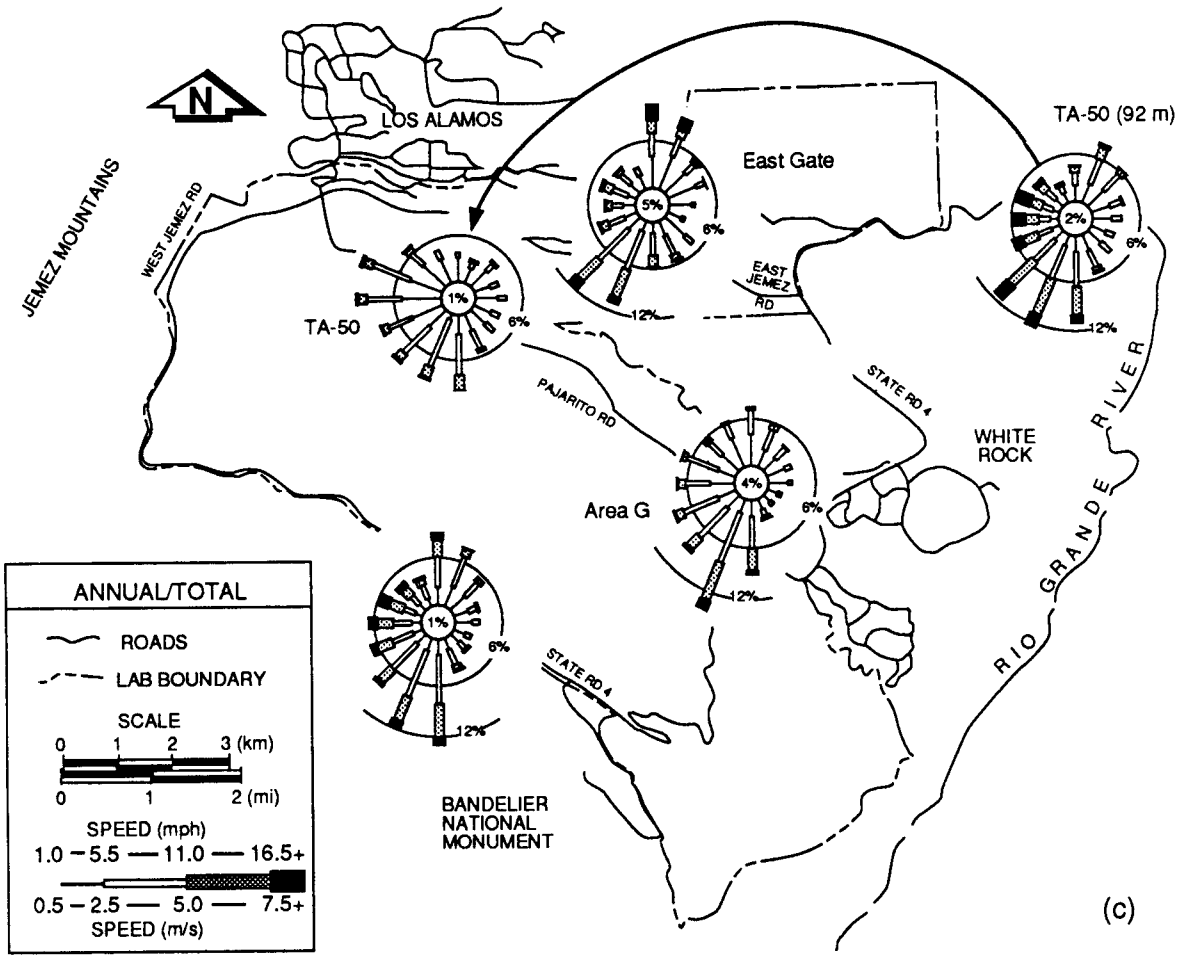


Fig. 31. Average total wind roses at Laboratory stations. Surface winds are represented at TA-59 (upper left) clockwise to East Gate, Area G, and Bandelier. TA-50 winds at the 92 m level are also shown.

winds, reflecting the dominance of the Rio Grande Valley winds. The high frequency of up-valley winds at night is from the thermally driven winds from daytime extending into the early evening, and possibly, to a lesser extent, channeled, larger-scale winds. A drainage wind sometimes forms down the Rio Grande Valley during the evening, causing the north to northeast winds. This wind usually continues for several hours after sunrise (notice the slight peak of northeast winds during the daytime). The large scale of the thermally driven up- and down-valley winds accounts for the lag with sunrise and sunset, respectively. In contrast, the plateau up- and downslope flows are smaller and coincide closely with sunrise and sunset.

The frequency of winds do vary dramatically with season (not shown). The Rio Grande down-valley wind predominates at night and morning during winter because of the long nights and dry atmosphere. The thermally driven, up-valley wind is more predominant in other seasons because of longer days and frequent, large-scale southerly winds.

3. Precipitation Summary. Precipitation ranged from near normal over the western parts of Los Alamos County to several inches above normal in the northeast and east. Figure 32 shows precipitation analyses for the summer monsoon season (July-September) and the entire year. Monthly precipitation totals are also listed in Table G-62.

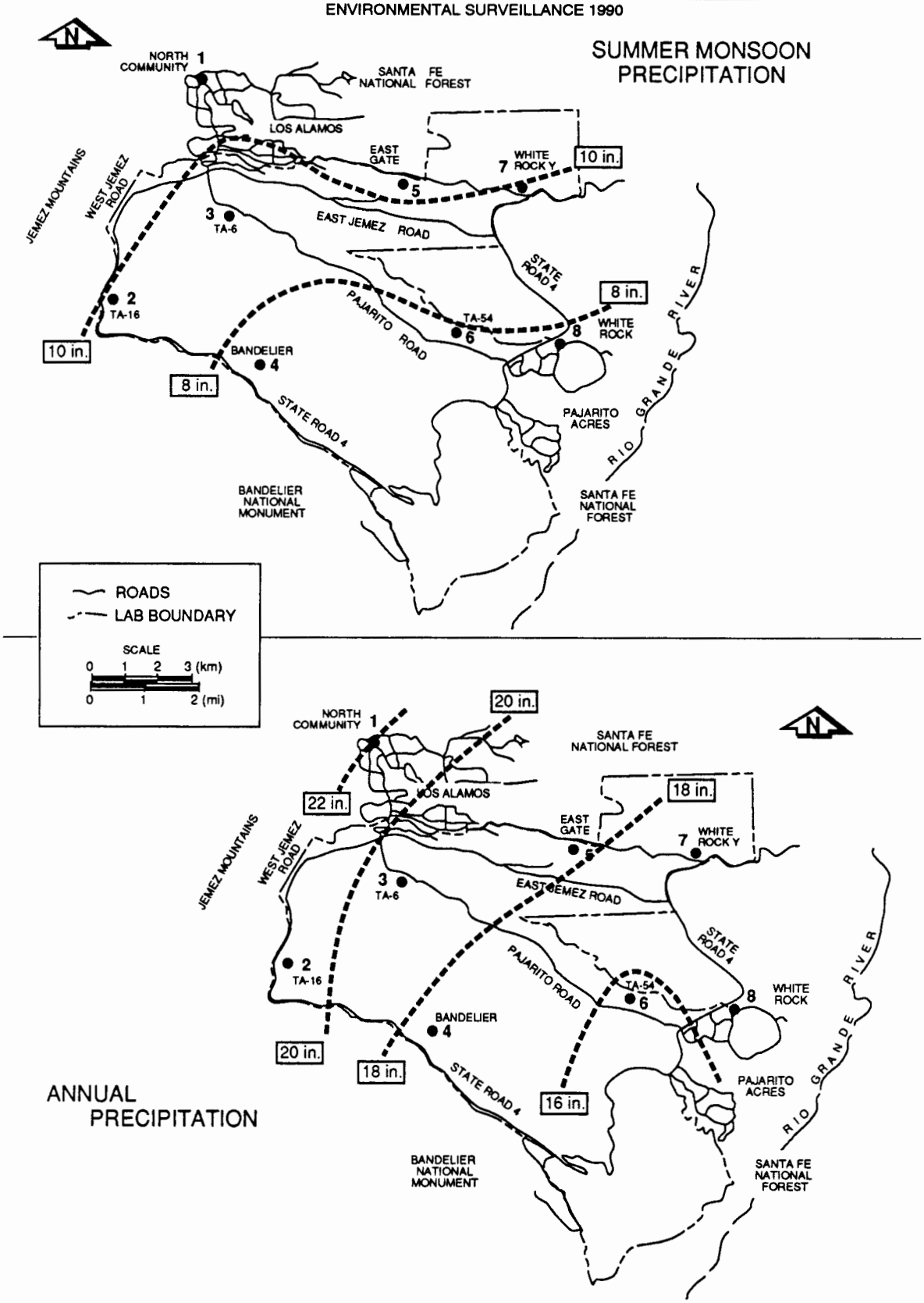


Fig. 32. Summer monsoon (June-September) and annual precipitation during 1990 (in inches).

Precipitation generally is concentrated over and near the mountains in the County and decreases east-southeastward toward the Rio Grande Valley (toward lower terrain). Typically, nearly half of the annual precipitation falls during the monsoon season, or July through September. The combination of a large-scale moist wind flow from the Gulf of Mexico into New Mexico, strong sunshine, warm temperatures, and elevated terrain are responsible for frequent afternoon and early evening showers and thundershowers. Monsoon rainfall ranged from near normal over western areas (Stations 1-4) to nearly 4 in. above normal in the northeast (Stations 5 and 7). Several heavy thunderstorms in July and September made big contributions to the rainfall totals at these sites. Likewise, these two stations along with the White Rock and Area G (Stations 6 and 8) had annual precipitation totals 2-4 in. above normal.

B. Environmental Studies at the Pueblo de San Ildefonso (W. D. Purtymun, Max Maes, and John Sorrell [Bureau of Indian Affairs])

To document the potential impacts of Laboratory operations on lands belonging to San Ildefonso Pueblo, the DOE entered into a memorandum of understanding (MOU) with the Pueblo and the Bureau of Indian Affairs (BIA) to conduct environmental sampling on Pueblo land. The agreement, entitled "Memorandum of Understanding Among the Bureau of Indian Affairs, the Department of Energy, and the Pueblo of San Ildefonso Regarding Testing for Radioactive and Chemical Contamination of Lands and Natural Resources Belonging to the Pueblo of San Ildefonso," No. DE-GM32-87AL37160, was concluded in June 1987. The agreement calls for both hydrologic pathway sampling (including water, soils, and sediments) and foodstuff sampling. This section deals with the hydrologic pathway. The foodstuff sampling is covered in Section VII of this report. During 1987, 1988, and 1989, water, soil, and sediment samples were collected in accord with the agreement (Purtymun 1988b, ESG 1989, EPG 1990).

In 1990, the formal sampling plan (Appendix A to the MOU) called for the Laboratory to collect and analyze special water samples from two stations east and two stations west of the Rio Grande (West: Station 3, Pajarito Well (both pumps); Station 8, Halladay Well; East: Station 17 [new], Don Juan Playhouse Well; and Station 9 Eastside Artesian Well). Special sediment samples were to be collected from four locations on San Ildefonso lands in Mortandad Canyon, designated A6, A7, A8, and A10 on Fig. 33. These samples were collected by Laboratory personnel on November 14, 1990, in the company of personnel from the San Ildefonso Pueblo Governor's Office and the BIA. Because of access difficulties, it was not possible to sample the Don Juan Playhouse Well, and instead, a sample was collected from the Old Community Well (Station 1). The plan also specifies collection and analysis of nine other water samples and seven other sediment samples that have long been included in the routine environmental sampling program as well as special sampling of storm runoff in Los Alamos Canyon as part of the Laboratory's routine monitoring. The additional water and sediment sampling locations are identified in Table IX-1 to permit cross-referencing to other sections in this report discussing the routine monitoring. Instead of storm runoff sampling this year, a special sampling of runoff fed by treated effluent from the Los Alamos County sewage treatment plant was conducted. Results and interpretation of this sampling are described in Section VI.C.6 of this report.

1. Groundwater. Radiochemical analyses in 1990 of groundwater from Stations 3 and 8 indicated no significant change from the analyses that were performed on wells at those locations in 1989 (Table IX-2) for all radioactive constituents except ^{137}Cs. The ^{137}Cs measurements appear somewhat higher for all the 1990 samples, but the uncertainty in those measurements is quite high because of analytical background; it is unlikely that there is any significant cesium present. The measured values appear to exceed the DOE derived concentration guide in three samples by as much as 26% (Table IX-2), but the uncertainties in the measurements make it impossible to conclusively infer the presence of cesium above the guide.

The gross alpha activity in water from Station 1 was 23×10^{-9} μCi/mL. As detailed in Purtymun 1988b, the gross alpha activity in this area is due to uranium and not radium. The activity attributable to uranium (44 μg/L is equivalent to about 30 pCi/L) fully accounts for all the gross alpha activity. Thus, the New Mexico

Table IX-1. Locations on San Ildefonso Lands for Water and Sediment Sampling Included in Routine Monitoring Program

Station Identification	Map Designation	See this Table for Results
Water Sampling Locations		
Rio Grande River		
Otowi	Fig. 16, No. 3	G-15, G-16
Springs in Los Alamos Canyon		
Basalt Spring	Fig. 16, No. 56	G-24, G-25
Indian Spring	Fig. 16, No. 12	G-17, G-18
Spring in Canyon North of Los Alamos Canyon		
Sacred Spring	Fig. 16, No. 11	G-17, G-18
Spring in Sandia Canyon		
Sandia Spring	Fig. 16, No. 13	G-19, G-20, G-21
Springs in White Rock Canyon		
La Mesita Spring	Fig. 16, No. 10	G-17, G-18
Spring 1	Fig. 16, No. 32	G-19, G-20, G-21
Spring 2	Fig. 16, No. 33	G-19, G-20, G-21
Sanitary Effluent Flow in Mortandad Canyon		
Mortandad at Rio Grande	Fig. 16, No. 38	G-19, G-20, G-21
Sediment Sampling Locations		
Los Alamos Canyon		
Los Alamos at SR-4	Fig. 21, No. 35	G-35
Los Alamos at Totavi[a]	Fig. 21, No. 36	G-35
Los Alamos at LA-2[a]	Fig. 21, No. 37	G-35
Los Alamos at Otowi	Fig. 21, No. 38	G-35
Sandia Canyon		
Sandia at SR-4	Fig. 21, No. 38	G-34
Sandia at Rio Grande	Fig. 21, SANDIA	G-34
Mortendad Canyon		
Mortandad at MCO-13	Fig. 21, No. 45 and Fig. 33, A-5	G-35
Mortandad at SR-4	Fig. 21, No. 15 and Fig. 33, A-9	G-34
Mortandad at Rio Grande	Fig. 21, MORTANDAD	G-34

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

Table IX-2. Radiochemical Quality of Groundwater from Wells, Pueblo de San Ildefonso

Station Number and Well Identification	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)
1 Old Community Well	0.2 (0.2)[a]	31 (59)	44 (0.4)	0.053 (0.019)	0.009 (0.009)	23 (5.)	11 (1.)
3 Pajarito Well (pump 1)	0.1 (0.2)	101 (62)	11 (0.1)	0.016 (0.010)	0.012 (0.007)	4. (2.)	5.8 (0.7)
3 Pajarito Well (pump 2)	0.3 (0.2)	125 (66)	7.6 (0.1)	0.004 (0.004)	0.004 (0.004)	9. (3.)	5.3 (0.7)
8 Halladay Well	0.3 (0.2)	135 (59)	1.4 (0.1)	0.019 (0.019)	0.026 (0.016)	4. (1.)	2.2 (0.4)
9 Eastside Artesian Well	0.4 (0.2)	151 (61)	7.2 (0.1)	0.004 (0.009)	0.004 (0.011)	10. (3.)	2.6 (0.5)
Summary							
Maximum concentration	0.4	151	44	0.053	0.166	23	11
Standard[b]	20[b]	120[c]	32[c]	1.6[c]	1.2[c]	15[b]	50[b]
Maximum as a percentage of standard	2.0	126	138	3.3	13.8	153	22
Limits of detection	0.7	40	1	0.1	0.1	3	3

[a]Counting uncertainties are in parenthesis.

[b]Maximum contaminant level–MCL, used for comparison only (NMEIB 1988, EPA 1989b).

[c]Derived concentration guide applicable to DOE drinking water systems – used for comparison only (see Appendix A).

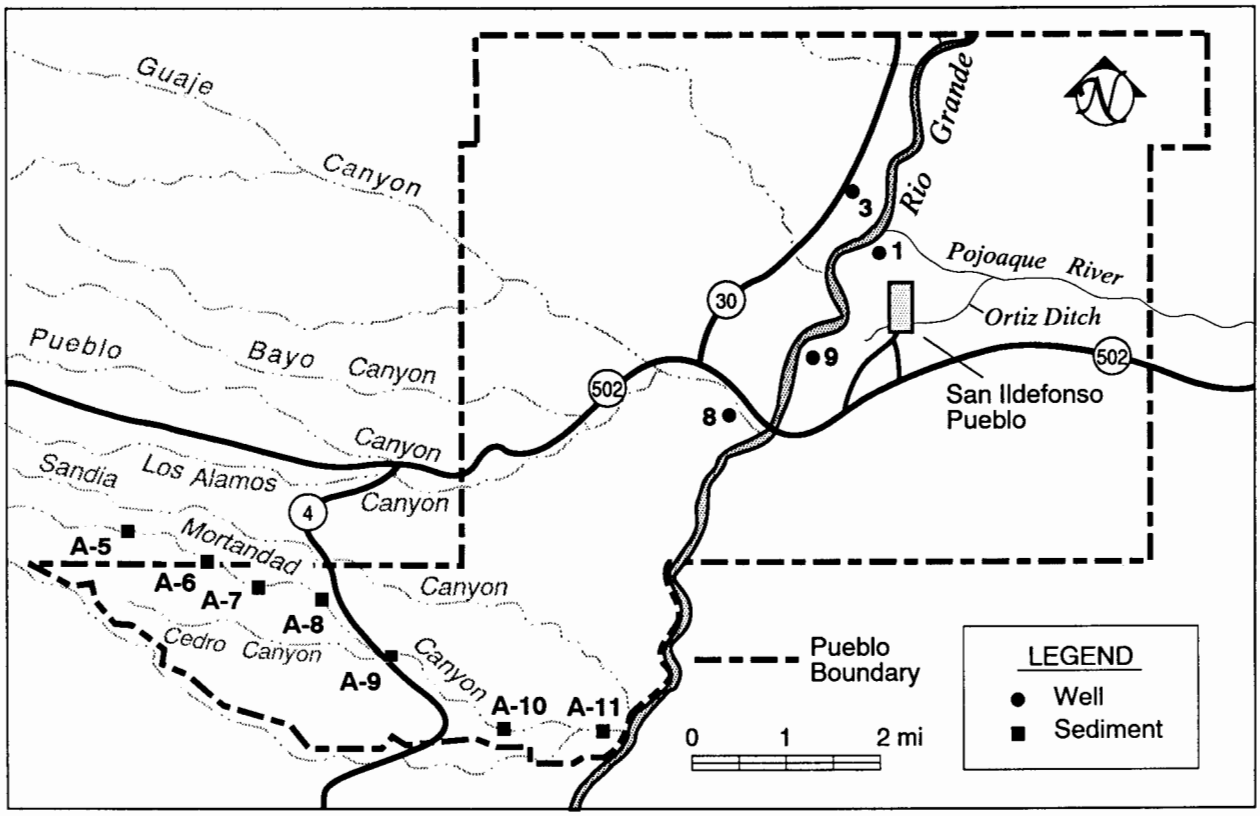


Fig. 33. Groundwater and sediment stations on Pueblo de San Ildefonso land.

Environmental Improvement Division (NMEID) drinking water gross alpha screening level of 5 pCi/L for radium (used for comparison only), which excludes activity from radon and uranium, is not exceeded by this or any of the samples. This well showed a similar, relatively high concentration of uranium when previously sampled (Purtymun 1988b). The plutonium measurements were all below the limits of detection (Table IX-2). (An initial ^{239}Pu measurement in the sample from Station 3 pump was about twice the detection limit and was re-analyzed as quality control evaluation of the data indicated a problem in the analysis recovery. The second analysis, included in Table IX-2, was below limits of detection; and quality assurance results were within control limits.)

No significant change was found in the chemical quality of the groundwater from Stations 3 and 8 from the 1989 data to the 1990 data (Table IX-3). The total dissolved solids standard (500 mg/L) was exceeded, with a concentration of 716 mg/L at Station 3. Other chemical constituents in water from Station 3 and from the other three stations were at or below the standards. All these constituents are naturally occurring, and the levels are as expected for the area.

Special sampling and analyses were conducted during 1989 at Station 3, known as the Pajarito Wells site, to investigate what appeared to be anomalous changes in the chemical quality of water that were noted between samples collected in 1987 and those collected in 1988 (ESG 1989). This sampling determined that the difference in quality is natural and is attributable to the different location and depth of the two separate wells operated at alternate times by a controller, with no indication of a contamination problem (EPG 1990). Samples collected in 1990 from both of the wells (Table IX-2) indicated the quality of water was within the range of values found previously for the two separate wells.

2. Sediments. The industrial waste treatment plant at TA-50 releases treated effluent into the upper reaches of Mortandad Canyon. The effluent, containing traces of radionuclides and other chemicals, infiltrates into the underlying alluvium, forming an aquifer of limited

Table IX-3. Chemical Quality of Groundwater from Wells, Pueblo de San Ildefonso (mg/L)[a]

	Standard[b]	Station 1 Community Well 1	Station 3 Pajarito Wells (pump 1)	Station 3 Pajarito Wells (pump 2)	Station 8 Halladay Well	Station 9 Eastside Artesian Well	Summary: Maximum Concen-tration	Summary: Maximum Concentration as a Percentage of Standard
Chemical Constituents								
Primary[b]								
Ag	0.05	—	<0.010	<0.010	<0.010	<0.010	<0.010	<20
As	0.05	—	<0.030	<0.030	<0.030	<0.030	<0.030	<60
Ba	1.0	—	0.160	0.140	0.090	0.061	0.160	16
Cd	0.01	—	<0.003	<0.003	<0.003	<0.003	<0.003	<30
Cr	0.05	—	<0.006	<0.006	0.014	<0.010	0.014	28
F	4.0	2.0	0.9	1.2	0.6	0.9	2.0	50
Hg	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<10
NO_3-N	10	0.7	0.4	1.6	1.4	1.8	1.6	16
Pb	0.05	—	<0.030	<0.030	<0.030	<0.030	<0.030	<60
Se	0.01	—	<0.030	<0.030	<0.030	<0.030	<0.030	<100
Secondary[b]								
Cl	250	9	165	68	3	165	165	66
Cu	1.0	—	<0.003	0.012	<0.003	<0.003	<0.003	<1
Fe	0.3	—	0.051	0.110	0.220	0.010	0.220	73
Mn	0.05	—	0.010	0.003	0.002	<0.001	0.010	20
SO_4	250	30	58	32	15	19	58	23
Zn	5.0	—	0.056	0.068	0.055	0.033	0.068	<2
TDS[c]	500	246	716	450	54	186	716	143

Table IX-3 (Cont)

	Standard[b]	Station 1 Community Well 1	Station 3 Pajarito Wells (pump 1)	Station 3 Pajarito Wells (pump 2)	Station 8 Halladay Well	Station 9 Eastside Artesian Well	Summary: Maximum Concen-tration	Summary: Maximum Concentration as a Percentage of Standard
Miscellaneous								
SiO_2	—	22	35	39	27	27	39	—
Be	—	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	—
Ca	—	19	56	43	4	9	56	—
Mg	—	9.8	4.9	2.6	0.5	0.5	9.8	—
K	—	3.4	4.0	3.2	0.8	0.8	4.0	—
Na	—	2	366	180	34	106	366	—
Ni	—	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	—
CO_3	—	<5	<5	<5	9	<5	9	—
HCO_3	—	177	481	251	85	150	481	—
P	—	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	—
Total hardness	—	88	160	120	12	24	160	—
Conductance (mS/m)	—	44.4	119.0	64.2	2.20	26.8	119.0	—
pH (standard units)	6.8–8.5	7.6	7.4	7.6	8.1	8.1	9.1	—

[a]Units are milligrams per liter, except as noted.

[b]Primary and secondary drinking water standards are used for comparison only (NMEIB 1988, EPA 1989). Samples were collected August 29, 1989.

[c]Total dissolved solids.

extent perched on the underlying tuff in the upper- and midreaches of the canyon within Laboratory boundaries. A large proportion of the radionuclides in the effluent when it is first released as surface flow is adsorbed or attached to the sediments in the stream channel; thus, the principal means of transport is in surface runoff. Mortandad Canyon heads on the Pajarito Plateau at TA-3 and has a small drainage area. The alluvium thickens in the middle and lower reaches of the canyon. The small drainage area and the thick section of unsaturated alluvium in the middle reach of the canyon have retained all the runoff since 1960 when hydrologic studies began in the canyon.

During 1990, Mortandad Canyon sediments were collected and analyzed for radionuclides from seven sediment stations, one west of the Laboratory and Pueblo boundary and six within the Pueblo (Fig. 33 and Table IX-4). The analytical results for samples from the stations were compared with results from regional soil and sediment samples collected over many years to establish background levels for northern New Mexico (Purtymun 1987a).

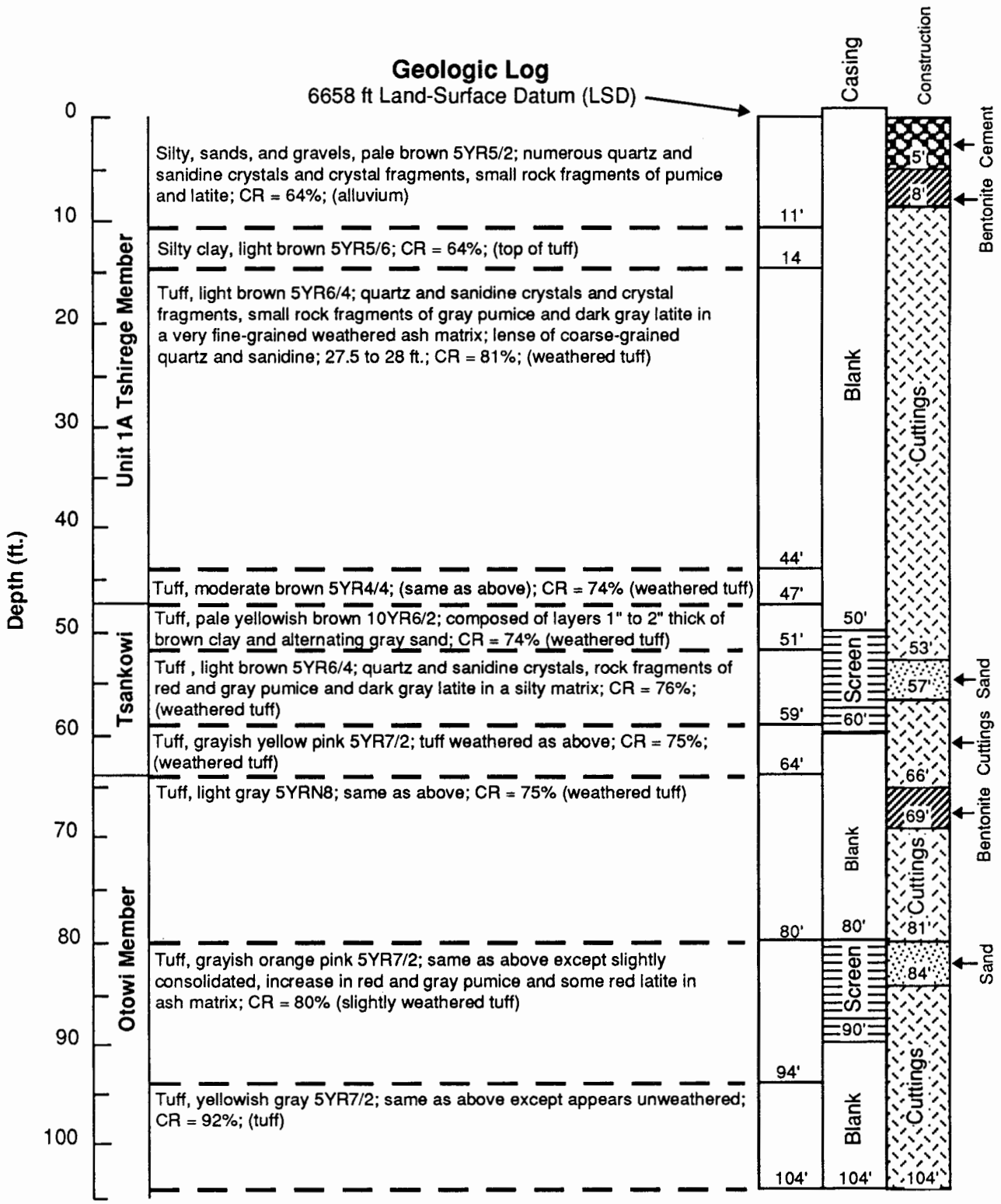
Plutonium concentrations in all Mortandad Canyon sediment samples taken in 1990 at and east of the Laboratory boundary were within the statistical range attributable to worldwide fallout in northern New Mexico (Table IX-4). The highest values for ^{239}Pu in 1990 were obtained at Stations A-5 (on Laboratory property upstream from the boundary with the Pueblo), A-6 (at the boundary), and A-7 (slightly downstream from the boundary). The sample from location A-5 had a ^{239,240}Pu concentration (0.024 pCi/g) just at the statistical background limit (0.023 pCi/g for sediment and 0.025 pCi/g for soil). The boundary sample (A-6) and the next one (A-7) downstream (0.0103 and 0.0136 pCi/g, respectively) had about half of the background limit and lower than levels in 1989. In 1989 both A-6 and A-7 had levels exceeding the statistical background limit.

The measurements are consistent with observation of the physical appearance of the stream channel at the time of collection, which gave no indication of any water runoff or transport of sediments across the Laboratory boundary. Observations during the thunderstorm season noted that no runoff in Mortandad Canyon extended near the Laboratory boundary. (No runoff has been observed to reach the Laboratory boundary in Mortandad Canyon since 1960 when the U.S. Geological Survey initiated special studies there.) For samples dominated by worldwide fallout at these low levels, considerable variability is expected because of different particle-size distributions in grab samples (Purtymun 1990b). Samples with a large percentage of small particles typically exhibit higher mass concentrations of plutonium because of their high adsorption capacity. The sediments in this part of Mortandad Canyon are more like soils because there has been no runoff to separate out silt and clay-size particles that typically show higher concentrations of plutonium.

Cesium concentrations from samples at Stations A-5, A-6, and A-7 showed minor differences from previous results. In 1990, the ^{137}Cs concentrations at Stations A-6 and A-7 (0.71 and 0.41 pCi/g, respectively) were lower than those in 1989 (1.1 and 0.45 pCi/g). The values were within the range of the statistical background limits for regional soils and sediments (0.44 to 1.09 pCi/g [Purtymun 1987a]).

3. Monitoring Well. A new monitoring well (SIMO-1) was installed in Mortandad Canyon just east of sediment sampling station A-6 (Fig. 33) on San Ildefonso Land. This was completed by BIA and Laboratory personnel on September 5 and 6, 1990, with permission from San Ildefonso under the general terms of the MOU. The purpose of the monitoring well was to confirm the absence of any perched water in the alluvium of Mortandad Canyon. The hole for the well was drilled with hollow stem auger and continuous core samples were collected from the surface to the total depth of 31.7 m (104 ft). The cores permitted detailed geologic logging and were analyzed for radiochemical constituents. The geologic log is summarized in Fig. 34. The radiochemical analyses are detailed in Tables G-64 and G-65.

No evidence of perched water was found, confirming previous inferences that no water could be moving from the Laboratory onto San Ildefonso beneath the surface. Even though the hole penetrated no saturated zones, it was completed by installing a polyvinyl chloride casing with screened sections located in two intervals that would be geologically likely locations for water to accumulate. This will permit periodic future moisture measurements to detect any possible changes in the subsurface occurrence of water.



NOTE: Cased with Schedule 40 PVC - 2" ID; screen slotted 0.010". Cuttings in construction are tuff from hole ranging from silts-sands-gravels. CR = Core Recovery for section.

Fig. 34. Test hold SIMO drilled with and in cooperation with San Ildefonso Pueblo and Bureau of Indian Affairs, September 5 and 6, 1990 (well dry).

Table IX-4. Radiochemical Analyses of Sediments from Mortandad Canyon

Station	Location	^{3}H (nCi/L)	^{137}Cs (pCi/g)	Total eUranium (µg/g)	^{238}Pu (pCi/g)	Gross $^{239,240}Pu$ (pCi/g)	Gamma (counts/min/g)
Sediments[a]							
A-5	Laboratory	—	1.8 (0.047)[b]	2.3 (0.2)	0.004 (0.005)	0.024 (0.008)	1.2 (0.4)
A-6	San Ildefonso	2.1 (0.3)	0.71 (0.13)	—	0.0005 (0.0005)	0.0103 (0.0016)	2.5 (0.5)
A-7	San Ildefonso	2.2 (0.4)	0.41 (0.10)	—	0.0015 (0.0009)	0.0136 (0.0021)	3.8 (0.5)
A-8	San Ildefonso	1.1 (0.3)	0.21 (0.09)	—	0.0013 (0.0008)	0.0041 (0.0010)	3.5 (0.5)
A-9	San Ildefonso	0.9 (0.3)	0.19 (0.07)	2.5 (0.2)	0.0037 (0.0021)	0.0032 (0.002)	0.4 (0.4)
A-10	San Ildefonso	0.6 (0.3)	0.09 (0.07)	—	0.000 (0.0005)	0.0025 (0.0007)	4.4 (0.6)
A-11	San Ildefonso	0.5 (0.3)	0.11 (0.09)	1.3 (0.1)	0.000 (0.001)	0.0011 (0.0009)	0.7 (0.4)
Background							
Sediments (1974–1986)		—	0.44	4.4	0.006	0.023	7.9
Soils (1974–1986)		7.2	1.09	3.4	0.005	0.025	6.6

[a]Samples in Mortandad Canyon were collected on November 14, 1990, with the exception of station A-5 (May 22, 1990); A-9 at State Road 4 (June 21, 1990); and A-11 at the Rio Grande (October 3, 1990).

[b]Counting uncertainties are in parenthesis.

The radiochemical analyses of the cores showed no evidence of any contaminants from the Laboratory (Table G-64 and G-65). The plutonium measurements were all at or below detection limits. Tritium in water vapor extracted from the cores from the surface down to 4.27 m (14 ft) was all at levels within the range attributable to background expected in northern New Mexico soils (Purtymun 1987a); below 4.27 m (14 ft) the tritium measurements were all below the limits of detection. Gross gamma and ^{137}Ce in all cores were at levels within the range attributable to background expected in northern New Mexico soils (Purtymun 1987a). Uranium was measured at levels well within the ranges for naturally occurring uranium expected for the Tshirege, Tsankawi, and Otowi formations penetrated by the hole (Becker 1985, and Crowe 1978).

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

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

The chemical quality of surface water and groundwaters in the vicinity of TA-57 (Fig. 35) has been monitored for use in geohydrologic and environmental studies. These water quality studies began before the construction and testing of the hot dry rock system (Purtymun 1974d).

Water samples for Fenton Hill monitoring have routinely been collected during periods of base flow (low surface water discharge) in late November or early December. A heavy snowfall in early December prevented access to some of the surface and spring locations. As a result only four surface water and six groundwater stations were sampled. The results of the 16 general chemical parameter analyses are presented in Table G-66, and the results of 11 trace metal analyses and uranium tests are presented in Table G-67. Slight variations were found in the chemical quality of surface waters and groundwaters among the individual stations when the analyses were compared with those from previous years; however, these variations are within typical seasonal fluctuations observed in the past (Purtymun 1988a). There were no significant changes in the chemical quality of surface water and groundwater at the individual stations from previous years (Purtymun 1988a).

D. Community Relations Program

The Laboratory's Environmental Safety and Health Community Involvement Team was formed to provide a program of involvement and information exchange among Laboratory personnel, residents in surrounding communities, special interest groups, media reporters, and representatives of city, state, and federal governments. The committee's goal is to inform the public of planned and ongoing actions, to focus on and attempt to resolve conflicts, and to identify and alleviate public concerns and fears.

As part of an ongoing series of information exchanges, a town hall meeting was held January 1990 in Española for area residents. The information presented and discussed was entitled "Hazardous Waste Incineration at LANL." The two-hour meeting included a talk presented during the first hour followed by a question and answer session. Attendee participation was substantial, indicating that the activity was well received.

In 1990, the Laboratory established, through HSE-13 and PA-3, a Community Relations Program as part of its Environmental Restoration (ER) Program. The Community Relations Program was a requirement of the Hazardous and Solid Waste Amendments (HSWA) Module of the Resource Conservation and Recovery Act (RCRA) Operating Permit which went into effect on May 23, 1990. This program is directly funded by the Department of Energy (DOE) through its Environmental Management (EM) Office for Environmental Restoration and Waste Management.

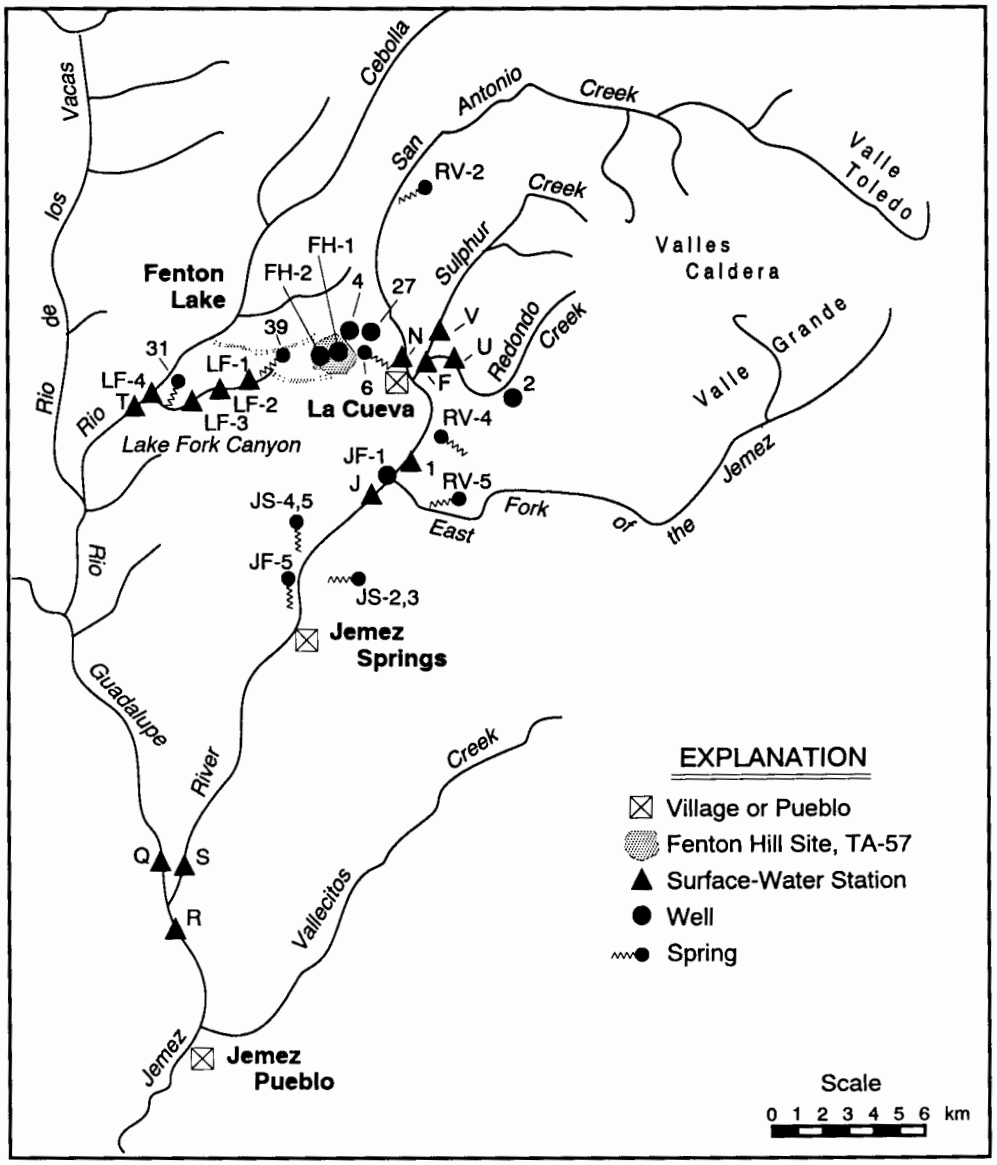


Fig 35. Sampling stations for surface water and groundwater near the Fenton Hill Site (TA-57).

The ER Community Relations Project Leader set up a series of interviews with public officials, community leaders, environmental interest groups, news organizations, and Laboratory personnel from the communities of Los Alamos, White Rock, Santa Fe, Taos, Española, Pojoaque, and Jemez Springs. The purpose of these interviews was to identify the issues of concern and the information needs of the different individuals representing their section of the neighboring communities.

From these community interviews, a Community Relations Plan was developed as a section of the ER Program's Installation Work Plan. The plan identified specific Community Relations requirements in the permit and the Laboratory activities to meet these requirements and also identified additional community relations activities that could be conducted based on public need and available time and resources.

In May of 1990, the ER Program gave a presentation to the Laboratory's Community Council in Santa Fe. The Council, composed of community leaders from northern New Mexico who engage in a regular dialogue with Laboratory officials on issues of common concern, asked questions and provided constructive critiques of the presentation so that the ER Program could improve its future presentations to community groups.

In July of 1990, the Laboratory hosted a briefing and tour of environmental activities for State legislators. The ER program was requested to deliver a presentation to the Hazardous Materials and Transportation Committee in August in Santa Fe.

In October of 1990, the Laboratory participated in the DOE's Five-Year Plan for Environmental Restoration and Waste Management Site-Specific Plan meeting in Los Alamos at Fuller Lodge. Laboratory officials provided a 30-minute presentation summarizing environmental activities performed in Fiscal Year 1990 and planned activities for Fiscal Year 1991. Laboratory and DOE officials responded to questions and listened to comments from the public in attendance.

Cultural resource staff of HSE-8 conducted a tour of Laboratory ruins for participants in a nationwide DOE Cultural Resource Management Workshop held in Santa Fe. A representative from the Advisory Council on Historic Preservation, Washington, D.C., visited LANL's remaining Manhattan Project structures as part of a study exploring historic preservation concerns at active military and research facilities. Tours were also conducted for University of New Mexico-Los Alamos and Colorado State University classes and for the San Juan County Archaeological Society.

Archaeology staff presented a paper on the LANL curation program and attended a round-table discussion for DOE-affiliated archaeologists at the Society for American Archaeology meetings in Las Vegas. A guest lecture on Pajarito Plateau archaeology was also given to the Santa Fe Archaeological Society.

The ER Program opened its Community Reading Room in December 1990 at 2101 Trinity Drive in downtown Los Alamos. The Reading Room, a multipurpose facility that can serve not only as an information repository, but also as a meeting place for small briefings, meetings, and workshops, is intended to be the primary source of information for the public on environmental activities at the Laboratory. Plans, reports, and documents required by the HSWA Module are available for public review, and other HSE documents and DOE plans and reports associated with environmental activities are available.

E. National Atmospheric Deposition Program Network Station (Craig Eberhart and David Jardine)

HSE-8 operates a wet deposition station that is part of the National Atmospheric Deposition Program network. The station is located at the Bandelier National Monument. The 1990 annual and quarterly deposition rates are presented in Table IX-5.

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

The natural pH of rainfall, without anthropogenic contributions, is unknown. Because of the contribution from entrained alkaline soil particles in the southwest, natural pH may be higher than 5.6, the pH of rainwater in equilibrium with atmospheric carbon dioxide. Some studies indicate that there may be an inverse relationship between elevation and pH effect that lowers the pH of samples measured in the field. For the latest quarter, all field measurements were below 5.6, possibly indicating contributions from acidic species other than carbon dioxide.

The NADP conducted an audit of the Bandelier site this year, examining the physical characteristics of the site and its operation. Except for a few minor equipment flaws, the operation of the station was in compliance with NADP guidelines.

Table IX-5. Annual and Quarterly Wet Deposition Statistics for 1990

	Quarter				
	First	Second	Third	Fourth	Total
Field pH (standard units)					
Mean	4.9	4.9	4.9	5.2	4.9
Minimum	4.4	4.4	4.6	4.8	4.4
Maximum	6.0	5.6	5.6	5.6	6.0
Precipitation (in.)	2.2	1.8	4.8	3.3	12.8
Deposition (microequivalents per square meter)					
Ca	1 925	1 208	1 196	434	8 055
Mg	196	164	186	67	613
K	43	50	48	25	167
Na	363	202	209	123	897
NH_4	857	839	1 924	451	4 070
NO_3	862	998	2 439	647	4 946
Cl	215	243	394	118	969
SO_4	1 520	1 379	2 462	1 209	6 570
PO_4	4.4	51	112	25	233
H	720	650	1 430	890	3 690

F. Preparation of a Performance Assessment for the Laboratory's Low Level Waste Site (Mac Ennis, Tom Buhl, Steve McLin, Alan Stoker, Brent Bowen, Everett Springer [EES-13], Johnny Harper [HSE-7], Ed Derr [HSE-7], Bill Kopp [HSE-7])

DOE Order 5820.2A became effective in September 1988. Section III of this order established policies, guidelines, minimum requirements, and performance criteria for low-level radioactive waste (LLW) and mixed waste (LLW that also contains nonradioactive hazardous waste components) management at DOE facilities. The order applies only to LLW disposed after the order became effective. The order requires that a performance assessment (PA) of the LLW site be made to demonstrate compliance with specific performance objectives stated in the order.

A draft performance assessment document is in preparation. It reports the results of preliminary calculations to assess the projected performance of Los Alamos National Laboratory's TA-54, Area G. Area G disposes only LLW; mixed waste is stored at the site for future disposition. Such disposition, to be determined in the future, may be on-site treatment of the hazardous waste component and disposal of the resulting material as LLW on-site, or shipment of the mixed waste off-site for treatment and subsequent disposal. The PA evaluates only the Laboratory's LLW stream; it does not consider mixed waste or transuranic wastes, which are not covered under Chapter III of the order.

An exposure scenario is a conceptual model that describes patterns of human activity, events, and processes that result in radiation exposure to people. Two classes of scenarios are considered in the PA: intruder scenarios and undisturbed site scenarios. Intrusion is assumed to occur after loss of institutional control at the waste site after periods of several hundreds of years. At this time, one or a few individuals are assumed to disturb the waste site, unaware of the presence of radioactive waste. Undisturbed scenarios assume that future inhabitants of the area are exposed to radioactive components of the waste that have been released from the waste site through normal environmental processes. These include possible impacts to groundwater from leaching and to surface water from erosion after long periods of time.

A variety of intruder scenarios have been defined. Inadvertent intrusion is a hypothetical event that may not occur at all. It is not possible to identify, let alone consider in the PA, all of the possible intrusion scenarios. Three hypothetical scenarios were chosen for analysis:

- Intruder-construction. A construction crew digs a pit for a basement and constructs a house at the waste site.
- Intruder-agriculture. The site is used by a farmer/gardener for the production of foodstuffs.
- Intruder-drilling. In this scenario, drilling for water, natural resources, or perhaps for site characterization cause a limited amount of deeper (shaft disposed) wastes to be brought to the surface. The major exposure pathways are direct exposure and inhalation.

Dose limits for intruders are established in DOE Order 5820.2A, Ch. III. The annual effective dose equivalent to inadvertent intruders (after the loss of institutional control) shall not exceed 100 mrem for continuous exposure or 500 mrem for a single acute exposure.

Under current waste-stream concentrations, none of the intruder scenarios produces doses that exceed the applicable dose criteria. In the intruder-construction scenario, ^{239}Pu, ^{241}Am, and ^{238}Pu account for 44%, 25%, and 15%, respectively, of the dose to an intruder. In the intruder-agriculture scenario, ^{239}Pu, ^{241}Am, and ^{238}Pu account for 41%, 30%, and 14%, respectively, of the dose to an intruder. In the analyses to date, the only radioactive materials treated as shaft-disposed radioactive wastes are $^{90}Sr/^{90}Y$ and ^{137}Cs. In this scenario, 98% of the dose is from ^{137}Cs by external exposure.

Although dose assessment for undisturbed site scenarios has not been completed, the depth to groundwater and the dryness of the climate are likely to reduce doses from these scenarios to insignificant levels. The migration of radionuclides by subsurface aqueous transport is always viewed as one of the critical components in assessing any waste site. Area G has the advantage of a large unsaturated zone (average distance to the saturated zone of 260 m) and low water contents in the intervening material. These advantages result in delaying radionuclide migration. Also, the minerals found in the tuff such as clays in fractures have a high affinity for many radionuclides so retardation may further slow radionuclide transport. These points will be discussed in more detail in the final performance assessment.

Waste management strategies involve maximizing distances from the source to the saturated zone while minimizing the potential for exposure by surface erosion of the mesa tops and lateral erosion of the canyon walls. The large unsaturated zone in conjunction with a retardation mechanism will allow this strategy to be effectively implemented.

G. Perched Zone Monitoring Under RCRA/HSWA Permit (A. K. Stoker, W. D. Purtymun, and M. N. Maes)

Module VIII of the Hazardous and Solid Waste portion of the RCRA permit (see Sec.VIII.A.) includes a requirement for special perched zone monitoring. In conformance with those requirements, new monitoring wells were installed in several of the canyons. The installation and construction of those wells was completed in 1990 (Purtymun 1990c). The wells were drilled and constructed in accord with EPA recommendations given in the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD) to the extent practicable and allowing for some site specific modifications based on more than 40 years experience with monitoring initiated by the U. S. Geological Survey. Data on the drilling and completion are presented in Table G-68.

The wells were all constructed with basically the same methods. A pilot hole was drilled with either a standard continuous-flight auger (4-1/2-in.) or cored with hollow stem auger (7-1/4-in. hole). The depth to the base of the aquifer was determined by the cuttings and drilling pressure or by direct inspection of the continuous core retrieved from the hole. The pilot hole provided a guide for reaming the hole using a larger diameter hollow stem auger (6-1/4-in. i.d.).

Two-inch-diameter casing was set through the hollow stem auger, with the screened portion resting on the bottom of the hole. The lowest portion of the casing consisted of one or two 10-foot lengths of 0.010 in. slotted screen with a plug at bottom. (In three wells a five-foot blank section was extended below the screen

section to provide for bailer descent needed to collect adequate sample volumes.) The annulus between the hollow stem auger and casing screen was filled with the filter pack (sand) in increments of 2 to 3 ft at which time the auger was pulled up a corresponding amount. Keeping the sand in the auger while raising the auger assured a continuous gravel pack between the bore-hole wall and the screen by preventing any formation material from caving in around the casing. At this point a seal of bentonite and/or cement was extended to the surface using the same method of emplacement through the auger to assure a continuous seal with no formation material collapsing in around the blank tubing. The upper part of the well was filled with cement and the wellhead security cap was set about 1-1/2 to 2-ft into the cement.

The wells were developed using a surge block, pumping, bailing, and jetting. At least two methods were used in each well. The choice of methods depended on the depth to water and observations of the saturated thickness. Jetting was the most commonly used method and was applied to all of the Mortandad and Los Alamos Canyons wells. However, none of the wells that have water in them have yet met the turbidity guideline of five nephelometric turbidity units. This is as expected based on previous experience with the 25- to 30-year-old U.S. Geological Survey wells. Because of this experience with continued turbidity resulting from the fine suspended clays and silts found in the aquifer, the smallest size screen generally available from commercial sources (0.010-inch) with matched size sand (0.010-to 0.020-in) was used in completing all the new wells. These clays and silts are derived from weathering of the ash matrix of the tuff.

Wells or borings were completed in several of the principal canyons of the Pajarito Plateau as follows: Pueblo Canyon (one exploratory boring); Los Alamos Canyon (three monitoring wells near existing wells LAO-3, LAO-4.5, and LAO-5); Sandia Canyon (two monitoring wells near water supply wells PM-1 and PM-3); Mortandad Canyon (three monitoring wells near existing wells MCO-4, MCO-6, and MCO-7); Potrillo Canyon (one monitoring well near State Road 4); Fence Canyon (one monitoring well near State Road 4); and Water Canyon (three monitoring wells near State Road 4, one mile west of State Road 4, and two miles west of State Road 4).

The new wells that contained water were sampled for detailed analysis of radiochemical, inorganic, and organic constituents (ERP 1990). They were first sampled on September 11 and 12, 1990. The new wells sampled include MCO-4B, MCO-6B, and MCO-7A in Mortandad Canyon, LAO-3A and LAO-4.5C in Los Alamos Canyon, and APCO-1 in Pueblo Canyon. At the same time, samples were collected from adjacent older wells in Mortandad and Los Alamos Canyons to permit comparison of the results from those wells with results from the new wells constructed in accord with the permit conditions. (The older wells include MCO-4, MCO-6, and MCO-7 in Mortandad Canyon, and LAO-3 and LAO-4 in Los Alamos Canyon. These older wells have long been monitored under the routine environmental surveillance program and data from them have been published annually in the Environmental Surveillance Reports [Sec. VI.C.4].)

The new wells were sampled a second time by the International Technology Corporation on November 1 and 2, 1990, for analysis of the entire RCRA Appendix IX list of constituents, including some analyses not presently performed by the Health and Environmental Chemistry Group (HSE-9).

The results of the laboratory analyses are summarized in four tables in Appendix G:

- **Table G-69** summarizes radiochemical analyses for gross gamma, gross alpha, ^{241}Am, total U, ^{3}H, ^{137}Cs, ^{238}Pu, and ^{239,240}Pu. All of the constituents were present in locations and amounts expected from the results of the long term monitoring program. Tritium concentrations were found to be comparable between adjacent old and new well pairs, indicating good hydrologic continuity as is expected because tritium in the water molecules is not subject to adsorption. Plutonium concentrations in samples from the new wells in Mortandad Canyon (MCO-4B, MCO-6B, and MCO-7A) were considerably lower than in samples from the old wells (MCO-4, MCO-6, and MCO-7). This is probably to be expected because construction of the new wells resulted in significant new disturbed surfaces for adsorption of plutonium.

- **Table G-70** summarizes the RCRA regulations Appendix IX Inorganic Constituents. Most of the metals were found in concentrations above detection limits in some or all of the samples, and, in general, fit expectations of occurrence based on results of the long-term monitoring program. Barium and lead levels were higher than previously observed. Sulfides were found in all the new wells at levels from 1 to 2.8 mg/L. Results from the two laboratories were generally comparable considering possible variation because of approximately seven weeks difference in sampling dates.

- **Table G-71** summarizes the RCRA Regulations Appendix IX Organic Compounds Detected. The only Appendix IX organics detected that could not be attributed to minor analytical laboratory contamination included diethylphthalate (18 μg/L) in the sample from one of the old wells (MCO-4.5) and the possible presence of N-nitrosomorpholine (3 μg/L) in two of the new wells (MCO-4B and MCO-6B) but at levels less than one-third of the reporting limit (10 μg/L) for the analytical method. There is apparently no organic contamination from effluent discharges or developed surface runoff in the alluvial water.

- **Table G-72** summarizes the general chemical parameters analyzed. These results indicate generally good comparability between the paired old and new wells. The data indicate good hydrologic continuity in the alluvium for materials that would not be significantly affected by adsorption or geochemical interactions such as sodium, nitrate, and total dissolved solids. Some other materials show much more variation between the adjacent wells; these are expectably subject to geochemical interactions with the newly disturbed tuff surfaces created by the drilling, and the emplacement of non-native filter pack material as required by the TEGD.

H. Drilling and Development of New Otowi Wells (Alan Stoker, Steve McLin, and Bill Purtymun [HSE-8] and Glenn Hammock [consultant to the Laboratory's Project Management Group, ENG-1])

Drilling started in the fall of 1989 on the first of two new water supply wells to be completed under the FY 1988 Utilities Restoration Water Well Replacement, a construction line item. These two wells are the initial part of a long-range plan to replace the capacity of the Los Alamos well field, which includes six wells drilled 29 to 43 years ago (Purtymun 1988c). The capabilities of all but one of the wells have deteriorated significantly with time. Only four of these wells contributed to the water supply in 1989 (see Sec. VI.C.5).

The contract for drilling the two new wells was awarded to Beylik Drilling, Inc., of La Habra, California. The first well, to be called Otowi-4 (O-4), is located in Los Alamos Canyon near test well 3 (map designation 41 in Fig. 16). Site preparation began in September 1989. The pilot hole was drilled to a depth of 855 m (2 806 ft) and was completed at a depth of 797 m (2 617 ft) as a gravel pack well. The well penetrated the Bandelier Tuff, Puye Conglomerate, and sediments of the Santa Fe Group. Several basalt flows are located in the Puye Conglomerate and the upper part of the Santa Fe Group. The top of the main aquifer (the only aquifer in the area capable of municipal and industrial supply) is at a depth of 241 m (790 ft). Step and aquifer tests indicate the formation will yield 1 500 gal/min. The well was completed in April 1991.

The second well, Otowi 1 (O-1), is located about 0.15 km (0.1 mi) west of test well 1 (map designation 39 in Fig. 16) in Pueblo Canyon. Construction began in April 1991. The pilot hole was drilled to a depth of 795 m (2 609 ft) and was completed at a depth of 760 m (2 493 ft) as a gravel pack well. The well penetrated only a small section of weathered Bandelier Tuff, Puye Conglomerate, and sediments of the Santa Fe Group. Basalt flows were encountered in the Puye Conglomerate.. A thin andesite basalt flow, or sill, about 6.7 m (22 ft) thick was penetrated in the lower part of the Santa Fe. The sediments of the Santa Fe Group in Well O-1 contained considerably more silt and clay than were encountered in Well O-4. The top

of the main aquifer is at a depth of 205 m (670 ft). Step and aquifer tests indicated that the formation will yield 800 to 1 000 gal/min.

To prevent surface contamination of the wells, the surface casing was cemented into the main aquifer (Well O-1) or a cement plug extended below the bottom of the surface casing (Well O-4) in to the top of the main aquifer. Water quality from the wells are acceptable for municipal use (see Sec. VIII, Environmental Compliance).

I. Impact of an Acid Spill on a Wetland in Sandia Canyon (Teralene S. Foxx, Kathryn Bennett, Joan Morrison, and Timothy Haarmann)

On May 19–21, 1990, an accidental spill of 1 000-1 400 gal. of sulfuric acid occurred in the effluent flow from the TA-3 Power Plant Environmental Tank to an effluent-maintained, cattail-dominated marsh. As a result of the incident, the Biological Resource Evaluations Team was asked to review the impact of the spill on the downstream wetland. No baseline information on the stream flora and fauna had been previously collected; therefore, the study was designed to obtain immediate baseline information on the spill damage and recovery potential. The following components were incorporated into the study:

- establishment of permanent photostations;
- weekly aquatic sampling of water quality and aquatic organisms;
- live trapping of small mammals;
- live trapping of amphibians; and
- observations of birds and large mammals.

Within ten days of the acid spill, cattails within a meter of the stream channel were chlorotic and the stream was devoid of aquatic organisms. Within one month of the incident the cattails were greened and aquatic fauna including tubificid worms, caddis fly larvae, mayfly larvae, water boatman, and whorlig beetles were collected from sampling locations. An amphibian species, canyon treefrog (*Hyla arenicolor*), was collected in the stream. Additionally, baseline information related to small mammals populations was obtained through live trapping and observations of large- and medium-sized mammals and birds.

To provide long-term information, monitoring of the aquatic fauna as related to water quality is continuing. Photographs are periodically taken at specific photostations to document seasonal changes.

Detailed information may be obtained from a report entitled "Biological Monitoring of an Acid Spill, Sandia Canyon," in preparation.

J. Preoperational Environmental Studies (Teralene Foxx, Philip Fresquez, and Joan Morrison)

Preoperational studies are required under DOE Order 5400.1. This order requires that chemical, physical, and biological characteristics be assessed before an area is disturbed. Three preoperational studies were undertaken during 1990. Detailed results may be obtained by referring to individual preoperational reports.

- **Sanitary Wastewater Systems Consolidation.** The potential ecological impact of this project was determined to be the potential release of 0-600 000 gal. of water into a presently dry canyon that has only seasonal intermittent streamflow. The following components of the ecosystem were quantitatively measured: vegetation, small mammals, birds, reptiles, and amphibians. Soils will be collected and analyzed during 1991.

- **The Weapons Engineering Tritium Facility and the Weapons Subsystem Laboratory.** The potential ecological impact of these projects was the potential release of tritium into the environment from the Weapons Engineering Tritium Facility and use of plutonium and uranium at the Weapons Subsystem Laboratory. Soils and plant materials were collected from around these facilities and analyzed to provide baseline information on tritium, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$.

- **Plant Uptake Study in a Piñon Juniper Woodland.** The potential for ecological impact of this project was the injection of small quantities of tritium into soils for plant uptake studies. Levels of tritium were analyzed in soil and vegetation to provide baseline information.

K. Environmental Restoration Program at Los Alamos National Laboratory

In 1989, DOE created the Office of Environmental Restoration and Waste Management (EM). The goal of the office is to implement the DOE's policy to ensure that its past, present, and future operations do not threaten human or environmental health and safety (DOE 1990b). The EM Office implements procedures to meet these goals through three associate directorates: ER, Waste Operations, and Technology Development. The ER Program in EM is responsible for assessing, cleaning up, decontaminating, and decommissioning sites at DOE facilities and sites formerly used by DOE.

Since the early 1970s, the Laboratory, as managed by the University of California (UC), has operated an environmental surveillance program that routinely samples air, water, soil, and foodstuffs throughout the Los Alamos area to determine levels of contamination. The data collected in this program are published annually for distribution to the public and to local, state, and federal agencies. These data indicate that Laboratory operations do not currently threaten human health or the environment. The ER Program at the Laboratory augments the environmental surveillance program by identifying potential future threats to human health and the environment and by mitigating them through efficient corrective actions that comply with applicable environmental regulations. Corrective actions include such measures as source containment to prevent contaminant migration, controls on future land use, and excavation and treatment of the source to permanently eliminate hazards to health and the environment.

Two primary laws govern ER activities at the Laboratory: the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA [Superfund]) and RCRA. The hazardous waste management provisions of RCRA, as enacted in 1976, govern the day-to-day operations of hazardous waste treatment, storage, and disposal (TSD) facilities. The law established a permitting system and set standards for all hazardous-waste-producing operations at a TSD facility. Under this law, the Laboratory qualifies as a treatment and storage facility and must have a permit to operate. In 1984, Congress amended RCRA by passing HSWA. Section 3004(u) of RCRA as amended by HSWA mandates that permits for TSD facilities include provisions for corrective action to mitigate releases from facilities currently in operation and to clean up contamination in areas designated as solid waste management units (SWMUs).

Congress conceived and passed CERCLA to clean up the nation's most hazardous abandoned waste sites. Under CERCLA, EPA ranks abandoned facilities that have hazardous waste sites according to their potential threat to human health and the environment. The high-scoring sites are listed on the National Priorities List (NPL) and are cleaned up in accordance with CERCLA regulations. When EPA ranked the Laboratory, the agency determined that current environmental conditions do not pose an imminent threat to human health. Hence, the Laboratory is not listed on the NPL. DOE/UC's RCRA permit includes a section called the HSWA Module, which prescribes a specific corrective action program for the Laboratory. Because the Laboratory has not been listed on the NPL, the HSWA Module provides the primary guidance for the Laboratory's ER Program. The HSWA Module specifies a three-step corrective action process (Figure 36):

1. The RCRA facility investigation. The goal of this step is to identify the extent of contamination at source points and environmental pathways for the exposure of potential human and environmental receptors. This step will be implemented by characterizing the extent of contamination in the detail necessary to determine what corrective measures, if any, need to be taken. This approach will focus effort on answering only those questions relevant to deciding further actions in a cost-effective manner.

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

3. Corrective measures implementation. This step implements the chosen remedy, verifies its effectiveness, and establishes ongoing control and monitoring requirements.

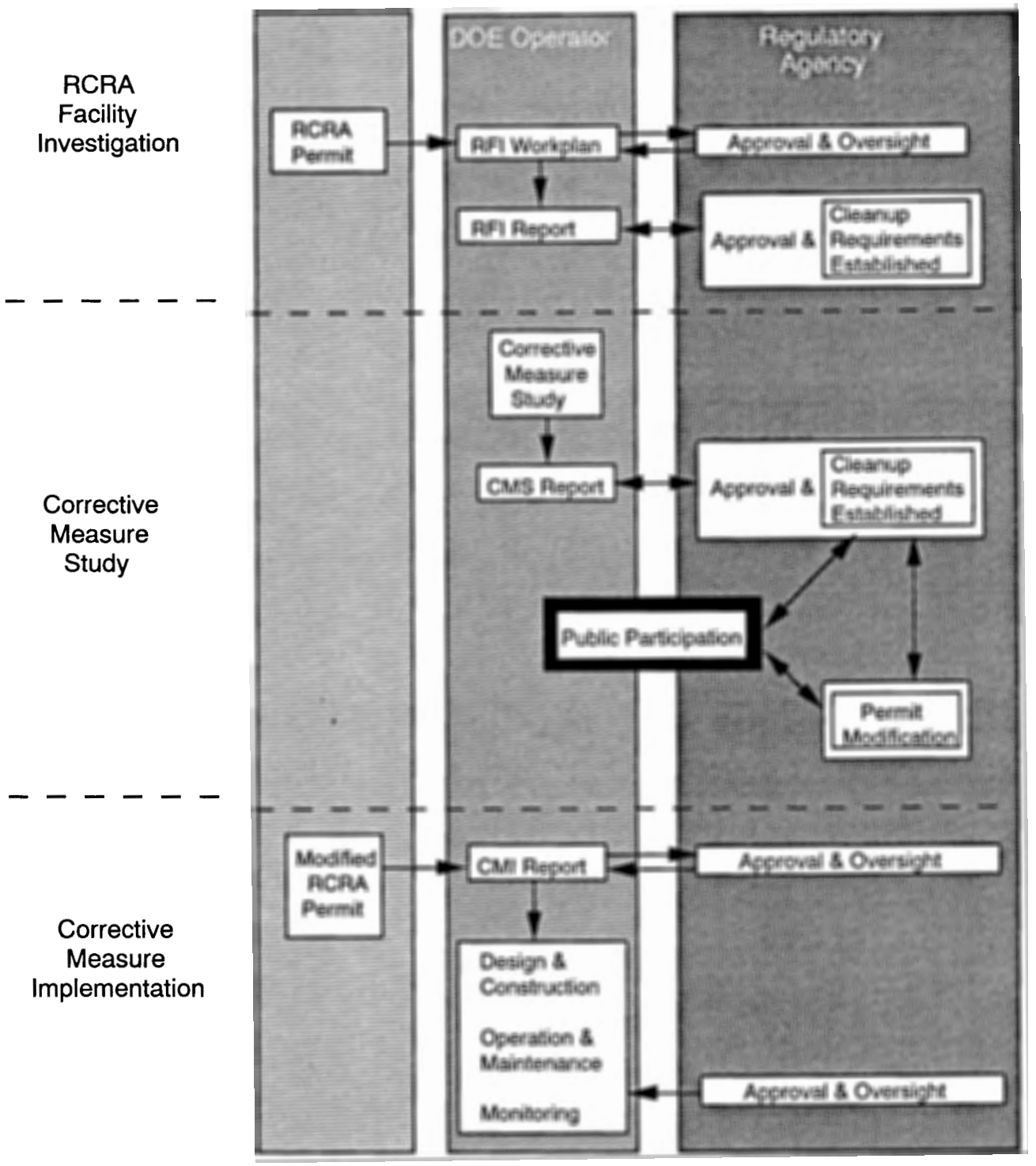


Fig. 36. Resource Conservation and Recovery Act corrective action process.

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

The HSWA Module provides a schedule for addressing 603 SWMUs that the EPA has selected from those identified by DOE/UC. The schedule requires that all 603 SWMUs be addressed in RFI work plans by May 23, 1994, and that CMSs be complete by May 23, 2000. The work plan requirement will be met by completing work plans for 24 operable units at the Laboratory. These work plans will describe the general approach that will be applied to each operable unit. Current risks from known SWMUs are low; hence, no operable unit or set of SWMUs has a priority for action over others based on health or environmental concerns. The order in which operable units will be addressed is therefore designed to meet the requirements of the HSWA Module. However, DOE/UC propose to extend the RFI schedule so that the CMS process is not complete until May 23, 2002. This is necessary because of the increased number of SWMUs identified at the Laboratory, and will allow the spread of effort over a period that is compatible with the availability of national resources, including funding.

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

- a technical approach for decisions to identify appropriate corrective actions that meets the requirements of the Environmental Protection Agency;
- a strategy for the conduct of interim remedial measures;
- program management that organizes and manages the Laboratory's ER effort, including projecting schedules and costs;
- a quality assurance program that ensures a technically defensible and valid program;
- a health and safety program that ensures adequate health and safety protection during implementation of the Laboratory's ER Program;
- a records management program that tracks and stores information and data throughout the ER Program; and
- a community relations program that provides information to and receives recommendations from the public throughout the life of the ER Program.

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

L. One-hundred-year Floodplain Study

The EPA stipulates that all regulated hazardous waste treatment, storage, and disposal facilities must apply for a RCRA operating permit. This permit was issued to the DOE and Los Alamos National Laboratory in November 1989. In March 1990, the EPA issued the HSWA portion of that permit to DOE/LANL. As a condition of that portion, LANL was required to define all 100-year floodplain elevations within the DOE/LANL facility boundary (40 CFR 270.14[b][11][iii]). These floodplain elevations must

be consistent with National Flood Insurance Program maps produced for the Federal Insurance Administration, or must use an equivalent method of mapping. Before this HSWA condition was imposed, floodplain boundary locations had never been completely mapped within the Laboratory complex. The methodology described below is recognized by the EPA and U.S. Army Corps of Engineers (COE) as an approved simulation technique for mapping floodplains in ungaged watersheds.

The floodplain mapping procedure outlined here used topographic data from the Laboratory's graphic information system (AUTOGIS-MOSS). About 65% of the Laboratory has 2-foot topographic contour interval coverage, while 35% has 10-foot coverage. Targeted stream channel segments were initially specified in the MOSS system, and cross-sectional topographic profiles at user-designated intervals along segments were extracted automatically. Each 2-D topographic profile was stored as a 3-D MOSS line feature using New Mexico State Plane coordinates. This procedure was initiated at the intersection of the eastern DOE/LANL facility boundary and each watershed stream channel, and proceeded upstream to the western facility boundary. These 3-D line features were then exported in a format satisfying computer model input data requirements.

Floodplain modeling efforts utilized the COE Hydrologic Engineering Center's (HEC) computer-based Flood Hydrograph Package (HEC-1) and the Water Surface Profiles Package (HEC-2). HEC-1 is used to simulate either real or hypothetical storm hydrographs in ungaged or gaged watersheds in response to user-specified rainfall hydrographs. As used here, HEC-1 employed a traditional 100-year, 6-hour Soil Conservation Service design storm event, although any alternative return period event can easily be incorporated. A representative 100-year, 6-hour design storm event is recommended by the COE for defining 100-year floodplains in northern New Mexico. Predicted HEC-1 hydrograph peaks at varying stream channel locations, along with stream channel geometry and watershed basin characteristics, were then utilized by HEC-2 to compute 100-year floodplain elevations. As previously mentioned, actual stream channel cross-sectional geometries at varying locations were obtained from the Laboratory's computer-based AUTOGIS-MOSS graphic information system database.

HEC-2-computed floodplain elevations were defined within the DOE/LANL boundary for 13 separate watersheds at 250-ft intervals using both HEC-1 and HEC-2. These watersheds have a total of 52 separate subbasins. Peak floods were also defined with HEC-1 for two additional watersheds having a total of eight separate subbasins; these later watersheds do not cross the DOE/LANL facility boundary. The HEC-1 and HEC-2 input data files used to generate these hydrograph peaks and floodplain elevations are maintained within HSE-8 for future reference. Parameter estimation procedures and construction of the data files are described in a separate report, which includes the AUTOGIS-MOSS data extraction technique utilized. Once all floodplains had been defined by HEC-2, this information was read back into the MOSS system. These data were then transformed within MOSS to determine New Mexico State Plane geographically referenced coordinates that uniquely define the 100-year floodpool at each stream cross-section. Finally 1:4 800 scale maps depicting the DOE/LANL boundary and all 100-year floodplains were prepared. This packet of maps is maintained on file in LANL's Facilities Engineering Planning Group (ENG-2) office. These maps satisfy the RCRA/HSWA permit requirement of mapping all 100-year floodplains within the DOE/LANL facility.

M. External Radiation Measurement Study.

1. Intercomparison study. In addition to the Laboratory's routine thermoluminescent dosimeter (TLD) monitoring of external penetrating radiation in 1990, which is described in Section IV, a special study was conducted from August 1990 through July 1991 to evaluate TLD measurements. This is part of a continuing study consisting of an intercomparison of Laboratory TLDs with TLDs obtained from a commercial contractor.

One phase of the study involved colocating environmental dosimeters obtained from the contractor next to Laboratory dosimeters at 29 locations in the routine environmental monitoring network. Two contractor TLDs were placed at five of these locations.

The study began in August, 1990. Contractor TLDs were colocated with the Laboratory TLDs for two months of the third quarter of 1990. Both the Laboratory TLDs and the contractor TLDs were exposed for the same time period, one calendar quarter, for the fourth quarter of 1990, and for the first and second quarter of 1991.

The intercomparison was a "blind" study as far as the contractor was concerned. The contractor's TLDs were set out and collected following the contractor's instructions. No information was given to the contractor concerning the nature of study. The TLDs provided to LANL were processed by the contractor as would be those from any other customer.

The preliminary measured annual average external radiation levels for the 22 stations for which data for all four quarters is available is shown in Figure 37. Please note that the contractor data for the third quarter of 1990 was corrected for its shorter exposure time by scaling the measurements to a full quarter exposure.

Figure 37 also shows the two-standard deviation acceptance band above and below the contractor's measurements. The LANL TLD measurements appear slightly but not significantly higher than those obtained from the contractor. In general good agreement was found between the contractor's and LANL's measurements.

2. Location of TLDs. A review of the 1990 monitoring data indicated that the locations for the dosimeters at Stations 10 (Shell) and 12 (White Rock) needed to be changed. These dosimeters had initially been placed in these new locations at the beginning of 1990. Both were subsequently found to be in locations of increased natural radioactivity. Gamma spectra were collected using a germanium detector at each of these two locations to determine what radionuclides were contributing to the increased external radiation dose rate. With the exception of a small level of cesium-137 that is consistent with world wide fallout, only naturally occurring radionuclides were found in either spectra.

These spectra were compared with spectra collected at the other TLD locations in Los Alamos County. It was found that external radiation from the naturally occurring uranium series, thorium series, and potassium-40 radionuclides were 2.1 times higher at Station 10 than the average for natural terrestrial radioactivity from these radionuclides at other locations in Los Alamos townsite. The increase in natural background radiation was found to be due to a cinder wall near the TLD location, and is consistent with the increase observed in the TLD measurement.

External radiation from naturally occurring uranium-series radionuclides, thorium-series radionuclides, and potassium-40 was 1.3 times higher at Station 12 than the average for natural terrestrial radiation background from each of these radionuclides at White Rock. The observed increase is consistent with the TLD measurement. The TLD had been placed near a rock outcropping with slightly higher concentrations of naturally occurring radionuclides.

In accordance with DOE guidance, Laboratory TLDs are not usually placed in relatively unoccupied areas of slightly elevated natural background radiation. Both of these stations have been relocated to nearby areas of more typical natural background radiation. Other TLDs are located at the original two locations to provide further documentation of these measurements.

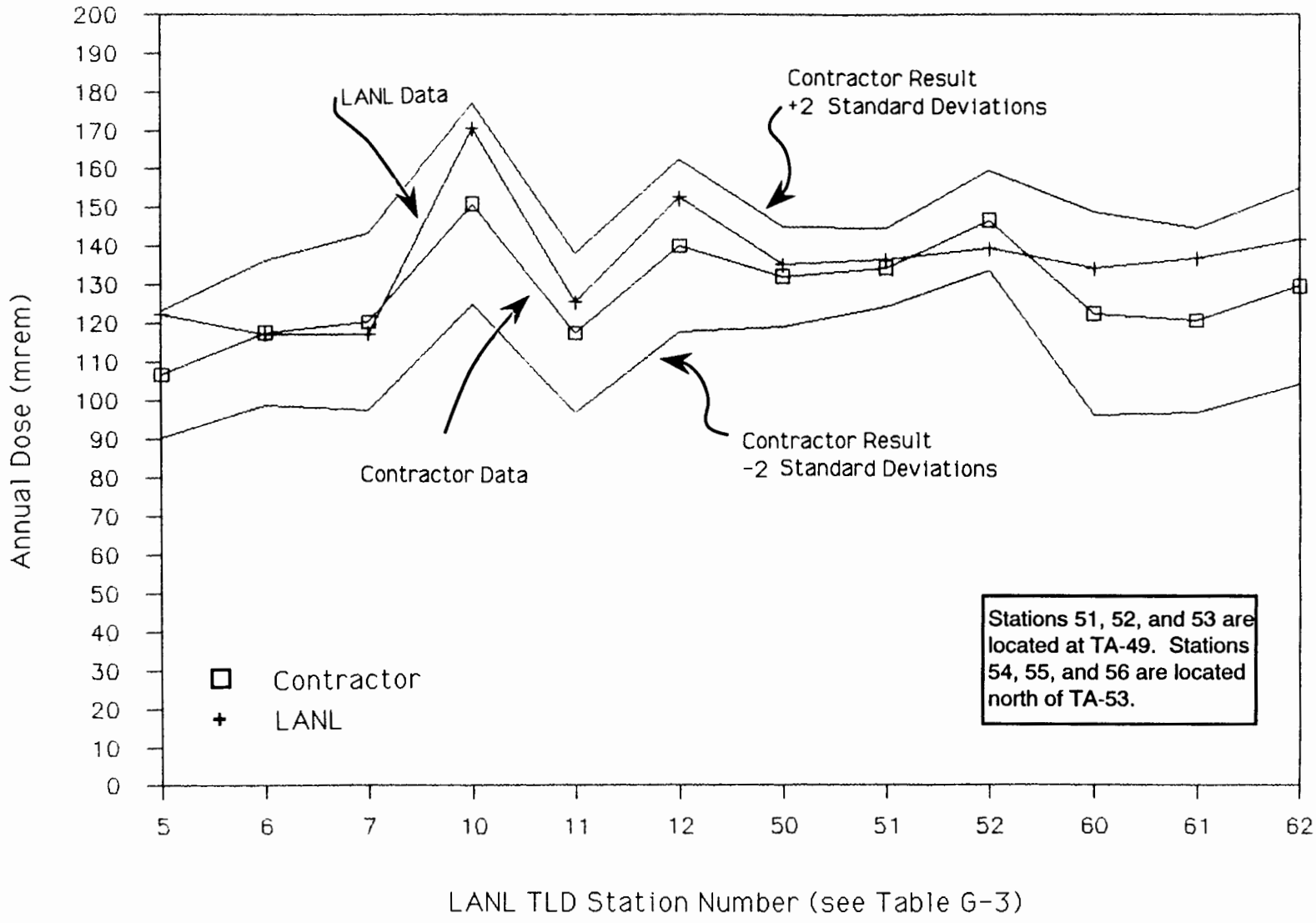


Fig. 37. Los Alamos National Laboratory/Contractor TLD Intercomparison, July 1990 through June, 1991. Please note that these data are for the period of July 1990 through June 1991, and so do not correspond to the January 1990 through December 1990 annual TLD results presented elsewhere in this report. These data are given to indicate the preliminary results of the intercomparison study.

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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 for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 5400.1, "General Environmental Program", 5400.5 "Radiation Protection of the Public and the Environment", 5480.1 "Environmental Protection, Safety, and Health Protection Standards", 5480.11 "Requirements for Radiation Protection for Occupational Workers", and 5484.1 "Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements," Chap. III, "Effluent and Environmental Monitoring Program Requirements". All of these DOE orders are being or have been revised.

DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operation. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-year dose commitments were calculated using dose factors from Refs. A1 and A2. The dose factors adopted by DOE are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP).[A3] Those factors that have been used in this report are presented in Appendix D.

In 1990, DOE issued Order 5400.5 which finalized the interim radiation protection standard (RPS) for the public.[A4] Table A-1 lists currently applicable RPSs, now referred to as public dose limits (PDLs), for operations at the Laboratory. DOE's comprehensive PDL for radiation exposure limits the effective dose equivalent that a member of the public can receive from DOE operations to 100 mrem/yr. The PDLs and the information in Ref. A1 and A2 are based on recommendations of the ICRP and the National Council on Radiation Protection and Measurements.[A3,A4]

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 to an individual organ. The effective dose is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the ICRP. The effective dose equivalent includes doses from both internal and external exposure.

Radionuclide concentrations in air and water in uncontrolled areas measured by the Laboratory's surveillance program are compared with DOE's derived concentration guides (DCGs) in this report (Table A-2).[A5] These DCGs represent the smallest estimated concentrations in water or air, taken in continuously for a period of 50 years, that will result in annual effective dose equivalents equal to the PDL of 100 mrem in the 50th year of exposure.

In addition to the 100 mrem/yr effective dose PDL, exposures from the air pathway are also limited by the Environmental Protection Agency's (EPA's) 1989 standard of 10 mrem/yr (effective dose equivalent).[A6] To demonstrate compliance with these standards, doses from the air pathway are compared directly with the EPA dose limits. This dose limit of 10 mrem/year replaced the previous EPA limits of 25 mrem/year (whole body) and 75 mrem/year (any organ).[A7]

Federal and State ambient air quality standards for nonradioactive pollutants are shown in Table A-3. New Mexico nonradiological standards are generally more stringent than national standards.

For chemical constituents in drinking water, standards have been promulgated by the EPA and adopted by the New Mexico Environmental Improvement Division (NMEID) (Table A-4).[A8] The EPA's primary maximum contaminant level (MCL) is the maximum permissible level of a contaminant in water that is

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

Exposure of Any Member of the Public [a]

	Effective Dose Equivalent[b] at Point of Maximum Probable Exposure
All Pathways	100 mrem/yr[c]

	Effective Dose Equivalent at Point of Maximum Probable Exposure
Air Pathway Only [d]	10 mrem/yr
Drinking Water	4 mrem/yr

Occupational Exposure [a]

Stochastic Effects	5 rem (annual effective dose equivalent[e])
Nonstochastic Effects	
Lens of eye	15 rem (annual dose equivalent[e])
Extremity	50 rem (annual dose equivalent[e])
Skin of the whole body	50 rem (annual dose equivalent[e])
Organ or tissue	50 rem (annual dose equivalent[e])
Unborn Child	
Entire gestation period	0.5 rem (annual effective dose equivalent[e])

[a]In keeping with DOE policy, exposures shall be limited to as small a fraction of the respective annual dose limits as practicable. DOE's RPS applies 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 Ref. A4. Limits for occupational exposure are taken from DOE Order 5480.11.

[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]Under special circumstances and subject to approval by the DOE, this effective dose equivalent limit may be temporarily increased up to 500 mrem/year, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem/year.

[d]This level is from EPA's regulations promulgated under the Clean Air Act (40 CFR 61, Subpart H).

[e]Annual effective dose equivalent is the effective dose equivalent received in a year.

Table A-2. DOE's Derived Concentration Guides for Public Dose and Derived Air Concentrations for Controlled Areas[a]

Nuclide	DCGs for Uncontrolled Areas (μCi/mL) Air	DCGs for Uncontrolled Areas (μCi/mL) Water	Calculated Guides for Drinking Water Systems (μCi/mL)	DACs for Controlled Areas (μCi/mL)
^{3}H	1×10^{-7}	2×10^{-3}	8×10^{-5}	2×10^{-5}
^{7}Be	4×10^{-8}	1×10^{-3}	4×10^{-5}	8×10^{-6}
^{89}Sr	3×10^{-10}	2×10^{-5}	8×10^{-7}	6×10^{-8}
^{90}Sr[b]	9×10^{-12}	1×10^{-6}	4×10^{-8}	2×10^{-9}
^{137}Cs	4×10^{-10}	3×10^{-6}	1.2×10^{-7}	7×10^{-8}
^{234}U	9×10^{-14}	5×10^{-7}	2×10^{-8}	2×10^{-11}
^{235}U	1×10^{-13}	6×10^{-7}	2.4×10^{-8}	2×10^{-11}
^{238}U	1×10^{-13}	6×10^{-7}	2.4×10^{-8}	2×10^{-11}
^{238}Pu	3×10^{-14}	4×10^{-8}	1.6×10^{-9}	2×10^{-12}
^{239}Pu[b]	2×10^{-14}	3×10^{-8}	1.2×10^{-9}	2×10^{-12}
^{240}Pu	2×10^{-14}	3×10^{-8}	1.2×10^{-9}	2×10^{-12}
^{241}Am	2×10^{-14}	3×10^{-8}	1.2×10^{-9}	2×10^{-12}
	(pg/m³)	(mg/L)	(mg/L)	(pg/m³)
Natural Uranium	1×10^{5}	8×10^{-1}	3×10^{-2}	3×10^{7}

[a]Guides for uncontrolled areas are based on DOE's PDL for the general public;[A4] those for controlled areas are based on occupational RPSs for DOE Order 5480.11 ("Radiation Protection for Occupational Workers," December 21, 1988). Guides apply to concentrations in excess of those occurring naturally or that are due to fallout.

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

delivered to the ultimate user of a public water system.[A9] The EPA's secondary water standards control contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water.[A9] 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.[A9] These regulations provide that combined ^{226}Ra and ^{228}Ra may not exceed 5×10^{-9} μCi/mL. Gross alpha activity (including ^{226}Ra, but excluding radon and uranium) may not exceed 15×10^{-9} μCi/mL.

A screening level of 5×10^{-9} μCi/mL for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water (Table A-4) and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2). For manmade beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem/yr, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that DOE-operated public water supplies not cause persons consuming the water to receive an effective dose equivalent exceeding 4 mrem/year. Drinking water concentration guides based on this requirement are in Table A-2.

In its regulations, the EPA has established minimum concentrations of certain contaminants in water extract from wastes that will cause the waste to be designated as hazardous by reason of toxicity.[A10] The toxicity characteristic leaching procedure (TCLP) must follow steps outlined by the EPA in 40 CFR 261, Appendix II. In this report, the TCLP minimum concentrations (Table A-5) are used for comparison with concentrations of selected constituents in extracts from the Laboratory's active waste areas.

Table A-3. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary
Sulfur dioxide	Annual arithmetic mean	ppm	0.02	0.03	
	24 hours[a]	ppm	0.10	0.14	
	3 hours[a]	ppm			0.05
Total suspended particulate matter	Annual geometric mean	μg/m³	60		
	30 days	μg/m³	90		
	7 days	μg/m³	110		
	24 hours[a]	μg/m³	150		
PM_{10}[b]	Annual arithmetic mean	μg/m³		50	50
	24 hours	μg/m³		150	150
Carbon monoxide	8 hours[a]	ppm	8.7	9	
	1 hour[a]	ppm	13.1	35	
Ozone	1 hour[c]	ppm	0.06	0.12	0.12
Nitrogen dioxide	Annual arithmetic mean	ppm	0.05	0.053	0.053
	24 hours[a]	ppm	0.10		
Lead	Calendar quarter	μg/m³		1.5	1.5
Beryllium	30 days	μg/m³	0.01		
Asbestos	30 days	μg/m³	0.01		
Heavy metals (total combined)	30 days	μg/m³	10		
Nonmethane hydrocarbons	3 hours	ppm	0.19		

[a]Maximum concentration, not to be exceeded more than once per year.

[b]Particles measured at an effective diameter of <10 μm.

[c]The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the limit is ≤1.

Table A-4. Maximum Allowable Contaminant Level in the Water Supply Inorganic Chemical and Radiochemical[a]

Inorganic Chemical Contaminant	MCL (mg/L)	Radiochemical Contaminant	MCL (μCi/mL)
Primary Standards			
Ag	0.05	Gross alpha[b]	15×10^{-9}
As	0.05	Gross beta[a]	50×10^{-9}
Ba	1	^{3}H	20×10^{-6}
Cd	0.010	^{90}Sr	8×10^{-9}
Cr	0.05		
F	4.0		
Hg	0.002		
NO_3 (as N)	10		
Pb	0.05		
Se	0.01		
Secondary Standards			
Cl	250		
Cu	1		
Fe	0.3		
Mn	0.05		
SO_4	250		
Zn	5.0		
TDS[c]	500		
pH	6.5–8.5		

[a]Refs. A8 and A9.

[b]See text for discussion of application of gross alpha MCL and gross alpha screening level of 5×10^{-9} μCi/mL.

[c]Ref. A8.

Table A-5. Toxicity Characteristic Leaching Procedure Levels[ab]

Contaminant	(mg/L)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0
m-Cresol	200.0
p-Cresol	200.0
Cresol	200.0
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor (and its epoxide)	0.008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentrachlorophenol	100.0
Pyridine	5.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TP (Silvex)	1.0
Vinyl chloride	0.2

[a]Concentrations of inorganic contaminants that constitute hazardous waste.
[b]Ref. A10.

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APPENDIX B

PROCEDURES FOR SAMPLING, DATA HANDLING, AND QUALITY ASSURANCE

A. Thermoluminescent Dosimeters

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 40°C (752°F) for 1 hour and then cooled rapidly to room temperature. This is followed by annealing at 100°C (212°F) for 1 hour and again cooling rapidly to room temperature. For the annealing conditions to be repeatable, chips are put into rectangular borosilicate glass vials that hold 48 LiF chips each. These vials are slipped into a borosilicate glass rack so they can be placed all at once into ovens maintained at 400°C and 100°C.

Four LiF chips constitute a dosimeter. The LiF chips are contained in a two-part threaded assembly made of an opaque yellow acetate plastic. A calibration set is prepared each time chips are annealed. The calibration set is read at the start of the dosimetry cycle. The number of dosimeters and exposure levels are determined for each calibration in order to efficiently use available TLD chips and personnel. Each set contains from 20 to 50 dosimeters. These are irradiated at levels between 0 and 80 mR using an 8.5-mCi ^{137}Cs source calibrated by the National Bureau of Standards.

A factor of 1 mrem (tissue) = 1.050 mR is used in evaluating the dosimeter data. This factor is the reciprocal of the product of the roentgen-to-rad conversion factor of 0.958 for muscle for ^{137}Cs and of 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 (the weighting factor is the variance).[B3]

The TLD chips used were all from the same production batch and were selected by the manufacturer so that the measured standard deviation in thermoluminescent sensitivity is 2.0% to 4.0% of the mean at a 10-R exposure. At the end of each field cycle, whether a calendar quarter or the Los Alamos Meson Physics Facility 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 the 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 28 continuously operating stations.[B6] Air pumps with flow rates of about 3 L/s 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 is passed through a cartridge containing silica gel to absorb atmospheric water vapor for tritium analyses. Air flow rates through both sampling cartridges are measured with rotameters, and sampling times are recorded. The entire air sampling train at each station is cleaned, repaired, and calibrated as needed.

Two clean control filters are used to detect any possible contamination of the 28 sampling filters while they are in transit. The control filters accompany the

28 sampling filters when they are placed in the air samplers and when they are retrieved. The control filters are analyzed for radioactivity along with the 28 sampling filters. Analytical results for the control filters are subtracted from the appropriate gross results to obtain net data.

At one on-site location, TA-59 (Station 30), airborne radioactivity samples are collected weekly. Airborne particulate matter on each 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 monthly on a filter from the Española (Station 1) regional air sampler.

On a quarterly basis, the monthly filters for each station are cut in half. The filter halves are combined to produce two quarterly composite samples for each station. The first group is analyzed for ^{238}Pu, $^{239,240}Pu$, and ^{241}Am (on selected filters). The second group of filter halves is saved for uranium 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 from 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 is calculated. This technique does not differentiate between ^{238}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 28 air sampling stations are analyzed monthly for tritiated water. The cartridges contain blue "indicating" gel to determine 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 gel cartridge and an aliquot of the distillate is analyzed for tritium by liquid scintillation counting. The amount of water absorbed by the silica gel is determined by the difference between weights of the gel before and after sampling.

Analytical quality control for analyses done in the air sampling program is described in Appendix C. In brief, both blanks and standards are analyzed in conjunction with 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 groundwater sampling stations are grouped by location (regional, perimeter, on-site) and hydrologic similarity. Water samples are taken once or twice a year. Samples from wells are collected after sufficient water has been pumped or bailed to ensure that the sample is representative of the aquifer. Spring samples (groundwater) are collected at the discharge point.

The water samples are collected in 4-L polyethylene bottles for radiochemical analyses. The 4-L bottles are acidified in the field with 5 mL of concentrated nitric acid and then are returned to the laboratory within a few hours of sample collection for filtration through a 0.45-μm millipore membrane filter. The samples are routinely analyzed radiochemically for ^{3}H, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$, as well as for gross alpha, beta, and gamma activities. Selected samples are also analyzed for ^{241}Am, ^{90}Sr, and accelerator-induced activation products. Analytical methodology and its quality assurance program are discussed in Appendix C of this report. Detailed container and preservation requirements of the Health and Environmental Chemistry Group (HSE-9) are documented in a handbook.[B8]

Water samples for inorganic and organic chemical analyses are collected at the same time. For most samples for inorganic analyses, three 1-L polyethylene bottles are collected, one with no additives, one with sulfuric acid, and one with nitric acid to provide the proper range of preservatives for the standard list of constituents. When necessary additional containers with appropriate preservatives are collected for mercury, cyanide, and sulfide analyses. For selected samples additional glass containers are collected for organic analyses. Details of container and preservation

requirements, and identification of EPA methodology for each analysis are contained in the HSE-9 Handbook.[B8]

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

Further details may be found in the water sampling quality assurance project plan.[B9]

D. Soil and Sediment Sampling

The soil sampling procedure involves taking five plugs, 75 mm (3.0 in.) in diameter and 50 mm (2.0 in.) deep, at the center and corners of a square area 10 m (33 ft) on a side. The five plugs are combined to form a single composite sample for radiochemical analysis.

Sediment samples are collected from dune buildup behind boulders in the main channels of perennially flowing streams. Samples from the beds of intermittently flowing streams are collected by scooping a line of uniform depth across the main channel. Reservoir sediments are collected from a boat, using an Eckman dredge. Bottom reservoir sediments are collected from an area 10 cm by 15 cm (4 in. by 6 in.) to a depth of 5 cm (2 in.).

Depending on the reason for taking a particular soil or sediment sample, it may be analyzed to detect any of the following: gross alpha and gross beta activities, ^{90}Sr, total uranium, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and possibly selected accelerator-induced activation products. Moisture distilled from soil samples may be analyzed for ^{3}H.

Further details may be found in the soil and sediment sampling quality assurance plan.[B9]

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.[B10] 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 and submitted for tritium analysis. Produce ash and dry soil are submitted for analyses of ^{90}Sr, ^{137}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.[B10] 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, and dissected. Wet, dry, and ash weights are determined, and 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.[B11]

F. Meteorological Monitoring

Meteorological data were continuously gathered at four instrumented towers during 1990. Data taken include wind speed and direction, standard deviations of wind speed and direction, vertical wind speed and its standard deviation, air and soil temperature, relative humidity, solar and terrestrial radiation, precipitation, and sensible and evaporative heat fluxes (vertical transport). Each variable is measured every 3 seconds. A Dopper Acoustic Sodar is also located at a tower site. This instrument measures wind direction and speed, vertical wind speed, horizontal and vertical wind standard deviations, and inversion information at 30 m levels up to 750 m. Finally, four additional sites monitor precipitation; one of these sites also measures temperature and relative humidity.

The tower and sodar data are averaged or summed over 15-minute intervals. Data are transmitted by phone line to a microcomputer at the Occupational Health Laboratory at TA-59. Charts from the four precipitation stations are picked up every week.

Data validation of 15-minute data is accomplished with automated and manual screening techniques. Computer codes screen incoming data for reasonableness and consistency. Invalid data are discarded. Other codes produce daily plots for each tower and the sodar. These graphics are reviewed to provide an additional check of the data. This screening helps to detect

problems with the instrumentation that might develop between calibrations.

Most instruments are calibrated semiannually, including a thorough audit by an outside contractor once a year. The outside audit was performed in June 1990.[B12]

Further details on quality assurance may be found in the meteorological monitoring quality assurance project plan.[B13]

G. Data Handling

Measurements of 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 calculations.[B14]

For individual measurements, uncertainties are reported as the standard deviation. These values are associated with the estimated variance of counting and indicate the precision of the counts.

Standard deviations for the station and group (regional, perimeter, on-site) means are calculated using the following equation:

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

where

c_i = for sample i,

$\bar{c}$ = mean of samples from a given station or group and,

N = number of samples comprising a station or group.

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

H. Quality Assurance

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

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

- number and type of samples;
- type of analyses and required limits of detection;
- proper sample containers;
- preparation of sample containers with preservative, if needed; and
- sample schedule to ensure minimum holding time of analyses to comply with EPA criteria.

The Laboratory's Health and Environmental Chemistry Group (HSE-9) issues to the collector a block of sample numbers (for example, 86.0071) with individual numbers assigned by the collector to an individual station. These sample numbers follow the sample from collection through analyses and posting of individual results.

Each number, representing 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 the sample number and station previously listed in the log book.

The sample container is labeled with station name, sample number, date, and preservative, if added.

After the sample is collected, it is delivered to the Group HSE-9 section leader, who makes out a numbered request form entitled "HSE-9 Analytical Chemical Request." The request form number is also entered in the collector's log book opposite sample numbers submitted, along with the date the sample was delivered to the chemist. The analytical request form serves as an audit trail or "chain-of-custody" for the samples.

The analytical request form contains the following information related to ownership and the sample program submitted: (1) requester (i.e., sample collector), (2) program code, (3) sample owner (i.e., program

manager), (4) date, and (5) total number of samples. The second part of the request form contains (1) sample number or numbers, (2) matrix (e.g., water), (3) types of analyses (i.e., specific radionuclide and/or chemical constituents), (4) technique (i.e., analytical method to be used for individual constituents), (5) analyst (i.e., chemist to perform analyses), (6) priority of sample or samples, and (7) remarks. One copy of the form goes to the collector for filing and the other copies follow the sample.

Quality control, analytical methods and procedures, and limits of detection related to Group HSE-9's 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,B9,B11,B13]

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APPENDIX C

ANALYTICAL CHEMISTRY METHODOLOGY

Most analytical chemistry services are provided by the Laboratory's Health and Environmental Chemistry Group (HSE-9). The HSE-9 sample coordination section functions as a working interface between the group and its customers. This section provides the reader with presampling information in the areas of sample containers, sample volumes, and sample preservation techniques. All samples are delivered to sample coordination personnel and are then scheduled and processed for proper distribution and analysis. The processing of samples includes (1) validating all samples for sampling correctness and integrity, (2) scheduling and labeling all samples for analysis, (3) initiating internal chain-of-custody procedures for all samples, and (4) arranging for the proper disposal of any unused portions of samples.

A. Radioactive Constituents

Environmental samples are routinely analyzed for the following radioactive constituents: gross alpha, beta, and gamma; isotopic plutonium; americium; uranium; cesium; tritium; and strontium. Detailed procedures have been published in this appendix in previous years[C1] and in the group's Analytical Methods Manual.[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 germanium lithide detectors. Depending on the concentration and matrix, ^{226}Ra is measured by emanation or by gamma-ray spectrometry of its ^{214}Bi decay product. Uranium isotopic ratios (^{235}U/^{238}U) are measured by neutron activation analysis where precisions of ±5% are adequate. More precise work requires mass spectrometry. Uranium isotopic ratios are readily determined in environmental materials with precisions of 1%–2% relative standard deviation, at considerably reduced cost relative to neutron activations by inductively coupled plasma mass spectrometry (ICPMS).

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, ICPMS, and inductively coupled plasma atomic emission spectrometry. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capabilities include flame, furnace, 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 Ref. C2. In 1986, the EPA Region VI administration granted HSE-9 limited approval for alternative test procedures for uranium in drinking water (delayed neutron assay) and for chloride in drinking water and wastewater (flow injection without distillation). EPA approval for other modified methods is actively being sought. HSE-9 is participating in the EPA-sponsored study to evaluate ICPMS for acceptance as an EPA-approved methodology.

C. Organic Constituents

Environmental soil and water samples are analyzed using EPA procedures outlined in EPA SW-846[C3] or modified procedures[C2] that meet QA criteria outlined in chapter one of SW-846, as shown in Table C-1. Methods used are supported by documented spike/recovery studies, method and field blanks, matrix spikes, surrogate spikes, and blind quality control samples. Volatile organics are analyzed using method 8260, SW-846. Tables C-2 and C-3 list volatile organics on the target list for water and soil samples,

respectively. Semivolatile organics are analyzed using method 8270, SW-846. Table C-4 is the target list for semivolatile organics in water. Soil-gas (pore-gas) monitoring is performed by collecting organic vapors on charcoal, extracting the charcoal with CS_2 and analyzing the CS_2 extracts using gas chromatography/mass spectrometry (GC/MS). Soil-gas target compounds are listed in Table C-5 and the Extraction Procedure (EP) toxicity target compounds are listed in Table C-6.

Instrumentation available for organic analysis includes GC/flame ionization detector (FID), GC/electron capture detector (ECD), GC/MS, high performance liquid (HPLC) with ultraviolet (UV) and refractive index detectors, a fourier transform infrared spectrometer, and a UV/visible spectrophotometer. Sample preparation methods include: Soxhlet extraction, ultrasonic extraction, continuous liquid/liquid extraction, kuderna danish concentration, evaporative blow down, and gel permeation chromatography cleanup of sample extracts.

Organic mixed waste analyses are performed for samples up to 100 nCi/g (solids/sludges) or 100 nCi/L (solutions) alpha, beta, or gamma. Higher-level samples are analyzed on a case-by-case basis. New methods are being developed for routine analysis of mixed waste greater than 100 nCi/g (or nCi/L). The Laboratory's capacity for mixed waste analyses will increase in the summer of 1991 when mixed waste analytical operations move to a dedicated facility.

D. Analytical Chemistry Quality Evaluation Program

1. Introduction. Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of several general types: calibration standards, reagent blanks, process blanks, matrix blanks, duplicates, spikes, and reference materials. Analysis of control samples fills two needs in analytical work: (1) it provides quality control over analytical procedures so that problems that might occur can be identified and corrected, and (2) data obtained from analysis of control samples permit evaluation of the capabilities of a particular analytical technique to determine a given element or constituent under a certain set of circumstances.

Blind quality control (QC) samples are disguised and numbered to resemble unknown samples in a set, and no attempt is made to conceal the identity of the open QC samples from the analyst. In neither case are the concentrations of the analytes of interest revealed until after the data have been formally reported.

These samples are submitted to the laboratory at regular intervals and are analyzed in association with other samples; that is, they are not handled as a unique set of samples. At least 10% of stable constituent, organic, and selected radioactive constituent analyses are run as quality control 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 annually since 1976.[C4]

2. Radioactive Constituents. In addition to those that are prepared internally, quality control and quality assurance samples for radioactive constituents are obtained from outside agencies. The Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA, Las Vegas) provides water, milk, and air filter samples for analysis of gross alpha, gross beta, ^{3}H, ^{40}K, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{106}Ru, ^{131}I, ^{134}Cs, ^{137}Cs, ^{226}Ra, and $^{239,240}Pu$ as part of an ongoing laboratory intercomparison program. The National Institute of Standards and Technology (NIST, formerly the National Bureau of Standards) provides several soil and sediment standard reference materials (SRMs) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{238}Pu, ^{239}Pu, ^{241}Am, and several other nuclides. The Department of Energy's Environmental Measurements Laboratory also provides quality assurance samples.

Soil, rock, and ore samples obtained from the Canadian Geological Survey are used for quality assurance of uranium and thorium determinations in silicate matrices. Our own in-house standards are prepared by adding known quantities of liquid NIST 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 NIST 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. Details of this program have been published elsewhere.[C4]

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.

4. Organic Constituents. Soil samples are received for the analysis of volatile and semivolatile organic compounds, pesticides, and herbicides for compliance work done under the Resource Conservation and Recovery Act. Certified matrix-based reference materials were not available for these analyses, so stock solutions of the analytes were prepared and spiked directly on blank soil by the quality assurance section. Because homogeneity of the sample could not be ensured, the entire sample was analyzed. Volatile organic compounds are analyzed by GC/MS and are spiked in the microgram-per-kilogram range.

The majority of water samples submitted during 1990 were environmental compliance samples for the analysis of pesticides, herbicides, volatile and semivolatile organic compounds, and polychlorinated biphenyls (PCBs). Methods were developed and refined for in-house preparation of quality control samples for volatile and semivolatile organic compounds in water.

Oil samples were received for the analysis of PCBs and organic solvents. The majority of these oils await disposal by the Laboratory's Waste Management Group (HSE-7) and include oil from decommissioned transformers. The remaining oil samples were environmental or industrial hygiene samples taken from areas of possible contamination.

Quality control samples for PCBs were prepared by diluting EPA standards or by preparing standards in hexane from the neat analyte. In the United States, the only PCBs that have been found in transformers have been PCBs 1242, 1254, and 1260. Samples submitted for analysis have contained only these PCBs, so they have been used to spike quality control samples. Vacuum pump oil was chosen for the oil base blank after an experiment with various brands of motor oil showed excessive matrix interferences.

5. Indicators of Accuracy and Precision. Accuracy is the degree of difference between average test results and true results when the latter are known or assumed. Precision is the degree of mutual agreement among replicate measurements (frequently assessed by calculating the standard deviation of a set of data points). Accuracy and precision are evaluated from results of analysis of reference materials. These results (r) are normalized to the known quality in the reference material to permit comparison among reference materials of a similar matrix containing different concentrations of the analyte:

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

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

$$R = \frac{\sum_i r_i}{N},$$

Standard deviations of R are calculated assuming a normal distribution of the population of analytical determinations (N):

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

These calculated values are presented as the HSE-9 "Ratio ± Std Dev" in Tables C-7 and C-8. The mean value of R is a measure of the accuracy of a procedure. Values of R greater than unity indicate a positive bias in the analysis; values less than unity, a negative bias.

The standard deviation is a measure of precision. Precision is a function of the concentration of analyte; that is, as the absolute concentration approaches the limit of detection, precision deteriorates. For instance, the precision for some determinations is quite large because many standards approach the limits

of detection of a measurement. We address this issue by calculating a new quality assurance parameter,

$$\left|\overline{X}_E - \overline{X}_C\right| < 1.96\sqrt{(S_E)^2 + (S_C)^2} \ ,$$

where X_E and X_c are the experimentally determined and certified or consensus mean elemental concentrations, respectively; and S_E and S_c are the standard deviations associated with X_E and X_c. 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. The percentage of the tests for each parameter that fell within ±2 propagated standard deviations (under control), between ±2 and ±3 propagated standard deviations (warning level), or outside ±3 propagated standard deviations (out of control) is shown in Tables C-7 to C-21. A summary of the overall state of statistical control for analytical work done by HSE-9 is also provided in Table C-22.

Table C-23 summarizes recovery information on organic surrogate compounds required for use in the EPA-Contract Laboratory Program protocol. Table C-24 summarizes HSE-9's overall record of meeting EPA SW-846 holding times for HSE-8 samples during 1990. The data include all samples where holding times were missed and the customer elected to either resample or accept the data as usable. Table C-25 reports the incidence of false positive results for blank QC samples and false negative results for spiked QC samples at the 95% confidence level.

For most radiochemical and inorganic analyses, more than 90% are within ±2 propagated standard deviations of the certified/consensus mean values (under control). Our performance on all classes of inorganic matrices remained virtually unchanged since 1989, while improvement in radiochemical determinations in biological materials was observed. Unfortunately, our overall control of radiochemical analyses in soils and silicates declined over our 1989 record. This area will be the focus of increased quality assurance/quality control efforts in the future. Overall control on organic measurements in waters and silicates improved markedly over 1989 and now over 90% of all organic determinations are under control. Data on analytical detection limits are given in Table C-26.

Table C-1.
Method Summary (Organic Compounds)

Analyte	Matrix	Method[a]	Technique[b]
Volatile organic compounds	Air	—	GC/MS
	Soil	8260	PAT/GC/MS
	Water	8260	PAT/GC/MS
EP[c] toxicity	Soil	1310, 8080 8150	GC/ECD
PCBs	Water	606	GC/ECD
	Soil	8080	GC/ECD
	Oil	IH 320	GC/ECD
Semivolatile organic compounds	Soil and waste	625	GC/MS

[a]Industrial hygiene (IH).

[b]Gas chromatography (GC), purge and trap (PAT), electron capture detection (ECD), and mass spectrometry (MS).

[c]Extraction procedure (EP).

Table C-2. Volatile Organic Compounds Determined in Water by PAT Analyses

Compound	CAS #	Representative Limit of Quantification (μg/L)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,2-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-2	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
Vinyl acetate	108-05-4	10
2-Butanone	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
1-Chlorohexane	544-10-5	5
Ethylbenzene	100-41-4	5
m,p-Xylene (total)	108-38-3 + 106-42-3	5
o-Xylene	95-47-6	5
Styrene	100-42-5	5

Table C-2 (Cont)

Compound	CAS #	Representative Limit of Quantification (μg/L)
1,1,2,2-Tetrachloroethane	79-34-5	5
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	95-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
1,2,4-Trichlorobenzene	120-82-1	N/A
Naphthalene	91-20-3	N/A
1,2,3-Trichlorobenzene	87-61-6	N/A
Hexachlorobutadiene	87-68-3	N/A
Dichlorodifluonomethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5
2-Chloroethylvinylether	110-75-8	50
Acrylonitrile	107-13-1	100
Acrolein	107-02-8	100

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

Table C-3. Volatile Organic Compounds Determined in Solids by SW-846 Method 8260

Compound	CAS #	Limit of Quantification (mg/kg)[a]
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,5-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-4	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
Vinyl acetate	108-05-4	10
2-Butanone (MEK)	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone (MIK)	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
1-Chlorohexane	544-10-5	5
Ethylbenzene	100-41-4	5
Mixed Xylene (total)	1330-20-7	5
Styrene	100-42-5	5
1,1,2,2-Tetrachloroethane	79-34-5	5

Table C-3 (Cont)

Compound	CAS #	Limit of Quantification (mg/kg)[a]
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	98-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
1,2,4-Trichlorobenzene	120-82-1	N/A
Naphthalene	91-20-3	N/A
1,2,3-Trichlorobenzene	87-61-6	N/A
Hexachlorobutadiene	87-68-3	N/A
Dichlorodifluonomethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5
2-Chloroethylvinylether	110-75-8	50
Acrylonitrile	107-13-1	100
Acrolein	107-02-8	100

[a]Column: 60 m × 0.32 mm SPB-5 fused silica capillary, using a methanolic partition with purge and trap. Limits of quantification are calculated from the intercept of the external calibration curve using a flame-ionization detector.

Table C-4. Semivolatile Organics in Water

Compound	CAS #	Limit of Quantification (mg/L)
N-Nitrosodimethylamine	62-75-9	10
Aniline	62-55-3	10
Phenol	108-95-2	10
bis(-2-Chloroethyl)ether	111-44-4	10
2-Chlorophenol	95-57-8	10
1,3-Dichlorobenzene	541-73-1	10
1,4-Dichlorobenzene	106-46-7	10
Benzyl alcohol	100-51-6	10
1,2-Dichlorobenzene	95-50-1	10
2-Methylphenol	95-48-7	10
bis(2-Chloroisopropyl)ether	39638-32-9	10
4-Methylphenol	106-44-5	10
N-Nitroso-di-*n*-propylamine	621-64-7	10
Hexachloroethane	67-72-1	10
Nitrobenzene	98-95-3	10
Isophorone	78-59-1	10
2-Nitrophenol	88-75-5	10
2,4-Dimethylphenol	105-67-9	10
Benzoid acid	65-85-0	10
bis(-2-Chloroethoxy)methane	111-91-1	10
2,4-Dichlorophenol	120-83-2	10
1,2,4-Trichlorobenzene	120-82-1	10
Naphthalene	91-20-3	10
4-Chloroaniline	106-47-8	10
Hexachlorobutadiene	87-68-3	10
4-Chloro-3-methylphenol	59-50-7	10
2-Methylnaphthalene	91-57-6	10
Hexachlorocyclopentadiene	77-47-4	10
2,4,6-Trichlorophenol	88-06-2	10
2,4,5-Trichlorophenol	95-95-4	10
2-Chloronaphthalene	91-58-7	10
2-Nitroaniline	88-74-4	10
Dimethyl phthalate	131-11-3	10
Acenaphthylene	208-96-8	10
3-Nitroaniline	99-09-2	10
Acenaphthene	83-32-9	10
2,4-Dinitrophenol	51-28-5	10
4-Nitrophenol	100-02-7	10
Dibenzofuran	132-64-9	10
2,4-Dinitrotoluene	121-14-2	10
2,6-Dinitrotoluene	606-20-2	10
Diethylphthalate	84-66-2	10
4-Chlorophenyl-phenylether	7005-72-3	10
Fluorene	86-73-7	10
4-Nitroaniline	100-01-6	10
4,6-Dinitro-2-methylphenol	534-52-1	10
N-Nitrosodiphenylamine	86-30-6	10

Table C-4 (Cont)

Compound	CAS #	Limit of Quantification (mg/L)
Azobenzene	103-33-3	10
4-Bromophenyl-phenylether	101-55-3	10
Hexachlorobenzene	118-74-1	10
Pentachlorophenol	87-86-5	10
Phenanthrene	85-01-8	10
Anthracene	120-12-7	10
Di-*n*-butylphthalate	84-74-2	10
Fluoranthene	206-44-0	10
Benzidine	92-87-5	10
Pyrene	129-00-0	10
Butylbenzylphthalate	85-68-7	10
3,3ó-Dichlorobenzidine	91-94-1	10
Benzo(*a*)anthracene	56-55-3	10
bis(2-Ethylhexyl)phthalate	117-81-7	10
Chrysene	218-01-9	10
Di-*n*-octyl phthalate	117-84-0	10
Benzo(*b*)fluoranthene	205-99-2	10
Benzo(*k*)fluoranthene	207-08-9	10
Benzo(*a*)pyrene	50-32-8	10
Indeno(1,2,3-*cd*)pyrene	193-39-5	10
Dibenzo(*a,h*)anthracene	53-70-3	10
Benzo(*g,h,i*)perylene	191-24-2	10

Table C-5. Volatiles Determined in Air (Pore Gas)

Compound	CAS #	Limit of Quantification (mg/tube)
Chloroform	67-66-3	8.0
1,1,1-Trichloroethane	71-56-6	8.0
Benzene	71-43-2	8.0
Carbon tetrachloride	56-23-5	8.0
Trichloroethene	79-01-6	8.0
Toluene	108-88-3	8.0
Tetrachloroethene	127-18-4	8.0
Chlorobenzene	108-90-7	8.0
Ethylbenzene	100-41-4	8.0
o-Xylene	95-47-6	8.0
m,p-Xylene (total)	108-38-3 + 106-42-3	8.0
1,2,4-Trimethylbenzene	95-63-6	8.0
Bromobenzene	108-86-1	8.0

Table C-6. Extraction Procedure Toxicity of Organic Contaminants

Contaminant	Maximum Concentration (mg/L)	Representative Detection Limits (mg/L)[a]
Endrin (1,2,3,4,10,10-Hexachloro-6 7-*epoxy*-1,4,4*a*,5,6,7,8,8*a*-octahydro-1 4-*endo*, *endo*-5, 8-dimethanonaphthalene)	0.02	0.006
Lindane ($\alpha,\alpha,\beta,\alpha,\alpha,\beta$-hexachlorocyclohexane, gamma isomer)	0.4	0.0002
Methoxychlor (1,1,1-trichloro-2,2-*bis*(*p*-methoxyphenyl)ethane)	10.0	0.004
Toxaphene (technical chlorinated camphene, 67–69% chlorine)	0.5	0.020
2,4-*D* (2,4-dichlorophenoxyacetic acid)	10.0	0.016
2,4,5-TP (Silvex) (2,4,5-trichlorophenoxypropionic acid)	1.0	0.005

[a]Column: 30 m × 0.32-mm SPB-5 fused silica capillary. Detection limit is calculated as four times the gas chromatography background noise found when an electron capture detector was used.

Table C-7. Summary of HSE-9 Quality Assurance Tests for 1990 (Stable Element Analyses in Biologicals)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
As	10	90	10	—	1.06 ± 0.13
B	5	100	—	—	0.91 ± 0.08
Br	3	100	—	—	1.10 ± 0.11
Cd	3	100	—	—	1.03 ± 0.08
F	13	100	—	—	1.05 ± 0.21
Hg	1	100	—	—	1.11
Li	1	100	—	—	0.86
U	10	100	—	—	1.05 ± 0.05

Table C-8. Summary of HSE-9 Quality Assurance Tests for 1990 (Stable Element Analyses in Filters)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Be	15	87	13	—	0.85 ± 0.12
U	43	95	2	2	1.04 ± 0.08

Table C-9. Summary of HSE-9 Quality Assurance Tests for 1990 (Stable Element Analyses in Bulk Materials)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Flashpoint	2	100	—	—	0.99

Table C-10. Summary of HSE-9 Quality Assurance Tests for 1990 (Stable Element Analyses in Soil)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Ag	55	95	2	4	9.60 ± 24.32
Al	84	96	2	1	1.00 ± 0.04
As	91	100	—	—	1.26 ± 1.53
Au	44	100	—	—	1.14 ± 0.27
B	7	43	—	57	1.80 ± 1.42
Ba	124	89	4	7	0.96 ± 0.26
Be	24	67	21	13	0.98 ± 0.68
Bi	1	100	—	—	3.89
Br	44	95	5	—	1.05 ± 0.18
Ca	83	94	5	1	0.98 ± 0.14
Cd	20	95	—	5	1.49 ± 2.13
Ce	79	89	—	11	1.91 ± 5.55
Cl	69	84	6	10	1.17 ± 0.36
Co	96	90	5	5	0.94 ± 0.24
Cr	104	92	1	7	1.06 ± 0.29
Cs	90	90	7	3	1.42 ± 2.09
Cu	105	98	—	2	1.04 ± 0.33
Dy	71	94	3	3	1.10 ± 0.45
Er	1	100	—	—	4.60
Eu	69	93	6	1	1.01 ± 0.39
F	7	100	—	—	1.05 ± 0.14
Fe	83	99	1	—	0.98 ± 0.07
Ga	74	96	4	—	1.00 ± 0.27
Gd	1	100	—	—	4.92
Ge	1	100	—	—	8.80
H^2O	4	100	—	—	0.94 ± 0.04
Hf	79	96	—	4	0.98 ± 0.21
Hg	68	99	1	—	2.38 ± 5.15
Ho	1	100	—	—	3.09
I	40	98	3	—	0.81 ± 0.16
In	44	100	—	—	—
K	82	98	2	—	0.98 ± 0.08
La	75	85	5	9	0.97 ± 0.31
Li	4	100	—	—	1.20 ± 0.75
Lu	62	95	5	—	1.06 ± 0.43
Mg	86	84	12	5	0.90 ± 0.11
Mn	96	89	9	2	1.08 ± 0.10
Mo	5	100	—	—	0.55
Na	80	99	1	—	1.00 ± 0.06
Nb	1	—	—	100	0.09
Nd	64	91	6	3	1.26 ± 0.55
Ni	26	100	—	—	0.86 ± 0.15

Table C-10 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Pb	36	100	—	—	1.04 ± 0.23
Pr	1	100	—	—	4.24
Rb	91	98	2	—	0.98 ± 0.13
Sb	89	85	12	2	0.89 ± 0.33
Sc	78	90	—	10	0.99 ± 0.39
Se	61	97	3	—	3.27 ± 4.39
Sm	72	93	4	3	1.05 ± 0.40
Sn	1	100	—	—	4.23
Sr	91	97	3	—	1.15 ± 0.31
Ta	71	100	—	—	0.99 ± 0.11
Tb	57	100	—	—	0.93 ± 0.45
Te	1	100	—	—	—
Th	95	92	3	5	0.99 ± 0.55
Ti	93	98	2	—	1.00 ± 0.26
Tl	6	83	—	17	1.00 ± 0.10
Tm	1	100	—	—	3.33
TSS (total suspended solids)	1	100	—	—	0.89
U	298	96	3	1	0.96 ± 0.10
V	90	97	1	2	0.98 ± 0.13
W	52	94	—	6	1.20 ± 1.46
Y	1	100	—	—	2.20
Yb	72	83	11	6	1.16 ± 0.36
Zn	96	93	1	6	1.09 ± 0.46
Zr	78	86	5	9	1.47 ± 0.92

Table C-11. Summary of HSE-9 Quality Assurance Tests for 1990 (Stable Element Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Ag	262	97	1	2	1.02 ± 0.14
Al	126	91	2	6	1.40 ± 1.70
As	238	96	3	1	1.04 ± 0.14
Au	8	100	—	—	—
B	75	99	—	1	1.01 ± 0.05
Ba	320	98	1	1	1.03 ± 0.08
Be	175	98	2	—	1.05 ± 0.13
Bi	8	100	—	—	—
Br	13	46	8	46	1.23 ± 0.33
Ca	67	91	9	—	1.17 ± 0.08
Cd	303	100	—	—	1.01 ± 0.09
Ce	8	100	—	—	—
Cl	85	98	1	1	1.03 ± 0.12
CN	115	89	9	3	0.86 ± 0.11
Co	27	100	—	—	1.08 ± 0.32
COD	30	100	—	—	1.03 ± 0.14
Conductivity	65	82	12	6	0.91 ± 0.07
Cr	288	97	3	—	1.07 ± 0.16
Cs	8	100	—	—	—
Cu	190	96	2	3	1.05 ± 0.24
Dy	8	100	—	—	—
Er	8	100	—	—	—
Eu	8	100	—	—	—
F	103	100	—	—	1.04 ± 0.10
Fe	83	98	—	2	1.02 ± 0.10
Ga	8	100	—	—	—
Gd	8	100	—	—	—
Ge	8	100	—	—	—
Hardness	47	98	2	—	1.13 ± 0.07
Hf	8	100	—	—	—
Hg	150	98	2	—	0.99 ± 0.11
Ho	8	100	—	—	—
In	8	100	—	—	—
Ir	8	100	—	—	—
K	63	100	—	—	1.02 ± 0.06
La	8	100	—	—	—
Li	14	100	—	—	1.04 ± 0.08
Lu	8	100	—	—	—
Mg	84	100	—	—	1.04 ± 0.07
Mn	99	98	1	1	1.08 ± 0.19
Mo	93	94	3	3	1.08 ± 0.19

Table C-11 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Na	66	98	2	—	1.12 ± 0.06
Nb	8	100	—	—	—
Nd	8	100	—	—	—
NH_3-N	47	96	2	2	0.98 ± 0.13
Ni	205	99	1	—	1.03 ± 0.16
NO_2-N	5	100	—	—	0.92 ± 0.14
NO_3-N	101	92	8	—	1.00 ± 0.09
Oil/grease	14	100	—	—	0.92 ± 0.08
P	77	92	6	1	0.97 ± 0.47
Pb	324	97	3	1	1.02 ± 0.17
Pd	8	100	—	—	—
pH	290	100	—	—	1.01 ± 0.02
Po_4-P	56	95	5	—	0.86 ± 0.20
Pr	8	100	—	—	—
Pt	8	100	—	—	—
Rb	8	100	—	—	—
Rh	8	100	—	—	—
Ru	8	100	—	—	—
Sb	100	97	—	3	1.02 ± 0.16
Se	197	100	—	—	1.01 ± 0.10
Sio2	71	100	—	—	1.00 ± 0.04
Sm	8	100	—	—	—
Sn	15	100	—	—	1.05 ± 0.07
So_4	82	96	4	—	1.19 ± 0.13
Sr	81	99	1	—	0.99 ± 0.06
Ta	8	100	—	—	—
Total alkalinity	64	95	2	3	0.99 ± 0.09
Tb	8	100	—	—	—
TDS (total dissolved solids)	57	86	7	7	0.98 ± 0.20
Te	8	100	—	—	—
Th	8	100	—	—	—
Ti	31	100	—	—	1.06 ± 0.30
Tl	165	96	4	1	1.01 ± 0.20
Tm	8	100	—	—	—
TDS (total suspended solids)	54	96	4	—	0.96 ± 0.10
U	276	97	1	2	0.99 ± 0.12
V	88	91	5	5	0.98 ± 0.15
W	8	100	—	—	—
Y	9	89	—	11	—
Yb	8	100	—	—	—
Zn	162	94	3	2	1.03 ± 0.28
Zr	8	100	—	—	—

Table C-12. Summary of HSE-9 Quality Assurance Tests for 1990 (Radiochemical Analyses in Biologicals)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
As	10	90	10	—	1.06 ± 0.13
B	5	100	—	—	0.91 ± 0.08
Br	3	100	—	—	1.10 ± 0.11
Cd	3	100	—	—	1.03 ± 0.08
F	13	100	—	—	1.05 ± 0.21
Hg	1	100	—	—	1.11
Li	1	100	—	—	0.86
U	10	100	—	—	1.05 ± 0.05

Table C-13. Summary of HSE-9 Quality Assurance Tests for 1990 (Radiochemical Analyses in Filters)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Alpha	104	100	—	—	0.90 ± 0.06
^{41}Am	16	75	25	—	0.84 ± 0.04
Beta	95	100	—	—	0.84 ± 0.02
^{238}Pu	17	100	—	—	0.92 ± 0.10
^{239}Pu	17	100	—	—	1.15 ± 0.06

Table C-14. Summary of HSE-9 Quality Assurance Tests for 1990 (Radiochemical Analyses in Soil)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Alpha	4	75	25	—	1.19 – 0.75
^{241}AM	12	75	17	8	0.89 ± 0.29
Beta	4	50	25	25	1.43 ± 0.70
^{137}CS	66	82	14	5	1.06 ± 0.63
Gamma	6	100	—	—	1.10
^{3}H	21	76	14	10	0.94 ± 0.06
^{238}PU	16	94	6	—	0.95 ± 0.14
^{239}PU	16	94	6	—	0.97 ± 0.09
^{90}SR	29	59	21	21	0.88 ± 0.35
$^{235/238}$U	15	87	13	—	0.97 ± 0.05

Table C-15. Summary of HSE-9 Quality Assurance Tests for 1990 (Radiochemical Analyses in Urine)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
^{241}AM	4	75	—	25	1.66
^{3}H	180	98	—	2	0.95 ± 0.09
^{238}PU	111	99	1	—	1.09 ± 0.15
^{239}PU	115	97	2	2	1.08 ± 0.17
^{235}U	70	89	9	3	0.85 ± 0.08
^{238}U	96	69	15	17	0.84 ± 0.14

Table C-16. Summary of HSE-9 Quality Assurance Tests for 1990 (Radiochemical Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Alpha	701	98	1	—	0.99 ± 0.22
^{241}Am	76	100	—	—	0.99 ± 0.08
Beta	703	98	1	1	0.98 ± 0.35
^{57}Co	25	100	—	—	1.37 ± 0.21
^{60}Co	50	100	—	—	0.95 ± 0.11
^{134}Cs	51	100	—	—	0.85 ± 0.09
^{137}Cs	117	98	1	1	1.05 ± 0.17
Gamma	48	90	8	2	1.21 ± 0.22
^{3}H	359	99	—	—	0.94 ± 0.07
^{54}Mn	48	100	—	—	1.12 ± 0.13
^{22}Na	48	100	—	—	0.96 ± 0.03
^{238}Pu	63	97	2	2	0.88 ± 0.14
^{239}Pu	63	98	—	2	0.95 ± 0.15
^{226}Ra	27	85	—	15	0.97 ± 0.19
^{90}Sr	8	88	13	—	0.90 ± 0.10
^{234}U	23	100	—	—	1.07 ± 0.12
^{235}U	52	100	—	—	0.98 ± 0.19
^{235,238}U	136	100	—	—	1.00 ± 0.05

Table C-17. Summary of HSE-9 Quality Assurance Tests for 1990 (Organic Analyses in Filters)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Mixed-Aroclor	70	94	4	1	0.97 ± 0.23
Aroclor 1242	70	96	3	1	0.95 ± 0.28
Aroclor 1254	70	100	—	—	1.05 ± 0.27
Aroclor 1260	70	99	1	—	0.97 ± 0.19

Table C-18. Summary of HSE-9 Quality Assurance Tests for 1990 (Organic Analyses in Bulk Materials)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Acenaphthene	1	100	—	—	—
Acenaphthenene	1	100	—	—	—
Acetone	1	—	—	100	—
Aniline	1	100	—	—	—
Anthracene	1	100	—	—	—
Mixed-Aroclor	41	95	2	2	0.84 ± 0.15
Aroclor 1242	41	100	—	—	0.88 ± 0.09
Aroclor 1254	41	100	—	—	—
Aroclor 1260	41	95	2	2	0.81 ± 0.18
Azobenzene	1	100	—	—	
Benzene	1	100	—	—	—
m-Benzidine	1	100	—	—	—
Benzo[*a*]anthracene	1	100	—	—	—
Benzo[*a*]pyrene	1	100	—	—	—
Benzo[*b*]fluoranthene	1	—	—	100	—
Benzo[*g,h,i*]perylene	1	100	—	—	—
Benzo[*k*]fluoranthene	1	—	—	100	—
Benzoic acid	1	100	—	—	—
Benzyl alcohol	1	100	—	—	—
Bis(2-chloroethoxy)methane	1	100	—	—	—
Bis(2-chloroethyl)ether	1	100	—	—	—
Bis(2-chloroisopropyl)ether	1	100	—	—	—
Bis(2-ethylhexyl)phthalate	1	100	—	—	0.92
Bromobenzene	1	100	—	—	—
Bromochloromethane	1	100	—	—	—
Bromodichloromethane	1	100	—	—	—
Bromoform	1	100	—	—	—
Bromomethane	1	100	—	—	—

Table C-18 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
4-Bromophenylphenyl ether	1	100	—	—	—
2-Butanone	1	—	—	100	—
n-Butylbenzene	1	100	—	—	—
sec-Butylbenzene	1	100	—	—	—
tert-Butylbenzene	1	100	—	—	—
Butylbenzyl phthalate	1	100	—	—	—
Carbon disulfide	1	100	—	—	2.31
Carbon tetrachloride	1	100	—	—	—
4-Chloro-3-methylphenol	1	100	—	—	—
4-Chloroaniline	1	100	—	—	—
Chlorobenzene	1	100	—	—	—
Chlorodibromomethane	1	100	—	—	—
Chloroethane	1	100	—	—	—
Chloroform	1	100	—	—	—
Chloromethane	1	100	—	—	—
2-Chloronaphthalene	1	100	—	—	—
o-Chlorophenol	1	100	—	—	—
4-Chlorophenylphenyl ether	1	100	—	—	—
o-Chlorotoluene	1	100	—	—	—
p-Chlorotoluene	1	100	—	—	—
Chrysene	1	100	—	—	—
Di-*n*-butyl phthalate	1	100	—	—	—
Di-*n*-octyl phthalate	1	100	—	—	—
Dibenzo[*a*,*h*]anthracene	1	100	—	—	—
Dibenzofuran	1	100	—	—	—
1,2-Dibromo-3-chloropropane	1	100	—	—	—
1,2-Dibromoethane	1	100	—	—	—
Dibromomethane	1	100	—	—	—
o-Dichlorobenzene (1,2)	2	100	—	—	—
m-Dichlorobenzene (1,3)	2	100	—	—	—
p-Dichlorobenzene (1,4)	2	100	—	—	—
3,3'-Dichlorobenzidine	1	100	—	—	—
1,2-Dichloroethane	1	100	—	—	—
1,1-Dichloroethane	1	100	—	—	1.37
1,1-Dichloroethene	1	100	—	—	—
trans-1,2-Dichloroethene	1	100	—	—	—
cis-1,2-Dichloroethylene	1	100	—	—	—
2,4-Dichlorophenol	1	100	—	—	—
1,3-Dichloropropane	1	100	—	—	—
2,2-Dichloropropane	1	100	—	—	—
1,2-Dichloropropane	1	100	—	—	—
1,1-Dichloropropene	1	100	—	—	—

Table C-18 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
trans-1,3-Dichloropropene	1	100	—	—	1.89
cis-1,3-Dichloropropene	1	—	—	100	0.40
Diethyl phthalate	1	100	—	—	—
Dimethyl phthalate	1	100	—	—	—
2,4-Dimethylphenol	1	100	—	—	—
2,4-Dinitrophenol	1	100	—	—	—
2,4-Dinitrotoluene	1	100	—	—	—
2,6-Dinitrotoluene	1	100	—	—	—
Ethylbenzene	1	—	—	100	0.12
Fluoranthene	1	100	—	—	—
Fluorene	1	100	—	—	—
Hexachlorobenzene	1	100	—	—	—
Hexachlorobutadiene	2	100	—	—	—
Hexachlorocyclopentadiene	1	100	—	—	—
Hexachloroethane	1	100	—	—	—
2-Hexanone	1	—	—	100	0.18
Indeno[1,2,3-cd]pyrene	1	100	—	—	—
Isophorone	1	100	—	—	—
Isopropylbenzene	1	100	—	—	—
4-Isopropyltoluene	1	100	—	—	—
4-Methyl-2-pentanone	1	100	—	—	—
2-Methyl-4,6-dinitrophenol	1	100	—	—	—
Methylene chloride	1	—	—	100	—
2-Methylnaphthalene	1	100	—	—	—
4-Methylphenol	1	100	—	—	—
2-Methylphenol	1	100	—	—	—
Naphthalene	2	100	—	—	—
2-Nitroaniline	1	100	—	—	—
4-Nitroaniline	1	100	—	—	—
3-Nitroaniline	1	100	—	—	—
Nitrobenzene	1	100	—	—	—
2-Nitrophenol	1	100	—	—	—
4-Nitrophenol	1	100	—	—	—
N-Nitrosodi-*n*-propylamine	1	100	—	—	—
N-Nitrosodimethylamine	1	100	—	—	—
N-Nitrosodiphenylamine	1	100	—	—	—
Pentachlorophenol	1	100	—	—	1.19
Phenanthrene	1	100	—	—	—
Phenol	1	100	—	—	—
Propylbenzene	1	100	—	—	—
Pyrene	1	100	—	—	1.01
Styrene	1	100	—	—	—
1,1,2,2-Tetrachloroethane	1	100	—	—	—

Table C-18 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
1,1,1,2-Tetrachloroethane	1	100	—	—	—
Tetrachloroethylene	1	100	—	—	—
Toluene	1	100	—	—	0.76
1,2,4-Trichlorobenzene	2	100	—	—	—
1,2,3-Trichlorobenzene	1	100	—	—	—
1,1,1-Trichloroethane	1	—	—	100	—
1,1,2-Trichloroethane	1	—	—	100	—
Trichloroethene	1	100	—	—	—
Trichlorofluoromethane	1	100	—	—	—
2,4,5-Trichlorophenol	1	100	—	—	—
2,4,6-Trichlorophenol	1	100	—	—	—
1,2,3-Trichloropropane	1	100	—	—	—
1,3,5-Trimethylbenzene	1	100	—	—	—
1,2,4-Trimethylbenzene	1	—	—	100	—
Vinyl acetate	1	100	—	—	—
Vinyl chloride	1	100	—	—	—
o-Xylene	1	—	—	100	—
Mixed-Xylenes (*o* + *m* + *p*)	1	—	—	100	—

Table C-19. Summary of HSE-9 Quality Assurance Tests for 1990 (Organic Analyses in Soil)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Acenaphthene	21	100	—	—	—
Acenaphthylene	21	100	—	—	—
Acetone	19	16	—	84	—
Acrolein	12	100	—	—	—
Acrylonitrile	12	100	—	—	—
Adipic ester	—	—	—	—	—
Aldrin	8	100	—	—	—
Aniline	21	81	—	19	0.08
Anthracene	21	95	5	—	0.71 ± 0.11
Mixed-Aroclor	46	96	2	2	1.00 ± 0.27
Aroclor 1242	46	98	2	—	1.07 ± 0.34
Aroclor 1254	46	100	—	—	—
Aroclor 1260	46	98	—	2	0.95 ± 0.19
Azobenzene	21	100	—	—	—
delta-BHC	8	100	—	—	—

Table C-19 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
beta-BHC	8	100	—	—	—
alpha-BHC	8	100	—	—	—
Benzene	19	84	—	16	0.68 ± 0.26
m-Benzidine	21	100	—	—	—
Benzo[*a*]anthracene	21	100	—	—	—
Benzo[*a*]pyrene	21	100	—	—	—
Benzo[*b*]fluoranthene	21	95	5	—	0.98
Benzo[*g,h,i*]perylene	21	100	—	—	—
Benzo[*k*]fluoranthene	21	100	—	—	—
Benzoic acid	21	67	—	33	0.56 ± 0.35
Benzyl alcohol	21	95	—	5	0.79 ± 0.27
Bis(2-chloroethoxy)methane	21	100	—	—	—
Bis(2-chloroethyl)ether	21	100	—	—	0.70 ± 0.04
Bis(2-chloroisopropyl)ether	21	100	—	—	—
Bis(2-ethylhexyl)phthalate	21	95	—	5	—
Bromobenzene	19	100	—	—	—
Bromochloromethane	19	89	5	5	0.52
Bromodichloromethane	19	100	—	—	—
Bromoform	19	95	—	5	—
Bromomethane	19	100	—	—	—
4-Bromophenylphenyl ether	21	100	—	—	—
2-Butanone	19	53	5	42	0.99 ± 0.62
n-Butylbenzene	19	95	—	5	0.25
sec-Butylbenzene	19	100	—	—	—
tert-Butylbenzene	19	100	—	—	—
Butylbenzyl phthalate	21	100	—	—	—
Carbon disulfide	19	79	—	21	0.34 ± 0.11
Carbon tetrachloride	19	63	—	37	0.62 ± 0.30
Chlordane	8	100	—	—	—
4-Chloro-3-methylphenol	21	100	—	—	—
4-Chloroaniline	21	100	—	—	—
Chlorobenzene	19	68	11	21	0.56 ± 0.24
Chlorodibromomethane	19	79	—	21	0.65 ± 0.29
Chloroethane	19	100	—	—	—
2-Chloroethylvinyl ether	12	100	—	—	—
Chloroform	19	100	—	—	—
Chloromethane	19	100	—	—	—
2-Chloronaphthalene	21	100	—	—	—
o-Chlorophenol	21	100	—	—	—

Table C-19 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
4-Chlorophenylphenyl ether	21	100	—	—	—
p-Chlorotoluene	19	95	—	5	—
o-Chlorotoluene	19	100	—	—	—
Chrysene	21	100	—	—	—
2,4-D	10	80	10	10	1.01 ± 0.82
p,p'-DDD	8	100	—	—	0.76
p,p'-DDE	8	100	—	—	0.89 ± 0.13
p,p'-DDT	8	100	—	—	1.65
Di-*n*-butyl phthalate	21	95	—	5	—
Di-*n*-octyl phthalate	21	100	—	—	—
Dibenzo[*a*,*h*]anthracene	21	100	—	—	—
Dibenzofuran	21	100	—	—	—
1,2-Dibromo-3-chloropropane	19	100	—	—	—
1,2-Dibromoethane	19	89	—	11	0.29
Dibromomethane	19	100	—	—	—
o-Dichlorobenzene (1,2)	40	100	—	—	—
m-Dichlorobenzene (1,3)	40	100	—	—	—
p-Dichlorobenzene (1,4)	40	95	—	5	0.09
3,3'-Dichlorobenzidine	21	100	—	—	—
Dichlorodifluoromethane	12	100	—	—	—
1,1—Dichloroethane	19	58	5	37	0.57 ± 0.22
1,2-Dichloroethane	19	53	16	32	0.72 ± 0.26
1,1—Dichloroethene	19	100	—	—	—
trans-1,2-Dichloroethene	19	100	—	—	—
cis-1,2-Dichloroethylene	19	100	—	—	—
2,4-Dichlorophenol	21	95	5	—	0.66
2,2-Dichloropropane	19	100	—	—	—
1,3-Dichloropropane	19	95	—	5	—
1,2-Dichloropropane	19	95	—	5	0.77
1,1—Dichloropropene	19	95	—	5	—
trans-1,3-Dichloropropene	19	95	—	5	0.86 ± 0.49
cis-1,3-Dichloropropene	19	84	—	16	0.32 ± 0.20
Dieldrin	8	100	—	—	—
Diethyl phthalate	21	100	—	—	1.02 ± 0.11
Dimethyl phthalate	21	100	—	—	0.79
2,4-Dimethylphenol	21	90	—	10	0.35

Table C-19 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
2,4-Dinitrophenol	21	100	—	—	—
2,6-Dinitrotoluene	21	100	—	—	—
2,4-Dinitrotoluene	23	100	—	—	0.87
Endosulfan I	3	100	—	—	—
Endosulfan II	3	100	—	—	—
Endosulfan sulfate	8	100	—	—	—
Endrin	8	100	—	—	—
Endrin aldehyde	8	100	—	—	—
Ethylbenzene	19	58	—	42	0.46 ± 0.23
Fluoranthene	21	100	—	—	—
Fluorene	21	100	—	—	—
HMX	2	100	—	—	0.95
Heptachlor	8	100	—	—	0.59
Heptachlor epoxide	8	100	—	—	0.87 ± 0.22
Hexachlorobenzene	21	95	—	5	0.54
Hexachlorobutadiene	40	93	3	5	0.58 ± 0.19
Hexachlorocyclopentadiene	21	90	—	10	0.36
Hexachloroethane	21	90	—	10	0.09
2-Hexanone	19	68	5	26	1.20 ± 0.63
Indeno[1,2,3-cd]pyrene	21	100	—	—	—
Isophorone	21	81	14	5	0.62 ± 0.10
Isopropylbenzene	19	100	—	—	—
4-Isopropyltoluene	19	74	—	26	—
Lindane	8	100	—	—	0.86 ± 0.31
Methoxychlor	7	100	—	—	0.68 ± 0.11
Methyl iodide	12	100	—	—	—
4-Methyl-2-pentanone	19	89	—	11	—
2-Methyl-4,6-dinitrophenol	21	100	—	—	—
Methylene chloride	19	79	—	21	—
2-Methylnaphthalene	21	100	—	—	—
4-Methylphenol	21	100	—	—	—
2-Methylphenol	21	100	—	—	—
Naphthalene	40	95	3	3	0.46
2-Nitroaniline	21	100	—	—	—
3-Nitroaniline	21	100	—	—	—
4-Nitroaniline	21	90	—	10	0.30
Nitrobenzene	21	90	5	5	0.59

Table C-19 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
2-Nitrophenol	21	100	—	—	—
4-Nitrophenol	21	100	—	—	0.97 ± 0.03
N-Nitrosodi-*n*-propylamine	21	100	—	—	—
N-Nitrosodimethylamine	21	100	—	—	—
N-Nitrosodiphenylamine	21	100	—	—	—
Pentachlorophenol	21	100	—	—	1.11 ± 0.03
Petroleum Hydrocarbons, Total	1	100	—	—	1.07
Phenanthrene	21	100	—	—	0.89
Phenol	21	90	5	5	0.65 ± 0.07
Propylbenzene	19	95	—	5	0.32
Pyrene	21	100	—	—	—
RDX	2	100	—	—	0.87
Styrene	19	89	—	11	0.36 ± 0.01
2,4,5-TP	10	100	—	—	0.91 ± 0.24
1,1,1,2-Tetrachloroethane	19	95	5	—	0.57
1,1,2,2-Tetrachloroethane	19	84	—	16	—
Tetrachloroethylene	19	47	5	47	0.45 ± 0.22
Tetryl(methyl-2,4,6-trinitroph	2	100	—	— 1.05	
Toluene	19	47	5	47	0.52 ± 0.29
Toxaphene	8	100	—	—	—
1,1,2-Trichloro-1,2,2-trifluor	12	100	—	—	—
1,2,3-Trichlorobenzene	19	100	—	—	—
1,2,4-Trichlorobenzene	40	100	—	—	—
1,1,1—Trichloroethane	19	79	—	21	0.53 ± 0.28
1,1,2-Trichloroethane	19	68	5	26	0.67 ± 0.32
Trichloroethene	19	68	5	26	0.43 ± 0.26
Trichlorofluoromethane	19	100	—	—	—
2,4,5-Trichlorophenol	21	100	—	—	0.75 ± 0.12
2,4,6-Trichlorophenol	21	100	—	—	—
1,2,3-Trichloropropane	19	100	—	—	—
1,2,4-Trimethylbenzene	19	89	—	11	0.39
1,3,5-Trimethylbenzene	19	100	—	—	—
2,4,6-Trinitrotoluene	2	100	—	—	0.96
Vinyl acetate	19	79	—	21	0.59 ± 0.43
Vinyl chloride	19	100	—	—	—
o-Xylene	6	100	—	—	—
Mixed-Xylenes (*o* + *m* + *p*)	19	84	—	16	0.35

Table C-20. Summary of HSE-9 Quality Assurance Tests for 1990 (Organic Analyses in Charcoal Tubes)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Benzene	71	93	4	3	0.84 ± 0.25
Bromobenzene	52	98	—	2	0.85 ± 0.16
Carbon tetrachloride	71	82	1	17	1.00 ± 0.40
Chlorobenzene	71	86	4	10	0.78 ± 0.33
Chloroform	71	90	4	6	1.01 ± 0.43
Ethylbenzene	71	75	10	15	1.03 ± 0.39
Ethylbenzene	71	75	10	15	1.03 ± 0.39
Tetrachloroethylene	71	97	—	3	1.16 ± 0.21
Toluene	71	82	4	14	0.83 ± 0.30
1,1,1-Trichloroethane	71	87	4	8	0.82 ± 0.38
Trichloroethene	71	99	—	1	1.24 ± 0.21
1,2,4-Trimethylbenzene	71	97	1	1	1.09 ± 0.35
o-Xylene	71	79	1	20	1.00 ± 0.22
m-Xylene	5	80	—	20	—
Mixed-Xylenes (*o* + *m* + *p*)	66	58	—	42	0.86

Table C-21. Summary of HSE-9 Quality Assurance Tests for 1990 (Organic Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Acenaphthene	20	100	—	—	0.83
Acenaphthylene	20	100	—	—	—
Acetone	30	63	—	37	—
Acrolein	18	100	—	—	—
Acrylonitrile	18	100	—	—	—
Aldrin	10	100	—	—	—
Aniline	20	100	—	—	0.90 ± 0.13
Anthracene	20	85	5	10	0.60 ± 0.15
Mixed-Aroclor	38	100	—	—	1.22 ± 0.25
Aroclor 1242	37	100	—	—	1.28 ± 0.19
Aroclor 1254	37	100	—	—	1.44 ± 0.18
Aroclor 1260	37	100	—	—	1.09 ± 0.22
Azobenzene	20	100	—	—	—
delta-BHC	10	100	—	—	—
alpha-BHC	10	100	—	—	—
beta-BHC	10	100	—	—	—

Table C-21 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Benzene	30	97	3	—	0.93 ± 0.30
m-Benzidine	20	100	—	—	—
Benzo[*a*]anthracene	20	95	—	5	—
Benzo[*a*]pyrene	20	100	—	—	0.81
Benzo[*b*]fluoranthene	20	100	—	—	0.86
Benzo[*g,h,i*]perylene	20	100	—	—	1.04
Benzo[*k*]fluoranthene	20	100	—	—	0.65
Benzoic acid	20	65	10	25	0.53 ± 0.34
Benzyl alcohol	20	95	5	—	0.67 ± 0.09
Bis(2-chloroethoxy)methane	20	100	—	—	0.67
Bis(2-chloroethyl)ether	20	100	—	—	0.66 ± 0.03
Bis(2-chloroisopropyl)ether	20	100	—	—	—
Bis(2-ethylhexyl)phthalate	20	80	5	15	0.81
Bromobenzene	30	100	—	—	—
Bromochloromethane	30	100	—	—	—
Bromodichloromethane	30	100	—	—	—
Bromoform	30	100	—	—	0.61
Bromomethane	30	100	—	—	—
4-Bromophenylphenyl ether	20	100	—	—	0.99
2-Butanone	30	63	10	27	0.92 ± 0.55
n-Butylbenzene	30	97	—	3	—
tert-Butylbenzene	30	100	—	—	—
sec-Butylbenzene	30	100	—	—	—
Butylbenzyl phthalate	20	95	—	5	—
Carbon disulfide	30	87	—	13	0.86 ± 0.42
Carbon tetrachloride	30	97	—	3	0.64 ± 0.21
Chlordane	10	100	—	—	—
4-Chloro-3-methylphenol	20	100	—	—	0.90
4-Chloroaniline	20	100	—	—	—
Chlorobenzene	30	97	—	3	0.85 ± 0.17
Chlorodibromomethane	30	93	3	3	0.80 ± 0.21
Chloroethane	30	100	—	—	—
2-Chloroethylvinyl ether	18	100	—	—	—
Chloroform	30	100	—	—	—
Chloromethane	30	100	—	—	—
2-Chloronaphthalene	21	100	—	—	0.71
o-Chlorophenol	20	100	—	—	0.67
4-Chlorophenylphenyl ether	20	100	—	—	0.90
o-Chlorotoluene	30	100	—	—	—
p-Chlorotoluene	30	100	—	—	—
Chrysene	20	95	—	5	0.94

Table C-21 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
2,4-D	6	100	—	—	1.83 ± 2.04
p,p'-DDD	10	100	—	—	0.94 ± 0.09
p,p'-DDE	10	90	10	—	0.73 ± 0.10
p,p'-DDT	10	100	—	—	1.39
Di-*n*-butyl phthalate	20	95	—	5	0.22
Di-*n*-octyl phthalate	20	95	—	5	—
Dibenzo[*a*,*h*]anthracene	20	100	—	—	1.10
Dibenzofuran	20	100	—	—	—
1,2-Dibromo-3-chloropropane	30	100	—	—	—
1,2-Dibromoethane	30	100	—	—	0.93
Dibromomethane	30	100	—	—	—
o-Dichlorobenzene (1,2)	51	100	—	—	0.66
m-Dichlorobenzene (1,3)	51	100	—	—	0.62
p-Dichlorobenzene (1,4)	51	96	2	2	0.64 ± 0.06
3,3'-Dichlorobenzidine	20	100	—	—	—
Dichlorodifluoromethane	18	100	—	—	—
1,1-Dichloroethane	30	93	—	7	0.98 ± 0.31
1,2-Dichloroethane	30	97	—	3	1.02 ± 0.16
trans-1,2-Dichloroethene	30	100	—	—	—
1,1-Dichloroethene	30	97	—	3	—
cis-1,2-Dichloroethylene	30	100	—	—	—
2,4-Dichlorophenol	20	95	—	5	0.64 ± 0.21
1,3-Dichloropropane	30	100	—	—	—
2,2-Dichloropropane	30	100	—	—	—
1,2-Dichloropropane	30	100	—	—	0.85
cis-1,3-Dichloropropene	30	67	23	10	0.53 ± 0.10
trans-1,3-Dichloropropene	30	100	—	—	1.70 ± 0.35
1,1-Dichloropropene	30	100	—	—	—
Dieldrin	10	100	—	—	—
Diethyl phthalate	20	75	—	25	0.16 ± 0.05
Dimethyl phthalate	20	85	—	15	—
2,4-Dimethylphenol	20	100	—	—	0.71
2,4-Dinitrophenol	20	100	—	—	—
2,4-Dinitrotoluene	20	100	—	—	0.96
2,6-Dinitrotoluene	20	100	—	—	0.91
Endosulfan I	10	100	—	—	—
Endosulfan II	10	100	—	—	—
Endosulfan sulfate	10	100	—	—	—
Endrin	10	100	—	—	—
Endrin aldehyde	10	100	—	—	—
Ethylbenzene	30	90	7	3	0.77 ± 0.19

Table C-21 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Fluoranthene	20	100	—	—	0.98
Fluorene	20	100	—	—	0.90
Heptachlor	10	90	—	10	0.58 ± 0.31
Heptachlor epoxide	10	100	—	—	1.06 ± 0.17
Hexachlorobenzene	21	90	10	—	0.72 ± 0.14
Hexachlorobutadiene	49	90	6	4	0.52 ± 0.09
Hexachlorocyclopentadiene	21	86	—	14	0.48
Hexachloroethane	21	86	5	10	0.52 ± 0.13
2-Hexanone	30	70	7	23	0.95 ± 0.43
Indeno[1,2,3-cd]pyrene	20	95	—	5	—
Isophorone	20	95	5	—	0.67 ± 0.10
Isopropylbenzene	30	100	—	—	—
4-Isopropyltoluene	30	100	—	—	—
Lindane	10	100	—	—	1.10 ± 0.30
Methoxychlor	9	100	—	—	1.14 ± 0.30
Methyl iodide	18	100	—	—	—
4-Methyl-2-pentanone	30	100	—	—	—
2-Methyl-4,6-dinitrophenol	20	100	—	—	0.74
Methylene chloride	30	90	—	10	—
2-Methylnaphthalene	20	100	—	—	—
4-Methylphenol	20	100	—	—	—
2-Methylphenol	20	100	—	—	—
Naphthalene	48	100	—	—	0.76
2-Nitroaniline	20	100	—	—	—
3-Nitroaniline	20	100	—	—	—
4-Nitroaniline	20	100	—	—	—
Nitrobenzene	20	95	—	5	0.69 ± 0.17
4-Nitrophenol	20	95	—	5	0.84 ± 0.19
2-Nitrophenol	20	100	—	—	0.75
N-Nitrosodi-*n*-propylamine	20	100	—	—	0.64
N-Nitrosodimethylamine	20	100	—	—	—
N-Nitrosodiphenylamine	20	100	—	—	—
Pentachlorophenol	20	95	5	—	0.92 ± 0.23
Phenanthrene	20	90	—	10	0.64
Phenol	20	90	5	5	0.52 ± 0.14
Propylbenzene	30	97	—	3	—
Pyrene	20	100	—	—	0.99
Styrene	30	100	—	—	0.70
2,4,5-TP	6	100	—	—	1.09 ± 0.33
1,1,2,2-Tetrachloroethane	30	97	—	3	—
1,1,1,2-Tetrachloroethane	30	100	—	—	0.85
Tetrachloroethylene	30	90	—	10	0.72 ± 0.17

Table C-21 (Cont)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Toluene	30	83	10	7	0.78 ± 0.19
Toxaphene	12	83	—	17	7.95
1,1,2-Trichloro-1,2,2-trifluor	18	100	—	—	—
1,2,4-Trichlorobenzene	49	100	—	—	0.69
1,2,3-Trichlorobenzene	28	96	—	4	—
1,1,2-Trichloroethane	30	97	—	3	0.95 ± 0.11
1,1,1-Trichloroethane	30	97	—	3	0.86 ± 0.24
Trichloroethene	30	97	—	3	0.71 ± 0.20
Trichlorofluoromethane	30	100	—	—	—
2,4,6-Trichlorophenol	20	100	—	—	0.82
2,4,5-Trichlorophenol	20	85	5	10	0.72 ± 0.17
1,2,3-Trichloropropane	30	100	—	—	—
1,2,4-Trimethylbenzene	30	93	—	7	—
1,3,5-Trimethylbenzene	30	100	—	—	—
Vinyl acetate	30	87	—	13	0.56 ± 0.38
Vinyl chloride	30	100	—	—	—
o-Xylene	9	100	—	—	—
Mixed-Xylenes (*o* + *m* + *p*)	30	97	—	3	—

Table C-22. Overall Summary of HSE-9 Quality Assurance Tests for 1990

Analysis	Number of Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)
Stable Elements				
Biological Materials	46	98	2	—
Filters	58	93	5	2
Bulk Materials	2	100	—	—
Soil	3 776	93	4	3
Water	3 270	96	2	2
Radiochemical Elements				
Biologicals	28	86	14	—
Filters	249	98	2	—
Soils	189	79	14	7
Water	2 598	98	1	1
Organic Compounds				
Filters	280	97	2	1
Bulk Materials	297	94	1	5
Soil	3 080	93	1	6
Charcoal Tube	975	85	3	12
Water	3 740	96	1	3

Table C-23. Summary of HSE-9 Organic Surrogate Compliance with EPA SW844 Criteria for 1990

Analysis	EPA SW-846 Range Low	EPA SW-846 Range High	Number of Surrogates In Range	Number of Surrogates Total	% In Range	% of Samples Run with Surrogate
Volatile Organic Compounds						
In Soil						
1,2-Dichloroethane d4	70	121	266	327	81.3	97.6
Toluene d8	81	117	264	327	80.7	97.6
4-Bromofluorobenzene	74	121	247	327	75.5	97.6
In Water						
1,2-Dichloroethane d4	76	114	142	205	69.3	93.2
Toluene d8	88	110	152	205	74.1	93.2
4-Bromofluorobenzene	86	115	181	205	88.3	93.2
Semivolatile Organic Compounds						
In Soil						
2-Fluorophenol	25	121	317	328	96.6	98.5
Phenol d6	24	113	326	331	98.5	99.4
Nitrobenzene d5	23	120	326	331	98.5	99.4
2-Fluorobiphenyl	30	115	318	331	96.1	99.4
2,4,6-Tribromophenol	19	122	314	329	95.4	98.8
p-Terphenyl d14	18	137	323	327	98.8	98.2
In Water						
2-Fluorophenol	21	100	126	132	95.5	99.2
Phenol d6	10	94	125	132	94.7	99.2
Nitrobenzene d5	35	114	127	132	96.2	99.2
2-Fluorobiphenyl	43	116	126	132	95.5	99.2
2,4,6-Tribromophenol	10	123	125	132	94.7	99.2
p-Terphenyl d14	33	141	108	132	81.8	99.2

Table C-23 (Cont)

Analysis	EPA SW-846 Range Low	EPA SW-846 Range High	Number of Surrogates In Range	Number of Surrogates Total	% In Range	% of Samples Run with Surrogate
Pesticides						
In Soil						
d8-DDT	—	—	0	0	0	0
Dibutyl chlorendate	20	150	0	15	0	18.3
In Water						
d8-DDT	—	—	0	0	0	0
Dibutyl chlorendate	24	154	0	21	0	22.8

Table C-24. EPA SW 846 Holding Time Summary for 1990

Organic Analysis Type	Number Meeting EPA Critera	Total Number Performed	% Within EPA Criteria
Extraction holding times			
Volatiles in soils	197	230	85.7
Volatiles in waters	80	85	94.1
Semivolatiles in soils	171	184	92.9
Semivolatiles in waters	87	90	96.7
Pesticides in soils	104	113	92.0
Pesticides in waters	79	82	96.3
Herbicides in soils	90	97	92.8
Herbicides in waters	34	48	70.8
PCBs in soils	208	208	100.0
PCBs in waters	119	121	98.3
Instrument analysis holding times			
Volatiles in soils	230	230	100.0
Volatiles in waters	85	85	100.0
Semivolatiles in soils	181	184	98.4
Semivolatiles in waters	89	90	98.9
Pesticides in soils	113	113	100.0
Pesticides in waters	82	82	100.0
Herbicides in soils	75	97	77.3
Herbicides in waters	48	48	100.0
PCBs in soils	208	208	100.0
PCBs in waters	121	121	100.0

Table C-25. Summary of HSE-9 False Positive/False Negative Occurances for HSE Quality Control Samples for 1990

Matrix Positive	False Negative	False Negative	Total Quality Control
INORGANIC ANALYSES			
Biologicals			
As	—	—	6
B	—	—	5
Cd	—	—	3
^{137}Cs	—	—	18
F	—	—	13
Hg	—	—	1
Li	—	—	1
^{238}PU	—	—	3
^{239}PU	—	—	3
^{90}Sr	—	—	3
U	—	—	10
Filters			
Alpha	—	—	104
^{241}Am	3	—	16
Be	—	—	15
Beta		—	95
^{238}PU	—	—	17
^{239}PU	—	—	17
U	1	—	43
Bulk Materials			
Flashpoint	—	—	2
Soils			
Ag	—	—	55
Al	—	—	93
Alpha	—	—	3
^{241}Am	2	—	12
As	—	—	92
Au	—	—	44
B	—	1	5
Ba	—	—	124
Be	—	—	24
Beta	—	—	3
Bi	—	—	1
Br	—	4	45
Ca	—	4	93
Cd	—	—	22
Ce	—	4	79
Cl	—	7	69
Co	—	—	96
Cr	—	—	104

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
INORGANIC ANALYSES			
Soils (Cont)			
Cs	—	—	90
^{137}Cs	1	—	66
Cu	—	2	106
Dy	3	1	71
Er	—	—	1
Eu	—	—	69
F	—	—	7
Fe	—	—	93
Ga	—	2	74
Gamma	—	—	6
Gd	—	—	1
Ge	—	—	1
^{3}H	5	—	21
H_2O-(Unbound Water)	—	—	4
Hf	—	—	79
Hg	—	2	69
Ho	—	—	1
I	—	—	40
In	—	1	44
K	—	1	93
La	—	3	75
Li	—	—	5
Lu	—	—	62
Mg	—	—	93
Mn	—	—	97
Mo	—	—	5
Na	—	—	93
Nb	—	—	1
Nd	—	—	64
Ni	—	2	26
Pb	—	—	36
Pr	—	—	1
^{238}Pu	—	—	16
^{239}Pu	1	—	16
Rb	—	—	91
Sb	—	5	89
Sc	—	—	78
Se	—	—	61
Sm	—	3	72
Sn	—	—	1
Sr	—	1	91
^{90}Sr	5	—	29
Ta	—	3	71

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
INORGANIC ANALYSES			
Soils (Cont)			
Tb	—	1	57
Te	—	—	1
Th	—	—	95
Ti	—	—	94
Tl	—	—	6
Tm	—	—	1
TSS (total suspended solids)	—	—	1
U	—	3	298
$^{235/238}U$-	—	—	15
V	—	—	90
W	—	1	52
Y	—	—	1
Yb	—	3	72
Zn	—	4	96
Zr	—	—	78
Waters			
Ag	—	—	213
Al	—	1	122
Alpha	—	1	241
^{241}Am	—	—	4
As	—	—	227
Au	—	—	8
B	—	1	74
Ba	1	—	273
Be	—	—	156
Beta	—	—	244
Bi	—	—	8
Br	—	4	13
Ca	—	—	54
Cd	—	—	250
Ce	—	—	8
Cl	—	—	68
Cn	—	—	53
Co	—	—	26
COD	—	—	21
Conductivity	—	—	47
Cr	—	—	225
Cs	—	—	8
^{137}Cs	1	—	64
Cu	—	1	128
Dy	—	—	8
Er	—	—	8

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
INORGANIC ANALYSES			
Waters (Cont)			
Eu	—	—	8
F	—	—	100
Fe	—	2	67
Ga	—	—	8
Gamma	—	—	49
Gd	—	—	8
Ge	—	—	8
^{3}H	2	1	314
Hardness	—	—	47
Hf	—	—	8
Hg	—	—	147
Ho	—	—	8
In	—	—	8
Ir	—	—	8
K	—	—	51
La	—	—	8
Li	—	—	14
Lu	—	—	8
Mg	—	—	71
Mn	—	—	98
Mo	—	—	92
Na	—	—	54
Nb	—	—	8
Nd	—	—	8
NH_3-N	—	—	17
Ni	—	—	148
NO_2-N	—	—	6
NO_3-N	—	—	82
Oil/Grease	—	—	14
P	—	—	21
Pb	—	—	273
Pd	—	—	8
Ph	—	—	48
PO_4-P	—	2	55
Pr	—	—	8
Pt	—	—	8
^{238}Pu	—	—	20
^{239}Pu	—	—	20
^{226}R	1	—	27
Rb	—	—	8
Rh	—	—	8
Ru	—	—	8
Sb	—	—	99

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
INORGANIC ANALYSES			
Waters (Cont)			
Se	—	—	194
SIO_2	—	—	66
Sm	—	—	8
Sn	—	—	15
SO_4	—	—	69
Sr	—	—	81
^{90}Sr	—	—	8
Ta	—	—	8
Total Alkalinity	—	2	58
Tb	—	—	8
TDS (total dissolved solids)	—	—	47
Te	—	—	8
Th	—	—	8
Ti	—	—	30
Tl	—	—	118
Tm	—	—	8
TSS	—	—	16
U	—	3	265
$^{235/238}Pu$	—	—	134
V	—	—	87
W	—	—	8
Y	1	—	9
Yb	—	—	8
Zn	—	—	100
Zr	—	—	8
ORGANIC ANALYSES			
Filters			
Mixed-aroclor	—	—	70
Aroclor 1242	—	—	70
Aroclor 1254	—	—	70
Aroclor 1260	—	—	70
Bulk Materials			
Acenaphthene	—	—	1
Acenaphthylene	—	—	1
Acetone	1	—	1
Aniline	—	—	1
Anthracene	—	—	1
Mixed-aroclor	—	—	41
Aroclor 1242	—	—	41
Aroclor 1254	—	—	41

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Bulk Materials (Cont)			
Aroclor 1260	—	—	41
Azobenzene	—	—	1
Benzene	—	—	1
m-benzidine	—	—	1
Benzo[*a*]anthracene	—	—	1
Benzo[*a*]pyrene	—	—	1
Benzo[*b*]fluoranthene	—	1	1
Benzo[*g,h,i*]perylene	—	—	1
Benzo[*k*]fluoranthene	1	—	1
Benzoic Acid	—	—	1
Benzyl Alcohol	—	—	1
Bis(2-chloroethoxy)methane	—	—	1
Bis(2-chloroethyl)ether	—	—	1
Bis(2-chloroisopropyl)ether	—	—	1
Bis(2-ethylhexyl)phthalate	—	—	1
Bromobenzene	—	—	1
Bromochloromethane	—	—	1
Bromodichloromethane	—	—	1
Bromoform	—	—	1
Bromomethane	—	—	1
4-Bromophenylphenyl Ether	—	—	1
2-Butanone	—	1	1
n-Butylbenzene	—	—	1
sec-Butylbenzene	—	—	1
tert-Butylbenzene	—	—	1
Butylbenzyl Phthalate	—	—	1
Carbon Disulfide	—	—	1
Carbon Tetrachloride	—	—	1
4-Chloro-3-methylphenol	—	—	1
4-Chloroaniline	—	—	1
Chlorobenzene	—	—	1
Chlorodibromomethane	—	—	1
Chloroethane	—	—	1
Chloroform	—	—	1
Chloromethane	—	—	1
2-Chloronaphthalene	—	—	1
o-Chlorophenol	—	—	1
4-Chlorophenylphenyl Ether	—	—	1
o-Chlorotoluene	—	—	1
p-Chlorotoluene	—	—	1
Chrysene	—	—	1
Di-*n*-butyl Phthalate	—	—	1
Di-*n*-octyl Phthalate	—	—	1

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Bulk Materials (Cont)			
Dibenzo[*a,h*]anthracene	—	—	1
Dibenzofuran	—	—	1
1,2-Dibromo-3-chloropropane	—	—	1
1,2-Dibromoethane	—	—	1
Dibromomethane	—	—	1
o-Dichlorobenzene (1,2)	—	—	2
m-Dichlorobenzene (1,3)	—	—	2
p-Dichlorobenzene (1,4)	—	—	2
3,3'-Dichlorobenzidine	—	—	1
1,1-Dichloroethane	—	—	1
1,2-Dichloroethane	—	—	1
1,1-Dichloroethene	—	—	1
trans-1,2-Dichloroethene	—	—	1
cis-1,2-Dichloroethylene	—	—	1
2,4-Dichlorophenol	—	—	1
1,2-Dichloropropane	—	—	1
1,3-Dichloropropane	—	—	1
2,2-Dichloropropane	—	—	1
1,1-Dichloropropene	—	—	1
cis-1,3-Dichloropropene	—	—	1
trans-1,3-Dichloropropene	—	—	1
Diethyl Phthalate	—	—	1
Dimethyl Phthalate	—	—	1
2,4-Dimethylphenol	—	—	1
2,4-Dinitrophenol	—	—	1
2,4-Dinitrotoluene	—	—	1
2,6-Dinitrotoluene	—	—	1
Ethylbenzene	—	—	1
Fluoranthene	—	—	1
Fluorene	—	—	1
Hexachlorobenzene	—	—	1
Hexachlorobutadiene	—	—	2
Hexachlorocyclopentadiene	—	—	1
Hexachloroethane	—	—	1
2-Hexanone	—	—	1
Indeno[1,2,3-*cd*]pyrene	—	—	1
Isophorone	—	—	1
Isopropylbenzene	—	—	1
4-Isopropyltoluene	—	—	1
4-Methy1-2-pentanone	—	—	1
2-Methy1-4,6-Dinitrophenol	—	—	1
Methylene Chloride	1	—	1
2-Methylnaphthalene	—	—	1
2-Methylphenol	—	—	1

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Bulk Materials (Cont)			
4-Methylphenol	—	—	1
Naphthalene	—	—	2
2-Nitroaniline	—	—	1
3-Nitroaniline	—	—	1
4-Nitroaniline	—	—	1
Nitrobenzene	—	—	1
2-Nitrophenol	—	—	1
4-Nitrophenol	—	—	1
N-Nitrosodi-*n*-propylamine	—	—	1
N-Nitrosodimethylamine	—	—	1
N-Nitrosodiphenylamine	—	—	1
Pentachlorophenol	—	—	1
Phenanthrene	—	—	1
Phenol	—	—	1
Propylbenzene	—	—	1
Pyrene	—	—	1
Styrene	—	—	1
1,1,1,2-Tetrachloroethane	—	—	1
1,1,2,2-Tetrachloroethane	—	—	1
Tetrachloroethylene	—	—	1
Toluene	—	—	1
1,2,3-Trichlorobenzene	—	—	1
1,2,4-Trichlorobenzene	—	—	2
1,1,1-Trichloroethane	1	—	1
1,1,2-Trichloroethane	—	1	1
Trichloroethene	—	—	1
Trichlorofluoromethane	—	—	1
2,4,5-Trichlorophenol	—	—	1
2,4,6-Trichlorophenol	—	—	1
1,2,3-Trichloropropane	—	—	1
1,2,4-Trimethylbenzene	1	—	1
1,3,5-Trimethylbenzene	—	—	1
Vinyl Acetate	—	—	1
Vinyl Chloride	—	—	1
o-Xylene	1	—	1
Mixed-xylenes (*o* + *m* + *p*)	1	—	1
Soils			
Acenaphthene	—	—	34
Acenaphthylene	—	—	34
Acetone	20	—	62
Acrolein	—	—	50
Acrylonitrile	—	—	50
Aldrin	—	—	8

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Soils (Cont)			
Aniline	—	2	34
Anthracene	—	—	34
Mixed-aroclor	—	—	46
Aroclor 1242	—	—	46
Aroclor 1254	—	—	46
Aroclor 1260	—	—	46
Azobenzene	—	—	34
Alpha-BHC	—	—	8
Beta-BHC	—	—	8
Delta-BHC	—	—	8
Benzene	—	2	57
m-Benzidine	—	—	34
Benzo[*a*]anthracene	—	—	34
Benzo[*a*]pyrene	—	—	34
Benzo[*b*]fluoranthene	—	—	34
Benzo[*g,h,i*]perylene	—	—	34
Benzo[*k*]fluoranthene	—	—	34
Benzoic Acid	3	—	34
Benzyl Alcohol	—	—	34
Bis(2-chloroethoxy)methane	—	—	34
Bis(2-chloroethyl)ether	—	—	34
Bis(2-chloroisopropyl)ether	—	—	34
Bis(2-ethylhexyl)phthalate	2	—	34
Bromobenzene	—	—	63
Bromochloromethane	—	1	62
Bromodichloromethane	—	—	63
Bromoform	—	1	63
Bromomethane	—	—	62
4-Bromophenylphenyl Ether	—	—	34
2-Butanone	8	2	63
n-Butylbenzene	—	—	63
sec-Butylbenzene	—	—	63
tert-Butylbenzene	—	—	63
Butylbenzyl Phthalate	—	—	34
Carbon Disulfide	1	1	62
Carbon Tetrachloride	—	6	63
Chlordane	—	—	8
4-Chloro-3-methylphenol	—	—	34
4-Chloroaniline	—	—	34
Chlorobenzene	—	—	57
Chlorodibromomethane	—	1	63
Chloroethane	—	—	62
2-Chloroethylvinyl Ether	—	—	50
Chloroform	—	—	62

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Soils (Cont)			
Chloromethane	—	—	62
2-Chloronaphthalene	—	—	34
o-Chlorophenol	—	—	34
4-Chlorophenylphenyl Ether	—	—	34
o-Chlorotoluene	—	—	63
p-Chlorotoluene	—	1	63
Chrysene	—	—	34
2,4-D	—	—	10
p,p'-DDD	—	—	8
p,p'-DDE	—	—	8
p,p'-DDT	—	—	8
Di-*n*-butyl Phthalate	1	—	34
Di-*n*-octyl Phthalate	—	—	34
Dibenzo[*a,h*]anthracene	—	—	34
Dibenzofuran	—	—	34
1,2-Dibromo-3-chloropropane	—	—	63
1,2-Dibromoethane	—	—	63
Dibromomethane	—	—	63
o-Dichlorobenzene (1,2)	—	—	97
m-Dichlorobenzene (1,3)	—	—	97
p-Dichlorobenzene (1,4)	—	1	97
3,3'-Dichlorobenzidine	—	—	34
Dichlorodifluoromethane	—	—	50
1,1-Dichloroethane	—	5	62
1,2-Dichloroethane	1	3	62
1,1-Dichloroethene	—	—	57
trans-1,2-Dichloroethene	—	—	62
cis-1,2-Dichloroethylene	—	—	62
2,4-Dichlorophenol	—	—	34
1,2-Dichloropropane	—	1	63
1,3-Dichloropropane	—	1	63
2,2-Dichloropropane	—	—	63
1,1-Dichloropropene	1	—	62
cis-1,3-dichloropropene	—	—	57
trans-1,3-dichloropropene	—	—	57
Dieldrin	—	—	8
Diethyl Phthalate	—	—	34
Dimethyl Phthalate	—	—	34
2,4-Dimethylphenol	—	—	34
2,4-Dinitrophenol	—	—	34
2,4-Dinitrotoluene	—	—	36
2,6-Dinitrotoluene	—	—	36
Endosulfan I	—	—	3
Endosulfan II	—	—	3

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Soils (Cont)			
Endosulfan Sulfate	—	—	8
Endrin	—	—	8
Endrin Aldehyde	—	—	8
Ethylbenzene	—	2	57
Fluoranthene	—	—	34
Fluorene	—	—	34
HMX	—	—	2
Heptachlor	—	—	8
Heptachlor Epoxide	—	—	8
Hexachlorobenzene	—	—	34
Hexachlorobutadiene	—	1	97
Hexachlorocyclopentadiene	—	1	34
Hexachloroethane	—	1	34
2-Hexanone	8	1	63
Indeno[1,2,3-*cd*]pyrene	—	—	34
Isophorone	—	1	34
Isopropylbenzene	—	—	63
4-Isopropyltoluene	5	—	63
Lindane	—	—	8
Methoxychlor	—	—	7
Methyl Iodide	—	—	50
4-Methy1-2-pentanone	—	2	63
2-Methy1-4,6-dinitrophenol	—	—	34
Methylene Chloride	6	—	62
2-Methylnaphthalene	—	—	34
2-Methylphenol	—	—	34
4-Methylphenol	—	—	34
Naphthalene	2	—	97
2-Nitroaniline	—	—	34
3-Nitroaniline	—	—	34
4-Nitroaniline	—	—	34
Nitrobenzene	—	—	34
2-Nitrophenol	—	—	34
4-Nitrophenol	—	—	34
N-Nitrosodi-*n*-propylamine	—	—	34
N-Nitrosodimethylamine	—	—	34
N-Nitrosodiphenylamine	—	—	34
Pentachlorophenol	—	—	34
Petroleum Hydrocarbons, Total Recoverable	—	—	1
Phenanthrene	—	—	34
Phenol	1	—	34
Propylbenzene	—	—	63
Pyrene	—	—	34

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Soils (Cont)			
RDX	—	—	2
Styrene	—	—	57
2,4,5-TP	—	—	10
1,1,1,2-Tetrachloroethane	—	—	63
1,1,2,2-Tetrachloroethane	—	3	63
Tetrachloroethylene	—	3	63
Tetryl(methy1-2,4,6-Trinitrophenylnitramine)	—	—	2
Toluene	1	3	57
Toxaphene	—	—	8
1,1,2-Trichloro-1,2,2-Trifluoroethane	—	—	50
1,2,3-Trichlorobenzene	1	—	63
1,2,4-Trichlorobenzene	—	—	97
1,1,1-Trichloroethane	2	1	63
1,1,2-Trichloroethane	2	1	63
Trichloroethene	—	3	57
Trichlorofluoromethane	—	—	62
2,4,5-Trichlorophenol	—	—	34
2,4,6-Trichlorophenol	—	—	34
1,2,3-Trichloropropane	—	—	63
1,2,4-Trimethylbenzene	1	—	63
1,3,5-Trimethylbenzene	—	—	63
2,4,6-Trinitrotoluene	—	—	2
Vinyl Acetate	—	—	62
Vinyl Chloride	—	—	62
o-Xylene	—	—	12
Mixed-xylenes (*o* + *m* + *p*)	1	1	63
Charcoal Tubes			
Benzene	1	—	70
Bromobenzene	—	—	51
Carbon Tetrachloride	3	2	70
Chlorobenzene	1	—	70
Chloroform	—	1	70
Ethylbenzene	3	4	70
Tetrachloroethylene	1	1	70
Toluene	—	2	70
1,1,1-Trichloroethane	1	1	70
Trichloroethene	—	1	70
1,2,4-Trimethylbenzene	—	1	70
m-Xylene	1	—	5
o-Xylene	1	13	70
Mixed-xylenes (*o* + *m* + *p*)	25	3	65

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Waters			
Acenaphthene	—	—	33
Acenaphthylene	—	—	27
Acetone	12	—	63
Acrolein	—	—	44
Acrylonitrile	—	—	44
Aldrin	—	—	10
Aniline	—	—	27
Anthracene	1	—	27
mixed-Aroclor	—	—	38
Aroclor 1242	—	—	37
Aroclor 1254	—	—	37
Aroclor 1260	—	—	37
Azobenzene	—	—	27
Alpha-BHC	—	—	10
Beta-BHC	—	—	10
Delta-BHC	—	—	10
Benzene	—	—	63
m-Benzidine	—	—	27
Benzo[*a*]anthracene	—	1	27
Benzo[*a*]pyrene	—	—	27
Benzo[*b*]fluoranthene	—	—	27
Benzo[*g,h,i*]perylene	—	—	27
Benzo[*k*]fluoranthene	—	—	27
Benzoic Acid	—	1	27
Benzyl Alcohol	—	—	27
Bis(2-chloroethoxy)methane	—	—	27
Bis(2-chloroethyl)ether	—	—	27
Bis(2-chloroisopropyl)ether	—	—	27
Bis(2-ethylhexyl)phthalate	4	1	27
Bromobenzene	—	—	63
Bromochloromethane	—	—	63
Bromodichloromethane	—	—	63
Bromoform	—	—	63
Bromomethane	—	—	63
4-Bromophenylphenyl Ether	—	—	27
2-Butanone	7	1	63
n-Butylbenzene	—	1	63
sec-Butylbenzene	—	—	63
tert-Butylbenzene	—	—	63
Butylbenzyl Phthalate	—	1	27
Carbon Disulfide	3	—	63
Carbon Tetrachloride	—	—	63
Chlordane	—	—	10

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Waters (Cont)			
4-Chloro-3-methylphenol	—	—	33
4-Chloroaniline	—	—	27
Chlorobenzene	—	—	63
Chlorodibromomethane	—	—	63
Chloroethane	—	—	63
2-Chloroethylvinyl Ether	—	—	44
Chloroform	—	—	63
Chloromethane	—	—	63
2-Chloronaphthalene	—	—	28
o-Chlorophenol	—	—	33
4-Chlorophenylphenyl Ether	—	—	27
o-Chlorotoluene	—	—	63
p-Chlorotoluene	—	—	63
Chrysene	1	—	27
2,4-D	—	—	6
p,p'-DDD	—	—	10
p,p'-DDE	—	—	10
p,p'-DDT	—	—	10
Di-*n*-butyl Phthalate	—	—	27
Di-*n*-octyl Phthalate	1	—	27
Dibenzo[*a,h*]anthracene	—	—	27
Dibenzofuran	—	—	27
1,2-Dibromo-3-chloropropane	1	—	63
1,2-Dibromoethane	—	—	63
Dibromomethane	—	—	63
o-Dichlorobenzene (1,2)	—	—	91
m-Dichlorobenzene (1,3)	—	—	91
p-Dichlorobenzene (1,4)	—	1	97
3,3'-Dichlorobenzidine	—	—	27
Dichlorodifluoromethane	—	—	44
1,1-Dichloroethane	—	—	63
1,2-Dichloroethane	1	—	63
1,1-Dichloroethene	1	—	63
trans-1,2-Dichloroethene	—	—	63
cis-1,2-Dichloroethylene	—	—	63
2,4-Dichlorophenol	—	—	27
1,2-Dichloropropane	—	—	63
1,3-Dichloropropane	—	—	63
2,2-Dichloropropane	—	—	63
1,1-Dichloropropene	—	—	63
cis-1,3-Dichloropropene	—	—	63
trans-1,3-Dichloropropene	—	—	63

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Waters (Cont)			
Dieldrin	—	—	10
Diethyl Phthalate	1	1	27
Dimethyl Phthalate	—	3	27
2,4-Dimethylphenol	—	—	27
2,4-Dinitrophenol	—	—	27
2,4-Dinitrotoluene	—	—	33
2,6-Dinitrotoluene	—	—	27
Endosulfan I	—	—	10
Endosulfan II	—	—	10
Endosulfan Sulfate	—	—	10
Endrin	—	—	10
Endrin Aldehyde	—	—	10
Ethylbenzene	—	—	63
Fluoranthene	—	—	27
Fluorene	—	—	27
Heptachlor	—	—	10
Heptachlor Epoxide	—	—	10
Hexachlorobenzene	—	—	28
Hexachlorobutadiene	—	1	86
Hexachlorocyclopentadiene	—	1	28
Hexachloroethane	—	1	28
2-Hexanone	8	1	63
Indeno[1,2,3-*cd*]pyrene	1	—	27
Isophorone	—	—	27
Isopropylbenzene	—	—	63
4-Isopropyltoluene	—	—	63
Lindane	—	—	10
Methoxychlor	—	—	9
Methyl Iodide	—	—	44
4-Methy1-2-pentanone	1	—	63
2-Methy1-4,6-dinitrophenol	—	—	27
Methylene Chloride	3	—	63
2-Methylnaphthalene	—	—	27
2-Methylphenol	—	—	27
4-Methylphenol	—	—	27
Naphthalene	3	—	85
2-Nitroaniline	—	—	27
3-Nitroaniline	—	—	27
4-Nitroaniline	—	—	27
Nitrobenzene	—	—	27
2-Nitrophenol	—	—	27
4-Nitrophenol	2	—	33
N-Nitrosodi-*n*-propylamine	—	—	33

Table 25 (Cont)

Matrix Positive	False Negative	False Negative	Total Quality Control
ORGANIC ANALYSES			
Waters (Cont)			
N-Nitrosodimethylamine	—	—	27
N-Nitrosodiphenylamine	—	—	27
Pentachlorophenol	—	—	33
Phenanthrene	—	1	27
Phenol	2	—	33
Propylbenzene	—	1	63
Pyrene	—	—	33
Styrene	—	—	63
2,4,5-TP	—	—	6
1,1,1,2-Tetrachloroethane	—	—	63
1,1,2,2-Tetrachloroethane	—	1	63
Tetrachloroethylene	—	—	63
Toluene	1	—	63
Toxaphene	—	—	12
1,1,2-Trichloro-1,2,2-Trifluoroethane	—	—	44
1,2,3-Trichlorobenzene	3	—	58
1,2,4-Trichlorobenzene	—	—	92
1,1,1-Trichloroethane	—	—	63
1,1,2-Trichloroethane	1	—	63
Trichloroethene	—	—	63
Trichlorofluoromethane	1	—	63
2,4,5-Trichlorophenol	—	1	27
2,4,6-Trichlorophenol	—	—	27
1,2,3-Trichloropropane	1	—	63
1,2,4-Trimethylbenzene	1	1	63
1,3,5-Trimethylbenzene	—	—	63
Vinyl Acetate	—	—	63
Vinyl Chloride	—	—	63
o-Xylene	—	—	10
Mixed-xylenes (*o* + *m* + *p*)	—	1	63

Table C-26. 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}	$\mu Ci/m^3$
^{238}Pu	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	$\mu Ci/m^3$
$^{239,240}Pu$	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	$\mu Ci/m^3$
^{241}Am	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	$\mu Ci/m^3$
Gross alpha	6.5×10^3 m^3	100 min	4×10^{-16}	$\mu Ci/m^3$
Gross beta	6.5×10^3 m^3	100 min	4×10^{-16}	$\mu Ci/m^3$
Uranium (delayed neutron)	2.0×10^4 m^3	60 s	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 s	4×10^{-8}	µCi/mL
^{238}Pu	0.5 L	8×10^4 s	9×10^{-12}	µCi/mL
$^{239,240}Pu$	0.5 L	8×10^4 s	3×10^{-11}	µCi/mL
^{241}Am	0.5 L	8×10^4 s	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 s	1	µg/L
Soil Sample				
Tritium	1 kg	50 min	0.003	pCi/g
^{137}Cs	100 g	5×10^4 s	0.1	pCi/g
^{238}Pu	10 g	8×10^4 s	0.002	pCi/g
$^{239,240}Pu$	10 g	8×10^4 s	0.002	pCi/g
^{241}Am	10 g	8×10^4 s	0.002	pCi/g
Gross alpha	2 g	100 min	1.4	pCi/g
Gross beta	2 g	100 min	1.3	pCi/g
Uranium (delayed neutron)	2 g	20 s	0.03	µg/g

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C3. Environmental Protection Agency, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846," Third Edition (1989).

C4. M. A Gautier, E. S. Gladney, N. Koski, E. A. Jones, M. B. Phillips, and B. T. O'Malley, "Quality Assurance for Health and Environmental Chemistry: 1989," Los Alamos National Laboratory report LA-11995-MS, Dec. 1990.

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 photon-emitting radionuclides and direct and scattered penetrating radiation). Estimates are made of the following exposures:

- Maximum organ doses and effective dose equivalent to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs. It assumes the individual is outdoors at the Laboratory boundary continuously (24 hours/day, 365 days/year).
- Maximum individual organ doses and effective dose equivalent to an individual at or outside the Laboratory boundary where the highest dose rate occurs and a person actually is present. It takes into account occupancy (the fraction of time that a person actually occupies that location), shielding by buildings, and self-shielding.
- Average organ doses and effective dose equivalents to nearby residents.
- Collective effective dose equivalent 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 factors are taken from the Department of Energy (DOE)[D3] and are based on factors in Publication 30 of the International Commission on Radiological Protection (ICRP).[D4]

Dose conversion factors for inhalation assume a 1-μm-activity median aerodynamic diameter, as well as the lung solubility category that will maximize the effective dose equivalent (for comparison with DOE's 100-mrem/yr public dose limit [PDL]) if more than one category is given. Similarly, the ingestion dose conversion factors are chosen to maximize the effective dose if more than one gastrointestinal tract uptake is given (for comparison with DOE's 100-mrem/yr PDL for all pathways).

These dose conversion factors extrapolate the 50-year dose commitment for internal exposure. The 50-year dose commitment is the total dose received by an organ during the 50-year period following the intake of a radionuclide that is attributable to that intake.

External doses are calculated using the dose-rate conversion factors published by DOE.[D5] These factors, which are given in Table D-2[D6], give the photon dose rate in millirem per year per unit radionuclide air concentration in microcuries per milliliter. The factors are used in the calculation of the population effective dose equivalent from external radiation for the 80 km (50 mi) area.

B. Inhalation Dose

Annual average air concentrations of ^{3}H, total uranium, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am, determined by the Laboratory's air monitoring network, are corrected for background by subtracting the average concentrations measured at regional stations. These net concentrations are then multiplied by a standard breathing rate of 8 400 m^3/yr[D7] to determine total annual intake via inhalation, in microcuries per year, for each radionuclide. Each intake is multiplied by appropriate factors to convert radionuclide intake into 50-year dose

Table D-1. Dose Conversion Factors for Calculating Internal Doses (rem/μCi Intake)

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}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}
^{234}U		1.1×10^{3}					1.3×10^{2}
^{235}U		1.0×10^{3}					1.2×10^{2}
^{238}U		1.0×10^{3}					1.2×10^{2}
^{238}Pu			8.1×10^{3}	6.7×10^{2}	1.8×10^{3}	1.0×10^{2}	4.6×10^{2}
$^{239,240}Pu$			9.3×10^{3}	7.4×10^{2}	2.0×10^{3}	1.2×10^{2}	5.1×10^{2}
^{241}Am			9.3×10^{3}	7.4×10^{2}	2.0×10^{3}	1.2×10^{2}	5.2×10^{2}

Ingestion

Radionuclide	Bone Surface	Red Marrow	Liver	Gonads	Kidney	Lungs	Breast	Thyroid
^{3}H	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}
^{7}Be		4.4×10^{-5}		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^{-2}	4.4×10^{-2}	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	67	5.6	15	8.5×10^{-1}				
$^{239,240}Pu$	78	5.9	16	9.6×10^{-1}				
^{241}Am	81	6.3	17	1.0				

Table D-1 (Cont)

Radionuclide	Target Organ: Soft Tissue	Lower Large Intestine Wall	Small Intestine Wall	Upper Large Intestine Wall	Remainder	Effective Dose
^{3}H	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}
^{7}Be		4.4×10^{-4}	2.0×10^{-4}	2.7×10^{-4}		1.1×10^{-4}
^{90}Sr						1.3×10^{-1}
^{137}Cs		5.2×10^{-2}	5.2×10^{-2}	5.2×10^{-2}	5.6×10^{-2}	5.0×10^{-2}
^{234}U						2.6×10^{-1}
^{235}U		2.0×10^{-1}				2.5×10^{-1}
^{238}U						2.3×10^{-1}
^{238}Pu						3.8
$^{239,240}Pu$						4.3
^{241}Am						4.5

Table D-2. Dose Conversion Factors for Calculating External Doses ([mrem/yr]/[μCi/m³])

Radionuclide[a]	Breast	Lung	Red Marrow	Bone Surface	Testes	Thyroid	Ovaries	Effective Dose
^{10}C								
^{11}C	5 540	4 450	4 560	5 210	5 980	5 530	3 980	5 110
^{13}N	5 540	4 450	4 560	5 210	5 980	5 530	3 980	5 110
^{16}N	31 500	25 300	27 400	26 900	33 800	30 600	22 200	29 300
^{14}O								
^{15}O	5 550	4 460	4 560	5 210	5 980	5 540	3 990	5 120
^{41}Ar	6 950	5 890	5 940	6 290	7 740	7 340	5 290	6 630

[a]Dose conversion factors for ^{11}C, ^{13}N, ^{16}N, ^{15}O, and ^{41}Ar were taken from Ref. D5. Dose conversion factors for ^{10}C and ^{14}O were not given in Ref. D5 and were calculated with the computer program DOSFACTER II[D6].

commitments. Following ICRP methods, doses are calculated for all organs that contribute more than 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 ^{3}H is increased by 50% to account for absorption through the skin.

This procedure for dose calculation conservatively assumes that a hypothetical individual is exposed to the measured air concentration continuously throughout the entire year (8 760 hours). 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 foodstuffs 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 uranium, ^{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 uranium in honey; and ^{90}Sr, ^{137}Cs, total uranium, ^{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-minute, 10-minute, 71-second, and 122-second half-lives, respectively. Neutron reactions with air at the Omega West Reactor (TA-2) and LAMPF also form ^{41}Ar, which has a 1.8-hour half-life.

The radioisotopes ^{11}C, ^{13}N, ^{14}O, and ^{15}O are sources of photon radiation because of the formation of two 0.511-MeV (million-electron-volt) 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, which are 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 would be received by an individual who spent 100% of his or her time during an entire year at the monitoring location.

The individual dose is estimated from these measurements by taking into account occupancy and shielding. At off-site locations where residences are present, an occupancy factor of 1.0 was used.

Two types of shielding are considered: (1) shielding by buildings, and (2) self-shielding. Each shielding type is estimated to reduce the external radiation dose by 30%.[D8]

Neutron doses from the critical assemblies at TA-18 were based on field measurements. Neutron fields were monitored, principally with TLDs placed in cadmium-hooded, 23 cm (9 in.) polyethylene spheres. No above-background neutron doses were detected at TA-18 during 1990 because operations of the critical assemblies were curtailed.

At on-site 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 given in the text.

E. Estimate of Maximum Individual Dose using AIRDOS-EPA/RADRISK

As required by the Environmental Protection Agency (EPA), compliance with regulation 40 CFR 61, Subpart H must be demonstrated with the computer codes PREPAR2, AIRDOS2, DARTAB2, and RADRISK, CAP-88 Version.[D8] These codes use measured radionuclide release rates and meteorological information to calculate transport and airborne concentrations of radionuclides released to the atmosphere. The programs estimate radiation exposures from inhalation of radioactive materials, external exposure to the radionuclides present in the atmosphere and deposited on the ground, and ingestion of radionuclides in produce, meat, and dairy products.

Calculations for Laboratory airborne releases use the radionuclide emissions given in Tables G-2 and G-7. Wind speed, wind direction, and stability class are continually measured at meteorology towers located at TA-54, TA-49, TA-59, East Gate, and TA-55. Emissions were modeled with the wind information most representative of the release point.

Chemical form was taken into account for tritium releases. The two principal chemical forms at the Laboratory are tritium oxide (HTO or T_2O) and gaseous tritium (HT or T_2). Tritium oxide is readily absorbed by the body and distributed in soft tissue, resulting in a whole-body exposure. In contrast, gaseous tritium exposure is mainly limited to lung tissue. Dose conversion factors for exposure to tritium oxide are much higher than the factors for exposure to gaseous tritium. Gaseous tritium is a major part of the tritium releases at the Laboratory. The 1990 releases at TA-41 were more than 90% gaseous tritium; releases at TA-33 were 40% gaseous tritium. Other tritium releases are assumed to have been tritium oxide.

Doses were calculated assuming that individuals were at the exposure location for 365 days, 24 hours/day. To account for shielding by buildings, doses from external penetrating radiation were reduced by 30%, as recommended by the National Council on Radiation Protection and Measurements (NCRP)[D9] for photon radiation with energies equivalent to those found in terrestrial penetrating radiation.

F. Population Dose

The collective effective dose equivalent from 1990 Laboratory operations was evaluated for the area within 80 km of the Laboratory. Over 99% of this dose is expected to have resulted from airborne radioactive emissions from Laboratory programs. As a result, the collective dose was estimated by modeling 1990 radioactive emissions, their transport off-site, and the resulting radiation exposures that could occur.

The 1990 collective effective dose equivalent (in person-rem) was calculated with the CAP-88 collection of computer codes PREPAR2, AIRDOS2, and DARTAB2. These codes were also used to calculate the maximum effective dose equivalent to a member of the public as required by the Environmental Protection Agency regulations 40 CFR Part 61[D8], and as discussed in Section E of this Appendix.

The radionuclide release rates used in calculating the collective dose are identical to those described in Section E. The calculation used the EPA's CAP-88-generated agricultural profile of the 80 km area. The same exposure pathways that were evaluated for the maximum individual dose were also evaluated for the collective dose. These pathways include inhalation of radioactive materials, absorption of external radiation from materials present in the atmosphere and deposited on the ground, and ingestion of radionuclides in meat, produce, and dairy products.

The calculations used in the 1990 population distribution given in Table II-1 of the main text, incorporate the results of the 1990 census.[D10] The population dose was calculated for the population residing within 80 km of the Laboratory.

CAP-88 uses dose conversion factors generated by the computer program RADRISK. The 50-year dose commitment conversion factors from RADRISK were compared with the ICRP/DOE dose conversion factors and found to agree within 5%. This agreement was judged more than adequate to justify using the RADRISK dose factors.

G. Estimation of Risk from Ionizing Radiation

To compare the risk from the radiation dose from Laboratory operations with risks that are routinely experienced in everyday life, the risks of cancer mortality from exposure to ionizing radiation are estimated for exposures to natural background radiation, to medical procedures, and to Laboratory operations in 1990. These risk estimates are based on two reports recently published by the National Research Council's Committee on the Biological Effects of Ionizing Radiation, or BEIR Committee.

These calculations are for comparison purposes only. The low doses and dose rates from natural background radiation and from Laboratory operations are considerably below the range of data on which the BEIR Committee based its observations. The committee itself did not calculate risks below a single 10-rem exposure or a continuous lifetime exposure of 0.1 rem/year, stating that these risks are difficult to quantify and "that the lower limit of the range of uncertainty in the risk estimates extends to zero."[D11]

1. Risks from Whole-Body Radiation. Radiation exposures considered in this report are of two types: (1) whole-body exposures, and (2) individual organ exposures. The primary doses from nonradon natural background radiation and from Laboratory operations are whole-body exposures. With the exception of natural background radon exposures, discussed below, radiation doses and associated risks from those radionuclides that affect only selected body organs are a small fraction of the dose and are negligible. Risks from whole-body radiation were estimated using the factors of the BEIR V report.[D11]

Risk factors are taken from the BEIR Committee's estimate (BEIR V report) of the risk from a single, instantaneous, high-dose rate exposure of 10 rem. The BEIR V report states that this estimate should be reduced for an exposure distributed over time that would occur at a substantially lower dose rate. The committee discussed dose rate effectiveness factors (DREFs) ranging from 2 to 10 that should be applied to the nonleukemia part of the risk estimate.

For the risk estimates presented in this report, a DREF of 2 is used for the nonleukemia risk. Following the BEIR V report, no dose rate reduction was made for the leukemia risk. The risk is then averaged over male and female populations. The total risk estimator is 440 cancer fatalities per 10^9 person-mrem.

2. Risks from Exposure to Radon. Radon and radon decay product exposures are an important part of natural background radiation. These exposures differ from the whole-body radiation discussed above in that they principally involve only the localized exposure of the lung and not other organs in any significant way. Consequently, the risks from radon exposure were calculated separately.

Radon (principally ^{222}Rn) and radon decay product exposure rates are usually measured with a special unit, the working level (WL); 1 WL corresponds to a liter of air containing short-lived radon decay products whose

total potential alpha energy is 1.3×10^5 MeV. An atmosphere having 100-pCi/L concentration of ^{222}Rn at equilibrium with its decay products corresponds to 1 WL. Cumulative exposure is measured in working-level months (WLMs). A WLM is equal to exposure to 1 WL for 170 hours.

The estimated national average radon effective dose that was given by the NCRP is 200 mrem/yr. The NCRP derived this dose from an estimated national average radon exposure of 0.2 WLM/yr. Because the risk factors are derived in terms of WLM, for the purposes of risk calculation it is more convenient to use the radon exposure of 0.2 WLM/yr than to use the radon dose of 200 mrem/yr. Both the 0.2-WLM/yr and the 200-mrem/yr effective dose, however, correspond to the same radiation exposure.

Risks from radon were estimated using a risk factor of 350×10^{-6}/WLM. This risk factor was taken from the BEIR IV report.[D12]

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APPENDIX E

UNITS OF MEASUREMENT

Throughout this report the International System of Units (SI) or metric system of measurements has been used, with some exceptions. For units of radiation activity, exposure, and dose, U.S. Customary Units (that is, 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
atto	0.000000000000000001 or 10^{-18}	a

Table E-2. Approximate Conversion Factors for Selected SI (Metric) Units

Multiply SI (Metric) Unit	By	To Obtain U.S. 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 technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Sec. II, Fig. 4. The main programs conducted at each of the areas are listed in this Appendix.

TA-2, Omega Site: Omega West Reactor, an 8-MW nuclear research reactor, is located here. It serves as a research tool by providing a source of neutrons for fundamental studies in nuclear physics and associated fields.

TA-3, Core Area: In this main technical area of the Laboratory is the Administration Building that contains the Director's office and administrative offices and laboratories for several divisions. Other buildings house the central computing facility, materials division, science museum, chemistry and materials science laboratories, physics laboratories, technical shops, cryogenics laboratories, a Van de Graaff accelerator, the main cafeteria, and the Study Center.

TA-5, Beta Site: This site contains some physical support functions, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, Two-Mile Mesa Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-8, GT Site (or Anchor Site West): This is a dynamic testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (x ray machines to 1 000 000 V and a 24-MeV betatron), radioactive-isotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East: At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site: Facilities are located here for testing explosive components and systems under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing non-hazardous materials, may be tested.

TA-14, Q Site: This dynamic testing 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 weapons functioning and systems behavior in non-nuclear tests, principally by electronic recording means.

TA-16, S Site: Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons warhead systems. Development and testing of high explosives, plastics, and adhesives, and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18, Pajarito Laboratory Site: The fundamental behavior of nuclear chain reactions with simple, low-power reactors called critical assemblies is studied here. Experiments are operated by remote control and observed by closed-circuit television. The machines are housed in buildings known as kivas and are used primarily to provide a controlled means of assembling a

critical amount of fissionable materials. This is done to study the effects of various shapes, sizes, and configurations. These machines are also used as a 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 research site. Currently, several structures are undergoing decontamination and decommissioning. The future use of TA-21 is being studied.

TA-22, TD Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-28, Magazine Area A: This is an explosives storage area.

TA-33, HP Site: An old high-pressure tritium handling facility located here is being phased out. The National Radio Astronomy Observatory's Very Large Baseline Array Telescope is located at this site.

TA-35, Ten Site: Nuclear safeguards research and development, which are conducted here, are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research in reactor safety and laser fusion is also done here.

TA-36, Kappa Site: Various explosive phenomena, such as detonation velocity, are investigated at this dynamic testing site.

TA-37, Magazine Area C: This is an explosives storage site.

TA-39, Ancho Canyon Site: Non-nuclear weapons behavior is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, and explosions involving other materials.

TA-40, DF Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-41, W Site: Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrications and evaluation of test materials for weapons.

TA-43, Health Research Laboratory: Research performed at this site includes 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: Applied photochemistry which includes development of technology for laser isotope separation and laser enhancement of chemical processes, is investigated here. Solar energy research, particularly in the area of passive solar heating for residences, is also done at this site.

TA-48, Radiochemistry Site: Laboratory scientists and technicians at this site study nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made, and "hot cells" are used for remote handling of radioactive materials.

TA-49, Frijoles Mesa Site: This site is currently restricted to carefully selected functions because of its location near Bandelier National Monument and past use in high-explosives and radioactive materials experiments.

TA-50, Waste Management Site: Personnel at this site have responsibility for treating and disposing of most industrial liquid and radioactive liquid waste received from Laboratory technical areas, for development of improved methods of solid waste treatment, and for containment of radioactivity removed by treatment.

TA-51, Animal Exposure Facility: At this site, 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 is done at this site.

TA-53, Meson Physics Facility: The Los Alamos Meson Physics Facility, a linear particle accelerator, is used to conduct research in areas of basic physics, cancer treatment, materials studies, and isotope production. The Los Alamos Neutron Scattering Center and the Proton Storage Ring are also located at this TA.

TA-54, Waste Disposal Site: The primary function of this site is radioactive solid and hazardous chemical waste management and disposal.

TA-55, Plutonium Facility Site: Processing of plutonium and research in plutonium metallurgy are done at this site.

TA-57, Fenton Hill Site: This is the location of the Laboratory's Hot Dry Rock geothermal project. Scientists at this site 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-59, Occupational Health Site: Occupational health and environmental science activities are conducted at this site.

TA-60, Sigma Mesa: This area contains physical support and infrastructure facilities, including the Test Fabrication Facility.

TA-61, East Jemez Road: This site is used for physical support and infrastructure facilities, including the sanitary landfill.

TA-63: This area contains physical support facilities operated by Johnson Controls World Services, Inc.

TA-64: This is the site of the Central Guard Facility.

TA-66: This site is used for public and corporate interface functions.

TA-69: This undeveloped TA serves as an environmental buffer for the dynamic testing area.

TA-70: This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-71: This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-72: This is the site of the Protective Forces Training facility.

TA-73: This area is the Los Alamos Airport.

TA-74, Otowi Tract: This large area, bordering San Ildefonso Pueblo on the east, is isolated from most of the Laboratory and contains significant concentrations of archaeological sites and an endangered species breeding area.

APPENDIX G

ENVIRONMENTAL DATA TABLES

Table G-1. Estimated Maximum Individual 50-Year Dose Commitments from 1990 Airborne Radioactivity[a]

Isotope	Critical Organ	Location[b]	Estimated Dose (mrem/yr)	Percentage of Public Dose Limit
^{3}H	Whole-body	White Rock	0.009	<0.1
^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar	Whole-body	East Gate (Station 6)	3.1	31
U, ^{238}Pu, $^{239,240}Pu$, ^{241}Am	Bone surface			

[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 a person actually resides. It takes into account shielding and occupancy factors.

[b]See Fig. 9 for station locations.

Table G-2. Airborne Radioactive Emissions from Laboratory Operations in 1990[a]

Location	$^{238,239,240}Pu$ [b] (μCi)	$^{235,238}U$ [c] (μCi)	Mixed Fission Products (μCi)	^{41}Ar [d] (Ci)	^{32}P (μCi)	^{3}H (Ci)	Activation Products: Gaseous[e] (Ci)	Activation Products: Particle/Vapor[f] (Ci)	Spallation Products[g] (Ci)
TA-2				160					
TA-3	21.6	196	38.9			496			
TA-21	1.0	43.2	<0.1			439			
TA-33						854			
TA-35	0.9					<0.1			
TA-41						4 444			
TA-43					9.0				
TA-46									
TA-48	1.5	0.2	1 042						2.0
TA-50	0.2		3.9						
TA-53						2.8	123 400	0.08	
TA-54	<0.1								
TA-55	0.5					116			
Rounded total	25.8	240	1 085	160	9.0	6 400	123 400	0.08	2.0

[a]As reported on DOE form F-5821.1.

[b]Plutonium values contain indeterminate traces of ^{241}Am, a transformation product of ^{241}Pu.

[c]Does not include aerosolized uranium from explosives testing (Table G-7).

[d]Does not include 625 Ci of ^{41}Ar present in gaseous, mixed activation products.

[e]Includes the following constituents: ^{16}N, 1.3%; ^{10}C, 1.6%; ^{14}O, 0.8%; ^{15}O, 57.9%; ^{13}N, 13.3%; ^{11}C, 24.7%; ^{41}Ar, 0.4%.

[f]Includes 19 nuclides, dominated by ^{72}Br and ^{7}Be.

[g]Includes the following constituents ^{77}Br, 43%; ^{72}As, 32%; ^{75}Se, 20%; ^{73}As and ^{74}As, <0.1%.

Table G-3. Thermoluminescent Dosimeter (TLD) Measurements

Station Location[a]	Annual Measurement Coordinates		1990 Dose (mrem)
Uncontrolled Areas			
Regional Stations (28–44 km)			
1. Española	—		89 (5)[b]*
2. Pojoaque	—		110 (5)*
3. Santa Fe	—		108 (6)*
Perimeter Stations (0–4 km)			
4. Barranca School	N180	E130	117 (5)*
5. Arkansas Avenue	N170	E030	113 (6)*
6. Cumbres School	N150	E090	111 (5)
7. 48th Street	N110	W010	122 (5)*
8. Los Alamos Airport	N110	E170	113 (5)*
9. Bayo Canyon	N120	E250	138 (5)
10. Shell Station	N090	E120	180 (5)*
11. Royal Crest Trailer Court	N080	E080	121 (5)*
12. White Rock	S080	E420	146 (5)*
13. Pajarito Acres	S210	E380	120 (5)*
14. Bandelier Lookout Station	S280	E200	131 (5)*
15. Pajarito Ski Area	N150	W200	131 (5)
Controlled Areas			
On-Site Stations			
16. TA-21 (DP West)	N095	E140	139 (4)*
17. TA-6 (Two Mile Mesa)	N025	E030	127 (5)*
18. TA-53 (LAMPF)	N070	E090	178 (5)*
19. Well PM-1	N030	E305	138 (5)*
20. TA-16 (S Site)	S035	W025	124 (5)*
21. Booster P-2	S030	E220	127 (5)*
22. TA-54 (Area G)	S080	E290	153 (5)*
23. State Highway 4	N070	E350	143 (5)
24. Frijoles Mesa	S165	E085	125 (5)*
25. TA-2 (Omega Stack)	N075	E120	155 (5)
26. TA-2 (Omega Canyon)	N085	E121	155 (6)*
27. TA-18 (Pajarito Site)	S040	E205	136 (5)
28. TA-35 (Ten Site A)	N040	E105	141 (5)
29. TA-35 (Ten Site B)	N040	E110	131 (5)
30. TA-59 (Occupational Health Lab)	N050	E040	113 (4)
31. TA-3 (Van de Graaff)	N050	E020	141 (6)
32. TA-3 (Guard Station)	N050	E020	125 (5)
33. TA-3 (Alarm Building)	N050	E020	162 (5)
34. TA-3 (Guard Building)	N050	E020	119 (5)
35. TA-3 (Shop)	N050	E020	138 (5)
36. Pistol Range	N040	E240	128 (5)
37. TA-55 (Plutonium Facility South)	N040	E240	109 (5)
38. TA-55 (Plutonium Facility West)	N040	E080	142 (5)
39. TA-55 (Plutonium Facility North)	N040	E080	132 (5)

[a]See Fig. 6.

[b]Measurement (95% confidence increments).
*Change in location.

Table G-4. Locations of Air Sampling Stations[a]

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate
Regional (28–44 km)		
1. Española	36°00′	106°06′
2. Pojoaque	35°52′	106°02′
3. Santa Fe	35°40′	106°56′
Perimeter (0–4 km)		
4. Barranca School	35°54′09″	106°16′55″
5. Arkansas Avenue	35°54′06″	106°19′10″
6. East Gate	35°52′32″	106°15′19″
7. 48th Street	35°52′58″	106°19′43″
8. Los Alamos Airport	35°52655″	106°16′33″
10. Shell Station	35°52′51″	106°18′21″
11. Royal Crest Trailer Park	35°52′21″	106°18′01″
12. White Rock	35°49′22″	106°12′46″
13. Pajarito Acres	35°47′35″	106°12′31″
14. Bandelier	35°46′52″	106°15′57″
33. McDonald's	35°52′42″	106°17′57″
34. White Rock Fire Station	35°49′44″	106°12′20″
35. White Rock Church of the Nazarene	35°49′20″	106°13′18″
On Site		
15. TA-21	35°52′30″	106°16′04″
16. TA-6	35°51′	106°20′
17. TA-53 (LAMPF)	35°52′12″	106°16′00″
18. Well PM-1	35°51′36″	106°13′31″
19. TA-52	35°51′30″	106°16′35″
20. TA-16	35°50′57″	106°21′28″
21. Booster P-2	35°50′43″	106°15′51″
22. TA-54	35°49′53″	106°14′08″
23. TA-49	35°49′35″	106°19′08″
24. TA-33	35°47′02″	106°15′26″
25. TA-2	35°52′	106°16′
26. TA-16-450	35°50′46″	106°21′19″

[a]See Fig. 8 for station locations.

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

Radioactive Constituent	Units	EPA[a] 1987—1989	Laboratory[b] 1990	DOE Guide for Uncontrolled Area[c]
Gross beta	10^{-15} µCi/mL	10.0 ± 0	18.0 ± 4.2	9 000
^{3}H	10^{-12} µCi/mL	—	0.5 ± 1.3	200 000
Uranium (natural)	pg/m^3	33.0 ± 9.0	114.0 ± 117.0	100 000
^{238}Pu	10^{-18} µCi/mL	1.2 ± 0.1	0.7 ± 0.7[d]	30 000
$^{239,240}Pu$	10^{-18} µCi/mL	0.7 ± 0.1	0.9 ± 0.7[e]	30 000
^{241}Am	10^{-18} µCi/mL	—	2.9 ± 1.0[f]	30 000

[a]EPA (1987–1989), Reports 49 through 58. Data are from the Santa Fe, New Mexico, sampling location and were taken from January 1987 through May 1989. Data for 1990 not available at time of publication.

[b]Data are annual averages from the regional stations (Española, Pojoaque, Santa Fe) and were taken during calendar year 1990.

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

[d]Minimum detectable limit is 4×10^{-18} µCi/mL.

[e]Minimum detectable limit is 3×10^{-18} µCi/mL.

[f]Minimum detectable limit is 2×10^{-18} µCi/mL.

Table G-6. Summary of Selected Radionuclides Half-life Information

Nuclide	Symbol	Half-Life (years)
Tritium	^{3}H	12
Beryllium-7	^{7}Be	0.15
Phosphorus-32	^{32}P	0.04
Potassium-40	^{40}K	1 260 000 00
Argon-41	^{41}Ar	0.000 08
Cobalt-60	^{60}Co	5.2
Strontium-85	^{85}Sr	0.18
Strontium-89	^{89}Sr	0.14
Strontium-90	^{90}Sr	27.7
Iodine-131	^{131}I	0.02
Cesium-134	^{134}Cs	2.05
Cesium-137	^{137}Cs	30
Uranium-234	^{234}U	247 000
Uranium-235	^{235}U	710 000 000
Uranium-238	^{238}U	4 510 000 000
Plutonium-238	^{238}Pu	86
Plutonium-239	^{239}Pu	24 390
Plutonium-240	^{240}Pu	6580
Americium-241	^{241}Am	458

Table G-7. Estimated Concentrations of Toxic Elements Aerosolized by Dynamic Experiments

Element	1990 Total Usage (kg)	Fraction Aerosolized (%)	Annual Average Concentration ($\mu g/m^3$) (4 km)[a]	Annual Average Concentration ($\mu g/m^3$) (8 km)[a]	Applicable Standard ($\mu g/m^3$)
Uranium	87	10	8.4×10^{-6}	3.4×10^{-6}	9[b]
Beryllium	0	2	0	0	0.01[c]
Lead	2	100[d]	2.1×10^{-6}	8.5×10^{-10}	1.5[e]
Heavy metals	234	100[d]	2.5×10^{-4}	9.8×10^{-5}	10[e]

[a]Distance downwind.
[b]DOE (1981).
[c]Standard for 30-day average, New Mexico Air Quality Control Regulation 201.
[d]No data are available; estimate was done assuming worst-case percentage was aerosolized.
[e]Standard for 3-month average (40 CFR 50.12).

Table G-8. Airborne Tritiated Water Concentrations for 1990

Station Location[a]	Total Air Volume (m^3)	No. of Monthly Samples	No. of Samples <MDL[b]	Concentrations (pCi/m^3 [10^{-12} $\mu Ci/mL$]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
1. Española	126.74	11[e]	10	2.4 (0.9)	−1.2 (0.8)	0.5 (0.9)	<0.1
2. Pojoaque	142.33	12	11	7.0 (1.0)	−0.3 (0.4)	0.7 (2.0)	<0.1
3. Santa Fe	140.57	11[e]	11	0.8 (0.3)	−0.6 (0.6)	0.3 (0.5)	<0.1
Group Summary		34	32	7.0 (1.0)	−1.2 (0.8)	0.5 (1.3)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
4. Barranca School	120.42	12	5	18.1 (1.4)	0.6 (0.6)	3.7 (4.8)	<0.1
5. Arkansas Avenue	128.51	12	11	3.3 (0.8)	0.0 (0.6)	1.0 (0.9)	<0.1
6. East Gate	144.49	12	3	7.8 (1.1)	0.7 (0.2)	3.6 (2.3)	<0.1
7. 48th Street	144.93	12	9	5.9 (2.5)	0.2 (0.1)	1.6 (1.6)	<0.1
8. Los Alamos Airport	162.28	12	2	16.3 (1.8)	1.1 (0.2)	6.7 (4.9)	<0.1
*10. Shell Station	127.85	12	5	9.1 (1.3)	0.6 (0.4)	2.8 (2.3)	<0.1
11. Royal Crest Trailer Park	133.57	12	4	9.9 (1.1)	0.6 (0.1)	3.3 (2.5)	<0.1
12. White Rock	125.73	11[e]	8	12.3 (2.3)	0.0 (0.2)	2.7 (3.6)	<0.1
13. Pajarito Acres	99.17	11[e]	7	24.1 (3.2)	0.5 (0.3)	3.6 (6.9)	<0.1
14. Bandelier	103.98	12	6	8.9 (1.0)	0.4 (0.4)	3.1 (2.4)	<0.1
33. McDonald's	29.10	3[g,h]	0	4.9 (0.7)	2.9 (0.4)	3.9 (0.5)	<0.1
34. White Rock Fire Station	23.00	2[g]	1	8.2 (1.3)	0.9 (0.4)	4.6 (0.9)	<0.1
35. White Rock Nazarene	22.50	2[g]	0	14.2 (1.9)	10.4 (1.5)	12.3 (1.7)	<0.1
Group Summary		125	60	24.1 (3.2)	0.0 (0.2)	4.1 (3.2)	<0.1

Table G-8 (Cont)

Station Location[a]	Total Air Volume (m^3)	No. of Monthly Samples	No. of Samples <MDL[b]	Concentrations (pCi/m^3 [10^{-12} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
On-Site Stations, Controlled Areas							
15. TA-21	123.10	11[f]	0	26.7 (1.6)	3.8 (0.4)	12.7 (8.1)	<0.1
16. TA-6	173.02	12	10	5.7 (1.1)	−0.2 (0.7)	1.4 (1.9)	<0.1
17. TA-53 (LAMPF)	105.70	11[e,f]	3	13.1 (1.5)	0.8 (0.3)	3.9 (3.3)	<0.1
18. Well PM-1	151.75	12	6	4.5 (0.9)	0.3 (0.3)	2.2 (1.4)	<0.1
19. TA-52	99.07	11[f]	6	13.3 (1.6)	0.4 (0.3)	3.2 (3.7)	<0.1
20. TA-16	126.24	11[e]	9	2.3 (0.5)	−0.5 (0.7)	1.0 (0.9)	<0.1
21. Booster P-2	141.81	12	8	6.5 (1.3)	−0.5 (0.5)	2.1 (2.3)	<0.1
22. TA-54	124.97	11[e]	1	48.2 (4.5)	0.0 (0.0)	16.4 (14.9)	<0.1
23. TA-49	132.15	12	11	3.9 (0.9)	−0.5 (0.5)	1.1 (1.2)	<0.1
24. TA-33	135.46	11[f]	2	25.5 (2.3)	0.6 (1.2)	7.9 (7.2)	<0.1
25. TA-2 (Omega)	136.26	12	0	20.4 (2.2)	2.5 (0.5)	11.4 (4.4)	<0.1
26. TA-16-450	129.98	12	10	8.0 (1.3)	−2.0 (2.0)	1.2 (2.4)	<0.1
Group Summary		138	66	48.2 (4.5)	−2.0 (2.0)	5.3 (7.5)	<0.1

[a]See Fig. 8 for map of local stations.

[b]Minimum detectable limit = 2×10^{-12} μCi/mL.

[c]Uncertainties are in parentheses (see Appendix B).

[d]Controlled area DOE Derived Air Concentration = 2×10^{-5} μCi/mL; uncontrolled area Derived Concentration Guide = 1×10^{-7} μCi/mL.

[e]Pump failure during one sample period.

[f]Electricity off during one sample period.

[g]New stations operated only part of 1990.

[h]Vandalism of station during two sample periods.

*Station 9 is no longer in operation.

Table G-9. Airborne $^{239,240}Pu$ Concentrations for 1990

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
1. Española	71 261	4	4	1.1 (0.6)	0.0 (0.5)	0.5 (0.6)	<0.1
2. Pojoaque	75 979	4	4	1.6 (0.7)	0.0 (0.0)	0.8 (0.7)	<0.1
3. Santa Fe	70 463	4	4	2.2 (1.2)	0.8 (0.7)	1.4 (0.6)	<0.1
Group Summary		12	12	2.2 (1.2)	0.0 (0.5)	0.9 (0.7)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
4. Barranca School	74 181	4	3	2.7 (0.7)	0.5 (0.5)	1.3 (1.0)	<0.1
5. Arkansas Avenue	79 898	4	4	1.1 (0.7)	0.2 (0.3)	0.4 (0.4)	<0.1
6. East Gate	84 848	4	4	1.3 (0.6)	0.0 (0.5)	0.6 (0.6)	<0.1
7. 48th Street	83 187	4	2	13.1 (1.8)	0.0 (0.4)	6.1 (7.1)	<0.1
8. Los Alamos Airport	84 295	4	4	1.9 (0.6)	0.5 (0.6)	1.5 (0.7)	<0.1
*10. Shell Station	76 527	4	4	1.2 (0.8)	0.3 (0.4)	0.8 (0.4)	<0.1
11. Royal Crest Trailer Park	73 869	4	4	0.4 (0.5)	0.2 (0.4)	0.3 (0.1)	<0.1
12. White Rock	75 534	4	4	1.3 (0.6)	0.9 (0.5)	1.1 (0.2)	<0.1
13. Pajarito Acres	77 824	4	4	1.0 (0.7)	0.4 (0.4)	0.7 (0.3)	<0.1
14. Bandelier	80 737	4	4	0.5 (0.4)	0.0 (0.5)	0.3 (0.2)	<0.1
33. McDonald's[e]	44 054	2	2	1.9 (0.7)	0.3 (0.3)	1.1 (0.5)	<0.1
34. White Rock Fire Station[e]	19 852	1	0	0.0 (0.0)	23.0 (2.4)	23.0 (2.4)	0.1
35. White Rock Nazarene[e]	23 012	1	1	0.7 (0.5)	0.7 (0.5)	0.7 (0.5)	<0.1
Group Summary		44	40	13.0 (1.8)	0.0 (0.5)	3.2 (1.2)	<0.1
On-Site Stations, Controlled Areas							
15. TA-21	83 256	4	4	4.0 (2.0)	0.2 (0.2)	1.4 (1.7)	<0.1
16. TA-6	64 966	4	4	1.8 (1.1)	0.3 (0.4)	1.3 (0.7)	<0.1
17. TA-53 (LAMPF)	73 441	4	3	2.5 (1.2)	0.8 (0.6)	1.5 (0.7)	<0.1
18. Well PM-1	73 789	4	3	8.2 (1.7)	0.2 (0.3)	2.4 (3.9)	<0.1
19. TA-52	67 662	4	4	1.1 (0.5)	0.5 (0.5)	0.8 (0.3)	<0.1
20. TA-16	76 535	4	3	2.8 (1.2)	0.4 (0.4)	1.4 (1.2)	<0.1
21. Booster P-2	78 324	4	4	1.6 (0.6)	0.4 (0.4)	0.8 (0.6)	<0.1
22. TA-54	78 298	4	0	9.3 (1.5)	2.1 (0.7)	3.9 (3.6)	<0.1
23. TA-49	86 823	4	4	0.7 (0.5)	0.0 (0.4)	0.3 (0.3)	<0.1
24. TA-33	82 834	4	3	19.5 (2.0)	0.0 (0.5)	7.1 (9.3)	<0.1
25. TA-2 (Omega)	83 709	4	4	0.9 (0.7)	0.2 (0.3)	0.5 (0.3)	<0.1
26. TA-16-450	80 863	4	4	1.7 (0.7)	0.2 (0.4)	0.7 (0.7)	<0.1
Group Summary		48	40	19.5 (2.0)	0.0 (0.5)	1.8 (3.3)	<0.1

[a]See Fig. 8 for map of local stations.
[b]Minimum detectable limit = 3×10^{-18} μCi/mL.
[c]Uncertainties are in parentheses (see Appendix B).
[d]Controlled area DOE Derived Air Concentration = 2×10^{-12} μCi/mL; uncontrolled area Derived Concentration Guide = 2×10^{-14} μCi/mL.
[e]New stations.
*Station 9 is no longer in operation.

Table G-10. Airborne ^{238}Pu Concentrations for 1990

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
1. Española	71 261	4	4	0.9 (0.4)	0.0 (0.5)	0.3 (0.4)	<0.1
2. Pojoaque	75 979	4	3	2.1 (0.8)	0.0 (0.0)	0.8 (0.9)	<0.1
3. Santa Fe	70 463	4	4	1.9 (0.7)	0.2 (0.5)	0.9 (0.8)	<0.1
Group Summary		12	11	2.1 (0.8)	0.0 (0.5)	0.7 (0.7)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
4. Barranca School	74 181	4	3	4.2 (1.1)	0.3 (0.6)	1.6 (1.7)	<0.1
5. Arkansas Avenue	79 898	4	4	1.0 (0.6)	0.2 (0.3)	0.6 (0.3)	<0.1
6. East Gate	84 848	4	4	0.9 (0.6)	0.2 (0.2)	0.6 (0.3)	<0.1
7. 48th Street	83 187	4	4	0.3 (0.4)	0.0 (0.5)	0.1 (0.2)	<0.1
8. Los Alamos Airport	84 295	4	4	0.8 (0.7)	0.2 (0.3)	0.5 (0.3)	<0.1
*10. Shell Station	76 527	4	4	1.8 (0.9)	0.0 (0.5)	0.9 (0.8)	<0.1
11. Royal Crest Trailer Park	73 869	4	4	1.4 (0.9)	0.0 (0.6)	0.7 (0.6)	<0.1
12. White Rock	75 534	4	4	1.1 (0.4)	0.2 (0.3)	0.6 (0.4)	<0.1
13. Pajarito Acres	77 824	4	4	0.9 (0.6)	0.2 (0.3)	0.4 (0.3)	<0.1
14. Bandelier	80 737	4	4	0.5 (0.4)	0.0 (0.5)	0.3 (0.2)	<0.1
33. McDonald's[e]	44 054	2	2	0.6 (0.4)	0.3 (0.3)	0.5 (0.4)	<0.1
34. White Rock Fire Station[e]	19 852	1	1	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	<0.1
35. White Rock Nazarene[e]	23 012	1	1	0.2 (0.2)	0.2 (0.2)	0.2 (0.2)	<0.1
Group Summary		44	43	4.2 (1.1)	0.0 (0.0)	0.5 (0.5)	<0.1
On-Site Stations, Controlled Areas							
15. TA-21	83 256	4	3	2.1 (1.0)	0.0 (0.5)	0.8 (0.9)	<0.1
16. TA-6	64 966	4	4	1.8 (1.0)	0.0 (0.6)	0.8 (0.7)	<0.1
17. TA-53 (LAMPF)	73 441	4	4	1.4 (0.7)	0.2 (0.5)	0.8 (0.6)	<0.1
18. Well PM-1	73 789	4	4	3.1 (1.6)	0.2 (0.4)	1.0 (1.4)	<0.1
19. TA-52	67 662	4	4	1.9 (1.6)	0.2 (0.4)	1.0 (0.8)	<0.1
20. TA-16	76 535	4	4	0.7 (0.5)	0.2 (0.4)	0.4 (0.2)	<0.1
21. Booster P-2	78 324	4	4	0.9 (1.0)	0.0 (0.5)	0.3 (0.4)	<0.1
22. TA-54	78 298	4	4	1.2 (0.6)	0.6 (0.5)	0.9 (0.2)	<0.1
23. TA-49	86 823	4	4	0.8 (0.6)	0.2 (0.5)	0.5 (0.3)	<0.1
24. TA-33	82 834	4	4	0.4 (0.4)	0.0 (0.5)	0.2 (0.2)	<0.1
25. TA-2 (Omega)	83 709	4	4	1.1 (0.8)	0.2 (0.7)	0.8 (0.4)	<0.1
26. TA-16-450	80 863	4	4	1.1 (0.7)	0.2 (0.7)	0.6 (0.4)	<0.1
Group Summary		48	47	3.1 (1.6)	0.0 (0.5)	0.7 (0.6)	<0.1

[a]See Fig. 8 for map of local stations.
[b]Minimum detectable limit = 4×10^{-18} μCi/mL.
[c]Uncertainties are in parentheses (see Appendix B).
[d]Controlled area DOE Derived Air Concentration = 2×10^{-12} μCi/mL; uncontrolled area Derived Concentration Guide = 3×10^{-14} μCi/mL.
[e]New stations.
*Station 9 is no longer in operation.

Table G-11. Airborne ^{241}Am Concentrations for 1990

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Max[c]	Min[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Station (44 km), Uncontrolled Area							
3. Santa Fe	15 648	1	0	2.9 (1.0)	2.9 (1.0)	2.9 (1.0)	<0.1
Group Summary		1	0	2.9 (1.0)	2.9 (1.0)	2.9 (1.0)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
6. East Gate	43 924	2	2	1.4 (0.7)	1.1 (0.5)	1.2 (0.3)	<0.1
8. Los Alamos Airport	62 843	3	2	2.5 (0.8)	1.2 (0.8)	1.7 (0.7)	<0.1
12. White Rock	75 534	4	3	4.0 (1.5)	1.4 (0.7)	2.1 (1.3)	<0.1
Group Summary		9	7	4.0 (1.5)	1.1 (0.5)	1.7 (0.9)	<0.1
On-Site Stations, Controlled Areas							
16. TA-6	64 966	4	3	3.1 (1.0)	0.4 (0.7)	1.6 (1.2)	<0.1
17. TA-53 (LAMPF)	73 441	4	3	5.3 (1.4)	0.9 (0.6)	2.2 (2.1)	<0.1
20. TA-16	58 532	3	2	6.8 (1.4)	0.0 (0.5)	2.8 (3.5)	<0.1
21. Booster P-2	78 324	4	4	2.7 (1.4)	1.0 (0.6)	1.8 (0.7)	<0.1
22. TA-54	78 298	4	1	4.8 (1.0)	2.0 (1.1)	3.2 (1.4)	<0.1
23. TA-49	41 927	2	2	1.8 (0.5)	1.7 (0.6)	1.7 (0.1)	<0.1
Group Summary		21	15	6.8 (1.4)	0.0 (0.5)	2.3 (1.7)	<0.1

[a]See Fig. 8 for map of station locations.
[b]Minimum detectable limit = 2×10^{-18} μCi/mL.
[c]Uncertainties are in parentheses (see Appendix B).
[d]Controlled area DOE Derived Air Concentration = 2×10^{-12} μCi/mL; uncontrolled area Derived Concentration Guide = 2×10^{-14} μCi/mL.

Table G-12. Airborne Uranium Concentrations for 1990

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (pg/m^3) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28—44 km), Uncontrolled Areas							
1. Española	71 260.70	4	1	102.9 (10.3)	0.0 (0.0)	50.9 (42.0)	<0.1
2. Pojoaque	75 979.10	4	1	270.7 (27.1)	0.0 (0.0)	138.1 (120.1)	<0.1
3. Santa Fe	70 463.30	4	0	392.6 (39.3)	42.9 (4.3)	153.1 (162.1)	<0.1
Group Summary		12	2	392.6 (39.3)	0.0 (0.0)	114.0 (117.4)	<0.1
Perimeter Stations (0—4 km), Uncontrolled Areas							
4. Barranca School	74 180.50	4	0	90.4 (9.0)	31.4 (3.1)	54.6 (25.2)	<0.1
5. Arkansas Avenue	79 898.00	4	0	45.1 (4.5)	14.1 (1.4)	26.4 (13.4)	<0.1
6. East Gate	84 848.40	4	0	40.5 (4.1)	29.1 (1.4)	35.6 (5.6)	<0.1
7. 48th Street	83 186.70	4	0	50.0 (5.0)	16.2 (1.6)	30.3 (15.2)	<0.1
8. Los Alamos Airport	84 295.10	4	0	63.2 (6.3)	32.7 (1.6)	43.6 (13.5)	<0.1
*10. Shell Station	76 526.70	4	0	86.6 (8.7)	50.7 (5.1)	70.8 (15.0)	<0.1
11. Royal Crest Trailer Park	73 869.41	4	0	48.0 (4.8)	23.0 (1.3)	39.7 (11.5)	<0.1
12. White Rock	75 533.90	4	0	94.4 (9.4)	30.1 (3.0)	49.3 (30.2)	<0.1
13. Pajarito Acres	77 823.70	4	0	52.0 (5.2)	20.7 (2.1)	30.8 (14.7)	<0.1
14. Bandelier	80 737.80	4	0	40.1 (4.0)	14.9 (1.5)	22.9 (11.6)	<0.1
33. McDonald's	44 054.00	2[e]	0	37.3 (3.7)	24.1 (2.4)	30.7 (3.0)	<0.1
34. White Rock Fire Station	19 852.40	1[f]	0	36.7 (3.7)	36.7 (3.7)	36.7 (3.7)	<0.1
35. White Rock Nazarene	23 012.20	1[f]	0	19.9 (2.0)	19.9 (2.0)	19.9 (2.0)	<0.1
Group Summary		44	0	94.4 (9.4)	14.1 (1.4)	37.8 (16.4)	<0.1

Table G-12 (Cont)

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (pg/m^3) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
On-Site Stations, Controlled Areas							
15. TA-21	83 256.10	4	0	70.9 (7.1)	31.2 (1.6)	48.9 (17.4)	<0.1
16. TA-6	64 966.30	4	0	66.0 (3.0)	25.4 (2.5)	46.4 (18.0)	<0.1
17. TA-53 (LAMPF)	73 440.51	4	0	160.1 (16.0)	33.7 (3.4)	70.8 (59.8)	<0.1
18. Well PM-1	73 788.80	4	0	56.4 (5.6)	24.8 (2.5)	38.5 (14.3)	<0.1
19. TA-52	67 662.40	4	0	49.5 (4.9)	20.4 (1.3)	32.3 (12.4)	<0.1
20. TA-16	76 535.41	4	0	56.9 (5.7)	23.0 (2.3)	44.9 (15.2)	<0.1
21. Booster P-2	78 324.10	4	0	62.3 (6.2)	23.7 (2.4)	44.8 (17.7)	<0.1
22. TA-54	78 297.61	4	0	75.6 (7.6)	39.9 (4.0)	52.0 (16.5)	<0.1
23. TA-49	86 823.30	4	0	44.5 (4.5)	14.3 (1.4)	27.2 (12.6)	<0.1
24. TA-33	82 833.51	4	0	79.2 (3.4)	35.2 (3.5)	56.0 (21.1)	<0.1
25. TA-2 (Omega)	83 708.51	4	0	40.2 (4.0)	15.6 (1.6)	23.6 (11.4)	<0.1
26. TA-16-450	80 862.60	4	0	35.8 (3.6)	15.3 (1.5)	21.9 (9.4)	<0.1
Group Summary		48	0	160.1 (16.0)	14.3 (1.4)	42.3 (24.3)	<0.1

[a]See Fig. 8 for map of local stations.

[b]Minimum detectable limit = 1 pg/m^3.

[c]Uncertainties are in parentheses (see Appendix B).

[d]Controlled area DOE Derived Air Concentration = 2×10^8 pg/m^3; uncontrolled area Derived Concentration Guide = 1×10^5 pg/m^3.

[e]New station ran only 2 quarters in 1990.

[f]New stations ran only 1 quarter in 1990.

*Station 9 is no longer in operation.

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-13. Airborne Beryllium Concentrations for 1990[a]

Station and Location[b]	Total Air Volume (m^3)	No. of Quarterly Samples	Concentrations (ng/m^3) Maximum[c]	Minimum[c]	Mean[c]
Regional Stations (28–44 km), Uncontrolled Areas					
2. Pojoaque	56 543	3	0.05 (0.01)	0.02 (0.01)	0.04 (0.01)
Perimeter Stations (0–4 km), Uncontrolled Areas					
4. Barranca School	53 112	3	0.03 (0.01)	0.02 (0.01)	0.02 (0.01)
7. Los Alamos, 48th Street	62 572	3	0.09 (0.01)	0.01 (0.0)	0.04 (0.003)
10. Shell Station	59 919	3	0.04 (0.01)	0.03 (0.01)	0.04 (0.01)
13. Pajarito Acres	57 802	3	0.02 (0.01)	0.01 (0.0)	0.01 (0.01)
Group Summary		12	0.09 (0.01)	0.01 (0.01)	0.03 (0.01)
On-Site Stations, Controlled Areas					
19. TA-52	60 476	3	0.01 (0.0)	0.01 (0.01)	0.01 (0.003)
20. TA-16	57 834	3	0.02 (0.01)	0.01 (0.0)	0.01 (0.003)
22. TA-54	58 821	3	0.03 (0.01)	0.02 (0.01)	0.02 (0.01)
26. TA-16-450	63 075	3	0.01 (0.0)	0.01 (0.0)	0.01 (0.0)
Group Summary		12	0.03 (0.01)	0.01 (0.01)	0.01 (0.004)

[a]Data available only through third quarter of 1990.

[b]See Fig. 9 for map of local stations.

[c]Uncertainties are in parentheses (see Appendix B).

Table G-14. Locations of Surface Water and Groundwater Sampling Stations

Station	Latitude or North-South Coordinate	Longitude or East-West 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″	3	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 Canyon	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 Stations				
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 5B	S275	E355	96	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 8B	S310	E285	97	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
Spring 2A	S105	E475	95	SWR

Table G-14 (Cont)

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate	Map Designation[a]	Type[b]
White Rock Canyon Stations (Cont)				
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
On-Site Stations				
Test Well 1	N070	E345	39	GWD
Test Well 2	N120	E150	40	GWD
Test Well 3	N080	E215	41	GWD
Test Well DT-5A	S110	E090	42	GWD
Test Well 8	N035	E170	43	GWD
Test Well DT-9	S155	E140	44	GWD
Test Well DT-10	S120	E125	45	GWD
Cañada del Buey	N010	E150	46	SW
Pajarito Canyon	S060	E215	47	SW
Water Canyon at Beta	S090	E090	48	SW
PCO-1	S054	E212	102	GWS
PCO-2	S081	E255	103	GWS
PCO-3	S098	E293	104	GWS
Effluent Release Areas				
Acid-Pueblo Canyons				
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 Spring	N110	E250	53	S
Test Well 1A	N070	E335	54	GWS
Test Well 2A	N120	E140	55	GWS
Basalt Spring	N065	E395	56	S
DP—Los Alamos Canyons				
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

Table G-14 (Cont)

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate	Map Designation[a]	Type[b]
Effluent Release Areas (Cont)				
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
Water Supply and Distribution System				
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 (standby)	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
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

[a]Regional surface water sampling locations are given in Fig. 15; perimeter, White Rock Canyon, on-site, and effluent release area sampling locations are given 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-15. Radiochemical Quality of Surface Water from Regional Stations[a]

Station	^{3}H (10^{-6} μCi/mL)	^{137}Cs (10^{-9} μCi/mL)	Total Uranium (μg/L)	^{238}Pu (10^{-9} μCi/mL)	$^{239,240}Pu$ (10^{-9} μCi/mL)	Gross Gamma (counts/min/L)
Rio Chama						
Chamita	0.3 (0.3)	−61 (88)	2.7 (0.2)	0.000 (0.010)	0.004 (0.011)	30 (80)
Rio Grande						
Embudo	0.2 (0.3)	42 (63)	1.9 (0.1)	0.000 (0.010)	0.004 (0.006)	200 (80)
Otowi	0.2 (0.3)	−5 (77)	3.1 (0.2)	0.008 (0.014)	0.012 (0.007)	190 (80)
Cochiti	0.3 (0.3)	−7 (77)	3.0 (0.2)	0.005 (0.005)	0.005 (0.005)	−260 (80)
Bernalillo	0.2 (0.3)	−40 (77)	3.0 (0.2)	0.013 (0.015)	0.004 (0.007)	−160 (80)
Jemez River						
Jemez	0.4 (0.3)	−25 (75)	1.0 (0.1)	0.008 (0.008)	0.004 (0.007)	−200 (80)
Maximum	0.4 (0.3)	42 (63)	3.1 (0.2)	0.013 (0.015)	0.012 (0.007)	200 (80)
Limits of detection	0.7	40	1	0.1	0.1	50

[a]Samples were collected in April 1990; counting uncertainties are in parentheses.

Table G-16. Chemical Quality of Surface Water from Regional Stations (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	NO_3-N	TDS[b]	Total Hard-ness	pH[c]	Conduc-tivity (mS/m)
Rio Chama																
Chamita	16	61	11.4	2	31	5	123	0.1	98	7	0.3	0.0	366	199	8.3	39
Rio Grande																
Embudo	22	44	7.2	2	20	5	107	0.1	50	5	0.5	0.1	324	139	8.5	26
Otowi	19	48	8.0	2	23	5	116	0.1	56	5	0.4	0.0	338	154	8.1	29
Cochiti	23	47	7.7	3	28	5	116	0.1	51	6	0.4	0.3	294	149	8.2	31
Bernalillo	23	51	9.6	4	50	5	128	0.1	68	22	0.5	0.0	356	167	8.4	40
Jemez River																
Jemez	34	40	3.8	5	35	5	140	0.2	19	28	0.6	0.1	336	116	8.3	30

[a]Samples were collected in April 1990.

[b]Total dissolved solids.

[c]Standard units.

Table G-17. Radiochemical Quality of Surface Waters and Groundwaters from Perimeter Stations[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (counts/min/L)
Los Alamos Reservoir	0.1 (0.3)	−8 (81)	0.2 (0.1)	0.000 (0.010)	0.005 (0.008)	600(100)
Guaje Reservoir	0.1 (0.3)	90 (82)	0.8 (0.1)	0.009 (0.011)	0.005 (0.010)	550(100)
Frijoles Canyon	0.3 (0.3)	205 (136)	0.5 (0.1)	0.007 (0.009)	0.000 (0.010)	530(100)
La Mesita Spring	0.5 (0.3)	30 (135)	12.1 (1.8)	0.004 (0.007)	0.004 (0.004)	570(100)
Sacred Spring	0.0 (0.3)	−17 (78)	1.7 (0.3)	0.013 (0.010)	0.009 (0.009)	600(100)
Indian Spring	−0.4 (0.3)	68 (93)	18.8 (2.7)	0.009 (0.013)	0.000 (0.010)	700(100)
Maximum	0.5 (0.3)	205 (136)	18.8 (2.7)	0.013 (0.010)	0.009 (0.009)	700(100)
Limits of detection	0.7	40	1	0.1	0.1	50

[a]Samples were collected in May 1990; counting uncertainties are in parentheses.

Table G-18. Chemical Quality of Surface Waters and Groundwaters from Perimeter Stations (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	NO_3-N	TDS[b]	Total Hardness	pH[c]	Conductivity (mS/m)
Los Alamos Reservoir	35	8	2.6	2.0	6	5	29	0.2	5	4	0.0	0.0	64	32	7.6	6.9
Guaje Canyon	55	11	2.9	2.6	8	5	40	312.0	6	1	0.2	4.9	118	39	7.9	6.9
Frijoles Canyon	56	12	2.9	1.9	10	5	41	0.3	92	57	0.0	0.0	164	42	7.7	9.7
La Mesita Spring	32	44	1.5	2.7	38	5	81	0.6	58	6	0.3	4.4	486	116	6.8	27.9
Sacred Spring	32	28	0.6	2.1	26	5	95	0.2	11	1	0.5	8.2	272	73	7.9	17.
Indian Spring	49	34	2.4	2.5	30	5	87	0.6	12	13	0.5	0.8	746	95	7.4	20.8
Maximum	56	44	2.9	2.7	38	<5	95	312.0	92	25	0.5	4.9	746	116	7.9	27.9

[a]Samples were collected in May 1990.
[b]Total dissolved solids.
[c]Standard units.

Table G-19. Radiochemical Quality of Surface and Spring Waters from White Rock Canyon[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (counts/min/L)
Group I						
Sandia Spring	0.2 (0.3)	69 (68)	<1.0	0.004 (0.010)	0.004 (0.007)	60 (80)
Spring 3	0.0 (0.3)	20 (11)	1.2 (1.0)	0.025 (0.012)	0.017 (0.008)	80 (80)
Spring 3A	0.4 (0.3)	-71 (70)	1.0 (1.0)	0.004 (0.008)	0.004 (0.010)	-10 (80)
Spring 3AA	-0.1 (0.3)	133 (83)	1.3 (1.0)	0.013 (0.014)	0.021 (0.013)	80 (80)
Spring 4	-0.1 (0.3)	18 (10)	1.1 (1.0)	0.016 (0.014)	0.000 (0.010)	-100 (80)
Spring 4A	0.0 (0.3)	12 (9)	1.1 (1.0)	0.008 (0.010)	0.000 (0.010)	10 (80)
Spring 5	0.2 (0.3)	135 (90)	<1.0	0.009 (0.009)	0.000 (0.010)	110 (80)
Spring 5AA	Dry					
Ancho Spring	-0.2 (0.3)	30 (12)	<1.0	0.004 (0.010)	0.008 (0.006)	-70 (80)
Maximum	0.4 (0.3)	135 (90)	1.3 (1.0)	0.025 (0.012)	0.021 (0.013)	80 (80)
Group II						
Spring 5A	0.2 (0.3)	-1 (79)	1.4 (1.0)	0.013 (0.014)	0.013 (0.014)	-20 (80)
Spring 5B	Not Sampled					
Spring 6	0.2 (0.3)	11 (10)	<1.0	0.016 (0.018)	0.005 (0.012)	-40 (80)
Spring 6A	0.0 (0.3)	25 (70)	<1.0	0.010 (0.016)	0.000 (0.010)	80 (80)
Spring 7	0.6 (0.3)	13 (10)	<1.0	0.008 (0.012)	0.008 (0.010)	80 (80)
Spring 8	-0.4 (0.3)	128 (81)	3.3 (1.0)	0.004 (0.004)	0.008 (0.008)	80 (80)
Spring 8A	-0.1 (0.3)	18 (11)	<1.0	0.000 (0.010)	0.012 (0.012)	60 (80)
Spring 8B	-0.1 (0.3)	10 (10)	2.0 (1.0)	0.000 (0.010)	0.015 (0.010)	120 (80)
Spring 9	-0.1 (0.3)	-45 (82)	<1.0	0.008 (0.010)	0.000 (0.010)	20 (80)
Spring 9A	0.4 (0.3)	1 (10)	1.1 (1.0)	0.004 (0.004)	0.004 (0.004)	0 (80)
Spring 9B	0.1 (0.3)	167 (84)	<1.0	0.015 (0.015)	0.000 (0.010)	-60 (80)
Doe Spring	0.2 (0.3)	58 (80)	<1.0	0.000 (0.010)	0.000 (0.010)	-90 (80)
Maximum	0.6 (0.3)	167 (84)	3.3 (1.0)	0.016 (0.018)	0.015 (0.010)	120 (80)

Table G-19 (Cont)

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (counts/min/L)
Group III						
Spring 1	0.1 (0.3)	17 (10)	2.8 (1.0)	0.009 (0.009)	0.000 (0.010)	–70 (80)
Spring 2	0.3 (0.3)	42 (75)	9.3 (1.0)	0.007 (0.011)	0.013 (0.016)	–90 (80)
Spring 2A	Dry					
Maximum	0.3 (0.3)	42 (75)	9.3 (1.0)	0.009 (0.009)	0.013 (0.016)	–70 (80)
Group IV						
Spring 3B	0.3 (0.3)	20 (11)	31 (3.1)	0.069 (0.019)	0.009 (0.007)	90 (80)
Streams						
Pajarito	0.4 (0.3)	15 (11)	1.2 (1.0)	0.004 (0.011)	0.012 (0.007)	90 (80)
Ancho	–0.5 (0.3)	96 (74)	<1.0	0.000 (0.010)	0.000 (0.010)	70 (80)
Maximum	0.4 (0.3)	96 (74)	1.2 (1.0)	0.004 (0.011)	0.012 (0.007)	90 (80)
Sanitary Effluent						
Mortandad	-0.1 (0.3)	114 (84)	1.4 (1.0)	0.011 (0.008)	0.004 (0.008)	–170 (80)

[a]Samples were collected in October 1990; counting uncertainties are in parentheses. No sample was taken from Springs 2A and 5AA because they were dry. Spring 5B was not sampled because of river level; they were included in 1989 because the flow in the Rio Grande was low.

Table G-20. Chemical Quality of Surface and Spring Waters from White Rock Canyon (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	NO_3-N	TDS[b]	Total Hardness	pH[c]	Conductivity (mS/m)
Group I																
Sandia Spring	45	46.4	2.22	2.73	19.2	5	177	0	7	4.8	0.7	0.19	62	125.0	8.3	20.2
Spring 3	51	30.2	1	3	18	5	88.0	0	6	4.5	0.6	0.861	146	83.3	8	16.2
Spring 3A	51	26.7	1	2	17	5	81.0	0	5	2.8	0.7	0.742	128	74.2	8	13.4
Spring 3AA	41	36.4	1.05	2.45	30.9	5	123	0.2	5.21	2.3	0.43	0.154	166	95.21	7.71	16.4
Spring 4	54	29.1	4	2	16	5	78.0	0	12	5.8	0.7	1.29	152	92.3	7	16.1
Spring 4A	69	27.8	5	2	14	5	82.0	0	8	4.8	0.5	0.78	136	90.7	7	17
Spring 5	67	27.4	5	2	14	5	83.0	0	6	3.9	0.6	0.467	172	89.4	8	16.9
Ancho Spring	75	18.1	3	1	12	5	64.0	0	3	2.1	0.5	0.339	226	59.4	7	11.8
Maximum	75	46.4	5	3.0	30.9	<5	177	0.2	12	5.8	0.7	1.29	226	125	8.3	20.2
Group II																
Spring 5A	58	30.9	3.02	2.87	22.2	5	97	0.18	8.32	4.1	0.44	0.545	214	89.59	7.87	19.2
Spring 6	72	17.2	4.04	1.94	12.5	5	62	0.17	3.46	2.1	0.38	0.388	210	59.59	7.92	11.2
Spring 6A	75	14.2	3.09	2.11	12.5	5	49	0	2	1.9	0.3	0.408	172	48.2	8.1	10.2
Spring 7	76	16.8	3.37	2.37	16.6	5	66	0.24	4.87	2.1	0.51	0.476	254	55.83	7.3	13.1
Spring 8	74	28.1	5	3	29	5	108.0	0	12	3.6	0.4	0.792	174	91.0	7	19.6
Spring 8A	75	16.2	3	2	13	5	65.0	0	2	1.8	0.5	0.04	176	54.9	8	9.2
Spring 8B	80	19.7	3	2	18	5	65.0	0	7	2.5	0.5	1.19	122	64.5	7	10.1
Spring 9	77	15.1	3	1	14	5	56.0	0	2	2.0	0.5	0.04	156	52.0	8	10.9
Spring 9A	74	14.6	3	1	13	5	53.0	0	2	2.0	0.5	0.232	80	50.3	7	8.1
Spring 9B	75	14.4	3	1	13	5	60.0	0	3	2.0	0.5	0.232	130	50.0	8	10.5
Doe Spring	75	16.3	3	1	14	5	61.0	0	3	2.2	0.5	0.048	122	55.5	8	11.7
Maximum	80	30.9	5.0	3.0	29	<5	108	0.24	12	4.1	0.51	1.19	254	91.0	8.1	19.2

Table G-20 (Cont)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	NO_3-N	TDS[b]	Total Hardness	pH[c]	Conductivity (mS/m)
Group III																
Spring 1	34	29.3	1.67	2.76	38.5	5	107	0.19	9.34	3.45	0.6	0.9	134	80	8.01	17.8
Spring 2	37	36.7	1	2	83	5	201.0	0	22	5.9	1.2	0.184	308	97.0	8	36
Maximum	37	36.7	1.67	2.76	83	<5	201	0.19	22	5.9	1.2	0.9	308	97.0	8.01	36
Group IV																
Spring 3B	44	28.4	1	4	140	5	300.0	0	20	3.6	0.7	2.8	328	78.0	7	55.1
Streams																
Pajarito	68	28.4	4.99	2.62	16.5	5	84	0.195	7.3	4.6	0.49	0.8	16	91	8.36	12.9
Ancho	74	18.0	3	2	13	5	68.0	0	3	2.5	0.4	0.04	170	59	8	12.7
Water	60	42.2	6.05	2.83	16.5	5	121	0.256	5.77	4.2	0.53	0.04	122	130	7.27	19.1
Frijoles	64	14.2	3	1	11	5	59.0	0	3	2.3	0.2	0.04	198	50	8	9.2
Maximum	78	42.2	6.05	2.83	16.5	<5	121	0.256	7.3	4.6	0.53	0.8	198	130	8.36	19.1
Sanitary Effluent																

[a]Samples were collected in October 1990. No sample was taken from Spring 2A, 5AA, or 5B because they were dry or not accessible.

[b]Total dissolved solids.

[c]Standard units.

Table G-21. Trace Metals in Surface and Spring Waters from White Rock Canyon (mg/L)[a]

Station	Ag	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Sb	Se	Sr	Tl	U	V	Zn
Group I																				
Sandia Spring	0.001	0.099	0.004	0.1	0.125	0.001	0.001	0.005	0.005	0.1	0.048	0.005	0.0195	0.001	0.001	0.292	0.001	1	0.005	0.005
Spring 3	0.0028	0.0623	0.004	0.1	0.039	0.001	0.001	0.0059	0.005	0.071	0.0094	0.005	0.016	0.001	0.001	0.21	0.001	1.2	0.014	0.0064
Spring 3A	0.001	0.067	0.004	0.1	0.033	0.001	0.001	0.0059	0.005	0.02	0.0058	0.005	0.015	0.001	0.001	0.236	0.001	1	0.014	0.0054
Spring 3AA	0.001	1.646	0.004	0.1	0.0756	0.001	0.001	0.0084	0.005	1.7	0.107	0.005	0.0162	0.001	0.001	0.154	0.001	1.3	0.0111	0.033
Spring 4	0.001	0.037	0.004	0.1	0.044	0.001	0.001	0.0051	0.005	0.043	0.002	0.005	0.011	0.001	0.001	0.138	0.001	1.1	0.0093	0.005
Spring 4A	0.001	0.0705	0.004	0.1	0.04	0.001	0.001	0.0093	0.005	0.02	0.0041	0.005	0.0209	0.001	0.0023	0.104	0.001	1.1	0.0054	0.0082
Spring 5	0.001	0.411	0.004	0.1	0.046	0.001	0.001	0.005	0.005	0.38	0.016	0.005	0.009	0.001	0.001	0.104	0.001	1	0.0091	0.0073
Ancho Spring	0.001	0.996	0.004	0.1	0.043	0.001	0.001	0.005	0.005	0.67	0.029	0.005	0.0096	0.001	0.001	0.058	0.001	1	0.0071	0.005
Group II																				
Spring 5A	0.0023	2.151	0.004	0.1	0.081	0.001	0.001	0.0067	0.005	1.5	0.073	0.005	0.0089	0.001	0.001	0.198	0.001	1.4	0.015	0.014
Spring 6	0.001	0.029	0.004	0.1	0.027	0.001	0.001	0.0061	0.005	0.02	0.002	0.005	0.014	0.001	0.001	0.064	0.001	1	0.0075	0.0083
Spring 6A	0.001	0.031	0.004	0.1	0.021	0.001	0.001	0.005	0.005	0.02	0.002	0.005	0.013	0.001	0.001	0.047	0.001	1	0.0064	0.005
Spring 7	0.001	0.081	0.004	0.1	0.031	0.001	0.001	0.0058	0.005	0.046	0.0079	0.005	0.017	0.001	0.001	0.071	0.001	1	0.0074	0.005
Spring 8	0.001	0.846	0.004	0.1	0.079	0.001	0.001	0.0063	0.005	0.73	0.048	0.005	0.022	0.001	0.001	0.133	0.001	3.3	0.014	0.011
Spring 8A	0.001	0.244	0.004	0.1	0.034	0.001	0.001	0.005	0.005	0.19	0.0068	0.005	0.019	0.001	0.001	0.0421	0.001	1	0.0089	0.005
Spring 8B	0.0029	0.181	0.004	0.1	0.0336	0.0032	0.0022	0.0059	0.005	0.11	0.0108	0.005	0.0128	0.0013	0.0015	0.0769	0.0017	2	0.0125	0.013
Spring 9	0.001	0.262	0.004	0.1	0.027	0.001	0.001	0.005	0.005	0.41	0.023	0.005	0.012	0.001	0.001	0.0425	0.001	1	0.0074	0.005
Spring 9A	0.001	1.16	0.004	0.1	0.023	0.001	0.001	0.013	0.005	0.76	0.0091	0.005	0.023	0.001	0.001	0.057	0.001	1.1	0.011	0.005
Spring 9B	0.001	0.0366	0.004	0.1	0.0049	0.001	0.001	0.0094	0.005	0.02	0.0141	0.005	0.0224	0.001	0.0015	0.0485	0.001	1	0.0085	0.0075
Doe Spring	0.001	0.379	0.0044	0.1	0.02	0.001	0.001	0.005	0.005	0.25	0.024	0.005	0.012	0.001	0.001	0.0454	0.001	1	0.007	0.011
Group III																				
Spring 1	0.001	3.255	0.0055	0.1	0.106	0.001	0.001	0.011	0.005	2.6	0.136	0.005	0.018	0.001	0	0.26	0.001	2.8	0.024	0.017
Spring 2	0.001	3.049	0.03	0.15	0.081	0.001	0.001	0.005	0.005	2.1	0.115	0.005	0.014	0.001	0.001	0.333	0.001	9.3	0.038	0.018
Group IV																				
Spring 3B	0.001	6.256	0.013	0.2	0.134	0.001	0.001	0.0572	0.005	5.5	0.148	0.006	0.029	0.001	0.001	0.299	0.001	31	0.069	0.028
Streams																				
Pajarito	0.001	0.0948	0.004	0.1	0.043	0.001	0.001	0.0069	0.005	0.13	0.0061	0.005	0.021	0.001	0.001	0.0622	0.001	1.2	0.01	0.0067
Ancho	0.001	0.784	0.004	0.1	0.043	0.001	0.001	0.005	0.005	0.64	0.025	0.005	0.019	0.001	0.001	0.056	0.001	1	0.0077	0.007
Water	0.001	1.433	0.004	0.1	0.187	0.001	0.001	0.0064	0.0061	0.64	0.516	0.005	0.0156	0.001	0.001	0.172	0.001	1	0.005	0.023
Frijoles	0.001	0.14	0.004	0.1	0.015	0.001	0.001	0.005	0.005	0.24	0.0096	0.005	0.014	0.001	0.001	0.026	0.001	1	0.005	0.005
Sanitary Effluent																				
Mortandad	0.0028	0.251	0.004	0.41	0.081	0.001	0.001	0.005	0.011	0.29	0.037	0.005	0.028	0.001	0.001	0.103	0.001	1.4	0.0098	0.021

[a]Samples were collected in October 1990. No sample was taken from Spring 2A, 5AA, or 5B because they were dry.
[b]Total dissolved solids.
[c]Standard units.

Table G-22. Radiochemical Quality of Surface Waters and Groundwaters from On-Site Stations[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (counts/min/L)
Ground Water (Main Aquifer)						
Test well 1	Well inactive					
Test well 2	Well inactive					
Test well 3	0.0 (0.3)	209 (98)	0.5 (0.1)	0.028 (0.013)	0.005 (0.008)	0 (80)
Test well DT-5A	0.0 (0.3)	81 (70)	0.5 (0.1)	0.000 (0.010)	0.005 (0.010)	−50 (80)
Test well 8	0.5 (0.3)	44 (64)	0.6 (0.1)	0.013 (0.013)	0.009 (0.011)	110 (80)
Test well DT-9	0.3 (0.3)	126 (71)	0.3 (0.1)	0.004 (0.004)	0.000 (0.010)	160 (80)
Test well DT-10	0.0 (0.3)	172 (88)	0.1 (0.1)	0.008 (0.008)	0.012 (0.009)	800 (100)
Maximum	0.5 (0.3)	209 (98)	0.6 (0.1)	0.028 (0.013)	0.028 (0.015)	800 (100)
Surface Water						
Cañada del Buey	0.3 (0.3)	9 (64)	0.2 (0.1)	0.008 (0.012)	0.000 (0.010)	−100 (80)
Pajarito Canyon	0.2 (0.3)	127 (88)	0.2 (0.1)	0.000 (0.010)	0.118 (0.031)	80 (80)
Water Canyon at Beta Hole	0.0 (0.3)	76 (94)	0.2 (0.1)	0.000 (0.010)	0.004 (0.009)	300 (80)
Maximum	0.3 (0.3)	127 (88)	0.2 (0.1)	0.008 (0.012)	0.118 (0.031)	300 (80)
Observation Wells (Pajarito Canyon)						
PCO-1	−0.1 (0.3)	1 (69)	1.2 (0.2)	0.009 (0.014)	0.027 (0.014)	−80 (80)
PCO-2	0.1 (0.3)	132 (97)	1.1 (0.1)	0.027 (0.012)	0.013 (0.010)	10 (80)
PCO-3	0.0 (0.3)	75 (63)	0.8 (0.1)	0.000 (0.010)	0.010 (0.014)	−30 (80)
Maximum	0.1 (0.3)	132 (97)	1.2 (0.2)	0.027 (0.012)	0.027 (0.014)	10 (80)

[a]Samples were collected April–May 1990; counting uncertainties are in parentheses.

Table G-23. Chemical Quality of Surface Waters and Groundwaters from On-Site Stations (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	NO_3-N	TDS[b]	Total Hardness	pH[c]	Conductivity (mS/m)
Ground Water (Main Aquifer)																
Test well 1	Well inactive															
Test well 2	Well inactive															
Test well 3	80	23	5.9	2	14	5	80	0	4	3	0.4	0.6	16	82	8.0	14.5
Test well DT-5A	65	13	2.7	1	12	5	68	0	2	1	0.2	0.3	64	44	8.2	9.6
Test well 8	67	16	4.8	1	12	5	62	0	3	2	0.2	0.2	422	61	8.3	11.2
Test well DT-9	73	14	3.2	1	13	5	57	0	3	1	0.3	0.4	274	48	8.4	9.68
Test well DT-10	53	15	3.9	1	13	5	67	0	2	2	0.3	0.3	200	53	8.7	10.4
Maximum	80	23	5.9	5	14	<5	80	0	4	3	0.4	0.6	422	82	8.7	14.5
Surface Water																
Cañada del Buey	34	17	3.5	2	33	5	31	0	18	34	0.67	0.9	200	56	6.4	17.2
Pajarito Canyon	31	25	6.2	4	24	5	42	0	14	39	0.0	0.4	288	88	7.1	22.5
Water Canyon at Beta Hole	36	15	4.1	3.5	18.5	5	55	0.075	14.2	9	0.2	0.4	188	53	7.3	12.5
Maximum	36	25	6.2	4	33	<5	55	0.075	18	39	0.67	0.9	288	88	7.1	22.5
Observation Wells (Pajarito Canyon)																
PCO-1	27	20	4.9	2	36	5	52	0	18	19	0.01	0.4	612	70	7.1	11.5
PCO-2	27	20	5.1	2	21	5	64	0	18	19	0.0	0.4	600	71	7.1	13.6
PCO-3	28	19	5.0	3	22	5	60	0	19	19	0.0	0.4	272	70	7.0	17
Maximum	28	20	5.1	3	36	<5	64	0	19	19	0.01	0.4	600	71	7.1	17

[a]Samples were collected in April 1990

[b]Total dissolved solids.

[c]Standard units.

Table G-24. Radiochemical Quality of Surface Waters and Groundwaters from Effluent Release Areas[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (counts/min/L)
Acid-Pueblo Canyon						
Acid Weir	0.4 (0.3)	116 (73)	0.9 (0.1)	0.005 (0.008)	0.360 (0.044)	490 (90)
Pueblo 1	0.0 (0.3)	141 (72)	<1.0	0.008 (0.014)	0.004 (0.009)	500 (90)
Pueblo 2	Dry					
Pueblo 3	–0.1 (0.3)	141 (100)	1.2 (0.1)	0.009 (0.007)	0.019 (0.011)	490 (90)
Hamilton Bend Spring	Dry					
Test well 1A	–0.2 (0.3)	37 (64)	0.7 (0.1)	0.009 (0.015)	0.028 (0.015)	–30 (80)
Test well 2A	0.3 (0.3)	7 (69)	0.6 (0.1)	0.000 (0.010)	0.005 (0.005)	530 (90)
Basalt Spring	0.0 (0.3)	162 (96)	2.5 (0.1)	0.000 (0.010)	0.005 (0.008)	500 (90)
Maximum	0.4 (0.3)	162 (96)	2.5 (0.1)	0.009 (0.015)	0.360 (0.044)	530 (90)
Los Alamos Canyon						
DPS-1	4.0 (0.5)	–43 (58)	0.6 (0.1)	0.004 (0.011)	0.057 (0.016)	490 (90)
DPS-4	1.8 (0.4)	52 (102)	0.2 (0.1)	0.023 (0.012)	0.060 (0.018)	470 (90)
LAO-C	0.2 (0.3)	122 (95)	1.0 (0.1)	0.019 (0.025)	0.019 (0.017)	410 (90)
LAO-1	35.0 (4.0)	62 (70)	0.3 (0.1)	0.014 (0.010)	0.017 (0.010)	380 (90)
LAO-2	1.3 (0.3)	117 (101)	0.6 (0.1)	0.036 (0.019)	0.077 (0.019)	400 (90)
LAO-3	0.1 (0.3)	47 (69)	6.6 (0.7)	0.025 (0.012)	0.046 (0.015)	480 (90)
LAO-4	0.6 (0.3)	97 (87)	0.2 (0.1)	0.008 (0.012)	0.054 (0.017)	450 (90)
LAO-4.5	1.0 (0.3)	19 (62)	0.3 (0.1)	0.000 (0.010)	0.393 (0.050)	510 (90)
Maximum	35.0 (4.0)	122 (95)	6.6 (0.7)	0.036 (0.019)	0.393 (0.050)	510 (90)
Sandia Canyon						
SCS-1	–0.2 (0.3)	–109 (65)	1.1 (0.1)	0.014 (0.017)	0.007 (0.016)	400 (90)
SCS-2	0.4 (0.3)	—	0.5 (0.1)	0.029 (0.016)	0.012 (0.012)	330 (80)
SCS-3	–0.1 (0.3)	35 (63)	0.5 (0.1)	0.000 (0.010)	0.011 (0.013)	380 (90)
Maximum	0.4 (0.3)	35 (63)	1.1 (0.1)	0.029 (0.016)	0.012 (0.012)	400 (90)

Table G-24 (Cont)

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (counts/min/L)
Mortandad Canyon						
GS-1	20.0 (2.0)	124 (64)	1.0 (0.1)	0.543 (0.054)	2.310 (0.250)	70 (80)
MCO-3	22.0 (2.0)	288 (110)	1.2 (0.1)	0.705 (0.058)	1.840 (0.105)	310 (80)
MCO-4	100.0(10.0)	110 (72)	4.8 (0.1)	0.701 (0.059)	2.650 (0.137)	180 (80)
MCO-5	190.0(20.0)	237 (108)	2.9 (0.1)	0.159 (0.028)	0.446 (0.046)	250 (80)
MCO-6	180.0(20.0)	–37 (68)	5.9 (0.1)	0.093 (0.023)	0.234 (0.032)	390 (90)
MCO-7	18.0 (2.0)	–5 (101)	1.3 (0.1)	0.003 (0.012)	0.042 (0.014)	230 (80)
MCO-7.5	110.0(10.0)	109 (71)	2.2 (0.1)	0.011 (0.019)	0.044 (0.027)	240 (80)
Maximum	190.0(20.0)	288 (110)	4.8 (0.1)	0.705 (0.058)	2.650 (0.137)	390 (90)
Limits of detection	0.7	40	1	0.1	0.1	50

[a]Samples were collected in April 1990; counting uncertainties are in parentheses.

Table G-25. Chemical Quality of Surface Water and Groundwaters from Effluent Release Areas (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	NO_3-N	TDS[b]	Total Hardness	pH[c]	Conductivity (mS/m)
Acid-Pueblo Canyon																
Acid Weir	18	16	1	4	115	5	41	0.4	6	42	0.3	1.3	52	47	7.0	33.2
Pueblo 1	28	31	5	8	156	5	50	0.7	70	174	0.4	1.2	362	99	7.4	43.9
Pueblo 3	58	25	2	62	148	5	165	5.8	42	48	1.0	10.6	344	73	7.9	54.6
Test well 1A	6	19	4	5.17	79	5	95	1.6	27	51	0.45	0.0	548	67	8.6	31.3
Test well 2A	39	39	7	3	28	5	78	1.1	23	44	0.2	1.4	132	130	7.1	30.5
Basalt Spring	41	47	10	4	36	5	124	0.8	8	7	0.4	2.2	332	165	7.6	32.2
Maximum	58	47	10	62	156	5	165	5.8	70	174	1.0	10.6	548	165	8.6	54.6
DP—Los Alamos Canyon																
DPS-1	14	32	1	17.5	83	5	69	0.1	50	45	0.55	0.1	358	88	6.9	21.7
DPS-4	19	18	1	9	77	5	52	0.2	17	28	1.4	0.5	364	53	6.6	26.2
LAO-C	34	21	4	10.2	142	5	41	1.2	11	93	0.01	0.2	610	71	7.3	29.2
LAO-1	36	31	5	4	61	5	87	0.2	21	96	0.4	0.5	410	99	7.0	43.6
LAO-2	40	22	4	18	38	5	111	0.2	21	29	1.3	0.7	556	72	7.1	23.6
LAO-3	49	20	3	10	32	5	102	0.3	18	13	1.2	0.6	542	63	7.0	20
LAO-4	41	15	3	7	38	5	91	0.3	20	6	0.8	0.3	136	53	7.0	19.1
LAO-4.5	39	15	3	4	38	5	73	0.3	15	17	0.9	0.1	882	49	7.1	15
Maximum	49	32	5	18	142	5	111	1.2	50	96	1.3	0.7	882	99	7.3	43.6
Sandia Canyon																
SCS-1	80	23	5	12.5	138	5	58	3.1	37	55	0.56	8.9	400	80	7.7	38.7
SCS-2	68	26	3	10.3	123	5	98	1.8	115	45	0.7	3.1	322	81	8.1	46.2
SCS-3	68	27	3	10.3	74	5	100	2.3	113	45	0.625	2.7	324	84	8.1	42.4
Maximum	80	27	5	12.5	138	5	100	3.1	115	55	0.625	8.9	400	84	8.1	46.2

Table G-25 (Cont)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	NO_3-N	TDS[b]	Total Hardness	pH[c]	Conductivity (mS/m)
Mortandad Canyon																
GS-1	54	45	2	13.8	48	5	147	0.1	16	11	1.1	9.2	322	125	8.3	34.9
MCO-3	53	49	2	15	34	5	154	0.0	18	11	1.2	12.7	352	136	8.3	34.7
MCO-4	40	64	3	34	170	5	215	0.1	53	29	1.7	63.1	910	177	7.8	86.9
MCO-5	35	50	5	36	229	5	198	0.1	51	31	1.9	86.2	982	150	7.5	94.1
MCO-6	35	46	5	39	209	5	203	0.2	41	27	1.9	76.2	1	139	7.4	91
MCO-7	43	17	3	5	101	5	122	0.7	21	28	1.9	7.1	1	58	7.1	42.1
MCO-7.5	37	32	7	7	234	5	158	0.3	41	28	1.45	77.0	792	111	7.1	89
Maximum	54	64	7	39	229	5	215	0.7	53	31	1.9	86.2	982	177	8.3	94.1

[a]Samples were collected in May 1990.

Table G-26. Trace Metals in Surface Water and Groundwater from Effluent Release Areas (mg/L)[a]

Station	Ag	Al	As	B	Ba	Be	Cd	CN	Cr	Cu	Fe	Hg	Mn	Ni	NO_2-N	Pb	Sb	Se	Sr	Tl	U	V	Zn
Acid-Pueblo Canyon																							
Acid Weir	0.0001	1.06	0.0022	0.1	0.0457	0.0003	0.0003	0.01	0.0041	0.0069	1.1	0.00022	0.082	0.0023	0.02	0.0269	0.0002	0.001	0.0629	0.0001	0.9	0.0187	0.0274
Pueblo 1	0.0001	0.0335	0.0052	0.14	0.0432	0.0001	0.0001	0.01	0.0013	0.0094	0.12	0.00031	0.186	0.0019	0.02	0.0007	0.0003	0.001	0.16	0.0001	0.1	0.0304	0.018
Pueblo 3	0.0025	0.261	0.0132	0.37	0.0343	0.0001	0.0001	0.041	0.0087	0.0244	0.39	0.00027	0.0523	0.0031	0.293	0.0023	0.0003	0.001	0.114	0.0001	1.2	0.0339	0.0366
Test well 2A	0.0001	0.0214	0.0029	0.19	0.0533	0.0001	0.0087	0.01	0.0021	0.0108	26	0.0002	0.228	0.0029	0.02	0.065	0.0012	0.001	0.184	0.0001	0.6	0.0107	0
Basalt Spring	0.0001	0.185	0.003	0.12	0.0526	0.0001	0.0002	0.01	0.0036	0.0056	0.12	0.0002	0.0045	0.0028	0.02	0.0006	0.0001	0.0016	0.19	0.0001	2.5	0.0112	0.005
DP-Los Alamos Canyon																							
DPS-1	0.0001	1.98	0.0025	0.18	0.0863	0.0014	0.0001	0.01	0.0027	0.0072	1.8	0.0002	0.0532	0.0005	0.02	0.00325	0.0007	0.001	0.1329	0.0001	0.6	0.0001	0.021
DPS-4	0.0001	1.5	0.0031	0.19	0.0594	0.0015	0.0001	0.01	0.0027	0.0042	1.4	0.0002	0.0111	0.0002	0.02	0.0036	0.0005	0.001	0.0903	0.0001	0.2	0.0065	0.0142
LAO-C	0.0001	2.64	0.0137	0.1	0.24	0.0005	0.0001	0.01	0.004	0.0079	30	0.0002	2.47	0.003	0.02	0.0237	0.0005	0.001	0.142	0.0001	1	0.0309	0.0293
LAO-1	0.0001	1.43	0.0025	0.12	0.0748	0.0002	0.0001	0.01	0.021	0.0028	1.8	0.0002	0.0766	0.0002	0.02	0.0034	0.0005	0.001	0.191	0.0001	0.3	0.0078	0.0101
LAO-2	0.0001	2.61	0.0031	0.14	0.0733	0.0006	0.0005	0.01	0.0029	0.0112	2.6	0.0002	0.0894	0.0017	0.02	0.0039	0.0005	0.001	0.118	0.0001	0.4	0.0064	0.0197
LAO-3	0.0001	3.35	0.003	0.2	0.0752	0.0004	0.0001	0.01	0.0064	0.006	2.3	0.0002	0.113	0.0004	0.02	0.0066	0.0005	0.001	0.0983	0.0001	1.6	0.0067	0.012
LAO-4	0.0001	1.57	0.0013	0.48	0.0536	0.0005	0.0002	0.01	0.0033	0.0063	1.4	0.0002	0.0344	0.0002	0.02	0.0024	0.0005	0.001	0.0875	0.0001	0.2	0.0037	0.0139
LAO-4.5	0.0001	2.4	0.0014	0.39	0.0482	0.0003	0.0001	0.01	0.0031	0.0073	2	0.0002	0.047	0.0003	0.02	0.0041	0.0005	0.001	0.0737	0.0001	0.3	0.0042	0.0164
Sandia Canyon																							
SCS-1	0.0192	0.29	0.0046	0.21	0.05755	0.0001	0.0005	0.164	0.0691	0.0005	0.78	0.00021	0.0567	0.0005	0.02	0.0118	0.0004	0.001	0.0947	0.0001	1.1	0.0175	0.0229
SCS-2	0.0025	0.615	0.0047	0.19	0.03275	0.0001	0.0006	0.019	0.0154	0.0005	0.56	0.0002	0.0151	0.0055	0.02	0.0031	0.0005	0.001	0.0917	0.0001	0.5	0.0165	0.064
SCS-3	0.0026	0.615	0.0048	0.2	0.0321	0.0001	0.0007	0.024	0.0152	0.021	0.61	0.0002	0.0136	0.0073	0.02	0.003	0.0004	0.001	0.0898	0.0001	0.4	0.0161	0.0644
Mortandad Canyon																							
GS-1	0.0002	0.451	0.0016	0.14	0.0308	0.0002	0.0005	---	0.001	0.0106	0.57	0.0002	0.04	0.0066	---	0.0005	0.0006	0.001	0.0797	0.0008	1	0.0081	0.008
MCO-3	0.0002	0.456	0.001	0.14	0.0308	0.0002	0.0005	---	0.0014	0.011	0.45	0.0002	0.025	0.0062	---	0.0005	0.0006	0.001	0.0853	0.001	1.2	0.0083	0.0092
MCO-4	0.0002	0.126	0.001	0.14	0.106	0.0002	0.0005	---	0.051	0.0293	0.33	0.0002	0.0031	0.0121	---	0.0036	0.0007	0.001	0.166	0.0002	4.8	0.0052	0.0866
MCO-5	0.0002	1.1	0.001	0.14	0.18	0.0002	0.0005	---	0.0125	0.0167	1.3	0.0002	0.0259	0.0085	---	0.0027	0.0005	0.001	0.19	0.0002	2.9	0.0066	0.041
MCO-6	0.0002	2.99	0.0019	0.14	0.184	0.0003	0.0017	---	0.005	0.0114	2	0.0002	0.137	0.0109	---	0.0082	0.0002	0.001	0.181	0.0002	4.6	0.0082	0.045
MCO-7	0.0004	7.4	0.0031	0.2	0.115	0.001	0.0005	---	0.0052	0.0306	3.9	0.0002	0.214	0.0082	---	0.0115	0.0002	0.001	0.0877	0.0002	1.3	0.0222	0.047
MCO-7.5	0.0002	4.5	0.001	0.17	0.245	0.0006	0.0005	---	0.0047	0.0074	3.3	0.0002	0.156	0.0071	---	0.0063	0.0002	0.001	0.149	0.0002	2.2	0.0112	0.021

[a]Samples were collected in May 1990.

Table G-27. Radiochemical Quality of Water from Supply Wells and the Distribution System[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total Uranium (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (counts/min/L)
Water Supply								
Los Alamos Field								
Well LA-1B	0.8(0.3)	-24(80)	5.6(0.6)	0.011(0.017)	0.022(0.015)	3.0(3.0)	2.8(0.4)	-120(80)
Well LA-2	0.6(0.3)	263(115)	4.7(0.1)	0.031(0.015)	0.010(0.010)	1.0(1.0)	1.8(0.4)	80(80)
Well LA-3	0.4(0.3)	-33(81)	1.6((0.1)	0.017(0.012)	0.004(0.011)	1.6(0.9)	3.1(0.5)	60(80)
Well LA-4	Well inactive							
Well LA-5	0.2(0.3)	-28(103)	0.5(0.1)	0.047(0.026)	0.033(0.015)	1.4(0.7)	3.2(0.5)	0(80)
Well LA-6	0.5(0.3)	12(73.5)	0.5(0.1)	0.039(0.017)	0.017(0.012)	1.0(0.9)	4.7(0.6)	50(80)
Guaje Field								
Well G-1	0.5(0.3)	7(76)	0.6(0.1)	0.017(0.012)	0.011(0.008)	-4.0(1.0)	1.6(0.4)	130(80)
Well G-1A	0.4(0.3)	26(76)	0.4(0.1)	0.000(0.010)	0.006(0.010)	-5.0(1.0)	1.5(0.4)	-10(80)
Well G-2	0.4(0.3)	-5(80)	0.9(0.1)	0.005(0.008)	0.000(0.010)	-5.0(2.0)	35.0(4.0)	0(80)
Well G-3	Well inactive							
Well G-4	0.1(0.3)	30(82)	0.8(0.1)	0.005(0.016)	0.005(0.005)	-3.0(1.0)	39.0(4.0)	20(80)
Well G-5	0.4(0.3)	-58(88)	1.0(0.1)	0.000(0.010)	0.031(0.013)	-4.0(1.0)	24.0(3.0)	20(80)
Well G-6	0.1(0.3)	-2(88)	0.5(0.1)	0.004(0.009)	0.000(0.010)	-4.0(1.0)	1.1(0.4)	90(80)
Pajarito Field								
Well PM-1	-0.1(0.3)	-11(29)	2.1(0.1)	0.008(0.016)	0.000(0.010)	0.9(0.8)	4.1(0.6)	-30(80)
Well PM-2	-0.2(0.3)	55(43)	0.3(0.1)	0.011(0.020)	0.005(0.014)	1.3(0.7)	2.3(0.4)	150(80)
Well PM-3	-0.4(0.3)	-37(37)	0.8(0.1)	0.004(0.013)	0.000(0.010)	0.0(0.8)	4.6(0.6)	-20(80)
Well PM-4	0.1(0.3)	18(42)	0.3(0.1)	0.000(0.010)	0.005(0.008)	0.6(0.6)	2.2(0.4)	170(80)
Well PM-5	-0.2(0.3)	13(34)	0.2(0.1)	0.005(0.008)	0.005(0.005)	0.9(0.7)	2.3(0.4)	120(80)
Water Canyon Gallery	-0.1(0.3)	82(100)	0.2(0.1)	0.020(0.009)	0.008(0.008)	1.1(0.4)	2.1(0.4)	-470(90)
Well Field maximum	0.8(0.3)	263(115)	5.6(0.6)	0.047(0.026)	0.031(0.013)	3.0(3.0)	39.0(4.0)	170(80)
Standby Well (LA-6)	0.5(0.3)	12 (73)	2.3 (73)	0.039(0.017)	0.017(0.012)	1.0(0.9)	4.7(0.6)	50(80)
Limits of detection	0.7	40	1	0.1	0.1	3	3	50

[a]Collected in April 1990; counting uncertainties are in parentheses.

Table G-28. Chemical Quality for Parameters Covered by EPA's Primary and Secondary Standards for Water from Supply Wells and the Distribution System (mg/L)[a]

Station	Ag	As	Ba	Cd	Cr	F	Hg	NO_3-N	Pb	Se
Supply System										
Los Alamos Field										
Well LA-1B	0.001	0.041	0.052	0.001	0.028	3.2	0.0002	0.5	0.001	0.001
Well LA-2	0.001	0.011	0.088	0.001	0.021	1.7	0.0002	0.5	0.001	0.001
Well LA-3	0.001	0.005	0.052	0.001	0.009	0.7	0.0002	0.5	0.001	0.001
Well LA-5	0.001	0.007	0.080	0.001	0.006	0.4	0.0002	0.4	0.002	0.001
Guaje Field										
Well G-1	0.001	0.005	0.062	0.001	0.005	0.5	0.0002	0.4	0.001	0.001
Well G-1A	0.001	0.014	0.042	0.001	0.008	0.5	0.0002	0.4	0.008	0.001
Well G-2	0.001	0.037	0.065	0.001	0.011	0.5	0.0002	0.4	0.001	0.001
Well G-3	Well inactive									
Well G-4	0.001	0.003	0.017	0.001	0.005	0.3	0.0002	0.6	0.001	0.001
Well G-5	0.001	0.002	0.013	0.001	0.003	0.3	0.0002	0.6	0.003	0.001
Well G-6	0.001	0.003	0.008	0.001	0.005	0.3	0.0002	0.4	0.001	0.001
Pajarito Field										
Well PM-1	0.001	0.002	0.081	0.001	0.007	0.3	0.0002	0.5	0.001	0.001
Well PM-2	0.001	0.001	0.027	0.001	0.007	0.2	0.0002	0.3	0.001	0.001
Well PM-3	0.001	0.002	0.048	0.001	0.006	0.3	0.0002	0.4	0.001	0.001
Well PM-4	0.001	0.000	0.029	0.001	0.012	0.3	0.0002	0.3	0.001	0.001
Well PM-5	0.001	0.001	0.029	0.001	0.008	0.3	0.0002	0.3	0.001	—
Water Canyon Gallery	0.000	0.001	0.020	0.000	0.001	0.0	0.00021	—	—	0.001
Water supply maximum	<0.001	0.041	0.088	0.001	0.028	23.2	<0.0002	0.6	0.008	0.001
Standby Well (LA-6)	0.001	0.155	0.040	0.001	0.020	2.6	0.0002	0.4	0.001	0.001
EPA and NMEID primary maximum concentration levels	0.05	0.05	1.0	0.01	0.05	4.0	0.002	10	0.05	0.01

Table G-28 (Cont)

Station	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH[b]
Supply Wells								
Los Alamos Field								
Well LA-1B	15	0.007	0.040	0.004	53	0.007	388	7.9
Well LA-2	11	0.004	0.040	0.001	17	0.007	212	8.6
Well LA-3	2	0.001	0.040	0.001	8	0.001	92	8.4
Well LA-5	1	0.001	0.040	0.001	4	0.001	72	8.6
Guaje Field								
Well G-1	2	0.004	0.040	0.001	5	0.013	148	8.4
Well G-1A	2	0.006	0.040	0.001	5	0.011	246	8.4
Well G-2	2	0.001	0.040	0.001	5	0.006	158	8.4
Well G-3	Well inactive							
Well G-4	2	0.003	0.040	0.001	4	0.014	154	8.3
Well G-5	2	0.005	0.040	0.001	5	0.022	96	8.3
Well G-6	2	0.001	0.047	0.001	4	0.012	142	8.3
Pajarito Field								
Well PM-1	5	0.005	0.040	0.001	7	0.016	150	8.1
Well PM-2	1	0.005	0.100	0.003	2	0.010	140	8.0
Well PM-3	6	0.007	0.040	0.001	7	0.010	186	7.9
Well PM-4	1	0.005	0.040	0.001	2	0.024	122	7.8
Well PM-5	2	0.005	0.069	0.005	3	0.237	78	7.9
Water Canyon Gallery	—	0.001	1.000	0.006	—	0.013	—	—
Water supply maximum	15	0.100	0.069	0.005	53	0.237	388	8.6
Fenton Hill TA-57, Well FH-1								
Standby well (LA-6)	3	0.003	0.590	0.016	8	0.024	200	9.1
EPA and NMEID secondary maximum concentration levels	250	1.0	0.3	0.05	250	5.0	500	6.8–8.5

[a]Samples were collected in April 1990.

[b]Standard units.

Table G-29. Chemical Quality of Water from Supply Wells and the Distribution System (mg/L)[a]

Station	Al	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hard-ness	Conduc-tivity (mS/m)
Supply Wells											
Los Alamos Field											
Well LA-1B	0.03	40	13	0	2	165	5	296	0	36	64
Well LA-2	0.02	32	13	0	1	71	5	122	0	36	28
Well LA-3	0.02	34	19	0	1	36	5	121	0	50	18
Well LA-4	Well Inactive										
Well LA-5	0.01	39	16	0	1	29	5	72	0	42	14
Guaje Field											
Well G-1	0.01	88	18	0	3	27	5	70	0	49	15
Well G-1A	0.01	76	15	0	3	31	5	71	0	41	15
Well G-2	0.01	76	18	0	3	28	5	77	0	50	14
Well G-3	Well Inactive										
Well G-4	0.01	59	24	3	2	15	5	69	0	76	15
Well G-5	0.01	60	24	4	2	15	5	67	0	70	15
Well G-6	0.01	56	21	2	2	20	5	73	0	69	10
Pajarito Field											
Well PM-1	0.01	78	35	7	3	24	5	112	0	118	23
Well PM-2	0.01	80	13	3	1	12	5	56	0	46	10
Well PM-3	0.01	89	33	9	3	22	5	114	0	123	23
Well PM-4	0.01	85	14	3	2	14	5	57	0	51	11
Well PM-5	0.02	85	14	3	2	14	5	53	0	52	11
Water Canyon Gallery	1.02	40	7	3	2	6	5	34	0	28	60
Water Well/Gallery maximum	1.02	88	35	7	3	165	<5	296	0	123	64
Fenton Hill Supply, TA-57											
Standby Well (LA-6)	2.01	37	8	0	0	93	5	141	0	22	24

Table G-29 (Cont)

Station	Drinking Water Priority List				List of 83 to be Regulated					Proposed MCL
	Al	B	Mo	Sr	V	Be	Ni	Sb	Tl	NO_2-N
Supply Wells										
Los Alamos Field										
Well LA-1B	0.030	0.5	0.019	0.18	0.043	0.0001	0.003	0.0005	0.0001	0.00
Well LA-2	0.020	0.3	0.010	0.18	0.024	0.0001	0.003	0.0005	0.0001	0.01
Well LA-3	0.017	0.1	0.003	0.21	0.018	0.0001	0.001	0.0005	0.0001	0.01
Well LA-4	Well Inactive									
Well LA-5	0.011	0.1	0.002	0.17	0.019	0.0001	0.001	0.0005	0.0001	0.01
Guaje Field										
Well G-1	0.010	0.1	0.002	0.10	0.021	0.0001	0.001	0.0005	0.0001	0.01
Well G-1A	0.010	0.1	0.004	0.07	0.040	0.0001	0.001	0.0005	0.0001	0.01
Well G-2	0.010	0.1	0.003	0.08	0.079	0.0001	0.001	0.0005	0.0001	0.01
Well G-3	Well Inactive									
Well G-4	0.010	0.1	0.001	0.10	0.016	0.0001	0.001	0.0005	0.0001	0.01
Well G-5	0.010	0.1	0.001	0.08	0.012	0.0002	0.001	0.0005	0.0001	0.01
Well G-6	0.010	0.1	0.001	0.07	0.019	0.0002	0.001	0.0005	0.0001	0.01
Pajarito Field										
Well PM-1	0.012	10.0	0.001	0.15	0.011	0.0001	0.002	0.0005	0.0005	0.01
Well PM-2	0.012	10.0	0.001	0.04	0.006	0.0001	0.002	0.0005	0.0005	0.01
Well PM-3	0.013	10.0	0.001	0.13	0.013	0.0001	0.002	0.0003	0.0005	0.01
Well PM-4	0.012	10.0	0.001	0.04	0.007	0.0001	0.002	0.0002	0.0005	0.01
Well PM-5	0.024	10.0	0.001	0.04	0.008	0.0001	0.004	0.0024	0.0005	0.01
Water Canyon Gallery	1.020	0.1	0.000	0.05	0.005	0.0002	0.000	0.0001	0.0001	0.02
Standby Well (LA-6)	2.010	0.3	0.005	0.05	0.248	0.0001	0.002	0.0005	0.0001	0.01

[a]Samples were collected in April 1990.

Table G-30. Transport of Radionuclides in Runoff in Pueblo Canyon at State Road 502

Date	Radioactivity in Solution[a]						Radioactivity on Suspended Sediments[b]	
	^{239}Pu 10^{-9}uCi/mL	^{238}Pu 10^{-9}uCi/mL	^{137}Cs 10^{-9}uCi/mL	^{90}Sr 10^{-9}uCi/mL	^{3}H 10^{-6}uCi/mL	U-Total ug/L	^{239}Pu pCi/g	^{238}Pu pCi/g
3/2/90	0.025 (0.015)[c]	0.006 (0.011)	27.6	—	<0.3	1.80	1.56 (0.07)	0.12 (0.01)
3/13/90	0.024 (0.014)	0.024 (0.017)	59.5	—	<0.3	1.40	5.02 (0.20)	0.04 (0.01)
3/26/90	0.010 (0.007)	0.005 (0.014)	8.2	1.10	0.70	2.70	4.11 (0.16)	0.05 (0.01)
4/9/90	0.024 (0.014)	0.005 (0.011)	131.	0.03	0.40	—	4.67 (0.23)	0.13 (0.03)
4/20/90	0.007 (0.007)	0.027 (0.012)	12.8	—	0.30	0.70	1.12 (0.06)	0.04 (0.01)
6/1/90	0.024 (0.013)	0.012 (0.012)	—	1.10	<0.3	2.20	—	
8/7/90	0.032 (0.014)	0.000 (0.010)	704.	—	<0.3	0.8	3.68 (0.13)	0.02 (0.01)
11/15/90	0.076 (0.031)	0.000 (0.010)	79.9	—	—	0.90	3.18 (0.11)	0.05 (0.01)
12/5/90	0.093 (0.036)	0.004 (0.007)	—	—	—	0.80	31.10 (1.13)	0.09 (0.04)

[a]As measured in liquid passing through 0.45 micron membrane filter.
[a]As measured on solids retained by 0.45 micron filter
[c]Counting uncertainities shown in parentheses for plutonium analyses.

Table G-31. Number of Results above the Analytical LOQs for Organic Compounds in Surface Water and Groundwaters from Perimeter and On-Site Locations (Noneffluent and Effluent Areas)[a]

	Date (1990)	Type of Organic Compound				
		Volatile	Semivolatile	Pesticide	Herbicide	PCB
Number of Compounds Analyzed		68	71	19	2	4
Perimeter Stations						
Los Alamos Reservoir		0	0	0	0	0
Guaje Canyon		0	1	0	0	1
Frijoles		0	0	0	0	0
La Mesita Spring		0	0	0	0	0
Sacred Spring		0	0	0	0	0
Indian Spring		0	1	0	0	0
On-Site Stations						
Test Well 3		0	0	0	0	0
Test Well DT-5A		0	0	0	0	0
Test Well 8		0	0	0	0	0
Test Well DT-9		0	0	0	0	0
Test Well DT-10		0	0	0	0	0
Cañada del Buey		0	0	0	0	0
Pajarito		0	0	0	0	0
Water Canyon at Beta		0	0	0	0	0
PCO-1		0	0	0	0	0
PCO-2		0	0	0	0	0
PCO-3		0	0	0	0	0
Effluent Release Areas						
Acid-Pueblo Canyon						
Test Well 1A		0	0	0	0	0
Water Supply and Distribution System						
Los Alamos Well Field						
Well LA-1B		0	0	0	0	0
Well LA-2		0	0	0	0	0
Well LA-3		0	0	0	0	0
Well LA-5		0	0	0	0	0
Well LA-6		0	0	0	0	0
Otowi Well Field						
Well O-1		0	0	0	0	0
Well O-4		0	1	0	0	0

[a]See Table VI-6 for values of analytical results reported above the LOQs and Appendix C for list of compounds analyzed in each set.

Table G-32. Locations of Soil and Sediment Sampling Stations

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate	Map Designation[a]
Regional Sediments			
Chamita	36°05″	106°07″	—
Embudo	36°12″	106°58″	—
Otowi	35°52″	106°08″	—
Sandia	S060	E490	—
Pajarito	S185	E410	—
Water	S237	E388	—
Ancho	S305	E335	—
Frijoles	S375	E235	—
Cochiti	35°37″	106°19″	—
Bernalillo	35°17″	106°36″	—
Jemez River	35°40″	106°44″	—
Perimeter Sediments[b]			
Guaje at SR-4	N135	E480	12
Bayo at SR-4	N100	E455	13
Sandia at SR-4	N025	E315	14
Mortandad at SR-4	S030	E350	15
Cañada del Buey at SR-4	S090	E360	16
Pajarito at SR-4	S105	E320	17
Potrillo at SR-4	S136	E285	18
Fence at SR-4	S139	E280	
Water at SR-4	S170	E260	19
Indio at SR-4			
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-32 (Cont)

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate	Map Designation[a]
Effluent Release Area Sediments (Cont)			
Mortandad Canyon			
Mortandad near CMR Building	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			
Los Alamos Sportsman 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
On-Site 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 are given in Figs. 15 and 20; sediment sampling locations, in Figs. 15 and 21.

[b]The five sediment stations on Potrillo, Fence, Indio, Water, and Ancho Canyons located at State Road 4 are considered perimeter stations because all Laboratory facilities are located west of State Road 4. Eight additional sediment stations are located at the confluence of the Rio Grande and the following major canyons: Sandia, Cañada Ancha, Mortandad, Pajarito, Water, Ancho, Chaquihui, and Frijoles.

Table G-33. Radiochemical Analyses of Regional Soils and Sediments[a]

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (counts/min/g)
Soils						
Chamita	0.7 (0.3)	0.36 (0.08)	3.6 (0.4)	0.104 (0.007)	0.092 (0.007)	1.5 (0.4)
Embudo	0.8 (0.3)	0.72 (0.13)	2.1 (0.2)	0.000 (0.001)	0.013 (0.002)	1.3 (0.4)
Otowi	0.5 (0.3)	0.45 (0.10)	2.6 (0.3)	0.001 (0.000)	0.023 (0.002)	2.0 (0.4)
Near Santa Cruz Lake	0.8 (0.3)	0.44 (0.12)	3.0 (0.3)	0.000 (0.000)	0.016 (0.002)	0.8 (0.4)
Cochiti	0.5 (0.3)	0.37 (0.12)	1.9 (0.2)	0.000 (0.004)	0.005 (0.001)	0.5 (0.4)
Bernalillo	0.5 (0.3)	0.16 (0.07)	1.5 (0.2)	0.000 (0.004)	0.001 (0.001)	0.8 (0.4)
Jemez	0.4 (0.3)	0.25 (0.11)	2.0 (0.2)	0.003 (0.004)	0.001 (0.001)	0.8 (0.4)
Maximum	0.8 (0.3)	0.72 (0.13)	3.6 (0.4)	0.104 (0.007)	0.092 (0.007)	2.0 (0.4)
Sediments						
Rio Chama						
Chamita	—	0.13 (0.09)	—	0.000 (0.000)	0.001 (0.001)	4.0 (0.6)
Rio Grande						
Embudo	—	0.12 (0.08)	—	0.001 (0.001)	0.002 (0.001)	4.5 (0.6)
Otowi	—	0.71 (0.44)	—	0.001 (0.001)	0.003 (0.001)	3.1 (0.5)
Sandia	0.3 (0.3)	0.24 (0.09)	2.7 (0.3)	0.000 (0.001)	0.002 (0.001)	1.7 (0.4)
Pajarito	0.3 (0.3)	0.22 (0.10)	3.3 (0.3)	0.001 (0.001)	0.003 (0.001)	1.6 (0.4)
Ancho	0.3 (0.3)	0.22 (0.08)	2.5 (0.3)	0.000 (0.001)	0.004 (0.001)	1.2 (0.4)
Frijoles	0.4 (0.3)	0.14 (0.10)	3.2 (0.3)	0.000 (0.000)	0.002 (0.001)	2.4 (0.5)
Bernalillo	—	0.13 (0.08)	—	0.004 (0.001)	0.004 (0.001)	4.7 (0.6)
Jemez River						
Near Jemez	—	0.64 (0.41)	—	0.004 (0.001)	0.003 (0.002)	5.1 (0.7)
Maximum	0.4 (0.3)	0.71 (0.44)	3.3 (0.3)	0.004 (0.001)	0.004 (0.001)	5.1 (0.7)

[a]Samples were collected in April-October 1990; counting uncertainties are in parentheses.

Table G-34. Radiochemical Analyses of Perimeter Sediments[a]

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (counts/min/g)
Perimeter Sediments						
Guaje at SR-4	0.5 (0.2)	0.70 (0.12)	2.7 (0.3)	0.000 (0.000)	0.001 (0.001)	–0.6 (0.4)
Bayo at SR-4	0.9 (0.4)	0.08 (0.10)	2.7 (0.3)	0.002 (0.001)	0.003 (0.002)	–0.4 (0.4)
Sandia at SR-4	0.4 (0.2)	0.10 (0.08)	4.1 (0.4)	0.014 (0.002)	0.069 (0.005)	0.4 (0.4)
Mortandad at SR-4	0.9 (0.3)	0.19 (0.07)	2.5 (0.2)	0.004 (0.002)	0.003 (0.002)	0.4 (0.4)
Cañada del Buey at SR-4	1.7 (0.3)	0.22 (0.09)	1.3 (0.1)	0.002 (0.001)	0.002 (0.002)	–1.0 (0.4)
Pajarito at SR-4	0.9 (0.3)	0.11 (0.11)	2.4 (0.2)	0.001 (0.001)	0.002 (0.001)	0.5 (0.4)
Potrillo at SR-4	1.1 (0.3)	0.34 (0.09)	2.4 (0.2)	0.002 (0.001)	0.002 (0.001)	0.3 (0.4)
Fence at SR-4	1.0 (0.4)	0.40 (0.12)	3.1 (0.3)	0.001 (0.000)	0.013 (0.002)	0.5 (0.4)
Indio at SR-4	1.7 (0.3)	–0.11 (0.03)	1.8 (0.2)	0.000 (0.000)	0.001 (0.000)	–1.4 (0.4)
Water at SR-4	2.2 (0.7)	0.04 (0.07)	1.5 (0.2)	0.000 (0.001)	0.002 (0.001)	–1.9 (0.4)
Ancho at SR-4	8.2 (0.9)	0.35 (0.13)	1.5 (0.2)	0.000 (0.001)	0.002 (0.001)	–1.2 (0.4)
Frijoles at Bandelier	0.5 (0.3)	0.15 (0.10)	5.2 (0.5)	0.002 (0.004)	0.006 (0.001)	4.7 (0.6)
Sandia at Rio Grande	0.8 (0.3)	0.04 (0.08)	1.6 (0.2)	0.002 (0.001)	0.033 (0.003)	0.2 (0.4)
Cañada Ancha at Rio Grande	0.4 (0.3)	0.07 (0.07)	1.5 (0.1)	0.000 (0.000)	0.001 (0.001)	–0.8 (0.4)
Mortandad at Rio Grande	0.5 (0.3)	0.11 (0.09)	1.3 (0.1)	0.000 (0.001)	0.001 (0.001)	0.7 (0.4)
Pajarito at Rio Grande	0.5 (0.3)	0.11 (0.09)	2.3 (0.2)	0.004 (0.001)	0.017 (0.002)	–0.2 (0.4)
Water at Rio Grande	0.5 (0.3)	0.11 (0.09)	1.2 (0.1)	0.000 (0.000)	0.002 (0.001)	0.2 (0.4)
Ancho at Rio Grande	0.3 (0.3)	0.44 (0.09)	3.9 (0.4)	0.000 (0.001)	0.005 (0.001)	2.6 (0.5)
Chaquihui at Rio Grande	0.5 (0.3)	0.17 (0.09)	2.4 (0.2)	0.000 (0.000)	0.003 (0.001)	–0.1 (0.4)
Frijoles at Rio Grande	0.2 (0.3)	0.16 (0.09)	2.9 (0.3)	0.001 (0.001)	0.005 (0.001)	1.8 (0.4)
Maximum	8.2 (0.9)	0.70 (0.12)	5.2 (0.5)	0.014 (0.002)	0.069 (0.005)	4.7 (0.6)

[a]Samples were collected in May-October 1990; counting uncertainties are in parentheses.

Table G-35. Trace Metals (total) in Perimeter Sediments (micrograms/gram)[b]

Location	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
Perimeter Sediments								
Guaje at SR-4	0.9	0.32	390	4	6	0.025	20.0	0.12
Bayo at SR-4	1.1	1.9	310	4	14	0.025	20.0	0.11
Pueblo at SR-4	0.5	0.25	90	4	4	0.025	20.0	0.27
Los Alamos at SR-4	1.2	0.24	123	4	4	0.025	20.0	0.14
Sandia at SR-4	0.9	0.22	120	4	9.1	0.025	20.0	0.13
Mortandad at SR-4	1.8	0.61	160	4	9.1	0.025	20.0	0.13
Cañada del Buey at SR-4	0.5	0.3	220	4	4	0.025	28.0	1.5
Pajarito at SR-4	0.38	0.38	220	4	4	0.025	20.0	0.05
Potrillo at SR-4	0.5	0.71	180	4	9.1	0.025	22.0	0.05
Fence at SR-4	0.5	0.8	250	4	8.2	0.03	20.0	0.055
Indio at SR-4	0.5	2.1	270	4	9.8	0.025	20.0	0.1
Water at SR-4	0.5	0.22	210	4	4	0.025	20.0	0.5
Ancho at SR-4	0.5	0.33	200	4	4.4	0.025	20.0	0.05
Detection Limit	0.5	1.0	100	4	4	0.025	20	0.5

[a]Samples were collected in May-October 1990;
[b]Analyses are for total abundance of selected metals in the sediment samples

Table G-36. Radiochemical Analyses of On-Site Soils and Sediments[a]

Location	^{3}H (10^{-6} µCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Gamma (counts/min/g)
On-Site Soils								
TA-21	3.6 (0.5)	—	0.42 (0.13)	—	0.002 (0.001)	0.001 (0.001)	—	3.3 (0.5)
East of TA-53	4.5 (0.6)	—	0.68 (0.12)	—	0.003 (0.001)	0.056 (0.004)	—	3.4 (0.5)
TA-50	2.6 (0.4)	—	1.90 (0.64)	—	0.004 (0.001)	0.012 (0.002)	—	2.8 (0.5)
Two-Mile Mesa	0.2 (0.3)	—	0.30 (0.40)	—	0.001 (0.001)	0.003 (0.001)	—	3.3 (0.5)
East of TA-54	1.3 (0.4)	—	0.10 (0.08)	—	0.001 (0.000)	0.007 (0.001)	—	3.2 (0.5)
R-Site Road	0.5 (0.3)	—	1.88 (0.45)	—	0.001 (0.001)	0.024 (0.003)	—	3.2 (0.5)
Potrillo Drive	1.1 (0.3)	—	0.63 (0.12)	—	0.001 (0.001)	0.022 (0.003)	—	3.8 (0.6)
S-Site	0.3 (0.3)	—	1.03 (0.42)	—	0.001 (0.001)	0.002 (0.001)	—	1.9 (0.4)
Near test well DT-9	0.6 (0.3)	—	0.93 (0.43)	—	0.000 (0.000)	0.005 (0.001)	—	4.0 (0.6)
Near TA-33	13.0 (1.0)	—	0.30 (0.08)	—	0.001 (0.001)	0.007 (0.001)	—	3.9 (0.6)
Maximum	13.0 (1.0)	—	1.90 (0.64)	—	0.004 (0.001)	0.056 (0.004)	—	4.0 (0.6)
Sediments from Effluent Release Areas								
Acid-Pueblo Canyon								
Acid Weir	0.3 (0.3)	—	0.25 (0.09)	1.8 (0.2)	0.043 (0.007)	5.170 (0.277)	—	4.8 (0.6)
Pueblo 1	0.3 (0.3)	—	0.19 (0.08)	3.1 (0.3)	0.054 (0.004)	0.563 (0.023)	—	3.4 (0.5)
Pueblo 2	3.0 (2.0)	—	0.42 (0.38)	1.8 (0.2)	0.004 (0.001)	0.453 (0.017)	—	1.9 (0.4)
Hamilton Bend Spring	0.7 (0.3)	—	0.68 (0.38)	3.5 (0.4)	0.002 (0.001)	0.210 (0.010)	—	5.0 (0.6)
Pueblo 3	0.4 (0.3)	—	0.12 (0.07)	2.9 (0.3)	0.000 (0.000)	0.004 (0.001)	—	2.4 (0.5)
Pueblo at SR-4	0.0 (0.3)	—	0.44 (0.41)	4.0 (0.4)	0.015 (0.002)	0.810 (0.027)	—	7.2 (0.8)
Maximum	3.0 (2.0)	—	0.68 (0.38)	4.0 (0.4)	0.054 (0.004)	5.170 (0.277)	—	7.2 (0.8)

Table G-36. (Cont)

Location	^{3}H (10^{-6} µCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Gamma (counts/min/g)
Sediments from Effluent Release Areas (Cont)								
DP—Los Alamos Canyon								
DP Canyon at DPS-1	—	0.26 (0.17)	0.16 (0.08)	2.0 (0.2)	0.005 (0.004)	0.020 (0.002)	0.056 (0.004)	1.8 (0.4)
DP Canyon at DPS-4	—	0.97 (0.24)	1.43 (0.23)	2.8 (0.3)	0.028 (0.003)	0.079 (0.005)	0.171 (0.008)	3.0 (0.5)
Los Alamos Canyon at Bridge	—	0.21 (0.16)	0.18 (0.11)	2.4 (0.2)	0.002 (0.004)	0.002 (0.004)	0.007 (0.001)	1.5 (0.4)
Los Alamos Canyon at LAO-1	—	0.07 (0.19)	0.21 (0.12)	2.5 (0.2)	0.007 (0.001)	0.153 (0.008)	0.007 (0.001)	2.9 (0.5)
Los Alamos Canyon at GS-1	—	0.17 (0.18)	0.06 (0.07)	2.7 (0.3)	0.012 (0.002)	0.073 (0.005)	0.012 (0.002)	3.7 (0.5)
Los Alamos Canyon at LAO-3	—	0.78 (0.19)	1.15 (0.19)	2.4 (0.2)	0.024 (0.003)	0.099 (0.006)	0.149 (0.008)	2.4 (0.5)
Los Alamos Canyon at LAO-4.5	—	0.93 (0.30)	1.23 (0.20)	2.1 (0.2)	0.023 (0.002)	0.072 (0.005)	0.103 (0.006)	2.0 (0.4)
Los Alamos Canyon at SR-4	—	0.32 (0.45)	0.88 (0.17)	2.0 (0.2)	0.020 (0.002)	0.053 (0.004)	0.066 (0.006)	1.6 (0.4)
Los Alamos Canyon at Totavi	—	0.12 (0.16)	0.02 (0.09)	1.7 (0.2)	0.000 (0.004)	0.016 (0.002)	0.009 (0.001)	1.4 (0.4)
Los Alamos Canyon at LA-2	—	0.11 (0.17)	0.11 (0.10)	1.9 (0.2)	0.001 (0.001)	0.026 (0.002)	0.008 (0.001)	1.3 (0.4)
Los Alamos Canyon at Otowi	—	0.39 (0.27)	0.11 (0.07)	2.1 (0.2)	0.000 (0.004)	0.149 (0.007)	0.021 (0.002)	2.0 (0.4)
Maximum	—	0.97 (0.24)	1.43 (0.23)	2.8 (0.3)	0.028 (0.003)	0.153 (0.008)	0.171 (0.008)	3.7 (0.5)
Mortandad Canyon								
Mortandad at CMR Building	—	0.93 (0.21)	0.13 (0.07)	1.9 (0.2)	0.043 (0.011)	0.000 (0.000)	0.064 (0.088)	-6.5 (0.7)
Mortandad west of GS-1	—	0.44 (0.19)	0.73 (0.41)	1.5 (0.2)	0.017 (0.010)	0.012 (0.007)	0.128 (0.095)	0.9 (0.4)
Mortandad at GS-1	—	0.90 (0.20)	27.40 (4.12)	3.1 (0.3)	7.480 (0.282)	16.800 (0.596)	31.000 (4.700)	68.0 (7.0)
Mortandad at MCO-5	—	2.37 (0.43)	1.08 (0.18)	1.8 (0.2)	3.040 (0.133)	10.400 (0.390)	14.200 (2.140)	14.0 (1.0)
Mortandad at MCO-7	—	0.80 (0.19)	3.38 (0.62)	2.1 (0.2)	2.450 (0.110)	3.590 (0.151)	4.450 (0.680)	14.0 (1.0)
Mortandad at MCO-9	—	0.41 (0.19)	0.41 (0.10)	5.0 (0.5)	0.008 (0.005)	0.011 (0.009)	0.226 (0.113)	4.1 (0.6)
Mortandad at MCO-13	—	0.50 (0.20)	1.78 (0.47)	2.3 (0.2)	0.004 (0.005)	0.024 (0.008)	0.044 (0.085)	1.2 (0.4)
Maximum	—	2.37 (0.43)	27.40 (4.12)	5.0 (0.5)	7.480 (0.282)	16.800 (0.596)	31.000 (4.700)	68.0 (7.0)

[a]Samples were collected in May 1990; counting uncertainties are in parentheses.

Table G-37. Trace Metals in Solution Extracted from On-Site Sediments[a]

Location	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
Sediments from Effluent Release Areas								
Acid-Pueblo Canyon								
Acid Weir	0.01	0.002	0.02	0.04	0.08	0.0002	0.2	0.001
Pueblo 1	0.01	0.0028	0.04	0.04	0.08	0.0002	0.2	0.001
Pueblo 2	0.01	0.002	0.01	0.04	0.08	0.0002	0.2	0.001
Hamilton Bend Spring	0.01	0.002	0.02	0.04	0.08	0.0002	0.2	0.001
Pueblo 3	0.01	0.002	0.12	0.04	0.08	0.0002	0.2	0.001
Pueblo at SR-4	0.01	0.0042	0.03	0.04	0.08	0.0002	0.2	0.001
DP—Los Alamos Canyon								
DP Canyon at DPS-1	0.01	0.002	0.11	0.06	0.08	0.0002	0.4	0.001
DP Canyon at DPS-4	0.01	0.002	0.14	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at Bridge	0.01	0.0021	0.08	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at LAO-1	0.01	0.002	0.065	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at GS-1	0.01	0.002	0.16	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at LAO-3	0.01	0.002	0.14	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at LAO-4.5	0.01	0.002	0.12	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at SR-4	0.01	0.002	0.036	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at Totavi	0.01	0.002	0.14	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at LA-2	0.01	0.002	0.16	0.06	0.08	0.0002	0.4	0.001
Los Alamos Canyon at Otowi	0.01	0.002	0.14	0.06	0.08	0.0002	0.4	0.001
Mortandad Canyon								
Mortandad at CMR Building	0.01	0.002	0.12	0.009	0.02	0.0002	0.08	0.001
Mortandad west of GS-1	0.01	0.002	0.67	0.009	0.02	0.0002	0.14	0.001
Mortandad at GS-1	0.01	0.002	0.11	0.009	0.02	0.0002	0.07	0.001
Mortandad at MCO-5	0.01	0.002	0.11	0.009	0.02	0.0002	0.07	0.001
Mortandad at MCO-7	0.01	0.002	0.2	0.009	0.02	0.0002	0.07	0.001
Mortandad at MCO-9	0.01	0.002	0.02	0.009	0.02	0.0002	0.08	0.001
Mortandad at MCO-13	0.01	0.002	0.006	0.009	0.02	0.0002	0.14	0.001
Extraction Procedure								
Toxic Threshold	5.0	5.0	100	1.0	5.0	2.0	5.0	1.0
Detection Limit	0.005	0.002	0.5	0.01	0.04	0.002	0.05	0.001

[a]Analysis (mg/L) by EP Toxicity methods; samples were collected in May 1990.

Table G-38. Radiochemical Analyses of Sediments from Reservoirs on the Rio Chama and Rio Grande[a]

Location	^{3}H (10^{-6} μCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (μg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Gamma (counts/min/g)
Abiquiu Reservoir								
Upper	0.0 (0.2)	0.10 (0.20)	0.234(0.088)	2.4 (0.2)	0.0001 (0.0001)	0.0008 (0.0001)	0.0019 (0.0011)	0.7 (0.4)
Middle	0.3 (0.2)	0.31 (0.20)	0.325(0.101)	2.5 (0.3)	0.00022(0.00006)	0.0037 (0.0002)	0.0034 (0.0009)	0.9 (0.4)
Lower	0.2 (0.2)	0.49 (0.20)	0.188(0.094)	2.9 (0.3)	0.0001 (0.0001)	0.0034 (0.0004)	0.0043 (0.0011)	1.2 (0.4)
Maximum	0.3 (0.2)	0.49 (0.20)	0.325(0.101)	2.9 (0.3)	0.00022(0.00006)	0.0037 (0.0002)	0.0043 (0.0011)	1.2 (0.4)
Cochiti Reservoir								
Upper	0.0 (0.3)	—	0.29(0.12)	2.9 (0.3)	0.007 (0.0001)	0.0209 (0.0011)	0.02 (0.004)	1.6 (0.4)
Middle	0.2 (0.3)	—	0.55(0.13)	4.6 (0.4)	0.0011 (0.0001)	0.0225 (0.0014)	0.016 (0.002)	3.1 (0.5)
Lower	0.0 (0.3)	—	0.40(0.09)	3.8 (0.4)	0.0016(0.0001)	0.0094 (0.0004)	0.011 (0.002)	3.0 (0.5)
Maximum	0.2 (0.3)	—	0.55(0.13)	4.6 (0.4)	0.007 (0.0001)	0.0225 (0.0014)	0.02 (0.004)	3.1 (0.5)
Background (1974—1986)[b]	—	0.87	0.44	4.4	0.006	0.023	—	—

[a]Samples were collected in June 1990; counting uncertainties are in parentheses.

[b]Background, upper limit (Purtymun 1987a).

Table G-39. Number of Results above the Analytical LOQs for Organics in Sediments from Regional and Perimeter Locations

	Type of Organic Compound				
	Volatile	**Semivolatile**	**Pesticide**	**Herbicide**	**PCB**
Number of Compounds Analyzed	68	71	19	2	4
Regional Sediments					
Rio Chama	1	1	0	0	0
Embudo	0	1	0	0	0
Otowi	1	1	0	0	0
Santa Cruz	0	1	0	0	0
Cochiti	0	0	0	0	0
Bernalillo	0	1	0	0	0
Jemez	0	0	0	0	0
Perimeter Sediments					
Guaje at SR-4	0	0	0	0	0
Bayo at SR-4	0	0	0	0	0
Sandia at SR-4	0	0	0	0	0
Mortandad at SR-4	0	0	0	0	0
Cañada de Buey at SR-4	0	0	0	0	0
Pajarito at SR-4	0	0	0	0	0
Potrillo at SR-4	0	0	0	0	0
Fence at SR-4	0	0	0	0	0
Indio at SR-4	0	0	0	0	0
Water at SR-4	0	0	0	0	0
Ancho at SR-4	0	0	0	0	0
Frijoles at National Monument Headquarters	0	1	0	0	0
Effluent Release Area Sediments					
Acid-Pueblo Canyons					
Pueblo at SR-4	0	0	0	0	0
DP-Los Alamos Canyons					
Los Alamos at SR-4	0	0	0	0	0

Table G-40. Radiochemical Analyses of Sediments from an Active Waste Management Area (TA-54)[a]

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	Gross $^{239,240}Pu$ (pCi/g)	Gamma (counts/min/g)
Station Number						
1	23.0(2.0)	-0.07(0.07)	1.6(0.2)	0.002(0.001)	0.003(0.001)	2.2(0.5)
2	23.0(2.0)	0.05(0.07)	2.7(0.3)	0.008(0.002)	0.026(0.004)	3.7(0.5)
3	88.0(9.0)	0.05(0.07)	2.3(0.2)	0.004(0.001)	0.012(0.002)	3.7(0.6)
4	54.0(5.0)	0.37(0.09)	3.8(0.4)	0.005(0.001)	0.021(0.002)	3.0(0.5)
5	71.0(7.0)	0.15(0.08)	2.2(0.2)	0.006(0.002)	0.017(0.002)	4.3(0.6)
6	38.0(4.0)	0.08(0.06)	2.3(0.2)	0.006(0.001)	0.020(0.002)	3.1(0.5)
7	44.0(4.0)	0.01(0.07)	2.1(0.2)	0.005(0.003)	0.029(0.003)	3.4(0.5)
8	43.0(4.0)	0.14(0.08)	2.7(0.3)	0.003(0.002)	0.013(0.003)	3.6(0.5)
9	49.0(5.0)	0.08(0.07)	2.3(0.2)	0.003(0.001)	0.013(0.002)	3.8(0.6)
Maximum concentration	88.0(9.0)	0.37(0.09)	3.8(0.4)	0.008(0.002)	0.029(0.003)	4.3(0.6)
Background (1974—1986)	7.2	0.44	4.4	0.006	0.023	7.9
Maximum concentration as a percentage of background	1200	84	86	133	126	54
Analytical limits of detection	0.7	0.1	0.3	0.002	0.002	0.1

[a]Samples were collected in August 1990; counting uncertainties are in parentheses.

Table G-41. Summary of Radiochemical Analyses of Sediments from TA-49

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total Uranium (mg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (counts/min/L)
A-1	21.0 (2.0)	0.08 (0.09)	3.2 (0.3)	0.000 (0.001)	0.002 (0.001)	3.1 (0.5)
A-2	5.2 (0.6)	0.15 (0.12)	2.2 (0.2)	0.005 (0.001)	0.003 (0.001)	1.4 (0.4)
A-3	7.8 (0.9)	0.20 (0.09)	2.8 (0.3)	0.000 (0.001)	0.002 (0.001)	1.3 (0.4)
A-4	13.0 (1.0)	0.20 (0.12)	3.3 (0.3)	0.002 (0.001)	0.002 (0.001)	2.4 (0.5)
A-4A	8.1 (0.9)	0.08 (0.08)	3.8 (0.4)	0.000 (0.000)	0.002 (0.001)	2.1 (0.5)
A-5	36.0 (4.0)	0.14 (0.12)	2.0 (0.2)	0.001 (0.001)	0.001 (0.001)	0.5 (0.4)
A-6	10.0 (1.0)	0.16 (0.09)	2.5 (0.2)	0.000 (0.000)	0.004 (0.001)	1.7 (0.4)
A-7	9.0 (1.0)	0.20 (0.12)	2.4 (0.2)	0.001 (0.001)	0.003 (0.001)	1.5 (0.4)
A-8	10.0 (1.0)	0.11 (0.08)	2.7 (0.3)	0.003 (0.001)	0.002 (0.001)	2.1 (0.5)
A-9	16.0 (2.0)	0.21 (0.13)	2.0 (0.2)	0.001 (0.001)	0.003 (0.001)	1.8 (0.4)
A-10	2.8 (0.4)	0.03 (0.08)	3.8 (0.4)	0.002 (0.001)	0.002 (0.001)	3.4 (0.5)
A-11	6.6 (0.8)	0.23 (0.12)	3.4 (0.3)	0.000 (0.000)	0.004 (0.001)	2.9 (0.5)
Sediment background (1974—1986)[a]		0.44	4.4	0.006	0.023	

[a]See Purtymun (1987a).

Table G-42. Trace Metals in Solution Extracted from Sediments at TA-49 (mg/L)

	Ag	As	Ba	Cd	Cr	Hg	Pb	Se	Be total mg/g	Ni CN mg/L	total mg/g
Extraction procedure toxic threshold	5.0	5.0	100	1.0	5.0	2.0	5.0	1.0	N/A	N/A	N/A
Limits of detection	0.005	0.002	0.5	0.01	0.04	0.002	0.05	0.001	0.01	0.01	0.01
Stations											
A-1	0.01	0.002	0.1	0.05	0.1	0.0002	1.0	0.001	0.0005	0.015	0.1
A-2	0.01	0.002	0.13	0.05	0.1	0.0002	1.0	0.001	0.0005	0.02	0.1
A-3	0.01	0.002	0.09	0.05	0.1	0.0002	1.0	0.001	0.0005	0.012	0.1
A-4	0.01	0.002	0.12	0.05	0.1	0.0002	1.0	0.003	0.0005	0.015	0.1
A-4A	0.01	0.002	0.09	0.05	0.1	0.0002	1.0	0.001	0.0005	0.015	0.1
A-5	0.01	0.002	0.08	0.05	0.1	0.0002	1.0	0.001	0.0005	0.015	0.1
A-6	0.01	0.002	0.1	0.05	0.1	0.0002	1.0	0.001	0.0005	0.015	0.1
A-7	0.01	0.002	0.12	0.05	0.1	0.0002	1.0	0.001	0.0005	0.012	0.1
A-8	0.01	0.002	0.09	0.05	0.1	0.0002	1.0	0.001	0.0005	0.015	0.1
A-9	0.01	0.002	0.08	0.05	0.1	0.0002	1.0	0.001	0.0005	0.01	0.1
A-10	0.01	0.002	0.15	0.05	0.1	0.0002	1.0	0.001	0.0005	0.015	0.1
A-11	0.01	0.002	0.1	0.05	0.1	0.0002	1.0	0.001	0.0005	0.015	0.1
Maximum	0.01	0.002	0.15	0.05	0.1	0.0002	1.0	0.001	0.0005	0.015	0.01

[a]BLD = below limits of detection.

Table G-43. Number of Results above the Analytical LOQ for Organic Compounds in Sediments from TA-49

	Type of Organic Compound				
	Volatile	Semivolatile	Pesticide	Herbicide	PCB
Number of Compounds Analyzed	68	71	19	2	4
Stations					
A-1	1	0	0	0	0
A-2	1	0	0	0	0
A-3	1	0	0	0	
A-4	1	0	0	0	0
A-4A	1	0	0	0	0
A-5	1	0	0	0	0
A-6	1	0	0	0	0
A-7	1	0	0	0	0
A-8	0	0	0	0	0
A-9	1	0	0	0	0
A-10	1	0	0	0	0
A-11	1	0	0	0	0

Table G-44. Locations of Beehives

Station	North-South Coordinate	East-West Coordinate
Regional Stations (28 – 44 km), Uncontrolled Areas		
1. Chimayo	—	—
13. San Pedro	—	—
Perimeter Stations (0 – 4 km), Uncontrolled Areas		
2. Northern Los Alamos County	N180	W020
3. Pajarito Acres	S210	E380
On-Site Stations, Controlled Areas		
4. TA-21 (DP Canyon)	N095	E180
5. TA-50 (Upper Mortandad Canyon)	N040	E095
6. TA-53 (LAMPF)	N050	E220
7. Lower Mortandad Canyon	N020	E185
8. TA-8 (Anchor Site W)	S020	W065
9. TA-33 (HP-Site)	S260	E265
10. TA-54 (Area G)	N050	E220
11. TA-9 (Anchor Site E)	S005	W040
12. TA-15 (R-Site)	S020	E065
14. Near TA-49, Frijoles Mesa	S160	E105
15. TA-16 (S-Site)	S055	W080

Table G-45. Radionuclides in Local and Regional Produce Collected During the 1990 Growing Season[a]

	^{3}H (pCi/mL)	^{90}Sr (10^{-3} pCi/dry g)	Uranium (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)
Española						
N	13	8	12	12	12	12
Mean	0.6	19	5.4	6.9	4.2	76
Std dev	0.3	19	3.3	13	7.7	84
Minimum	0.0 (0.3)[b]	1.5 (2.4)	0.6 (0.1)	−13.5 (0.6)	−7.3 (0.3)	−15 (30)
Maximum	1.0 (0.3)	53 (22.0)	10.2 (1.0)	40 (40.0)	20.7 (17.7)	231 (262)
San Ildefonso						
N	3	3	3	2	3	3
Mean	0.7	17	15	1.2	8	143
Std dev	0.2	17	24.5	1.8	5.3	139
Minimum	0.5 (0.3)	1.3 (2.3)	0.7 (0.1)	0.0 (2.5)	3.6 (2.2)	18 (53)
Maximum	0.9 (0.3)	34 (4.5)	43.7 (4.4)	2.5 (17.2)	13.6 (13.8)	292 (256)
Cochiti/Santo Domingo						
N	12	11	13	13	13	13
Mean	0.5	14	7	2.4	39	165
Std dev	0.2	16	4.5	9.9	71	144
Minimum	0.2 (0.3)	0.3 (1.8)	0.4 (0.0)	−21.5 (3.6)	−4.3 (2.2)	2.7(30)
Maximum	0.8 (0.3)	4.8 (6.9)	17.5 (1.8)	18.7 (21.5)	239 (239.0)	413.3(274)
Los Alamos/White Rock						
N	15	7	16	15	15	15
Mean	1.0	13	5.1	17	27	157
Std dev	0.5	9.6	3.5	24	48	186
Minimum	0.2 (0.3)	1.2 (3.6)	1.7 (0.2)	0.0 (2.2)	−4.3 (2.2)	29 (26)
Maximum	2.1 (0.4)	27 (19.0)	13.6 (1.4)	73 (77.0)	175 (64.5)	733 (414)
On-Site						
N	7	2	7	6	6	7
Mean	1.8	6.8	6.3	24	10	46
Std dev	1.4	5.1	3.3	30	22	60
Minimum	0.5 (0.3)	3.2 (4.0)	1.4 (0.1)	0.0 (3.9)	−16 (0.0)	−31 (33)
Maximum	4.0 (0.5)	10 (4.0)	10.0 (1.0)	78 (56.0)	40 (36.3)	121 (63)

[a]There are no concentration guides for produce.
[b]Counting uncertainties are in parentheses.

Table G-46. Radionuclides in Fish.[a]

	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	Uranium (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
Catfish					
Abiquiu[b]					
N	11	11	11	11	11
Mean	44	268	6.5	5	3
Std dev	31	334	0.6	10	8
Minimum	2 (2)	−90 (58)	0.7 (0.1)	−7 (2)	0 (2)
Maximum	98 (10)	927 (748)	12.3 (1.3)	27 (32)	16 (32)
Cochiti[b]					
N	12	12	12	12	12
Mean	16	178	5.9	3	−0.2
Std dev	9	177	3.6	7	3
Minimum	5 (2)	48 (44)	1.4 (0.2)	−8 (0)	−6 (1)
Maximum	30 (4)	642 (384)	10.4 (1.0)	13 (9)	5 (7)
Crappie					
Abiquiu[c]					
N	36	46	46	25	25
Mean	116	22	1.7	2	5
Std dev	64	52	0.4	4	4
Minimum	26 (2)	−210 (120)	0.5 (0.1)	−14 (11)	−5 (6)
Maximum	500 (25)	240 (170)	3.2 (0.3)	14 (10)	14 (14)
Cochiti[b]					
N	12	12	12	12	12
Mean	76	203	4.9	5	7
Std dev	19	209	1.0	10	11
Minimum	48 (6)	−32 (60)	3.6 (0.1)	−11 (3)	−5 (3)
Maximum	122 (18)	496 (459)	7.6 (0.7)	21 (35)	35 (26)

[a]Counting uncertainties are in parentheses.

[b]Data are from 1990.

[c]Data are from 1986–1989.

Table G-47. Selected Radionuclides in Local and Regional Honey Collected During 1989.[a]

Station	^{3}H (pCi/L)	^{7}Be (pCi/L)	^{22}Na (pCi/L)	^{54}Mn (pCi/L)	^{57}Co (pCi/L)	^{83}Rb (pCi/L)	^{137}Cs (pCi/L)
El Rancho	0 (300)	68 (1 700)	16 (400)	2 (300)	8 (110)	22 (460)	58 (300)
Chimayo	600 (300)	180 (1 700)	−12 (400)	29 (300)	22 (110)	44 (460)	40 (300)
San Juan	200 (300)	—	—	—	—	—	—
Los Alamos	100 (300)	—	—	—	—	—	—
Lower Mortandad	1 600 (400)	370 (1 700)	14 (400)	−2 (300)	44 (110)	44 (460)	28 (300)
State Road 4[b]	7 100 (800)	83 (1 700)	20 (400)	30 (300)	38 (110)	86 (460)	69 (200)
State Road 4[c]	300 (300)	515 (1 700)	29 (400)	22 (300)	52 (110)	52 (460)	−19 (300)
TA-9	1 400 (300)	330 (1 700)	21 (400)	58 (300)	26 (110)	41 (460)	45 (300)
TA-15	3 000 (500)	270 (1 700)	−4 (400)	59 (300)	15 (110)	58 (460)	16 (300)
TA-16	2 600 (400)	380 (1 700)	−2 (400)	53 (300)	−20 (110)	−10 (460)	27 (300)
TA-21	31 000 (3 000)	52 (1 700)	11 (400)	64 (300)	11 (110)	52 (460)	30 (300)
TA-33	55 000 (6 000)	−100 (1 700)	−9 (400)	−19 (300)	19 (110)	46 (460)	31 (300)
TA-50	7 100 (800)	130 (1 700)	1 (400)	40 (300)	−15 (110)	−1 (460)	31 (300)
TA-53	74 000 (8 000)	5 (1 700)	−110 (400)	33 (300)	59 (110)	140 (460)	−13 (300)
TA-54	370 000 (40 000)	4 (1 700)	14 (400)	74 (300)	−9 (110)	−11 (460)	26 (300)

[a]Counting uncertainties are in parentheses.
[b]Located near the Met. towers.
[c]Located near the camp ground.

Table G-48. Selected Trace Metals in Local and Regional Honey Collected During 1989.[a]

Station	Arsenic (μg/g)	Beryllium (μg/g)	Cadmium (ng/g)	Chromium (μg/g)	Fluorine (μg/g)	Lead (μg/g)	Mercury (ng/g)	Selenium (μg/g)
Chimayo	0.1	<0.1	<50	<0.1	0.3	0.5	<0.2	<0.1
San Juan	0.1	<0.1	<50	<0.1	0.3	0.6	<0.2	<0.1
Los Alamos	0.1	<0.1	<50	<0.1	0.3	0.5	<0.2	<0.1
El Rancho	<0.1	<0.1	<50	<0.1	0.4	0.5	<0.2	<0.1
Lower Mortandad	0.1	<0.1	<50	<0.1	0.2	0.4	<0.2	<0.1
State Road 4[b]	<0.1	<0.1	<50	<0.1	0.5	0.5	<0.2	<0.1
State Road 4[c]	<0.1	<0.1	<50	<0.1	0.6	0.5	<0.2	<0.1
TA-9	<0.1	<0.1	<50	<0.1	0.7	0.4	<0.2	<0.1
TA-15	0.1	<0.1	<50	<0.1	0.7	0.6	<0.2	<0.1
TA-16	<0.1	<0.1	<50	<0.1	0.6	0.6	<0.2	<0.1
TA-21	0.2	<0.1	<50	<0.1	0.5	0.8	<0.2	<0.2
TA-33	0.1	<0.1	<50	<0.1	0.5	1.1	<0.2	<0.1
TA-50	0.1	<0.1	<50	<0.1	0.2	81.0	<0.2	<0.1
TA-53	0.2	<0.1	<50	<0.1	0.3	0.9	<0.2	<0.1
TA-54	0.1	<0.1	<50	<0.1	0.4	0.4	<0.2	<0.1

[a]Uncertainty of the results is ±10%. The density of honey is about 1860 g/L.
[b]Located near the Met. tower.
[c]Located near the camp ground.

Table G-49. Selected Radionuclides in Local and Regional Bees Collected during 1989.[a]

Station	^{3}H (pCi/L)	^{7}Be (pCi/g)	^{22}Na (pCi/g)	^{54}Mn (pCi/g)	^{57}Co (pCi/g)	^{83}Rb (pCi/g)	^{137}Cs (pCi/g)	Uranium (ng/g)
El Rancho	700	4.80	−0.24	0.11	0.08	0.30	0.18	14
	(300)	(78)	(5.30)	(4.54)	(1.29)	(10.35)	(3.03)	(1.5)
Chimayo	200	2.76	−0.07	0.04	0.17	−0.15	0.17	20
	(300)	(71)	(4.84)	(4.14)	(1.17)	(9.44)	(2.76)	(1.8)
San Juan	300	11.01	0.22	0.21	0.08	0.45	0.18	9
	(300)	(72)	(4.92)	(4.22)	(1.20)	(9.61)	(2.81)	(1.1)
Los Alamos	100	10.41	−0.35	−0.09	0.25	0.57	0.07	14
	(300)	(77)	(5.20)	(4.46)	(1.26)	(10.16)	(2.97)	(1.4)
Lower Mortandad	44 000	1.87	0.59	0.33	0.09	0.11	0.01	53
	(4 000)	(61)	(4.10)	(3.51)	(1.00)	(8.00)	(2.34)	(3.0)
State Road 4[b]	8 600	0.66	0.03	−0.12	0.14	0.08	0.08	33
	(1 000)	(73)	(4.97)	(4.26)	(1.21)	(9.71)	(2.84)	(3.0)
State Road 4[c]	5 200	7.05	−0.36	−0.06	0.14	0.44	0.16	29
	(600)	(75)	(5.11)	(4.38)	(1.24)	(9.97)	(2.92)	(2.0)
TA-9	1 500	4.23	0.09	−0.11	0.04	0.65	0.10	31
	(300)	(59)	(4.04)	(3.46)	(0.98)	(7.89)	(2.30)	(2.0)
TA-15	780 000	5.37	0.42	−0.11	0.15	0.27	0.11	30
	(80 000)	(69)	(4.68)	(4.01)	(1.14)	(9.13)	(2.67)	(2.0)
TA-16	1 800	4.21	0.37	0.10	0.05	0.23	0.06	23
	(400)	(54)	(3.68)	(3.16)	(0.89)	(7.19)	(2.11)	(1.0)
TA-21	18 000	5.93	0.18	0.17	0.22	0.59	0.04	100
	(2 000)	(57)	(3.89)	(3.33)	(0.94)	(7.59)	(2.22)	(5)
TA-33	430 000	3.77	−54	−0.21	0.08	0.32	0.14	47
	(40 000)	(84)	(5.66)	(4.85)	(1.37)	(11.05)	(3.23)	(3.0)
TA-50	190 000	3.40	−0.16	−0.12	0.20	0.11	0.00	37
	(2 000)	(66)	(4.46)	(3.82)	(1.08)	(8.71)	(2.55)	(3.0)
TA-53	3 300 000	8.29	45.76	6.05	6.56	0.21	0.24	20
	(300 000)	(73)	(1.49)	(0.57)	(0.28)	(9.71)	(2.84)	(1.8)
TA-54	1 800 000	3.10	0.45	0.04	0.19	0.26	0.03	24
	(200 000)	(74)	(5.01)	(4.29)	(1.22)	(9.77)	(2.86)	(1.9)

[a]Counting uncertainties are in parentheses.
[b]Located near Met. Tower.
[c]Located near camp ground.

Table G-50. Selected Trace Metals in Local and Regional Bees Collected during 1989.

Station	Arsenic[a] (ng/g)	Beryllium[a] (ng/g)	Cadmium[b] (ng/g)	Chromium[a] (ng/g)	Fluorine[b] (μg/g)	Lead[a] (μg/g)	Mercury[b] (ng/g)	Selenium[a] (ng/g)
Chimayo	—	—	19	—	1.8	—	<3	—
San Juan	<1	<2	21	81	1.0	0.3	<3	<1
Los Alamos	—	—	22	—	1.2	—	<3	—
El Rancho	170	<2	27	1.8	1.7	0.7	<3	<1
Lower Mortandad	—	—	29	—	2.0	—	<3	—
State Road 4[c]	—	—	15	—	1.1	—	<3	—
State Road 4[d]	—	—	29	—	1.1	—	<3	—
TA-9	180	<2	17	1.7	<0.1	0.8	<3	—
TA-15	100	<2	23	740	<0.1	1	<3	<1
TA-16	11	<2	21	100	<0.1	0.5	<3	<1
TA-21	90	<2	30	710	3.6	0.4	<3	—
TA-33	25	<2	32	140	1.7	0.3	<3	—
TA-50	45	<2	6	150	2.1	0.3	<3	<1
TA-53	25	<2	24	120	7.6	3	<3	—
TA-54	90	75	19	235	1.1	0.5	<3	—

[a]Data are from 1988; uncertainty of the results is ±10%.
[b]Data are from 1989.
[c]Located near Met. tower.
[d]Located near camp ground.

Table G-51. Hazardous Waste Management Facilities at Los Alamos National Laboratory.

Technical Area	Facility Type	<90-Day Storage	Inclusion in Part B Permit Application or Interim Status
TA-3-29	Container storage (2 units)	Yes	Interim status
TA-14 (2 units)	Miscellaneous unit		Interim status
TA-15	Miscellaneous unit		Interim status
TA-15-184	Miscellaneous unit	Yes	Interim status
TA-16	Surface impoundment	Closed	
TA-16 (6 units)	Miscellaneous unit		Interim status
TA-16, Area P	Landfill[a]		Neither
TA-16-88	Container storage	Yes	Interim status
TA-21-61	Container storage	Yes	Interim status
TA-33-90	Container storage	Yes	Interim status
TA-33-92	Container storage	Yes	Interim status
TA-35-85	Surface impoundment		Neither
TA-35-125	Surface impoundment		Neither
TA-36	Miscellaneous unit		Interim status
TA-36-8	Miscellaneous unit	Yes	Interim status
TA-39-6	Miscellaneous unit		Interim status
TA-39-57	Miscellaneous unit		Interim status
TA-40 (detonation pit)	Miscellaneous unit		Neither
TA-50-1	Batch treatment		Permitted
	Container storage		Permitted
	Container storage (60D)	Yes	Interim status
	Cementing process	Yes	Interim status
TA-50-37	Controlled-air incinerator		Permitted
	Container storage (room 115)	Yes	Interim status
	Container storage (room 117)		Permitted
	Container storage (room 117)	Yes	Interim status
	Container storage (room 118)	Yes	Interim status
	2 waste feed tanks for incinerator	Yes	Interim status
	Incinerator	Yes	Interim status
TA-50-69	Container storage (outside)	Yes	Interim status
	Container storage (inside)	Yes	Interim status
TA-50-114	Container storage	Yes	Interim status
TA-53-166	Surface impoundment (South)	Yes	Interim status
	Surface impoundment (Northwest)	Yes	Interim status
	Surface Impoundment (Northeast)	Yes	Interim status
TA-54, Area G	Landfill[a]		Neither
TA-54, Area H	Landfill[a]		Neither
TA-54, Area L	Tank treatment		Permitted
	Container storage		Permitted

Table G-51 (Cont.)

Technical Area	Facility Type	<90-Day Storage	Inclusion in Part B Permit Application or Interim Status
TA-54, Area L	Landfill[a]		Neither
	Oil storage tanks		Closed
	Container storage (2 units)	Yes	Interim status
	Gas cylinder storage (2 units)	Yes	Interim status
TA-54-8, Area G	Container storage (6 units)	Yes	Interim status
	Retrievable storage (3 units)	Yes	Interim status
TA-54-33, Area G	Retrievable storage shaft (6 units)	Yes	Interim status
TA-55-4	Container storage (5 units)	Yes	Interim status
	Container storage pad	Yes	Interim status
	13 waste storage tanks for evaporator bottoms solution	Yes	Interim status
	Cementing process	Yes	Interim status

[a]Interim status was terminated in November 1985. These landfills are in the process of being closed in accordance with New Mexico Hazardous Waste Management Regulations.

Table G-52. Resource Conservation and Recovery Act Interactions among the Laboratory, the U.S. Environmental Protection Agency, and New Mexico's Environmental Improvement Division in 1990

January 24, 1990	LANL is visited by EPA and NMEID for a joint inspection of the UST Program.
January 26, 1990	The Laboratory submitted the 1989 Federal Hazardous Waste Activities report to DOE EPA/NMEID.
February 12, 1990	LANL receives approved closure plan for TA-16 Surface Impoundment from NMEID.
March 5, 1990	The NMEID/EPA conducted the annual RCRA compliance inspection of LANL on March 5 - 9, 1990. Several minor violations were noted in the closeout.
March 8, 1990	The EPA issues the HSWA portion of the hazardous waste permit. Becomes module VIII of the permit. Effective date - April 23, 1990. Portions appealed (Rad monitoring).
March 16, 1990	The Laboratory submitted the 1989 Hazardous Waste and Waste Minimization Report to DOE to send to NMEID/EPA.
May 4, 1990	The Laboratory received a notice of findings for January's UST inspection. Two minor violations were noted.
June 18, 1990	The Laboratory received a Notice of Violation (NOV) for the findings of March 5, 1990 NMEID/EPA annual RCRA compliance inspection.
July 5, 1990	LANL, DOE submit 1990-1991 invoice/registration and payment for USTs.
July 20, 1990	LANL, DOE submit a written response to the June 18, 1990 RCRA NOV.
July 31, 1990	NMEID acknowledges receipt of the response to the RCRA NOV and recognizes that all cited violations have been addressed. The NOV action will be formally closed when information on the closure of a mixed waste tank is submitted to the State.
August 24, 1990	LANL, DOE submit written notification to NMEID regarding three USTs that failed tightness tests.
September 18, 1990	LANL submits final Closure Report for the TA-16 Surface Impoundment to NMEID. A copy was also sent to EPA Region VI.
September 19, 1990	Met with NMEID to discuss classified waste, mixed waste Part A, permit modification request, and ER Program approach to closure of RCRA units.
September 26, 1990	Again met with State on permit modification request.

Table G-52 (Cont)

October 2, 1990	LANL, DOE submit information of TA-53 tank cited in the June 18 RCRA NOV.
October 3, 1990	LANL, DOE submit written notification to NMEID regarding two USTs that failed tightness tests.
October 10, 1990	LANL, DOE call NMEID to satisfy a 24 hr. notification requirement. The notification was for a release from UST at TA-55.
October 16, 1990	LANL, DOE submit written notification to NMEID of a UST being ruptured at TA-55 by a backhoe.
November 2, 1990	DOE submits Class 1 modification to the RCRA Permit to clarify information regarding radioactive waste.
November 7, 1990	LANL sends written notification to NMEID UST Bureau regarding the removal and replacement of tank at TA-16 Service Station.
November 28, 1990	LANL sends written status report to NMEID UST Bureau regarding UST removal at TA-55. This was the final report required by Part XII of the NM UST regulations.
November 28, 1990	LANL sends written notification to NMEID UST Bureau notifying them that the Laboratory plans on removing several USTs during FY91. This notification must be received 30 days prior to construction.
December 12, 1990	NMEID issues letter stating the Attachment I reports submitted to them can be in the form if summary reports if all the records are available for their review.
December 14, 1990	NMEID issues NOV stating that summary reports have not been submitted on time
December 20, 1990	DOE/LANL have meeting with NMEID explaining a misunderstanding on the submittal of the reports (i.e., LANL awaiting the letter from the NMEID - issued on 12/12/90)
December 29, 1990	DOE issues letter drafted by HSE-8 bringing into question proposed solid waste management regulations. At issue were proposals to potentially restrict low level radioactive wastes, conflict with the ER program, and unfair restrictions on government facilities seeking variances from the regulations.

Table G-53. Types of Discharges and Parameters Monitored at the Laboratory under its NPDES Permit NM0028355

EPA Identification No.	Type of Discharge	Number of Outfalls	Monitoring Required	Sampling Frequency
01A	Power plant	1	Total suspended solids, free available chlorine, pH, flow	Monthly
02A	Boiler blowdown	2	pH, total suspended solids, flow, copper, iron, phosphorus, sulfite, total chromium	Weekly
03A	Treated cooling water	38	Total suspended solids, free available chlorine, phosphorus, pH, flow	Weekly
04A	Noncontact cooling water	34	pH, flow	Weekly
050 051	Radioactive waste treatment plant (TA-21 & TA-50)	2	Ammonia, chemical oxygen demand, total suspended solids, cadmium, chromium, copper, iron, lead, mercury, zinc, pH, flow	Weekly
05A	High explosives wastewater	21	Chemical oxygen demand, pH, flow, total suspended solids	Weekly
06A	Photo waste water	13	Cyanide, silver, pH, flow	Weekly
128	Printed circuit board	1	pH, chemical oxygen demand, total suspended solids, iron, copper, silver, flow	Weekly
S	Sanitary wastewater	10	Biochemical oxygen demand, flow, pH, total suspended solids, fecal coliform bacteria	Variable frequency, from three per month to once quarterly

Table G-54. Limits Established by NPDES Permit NM0028355 for Sanitary Outfall Discharges.

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01S TA-3 Treatment Plant	BOD	30.0	45.0	mg/l
		225.2	N/A	lb/day
	TSS	30.0	45.0	mg/l
		225.2	N/A	lb/day
	Fecal coliform bacteria	1 000.0	2 000.0	org/100 ml
	pH	6–9	6–9	standard unit
02S TA-9 Lagoon and Sand Filters	BOD	30.0	45.0	mg/l
		0.3	N/A	lb/day
	TSS	30.0	45.0	mg/l
		0.3	N/A	lb/day
	pH	6–9	6–9	standard unit
03S TA-16 Treatment Plant	BOD	30.0	45.0	mg/l
		25.0	N/A	lb/day
	TSS	30.0	45.0	mg/l
		25.0	N/A	lb/day
	pH	6–9	6–9	standard unit
04S TA-18 Lagoons	BOD	30.0	45.0	mg/l
		0.5	N/A	lb/day
	TSS	30.0	90.0	mg/l
		0.5	N/A	lb/day
	pH	6–9	6–9	standard unit
05S TA-21 Package Plant	BOD	30.0	45.0	mg/l
		4.3	N/A	lb/day
	TSS	30.0	45.0	mg/l
		4.3	N/A	lb/day
	pH	6–9	6–9	standard unit

Table G-54 (Cont)

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
07S TA-46N Lagoons & Sand Filters	BOD	30.0	45.0	mg/l
		1.3	N/A	lb/d
	TSS	30.0	45.0	mg/l
		1.3	N/A	lb/d
	pH	6–9	6–9	standard unit
09S TA-53 Lagoons	BOD	30.0	45.0	mg/l
		2.3	N/A	lb/day
	TSS	30.0	90.0	mg/l
		2.3	N/A	lb/day
	pH	6–9	6–9	standard unit
10S TA-35 Lagoons & Sand Filters	BOD	30.0	45.0	mg/l
		3.0	N/A	lb/d
	TSS	30.0	90.0	mg/l
		3.0	N/A	lb/d
	pH	6–9	6–9	standard unit
12S TA-46S Lagoons	BOD	30.0	45.0	mg/l
		0.5	N/A	lb/d
	TSS	30.0	90.0	mg/l
		0.5	0.5	lb/d
	pH	6–9	6–9	standard unit

Table G-55. NPDES Permit Monitoring of Effluent Quality at Sanitary Sewage Treatment Outfalls

Discharge Location (Outfall)	Permit Parameters	Number of Deviations	Range of Deviation
TA-3 (01S)	BOD[a]	1	46.8
	TSS[b]	1	98.5
	Fecal coliform bacteria[c]	1	1 200 000
	pH[d]	0	—
TA-9 (02S)	BOD	0	—
	TSS	0	—
	pH	0	—
TA-16 (03S)	BOD	0	—
	TSS	0	—
	pH	1	9.3
TA-18 (04S)	BOD	0	—
	TSS (90)	0	—
	pH	0	—
TA-21 (05S)	BOD	1	76.6
	TSS	1	52.0
	pH	0	—
TA-35 (10S)	BOD	0	—
	TSS (90)	0	—
	pH	0	—
TA-41 (06S)	BOD	0	—
	TSS	0	—
	Fecal coliform bacteria	0	—
	pH	0	—
TA-46 (07S)	BOD	0	—
	TSS	0	—
	pH	0	—
TA-46 (12S)	BOD	1	180.0
	TSS	1	105.1
	pH	1	9.9
TA-53 (09S)	BOD	0	—
	TSS (90)	0	—
	pH	0	—

[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), dependent on the specific outfall.

[c]Fecal coliform bacteria limits are 1 000 organisms/100 mL (20-day average) and 2 000 organisms/100 mL (7-day average).

[d]Range of permit pH limits is between 6.0 and 9.0 standard units.

Table G-56. Limits Established by NPDES Permit NM0028355 for Industrial Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01A Power plant	TSS	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	pH	6–9	6–9	standard unit
02A Boiler blowdown	TSS	30	100	mg/L
	Fe	10	40	mg/L
	Cu	1	1	mg/L
	P	20	40	mg/L
	SO_3	35	70	mg/L
	Cr	Report	Report	mg/L
	pH	6–9	6–9	standard unit
03A Treated cooling water	TSS	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	P	5.0	5.0	mg/L
04A Noncontact cooling water	pH	6–9	6–9	standard unit
050 Radioactive waste	COD[a]	18.8	37.5	lb/day
051 treatment plant	COD[b]	94.0	156.0	lb/day
	TSS[a]	3.8	12.5	lb/day
	TSS[b]	18.8	62.6	lb/day
	Cd[a]	0.01	0.06	lb/day
	Cd[b]	0.06	0.3	lb/day
	Cr[a]	0.02	0.08	lb/day
	Cr[b]	0.19	0.38	lb/day
	Cu[a]	0.13	0.13	lb/day
	Cu[b]	0.63	0.63	lb/day
	Fe[a]	0.13	0.13	lb/day
	Fe[b]	1.0	2.0	lb/day
	Pb[a]	0.01	0.03	lb/day
	Pb[b]	0.06	0.15	lb/day
	Hg[a]	0.007	0.02	lb/day
	Hg[b]	0.003	0.09	lb/day
	Zn[a]	0.13	0.37	lb/day
	Zn[b]	0.62	1.83	lb/day
	pH[a]	6–9	6–9	standard unit
	pH[b]	6–9	6–9	standard unit

Table G-56 (Cont)

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
05A High explosive	COD	150.0	250.0	mg/L
	TSS	30.0	45.0	mg/L
	pH	6–9	6–9	standard unit
06A Photo waste	CN	0.2	0.2	mg/L
	Ag	0.5	1.0	mg/L
	pH	6–9	6–9	standard unit
128 Printed circuit board	COD	1.9	3.8	lb/day
	TSS	1.25	2.5	lb/day
	Fe	0.05	0.1	lb/day
	Cu	0.05	0.1	lb/day
	Ag	Report	Report	lb/day
	pH	6–9	6–9	standard unit

[a]Limitations for outfall 050 located at TA-21-257; COD = chemical oxygen demand.
[b]Limitations for outfall 051 located at TA-50-1.

Table G-57. NPDES Permit Monitoring of Effluent Quality at Industrial Outfalls[a]

Discharge Category	Outfall No.	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls with Deviations
Power plant	01A	1	TSS[b]	1	682.0	1
			Free Cl	0	—	0
			pH	21	2.2–12.5	1
Boiler blowdown	02A	2	pH	2	9.5	1
			TSS	0	—	0
			Cu	0	—	0
			Fe	0	—	0
			P	0	—	0
			SO_3	0	—	0
			Cr	0	—	0
Treated cooling water	03A	38	TSS	2	101.0–300.0	2
			Free Cl	3	0.7–17.9	3
			P	6	5.9–24.2	4
			pH	0	—	0
			Oil Sheen[c]	3	—	1
			Off-Normal Discharge[c]	1	—	1
Noncontact cooling water	04A	34	pH	0	—	0
Radioactive waste treatment plant	051 and 050	2	COD[d]	0	—	0
			TSS	0	—	0
			Cd	0	—	0
			Cr	0	—	0
			Cu	0	—	0
			Fe	0	—	0
			Pb	0	—	0
			Hg	0	—	0
			Zn	0	—	0
			pH	0	—	0
High explosive	05A	21	COD	1	452.0	1
			TSS	1	144.0	1
			pH	0	—	0
			Oil Release[c]	1	—	1

Table G-57 (Cont)

Discharge Category	Outfall No.	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls with Deviations
Photo waste	06A	13	CN	0	—	0
			Ag	1	1.8	1
			TSS	0	—	0
			pH	0	—	0
Printed circuit board	128	1	pH	0	—	0
			COD	0	—	0
			Ag			
			Fe	1	0.246	1
			Cu	0	—	0
			TSS	0	—	0
		112				

[a]Limits set by the NPDES permit are presented in Table G-54.

[b]Total suspended solids.

[c]Limits not included in NPDES permit.

[d]Chemical oxygen demand.

Table G-58. Federal Facility Compliance Agreement: Schedule for Upgrading the Laboratory's Wastewater Outfalls

Outfalls	Date	Status or Target Date
Outfall 02A (Boiler Blowdown)		
Final design complete	December 1988	Completed
Advertisement of construction contract	February 1989	Completed
Award of construction contract	April 1989	Completed
Construction completion	September 1989	Completed
In compliance with final limits	October 1989	Completed
Outfall 05A (HE Wastewater Discharge)		
Final design complete	December 1988	Completed
Advertisement of construction contract	February 1989	Completed
Award of construction contract	April 1989	Completed
Construction completion	August 1989	Completed
In compliance with final limits	October 1989	Completed
Outfall 04S (TA-18 Sanitary Treatment Plant) [a]		
Outfall 09S (TA-53 Sanitary Lagoons) [a]		
Outfall 10S (TA-35 Sanitary Lagoons) [a]		
Final design complete	June 1990	Completed
Advertisement of construction contract	September 1990	Completed
Award of construction contract	December 1989	Completed
Construction completion	January 1992	June 1992
Special facilities completion and facility startup	June 1992	June 1992
In compliance with final limits	July 1992	July 1992
Outfall 05S (TA-21 Sanitary Package Plant) [b]		
Final design complete	August 1990	Completed
Advertisement of construction contract	September 1990	Completed
Award of construction contract	December 1990	Completed
Construction completion	January 1992	Completed
Special facilities completion and facility startup	June 1992	Completed
In compliance with final limits	July 1992	Completed

[a]Schedule based on Phase I (Treatment Plant Construction) of the Sanitary Wastewater Systems Consolidation (SWSC) Project.
[b]Schedule based on Phase I (Sand Filter Addition) of the TA-21 Plant Upgrades.

Table G-59. Federal Facility Compliance Agreement: Interim Compliance Limits

Effluent Characteristic	Discharge Limitation[a] Daily Average (lb/day)	Daily Average (mg/L)	Daily Maximum (mg/L)
Industrial Outfalls			
Outfall 05A (High Explosive)			
Flow	N/A	Report	Report
Chemical oxygen demand	N/A	650.0	1 000
Total suspended solids	N/A	60.0	90
Outfall 02A (Boiler Blowdown)			
Flow	N/A	Report	Report
Total suspended solids	N/A	180.0	250.0
Total iron	N/A	20.0	60.0
Total copper	N/A	2.0	2.0
Total phosphorous	N/A	30.0	60.0
Sulfite (as SO_3)	N/A	45.0	80.0
Total chromium	N/A	Report	Report
Sanitary Waste-Water Outfalls			
Outfall 04S (Located at TA-18)			
Flow	N/A	Report	Report
Biochemical oxygen demand	2.5	100	175
Total suspended solids	2.5	100	200
pH[b]	N/A	5.5 minimum	11.5 maximum
Outfall 05S (Located at TA-21)			
Flow	N/A	Report	Report
Biochemical oxygen demand	12.5	100	175
Total suspended solids	12.5	150	200
pH[b]	N/A	5.5 minimum	11.5 maximum
Outfall 09S (Located at TA-53)			
Flow	N/A	Report	N/A
Biochemical oxygen demand	94	100	175
Total suspended solids	94	150	200
pH[b]		5.5 minimum	11.5 maximum
Outfall 10S (Located at TA-35)			
Flow	N/A	Report	Report
Biochemical oxygen demand	94	100	175
Total suspended solids	94	150	200
pH[b]	N/A	5.5 minimum	11.5 maximum

[a]Flows must be monitored and reported (in millions of gallons per day).

[b]The pH must be between 6.0 and 9.0 standard units.

Table G-60. Los Alamos, New Mexico,[a] Climatological Summary (1911–1990), Temperature and Precipitation Means[b] and Extremes

	Temperature (°F)[c]										
	Normals			Extremes							
Month	Mean Maximum	Mean Minimum	Average	High Average	Year	Low Average	Year	High Daily Maximum	Date	Low Daily Minimum	Date
January	39.5	17.4	28.4	37.6	1986	20.9	1930	64	1/12/81	–18	1/13/63
February	43.5	21.1	32.3	37.4	1934	23.0	1939	69	2/25/86	–14	2/01/51
March	49.6	26.5	38.0	45.8	1972	32.1	1948	73	3/11/89	–3	3/11/48
April	58.4	33.3	45.8	54.3	1954	39.7	1973	80	4/23/50	5	4/09/28
May	67.6	42.0	54.8	60.5	1956	50.1	1957	89	5/29/35	24	5/01/76[d]
June	77.8	51.1	64.5	69.6	1990	60.4	1965	95	6/22/81	28	6/03/19
July	80.6	55.3	68.0	71.4	1980	63.3	1926	95	7/11/35	37	7/07/24
August	77.5	53.5	65.5	70.3	1936	60.9	1929	92	8/10/37	40	8/16/47
September	71.1	47.2	59.1	65.8	1956	56.2	1965	94	9/11/34	23	9/29/36
October	61.5	37.6	49.2	54.7	1963	42.8	1984	84	10/01/80	15	10/19/76
November	48.9	27.1	38.0	44.4	1949	30.5	1972	72	11/01/50	–14	11/28/76
December	40.8	19.4	30.1	38.4	1980	24.0	1990	64	12/27/80	–13	12/09/78
Annual	59.7	36.0	47.8	52.0	1954	46.2	1932	95	6/22/81[d]	–18	1/13/63

Table G-60 (Cont)

	Precipitation (in.)[c]										Mean Number of Days Per Year		
	Precipitation[e]					Snow							
Month	Mean	Maximum	Year	Daily Maximum	Date	Mean	Maximum	Year	Daily Maximum	Date	Precip. ≥0.10 in.	Max. Temp. ≥90°F	Min. Temp. ≤32°F
January	0.86	6.75	1916	2.45	1/12/16	12.1	64.8	1987	22.0	1/15/87	2	0	29
February	0.80	2.78	1987	1.05	2/20/15	9.9	48.5	1987	20.0	2/19/87	2	0	27
March	1.22	4.11	1973	2.25	3/30/16	12.0	36.0	1973	18.0	3/30/16	3	0	24
April	1.01	4.64	1915	2.00	4/12/75	4.6	33.6	1958	20.0	4/12/75	3	0	14
May	1.17	4.47	1929	1.80	5/21/29	0.9	17.0	1917	12.0	5/02/78	3	0	3
June	1.36	5.67	1986	2.51	6/10/13	—	—	—	—	—	3	1	0
July	3.26	7.98	1919	2.47	7/31/68	—	—	—	—	—	8	1	—
August	3.52	11.18	1952	2.26	8/01/51	—	—	—	—	—	8	0	—
September	2.12	5.79	1941	2.21	9/22/29	0.1	6.0	1913	6.0	9/25/13	5	0	0
October	1.30	6.77	1957	3.48	10/05/11	2.0	20.0	1984	9.0	10/31/72	3	0	7
November	1.02	6.60	1978	1.77	11/25/78	4.6	34.5	1957	14.0	11/22/31	2	0	22
December	1.08	3.21	1984	1.60	12/06/78	12.8	41.3	1967	22.0	12/06/78	3	0	30
Annual	18.72	30.34	1941	3.48	10/05/11	59.0	178.4	1987	22.0	1/15/87	46	3	156
Season							153.2	1986–87		12/06/78			

[a]Latitude 35°52 north, longitude 106°19 west; elevation 2263 m. (Measurements taken at TA-6 starting August, 1990 - previously taken at TA-59.)

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

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

[d]Most recent occurrence.

[e]Includes water equivalent of frozen precipitation.

Table G-61. Los Alamos Climatological Summary for 1990

	Temperature (°F)[a]						
	Means			Extremes			
Month	Mean Maximum	Mean Minimum	Average	High	Date	Low	Date
January	38.2	16.5	27.3	56	11	5	5
February	41.6	20.4	31.0	56	26	4	16
March	51.6	29.2	40.4	65	21–23	15	14
April	59.2	35.8	47.5	72	14	28	2
May	66.8	42.0	54.4	78	23	31	2,3
June	84.2	55.1	69.6	93	24	38	2
July	76.9	53.2	65.1	90	1	46	15
August	76.3	50.7	63.5	87	29	42	7
September	72.3	48.2	60.3	83	13	41	24
October	62.3	36.0	49.2	70	4	25	21
November	48.5	26.8	37.6	61	15	11	28
December	34.8	13.3	24.0	51	9	–10	23,24
Annual	59.4	35.6	47.5	93	6/24	–10	12/23,24

Table G-61 (Cont)

	Precipitation (in.)[a]						Number of Days		
	Water Equivalent			Snow					
Month	Total	Daily Maximum	Date	Total	Daily Maximum	Date	Precip. ≥0.10 in.	Max. Temp. ≥90°F	Min. Temp. ≤32°F
January	0.97	0.67	18	17.5	12.0	18	2	0	31
February	0.38	0.15	19	6.3	2.8	19	1	0	27
March	0.62	0.41	29	1.9	1.5	29	1	0	21
April	1.50	0.32	7	1.2	1.2	1	7	0	9
May	0.89	0.44	2	0	0	—	2	0	3
June	0.93	0.31	10,11	0	0	—	3	6	0
July	3.65	1.24	22	0	0	—	9	1	0
August	1.87	0.96	14	0	0	—	4	0	0
September	3.37	0.94	16	0	0	—	7	0	0
October	0.66	0.23	20	T	T	20	3	0	7
November	2.08	1.24	2	5.5	2.5	3	5	0	22
December	1.79	0.81	16	10.5	3.5	16	4	0	31
Annual	18.71	1.24	7/22 & 11/2	42.9	12.0	1/18	48	7	151

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

Table G-62. Los Alamos Precipitation for 1990[a]
(in.)

	North Community (Site 1)	S-Site (Site 2)	TA-6[b] (Site 3)	Bandelier (Site 4)	East Gate (Site 5)	TA-54 (Area G) (Site 6)	White Rock Y (Site 7)	White Rock (Site 8)
January	1.13	0.97	0.97	0.92	0.74	0.59	0.73	0.67
February	0.70	0.53	0.38	0.38	0.27	0.22	0.23	0.38
March	0.93	0.91	0.62	1.00	0.51	0.55	0.54	0.73
April	1.99	2.15	1.50	1.44	1.37	1.39	1.07	1.59
May	1.03	1.03	0.89	0.93	0.66	0.71	0.63	0.76
June	0.57	0.94	0.93	0.63	0.51	0.75	0.60	0.92
July	4.70	3.23	3.65	3.30	4.48	4.17	4.94	4.64
August	3.12	2.57	1.87	1.36	3.28	1.04	1.61	0.88
September	2.99	4.09	3.37	2.75	2.90	2.67	3.28	2.28
October	0.71	0.89	0.66	0.54	0.40	0.33	0.43	0.28
November	2.27	2.41	2.08	1.83	1.65	1.53	1.50	1.73
December	1.96	1.80	1.79	1.94	1.60	1.82	1.73	1.91
Annual	22.10	21.52	18.71	17.02	18.37	15.77	17.29	16.77

[a]Metric conversion: 1 in. = 2.5 cm; see Fig. 28 for site locations.
[b]Precipitation measurements taken at TA-59 January-July, At TA-6 August-December.

Table G-63. 1990 Weather Highlights

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.
TMDP	Tied maximum daily precipitation record.
SMDS	Set maximum daily snowfall record.

January

Snowy.
Snowfall = 17.5 in. (normal = 12.1 in.).
SMDS on the 18th: 12.0 in.
Strong winds with peak gusts of 58 and 71 mph on the 24th and 29th, respectively.

February

Dry.
Precipitation = 0.38 in. (normal = 0.80 in.).
Strong winds with peak gusts of 62 mph on the 15th.

March

Dry with little snowfall.
Precipitation = 0.62 in. (normal = 1.22 in.).
Snowfall = 1.9 in. (normal = 12.0 in.).
TMDH on the 21th: 65°F.
TMDH on the 22nd: 65°F.

April

TMDH on the 14th: 72°F.
TMDH on the 28th: 71°F.
Strong winds with peak gust of 54 mph on the 28th.

May

Strong winds with peak gust of 50 mph on the 24th.

June

Hot - warmest June on record.
Mean Temperature - 69.6°F. (normal = 64.5°F).
Previous warmest June: 69.4°F. (1980)
Second most 90°+F days in June: 6 (Most in 1980 with 7).
SMDH on the 5th: 87°F.
SMDH on the 6th: 85°F.
TMDH on the 8th: 87°F.
TMDH on the 23rd: 90°F.
SMDH on the 24th: 93°F.

Table G-63 (Cont)

July

TMDH on the 1st: 90°F.
Severe hailstorm in White Rock on 20th - $9 million paid in insurance claims for property damage. Some baseball-sized hail in White Rock with golf-ball-sized falling in East Gate area.
Precipitation (rain & hail) averaged 1.25 in. in White Rock, White Rock Y and East Gate on the 20th.
SMDP on the 22nd: 1.24 in. (1.18 in. falls in 1 hr.).

August

Cool and dry.
Precipitation = 1.87 in. (normal = 3.52 in.).
TMDL on the 1st: 46°F.
TMDL on the 6th: 46°F.
SMDL on the 7th: 42°F.
Heavy rain at East Gate on the 21st: 1.64 in. (falls during one hour).

September

Wet - wettest September since 1975.
Precipitation = 3.37 in. (normal = 2.12 in.).
SMDP on the 16th: 0.94 in.
SMDP on the 28th: 0.50 in.

October

Dry.
Precipitation = 0.66 in. (normal = 1.30 in.).
SMDL on the 9th: 26°F.

November

Wet.
Precipitation = 2.08 in. (normal = 1.02 in.).
Strong wind reported at Ancho Canyon on the 1st: modular building damaged and some ponderosa pines blown down.
Peak gust = 57 mph on the 1st at Area G.
SMDP on the 2nd = 1.04 in.
Peak gust = 54 mph on the 26th.

December

Very cold - coldest December on record.
Mean temperature = 24°F (Previous coldest = 24.6°F in 1931).
Normal temperature = 30.1°F.
TMDL on the 2nd: 11°F.
SMDL on the 22nd: -3°F.
SMDL on the 23rd: -10°F (Previous coldest = -13°F on December 9, 1978).
SMDL on the 24th: -10°F.
Some pipes burst from the cold on the 23rd & 24th.
SMDL on the 30th: 1°F.
Strong winds with gusts of 63 and 64 mph on the 2nd and 30th, respectively.

Table G-63 (Cont)

Annual

1990 mean temperature = 47.5°F (normal = 47.8°F).
1990 precipitation - 18.71 in. (normal = 18.72 in.).
1990 snowfall = 42.9 in. (normal = 59.0 in.).
Least annual snowfall since 1981.
1989–1990 winter season snowfall = 41.2 in.
Least seasonal snowfall since 1977–1978.

Table G-64. Hole SIMO-1 Moisture (gravimetric) and Tritium Concentration in Moisture Extracted from Core Samples

Depth[a] (ft)	Moisture (% by mass)	H-3[b] (nCi/L)
4	4.5	1.6
9	4.0	1.4
14	8.0	1.1
19	7.7	0.4
24	5.7	0.2
29	6.1	0.6
33	5.3	0.0
39	7.0	-0.1
44	8.1	0.3
49	2.8	0.2
54	8.8	0.2
59	3.9	0.1
64	4.1	0.0
69	2.3	-0.2
74	7.9	0.1
79	7.3	-0.2
84	11.2	-0.4
89	10.3	-0.1
94	19.2	-0.2
99	9.3	0.3
104	9.4	0.0

[a] depth below surface
[b] Detection limit 0.7 nCi/L

Table G-65. Radiochemical Analyses of Core Samples from Hole SIMO-1

Sample depth (ft)	^{3}H (nCi/L)	^{137}CS (pCi/g)	Gross (cpm/g)	^{238}PU (pCi/g)	$^{239,240}PU$ (pCi/g)	Total Uranium (ug/g)	Gross (pCi/g)	Gross (pCi/g)
4	1.6(0.3)	0.043(0.077)	2.7(0.5)	0.001(0.001)	0.002(0.001)	2.2(0.2)	3.7(0.8)	1.4(0.2)
9	1.4(0.3)	0.347(0.135)	4.0(0.6)	0.008(0.001)	0.003(0.001)	2.9(0.3)	6.0(1.0)	2.1(0.3)
14	1.1(0.3)	0.124(0.079)	4.0(0.6)	0.000(0.000)	0.002(0.001)	4.6(0.5)	14.0(3.0)	5.5(0.6)
19	0.4(0.3)	0.185(0.126)	4.4(0.6)	0.002(0.002)	0.001(0.001)	4.6(0.4)	14.0(3.0)	5.9(0.7)
24	0.2(0.3)	0.161(0.081)	4.0(0.6)	0.000(0.000)	0.002(0.001)	4.1(0.4)	10.0(2.0)	5.4(0.6)
29	0.6(0.3)	0.243(0.133)	4.0(0.6)	0.002(0.001)	0.003(0.002)	3.6(0.4)	13.0(3.0)	5.0(0.6)
33.5	0.0(0.3)	0.128(0.081)	4.8(0.6)	0.000(0.001)	0.006(0.006)	3.9(0.4)	9.0(2.0)	4.0(0.5)
39	–0.1(0.3)	0.043(0.116)	2.9(0.5)	0.000(0.001)	0.002(0.001)	3.9(0.4)	9.0(2.0)	2.9(0.4)
44	0.3(0.3)	0.032(0.085)	3.9(0.6)	0.006(0.006)	0.001(0.001)	4.0(0.4)	8.0(2.0)	3.3(0.4)
49	0.2(0.3)	0.150(0.126)	2.4(0.5)	0.000(0.000)	0.000(0.001)	1.6(0.2)	2.7(0.6)	2.0(0.3)
54	0.2(0.3)	0.057(0.079)	6.7(0.8)	0.001(0.000)	0.001(0.001)	5.4(0.5)	7.0(2.0)	3.1(0.4)
59	0.1(0.3)	0.119(0.119)	4.0(0.6)	0.001(0.000)	0.002(0.001)	2.8(0.3)	4.1(0.9)	1.5(0.2)
64	0.0(0.3)	0.094(0.078)	3.7(0.5)	0.003(0.001)	0.002(0.001)	2.8(0.3)	5.0(1.0)	1.7(0.2)
69	–0.2(0.3)	0.147(0.117)	1.8(0.4)	0.000(0.000)	0.001(0.001)	1.5(0.2)	3.0(0.7)	1.2(0.2)
74	0.1(0.3)	0.107(0.081)	7.0(0.8)	0.001(0.001)	0.001(0.001)	6.7(0.7)	8.0(2.0)	2.7(0.3)
79	–0.2(0.3)	0.202(0.132)	5.6(0.7)	0.001(0.000)	0.001(0.001)	5.9(0.6)	7.0(1.0)	2.2(0.3)
84	–0.4(0.3)	–0.077(0.080)	7.1(0.8)	0.001(0.000)	0.001(0.001)	6.3(0.6)	8.0(2.0)	3.5(0.4)
89	–0.1(0.3)	0.189(0.120)	4.1(0.6)	0.000(0.000)	0.001(0.000)	3.9(0.4)	9.0(2.0)	3.1(0.4)
94	–0.2(0.3)	0.102(0.079)	5.0(0.6)	0.000(0.000)	0.004(0.001)	5.6(0.6)	3.7(0.8)	1.8(0.2)
99	0.3(0.3)	0.090(0.118)	3.9(0.6)	0.000(0.010)	0.003(0.001)	5.6(0.6)	3.1(0.7)	1.6(0.2)
104	0.0(0.3)	0.004(0.086)	5.3(0.7)	0.000(0.010)	0.001(0.001)	5.5(0.5)	2.4(0.6)	1.6(0.2)

Table G-66. Analyses of Surface Water and Groundwater Quality at Fenton Hill, December, 1990[a]

Station	Location	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	NO_3-N	TDS[b]	Total Hardness	pH[c]	Specific Conductance (mS/m)
Surface Waters																	
J	Jemez River	50	19	3.2	2.9	27	5	63	0.1	13	4	0.9	0.1	102	60	8.2	9.7
N	San Antonio Creek	56	21	2.4	3.1	23	5	49	0.1	19	2	1.3	0.1	80	63	7.8	10.7
Q	Rio Guadalupe	28	99	7.8	3.0	26	5	159	0.0	9	10	0.6	0.1	184	281	8.2	25.9
S	Jemez River	51	67	5.5	14.5	107	5	159	0.1	18	104	1.2	0.1	398	190	8.5	49.4
Ground Waters																	
JS-4,5	Jemez Village (spring)	80	54	6.1	5.5	87	5	196	0.2	18	27	1.5	0.2	326	162	7.8	36.3
FH-1	Fenton Hill (well)	68	125	10.4	7.0	30	5	209	0.1	13	56	0.2	0.1	420	356	7.7	49.6
JF-1	Jemez Canyon (hot spring)	46	242	25.8	78.9	581	5	715	0.1	46	70	2.6	0.3	1986	710	7.6	303.2
JF-5	Soda Dam (hot spring)	47	578	33.4	250.6	1150	5	1	0.1	49	1523	4.0	0.0	3890	1	6.6	650.8
Loc. 4	La Cueva (well)	84	24	5.2	2.0	24	5	62	0.2	5	3	0.3	0.2	90	77	7.7	13.6
Loc. 6	La Cueva (spring)	67	36	8.6	4.9	32	5	105	7.3	17	4	0.4	0.1	164	126	6.9	20.6

[a]Analysis units are milligrams per liter, except as noted.

[b]Total dissolved solids.

[c]Standard units.

Table G-67. Trace Metals in Surface and Ground Waters, Fenton Hill, December 1990[a]

Station	Location	Ag	As	B	Ba	Cd	Cr	Cu	Fe	Hg	Pb	Se	Total Uranium (µg/L)
Surface Water													
J	Jemez River	0.021	0.012	0.2	0.022	0.006	0.011	0.026	0.255	0.0002	0.011	0.002	<1
N	San Antonio Creek	0.021	0.003	0.2	0.032	0.006	0.011	0.026	0.355	0.0002	0.011	0.002	<1
Q	Rio Guadalupe	0.015	0.002	0.2	0.104	0.004	0.011	0.018	0.170	0.0002	0.006	0.002	2.8
S	Jemez River	0.021	0.079	1.0	0.072	0.006	0.013	0.026	0.455	0.0002	0.007	0.002	<1
Ground Water													
JS-4,5	Jemez Village (spring)	0.021	0.029	0.3	0.041	0.008	0.025	0.027	0.040	0.0002	0.019	0.002	1.1
FH-1	Fenton Hill (well)	0.021	0.002	0.7	0.146	0.006	0.027	0.049	0.665	0.0002	0.027	0.002	4.8
JF-1	Jemez Canyon (hot spring)	0.015	0.008	6.0	0.233	0.004	0.037	0.018	0.530	0.0002	0.011	0.005	1.2
JF-5	Soda Dam (hot spring)	0.021	1.017	14.7	0.418	0.011	0.052	0.026	0.080	0.0002	0.013	0.005	1
Loc. 4	La Cueva (well)	0.021	0.002	0.1	0.029	0.006	0.012	0.026	0.050	0.0002	0.014	0.002	<1
Loc. 6	La Cueva (well)	0.021	0.033	0.2	0.664	0.006	0.037	0.044	34.000	0.0002	0.042	0.002	8.8

[a]Analysis units are milligrams per liter, except as noted.

Table G-68. Well Characteristics and Water Levels

	Date Drilled	Date Completed	Depth Drilled (ft)	Depth Completed (ft)	Water Levels Below Land Surface Datum (ft)			
					Date	Water Level	Date	Water Level
Pueblo Canyon								
APCO-1	8/15/90	8/17/90	20	19.7	—	—	8/17/90	6.2
Los Alamos Canyon								
LAO-3A	9/14/89	9/14/89	18	14.7	9/14/89	6.7	6/21/90	5.5
LAO-4.5A	9/13/89	9/14/89	20	18.5	9/14/89	Dry	6/21/90	Dry
LAO-4.5B	9/15/89	9/16/89	35	34.9	9/16/90	Dry	6/21/90	Dry
LAO-4.5C	11/21/89	11/22/89	25	23.3	11/22/89	10.6	6/21/90	10.7
LAO-6A	8/17/89	8/17/89	15	14.2	8/17/89	9.0	6/21/90	Dry
Sandia Canyon								
SCO-1	8/14/89	8/15/89	79	19.3	8/15/89	Dry	6/22/90	Dry
SCO-2	8/16/89	8/16/89	29	18.4	8/16/89	Dry	6/22/90	Dry
Mortandad Canyon								
MCO-4A	11/01/89	11/01/89	24	19.4	11/14/89	5.1	8/15/90	Dry
MCO-4B	8/20/90	8/21/90	34	33.9	—	—	8/21/90	21.7
MCO-6A	11/02/89	11/06/89	33	32.7	11/09/89	30.3	6/02/90	Dry
MCO-6B	8/09/90	8/13/90	48	47.1	—	—	8/13/90	33.2
MCO-7A	11/06/89	11/14/89	47	44.8	11/09/89	35.2	6/21/90	37.2
Potrillo Canyon								
PCTH-1[a]	10/18/89	10/20/89	74	—	10/20/89	Dry	—	—
Fence Canyon								
FCO-1	8/22/89	8/22/89	29	12.4	8/22/89	Dry	8/24/90	Dry
Water Canyon								
WCO-1	10/26/89	10/31/89	37	34.4	11/01/89	Dry	8/24/90	Dry
WCO-2	10/26/89	10/26/89	38	23.5	10/26/89	Dry	8/24/90	Dry
WCO-3	10/25/89	10/25/89	14	12.4	10/25/89	Dry	8/24/90	Dry

[a]Cored test hole; plugged.

Table G-69. Summary of Radiochemical Analyses of Samples from Perched Zone Monitoring Wells

PARAMETER (pCi/L except where noted, +/- value is analytical standard deviation)

WELL	LAB[a]	^{3}H	^{238}Pu	$^{239,240}Pu$	^{137}Cs	Gross ^{241}Am	Gross Beta Alpha	Gross (cm/L)	Total Uranium Gamma	(mg/L)
MCO-4B	HSE-9	67000±7000	0.0529±0.0213	0.112±0.027	28±69	1.47±0.10	9±3	120±10	110±80	6.4±0.1
MCO-4	HSE-9	43000±4000	0.371±0.042	1.42±0.92	101±70	4.14±0.19	8±3	160±20	80±80	1.5±0.1
MCO-6B	HSE-9	130000±10000	0.0187±0.0148	0.0327±0.0169	163±73	2.27±0.13	34±8	59±6	10±80	18.1±0.4
MCO-6	HSE-9	100000±10000	1.12±0.01	3.18±0.20	90±71	2.52±0.13	10±3	100±10	180±80	5.9±0.1
MCO-7A	HSE-9	21000±2000	0.0172±0.0106	0.0344±0.0137	20±70	0.375±0.042	7±2	18±2	20±80	6.5±0.2
MCO-7	HSE-9	13000±1000	0.0178±0.0154	0.444±0.0155	87±70	0.216±0.034	3±1	12±1	210±80	1.4±0.1
APCO-1	HSE-9	0±300	0.0038±0.0085	0.152±0.026	46±71	0.0584±0.0178	23±6	18±2	80±80	1.7±0.2
LAO-3A	HSE-9	1100±300	0.0047±0.0081	0.0094±0.0094	0±83	0.0389±0.0168	5±2	130±10	10±80	0.1±0.1
LAO-3	HSE-9	1300±300	0.0089±0.0089	0.0045±0.0077	11±63	0.0635±0.0203	5±2	130±10	20±80	6.6±0.7
LAO-4.5C	HSE-9	700±300	0.039±0.0184	0.0742±0.0197	83±70	0.098±0.216	4±1	9±1	120±80	0.3±0.1
LAO-4.5	HSE-9	700±300	0.0084±0.0103	0.0126±0.0094	2±64	0.171±0.0306	2.4±0.9	7.5±0.9	280±80	0.1±0.1

[a]Entry indicates particular sampling date and analytical laboratory performing analyses.

HSE-9 samples collected on September 11 (MCO-4B, MCO-4, MCO-6B, MCO-7A, and MCO-7) or September 12, 1990 (MCO-6, APCO-1, LAO-3A, LAO-3, LAO-4.5C, and LAO-4.5) and analyzed by Los Alamos National Laboratory, Environmental and Health Chemistry Group, HSE-9.

Table G-70. Summary of Appendix IX Inorganic Analyses on Samples from Perched Zone Monitoring Wells

		PARAMETER (micrograms/L)																		
WELL	LAB[a]	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Ni	Se	Ag	Tl	Sn	V	Zn	CN (mg/L)	Sulfides (mg/L)
MCO-4B	IT	<30	<40	190	<1	<5	<10	<20	10	<30	<1	<20	<60	<5	<40	<20	<10	81	0.01	2.0
	HSE-9	0.5	15.1	337	2.1	0.9	17.3		16.5	42.3	<0.2	10.9	2.5	0.3	0.4		171	72	0.041	
MCO-4	HSE-9	0.7	19.1	128	<0.1	0.9	15.9		17	2.8	<0.2	14.8	2.4	0.2	0.2		215	20	0.036	
MCO-6B	IT	<30	<40	690	4	<5	30	<20	30	70	<1	<20	<60	<5	<40	<20	30	150	<0.01	1.0
	HSE-9	<0.5	12.7	1670	8.3	0.7	22.5		17	163	<0.2	17.3	2.2	1.3	2.1		155	149	0.046	
MCO-6	HSE-9	<0.5	17.7	231	0.4	0.6	19.8		12.3	16.2	<0.2	16.3	2.6	<0.2	0.2		185	43	0.046	
MCO-7A	IT	<30	<40	420	3	<5	20	<20	30	50	<1	30	<60	<5	<40	<20	40	100	<0.01	1.6
	HSE-9	<0.5	15.8	820	4.7	0.7	28		21.2	94	<0.2	20.3	1	0.4	0.8		147	107	0.026	
MCO-7	HSE-9	<0.5	15.6	254	0.9	<0.5	15.8		49.7	16.8	<0.2	10.3	1	0.6	0.2		126	74	0.026	
APCO-1	IT	<30	<40	970	4	<5	30	40	120	80	<1	50	<60	<5	<40	<20	70	200	<0.01	1.6
	HSE-9	0.5	3.5	301	2.1	1.1	29.5		33	10.6	<0.2	37	1.	1.0	0.5		91	123	0.26	
LAO-3A	IT	<30	<40	180	2	<5	20	<20	30	40	<1	<20	<60	<5	<40	<20	10	54	<0.01	2.8
	HSE-9	<0.5	<1	96.1	<0.1	0.6	1.9		<1	<0.5	<0.2	3.4	1.7	<0.2	<0.2		<1	<5	0.015	
LAO-4.5C	IT	<30	<40	95	<1	<5	10	<20	30	<30	<1	<20	<60	<5	<40	<20	<10	52	<0.01	2.2
	HSE-9	<0.5	<1	46.5	0.2	0.6	3.2		3	2	<0.2	4.1	<1.	<0.2	<0.2		4.1	20	0.01	
LAO-4.5	HSE-9	<0.5	<1	41.7	0.4	<0.5	14.4		38	<0.5	<0.2	7.3	1.	<0.2	<0.2		100	34	0.01	

[a]Entry indicates particular sampling date and analytical laboratory performing analyses.

IT samples collected on November 1 (MCO-6B and MCO-7A) and November 2 (MCO-4B, LAO-3A, LAO-4.5C, and APCO-1),1990, and analyzed by IT Corporation.

HSE-9 samples collected on September 11 (MCO-4B, MCO-4, MCO-6B, MCO-7A, and MCO-7) or September 12, 1990 (MCO-6, APCO-1, LAO-3A, LAO-3, LAO-4.5C, and LAO-4.5) and analyzed by Los Alamos National Laboratory, Environmental and Health Chemistry Group, HSE-9.

Table G-71. Summary of Appendix IX Organic Analyses (Compounds Detected) on Samples from Perched Zone Monitoring Wells[a]

WELL	LAB[b]	RESULTS
MCO-4B	IT	N-Nitrosomorpholine, estimated at 3 µg/L, noted by laboratory as below reporting limit of10 µg/L for method.
	HSE-9	None detected
MCO-4	HSE-9	Diethyl phthalate, 18 µg/L; also found in blank at 13.7 µg/L, analyst judges to be from laboratory contamination.
MCO-6B	IT	N-Nitrosomorpholine, estimated at 2 µg/L, noted by laboratory as below reporting limit of 10 µg/L for method
	HSE-9	Methylene chloride 6 µg/L, analyst judges to be from sample preparation or storage.
MCO-6	HSE-9	None detected.
MCO-7A	IT	Organophosphorus pesticide sample fraction exceeded holding time one day, nothing detected; resampled on Nov. 30 for reanalysis
	HSE-9	None detected.
MCO-7	HSE-9	1,1,2-Trichloro-1,2,2-trifluoroethane 6 µg/L, analyst judges to be from sample preparation or storage.
APCO-1	IT	
	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 µg/L; analyst judges to be laboratory contamination)
LAO-3A	IT	
	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 µg/L; analyst judges to be laboratory contamination)

Table G-71. (Cont)

WELL	LAB[b]	RESULTS
LAO-3	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 µg/L; analyst judges to be laboratory contamination)
LAO-4.5C	IT	
	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 µg/L; analyst judges to be laboratory contamination)
LAO-4.5	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 µg/L; analyst judges to be laboratory contamination) Diethylphthalate, 1800 µg/L; 13.7 µg/L in lab blank.

Notes:
[a]This table notes only compounds detected and summarizes related interpretations.
See the detailed report (ERP 1990) for listings of all compounds analyzed, limits of quantification, and quality assurance information.

[b]Entry indicates particular sampling date and analytical laboratory performing analyses.
IT samples collected on November 1 (MCO-6B and MCO-7A) and November 2 (MCO-4B, LAO-3A,LAO-4.5C, and APCO-1),1990, and analyzed by IT Corporation.

HSE-9 samples collected on September 11 (MCO-4B, MCO-4, MCO-6B, MCO-7A, and MCO-7) or September 12, 1990 (MCO-6, APCO-1, LAO-3A, LAO-3, LAO-4.5C, and LAO-4.5) and analyzed by Los Alamos National Laboratory, Environmental and Health Chemistry Group, HSE-9.

Table G-72. Summary of General Chemical Parameter Analyses of Samples from Perched Zone Monitoring Wells

		PARAMETER (µg/L except where noted)													
WELL	LAB[a]	Ca	Mg	K	Na	P	SO4	Cl	NO3-N	Al	Fe	Mn	TDS	pH (pH)	Cond. (µmho/cm)
MCO-4B	HSE-9	55.4	5.66	45.1	209	0.361	46.5	<0.5	50.2	15	--	0.518	712	7.54	717
MCO-4	HSE-9	55.4	3.64	46.5	142	0.276	40.9	19.2	40.5	1.5	--	0.030	568	7.47	635
MCO-6B	HSE-9	53	10.2	32.8	278	0.876	54.9	34.4	15	113	--	2.56	834	7.31	905
MCO-6	HSE-9	57.6	6.61	54.9	268	0.333	49.4	29.3	70.1	8.3	--	0.265	884	7.37	894
MCO-7A	HSE-9	25	5.78	11.3	112.6	0.924	22.9	28.1	18.8	57.4	--	1.62	220	6.96	220
MCO-7	HSE-9	26.9	5.42	8.90	89.6	0.566	21.6	<0.5	13.7	280	--	0.206	280	7.06	300
APCO-1	HSE-9	22.4	3.43	14.8	103	6.12	40	17.3	4.52	448	2.9	1.05	448	7.04	304
LAO-3A	HSE-9	29.1	5.55	12.1	47.9	0.317	20	17.5	1.16	58	<0.02	0.015	274	7.0	257
LAO-3	HSE-9	29.4	5.67	11.7	47.2	0.328	20.3	17.3	1.05	116	15	0.412	234	7.08	294
LAO-4.5C	HSE-9	18.4	5.16	5.93	46	0.146	20.5	13.3	0.094	2.6	0.037	0.011	188	7.01	185
LAO-4.5	HSE-9	4.12	5.05	5.51	46.8	0.161	17.4	13.5	0.073	2.5	<0.02	0.002	154	7.12	201

[a] Entry indicates particular sampling date and analytical laboratory performing analyses.

HSE-9 samples collected on September 11 (MCO-4B, MCO-4, MCO-6B, MCO-7A, and MCO-7) or September 12, 1990 (MCO-6, APCO-1, LAO-3A, LAO-3, LAO-4.5C, and LAO-4.5) and analyzed by Los Alamos National Laboratory, Environmental and Health Chemistry Group, HSE-9.

GLOSSARY OF TERMS AND ACRONYMS

activation products — Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.

ALARA — As low as reasonably achievable. The term that describes an approach to radiation exposure control or management whereby the exposures and resulting doses are maintained as far below the limits specified for the appropriate circumstances as economic, technical, and practical considerations permit.

alpha particle — A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.

ambient air — The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.

aquifer — A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

atom — Smallest particle of an element capable of entering into a chemical reaction.

AEC — Atomic Energy Commission. A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian applications. It was abolished by the Energy Reorganization Act of 1974 and succeeded by the Energy Research and Development Administration (now part of the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission).

background radiation — Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from

naturally occurring radioactive elements in the human body; and radiation from medical diagnostic procedures.

beta particle — A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.

BOD — Biochemical (biological) oxygen demand. A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.

CERCLA — Comprehensive Environmental Response, Compensation and Liability Act of 1980. Also known as Superfund, this law authorizes the Federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The Environmental Protection Agency (EPA) is responsible for managing Superfund. The major step in the Superfund process is the Remedial Investigation/Feasibility Study (RI/FS).

chain-of-custody — A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

CFR — Code of Federal Regulations. A codification of all regulations developed and finalized by Federal government agencies in the *Federal Register*.

contamination — The deposition of unwanted radioactive material on the surfaces of structure, areas, objects, or personnel.

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.

Ci — Curie unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.

DCG — Derived Concentration Guide. The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would

result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and lens of the eye. The standards for radionuclides in air and water are given in DOE Order 5400.5.

DOE — U.S. Department of Energy. The Federal agency that sponsors energy research and regulates nuclear materials used for weapons production.

dose — A term denoting the quantity of radiation energy absorbed.

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 serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100 mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to (100 × 0.12) = 12 mrem.

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 100% of the time (full occupancy), and it 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 1 000 people each received a radiation dose of 1 rem, their population dose would be 1 000 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).

EA Environmental Assessment. A report that identifies potentially significant environmental impacts from any Federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.

effluent A liquid or gaseous waste discharge to the environment.

EIS Environmental Impact Statement. A detailed report, required by Federal law, on the significant environmental impacts that a pending structure or development will have on the environment. An EIS must be prepared by a government agency when a major Federal action that will have significant environmental impacts is planned.

environmental surveillance The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media to determine environmental quality of an industry or community. It is commonly performed at sites containing nuclear facilities.

EPA Environmental Protection Agency. The Federal agency responsible for enforcing environmental laws. Although some of this responsibility may be delegated to state and local regulatory agencies, EPA retains oversight authority to ensure protection of human health and the environment. EPA administers the Superfund legislation and works with State and local agencies to provide technical oversight for clean-up activities at Federal facilities regulated by the Superfund program.

exposure A measure of the ionization produced in air by x or gamma radiation. (The unit of exposure is the roentgen).

external radiation Radiation originating from a source outside the body.

fission products Atoms created by the splitting of larger atoms into smaller ones accompanied by release of energy.

friable asbestos Asbestos that is brittle or readily crumbled.

gallery An underground collection basin for spring discharges.

gamma radiation — Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) 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.

^3H — 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.

half-life, radioactive — The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$), after three half-lives, one-eighth ($1/2 \times 1/2 \times 1/2$), and so on.

hazardous waste — Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or EP-toxicity (yielding toxic constituents in a leaching test). In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term more generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act regulations set strict controls on the management of hazardous wastes.

hazardous waste constituent — The specific substance in a hazardous waste that makes it hazardous, and therefore subject to regulation under Subtitle C of RCRA.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

HSWA — Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed

EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.

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.

isotopes — Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

- long-lived isotope - A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
- short-lived isotope - A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

joule (J) — The unit for work and energy equal to one newton along a distance of one meter.

LANL — Los Alamos National Laboratory or the Laboratory.

MCL — Maximum Contaminant Level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-3). The MCLs are specified by the EPA.

mrem — Millirem (10^{-3} rem). See rem definition. The dose equivalent that is one-thousandth of a rem.

NEPA — National Environmental Policy Act. This Federal legislation, passed in 1969, regulates the issuance of permits for the construction and operation of facilities that have the potential to impact the environment or public health. One provision of NEPA requires the preparation of an EIS by Federal agencies when major actions are taken.

NESHAP — National Emission Standards for Hazardous Air Pollutants. These standards are found in the Clean Air Act; they set limits for such pollutants as beryllium and radionuclides.

nonpoint source — Any nonconfined area from which pollutants are discharged into a body of water (e.g., agricultural runoff, construction runoff, and parking lot drainage).

NPDES — National Pollutant Discharge Elimination System. This Federal regulation, under the Clean Water Act, requires permits for discharges into surface waterways.

PCBs — Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers as insulators and coolants, in lubricants, carbonless copy paper, adhesives, and caulking compounds. They are also produced in certain combustion processes. PCBs are extremely persistent in the environment because they do not break down into new and less-harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976. In general, PCBs are not as toxic in acute short-term doses as some other chemicals, although acute and chronic exposure can cause liver damage. PCBs have also caused cancer in laboratory animals. When tested, most people show traces of PCBs in their blood and fatty tissues.

PDL — Public Dose Limit. The new term for RPS, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (See Appendix A and Table A-2.).

perched water — A groundwater body above an impermeable layer that is separated from an underlying main body of groundwater by an unsaturated zone.

person-rem — The unit of population dose that expresses the sum of radiation exposures received by a population. For example, two persons, each with a 0.5 rem exposure, receive 1 person-rem, and 500 people, each with an exposure of 0.002 rem, also receive 1 person-rem.

pH — A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 6, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.

ppb — Part per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as μg/L or ng/mL.

ppm — Part per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L.

QA — Quality assurance. Any action in environmental monitoring to assure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.

QC — Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

rad — A unit of absorbed dose from ionizing radiation. A dose of 1 rad equals the absorption of 100 ergs of radiation energy per gram of absorbing material.

radiation — The emission of particles or energy as a result of an atomic or nuclear process.

radionuclide — An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

RCRA — Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first Federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.

reagent — Any substance used in a chemical reaction to detect or measure another substance or to convert one substance into another by means of the reaction that it causes.

release — Any unintentional discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem — The unit of radiation dose equivalent that takes into account different kinds of ionizing radiation and permits them to be expressed on a common basis. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the necessary modifying factors.

R — Roentgen. A unit of radiation exposure that expresses exposure in terms of the amount of ionization produced by x rays in a volume of air. One roentgen (R) is 2.58×10^{-4} coulombs per kilogram of air.

RPS — Radiation Protection Standards. See of PDL.

SARA — Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title III of this act is also known as the Emergency Planning and Community Right-to-Know Act of 1986.

SWMU — Solid Waste Management Unit. Any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released. Potential release sites include, for example: waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, LANL canyons, and contaminated areas resulting from leaking product storage tanks (including petroleum).

TCLP — Toxicity Characteristic Leaching Procedure. An analytical method designed to determine the mobility of both organic and inorganic compounds present in liquid, solid, and multiphase wastes. It is used to determine applicability of Land Ban regulations to a waste.

terrestrial radiation — Radiation emitted by naturally occurring radionuclides such as ^{40}K; the natural decay chains ^{235}U, ^{238}U, or ^{232}Th; or cosmic-ray-induced radionuclides in the soil.

TLD — Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that, after being exposed to radiation, luminesces upon being heated. The amount of light the material emits is proportional to the amount of radiation (dose) to which it was exposed.

total suspended particulates — Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

TRU — Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and NRC. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium.

TSCA — Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is

required by the Act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this Act for controlling substances found to be detrimental to human health and to the environment.

tuff — Rock of compacted volcanic ash and dust.

uncontrolled area — An area beyond the boundaries of a controlled area (see controlled area in this glossary).

uranium, depleted — Uranium consisting primarily of ^{238}U and having less than 0.72 wt % ^{235}U. Except in rare cases, depleted uranium is manmade.

uranium, total — The amount of uranium in a sample, assuming that the uranium has the isotopic content of uranium in nature (99.27 wt % ^{238}U, 0.72 wt % ^{235}U, and 0.0057 wt % ^{234}U).

UST — Underground storage tank. A stationary device designed to contain an accumulation of hazardous materials or waste. A tank is constructed primarily of nonearthen material, but the entire surface area of the tank is totally below the surface of the ground.

vadose zone — The partially saturated or unsaturated region above the water table that does not yield water to wells.

VOC — Volatile organic compound. Liquid or solid organic compounds that have a tendency to spontaneously pass into the vapor state.

watershed — The region draining into a river, river system, or body of water.

water table — The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.

water year — October through September.

wetlands — A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.

WLM

Working level month. A unit of exposure to ^{222}Rn and its decay products. Working level (WL) is any combination of the short-lived ^{222}Rn decay products in 1 L of air that will result in the emission of 1.3×10^5 MeV potential alpha energy. At equilibrium, 100 pCi/L of ^{222}Rn corresponds to 1 WL. Cumulative exposure is measured in working level months, which is 170 WL-h.

worldwide fallout

Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

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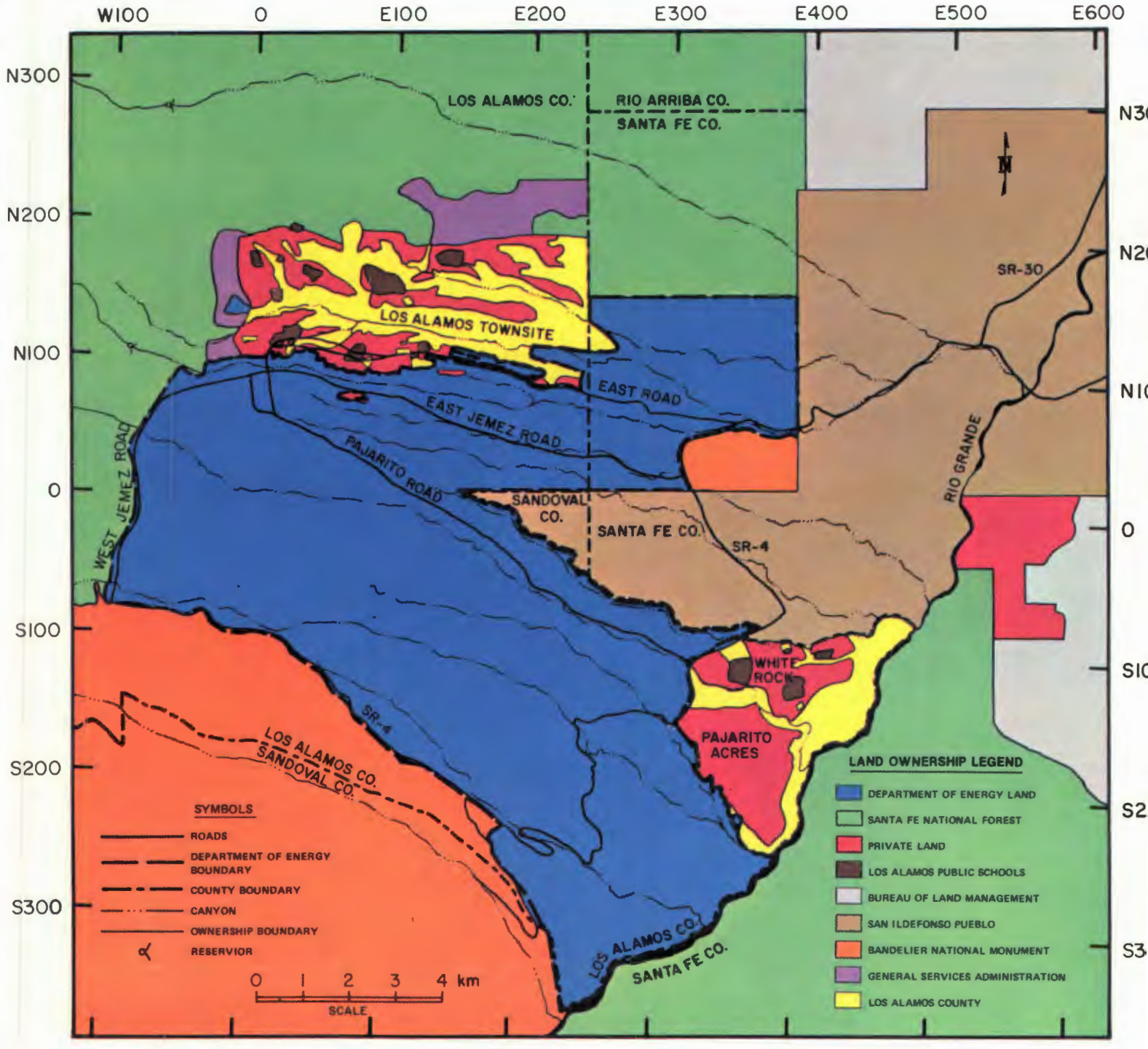

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