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ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1982

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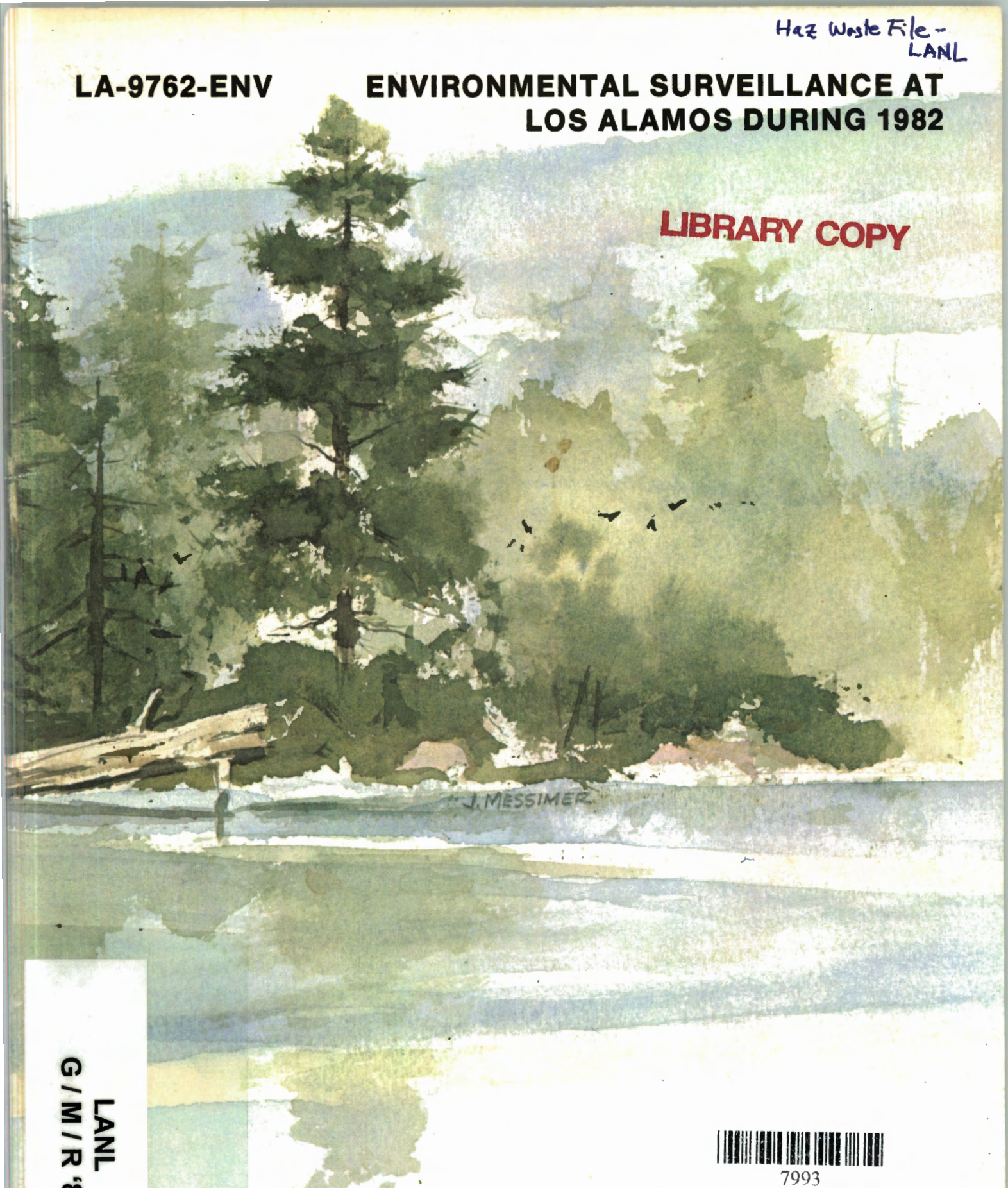

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Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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

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ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1982

Environmental Surveillance Group

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

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The four most recent reports in this unclassified series are LA-7800-ENV, LA-8200-ENV, LA-8810-ENV, and LA-9349-ENV.

This report was compiled by the
Environmental Surveillance Group H-8.

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FOREWORD

SUGGESTIONS ON HOW TO READ THIS REPORT

This report addresses a mixed audience of laypeople and scientifically oriented people. Within each of these two groups are those people with a limited interest in this report and those with a more comprehensive interest. An attempt has been made to make this report accessible to all without compromising its scientific integrity. Following are directions advising each specific audience on how best to use this document.

1. *LAYPERSON WITH LIMITED INTEREST.* Read Part I, the Environmental Monitoring Summary, which describes the Laboratory's environmental monitoring operations and summarizes environmental data for this year. Emphasis is placed on significance of findings and results are explained in common language. Technical terms are avoided. A glossary, list of acronyms and abbreviations, and list of units are in the front of the report to assist you.

2. *LAYPERSON WITH COMPREHENSIVE INTEREST.* Follow directions for the "Layperson With Limited Interest" given above. Also, summaries of each section of the report are in boldface type and precede the more technically oriented text. Read summaries of those sections that interest you. Further detail can be gleaned by reading the text that follows each summary. Appendix A (Standards for Environmental Contaminants) and Appendix F (Descriptions of Technical Areas and Their Associated Programs) may also be helpful to you.

3. *SCIENTIST WITH LIMITED INTEREST.* Read Part I, the Environmental Monitoring Summary, to determine which specific parts of the Laboratory's environmental monitoring program are of interest to you. You can then read summaries and technical details of these parts in the body of the report. Also, detailed data tables are in Appendix E.

4. *SCIENTIST WITH COMPREHENSIVE INTEREST.* Read Part I, the Environmental Monitoring Summary, which describes the Laboratory's environmental monitoring operations and summarizes environmental data for 1982. Also, read the summaries (in boldface) that head each major subdivision of this report. Further detail can be gleaned from the text and appendixes.

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

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ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
BOD_5	5-day biochemical oxygen demand
COD	chemical oxygen demand
CG	Concentration Guide
DOE	Department of Energy
EA	environmental assessment
EEC	Environmental Evaluations Coordinator
EPA	Environmental Protection Agency
FEIS	final environmental impact statement
H-7	Waste Management Group at the Laboratory
H-8	Environmental Surveillance Group at the Laboratory
HDR	hot dry rock
HTO	tritiated water
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
Laboratory	Los Alamos National Laboratory
LAMPF	Los Alamos Meson Physics Facility
LERC	Laboratory Environmental Review Committee
LS-6	Environmental Sciences Group at the Laboratory
MAP	mixed activation products
MCL	Maximum Contaminant Level
N	normal (chemical term)
NADP	National Atmospheric Deposition Program
NBS	National Bureau of Standards
NCRP	National Council on Radiation Protection and Measurements
NERP	National Environmental Research Park
NIPDWR	National Interim Primary Drinking Water Regulations
NMEID	New Mexico Environmental Improvement Division
NPDES	National Pollutant Discharge Elimination System
QA	quality assurance
RPS	Radiation Protection Standard
SRM	standard reference material
TA	technical area
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TRU	transuranic wastes
TSS	total suspended solids
USGS	United States Geological Survey
α	alpha
β	beta
γ	gamma
s	standard deviation
$\bar{x}$	mean

SYSTEM INTERNATIONAL PREFIXES

Exponent	Prefix	Symbol
10^6	mega	M
10^3	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

UNITS

Abbreviation	Unit
c	count
aCi	attocurie (10^{-18} curies)
Btu	British thermal unit
°C	Celsius degree
Ci	curie (unit of radioactivity)
cm	centimeter
fCi	femtocurie (10^{-15} curies)
ft	foot
g	gram
h	hour
ha	hectare
in.	inch
keV	kiloelectron volt
kg	kilogram
km	kilometer
km^2	square kilometer
ℓ	liter
m	meter
m^3	cubic meter
mCi	millicurie (10^{-3} curies)
MeV	megaelectron volt
mg	milligram (10^{-3} grams)
min	minute
mℓ	milliliter (10^{-3} liters)
mm	millimeter (10^{-3} meters)
mph	miles per hour
mR	milliroentgen (10^{-3} roentgens)
mrem	millirem (10^{-3} rems)
mS/m	milliSiemens/meter (1 mS/m = 10 μmho/cm)
MGD	million gallons per day
MT	megaton (10^6 tons)
μCi	microcurie (10^{-6} curies)
μg	microgram (10^{-6} grams)
μm	micrometer (10^{-6} meters)
nCi	nanocurie (10^{-9} curies)
ng	nanogram (10^{-9} grams)
pCi	picocurie (10^{-12} curies)
pg	picogram (10^{-12} grams)
ppb	parts per billion (1 in 1 000 000 000)
ppm	parts per million (1 in 1 000 000)
rad	62.5×10^6 MeV/g (unit of absorbed dose)
rem	roentgen equivalent man (unit of dose equivalence)
R	roentgen
sec	second
wt%	weight per cent
yr	year

GLOSSARY

alpha particle	A charged particle (identical to the helium nucleus) composed of two protons and two neutrons that is emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
activation products	In nuclear reactors and some high energy research facilities, neutrons and other subatomic particles that are being generated can produce radioactive species through interaction with materials such as air, construction materials, or impurities in cooling water. These "activation products" are usually distinguished, for reporting purposes, from "fission products."
background radiation	Ionizing radiation coming from sources other than the Laboratory. It includes cosmic radiation; external radiation from naturally occurring radioactivity in the earth, air, and water; and internal radiation from naturally occurring radioactive elements in the human body.
beta particle	A charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum or less.
Concentration Guide (CG)	The concentration of a radionuclide in air or water that results in a whole body or organ dose in the 50th year of exposure equal to the Department of Energy's Radiation Protection Standard for external and internal exposures. This dose is calculated assuming the air is continuously inhaled or the water is the sole source of liquid nourishment for 50 years.
Controlled Area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
cosmic radiation	High energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
curie (Ci)	A special unit of radioactivity. One curie equals 3.70×10^{10} nuclear transformations per second.
dose	A term denoting the quantity of radiation energy absorbed.

dose, maximum boundary	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, maximum individual	The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to a hypothetical individual who is in an Uncontrolled Area where the highest dose rate occurs. It assumes that the hypothetical individual is present for 100% of the time (full occupancy) and does not take into account shielding (for example, by buildings).
external radiation	Radiation originating from a source outside the body.
fission products	Those atoms created through the splitting of larger atoms into smaller ones, accompanied by release of energy.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (microwaves, visible light, radiowaves, etc.) have longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
ground water	A subsurface body of water in the zone of saturation.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$), after three half-lives, one-eighth ($1/2 \times 1/2 \times 1/2$), etc.

internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms.
Laboratory	Los Alamos National Laboratory.
Maximum Contaminant Level (MCL)	Maximum permissible level of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-III). The MCLs are specified by the Environmental Protection Agency.
perched water	A ground water body above an impermeable layer that is separated from an underlying main body of ground water by an unsaturated zone.
person-rem	The unit of population dose, it expresses the sum of radiation exposures received by a population. For example, two persons each with a 0.5 rem exposure have received 1 person-rem. Also, 500 people each with an exposure of 0.002 rem have received 1 person-rem.
population dose	The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem (for example, if 1000 people each received a radiation dose of 1 rem, their population dose would be 1000 person-rem).
rad	A special unit of absorbed dose from ionizing radiation. A dose of 1 rad equals the absorption of 100 ergs of radiation energy per gram of absorbing material.
radiation	The emission of particles or energy as a result of an atomic or nuclear process.
Radiation Protection Standard (RPS)	Standards for external and internal exposure to radioactivity as defined in Department of Energy Order 5480.1A, Chapter XI (see Appendix A and Table A-II in this report).
rem	The unit of radiation dose equivalent that takes into account different kinds of ionizing radiation and permits them to be expressed on a common basis. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the necessary modifying factors.

roentgen (R)	A unit of radiation exposure that expresses exposure in terms of the amount of ionization produced by x rays in a volume of air. One roentgen (R) is 2.58×10^{-4} coulombs per kilogram of air.
terrestrial radiation	Radiation emited by naturally occurring radionuclides, such as ^{40}K, the natural decay chains ^{235}U, ^{238}U, or ^{232}Th, or from cosmic-ray induced radionuclides in the soil.
thermoluminescent dosimeter (TLD)	A material (the Laboratory uses lithium fluoride) that, after being exposed to radiation, luminesces upon being heated. The amount of light the material emits is proportional to the amount of radiation (dose) to which it was exposed.
uranium, depleted	Uranium consisting primarily of ^{238}U and having less than 0.72 wt% ^{235}U. Depleted uranium generally contains less than 0.2 wt% ^{235}U. Except in rare cases occurring in nature, depleted uranium is manmade.
uranium, total	The amount of uranium in a sample, assuming the uranium has the isotopic content of uranium in nature (99.27 wt% ^{238}U, 0.72 wt% ^{235}U, 0.0057 wt% ^{234}U).
tritium (^{3}H)	A radionuclide of hydrogen with a half-life of 12.3 years. The very low energy of its radioactive decay makes it one of the least hazardous radionuclides.
tuff	Rock of compacted volcanic ash and dust.
Uncontrolled Area	An area beyond the boundaries of a Controlled Area (see definition of "Controlled Area" in this Glossary).

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1982

by

Environmental Surveillance Group

ABSTRACT

This report documents the environmental surveillance program conducted by the Los Alamos National Laboratory during 1982. Routine monitoring for radiation and radioactive or chemical substances is conducted on the Laboratory site and in the surrounding region to determine compliance with appropriate standards and permit early identification of possible undesirable trends. Results and interpretation of data for 1982 are included on penetrating radiation; on the chemical and radiochemical quality of ambient air, surface and ground water, municipal water supply, soil and sediments, and food; and on the quantities of airborne emissions and liquid effluents. Comparisons with appropriate standards, regulations, and background levels from natural or other non-Laboratory sources provide a basis for concluding that environmental effects attributable to Laboratory operations are insignificant and are not considered hazardous to the population of the area. Results of several special studies describe some unique environmental conditions in the Laboratory environs.

I. ENVIRONMENTAL MONITORING SUMMARY

Los Alamos National Laboratory policy emphasizes protection of the general public and environment from any harm that could arise from Laboratory activities and mitigation of environmental impacts to the greatest degree practicable. In keeping with this policy and Department of Energy (DOE) requirements to assess and document possible influences of operations on the environment, this report provides data and interpretation of environmental conditions in the vicinity of the Laboratory during 1982.

A. Monitoring Operations

Routine monitoring for radiation, radioactive materials, and chemical substances is conducted on the Laboratory site and in the surrounding region to document compliance with appropriate standards, identify possible undesirable trends, provide information for the public, and contribute to general environmental knowledge. Information from monitoring of the environment complements data on specific releases, such as those from radioactive waste treatment plants and various stacks at nuclear research facilities.

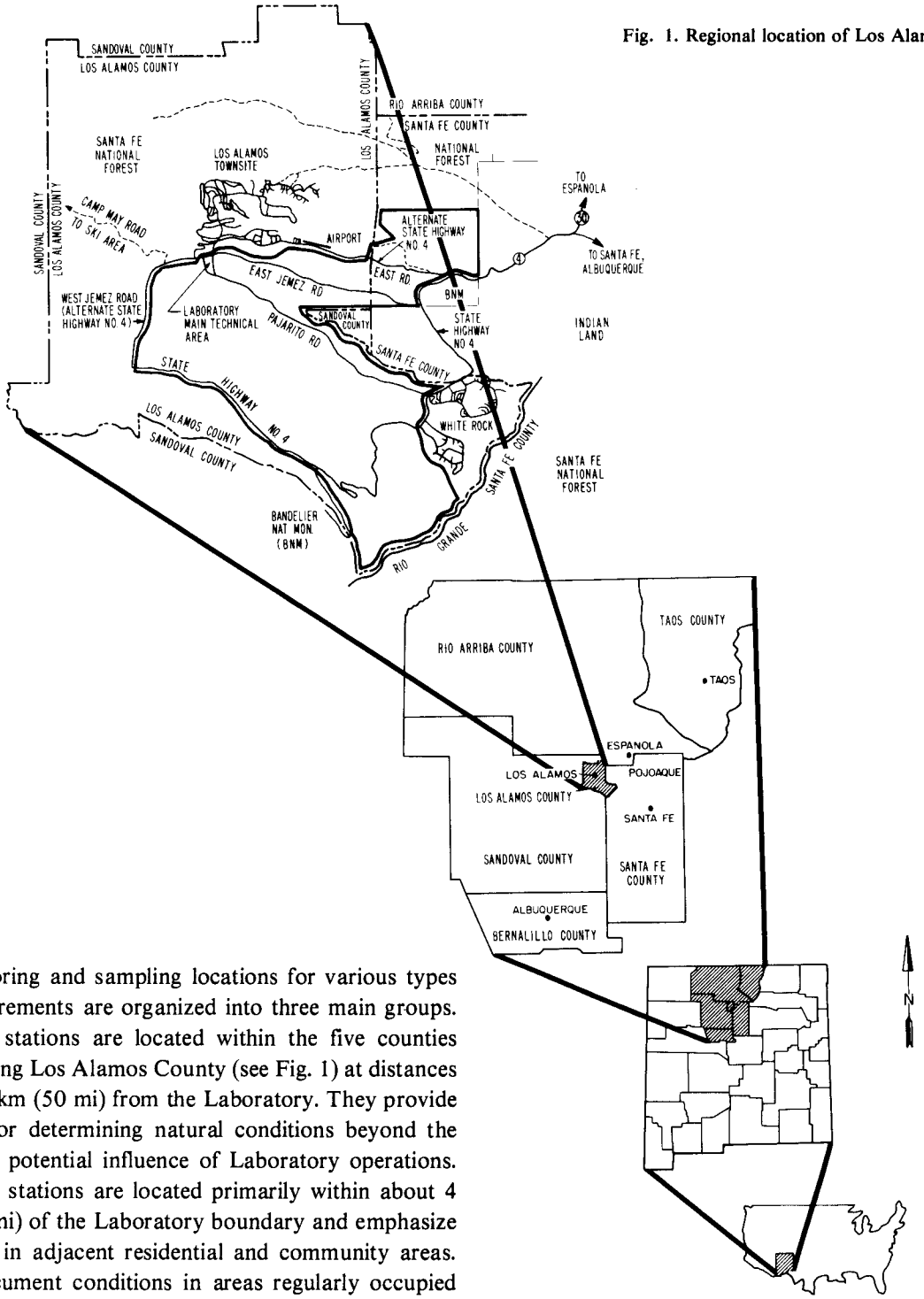


Fig. 1. Regional location of Los Alamos.

Monitoring and sampling locations for various types of measurements are organized into three main groups. Regional stations are located within the five counties surrounding Los Alamos County (see Fig. 1) at distances up to 80 km (50 mi) from the Laboratory. They provide a basis for determining natural conditions beyond the range for potential influence of Laboratory operations. Perimeter stations are located primarily within about 4 km (2.5 mi) of the Laboratory boundary and emphasize locations in adjacent residential and community areas. They document conditions in areas regularly occupied by the general public and likely to be influenced by Laboratory operations. Onsite stations are within the Laboratory boundary and most are in areas accessible only to employees during normal working hours. Their data are useful for continuity of interpretation and for documentation of conditions in parts of the Laboratory site where the public has limited access (for example, commuters on cross-site roads or near some boundaries). The number of stations in each group is shown in Table I.

TABLE I

NUMBER OF SAMPLING LOCATIONS

Type of Monitoring	Number of Sampling Stations in Group		
	Regional	Perimeter	Onsite
External radiation[a]	4	12	21
Air	3	11	11
Surface and ground water[b]	6	32	37
Soils and sediments	16	16	34
Foodstuffs	8	5	9

[a]An additional 24 stations at the Los Alamos Meson Physics Facility and 91 stations at the Los Alamos Radioactive Waste Disposal Site were also used for monitoring external radiation.
[b]An additional 26 stations for the water supply and 33 special surface and ground water stations related to the Fenton Hill Geothermal Program were also sampled and analyzed as part of the monitoring program.

The types of routine monitoring conducted at these stations include measurements of radiation and collection of samples of air particulates, water, soils, and foodstuffs for subsequent analysis. External penetrating radiation (the x and gamma ray and charged particle contributions from natural, cosmic, and terrestrial sources, plus any Laboratory contributions) is measured at 152 locations by thermoluminescent dosimeters (TLDs): 37 routine sampling stations, 24 stations at the Los Alamos Meson Physics Facility, and 91 stations at the Los Alamos Radioactive Waste Disposal Site. Airborne radioactivity samples are accumulated during monthly intervals by continuously operating samplers at 25 locations. Surface and ground water samples are collected periodically at 134 locations: 75 of which are indicated in Table I, plus 26 for the Department of Energy's water supply wells and distribution system, and 33 related to the Hot Dry Rock Geothermal Project at Fenton Hill.

Samples of foodstuffs, principally vegetables, fruit, and fish, are collected at 22 locations. Soil and sediment samples are collected periodically from 66 locations. Additional samples are collected at various times and locations to gain information about particular events, such as major runoff events in intermittent streams, nonroutine releases, or special studies. During 1982, more than 18 100 analyses for chemical and radiochemical constituents were performed on these environmental samples. Resulting data are used for comparison with standards and natural background, dose calculations, and other interpretations.

B. Summary of 1982 Results

The large number of samples and wide range of purposes for which they are collected makes a brief summary difficult without leading to possible misinterpretation. Consequently, this summary presents an overview of monitoring results with selected highlights, emphasizing comparisons with standards or other bases for indicating significance. Full details of the results, their contexts, and interpretative methodologies are explained in the body of the report and appendixes.

1. Radiation Doses

Individual whole body radiation doses to the public attributable to Laboratory operations are compared to applicable Radiation Protection Standards in Table II. Radiation doses for various mechanisms of exposure are expressed as a percentage of the 500 mrem/yr Radiation Protection Standard for whole body radiation. This Radiation Protection Standard is for doses from exposures above natural background and medical exposures. Doses presented here are those calculated to be possible doses to individuals under realistic conditions of exposures and do not include some of the maximum hypothetical exposures discussed in the body of this report that have minimal likelihood of occurring.

Maximum boundary doses and maximum individual doses for the past 5 years are shown in Fig. 2. These doses are compared to the 500 mrem/yr standard and historically have been less than 4% of the standard. In 1982 the maximum individual dose was 1.7% of the standard. The apparent increase in maximum individual dose between 1981 and 1982 resulted from estimates of increased occupancy in a location near the Laboratory boundary (where doses have been elevated for many years).

Another perspective is gained by comparing these estimated doses with the estimated whole body dose

TABLE II

COMPARISON OF INDIVIDUAL WHOLE BODY RADIATION DOSES WITH RADIATION PROTECTION STANDARDS

Calculated Doses Attributable to Laboratory Operations from:	% Radiation Protection Standard[a]		
	Regional	Perimeter	Onsite
Direct external radiation	<0.001	<0.001	0.1
Airborne radioactivity	0.002	1.7	<0.001
Food pathways	<0.001	0.01	0.8

[a]The Radiation Protection Standard for whole body radiation dose is 500 mrem/yr above natural background and medical doses for a member of the public.

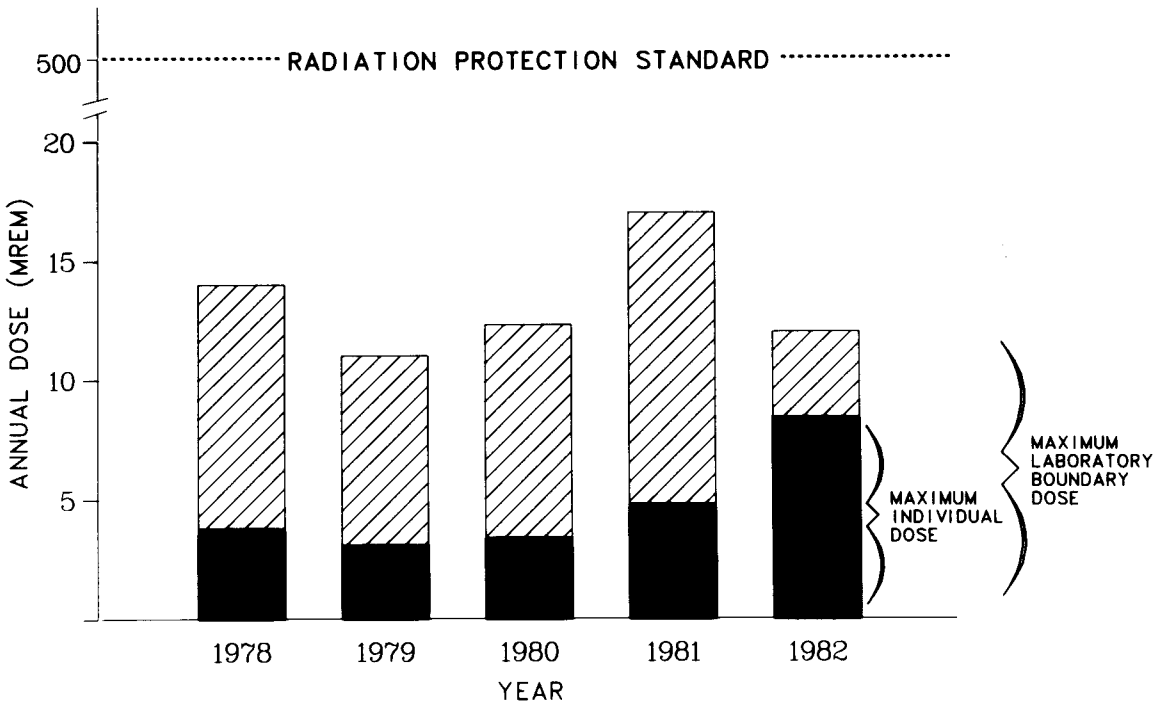


Fig. 2. Maximum boundary and maximum individual above background doses from 1978-1982.

attributable to natural background radiation. The highest estimated dose due to Laboratory operations was about 7% of the dose attributable to naturally occurring radioactivity in Los Alamos in 1982.

The estimated maximum regional doses shown in Table II for direct external radiation and airborne radioactivity are both based on exposure to theoretically calculated concentrations of airborne emissions from the Los Alamos Meson Physics Facility (a linear particle accelerator) and Omega West research nuclear reactor. The maximum estimated regional dose is based on a food pathway that includes consumption of liver from a steer that grazed in Los Alamos Canyon and drank water containing some radioactivity on suspended sediments during a long spring runoff.

Estimated perimeter doses from direct external radiation and airborne radioactivity occur at a residence near the boundary north of the Los Alamos Meson Physics Facility and are attributable to its operation. The perimeter food pathway is based on consumption of honey from a hive located near the Laboratory boundary.

The onsite external radiation dose is that estimated for a commuter regularly traveling past a Laboratory facility on one of the Department of Energy's roads normally open to public travel. The onsite airborne pathway was calculated for a half-day visit to the Laboratory's science museum. The onsite food pathway could occur from consumption of venison from a deer frequenting a canyon where treated radioactive liquid effluents are discharged.

2. Significance of Radiation Doses

To provide a perspective for comparing the significance of radiation exposures, estimates of the added risk of cancer were calculated. Increases in risk estimated for average individual exposures to ionizing radiation from 1982 Laboratory operations are presented in Table III, along with estimated incremental risks from natural and diagnostic medical radiation. The maximum potential Laboratory contribution to cancer risk is small when compared to overall cancer risks. The overall United States lifetime risks of contracting some form of cancer from all causes is 1 chance in 4. The lifetime risk of cancer mortality is 1 chance in 5. The Los Alamos and White Rock incremental doses attributable to the 1982 Laboratory operations are equivalent to the additional exposure a person would get flying in a commercial jet for 46 and 22 minutes, respectively.

The factors used for risk calculation are those given by the International Commission on Radiological Protection, which are based on observed radiation damage at high doses and linearly extrapolated to effects at low doses and dose rates (that is, the injury is assumed to be directly proportional to dose). The International Commission on Radiological Protection warns that these radiation risk estimates should be used with caution, because the factors may overestimate actual risk. The National Council on Radiation Protection and Measurements has also taken the official position that linear extrapolation methods "have such a high probability of

TABLE III

ADDED INDIVIDUAL LIFETIME CANCER MORTALITY RISKS ATTRIBUTABLE TO 1982 RADIATION EXPOSURE

Exposure Source	Added Risk (Chance) to an Individual of Cancer Mortality	Incremental Dose (mrem) Used in Risk Estimate
Average Exposure from Laboratory Operations		
Los Alamos Townsite	1 in 60 000 000	0.17
White Rock Area	1 in 125 000 000	0.08
Natural Radiation		
Cosmic, Terrestrial, and Self-Irradiation		
Los Alamos Townsite	1 in 82 000	122 [a]
White Rock Area	1 in 90 000	111 [a]
Medical X-Rays (Diagnostic Procedures)		
Average Whole Body Exposure	1 in 97 000	103

[a]Based on measured dose rates for cosmic and terrestrial components with reductions made for structural and self-shielding.

overestimating the actual risk as to be of only marginal value, if any, for purposes of *realistic* risk-benefit evalution." Thus, keep in mind that the radiation risks are likely to be less than those stated in Table III.

3. Penetrating Radiation

Levels of 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 61 locations divided into two networks. The 24 onsite thermoluminescent dosimeter stations are specially located to monitor radioactivity from the Los Alamos Meson Physics Facility and showed an increase above background of 12 ± 3 mrem/yr at the Laboratory boundary north of the Facility.

The other network consists of 37 locations divided into regional, perimeter, and onsite groups. No measurements at these regional or perimeter locations for any calendar quarter showed any statistically distinguishable increase in radiation levels that could be attributed to Laboratory operations (see Table IV). Apparent differences between the regional and perimeter groups are attributable to differences in the natural radioactivity content of geologic formations. Some measurements at 21 onsite stations were expectably above background levels, reflecting ongoing research activities at the Laboratory.

4. Radioactivity in Air and Water

Measurements of radioactivity in air and water are compared to standards, known as Concentration Guides, that are set by the Department of Energy (see Appendix A). The Concentration Guides are concentrations of radioactivity in air breathed continuously or water constituting all that is drunk during a year that result in whole body or organ doses equal to the Radiation Protection Standards [standards for external or internal exposure to radioactivity (see Appendix A)]. The 1982 results for the principal isotopes (including amounts present from worldwide fallout) potentially influenced by Laboratory operations are shown in Table V as ranges of percentages of the Concentration Guides. The values shown represent a statistical range (from two standard deviations below to two standard deviations above the mean) that encompasses 90 to 95% of the individual results. All comparisons in Table V are with Concentration Guides applicable to individuals in the general public, even though the public has only restricted access to many onsite locations.

TABLE IV

EXTERNAL PENETRATING RADIATION DURING 1982

	Dose (mrem)		
Group	Minimum	Maximum	Average
Regional	84	122	95
Perimeter	90	127	109
Onsite	104	196	136

a. Radioactivity in Air. During 1982, atmospheric concentrations of gross alpha, gross beta, americium, plutonium, and uranium were measured at regional, perimeter, and onsite sampling locations. For all analyses, the regional annual means were lower than the perimeter and onsite annual means. This indicates there was some Laboratory contribution to concentrations of these radioactive species at the perimeter and onsite locations. Data in Table V show that tritium, plutonium ($^{239+240}Pu$), and uranium atmospheric concentrations were small percentages of their respective Concentration Guides. Results from only 3 of 100 plutonium (^{238}Pu) samples and 2 of 44 americium (^{241}Am) samples were above analytical detection limits and so were not included in Table V.

Atmospheric gross alpha and beta analyses serve as indicators of overall radioactivity levels. The highest gross alpha and beta concentrations were 0.6% and 0.4%, respectively, of the Concentration Guides. Gross beta annual means were about 4 to 6 times lower than last year. This decreased activity was primarily due to the fact that there have been no atmospheric tests of nuclear weapons within the past 2 years.

b. Radioactivity in Water. Surface and ground waters are monitored to provide routine surveillance of potential dispersion of radionuclides from Laboratory operations. Results of analyses are compared to the Concentration Guides (see Table V) to show how low concentrations of

TABLE V

ANNUAL RADIONUCLIDE CONCENTRATIONS IN AIR AND WATER AS PERCENTAGES OF CONCENTRATION GUIDES

	% Concentration Guide[a]		
	Regional	Perimeter	Onsite
Air			
Tritium (^{3}H)	0.004 - 0.008	0.007 - 0.02	0.01 - 0.02
Plutonium ($^{239+240}Pu$)	0.001 - 0.007	0.003 - 0.005	0.003 - 0.008
Uranium (U)	0.0005 - 0.002	0.0005 - 0.001	0.0007 - 0.001
Water			
Tritium (^{3}H)	0.0 - 0.03	0.0 - 0.2	0.0 - 0.7
Plutonium (^{239}Pu)	0.0 - 0.00006	0.0 - 0.00006	0.0 - 0.0002
Cesium (^{137}Cs)	0.0 - 0.2	0.0 - 0.6	0.0 - 0.4

[a]Values in table are ($\bar{x}$ – 2s) to ($\bar{x}$ + 2s) as percent of Concentration Guide.

radionuclides are in the environment. Other radionuclides measured but not listed in this table are ^{238}Pu (most analyses were at or below analytical detection limits), gross alpha and beta (used only as gross indicators of radioactivity), and uranium (concentrations low and generally indistinguishable from levels naturally in the environment). Waters in onsite liquid effluent release areas contain measurably higher concentrations of radioactivity, but at levels that are still small fractions of the Concentration Guides. These onsite waters are not a source of industrial, agricultural, or municipal water supplies. Results of the 1982 radiochemical quality analyses of water from regional, perimeter, water supply, and onsite noneffluent release areas indicate no significant effect from effluent releases from the Laboratory.

The water supply met all applicable US Environmental Protection Agency chemical quality and radioactivity standards. The integrity of geological formations protecting the deep ground water aquifer was confirmed by lack of any measurements indicative of nonnatural radioactivity or chemical contamination in municipal water supply sources.

5. Radioactivity in Other Media

Measurements of radioactivity in samples of soils, sediments, and a variety of foodstuffs are made to provide information on less direct natural mechanisms that could result in exposures to people. Estimated doses potentially resulting from these mechanisms, or pathways, such as wind resuspension of dust and incorporation into food chains, are summarized in Section I.B.1.

Measurements of radioactivity in soils and sediments are also useful for monitoring and understanding hydrologic transport of some radioactivity that occurs in intermittent stream channels in and adjacent to radioactive waste disposal operations. Pueblo, Los Alamos, and Mortandad Canyons all have concentrations of radioactivity on sediments at levels higher than those attributable to worldwide fallout. Some radioactivity on sediments in Pueblo Canyon (from pre-1964 effluent disposal) and upper Los Alamos Canyon (from 1952 to current treated effluent disposal) has been transported during runoff events to the Rio Grande. Theoretical

estimates, confirmed by measurements, show the incremental effect on Rio Grande sediments is small in comparison with levels of activity on soils and sediments attributable to worldwide fallout and to variability in such measurements. No radioactivity on sediments or in water has been transported past the Laboratory boundary in Mortandad Canyon.

Measurements of above-background but low-level radioactivity on soils from a few locations indicate probable deposition of some airborne emissions from facilities known to have had higher emission rates in the past, especially prior to 1974.

Most fruit, vegetable, fish, and honey samples analyzed in 1982 showed no increments of radioactivity distinguishable from that attributable to natural sources or worldwide fallout at any offsite location. Produce collected from several gardens in areas possibly affected by Laboratory releases showed slightly elevated tritium concentrations. The dose associated with this tritium is 0.001% of the Radiation Protection Standard for the public. At onsite locations near facilities emitting tritium. some elevated levels of tritiated water were found in fruit. At several perimeter and onsite locations, trace amounts of radionuclides associated with Laboratory effluents were detected in honey from experimental hives.

6. Other Monitoring Results

Airborne radioactive emissions were monitored as released from 88 points at the Laboratory. The results are summarized in Table VI and show an approximate 25% decrease in total radioactivity released during 1982 when compared with 1981. This decrease is due to improved control technologies and changes in program activities. Liquid effluents from two radioactive waste treatment plants (Table VI) and one sanitary sewage lagoon contained some radioactivity, all at levels well within Concentration Guides.

Nonradioactive airborne emissions from the beryllium fabrication shop, gasoline storage and combustion, power plant, gases and volatile chemicals, waste explosive burning, and dynamic testing did not result in any measurable or theoretically calculable degradation of air quality. A single National Pollutant Discharge Elimination System (NPDES) permit covers 103 industrial discharge points and 11 sanitary sewage treatment facilities. This year 8 of the 11 sanitary sewage treatment facilities exceeded one or more of the NPDES limits (excluding flow rate limitations) in one or more months. Fewer than 6% of all samples from the 103 industrial outfalls exceeded NPDES limits.

Some special environmental research programs were conducted this year to gain a better understanding of the ecosystems at Los Alamos. Among these projects were environmental surveillance of radioactive waste disposal sites, evaluation of transuranic waste management methods, study of hydrologic transport of sediments, and use of honeybees as biological monitors.

TABLE VI

COMPARISON OF 1981 AND 1982 RADIOACTIVE RELEASES FROM THE LABORATORY

Airborne Stack Emissions

Radioactive Constituent	Units	Activity Released 1981	Activity Released 1982	Ratio [1982/1981]
^{241}Am	μCi	0.029	0.035	1.2
^{41}Ar	Ci	300	342	1.1
^{3}H	Ci	7225	15 856	2.2
^{131}I	μCi	44	785	17.8
^{32}P	μCi	20	4.8	0.2
$^{238,239}Pu$	μCi	56	112	2.0
U	μCi	1273	1373	1.1
Gaseous Mixed Activation Products	Ci	352 340	251 000	0.7
Mixed Fission Products	μCi	1544	1184	0.8
Particulate/Vapor Activation Products	Ci	---	182	---
Total	Ci	360 925	267 334	0.7

Liquid Effluents

Radioisotopes	Activity Released (mCi) 1981	Activity Released (mCi) 1982	Ratio [1982/1981]
$^{238,239}Pu$	59	19.9	0.3
^{241}Am	24	19	0.8
$^{89,90}Sr$	65	25	0.4
^{3}H	17 436	15 330	0.9
^{137}Cs	123	210	1.7
^{234}U	1.9	2.1	1.1

II. BACKGROUND ON LOS ALAMOS

A. Description of the Area

1. Geographic Setting

The Los Alamos National Laboratory and associated residential areas of Los Alamos and White Rock are located in Los Alamos County in northcentral New Mexico, approximately 100 km (60 mi) NNE of Albuquerque and 40 km (25 mi) NW of Santa Fe (Fig. 1). The 111 km^2 (27 500 acres) Laboratory site and adjacent communities are situated on Pajarito Plateau. The Plateau consists of a series of finger-like mesas separated by deep east-west oriented canyons cut by intermittent streams. The mesa tops range in elevation from approximately 2400 m (7800 ft) at the flank of the Jemez Mountain to about 1800 m (6200 ft) on their eastern margin terminating above the Rio Grande valley.

All Los Alamos County and vicinity locations referenced in this report are identified by the Laboratory cartesian coordinate system, which is based on English units of measurement. This system is standard throughout the Laboratory, but is independent of the US Geological Survey and New Mexico State Survey coordinate systems. The major coordinate markers shown on the maps are at 3.048 km (10 000 ft) intervals, but for the purpose of this report are identified to the nearest 0.30 km (1000 ft). The area within the Laboratory boundary is controlled by the Department of Energy, which has the option to completely restrict access. This control can be instituted when necessary.

2. Land Use

Most Laboratory and community developments are confined to mesa tops (see Fig. 3 and inside front cover). The surrounding land is largely undeveloped with large tracts of land north, west, and south of the Laboratory site held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County (see land ownership map inside back cover). The San Ildefonso Pueblo borders the Laboratory to the east.

Laboratory land is used for building sites, test areas, waste disposal locations, roads, and utility rights-of-way. However, these account for only a small fraction of the total land area. Most land provides isolation for security and safety and as reserves for future structure locations. A comprehensive Master Plan for Laboratory lands helps assure adequate planning for the best possible use of available land in the future.

Limited access by the public is allowed in certain areas of the Laboratory reservation. An area north of Ancho Canyon between the Rio Grande and State Road 4 is open to hikers, rafters, and hunters, but woodcutting and vehicles are prohibited. Portions of Mortandad and Pueblo Canyons are also open to the public. An archeological site (Otowi Tract) northwest of State Road 4 is open to the public subject to the restrictions of the Antiquities Act.

3. Geology-Hydrology

Most of the finger-like mesas in the Laboratory area are formed by Bandelier Tuff (see Fig. 4, tuff). This is ashfall and ashflow pumice and rhyolite tuff that form the surface of Pajarito Plateau. The tuff ranges from nonwelded to welded and is in excess of 300 m (1000 ft) thick in the western part of Pajarito Plateau and thins to about 80 m (260 ft) toward the east above the Rio Grande. It was deposited as a result of a major eruption of a volcano in the Jemez Mountains to the west about 1.1 to 1.4 million years ago.

The tuffs lap onto older volcanics of the Tschicoma Formation, which form the Jemez Mountains along the western edge of the Plateau. They are underlain by the conglomerate of the Puye Formation (see Fig. 4, conglomerate) in the central and eastern edge along the Rio Grande. Chino Mesa basalts (see Fig. 4, basalt) interfinger with the conglomerate along the river. These formations overlie the siltstone/sandstone Tesuque Formation (see Fig. 4, sediments), which extends across the Rio Grande valley and is in excess of 1000 m (3300 ft) thick.

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

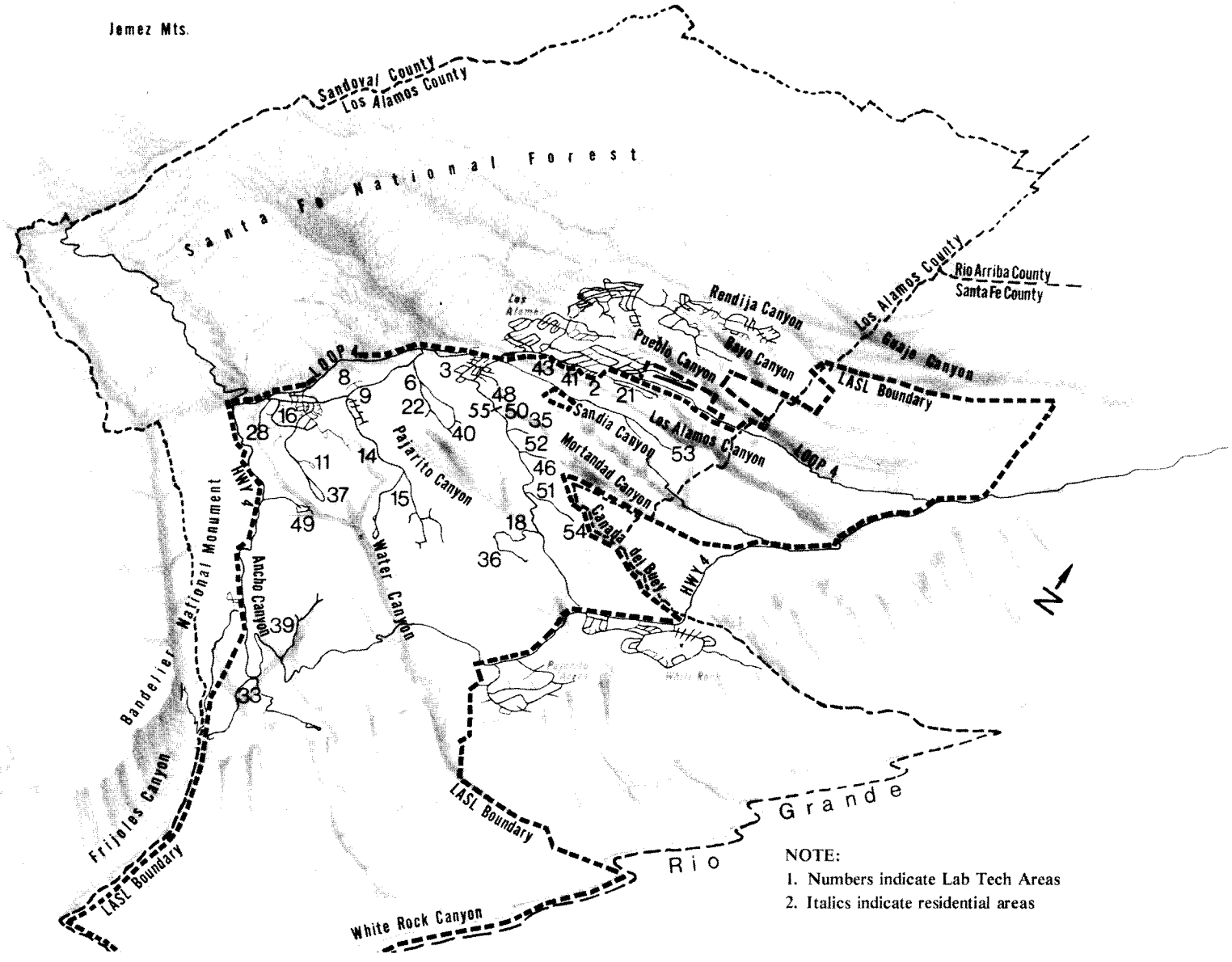


Fig. 3. Topography of the Los Alamos, New Mexico, area.

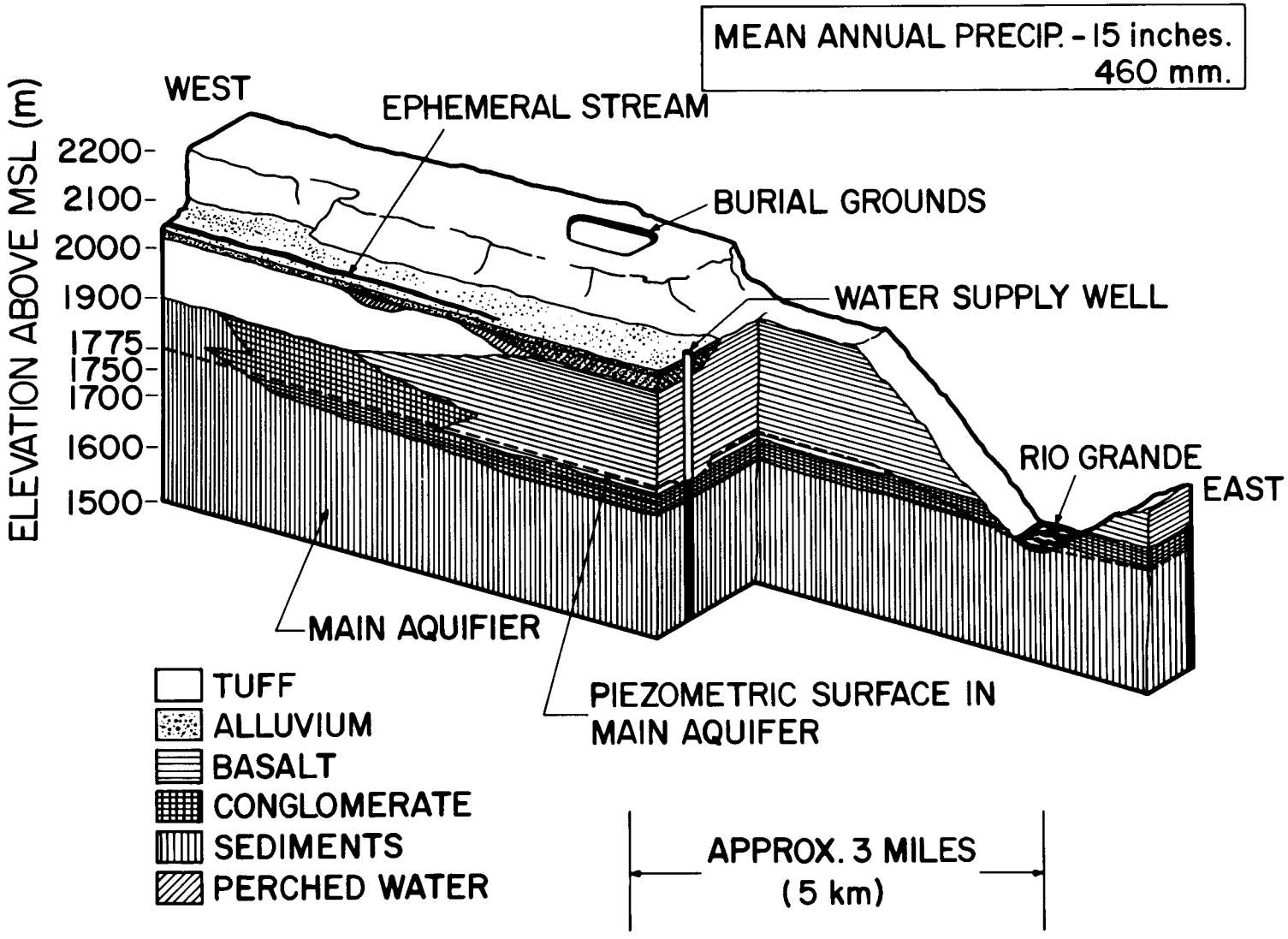


Fig. 4. Conceptual illustration of geologic-hydrologic relationships in the Los Alamos area.

Ground water occurs in three modes in the Los Alamos area: (1) water in shallow alluvium in canyons, (2) perched water (a ground water body above an impermeable layer that is separated from an underlying main body of ground water by an unsaturated zone), and (3) the main aquifer of the Los Alamos area (see Fig. 4, alluvium, perched water, and main aquifer).

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

Perched water occurs in one limited area about 40 m (120 ft) beneath the mid-reach of Pueblo Canyon and in a second area about 50 to 70 m (150 to 200 ft) beneath the surface in lower Pueblo and Los Alamos Canyons near their confluence. The second area is mainly in the basalts (see Fig. 4, perched water and basalt) and has one discharge point at Basalt Springs in Los Alamos Canyon.

The main aquifer of the Los Alamos area is the only aquifer in the area capable of serving as a municipal water supply. The surface of the aquifer rises westward from the Rio Grande within the Tesuque Formation into the lower part of the Puye Formation beneath the central and western part of the Plateau. Depth to the aquifer decreases from 360 m (1200 ft) along the western margin of the Plateau to about 180 m (600 ft) at the eastern margin. The main aquifer is isolated from alluvial water and perched water by about 110 to 190 m (350 to 620 ft) of dry tuff and volcanic sediments. Thus, there is no hydrologic connection or potential for recharge to the main aquifer from alluvial or perched water.

Water in the main aquifer is under water table conditions in the western and central part of the Plateau and under artesian conditions in the eastern part and along the Rio Grande.[2] The major recharge area to the main aquifer is from the intermountain basin of the Valles Caldera in the Jemez Mountains west of Los Alamos (see Fig. 1 and inside front cover). The water table in the Caldera is near land surface. The underlying lake sediment and volcanics are highly permeable and recharge the aquifer through Tschicoma Formation interflow breccias (rock consisting of sharp fragments embedded in a fine-grained matrix) and the Tesuque Formation. The Rio Grande receives ground water discharge from springs fed by the main aquifer. The 18.4 km (11.5 mi) reach of the river in White Rock Canyon between Otowi Bridge and the mouth of Rito de Frijoles receives an estimated 5.3 to 6.8×10^3 m^3 (4300 to 5500 acre-feet) annually from the aquifer.

4. Climatology

Los Alamos has a semiarid, temperate mountain climate. The average annual precipitation of 18 in. (45 cm) is produced by warm-season showers and thundershowers and cold-season migratory storms. Forty per cent of the annual moisture total falls during July and August, primarily from afternoon thundershowers. Winter precipitation primarily falls as snow, with accumulations of about 51 in. (130 cm).

Summers are generally sunny and pleasant. Maximum temperatures are usually below 90°F (32°C). Brief afternoon thundershowers are very common, especially in July and August. The high altitude, light winds, clear skies, and dry atmosphere allow night temperatures to drop into the 54 to 59°F (12 to 15°C) range. Winter temperatures are typically in the range of 14 to 41°F (−10 to 5°C). Many winter days are clear with light winds, so strong sunshine makes conditions quite comfortable even when air temperatures are cold. Occasionally, temperatures do drop to near 0°F (−18°C) or below.

Significant spatial and daily variations of surface winds in Los Alamos are caused by the complex terrain. With weak large-scale winds and clear skies, a distinct daily wind cycle exists: a light southeasterly upslope wind during daytime hours and a light westerly drainage wind durig nighttime hours. On the east end of Pajarito Plateau, near the Rio Grande Valley, a different daily wind cycle is evident; a moderate up-valley wind during daytime hours and a light down-valley wind during nighttime hours. On the whole, the predominant winds are westerly over the Laboratory and more southwesterly nearer the Rio Grande Valley.

Historically, no tornadoes have been reported in Los Alamos County. However, strong wind gusts exceeding 60 mph (27 m/sec) are common during spring months. Lightning is very common over the Pajarito Plateau. There is a high average of 58 thunderstorm days per

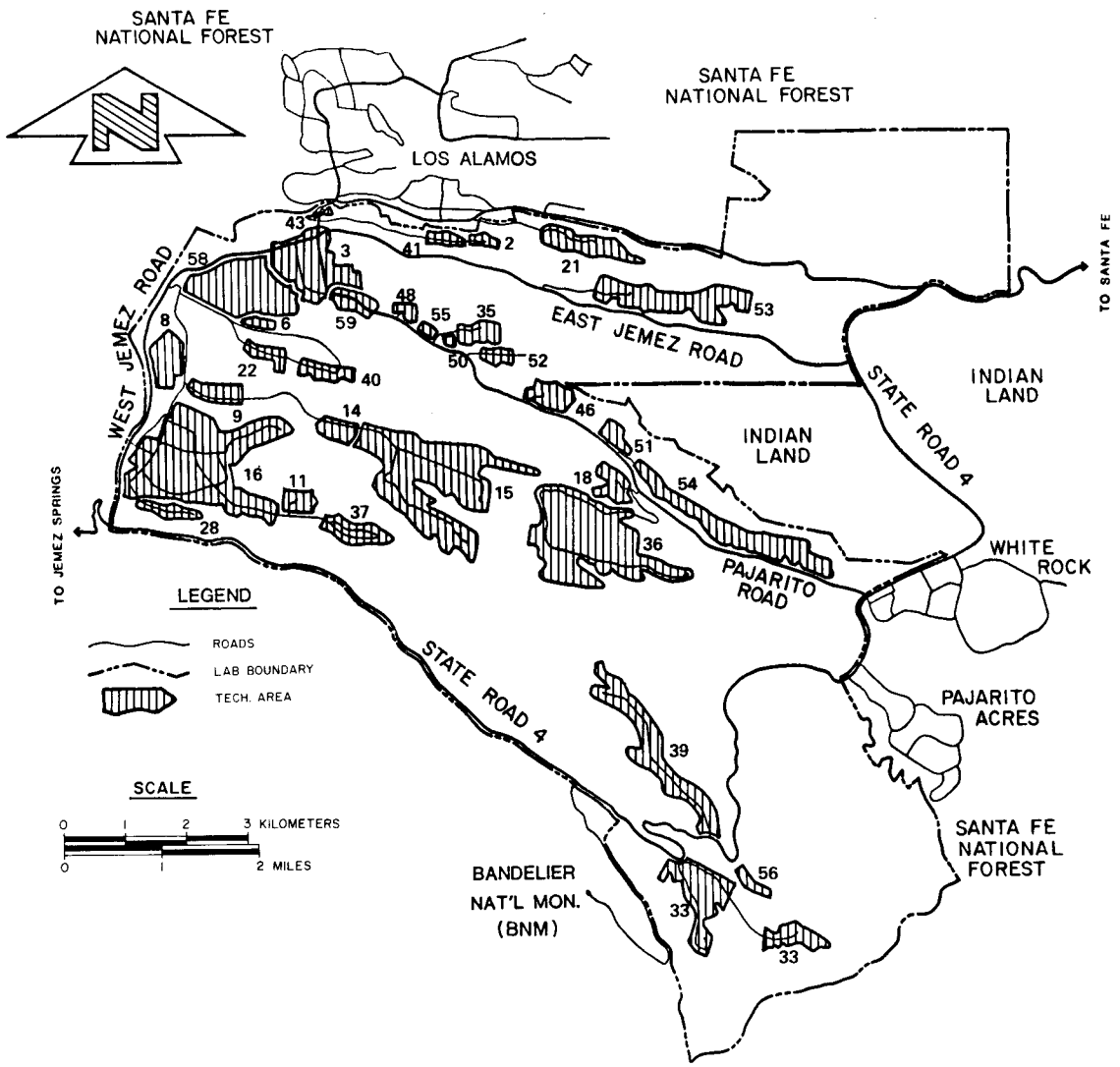


Fig. 5. Los Alamos National Laboratory's technical areas and adjacent communities.

year. Lightning protection is an important consideration applied to each facility at the Laboratory. Hailstones with diameters up to 0.25 in. (0.6 cm) are common, while 0.5 in. (1.3 cm) diameter hailstones are rather rare.

5. Population Distribution

Los Alamos County has an estimated 1982 population of 18 159 (based on the 1980 census adjusted for 1982). Two residential and related commercial areas exist in the county (see Fig. 5 and inside back cover). The Los Alamos townsite, the original area of development (and now including residential areas known as the Eastern Area, the Western Area, North Community, Barranca Mesa, and North Mesa), has an estimated population of 11 179. The White Rock area (including the residential areas White Rock, La Senda, and Pajarito Acres) has about 6980 residents. About one-third of those employed in Los Alamos commute from other counties. Population estimates for 1982 place about 125 000 people within an 80 km (50 mi) radius of Los Alamos.

B. Los Alamos National Laboratory

1. Programs and Facilities

Since its inception in 1943, the Laboratory's primary mission has been nuclear weapons research and development. Programs include weapons development, magnetic

and inertial fusion, nuclear fission, nuclear safeguards and security, and laser isotope separation. There is also basic research in the areas of physics, chemistry, and engineering that support such programs. Research on peaceful uses of nuclear energy has included space applications, power reactor programs, radiobiology, medicine, and magnetic and inertial fusion. In more recent years, other programs have been added in applied photochemistry, astrophysics, earth sciences, energy resources, nuclear fuel safeguards, lasers, computers, solar energy, geothermal energy, biomedical and environmental research, and nuclear waste management research.

A unique combination of facilities that contributes to the various research programs exist at Los Alamos. These facilities include an 800 MeV linear particle accelerator, a tandem Van de Graaff accelerator, a High Energy Gas Laser Facility, and an 8 megawatt nuclear research reactor. Some of these facilities encourage participation and joint projects by researchers from other laboratories and research facilities.

In August 1977 the Laboratory site, encompassing 111 km^2 (27 500 acres), was dedicated as a National Environmental Research Park. The ultimate goal of programs associated with this regional facility is to encourage environmental research that will contribute understanding of how man can best live in balance with nature while enjoying the benefits of technology. Park resources are available to individuals and organizations outside of the Laboratory to facilitate self-supported research on these subjects deemed compatible with the Laboratory programmatic mission.

A Final Environmental Impact Statement (FEIS)[3] that assesses potential cumulative environmental impacts associated with current, known future, and continuing activities at the Laboratory was completed in 1979. The FEIS provides environmental input for decisions regarding continuing activities at the Laboratory. It also provides detailed information on the environment of the Los Alamos area.

The Laboratory is administered by the University of California for the Department of Energy under contract W-7405-ENG-36. The Labortory's environmental program, conducted by the Environmental Surveillance Group, is part of a continuing investigation and documentation program.

2. Waste Management

The Laboratory's activities are conducted in 32 active technical areas (TAs) distributed over the site (see Fig. 5 and Appendix F for descriptions of activities at the TAs). Wastes requiring disposal are generated at virtually all these locations. Sanitary sewage is handled by a number of plants employing conventional secondary treatment processes or by septic tanks. Uncontaminated solid waste is disposed of in the County-operated landfill located within the Laboratory boundary. Nonradioactive airborne emissions include combustion products from the power and steam plants, vapors or fumes from numerous local exhaust systems (such as chemistry laboratory hoods), and burning of high explosive wastes.

Most liquid radioactive and chemical laboratory waste effluents are routed to either of two waste treatment facilities by a collection system that is independent from the sanitary sewage system. The balance of such wastes from remote locations is accumulated in holding tanks and periodically collected and transported to a treatment plant for processing. Radioactivity is removed by physicochemical processes that produce a concentrated sludge that is subsequently handled as solid radioactive waste. The treated effluents are released to canyons.

From 90 to 95% of the total volume of radioactively contaminated solid waste from the Laboratory is disposed of by burial at the waste disposal area (TA-54). The remaining 5 to 10% is classed as transuranic waste and stored retrievably also at TA-54. Buried waste is confined from the environment by the dry geologic formation of the burial ground. Stored waste is placed in berms of crushed tuff or in concrete casks placed in shafts.

Airborne radioactive emissions are discharged from a number of facilities after receiving appropriate treatment, such as filtration for particulates, catalytic conversion and adsorption of tritium, or temporary storage to permit decay of short-lived activation gases.

III. RADIATION DOSES

Small incremental radiation doses above those received from background levels of natural and worldwide fallout are received by Los Alamos County residents as a result of Laboratory operations. The largest estimated dose at an occupied location was 8.4 mrem or 1.7% of the Radiation Protection Standard. This estimate is based on boundary dose measurements of airborne and scattered radiation from the linear particle accelerator at TA-53. Other minor exposure pathways may result in several mrem/yr doses to the public.

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

The total cumulative whole-body dose received by the population living within 80-km of the Laboratory during 1982 was conservatively estimated to be 3.1 person-rem. This is about 0.02% of the 13 500 person-rem received by the same population from natural radiation sources and 0.02% of the 12 900 person-rem dose received from diagnostic medical procedures. About 91% of this dose, 2.8 person-rem, was received by persons living in Los Alamos County. This dose is 0.1% of the 2100 person-rem received by the population of Los Alamos County from natural background radiation and 0.1% of the 1900 person-rem from diagnostic medical procedures.

The average added risk of cancer mortality to Los Alamos townsite residents from radiation from this year's Laboratory operations is 1 chance in 60 000 000. This risk is much less than the 1 chance in 82 000 from background radiation. The Environmental Protection Agency has estimated average lifetime risk for cancer incidence as 1 chance in 4 and for cancer mortality as 1 chance in 5.

A. Introduction

One means of evaluating the significance of environmental releases of radioactivity is to compare doses received by the public from exposure to these releases with appropriate standards[4] and with doses from naturally present background radiation. The principal exposure pathways considered for the Los Alamos area were atmospheric transport of airborne radioactive emissions, hydrologic transport of liquid effluents, food chains, and direct exposure to penetrating radiation. Exposures to radioactive materials or radiation in the environment were determined by direct measurements of some airborne and waterborne contaminants and of external penetrating radiation. Theoretical dose calculations based on atmospheric dispersion were made for other airborne contaminants present at levels too low for direct measurement.

Doses were calculated from measured or derived exposures utilizing models based on recommendations of the International Commission on Radiological Protection (ICRP, see Appendix D for details) for each of the following categories.[5]

1. *Maximum Boundary Dose.* Maximum dose to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs. It assumes the individual is at the Laboratory boundary continuously (24 hours a day, 365 days a year).
2. *Maximum Individual Dose.* Maximum dose to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where there

is a person. It takes into account occupancy (for example, 40 hours a week) and shielding (for example, by buildings) factors.

3. *Average Dose.* Average doses to nearby residents.
4. *Whole Body Cumulative Dose.* The whole body cumulative dose for the population within an 80 km radius of the Laboratory.

Doses calculated for these categories are summarized in Table VII. The data on which these calculations are based are discussed in the following sections, while the calculational procedure is described in Appendix D.

The maximum boundary dose and maximum individual dose over the past 5 years are summarized in Fig. 2. Over 95% of each of these doses is due to emissions of air activation products from the Los Alamos Meson Physics Facility (LAMPF). The larger doses in 1981 resulted from the relatively larger 1981 LAMPF emissions of 352 340 curies. The LAMPF releases in 1982 decreased to 251 000 curies, which is reflected in the lower boundary dose in 1982. The maximum individual dose in 1982 is a larger fraction of the maximum boundary dose than it had been in previous years because of estimates of increased occupancy for 1982. A 30% reduction in dose due to shielding from a building was used for the 1982 maximum individual dose as well as the previous maximum individual doses.

In addition to compliance with dose guidelines, which define an upper limit for doses to the public, there is a concurrent commitment to maintain radiation exposure to individuals and population groups to levels as low as reasonably achievable (ALARA). This policy is followed at the Laboratory by applying strict controls on airborne emissions, liquid effluents, and operations to minimize doses to the public and to limit releases of radioactive materials to the environment. Ambient monitoring described in this report documents the effectiveness of these controls. The success of the ALARA program in 1982 can be judged from the highest reported calculated dose to a member of the public (8.4 mrem to the whole body) being approximately 2% of the applicable Radiation Protection Standard.[4]

B. Doses to Individuals from Inhalation of and Exposure to Airborne Emissions

The maximum boundary and individual doses attributable to inhalation of and exposure to airborne releases are summarized in Table VIII with a comparison to the Radiation Protection Standards for individual doses[4] (see Appendix A).

Exposure to airborne ^{3}H (as tritiated water vapor) was determined by actual measurements. A background correction was made assuming that natural and worldwide fallout activity was represented by data from the three regional sampling locations at Española, Pojoaque, and Santa Fe.

Exposures to ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar from the Los Alamos Meson Physics Facility (a linear particle accelerator) were inferred from direct radiation measurements (see Section IV.A.1). Exposure from ^{41}Ar released from the stack of a research nuclear reactor at TA-2 was theoretically calculated from measured stack releases and standard atmospheric dispersion models. These models used 1982 meteorological data measured at the Laboratory (see Section IV.C and Appendix D). Doses from these exposures are discussed in Section III.E.

Estimates of maximum exposures (Table VIII) to plutonium, americium, and uranium were calculated by subtracting the average concentration at the regional stations from the average concentration from the perimeter station with the highest measured concentration for each of these radionuclides.

All other atmospheric releases of radioactivity (Table E-I) were evaluated by theoretical calculations. All potential doses were found to be less than the smallest ones presented in this section and were thus considered insignificant.

C. Doses to Individuals from Liquid Effluents

Liquid effluents do not flow beyond the Laboratory boundary but are absorbed in alluvium of the receiving canyons. These effluents are monitored at their point of discharge and their behavior in the alluvium of the canyons below outfalls has been studied.[6-9] Small quantities of radioactive contaminants transported during periods of heavy runoff have been measured in canyon sediments beyond the Laboratory boundary. Calculations made for the radiological survey of Acid, Pueblo, and Los Alamos Canyons[10] indicate a maximum exposure pathway (eating liver from a steer that drinks water from and grazes in lower Los Alamos Canyon) to man from these canyon sediments results in a maximum 50-yr dose commitment of 0.0013 mrem to the bone, 0.0001% of the Radiation Protection Standard.[4]

D. Doses to Individuals from Ingestion of Foodstuffs

Data from sampling of fruit, vegetables, fish and honey during 1982 (see Section IV.A.5 for a discussion

TABLE VII

SUMMARY OF ANNUAL DOSES DUE TO 1982 LABORATORY OPERATIONS

	Maximum Dose at Laboratory Boundary[a]	Maximum Dose to an Individual[b]	Average Dose to Nearby Residents		Cumulative Dose to Population Within 80 km of the Laboratory
			Los Alamos	White Rock	
Dose	12 ± 3	8.4	0.17 mrem	0.08 mrem	3.1 person-rem
Critical organ	Whole Body	Whole Body	Whole Body	Whole Body	Whole Body
Location	Boundary N. of TA-53	Residence N. of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
Radiation Protection Standard	---	500	500	500	---
Per Cent of Radiation Protection Standard (%)	---	1.7	0.03	0.02	---
Natural background	122 mrem	122 mrem	122 mrem	111 mrem	13 500 person-rem
Per cent of natural background (%)	10	7	0.1	0.07	0.02

[a]Maximum boundary dose is the dose to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs. It assumes that the hypothetical individual is at the Laboratory boundary continuously (24 hours a day, 365 days a year).

[b]Maximum individual dose is the dose to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where there is a person. It takes into account occupancy (for example, 40 hours a week) and shielding (for example, by buildings) factors.

TABLE VIII

MAXIMUM BOUNDARY AND INDIVIDUAL DOSES FROM 1982 AIRBORNE RADIOACTIVITY

Isotope	Critical Organ	Maximum Boundary Dose[a]		Maximum Individual Dose[b]		
		Location	Dose (mrem/yr)	Location	Dose (mrem/yr)	Percentage of Radiation Protection Standard
^{3}H (HTO)	Whole Body	TA-39 (Station 25)[d]	0.18	Pajarito Acres (Station 13)[d]	0.069	0.01
$^{11}C, ^{13}N, ^{15}O$	Whole Body	Boundary N. of TA-53[e]	12	Residence N. of TA-53[e]	8.4	1.7
^{41}Ar	Whole Body	Boundary N. of TA-2 Stack[e]	0.3	Apts. N. of TA-2 Stack[e]	0.2	0.04
U, ^{238}Pu, ^{239}Pu, ^{241}Am[c]	Lung	TA-54 (Station 22)[d]	0.009	LA Airport (Station 8)[d]	0.008	0.0005

[a]Maximum boundary dose is the dose to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs. It assumes the individual is at the Laboratory boundary continuously (24 hours a day, 365 days a year).
[b]Maximum individual dose is the dose to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where there is a person. It takes into account occupancy (for example, 168 hours a week) and shielding (for example, by buildings) factors.
[c]For a 50-yr dose commitment, bone is the critical organ. A maximum exposed individual (at Gulf Station, Location 10) would receive a 50-yr bone dose commitment of 0.32 mrem, which is 0.02% of the Radiation Protection Standard.
[d]See Fig. 10 for station locations.
[e]See Fig. 5 for technical area (TA) locations.

of the sampling data) were used to estimate doses due to consumption of foodstuffs that may result from Laboratory operations. All calculated doses are less than 0.02% of the Radiation Protection Standard.

Of the six radionuclides (^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, and total U) that the fruit and vegetable samples were analyzed for, only the mean ^{3}H levels in samples from Los Alamos, White Rock/Pajarito Acres, and Cochiti were statistically significantly above the mean ^{3}H levels from samples taken from background areas. Consumption of 120 kg/yr of fruit and vegetables (which assumes that a garden supplies 25% of the 479 kg of fruit and vegetables consumed annually by a teenager, see Table D-I) having the highest mean ^{3}H concentration of 1.22 pCi/mℓ measured at these three sites, after correction for background, would result in a whole body 50-year dose commitment of 0.007 mrem, which is 0.002% of the Radiation Protection Standard. All other doses would be less than this dose.

Samples of edible parts of fish showed no statistically significant difference between radionuclide concentrations in fish taken from a reservoir downstream from the Laboratory and concentrations in fish taken from upstream reservoirs for ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, and total

U. Fish digestive tracts and their contents were also analyzed for the same radionuclides. While no statistically significant differences between upstream and downstream samples were found for most radionuclides, ^{137}Cs in higher trophic level feeder gut and ^{238}Pu in bottom feeder gut were different at the 95% confidence level. These differences indicate ingestion of sediments. No above-background radiation doses would result from consumption of fish since radionuclide concentrations in the edible parts of the fish from downstream areas were indistinguishable from those from control locations.

Trace concentrations of radionuclides associated with Laboratory effluents were found in honey samples. Doses were calculated for each honey sample assuming that an individual consumed 5 kg of honey in a year. The 50-year dose commitment to whole body, which is the organ receiving the dose that is the highest fraction of the Radiation Protection Standard, is 0.05 mrem, or 0.01% of the Radiation Protection Standard.

A possible minor exposure pathway exists by eating venison from deer that cross into Laboratory property to graze and drink. The maximum dose calculated via this pathway is 3.9 mrem/yr and unlikely to occur.[11]

E. Doses to Individuals from External Penetrating Radiation (from Airborne Emissions and Direct Radiation)

No measurements (see Section IV.A.1) of external penetrating radiation at regional and perimeter stations indicated any discernable increase in radiation levels attributable to Laboratory operations, except those along State Road 4 north of the Los Alamos Meson Physics Facility (TA-53). The special thermoluminescent dosimeter network at the Laboratory boundary north of the Los Alamos Meson Physics Facility indicated a 12 mrem increment above natural background as shown in Table VIII. This increment is attributed to emission of air activation products from the Los Alamos Meson Physics Facility.

Based on shielding, this 12 mrem increment translates to an estimated 8.4 mrem whole body dose to an individual living at the Laboratory boundary just north of the Los Alamos Meson Physics Facility. This dose represents 1.7% of the Radiation Protection Standard for a member of the public.[4] This location north of the Los Alamos Meson Physics Facility has been the area where the highest boundary and individual doses have been measured since thermoluminescent dosimeter monitoring began there 5 years ago. The boundary doses at this location are discussed in Section IV.A.1. The decrease in dose from 17.1 mrem in 1981 to 12 mrem in 1982 is probably mainly attributable to the decrease in the Los Alamos Meson Physics Facility's airborne emissions from 352 340 Ci in 1981 to 251 000 Ci in 1982.

A maximum onsite dose to a member of the public from external radiation from all Laboratory airborne emissions of 0.0017 mrem was estimated for a person spending 4 hours at the Laboratory's science museum.

The average annual dose to residents in Los Alamos townsite attributable to Laboratory operations was 0.17 mrem (whole body). The corresponding dose to White Rock residents was 0.08 mrem (whole body). These doses are 0.03% and 0.02%, respectively, of the Radiation Protection Standard.[4] These doses were theoretically calculated using measured stack releases (Table E-I) and 1982 meteorological data (Appendix D). They were about 80% lower than last year, because radioactive stack releases (see Table VI) were much lower in 1982 and because measurements made in 1982 indicated that the composition of emissions from the Los Alamos Meson Physics Facility contained a greater proportion of shorter-lived radioisotopes.

Emissions dispersed from TA-2 and TA-53 could result in a theoretically calculated annual regional dose of 0.008 mrem (whole body) at Española. This dose is 0.002% of the Radiation Protection Standard.

Onsite measurements of above background doses from direct radiation were expected and do not represent potential exposure to the public except in the vicinity of TA-18 (a nuclear criticality study area) on Pajarito Road. Members of the public regularly utilizing the Department of Energy-controlled road passing by TA-18 would likely receive no more than 0.37 mrem/yr of direct gamma and neutron radiation. This value was derived from 1975 data[12] on total gamma plus neutron dose rates using 1982 gamma doses measured by thermoluminescent dosimeters. Exposure time was estimated by assuming a person made 15 round trips per week at an average speed of 65 km/h past TA-18 while tests were being conducted. The onsite station (see Section IV.A.1, Station 24 in Fig. 6) near the northeast Laboratory boundary recorded an above natural background dose of 67 mrem, which reflects a localized accumulation of ^{137}Cs on sediments transported from a treated effluent release point upstream.

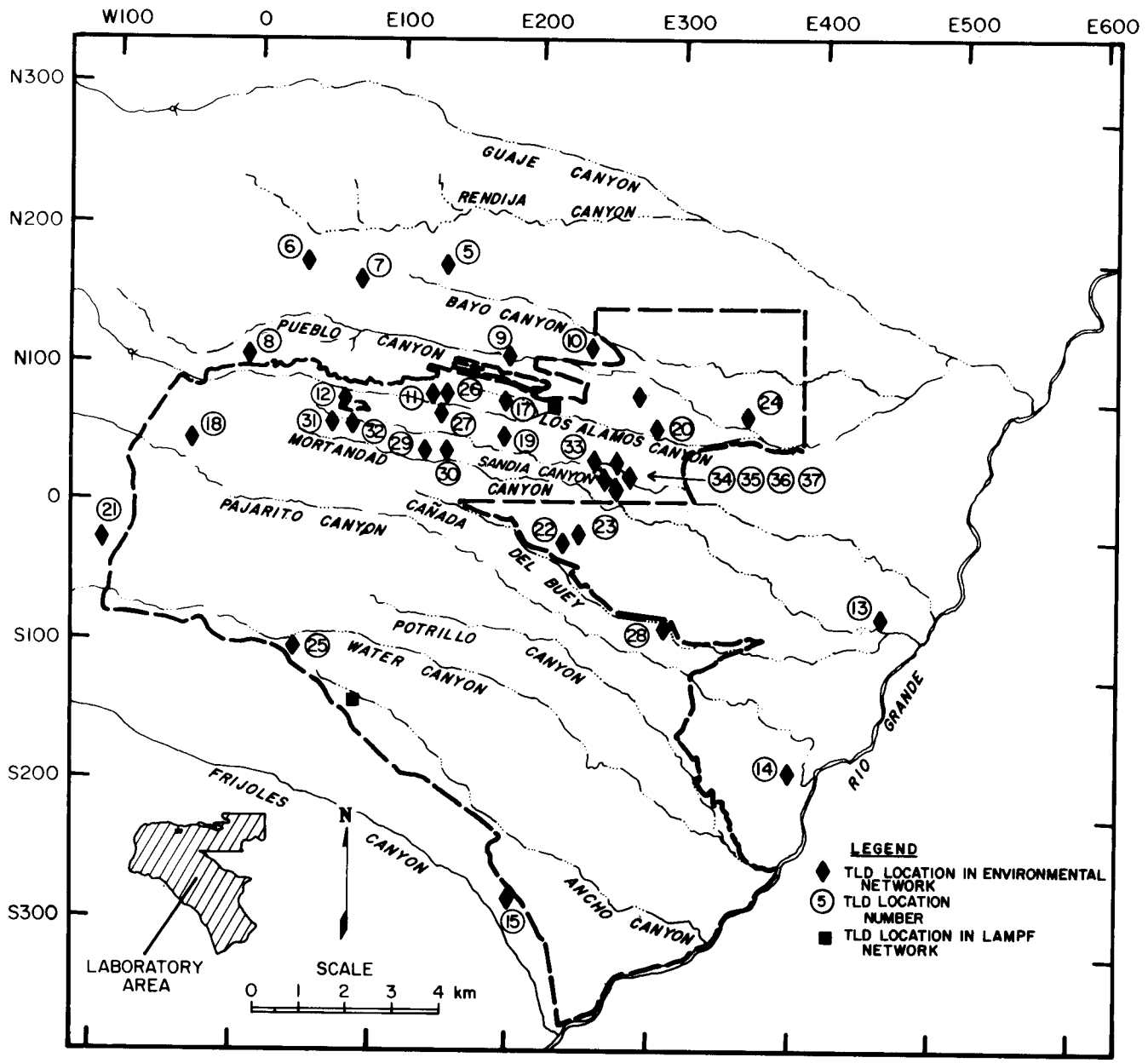


Fig. 6. Thermoluminescent dosimeter locations on or near the Laboratory site.

F. Whole Body Cumulative Doses

Cumulative 1982 whole body doses attributable to Laboratory operations both to persons living within 80-km of the Laboratory and to Los Alamos County residents are compared to exposure from natural radiation and medical radiation in Table IX. Population data are based on the 1980 US Bureau of Census count (adjusted for 1982, see Appendix D). These doses are about 70% lower than last year, because radioactive stack releases (see Table VI) were much lower in 1982 and because measurements made in 1982 indicated that the estimated composition of emissions from the Los Alamos Meson Physics Facility contained a greater proportion of shorter-lived radioisotopes.

The calculated 3 person-rem from 1982 Laboratory operations is probably high because of the conservative assumptions that were used (see Appendix D) to calculate the dose. The whole body population dose from

TABLE IX

WHOLE BODY POPULATION DOSES DURING 1982

Exposure Mechanism	Los Alamos County Whole-Body Population Dose (person-rem)	80-km Region Whole-Body Population Dose (person-rem)
Atmospheric Total U, ^{238}Pu, ^{239}Pu, ^{241}Am	0.03	0.03
Atmospheric Tritium (as HTO)	0.35	0.35
Atmospheric ^{11}C, ^{13}N, ^{15}O	2.05	2.22
Atmospheric ^{41}Ar	0.36	0.46
Total Due to Laboratory Atmospheric Releases	2.79	3.06
Total Due to Natural Sources of Radiation[a]	2100	13 500
Average Due to Airline Travel (~0.22 mrem/h at 9 km[13])	15	b
Diagnostic Medical Exposure (~103 mrem/yr per person[14])	1900	12 900

[a]Calculations are based on thermoluminescent dosimeter measurements. They include a 10% reduction in cosmic radiation from shielding by structures and a 40% reduction in terrestrial radiation from shielding by structures and self-shielding by the body.
[b]Not estimated for the population in the 80-km region.

Laboratory operations to the estimated 125 000 inhabitants within an 80 km radius of Los Alamos is estimated to be 3 person-rem, which is approximately the population dose to Los Alamos County inhabitants. This is because other population centers are far enough away that dispersion, dilution, and decay in transit (particularly for ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar) make their exposure undetectable and theoretically less than 10% of the estimated 3 person-rem. By contrast, natural radiation exposure to the inhabitants within an 80 km radius is 13 500 person-rem.

Thus, doses potentially attributable to releases from Laboratory operations contribute about 0.1% of the total dose received by Los Alamos County residents from natural radiation, about 0.1% to the same population from diagnostic medical radiation, and about 0.02% of the dose from natural radiation received by the population within an 80 km radius of the Laboratory.

G. Estimates of Risk to an Individual from Laboratory Releases

Risk estimates of possible health effects from radiation doses to the public resulting from Laboratory operations have been made. However, these calculations may overestimate actual risk. The National Council on Radiation Protection and Measurements[15] has warned "risk estimates for radiogenic cancers at low doses and low dose rates derived on the basis of linear (proportional) extrapolation from the rising portions of the dose

incidence curve at high doses and high dose rates... cannot be expected to provide realistic estimates of the actual risks from low level, low-LET (linear energy transfer) radiations, and have such a high probability of overestimating the actual risk as to be of only marginal value, if any, for purposes of *realistic* risk-benefit evaluation."

The International Commission on Radiological Protection[16] estimates that the total risk of cancer mortality from uniform whole body irradiation for individuals is 0.0001 per rem, that is, there is 1 chance in 10 000 that an individual exposed to 1000 mrem (1 rem) of whole body radiation would develop a cancer. In developing risk estimates, the International Commission on Radiological Protection[16] has warned "radiation risk estimates should be used only with great caution and with explicit recognition of the possibility that the actual risk at low doses may be lower than that implied by a deliberately cautious assumption of proportionality."

During 1982, persons living in Los Alamos and White Rock received an average of 122 and 111 mrem, respectively, of whole body radiation from natural sources (including cosmic and terrestrial radiation with allowances for shielding, self-irradiation and cosmic neutron exposure, but excluding that radiation received from airline travel, luminous dial watches, building materials, etc.). Thus, the added cancer mortality risk attributable to natural whole body radiation in 1982 was 1 chance in 82 000 in Los Alamos and 1 chance in 90 000 in White Rock (Table III).

Laboratory operations contributed an average dose of 0.17 mrem to individuals in Los Alamos and 0.08 mrem to individuals in White Rock. These doses are estimated to add lifetime risks of about 1 chance in 60 000 000 in Los Alamos and 1 chance in 125 000 000 in White Rock to an individual's risk of cancer mortality due to 1982 Laboratory activities (Table III).

For Americans the average lifetime risk is a 1 in 4 chance of contracting a cancer from all causes and a 1 in 5 chance of dying from the disease.[17,18] The Los Alamos and White Rock incremental doses attributable to Laboratory operations are equivalent to the additional exposure a person would get from flying in a commercial jet aircraft for 46 and 22 min, respectively.

The additional exposure and subsequent risk to Los Alamos County residents are well within variations in natural exposure and risks in life that are accepted routinely by most people. For example, one study[19] showed the annual dose rate on the second floor of single-family frame dwellings was 14 mrem/yr less than the dose rate on the first floor. Energy conservation measures, such as sealing and insulating houses and installing passive solar systems, are likely to contribute much larger doses to Los Alamos County residents than Laboratory operations because of increased radon levels inside the homes. The Environmental Protection Agency has estimated the annual whole body dose to individuals from global fallout to be 4.4 mrem.[20]

IV. MONITORING RESULTS

A. Radiation and Radioactivity

1. Penetrating Radiation

Levels of 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. Data from regional and perimeter locations for each calendar quarter did not show any statistically discernible increase in radiation levels attributable to Laboratory operations. Onsite measurements were slightly above background levels, reflecting research activities at the Laboratory. A special group of dosimeters, which monitors radioactivity of gaseous emissions from the Los Alamos Meson Physics Facility, showed a small increase in radiation levels due to operation of this linear particle accelerator.

Natural penetrating radiation has two components. The natural terrestrial component results from decay of ^{40}K and of radioactive daughters from the decay chains of ^{232}Th and ^{238}U. The cosmic component includes photon radiation, charged particles, and neutrons. Thermoluminescent dosimeters (TLDs) are used at the Laboratory to measure this penetrating radiation. 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 monitoring program are insensitive to cosmic neutrons, so the neutron contribution to natural background radiation is not measured.

Cosmic ionizing radiation increases with elevation because of reduced shielding by the atmosphere. At sea level it averages between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km, receives about 60 mrem/yr from the cosmic component. The regional monitoring locations, ranging from about 1.7 km elevation at Pojoaque to about 2.65 km at Fenton Hill, receive from 50 to 70 mrem/yr.[13]

In contrast to this fairly constant cosmic component, doses from the natural terrestrial component in the Los Alamos area are highly variable. Temporal variation at any particular location (Figs. 6 and 7) is about 15 to 25% because of variations in soil moisture and snow cover.[13] Figure 7, which compares TLD data from the last 6 years, shows this temporal variation in the regional and perimeter averages. The variation in onsite averages is more influencd by changes in research programs at particular Laboratory sites than by changes in soil moisture or snow cover. There is also spatial variation because of different soil and rock types in the area.[11] These natural sources of variation make it difficult to detect any increases in the radiation level from manmade sources, especially if the magnitude of such an increase is small compared to natural fluctuations.

Levels of 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 TLDs deployed in two independent networks. The environmental network consists of 37 locations divided into three groups. Three of these locations, 28 to 44 km from the Laboratory boundary at air sampling stations in the neighboring communities of Española, Pojoaque, and Santa Fe, along with the Fenton Hill Site 30 km west of Los Alamos, form the regional group (Figs. 1 and 6). The perimeter group consists of 12 dosimeters placed within 4 km of the boundary. Twenty-one locations within the Laboratory boundary comprise the onsite group. The dosimeters are changed each calendar quarter. See Appendix B for more information on handling of the TLDs.

Tables IV and E-II summarize the annual total doses by the regional, perimeter, and onsite groups for 1982. Figure 7 shows a comparison of above background dose averages for the last 6 years. No measurements at regional or perimeter locations in the environmental network for any calendar quarter showed any statistically discernible increase in radiation levels attributable to Laboratory operations. Onsite measurements were slightly above background levels, reflecting research activities at the Laboratory.

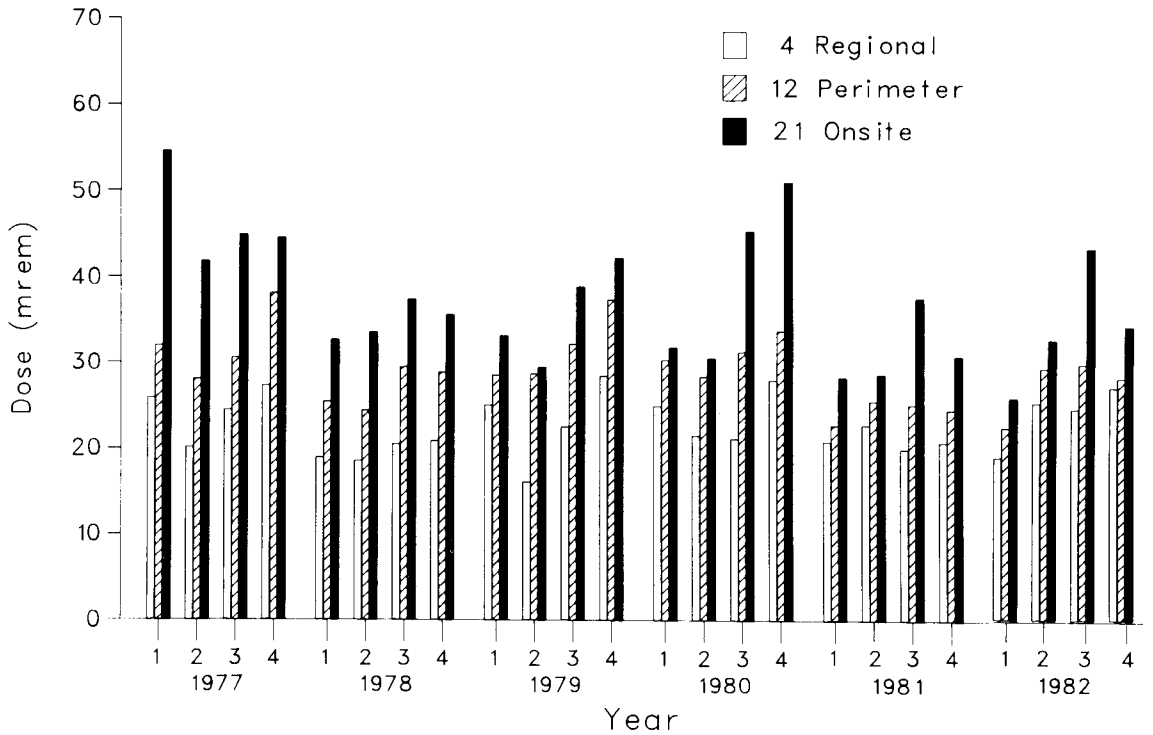


Fig. 7. Quarterly above-background dose averages for three station groups during the last 6 years.

The second network monitors radiation from radioactive gas released by the Los Alamos Meson Physics Facility (a linear particle accelerator), TA-53. The dose contribution from the Los Alamos Meson Physics Facility's operations is very small. To improve the accuracy and decrease the uncertainty of this measurement, 12 TLD sites are located at the Laboratory boundary north of the Los Alamos Meson Physics Facility along 800 m of canyon rim. Twelve background TLD sites are similarly located about 9 km from the facility along a canyon rim near the southern boundary of the Laboratory (Fig. 6). This background location is not influenced by any Laboratory radiation sources.

These 24 TLDs are changed in accordance with the operational schedule of the Los Alamos Meson Physics Facility. The difference between the average of the dosimeters at the north and south boundaries represents the contribution to the dose from Los Alamos Meson Physics Facility's operations and is plotted in Fig. 8. The Los Alamos Meson Physics Facility network showed an increase above background of 12 ± 3 mrem/yr at the Laboratory boundary north of the Los Alamos Meson Physics Facility due to its operation.

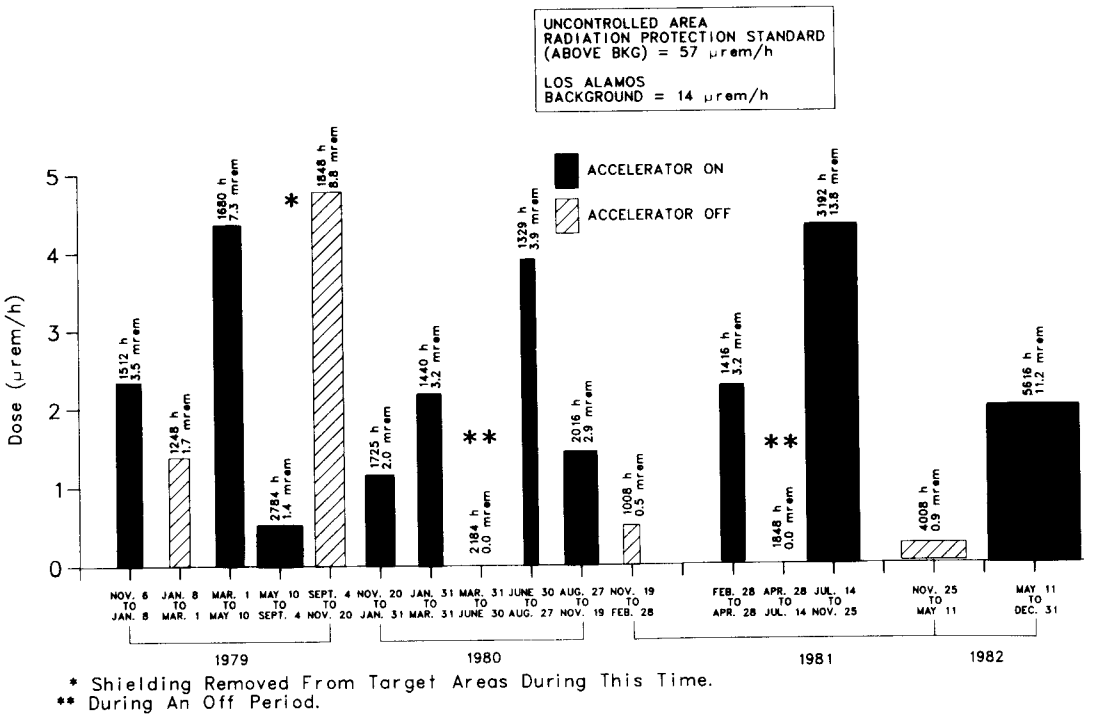


Fig. 8. Above-background dose rate from operation of the Los Alamos Meson Physics Facility.

2. Atmospheric Radioactivity

Worldwide background atmospheric radioactivity is composed of fallout from atmospheric nuclear weapon tests, natural radioactive constituents in dust from the earth's surface, and radioactive materials resulting from interactions with cosmic radiation. Air is routinely sampled at several locations on Laboratory land, along the Laboratory perimeter, and in distant areas to determine the existence and composition of any contributions to radionuclide levels from Laboratory operations. Atmospheric concentrations of gross alpha, gross beta, americium, plutonium, and uranium are measured and analyzed. The highest measured concentrations of these radioactive materials were less than 10% of the Department of Energy's Concentration Guides, while most of the annual average concentrations were less than 1% of the Concentration Guides.

a. Introduction. Atmospheric radioactivity samples are collected at 25 continuously operating air sampling stations in Los Alamos County and vicinity. Onsite and perimeter station locations are shown in Fig. 9 and identified by map coordinates in Table E-III. Perimeter stations are within 4 km of the Laboratory boundary. The regional monitoring stations, located 28 to 44 km from the Laboratory at Española, Pojoaque, and Santa Fe (Fig. 1), are reference points for determining regional background for atmospheric radioactivity. A complete description of sampling procedures and statistical treatment of data is given in Appendix B.

When interpreting data from this air sampling program, one must be aware of natural and fallout radioactivity levels and their fluctuations. Worldwide background atmospheric radioactivity is largely composed of

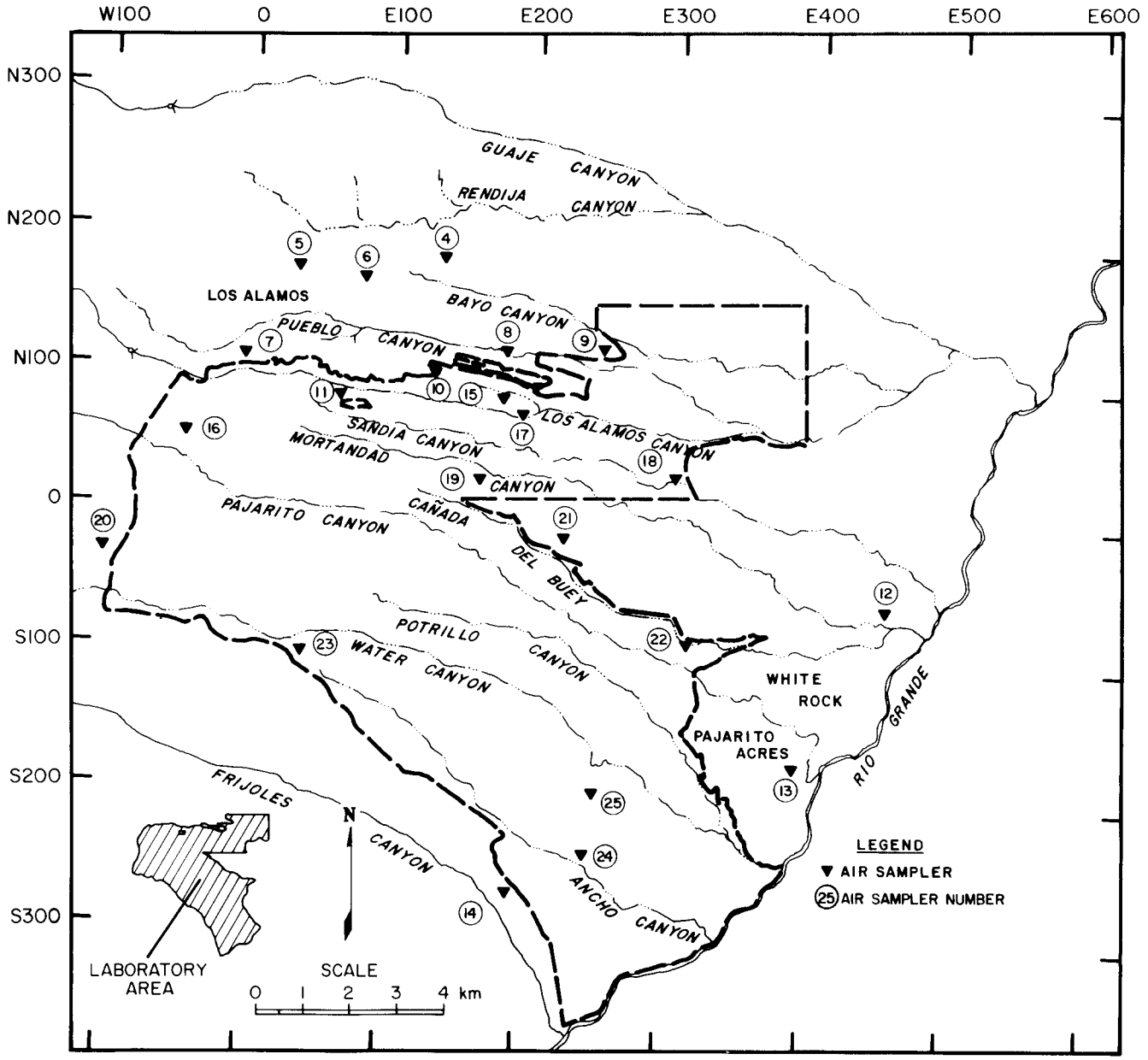


Fig. 9. Air sampler locations on or near the Laboratory site.

fallout from atmospheric nuclear weapons tests, natural radioactive constituents in dust from the decay chains of ^{232}Th and ^{238}U, and materials resulting from interactions with cosmic radiation (such as tritiated water vapor). Background radioactivity concentrations are summarized in Table E-IV and are useful in interpreting the air sampling data.

Because airborne particulates are mostly from soil resuspension, there are large temporal fluctuations in airborne radioactivity as a result of changing meteorological conditions. Periods of high winds result in relatively high suspended particulate concentrations, whereas periods of heavy precipitation remove many airborne particles. Spatial variations are dependent on these same factors.

b. Annual Gross Alpha and Beta Radioactivity. Gross alpha and beta analyses serve as indicators of

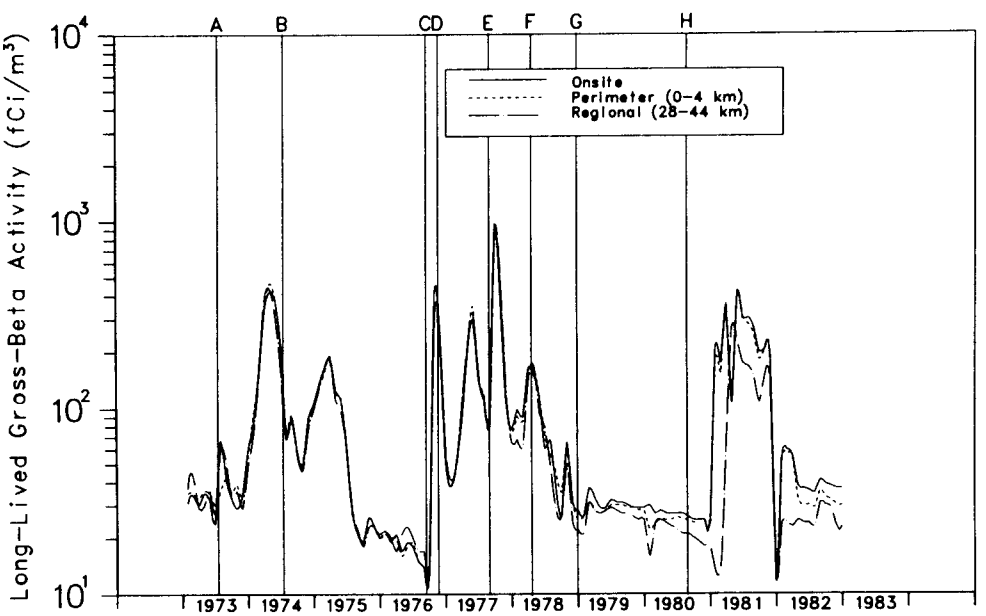
overall radioactivity concentrations in the air. The annual average 4-week gross alpha and beta concentrations are summarized in Table X and described in detail in Table E-V.

The gross alpha data showed that the regional annual mean (1.6×10^{-15} μCi/mℓ) was significantly lower than the perimeter annual mean (3.1×10^{-15} μCi/mℓ) and onsite annual mean (3.9×10^{-15} μCi/mℓ). This is expected because the regional stations are 28 to 40 km distant from the Laboratory, so they are not influenced by its operation.

The gross beta data showed the regional annual mean (25×10^{-15} μCi/mℓ) to be lower than the perimeter annual mean (37×10^{-15} μCi/mℓ) and onsite annual mean (42×10^{-15} μCi/mℓ). The gross beta annual means were about 4 to 6 times lower than last year (Fig. 10). This decrease was primarily because the last atmospheric test of a nuclear weapon was on October 16, 1980.

c. Tritium. Atmospheric tritiated water concentrations for each sampling station for 1982 are summarized in Table X, detailed in Table E-VI, and plotted in Fig. 11. The regional annual mean (11×10^{-12} μCi/mℓ) was significantly lower than the perimeter annual mean (21×10^{-12} μCi/mℓ) and onsite annual mean (34×10^{-12} μCi/mℓ). Tritium emissions from TA-33 caused the TA-33 (Station 24) annual mean (88×10^{-12} μCi/mℓ) and the nearby TA-39 (Station 25) annual mean (149×10^{-12} μCi/mℓ) to both be higher than the other onsite station annual means. These concentrations are 0.0018% and 0.0030%, respectively, of the Department of Energy's Controlled Area Concentration Guide for tritium in air.

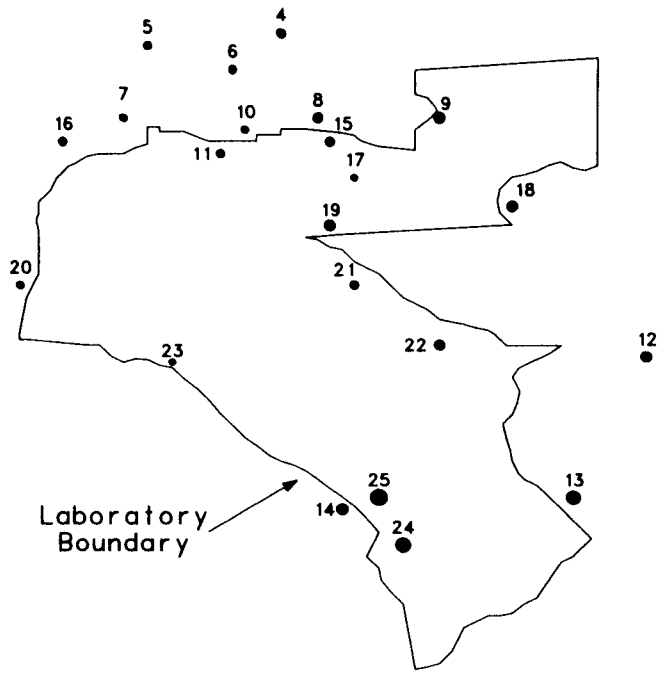
d. Plutonium. Annual average ^{238}Pu concentrations are summarizd in Table X and detailed in Table E-VII. There were just 3 of 100 measured ^{238}Pu concentrations greater than the minimum detectable value of 2×10^{-18} μCi/mℓ. The highest of the three detectable values was 50×10^{-18} μCi/mℓ, which occurred at the Gulf Station (Station 10). It was 0.07% of the Department of Energy's Concentration Guide for ^{238}Pu in air for Uncontrolled Areas.



Chinese Nuclear Atmospheric Tests

A.	26 June 1973	2-3 MT
B.	17 June 1974	0.2-1 MT
C.	26 September 1976	0.2 MT
D.	17 November 1976	4 MT
E.	17 September 1977	0.02 MT
F.	14 March 1978	0.02 MT
G.	14 December 1978	0.02 MT
H.	16 October 1980	0.2-1 MT

Fig. 10. Monthly average gross-beta activity in air, 1973-1982, by sampling station groups.



NOTE

The size of each dot is proportional to the annual atmospheric tritium concentration at a particular sampling location. The number by each dot identifies the sampling station. Table E-IV gives sampling station locations.

• – Represents 10 pCi/m^3

● – Represents 100 pCi/m^3

Fig. 11. Annual mean atmospheric tritiated water vapor concentrations on or near the Laboratory site.

For $^{239+240}$Pu in air, the regional (2.3×10^{-18} μCi/mℓ), perimeter (2.5×10^{-18} μCi/mℓ), and onsite (3.4×10^{-18} μCi/mℓ) annual means were all relatively low. The highest measured $^{239+240}$Pu concentration was 38×10^{-18} μCi/mℓ at the radioactive solid waste disposal area, TA-54 (Station 22). This concentration is 0.002% of the Department of Energy's Guide for $^{239+240}$Pu in air for Controlled Areas.

e. Uranium and Americium. The 1982 atmospheric uranium concentrations are summarized in Table X and listed in Table E-VIII. Uranium concentrations are heavily dependent on the immediate environment of the sampling station. Those stations with higher annual averages and maximums are all in dusty areas, where historically a higher filter dust loading accounts for collection of more natural uranium from resuspended soil particles. This year the highest annual average was at the Los Alamos Airport (Station 8). It was 112 pg/m^3, which is 0.0018% of the Department of Energy's Concentration Guide for uranium in air in Uncontrolled Areas.

The 1982 atmospheric ^{241}Am concentrations are summarized in Table X and listed in Table E-IX. Analyses for ^{241}Am are done because it is a daughter of ^{241}Pu and is much easier to detect than ^{241}Pu. Weapon-grade plutonium contains ^{241}Pu, so fallout from atmospheric nuclear tests often contain ^{241}Pu and ^{241}Am. This year only 2 of 44 analyses for ^{241}Am were above the detectable limit of 2×10^{-18} μCi/mℓ. The highest of these two concentrations was 11×10^{-18} μCi/mℓ at Santa Fe (Station 3) and was 0.0004% of the Department of Energy's Concentration Guide for ^{241}Am in air in Uncontrolled Areas.

TABLE X

SUMMARY OF ANNUAL ATMOSPHERIC RADIOACTIVITY MONITORING FOR 1982

Analysis	Group	Units	Maximum Observed	Minimum Observed	Annual Mean	Mean as % of Concentration Guide
Gross alpha	Regional	10^{-15} μCi/mℓ	4.6 ± 2.0	0.6 ± 0.3	1.6 ± 0.3	2.7
	Perimeter	10^{-15} μCi/mℓ	12 ± 6	0.0 ± 0.1	3.1 ± 0.3	5.2
	Onsite	10^{-15} μCi/mℓ	13 ± 6	0.3 ± 0.2	3.9 ± 0.3	0.2
Gross beta	Regional	10^{-15} μCi/mℓ	39 ± 10	16 ± 4	25 ± 2	0.08
	Perimeter	10^{-15} μCi/mℓ	110 ± 28	0.0 ± 0.1	37 ± 4	0.12
	Onsite	10^{-15} μCi/mℓ	94 ± 24	8 ± 2	42 ± 3	0.004
Tritiated water vapor	Regional	10^{-12} μCi/mℓ	45 ± 14	0.5 ± 0.6	11 ± 4	0.005
	Perimeter	10^{-12} μCi/mℓ	330 ± 100	1.1 ± 0.8	21 ± 7	0.011
	Onsite	10^{-12} μCi/mℓ	690 ± 220	1.3 ± 1.4	34 ± 15	0.0007
^{238}Pu	Regional	10^{-18} μCi/mℓ	2.2 ± 6.7	−1.6 ± 1.1	−0.6 ± 0.6	0.0
	Perimeter	10^{-18} μCi/mℓ	50 ± 9	−4.6 ± 7.1	1.3 ± 3.1	0.004
	Onsite	10^{-18} μCi/mℓ	3.2 ± 2.3	−2.6 ± 2.1	−0.6 ± 0.3	0.0
$^{239+240}$Pu	Regional	10^{-18} μCi/mℓ	9.1 ± 13	−1.3 ± 1.2	2.3 ± 1.6	0.004
	Perimeter	10^{-18} μCi/mℓ	11 ± 3.8	−1.7 ± 6.2	2.5 ± 0.8	0.004
	Onsite	10^{-18} μCi/mℓ	38 ± 8.8	−1.6 ± 1.4	3.4 ± 1.7	0.0002
^{241}Am	Regional	10^{-18} μCi/mℓ	11 ± 7.2	−0.5 ± 2.8	0.7 ± 3.0	0.0004
	Perimeter	10^{-18} μCi/mℓ	2.5 ± 3.7	−1.5 ± 2.7	0.07 ± 0.33	0.0000
	Onsite	10^{-18} μCi/mℓ	9.5 ± 3.5	−1.4 ± 3.2	0.04 ± 0.20	0.0000
Total U	Regional	pg/m^3	230 ± 46	5.7 ± 2.5	61 ± 34	0.001
	Perimeter	pg/m^3	240 ± 49	2.6 ± 2.5	44 ± 13	0.0007
	Onsite	pg/m^3	130 ± 27	7.8 ± 2.6	52 ± 8.4	0.00003

3. Radioactivity in Surface and Ground Waters

Surface and ground waters are monitored to provide routine surveillance of dispersion of radionuclides from Laboratory operations. Results of these analyses are compared to the Department of Energy's Concentration Guides for water. Regional background concentrations are an indication of the small amount of radionuclides (natural and fallout) in the environment. The 1982 radiochemical quality analyses of water from regional, perimeter, water supply, and onsite noneffluent release areas indicate no significant effect from effluent releases from the Laboratory. Waters in onsite liquid effluent release areas contain trace amounts of radioactivity. These onsite waters are not a source of industrial, agricultural, or municipal water supplies.

a. Regional and Perimeter Waters. Analyses of surface and ground waters from regional and perimeter stations reflect base line levels of radioactivity in areas outside the Laboratory boundary. Regional surface waters are collected within 75 km of the Laboratory from six stations on the Rio Grande, Rio Chama, and Jemez Rivers (Fig. 12, Table E-X). Surface water from these rivers is used for irrigation of crops in the Rio Grande Valley, both upstream and downstream from Los Alamos. Waters of the Rio Grande, Rio Chama, and Jemez Rivers are part of recreational areas on state and federal lands. Samples are also collected from 6 perimeter stations located within about 4 km of the Laboratory boundaries and from 25 stations in White Rock Canyon of the Rio Grande (Fig. 13, Table XI).

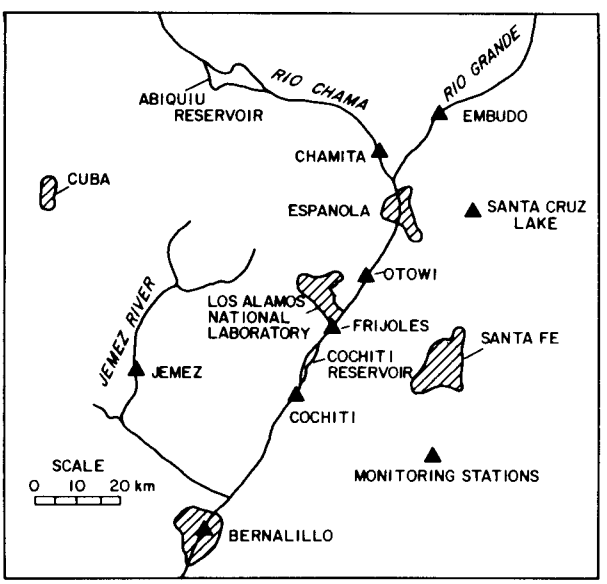


Fig. 12. Regional surface water, sediment, and soil sampling locations.

Water from Los Alamos and Guaje Reservoirs is used during the summer for irrigation of lawns and shrubs at the Laboratory and public schools. These two locations are also sampled as part of the perimeter group.

A comparison of the maximum concentrations found in these waters with the Department of Energy's Concentration Guides (see Appendix A) for Uncontrolled Areas is given in Table XI. However, the Concentration Guides do not account for concentration mechanisms that may exist in environmental media. Consequently, other media such as sediments, soils, and foods are monitored (as discussed in subsequent sections). Detailed data from regional, perimeter, and White Rock Canyon stations are in Tables E-XI, E-XII, and E-XIII, respectively. See Appendix B.3 for methods of collection, analysis, and reporting of water data.

Radionuclide concentrations in surface and ground waters from the six regional and six perimeter stations were low and showed no effect from release of liquid effluents at the Laboratory. Plutonium concentrations were near minimum detection levels and were well below Concentration Guides for Uncontrolled Areas.

Stations in White Rock Canyon are divided into four groups. Three groups are of similar aquifer-related chemical quality, while the fourth group reflects localized conditions in the aquifer. Flow from three streams that enter the Rio Grande in White Rock Canyon are also analyzed. Treated sanitary effluent from the community of White Rock is also collected and analyzed as it reaches the Rio Grande. Radionuclide concentrations in water from the 26 stations reflect naturally occurring radionuclides (Table E-XIII).

Excluded from this discussion is Acid-Pueblo Canyon, a former release area for industrial liquid waste, which has four offsite stations and three onsite stations (Fig.

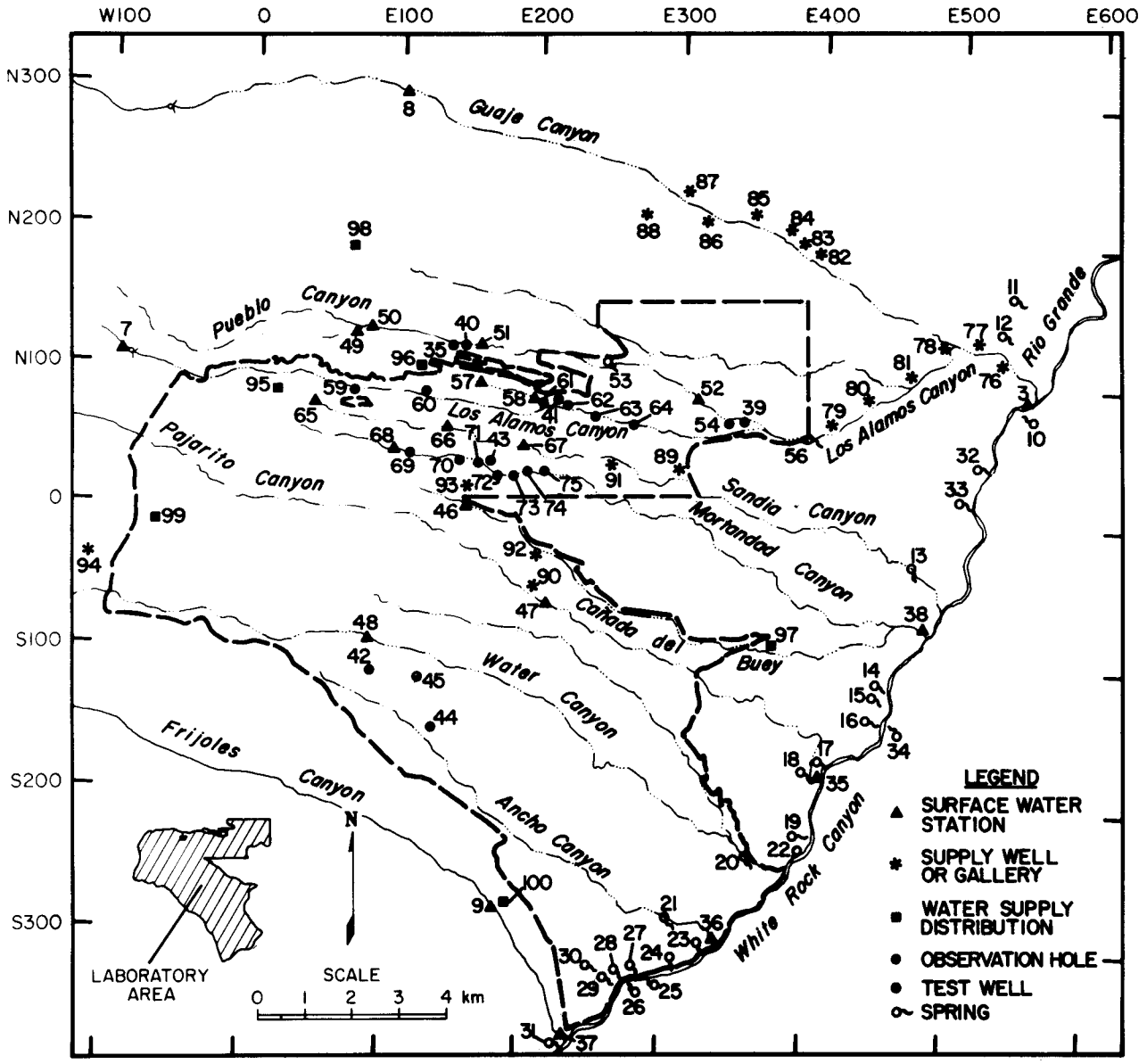


Fig. 13. Surface and ground water sampling locations on or near the Laboratory site.

13). As a known release area and for hydrologic continuity, all monitoring results from Acid-Pueblo Canyon are discussed in the following section concerning onsite surface and ground waters.

b. Onsite Surface and Ground Waters. Onsite sampling stations are grouped according to those located away from effluent release areas and those located in areas that receive or have received industrial liquid effluents. Sampling locations in onsite noneffluent release areas consist of seven test wells completed into the main aquifer and three surface water sources (Fig. 13, Table E-X). Maximum concentrations of radioactivity at the 10 stations are in Table XI. The concentrations were low, near or below detection limits, and well below Concentration Guides for Controlled Areas. Results of detailed radioachemical analyses are in Table E-XIV.

Canyons that receive or have received industrial effluents are Acid-Pueblo, DP-Los Alamos, Sandia, and Mortandad. Samples are collected from surface water stations or shallow observation holes completed in the alluvium (Fig. 13, Tables E-XV through E-XVIII).

TABLE XI

MAXIMUM RADIOACTIVITY IN SURFACE AND GROUND WATER FROM OFFSITE, ONSITE, AND WATER SUPPLY STATIONS
(each sample result in table is the maximum concentration from a group of samples, along with ±2 standard deviations)

	Number of Stations	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	Total U (μg/ℓ)	^{241}Am (10^{-9} μCi/mℓ)
Offsite Stations (Uncontrolled Areas)										
Concentration Guide (CG) for Uncontrolled Areas[a]	---	20 000	5000	5000	5000[b]	300[c]	3000	300	1800	4000
Regional	6	40 ± 148	0.034 ± 0.038	0.006 ± 0.034	54 ± 22	31 ± 6.0	0.9 ± 0.6	---	4.2 ± 0.8	---
Perimeter	6	95 ± 60	0.020 ± 0.140	0.005 ± 0.020	9.0 ± 4.0	11 ± 1.4	4.3 ± 0.6	---	10 ± 2.0	---
White Rock Canyon	25	79 ± 114	0.034 ± 0.036	0.030 ± 0.040	14 ± 8.0	32 ± 6.0	0.8 ± 0.8	---	20 ± 4.0	---
Offsite Station Group Summary:										
Maximum Concentration	---	95 ± 60	0.034 ± 0.038	0.006 ± 0.034	54 ± 22	32 ± 6.0	4.3 ± 0.6	---	20 ± 4.0	---
Maximum Concentration as Per Cent of CG for Uncontrolled Areas	---	<1	<1	<1	1	11	<1	---	1	---
Onsite Station (Controlled Areas)										
Concentration Guide (CG) for Controlled Areas[a]	---	400 000	100 000	100 000	100 000	10 000	100 000	10 000	60 000	100 000
Noneffluent Areas	10	116 ± 212	0.030 ± 0.080	0.170 ± 0.000	6.6 ± 3.2	20 ± 4.0	25 ± 1.0	---	1.2 ± 0.8	---
Effluent Areas										
Acid-Pueblo	8	262 ± 272	0.015 ± 0.028	1.19 ± 0.160	10 ± 6.0	145 ± 30	97 ± 3.0	6.1 ± 2.3	8.0 ± 1.6	0.140 ± 0.080
DP-Los Alamos	8	95 ± 172	0.610 ± 0.140	10.4 ± 1.00	470 ± 200	2000 ± 400	64 ± 22	362 ± 16	270 ± 60	8.00 ± 0.800
Sandia	3	60 ± 100	0.007 ± 0.008	0.004 ± 0.024	18 ± 10	46 ± 10	10 ± 0.6	2.6 ± 0.6	2.0 ± 0.8	0.180 ± 0.080
Mortandad	7	692 ± 238	143 ± 3.6	1493 ± 30	15 000 ± 6000	1760 ± 360	99 ± 3.2	52 ± 2.4	4.5 ± 0.8	23.3 ± 1.20
Onsite Station Group Summary:										
Maximum Concentration	---	692 ± 238	143 ± 3.6	1493 ± 30	15 000 ± 6000	2000 ± 400	99 ± 3.2	362 ± 16	270 ± 60	23.3 ± 1.20
Maximum Concentration as Per Cent of CG for Controlled Areas	---	<1	<1	<1	15	20	<1	4	<1	<1

TABLE XI (cont)

	Number of Stations	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	Total U (μg/ℓ)	^{241}Am (10^{-9} μCi/mℓ)
Water Supply										
Maximum Contaminant Level (MCL)[d]	---	200	15	15	15[e]	---	20	8	1800[f]	7.5
Wells										
Maximum Concentration	16	40 ± 60	0.018 ± 0.024	0.010 ± 0.060	20 ± 8.0	28 ± 6.0	4.2 ± 0.6	---	7.0 ± 1.4	---
Maximum Concentration as Per Cent of MCL	---	20	<1	<1	130	---	5	---	<1	---
Distribution System (Los Alamos)										
Maximum Concentration	6	40 ± 80	0.011 ± 0.018	−0.007 ± 0.006	2.2 ± 2.0	5.1 ± 2.0	2.4 ± 0.6	---	3.4 ± 0.8	---
Maximum Concentration as Per Cent of MCL	---	28	<1	<1	11	---	12	<1	---	
Distribution System (Fenton Hill)										
Maximum Concentration	1	5 ± 34	−0.024 ± 0.036	−0.063 ± 0.024	5.6 ± 1.5	7.0 ± 2.2	0.5 ± 0.6	---	2.2 ± 0.8	---
Maximum Concentration as Per Cent of MCL	---	3	<1	<1	37	---	3	---,<1	---	

[a]Department of Energy Order 5480.1A, Chapter XI.
[b]The Concentration Guide for ^{239}Pu from the Department of Energy's Order 5480.1A, Chapter XI, is used for gross alpha standard.
[c]The Concentration Guide for ^{90}Sr from the Department of Energy's Order 5480.1A, Chapter XI, is used for gross beta standard.
[d]The Environmental Protection Agency's National Interim Primary Drinking Water Regulations.
[e]The Environmental Protection Agency's MCL for gross alpha is 15×10^{-9} μCi/mℓ. However, gross alpha results from the distribution system that exceed EPA's screening limit of 5×10^{-9} μCi/mℓ require isotopic analysis to determine radium content.
[f]Level recommended by International Commission on Radiological Protection.

Maximum concentrations of radioactivity in each of the four canyons are given in Table XI. Radioactivity observed in Acid-Pueblo Canyon (Table E-XV) results from residuals of treated and untreated radioactive liquid waste effluents released into the canyon before 1964. Radionuclides that were absorbed by channel sediments are now being resuspended by runoff and municipal sanitary effluents.

Sandia Canyon receives cooling tower blowdown from the TA-3 power plant and some sanitary effluent from TA-3 facilities (Table E-XVI). The DP-Los Alamos Canyon receives industrial effluents that contain low levels of radionuclides and some sanitary effluents from TA-21 (Table E-XVII). Tritium concentrations above background in upper Los Alamos Canyon in shallow well LAO-1 are due to release of cooling water from the research nuclear reactor at TA-2. Mortandad Canyon receives treated industrial effluent containing radionuclides (Table E-XVIII). Water in these canyons contains radionuclides from treated effluents from the treatment plants.

Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons all contain surface and ground water with measurable amounts of radioactivity that are well below Concentration Guides for Controlled Areas. Surface and ground waters of these canyons are not a source of municipal, industrial, or agricultural supply. Surface waters in these canyons normally infiltrate into alluvium of stream channels within the Laboratory's boundaries. Only during periods of heavy precipitation or snowmelt does water from Acid-Pueblo and DP-Los Alamos Canyons reach the Rio Grande. In Mortandad Canyon, there has been no surface water runoff past the Laboratory's boundary since hydrologic studies in the canyon began in 1960, 3 years before release of any industrial effluents.

c. Water Supply. The municipal and industrial water supply for the Laboratory and community is from 16 deep wells (in three well fields). The wells are located on Pajarito Plateau and in canyons east of the Laboratory (Fig. 13). Water is pumped from the main aquifer, which lies about 350 m below the surface of the Plateau. The gallery discharges from a perched water zone (a ground water body above an impermeable layer that is separated from an underlying main body of ground water by an unsaturated zone) in volcanics on the flanks of the mountains west of the Plateau.

During 1982 production from the wells and gallery was about 5.8×10^6 m^3, with the wells furnishing about 97% of the total production and a gallery about 3%. Water samples are collected from the wells and at six stations in the distribution system. The five stations in the distribution system are located within the Laboratory and community, while the sixth is located at Bandelier National Monument (Fig. 13, Table E-XIX). The water supply distribution system at TA-57, the Fenton Hill Geothermal Site, is also sampled. This water is pumped from a well about 133 m deep at the site.

A comparison of maximum concentrations found in these waters with the Environmental Protection Agency's National Interim Primary Drinking Water Standards[21] is given in Table XI. Detailed radiochemical analyses of water from the wells, gallery, and distribution system (including Fenton Hill) are presented in Table E-XIX. Radiochemical standards are related to the safety of drinking water.[21] Radioactivity in water from the wells, gallery and distribution system is low and naturally occurring in the aquifer. Gross alpha activity in water from Well PM-4 ($20 \pm 8.0 \times 10^{-9}$ $\mu Ci/m\ell$) is above the standard (15×10^{-9} $\mu Ci/m\ell$). However, mixture of water from Well PM-4 with other wells reduces the concentrations in the distribution system to acceptable levels (Table E-XIX). Radium-226 analyses of water from Well PM-4 was 0.03×10^{-9} $\mu Ci/m\ell$, much less than 5×10^{-9} $\mu Ci/m\ell$ drinking water standard. The high gross alpha activity may reflect contamination of the sample after collection.

4. Radioactivity in Soils and Sediments

Soil samples are collected from 23 stations and sediment samples from 42 stations in and adjacent to the Los Alamos area. Concentrations of ^{137}Cs, $^{238+239}Pu$, gross alpha, and gross beta from regional soil and/or sediment stations were slightly above regional levels. The low concentrations are due to variability of worldwide fallout. Samples from soil and sediment perimeter stations and onsite stations had concentrations of radioactivity in excess of normal or regional levels. Concentrations of radioactivity from these stations are less than twice the normal or regional levels, except in areas where treated radioactive effluents are released.

a. Regional Soil and Sediments. Regional soils are collected in the same general locations as regional waters (Fig. 12). Regional sediments are also collected at the same general locations with additional samples collected from Otowi to Cochiti on the Rio Grande. The exact locations are presented in Table E-XX and detailed results are in Table E-XXI. See Appendix B.3 for methods of collection, analysis, and reporting of soil and sediment data.

Regional and perimeter soil and sediment radiochemical data collected from 1974 through 1977 are used to distinguish between background radioactivity (the result of natural and worldwide fallout) and radioactivity from nuclear weapons tests.[23] These data are used for comparison with 1982 soil and sediment results (Table XII). Soil analyses from regional stations indicate that ^{137}Cs concentrations at three stations and a ^{239}Pu concentration at one station were slightly above regional levels for the period 1974-1977. Sediment analyses from regional stations indicated that a ^{238}Pu concentration at one station, ^{239}Pu concentrations at three stations, and gross alpha and beta concentrations at two stations were slightly above background levels found for the period 1974-1977. All these concentrations are low and due to variability of naturally occurring or variability in worldwide fallout.

b. Perimeter Soils and Sediments. Six perimeter soil stations are sampled in areas within 4 km of the Laboratory. Ten sediment samples are collected from major intermittent streams that cross Pajarito Plateau. Locations of the soil and sediment stations are described in Table E-XX and shown in Figs. 14 and 15. Detailed analyses are in Table E-XXII.

Perimeter soil analyses indicate concentrations of ^{137}Cs (three stations), ^{239}Pu (four stations), gross beta (two stations), ^{3}H (two stations), and total U (one station) were slightly elevated when compared to regional levels 1974-1977. Perimeter sediment analyses indicated concentrations of ^{137}Cs (one station), ^{239}Pu (one station), gross alpha (one station), gross beta (one station), and total U (two stations) were slightly above levels of 1974-1977. Some of the elevated levels may be related to the releases (soils, airborne; sediment, transport from liquid release areas) from the Laboratory, such as airborne from TA-21[25] (see Section VI.H) or liquid effluents from treatment plants (see Sections VI.G, I, and J).

c. Onsite Soil and Sediments. Onsite soil samples are collected from 10 stations within Laboratory boundaries. Sediment samples are collected from 24 stations within the boundaries (Fig. 14, Table E-XX). Analytical results are shown in Table E-XXIII and maximum concentrations in Table XII. Locations of soil and sediment stations are shown in Figs. 14 and 15.

Soil analyses indicate that concentrations of ^{137}Cs (two stations), ^{239}Pu (two stations), gross alpha (one station), gross geta (three stations), ^{3}H (five stations), and total U (one station) were above normal or regional levels from 1974-1977 (Table XII).

Sediments from stations in Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons had radionuclide concentrations in excess of background levels (Table XII and E-XXIII). These canyons have or are now receiving treated industrial effluents. The radionuclides in effluents are adsorbed or attached to sediment particles in the alluvium. These concentrations are generally highest near the point of discharge from the treatment plant. They decrease downgradient in the canyon as the sediments and radionuclides are transported and dispersed by the effluents and periodic storm runoff.

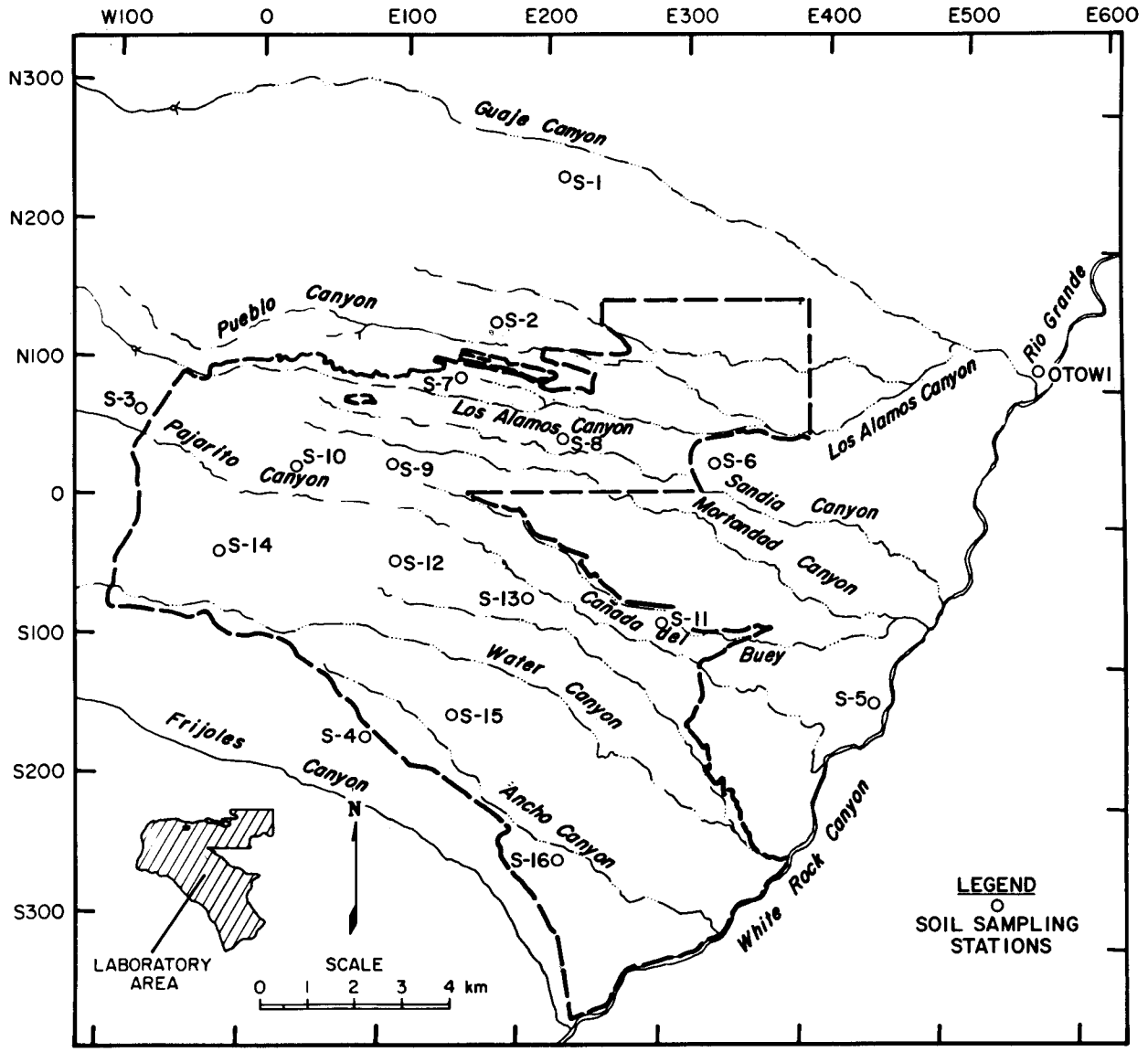


Fig. 14. Soil sampling stations on or adjacent to the Laboratory site.

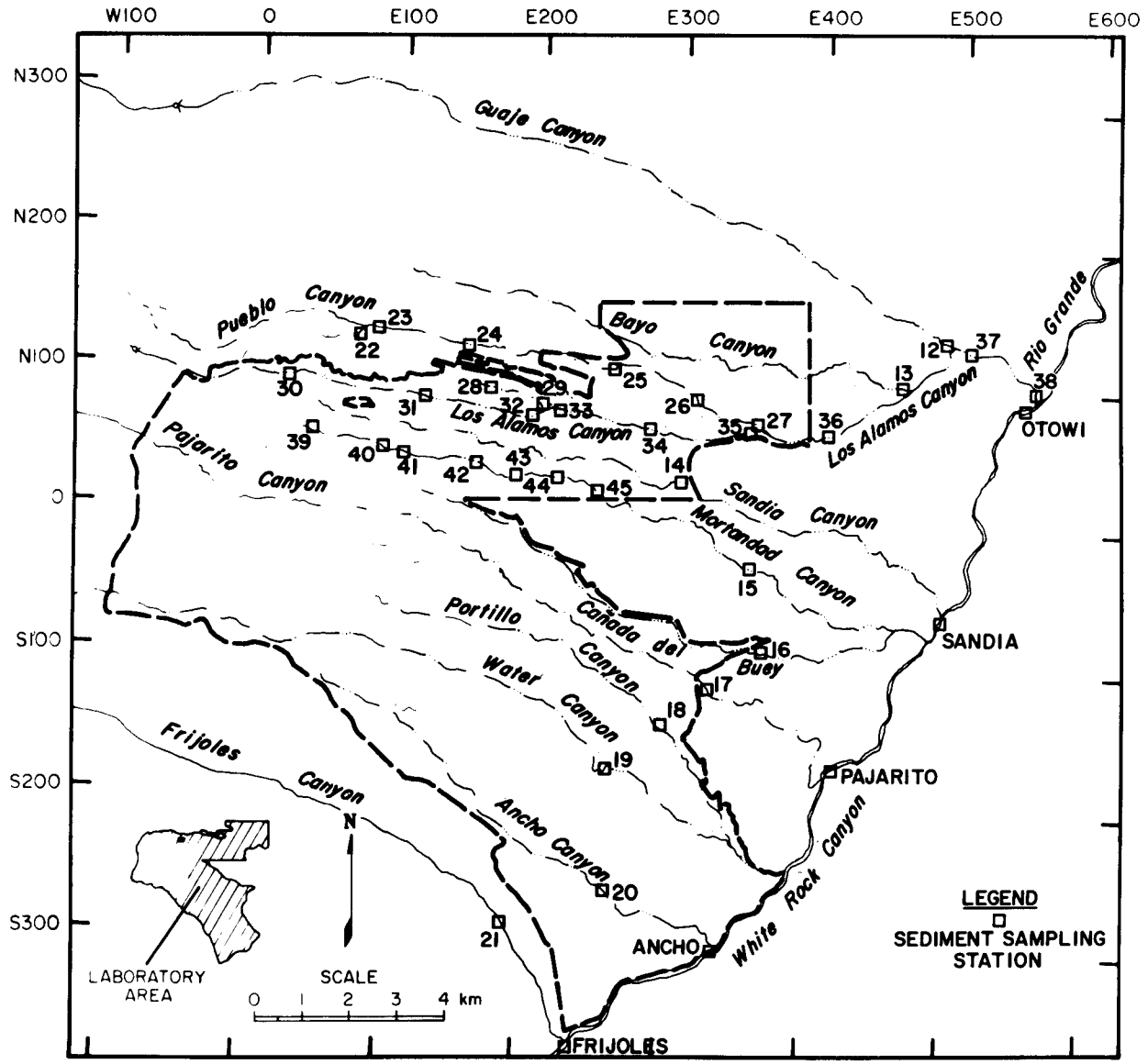


Fig. 15. Sediment sampling stations on or adjacent to the Laboratory site.

TABLE XII

MAXIMUM RADIOACTIVITY IN SOILS AND SEDIMENTS FROM REGIONAL, PERIMETER, AND ONSITE STATIONS

	Number of Stations	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta pCi/g)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/g)	^{90}Sr (pCi/g)
Average maximum soil and sediment concentrations at regional stations due to worldwide fallout for Northern New Mexico, 1974-1977[a]	26	0.92	0.008	0.028	11	11	7.3[b]	4.4	0.79
Regional Stations									
Soil	7	1.37 ± 0.16 (3)	0.005 ± 0.002 (0)	0.029 ± 0.008 (1)	11 ± 6.0 (0)	11 ± 2.6 (0)	5.0 ± 0.6 (0)	3.7 ± 0.6 (0)	---
Sediment	8	0.39 ± 0.06 (0)	0.023 ± 0.030 (1)	0.210 ± 0.260 (3)	16 ± 8.0 (2)	18 ± 3.8 (2)	---	3.1 ± 0.6 (0)	---
Perimeter Stations									
Soil	6	2.69 ± 0.26 (3)	0.005 ± 0.002 (0)	0.085 ± 0.010 (4)	10 ± 4.0 (0)	15 ± 3.2 (2)	14 ± 0.8 (2)	6.3 ± 1.2 (1)	---
Sediment	10	1.27 ± 0.14 (1)	0.004 ± 0.004 (0)	0.032 ± 0.008 (1)	13 ± 6.0 (1)	12 ± 2.8 (1)	4.7 ± 1.0 (0)	4.7 ± 1.0 (2)	
Onsite Stations									
Soil	10	2.13 ± 0.16 (2)	0.002 ± 0.002 (0)	0.320 ± 0.038 (2)	12 ± 6.0 (1)	17 ± 3.6 (3)	93 ± 3.0 (5)	5.3 ± 0.6 (1)	---
Sediments (Effluent Release Areas)[c]									
Acid-Pueblo Canyon	6	1.26 ± 0.12 (1)	0.080 ± 0.080 (5)	18.5 ± 1.40 (9)	18 ± 8.0 (2)	9.5 ± 2.2	---	4.6 ± 1.0 (1)	1.4 ± 0.16 (1)
DP-Los Alamos Canyon	11	23.9 ± 2.4 (7)	0.670 ± 0.040 (15)	2.67 ± 0.100 (19)	22 ± 10 (1)	25 ± 6.0 (4)	---	4.8 ± 1.0 (1)	1.4 ± 0.14 (1)
Mortandad Canyon	7	312 ± 19 (5)	17.6 ± 0.400 (9)	237 ± 3.4 (10)	420 ± 180 (6)	950 ± 200 (7)	---	4.0 ± 0.8 (0)	---

[a]Average maximum value ($\bar{x}$ + 2s) for soil and sediments, 1974-1977 (Ref. 23).
[b]Average maximum value ($\bar{x}$ + 2s) for soils, 1981 (Ref. 35).
[c]Two analyses per station.

Note: Number in parentheses indicates number of stations exceeding worldwide fallout concentrations for Northern New Mexico, 1974-1977.

5. Radioactivity in Foodstuffs

Most fruit, vegetable, and fish samples collected in the vicinity of the Laboratory showed no apparent influence from Laboratory operations. Fruit collected onsite and produce from several gardens that could have been influenced by Laboratory releases had slightly elevated concentrations of tritium. Fish gut samples from Cochiti showed slightly higher concentrations of ^{137}Cs and ^{238}Pu than did gut samples from fish taken at background locations. These relatively small increases indicate possible ingestion of sediment. However, no increases in any radionuclides were detected in edible portions of fish. Honey samples collected on or near the Laboratory showed trace amounts of radionuclides primarily associated with effluent discharges. Radiation doses from consumption of foodstuffs are discussed in Section III.D.

a. Introduction. Fruit, vegetable, fish, and honey samples were collected during 1982 to monitor foodstuffs for possible radioactive contamination from Laboratory operations. Fruits and vegetables were collected in the Los Alamos area and in the Rio Grande Valley above and below confluences of intermittent streams that cross the Laboratory and flow into the Rio Grande (see Fig. 12). Fish were collected from locations above (Abiquiu, Heron, and El Vado reservoirs that are on the Rio Chama, a tributary of the Rio Grande) and below (Cochiti Reservoir) confluences of these intermittent streams.

Fruit and vegetables collected in the Rio Grande Valley in the Española area and fish collected at the Abiquiu, Heron, and El Vado reservoirs would be unaffected by Laboratory operations. These locations are upstream from the confluences with the Rio Grande of intermittent streams crossing the Laboratory. They are also distant from the Laboratory so are unaffected by airborne emissions. These areas were used as control locations for fruit, vegetable, and fish sampling programs.

Fish samples were taken from bottom feeders, such as carp and suckers, which have a greater probability than higher trophic orders of ingesting any activity that might be associated with sediments. Higher level feeders were also sampled. Honey was collected from hives established in 1978 at several locations within the Laboratory boundary near waste stream outfalls and a tritium facility. Background honey samples came from other locations: Barranca Mesa (in Los Alamos), Pajarito Acres, and Chimayo, New Mexico.

Fruit and vegetable samples were analyzed for tritiated water, ^{90}Sr, ^{137}Cs, total U, ^{238}Pu, and ^{239}Pu. Fish sample analyses included ^{90}Sr, ^{137}Cs, total U, ^{238}Pu, and ^{239}Pu. Honey samples were analyzed for tritiated water, ^{7}Be, ^{22}Na, ^{54}Mn, ^{57}Co, ^{83}Rb, ^{134}Cs, ^{137}Cs, and total U.

b. Fruits and Vegetables. Data in Tables XIII and XIV summarize fruit and vegetable sample results for tritium, strontium, cesium, uranium, and plutonium according to different water supplies. Sample moisture ranged from 60 to 95% of total sample weight.

Concentrations of ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{137}Cs, and total U in fruits and vegetables at locations potentially affected by Laboratory activities were statistically indistinguishable from concentrations in samples taken in background areas. Concentrations for these radionuclides were low and typical of values expected from natural background or worldwide fallout.

Tritium concentrations in water extracted from fruit and vegetables were statistically higher in the produce samples collected in Los Alamos, White Rock/Pajarito Acres, and Cochiti, than were the concentrations in samples from background locations. Tritium concentrations in background samples ranged from 0.3 to 1.4 pCi/mℓ, and concentrations in offsite samples from areas potentially affected by Laboratory operations ranged from –0.1 to 4.8 pCi/mℓ.

Since there are no concentration limits for tritium in produce, these measured tritium levels were compared to limits for concentrations of tritium in water. This comparison is conservative (more restrictive), since the limits on tritium in water are based on an annual water intake

TABLE XIII

TRITIATED WATER CONTENT OF FRUITS AND VEGETABLES

Location	Water Source	Number of Samples	Tritiated Water Concentration (10^{-6} μCi/mℓ) Average (± 1s)	Range	Average Moisture (%)
Española	Rio Grande[a]	5	0.66 ± 0.38	0.3 to 1.3	85 ± 3
Española	Rio Chama[a]	5	0.50 ± 0.20	0.3 to 0.8	88 ± 3
Cochiti	Rio Grande[b]	16	1.2 ± 1.1	0.3 to 4.8	83 ± 8
Los Alamos	Community System	5	1.22 ± 0.55	0.6 to 1.9	89 ± 7
White Rock/Pajarito Acres	Community System	9	1.02 ± 0.63	–0.1 to 2.2	85 ± 5
TA-35	Community System	1	17.0 ± 0.4[c]	---	87
TA-21	Precipitation	2	4.25 ± 0.35	4.0 to 4.5	81 ± 1
TA-3	Community System	1	4.2 ± 0.3[c]	---	88

[a]Upstream from Laboratory stream confluence.
[b]Downstream from Laboratory stream confluence.
[c]Counting uncertainty.

(and, consequently, tritium intake) larger than the annual intake of produce, which would result in concentration limits for tritium in water lower than those in produce. The tritium concentrations in produce measured here are well below the Department of Energy's Concentration Guide for water in Uncontrolled Areas of 3000 pCi/mℓ[36] and the Environmental Protection Agency's National Interim Primary Drinking Water Standard for tritium in drinking water of 20 pCi/mℓ[21] (see Appendix A). The radiation dose that may result from these tritium levels is discussed in Section III.D.

The tritium content of peaches at TA-35 was similar to previously reported relatively higher values at that location.[26] The TA-35 facility releases airborne tritium (see Table E-I). Elevated tritiated water concentrations were also measured in apples and peaches from trees located near a facility in TA-21, and in peaches at TA-3, where airborne tritium is also released. These few peaches and apples do not represent a significant pathway to man because they represent a very small volume of edible material, and have considerably less tritium than the Uncontrolled Area Concentration Guide for water[36] (3000×10^{-6} μCi/mℓ).

c. Fish. No statistically significant differences between average radionuclide concentrations in edible flesh of fish from background areas and from Cochiti, the area potentially affected by Laboratory operations, were found for any radionuclides monitored by the sampling program (see Table XV). The radionuclide concentrations that were measured were low and typical of worldwide fallout.

Radionuclide concentrations in gut samples from Cochiti were indistinguishable from those in gut samples from background areas for all radionuclides except ^{238}Pu in bottom feeder gut and ^{137}Cs in gut samples from higher trophic level feeders. Increased radioactivity in gut samples is related to ingestion of sediments. All radionuclide levels found in these gut samples were low, and mean values were in the range of the levels normally found in sediments due to natural background or worldwide fallout. The radiological impact of these concentrations is discussed in Section III.D.

Both ^{90}Sr and ^{137}Cs are present in the environment due to worldwide fallout from nuclear weapons testing. Of the 52 samples analyzed for ^{90}Sr, detectable concentrations were found in 43 samples: 29 from background

TABLE XIV

RADIONUCLIDE CONTENT OF FRUITS AND VEGETABLES

Location:	Background		Offsite			Onsite		
Water Source:	Española Rio Chama	Española Rio Grande	Cochiti Rio Grande	Los Alamos Community System	White Rock/ Pajarito Acres Community System	TA-3	TA-21	TA-35
Radionuclide:								
^{238}Pu (pCi/g dry weight)								
No. of Samples	5	5	16	5	9	1	2	1
Maximum[a]	0.00085 ± 0.00051	0.00023 ± 0.00019	0.00038 ± 0.00019	0.00044 ± 0.00044	0.00019 ± 0.00013	---	0.00008 ± 0.00011	---
Minimum[a]	–0.00028 ± 0.00019	–0.00007 ± 0.00013	–0.00031 ± 0.00046	0.00004 ± 0.0011	–0.00007 ± 0.00007	---	–0.00005 ± 0.00011	---
Average ± s	0.00031 ± 0.00046	0.00012 ± 0.00012	0.00015 ± 0.00019	0.00031 ± 0.00013	0.00008 ± 0.00010	0.00016 ± 0.00024[a]	0.00002 ± 0.00009	–0.00008 ± 0.00012[a]
^{239}Pu (pCi/g dry weight)								
No. of Samples	5	5	16	5	9	1	2	1
Maximum[a]	0.00037 ± 0.00028	0.00014 ± 0.00018	0.00031 ± 0.00061	0.00033 ± 0.00044	0.00033 ± 0.00050	---	0.00019 ± 0.00016	---
Minimum[a]	–0.00018 ± 0.00018	–0.00009 ± 0.00015	–0.00018 ± 0.00025	–0.00027 ± 0.00023	–0.0004 ± 0.0006	---	0.00017 ± 0.00011	---
Average ± s	0.00006 ± 0.00024	0.00003 ± 0.00009	0.00013 ± 0.00023	0.00007 ± 0.00030	0.00011 ± 0.00021	0.00032 ± 0.00039[a]	0.00018 ± 0.00001	0.00008 ± 0.00027[a]
Uranium (μg/g dry weight)								
No. of Samples	5	5	16	5	9	1	2	1
Maximum[a]	0.0096 ± 0.0024	0.0703 ± 0.0069	0.0121 ± 0.0017	0.00428 ± 0.00069	0.0088 ± 0.0013	---	0.00361 ± 0.00036	---
Minimum[a]	–0.0010 ± 0.0019	0.0001 ± 0.0036	–0.0009 ± 0.0014	–0.0003 ± 0.0012	–0.00009 ± 0.00082	---	0.00084 ± 0.00054	---
Average ± s	0.0027 ± 0.0041	0.017 ± 0.030	0.0024 ± 0.0033	0.0014 ± 0.0018	0.0032 ± 0.0034	0.0091 ± 0.0016[a]	0.0022 ± 0.0020	0.0034 ± 0.0008[a]
^{137}Cs (pCi/g dry weight)								
No. of Samples	5	5	16	5	9	1	2	1
Maximum[a]	3.8 ± 1.2	0.41 ± 0.53	2.9 ± 1.5	3.9 ± 2.0	0.50 ± 0.66	---	0.69 ± 0.33	---
Minimum[a]	0.06 ± 0.98	–0.51 ± 0.58	–0.71 ± 0.52	0.11 ± 0.24	–0.82 ± 0.43	---	0.40 ± 0.32	---
Average ± s	1.5 ± 1.5	0.013 ± 0.39	0.38 ± 0.87	1.5 ± 1.6	0.08 ± 0.37	1.38 ± 0.99[a]	0.55 ± 0.21	–0.12 ± 0.70[a]
^{90}Sr (pCi/g dry weight)								
No. of Samples	4	4	14	4	5	1	2	---
Maximum[a]	0.0050 ± 0.0040	0.0220 ± 0.0020	0.0167 ± 0.0019	–0.0280 ± 0.0020	0.0130 ± 0.0030	---	–0.0080 ± 0.0020	---
Minimum[a]	–0.0340 ± 0.0040	–0.0240 ± 0.0030	–0.0330 ± 0.0030	–0.0730 ± 0.0050	–0.0350 ± 0.0040	---	–0.0164 ± 0.0017	---
Average ± s	–0.016 ± 0.021	–0.004 ± 0.019	–0.011 ± 0.013	–0.051 ± 0.024	–0.017 ± 0.018	–0.0070 ± 0.0030[a]	–0.0122 ± 0.0059	---

[a]Counting uncertainty.

TABLE XV

RADIONUCLIDE CONTENT OF FISH

Location	Abiquiu, El Vado, and Heron Reservoirs				Cochiti Reservoir			
	Bottom Feeder[b]	Bottom Feeder (gut)[c]	Higher Level[b]	Higher Level (gut)[c]	Bottom Feeder[b]	Bottom Feeder (gut)[c]	Higher Level[b]	Higher Level (gut)[c]
Radionuclide:								
^{238}Pu (pCi/g dry weight)								
No. of Samples	16	12	5	4	8	8	4	3
Maximum[a]	0.0012 ± 0.0007	0.00023 ± 0.00013	0.00006 ± 0.00010	0.00016 ± 0.00018	0.0002 ± 0.0002	0.0020 ± 0.0060	0.0011 ± 0.0003	0.0018 ± 0.0014
Minimum[a]	–0.00016 ± 0.00009	–0.00016 ± 0.00021	–0.00005 ± 0.00002	0.00005 ± 0.00009	–0.0001 ± 0.0002	0.00002 ± 0.00004	–0.00012 ± 0.00008	–0.00002 ± 0.00005
Average ± s	0.00011 ± 0.00031	0.00008 ± 0.00010	0.000005 ± 0.000044	0.00012 ± 0.00005	0.00006 ± 0.00010	0.00060 ± 0.00068	–0.0027 ± 0.0062	0.0006 ± 0.0010
^{239}Pu (pCi/g dry weight)								
No. of Samples	16	12	5	4	8	8	4	3
Maximum[a]	0.00063 ± 0.00016	0.00092 ± 0.00050	0.00017 ± 0.00013	0.00026 ± 0.00021	0.00015 ± 0.00010	0.0030 ± 0.0030	0.0003 ± 0.0002	0.0050 ± 0.0020
Minimum[a]	–0.00009 ± 0.00008	0.00004 ± 0.00008	–0.00006 ± 0.00008	–0.00011 ± 0.00016	–0.0004 ± 0.0003	–0.0030 ± 0.0030	–0.00007 ± 0.00018	0.00002 ± 0.00007
Average ± s	0.00010 ± 0.00017	0.00029 ± 0.00029	0.000030 ± 0.000087	0.00008 ± 0.00015	–0.00009 ± 0.00021	–0.0001 ± 0.0018	0.00010 ± 0.00016	0.0017 ± 0.0029
Uranium (μg/g dry weight)								
No. of Samples	16	12	5	4	8	8	4	4
Maximum[a]	0.0224 ± 0.0022	0.354 ± 0.036	0.00441 ± 0.00059	0.0183 ± 0.0018	0.0219 ± 0.0034	1.14 ± 0.11	0.0139 ± 0.0056	1.21 ± 0.12
Minimum[a]	0.0000 ± 0.0016	0.0039 ± 0.0017	0.0000 ± 0.0003	0.00751 ± 0.00070	0.00423 ± 0.00045	0.0427 ± 0.0045	0.0000 ± 0.0036	0.0043 ± 0.0005
Average ± s	0.0100 ± 0.0064	0.14 ± 0.12	0.0027 ± 0.0016	0.0124 ± 0.0045	0.0130 ± 0.0066	0.33 ± 0.36	0.0063 ± 0.0061	0.41 ± 0.57
^{137}Cs (pCi/g dry weight)								
No. of Samples	16	12	5	4	8	8	4	3
Maximum[a]	0.43 ± 0.17	1.79 ± 0.51	0.35 ± 0.13	0.38 ± 0.18	0.32 ± 0.57	1.8 ± 1.2	0.16 ± 0.05	0.54 ± 0.67
Minimum[a]	–0.20 ± 0.17	–0.05 ± 0.16	0.044 ± 0.017	–0.043 ± 0.057	–0.12 ± 0.02	–0.62 ± 0.49	–0.13 ± 0.14	0.33 ± 0.16
Average ± s	0.16 ± 0.18	0.62 ± 0.63	0.17 ± 0.12	0.16 ± 0.18	0.13 ± 0.14	0.20 ± 0.74	0.05 308 ± 0.13	0.45 ± 0.11
^{90}Sr (pCi/g dry weight)								
No. of Samples	15	9	4	4	7	6	4	3
Maximum[a]	0.131 ± 0.009	0.0400 ± 0.0020	0.0290 ± 0.0020	0.0480 ± 0.0030	0.1240 ± 0.0060	0.0452 ± 0.0018	0.1150 ± 0.0050	0.0060 ± 0.0050
Minimum[a]	0.0032 ± 0.0015	0.0006 ± 0.0010	0.0004 ± 0.0005	0.0036 ± 0.0016	0.040 ± 0.030	–0.048 ± 0.005	0.014 ± 0.001	–0.042 ± 0.009
Average ± s	0.081 ± 0.043	0.017 ± 0.014	0.015 ± 0.012	0.025 ± 0.019	0.076 ± 0.028	0.009 ± 0.032	0.046 ± 0.046	–0.011 ± 0.027

[a]Counting uncertainty.
[b]Samples consisted of fish less digestive system (gut).
[c]Samples consisted of gut only.

areas and 14 from Cochiti. Mean values for samples from background areas and for samples from Cochiti were statistically indistinguishable.

Low levels of ^{137}Cs were detected in 13 of 60 samples analyzed. Results were scattered, with mean values from areas not influenced by Laboratory operations being slightly higher than those downstream from the Laboratory for three of four sample types.

Two samples, one from a background area and one from Cochiti, had detectable ^{238}Pu. Seven samples had detectable ^{239}Pu. Of these seven samples, three samples, all from bottom feeder meat were from background areas. The other four samples, which were all of fish gut, were from Cochiti. All detectable ^{238}Pu and ^{239}Pu concentrations were on the order of or less than the mean ^{238}Pu and ^{239}Pu levels found in sediments from background locations. Detection of plutonium in fish is expected,because plutonim is in the environment at low levels from worldwide fallout from nuclear weapons tests and atmospheric reentry and burnup of a satellite containing a ^{238}Pu power source. The impacts of these sources serve as background for the impacts of any potential Laboratory plutonium releases that would only affect Cochiti reservoir.

As expected, a large proportion of samples from both Cochiti and control areas (55 of 61 samples, or 90%) had detectable levels of uranium. Uranium is present naturally in the environment and is detectable in foodstuffs at trace levels similar to those found in this sampling. No statistically significant difference was found between uranium concentrations at Cochiti and at control locations.

d. Honey. Honey samples were analyzed for ^{3}H (tritiated water), ^{7}Be, ^{22}Na, ^{54}Mn, ^{57}Co, ^{83}Rb, ^{134}Cs, ^{137}Cs, and total U. Results are shown in Table E-XXIV. Also shown are analytical results from previous years for ^{3}H (tritiated water), ^{7}Be, ^{22}Na, ^{137}Cs, and total U.

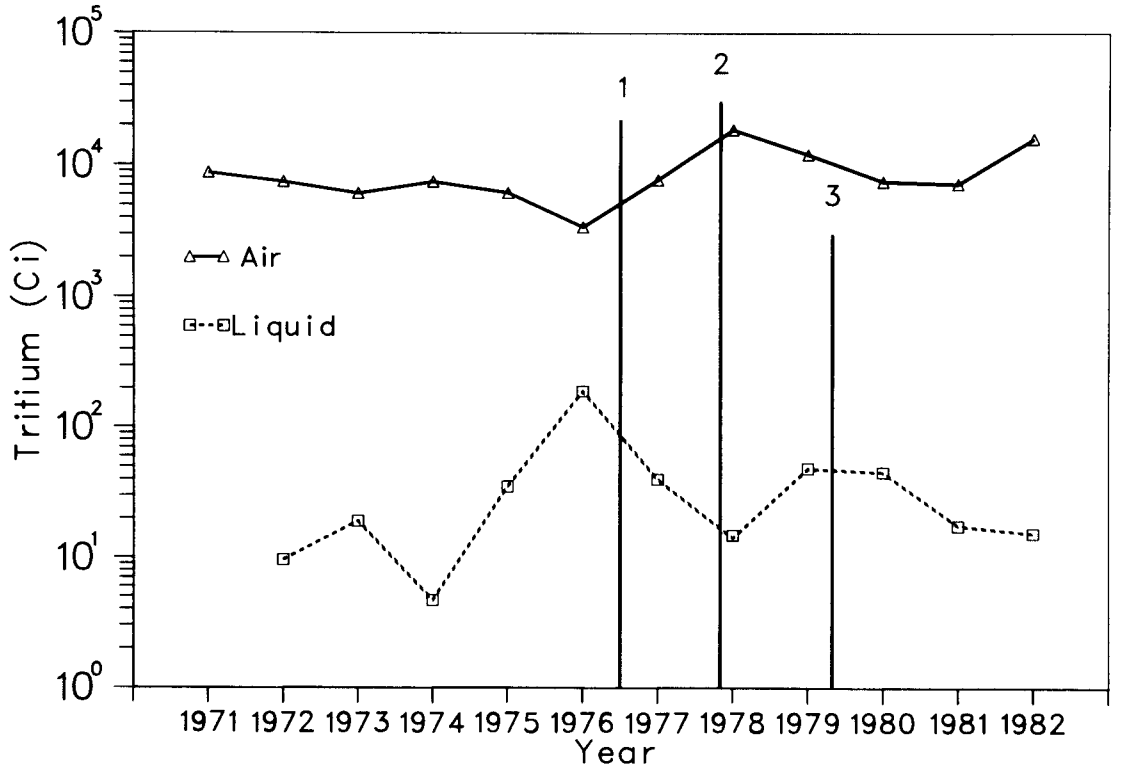
The honey sampling program serves as an indicator of biologically available radionuclides. It can be seen from Table E-XXIV that honey samples collected from onsite hives were generally higher in most radionuclides than the offsite honey samples from Chimayo, Barranca Mesa, and Pajarito Acres. The radiological doses associated with consumption of honey are discussed in Section III.D.

6. Radioactive Airborne Emissions and Liquid Effluents

Quantities of airborne radioactive emissions released from Laboratory operations in 1982 were lower for mixed fission products, phosphorus, and gaseous mixed activation products when compared to 1981. The emissions were higher for plutonium, uranium, tritium, argon, iodine, americium, and particulate/vapor activation products. The increases and decreases were due to changing programmatic activities and ventilation system improvements at various facilities at the Laboratory. Overall, the 1982 airborne radioactive emissions were about 25% lower (93 590 Ci less) than in 1981. Liquid effluents from two waste treatment plants contained radioactivity levels well below the Department of Energy's Controlled Area Concentration Guides.

Radioactive airborne emissions are discharged at the Laboratory from 88 stacks and liquid effluents are discharged from 2 industrial waste treatment plants and 1 sanitary sewage lagoon system. The airborne emissions consist principally of filtered ventilation exhausts from gloveboxes, experimental facilities, process facilities (such as liquid waste treatment plants), the research reactor at TA-2, and the linear particle accelerator at the Los Alamos Physics Facility. Releases of various isotopes from the Laboratory are detailed in Table E-I.

Quantities of airborne radioactivity released depend on the kinds of research programs conducted, so vary significantly from year to year (see Figs. 16-18 and Table VI). During 1982, tritium emissions were significantly higher at TA-33. The TA-33 tritium handling facility is quite old and a new facility will soon be



1 22,000 Ci accidental release July 15, 1976
2 30,800 Ci accidental release October 6, 1977
3 3,000 Ci accidental release May 4, 1979

Fig. 16. Summary of tritium releases (air and liquid).

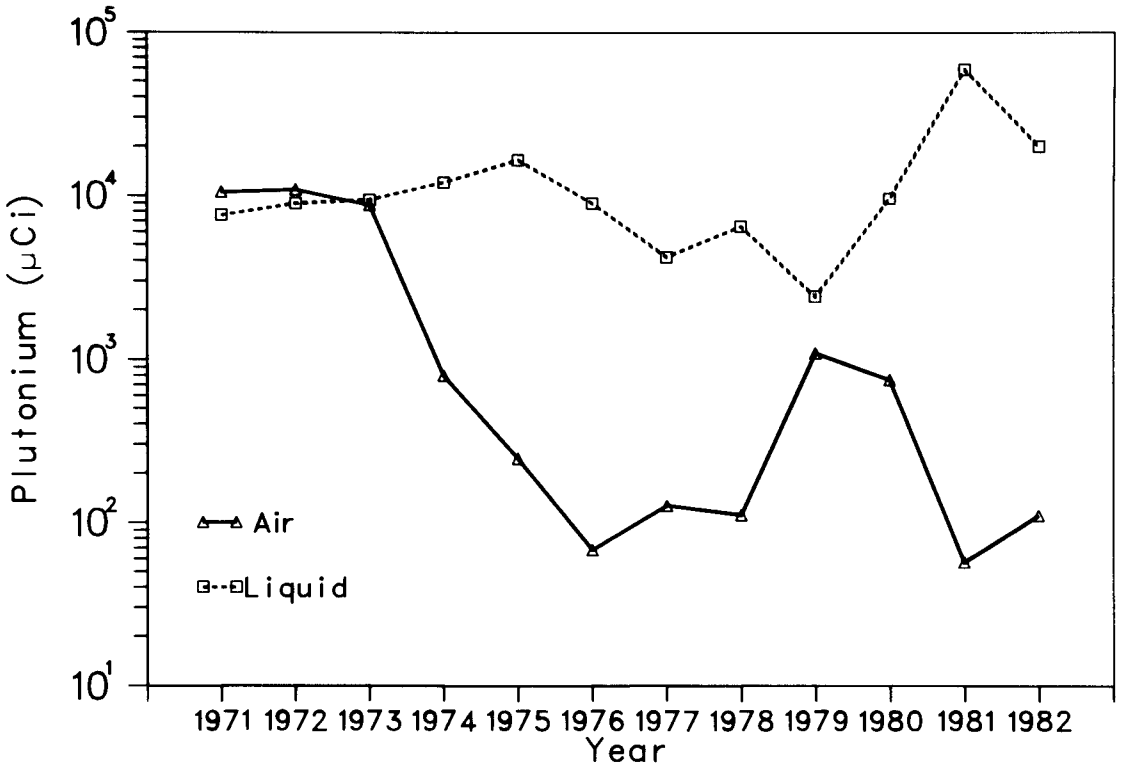


Fig. 17. Summary of plutonium releases (air and liquid).

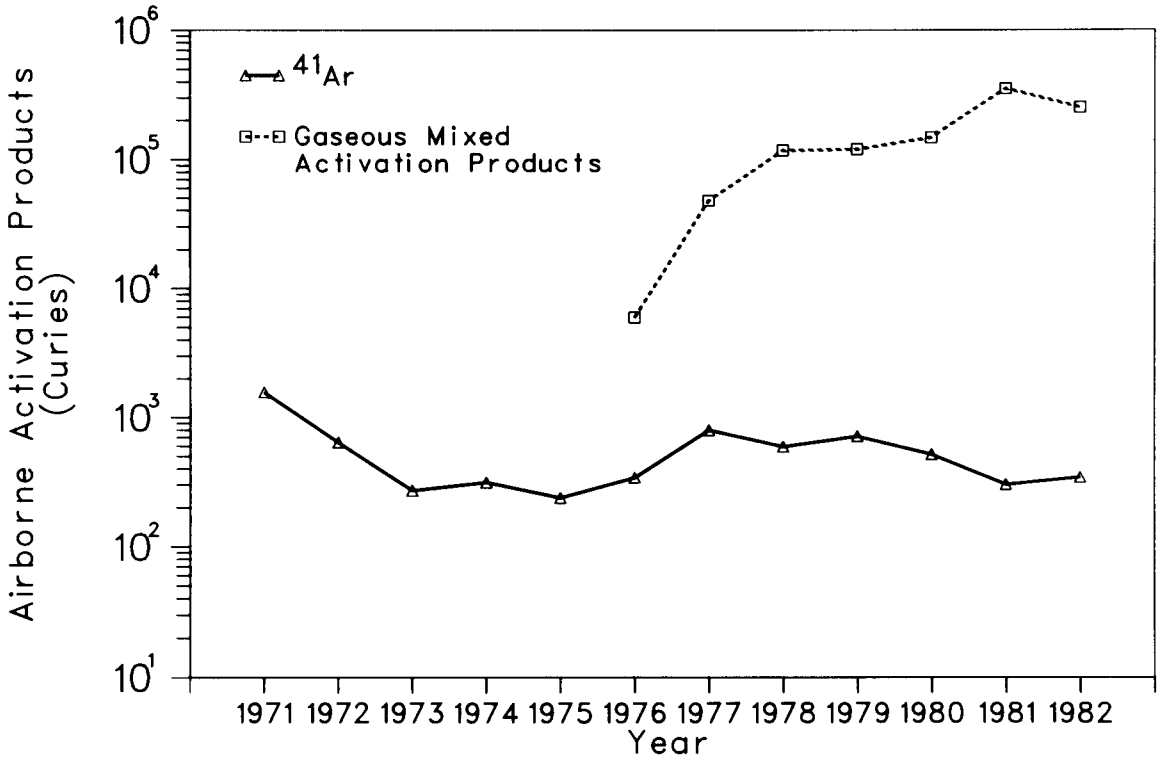


Fig. 18. Summary of ^{41}Ar and gaseous mixed activation product airborne emission releases.

constructed to house these tritium operations. The increase in ^{131}I emissions were due to system testing and renovations at the Chemistry-Metallurgical Research Facility. There was a large decrease in emissions of gaseous mixed activation products at the Los Alamos Meson Physics Facility. The emissions were down over 100 000 Ci during 1982 because of elimination of leaks in the cooling water system for the linear accelerator.

In addition to airborne releases from facilities, some depleted uranium (uranium consisting primarily of ^{238}U) is dispersed by experiments employing conventional high explosives. In 1982, about 1059 kg of depleted uranium were used in such experiments. Based on known isotopic composition of the depleted uranium, this mass is estimated to contain approximately 0.37 Ci of activity. Most debris from these experiments is deposited on the ground in the vicinity of the firing sites. Limited experimental information indicates that no more than about 10% of the depleted uranium becomes airborne. Approximate dispersion calculations indicate that resulting airborne concentrations would be in the same range as attributable to natural crustal-abundance uranium in resuspended dust. This theoretical evaluation is compatible with the concentrations of atmospheric uranium measured by the routine air samplig program (see Section IV.A.2). Estimates of nonradioactive releases from these experiments are discussed in Section IV.B.2.

Treated liquid effluents containing low levels of radioactivity are released from the Central Liquid Waste Treatment Plant (TA-50), a smaller plant serving a uranium processing facility (TA-21), and a sanitary sewage lagoon system serving the Los Alamos Meson Physics Facility. Detailed results of the effluent radioactivity monitoring are in Table VI, Table E-XXV, and Figs. 16, 17, and 19.

A total of 2.7×10^7 ℓ of effluent was discharged from the TA-53 sanitary lagoon system containing 0.17 Ci of ^{22}Na, 2.9 Ci of ^{7}Be, and 15 Ci of ^{3}H. The source of the radioactivity was activated water from beam-stop cooling systems. Samples of water, sediments, and transpirate from trees adjacent to the discharge from the lagoons have been collected this year and the results of this sampling program are discussed in Section VI.D.

Releases from the larger radioactive liquid waste treatment plant (TA-50) are discharged into a normally dry stream channel in Mortandad Canyon where surface

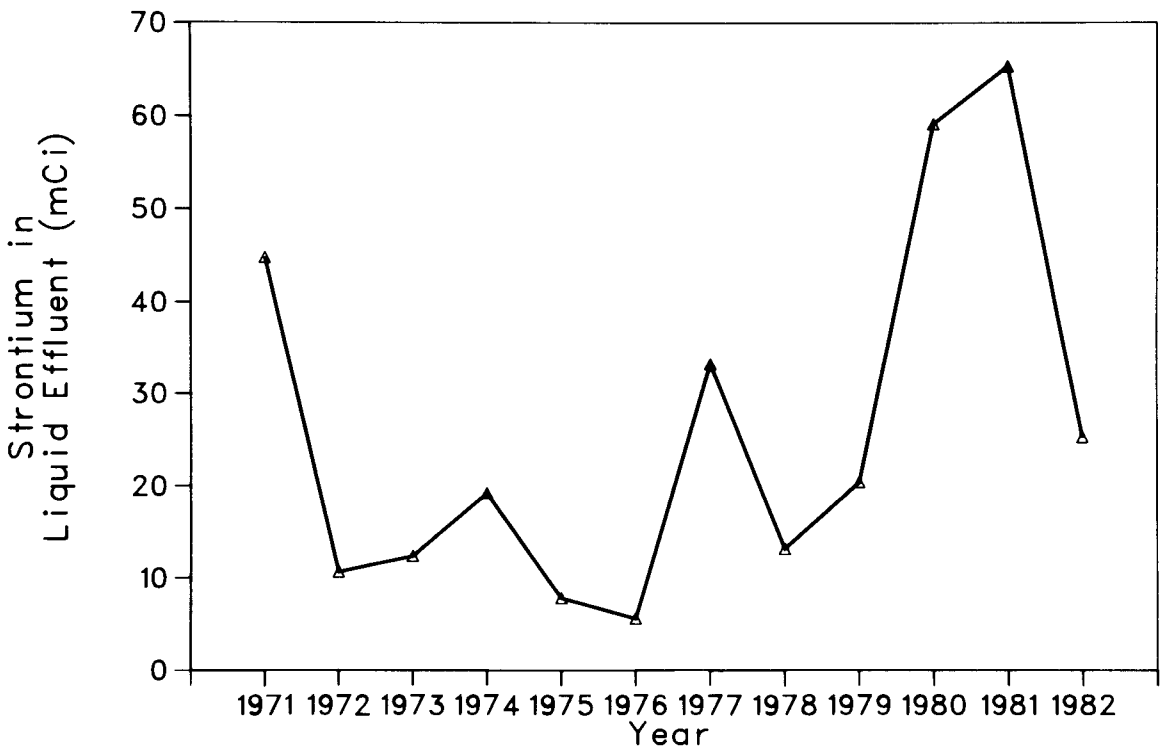


Fig. 19. Summary of strontium liquid effluent releases.

flow has not passed beyond the Laboratory boundary since before the plant began operation (see Fig. 2). Discharges from the smaller plant (TA-21) are into DP Canyon, a tributary of Los Alamos Canyon where runoff does at times flow past the boundary and transports some residual radioactivity adsorbed on sediments (see Fig. 2). Effluent from the Los Alamos Meson Physics Facility's sanitary lagoon system sinks into alluvium with the Laboratory's boundary (see Section VI.D).

7. Unplanned Releases

a. Industrial Waste Line Leak. On March 19, 1982, a section of industrial waste line serving the Radiochemistry Technical Area (TA-48) was found leaking. A limited volume of liquid from the waste line carrying fission products from radioactive materials laboratories flowed out of the security area of TA-48. It proceeded through a pipe, under a road along the north end of TA-48, and into Mortandad Canyon. All affected areas were well within Laboratory boundaries.

Eight soil samples from the contaminated areas and three soil samples from background locations were taken. The samples were analyzed for gross alpha, gross beta, and gamma activity. No sample had above-background levels of gross alpha activity greater than the lower detection limit of 25 pCi/g. However, gross beta levels were elevated, ranging from 124 to 4175 counts per minute, for samples from the contaminated areas. All background samples had fewer than 50 counts per minute of gross beta activity. The gamma spectra indicated the presence of fission products (^{54}Mn, ^{58}Co, ^{60}Co, ^{65}Zn, ^{88}Y, and ^{134}Cs). Two of these radionuclides, ^{134}Cs and ^{60}Co, have half-lives greater than a year.

A field survey was performed in the TA-48 site and affected area of Mortandad Canyon using portable radiation detection instruments. As expected, contaminated soil was found in the area of the leak and in the drainage areas into Mortandad Canyon. The contaminated zone extended about 15 m down the slope of the Canyon side, where the contaminated zone ended, apparently due to absorption of the liquid into the soil. Surveys extending from the point where the contamination ended down to the canyon floor detected only background levels of radiation.

The soil sampling and field surveys determined the areas and degree of soil contamination and radionuclides

involved. On the basis of these results, the affected soil from the areas along both sides of the road north of TA-48 were removed (down to bedrock) up to the edge of Mortandad Canyon and replaced with clean soil. Radiological surveys of the exposed bedrock found no residual contamination. Soil samples taken after the area was restored registered background levels of gross alpha and gross beta activity.

b. Tritium Release at the Van de Graaff Facility. On March 24, 1982, about 10 Ci of tritium leaked from a pump in the Van de Graaff Facility (TA-3) and into a room, setting off room air tritium monitors. Approximately 80% of this tritium was released directly from this room between 10:30 and 11:30 a.m.; the remainder was released through a 10-m high vent at 4:00 p.m. The tritium was believed to be almost entirely in gaseous form as HT.

Radiological doses to the public resulting from the release were estimated using meteorological modeling and tritium air sampling results. Samples from five air samplers from the Laboratory's routine air sampling network were analyzed for tritium. These samples were of tritiated water vapor (HTO), not of gaseous tritium (HT).

The maximum dose, which occurred approximately 50 m downwind of the morning release point, was 0.4 mrem to the whole body, or 0.08% of the Radiation Protection Standard for members of the public (500 mrem/yr for whole body radiation). The highest dose occurring offsite (on West Jemez Road) was 0.003 mrem to the whole body, 0.006% of the Radiation Protection Standard. These doses were estimated using meteorological modeling.

The dose associated with the highest measured tritium in air concentration (at Station 5, Arkansas Avenue) was 0.0044 mrem, or 0.0009% of the Radiation Protection Standard. Since this station was farthest from the release point of any station sampled and since meteorological analysis indicated this station was out of the zone principally affected by the release, it is probably due to the commonly observed fluctuations of tritium in air concentrations. All other doses calculated from measured tritium in air concentrations were lower than 0.0044 mrem.

c. Cooling Water Release at Omega Site. On October 26, 1982, a release of about 1100 ℓ of secondary cooling water occurred from the nuclear research reactor at Omega Site (TA-2). The released cooling water contained activation products that generally have short half-lives (an hour or less) and tritium (half-life is 12.3 yr).

The release occurred over about a 30-min period at a rate of about 40 ℓpm and was into Los Alamos Canyon, which is a tributary to the Rio Grande. Stream flow at the reactor site was estimated at 750 ℓpm at the time of the release. Consequently, the released cooling water was diluted about 20 to 1. Stream flow in Los Alamos Canyon did not reach State Road 4 (SR-4 is the Laboratory boundary; see Fig. 1). The Rio Grande lies about 6.4 km east of SR-4.

A total of 25 surface water, shallow ground water in the alluvium, and sediment samples were collected for analysis (gross alpha, gross beta, gamma, and tritium) upstream and downstream from Omega Site on October 27 and November 4, 1982. No radioactivity in any of the samples was at concentrations that could be attributed to the secondary cooling water release.

B. Chemical Constituents

1. Chemical Quality of Surface Waters

Chemical analyses of surface and ground waters from regional, perimeter, and onsite noneffluent release areas varied slightly from previous years. However, these variations in concentrations were within the normal range of seasonal fluctuations. Chemical quality of water from the municipal supply for the Laboratory and community meets standards set by the Environmental Protection Agency. Analyses of samples from onsite effluent release areas indicated that some constituents were higher than in naturally occurring waters. However, these waters are not a source of municipal, industrial, or agricultural supply.

a. Regional and Perimeter Surface and Ground Waters. Regional and perimeter surface and ground waters are sampled at the same locations as are used for radioactivity monitoring (Table E-X). Surface waters are sampled at 6 regional stations, 6 perimeter stations, and 25 stations in White Rock Canyon (Figs. 12 and 13). Maximum concentrations for five parameters are in Table XVI. Maximum concentrations are compared to drinking water standards for reference, even though the waters are not used for municipal or industrial supply. Individual analyses from the regional perimeter, and White Rock stations are presented in Tables E-XI, E-XII, and E-XIII, respectively. (See Appendix B.3 for methods of collection, analyses, and reporting of water data.)

The chemical quality of surface water varies at given stations during a year because of dilution of base flow with runoff from precipitation. There has been no significant change in water quality from previous years' analyses.

b. Onsite Surface and Ground Waters. Water samples are collected from three surface water stations and seven wells completed in the main aquifer (Table E-X). Maximum concentrations for selected constituents are in Table XVI. They are located in onsite areas that do not receive industrial effluents (Fig. 13). Detailed results of analyses are given in Table E-XIV. Detailed chemical data from onsite effluent release areas and water supply wells are shown in Tables E-XV through E-XIX. Water quality at the surface water stations varies slightly as base flow is diluted with varying amounts of storm runoff. The quality of surface and ground waters has not changed significantly from previous years' analyses.

Maximum concentrations of selected constituents found in each canyon are summarized in Table XVI. Tables E-XV through E-XVIII detail individual chemical quality analyses of surface and ground waters from 36 stations in canyons that receive sanitary and/or industrial effluent (Fig. 13, Table E-X). Detailed chemical analyses showing 26 chemical and metal ions from two stations in each of the four effluent release areas are shown in Table E-XXVI. Additional chemical quality of surface and ground waters from miscellaneous areas are in Table E-XXVII.

Acid-Pueblo Canyon received industrial effluents from 1943 to 1964. Currently, it receives treated sanitary effluents, which are now the major part of the flow. The effluents are from a Los Alamos County operated plant. Sandia Canyon receives cooling tower blowdown and some treated sanitary effluents. DP-Los Alamos and Mortandad Canyons receive treated industrial effluents that contain some radionuclides and residual chemicals used in the waste treatment processes. The high total dissolved solids (TDS) and chlorides result from effluents released into each of these canyons. The maximum concentration of chloride occurs in Sandia Canyon; fluoride occurs in Mortandad Canyon. All of these concentrations were above drinking water standards. However, these onsite waters are not a source of municipal, industrial, or agricultural supply. Maximum concentrations occurred near effluent outfalls. The chemical quality of the water improves downgradient from the outfalls. Surface flow to the Rio Grande in these canyons occurs only during periods of heavy precipitation of spring snowmelt.

TABLE XVI

MAXIMUM CHEMICAL CONCENTRATIONS IN SURFACE AND GROUND WATERS

	Number of Stations	mg/ℓ				
		Cℓ	F	NO_3	TDS	pH
Standard[a]		250	2.0	45	1000	6.5 - 8.5
Offsite Stations						
Regional Stations	6	44	0.6	0.9	334	8.2
Perimeter Stations	6	11	0.5	7.5	251	7.7
White Rock Canyon	25	47	1.3	34	460	8.5
Summary:						
Maximum Concentration		47	1.3	34	460	8.5
Maximum Concentration as Per Cent of Standard		19	65	76	46	100
Onsite Stations						
Noneffluent Areas	10	92	1.9	390	345	9.7
Effluent Release Areas						
Acid-Pueblo Canyon	8	123	1.2	76	395	8.1
DP-Los Alamos	8	240	18.5	124	1160	8.2
Sandia	3	187	1.9	7.5	868	7.8
Mortandad	7	45	7.5	650	1207	10.5
Summary:						
Maximum Concentration		187	18.5	650	1207	10.5
Maximum Concentration as Per Cent of Standard		75	925	166	120	123

[a]References 21 and 22.

c. Water Supply. Municipal and industrial water supplies for the Laboratory and community are sampled at 16 deep wells, 1 gallery (an underground collection basin for spring discharges), 5 stations in the distribution system, and at Bandelier National Monument (Table E-X, Fig. 13). Water at Bandelier is from the Los Alamos system. Also shown as part of the distribution system is Fenton Hill (TA-57), which has its own supply well. The Fenton Hill site is located about 30 km west of Los Alamos. Appendix A gives federal and state standards and criteria for municipal water supplies. Maximum concentrations of chemical constituents from well, gallery, and distribution system stations are compared to standards in Table XVII. Detailed analyses are in Table E-XIX.

The concentration of fluoride in water from Well LA-1B was 2.6 mg/ℓ, which exceeds the standards[21] (Table XVII). Iron concentrations (0.325 mg/ℓ) in water from the gallery in Water Canyon exceed the secondary standards. However, mixing of water from the other wells reduces concentrations at points of use to levels that are within standards. Water from all sources, wells, and the gallery is basic with pH ranging from 7.5 to 8.6 (average of 8.1). In the distribution system the pH

TABLE XVII

MAXIMUM CHEMICAL CONCENTRATIONS IN WATER SUPPLY AND DISTRIBUTION
(analyses in mg/ℓ)

Inorganic Chemical Contaminant	Standard	Supply: Well and Gallery	Supply: Per Cent of Standard	Distribution: Los Alamos Bandelier TA-57	Distribution: Per Cent of Standard
	Primary[a]				
Ag	0.05	<0.0005	<1	<0.0005	<1
As	0.05	0.048	96	0.019	38
Bd	1.0	0.09	9	0.09	9
Cd	0.01	<0.001	<10	<0.001	<10
Cr	0.05	0.022	44	0.040	80
F	2.0	2.6	130	1.2	60
Hg	0.002	<0.0002	<10	<0.0002	<10
NO_3	45	7.6	17	2.1	5
Pb	0.05	0.005	10	0.003	6
Se	0.01	<0.003	<30	<0.003	<30
	Secondary[b]				
Cℓ	250	16	6	41	16
Cu	1.0	0.013	1	0.020	2
Fe	0.3	0.325	108	0.056	19
Mn	0.05	0.005	10	<0.002	<4
SO_4	250	27	10	10	4
Zn	5.0	0.12	2	0.91	18
TDS	500	408	82	274	54
pH	6.5 - 8.5	8.6	101	8.5	100

[a]Reference 21.
[b]Reference 22.

ranged from 7.5 to 8.5 (average of 8.2). In the distribution system the pH is at or within standards (Table XVII). Comparison of quality of water in the distribution system at Los Alamos, Bandelier National Monument, and Fenton Hill with the Environmental Protection Agency's standards shows that the two systems (Los Alamos and Fenton Hill) are in compliance.

Water from Well LA-6 is not used as part of the water supply for Los Alamos. The water from the well contains excessive amounts of arsenic that are 3.7 times the standard. The water cannot be mixed with water from other wells to reduce the concentrations below the standards.

2. Nonradioactive Airborne Emissions and Liquid Effluents

Nonradioactive airborne emissions from the beryllium fabrication shop, gasoline storage and combustion, power plant, waste explosive burning, and dynamic testing did not result in any measurable or theoretically calculable degradation of air quality.

A single National Pollutant Discharge Elimination System permit covers nonradioactive liquid effluents from 103 industrial discharge points and 11 sanitary treatment facilities. This year 8 of 11 sanitary sewage treatment facilities exceeded one or more of the National Pollutant Discharge Elimination System permit limits (excluding flow rate limitations) in one or more months. Fewer than 6% of all samples from the industrial outfalls exceeded National Pollutant Discharge Elimination System permit limits.

a. Particulate Air Quality. Airborne particulate concentrations in the Los Alamos and White Rock areas are routinely measured by the New Mexico State Environmental Improvement Division. The highest 24 h averages and annual averages are compared to the New Mexico Ambient Air Quality Standards for particulates in Table XVIII. Table E-XXVIII summarizes these data for 1982. The annual geometric means for Los Alamos and White Rock are well within state standards. Although true 7-day and 30-day averages cannot be calculated, there is no indication that they would exceed state standards. In 1982 the annual geometric mean of 48 $\mu g/m^3$ for Los Alamos was relatively higher than previous years. The highest previous annual geometric mean was 38 $\mu g/m^3$

b. Airborne Emissions. Airborne emission sources at the Laboratory that are routinely assayed include the beryllium shop, gasoline storage and combustion, the TA-3 power plant, gas and volatile chemical usage, waste explosive burning, and dynamic testing operations. These sources are discussed separately in the following paragraphs.

Beryllium concentrations in stack gases from the beryllium shop during 1982 ranged from 0.001 to 0.043 $\mu g/m^3$. The state ambient air quality standard for beryllium is 0.01 $\mu g/m^3$, as a 30-day average. Although the stack gas concentration can intermittently exceed this value, dispersion of the gas upon discharge reduces the ambient concentration to below the state standard. Total beryllium emissions for the year were about 13.6 mg.

TABLE XVIII

SUMMARY OF ATMOSPHERIC PARTICULATE CONCENTRATIONS IN LOS ALAMOS AND WHITE ROCK DURING 1982

	National Secondary and New Mexico Ambient Air Quality Standards for Particulates ($\mu g/m^3$)	Los Alamos ($\mu g/m^3$)	White Rock ($\mu g/m^3$)
Maximum 24 h average	150	122	135
Maximum 7 day average	110	---	---
Maximum 30 day average	90	---	---
Annual geometric mean	60	48	37

This is considerably higher than in 1980 or 1981, when emissions were 2 to 5 mg. Prior to 1980, emissions of 15 to 20 mg per year were usual. The emissions were higher this year because of increased use of the Beryllium Fabrication Shop.

A large fleet of cars and trucks is maintained for the Laboratory complex by the Zia Company. During fiscal year 1981, a total of 2.3×10^6 ℓ of gasoline were used by this fleet to cover 9.8×10^6 km. These figures are nearly identical to those for fiscal years 1980 and 1981.

Carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides, and particulates are emitted during vehicle operations. There also are gasoline evaporative losses associated with gasoline storage and vehicle refueling. By breaking down total gasoline usage among the size classes of vehicles and by applying the most appropriate Environmental Protection Agency emission factors[28,29] to these data, air emissions associated with maintenance and operation of the vehicle fleet were estimated (Table XIX). The emissions are up slightly from 1981.

The TA-3 power plant is fueled with natural gas and thus comes under state regulations for gas burning equipment. These regulations specify maximum allowable nitrogen oxide emissions, but also contain a provision exempting facilities that have a heat input of less than 1×10^{12} Btu/yr/unit. Heat inputs for the TA-3 power plant individual boilers during 1982 were 0.64×10^{12} Btu, 0.70×10^{12} Btu, 0.53×10^{12} Btu, respectively. Total heat input for the power plant was 1.. but inputs for the individual boilers were bel. 10^{12} Btu/yr exemption threshold.

Measured concentrations of nitrogen oxides (NO_x) .. the power plant stack gas ranged from 9 to 48 ppm and averaged 34 ppm, which is about 20% of the standard that would apply if the heat input threshold was exceeded. Sulfur dioxide (SO_2) analyses of the stack gas are not performed routinely, but the sulfur content of the natural gas fed to the boilers is so low that it precludes any significant SO_2 emissions. Table XX shows estimated total power plant emissions for 1982, based on Environmental Protection Agency emission factors[28] for natural gas burning facilities.

The Laboratory complex uses large quantities of various volatile chemicals and gases, some of which are released into the atmosphere by evaporation or exhaust. Using data from stock records, a table of patterns of chemical usage over past years has been compiled (Table E-XXIX). Data for 1982 were not available for this report.

During 1982 a total of 16 238 kg of high-explosive wastes was disposed of by open burning at the Laboratory. Estimates of emissions (Table XXI) were made by using data from experimental work carried out by Mason & Hanger-Silas Mason Co., Inc.[30] Open burning of high-explosive wastes is permitted by New Mexico Air Quality Control regulations.

Dynamic experiments employing conventional explosives are routinely conducted in certain test areas at the Laboratory and may contain quantities of potentially toxic metals, including beryllium, lead, and uranium.

TABLE XIX

ESTIMATES OF AIR POLLUTANT EMISSIONS ASSOCIATED WITH MAINTENANCE AND OPERATION OF THE VEHICLE FLEET

Pollutant	Estimated Amount (metric tons)	Change From 1980 (%)
Gasoline evaporative losses	6.9	+6.2
Carbon monoxide	357	+5.3
Hydrocarbons	16.7	+7.7
Nitrogen oxides	9.7	+3.2
Sulfur oxides	1.2	+9.1
Particulates, exhaust	0.7	0.0
Particulates, tires	1.3	+8.3

TABLE XX

ESTIMATES OF STACK GAS EMISSIONS FROM THE TA-3 POWER PLANT

Pollutant	Estimated Amount (metric tons)
Sulfur oxides	0.48
Hydrocarbons	0.80
Carbon monoxide	13.5
Particulates	8.0
Nitrogen oxides	193

TABLE XXI

ESTIMATED EMISSIONS FROM BURNING OF EXPLOSIVE WASTES

Pollutant	Estimated Amount (kg)
Carbon monoxide	127
Particulates	292
Nitrogen oxides	491

Some limited field experiments, based on aircraft sampling of debris clouds, provided information on the proportion of such materials aerosolized. This information was employed to prepare estimates of airborne concentrations at the Laboratory boundary based on the amounts of explosives used during 1982. The results are presented in Table E-XXX along with comparisons to applicable air quality regulations. The average concentrations of uranium, beryllium, and lead are all less than 0.008% of applicable standards.

During February of 1982 a partially full cylinder of fluorine was shot open at Area L because of a leaking valve that precluded handling in any other fashion. The exact amount of fluorine in the cylinder was unknown. Assuming a half-full cylinder (maximum possible content), dispersion modeling indicated that rather high instantaneous fluorine concentrations were possible within 1 km of Area L. However, visual observation of trees in the vicinity of Area L for several weeks after the release did not find any damage.

Juniper trees at Area L were damaged in August by fumes arising from aqueous decomposition of lithium hydride in disposal pits. Analysis of foliage from the damaged trees indicated lithium concentrations as high as 16 ppm. This is above the toxic limit established for other species of vegetation in controlled studies.

During the fall of 1982, several cylinders of potentially dangerous gases were disposed of at TA-36 by blowing them up with waste explosives. These cylinders were damaged or corroded to such an extent that compressed gas suppliers would not take them back, and movement for any great distance was unsafe. Disposal was contingent upon safe meteorological conditions and air monitoring of the initial shots indicated that the gases were thoroughly decomposed and/or dispersed.

c. Monitoring Rain for Chemical Constituents. In June of 1982, a National Atmospheric Deposition Program (NADP) rain gauging station was put into operation by the Los Alamos National Laboratory. The primary purpose of the NADP rain gauge network, which covers the entire United States, is to monitor for acid rain, but rain samples are analyzed for a variety of substances in addition to pH. The bucket is removed every week and sent to the Central Analytical Laboratory of the Illinois State Water Survey, where all NADP analyses are performed. Table XXII shows the data received to date for 1982.

d. Liquid Effluents. Nonradioactive liquid waste discharges are authorized by a new National Pollutant Discharge Elimination System (NPDES) permit number NM 0028355 issued by the Environmental Protection Agency effective September 25, 1981. For administrative reasons the permit was not implemented until April 1, 1982. The new NPDES permit authorizes discharges from 103 industrial outfalls in 10 categories and 11 domestic waste outfalls. Tables E-XXXI and E-XXXII summarize the effluent quality of the domestic and industrial outfalls. The delay from September 25, 1981, to April 1, 1982, in implementing the new permit was caused by a lack of resolution of certain issues regarding state certification by New Mexico.

In 1982 corrective action was taken to mitigate continued noncompliance at the Laboratory's steam plant. Construction of intermittent sand filters scheduled for 1982 completion at one of the domestic waste treatment facilities was delayed until 1983 because of harsh winter weather. The Environmental Protection Agency and the local area office of the Department of Energy (with Laboratory input) have been negotiating a Federal Facility Compliance Agreement that contains an abatement schedule concerning two domestic waste treatment facilities and seven industrial waste treatment facilities. The proposed compliance dates range from January 1983 to September 1989. The Federal Facility Compliance Agreement is scheduled to be signed in 1983.

The two radioactive waste treatment plants have the largest number of limits with which to comply, and those plants exceeded one or more limits in fewer than 1% of the samples taken. Details of the effluent quality from these two plants are given in Table E-XXV for nonradioactive (including several not regulated by the NPDES permit) and radioactive constituents.

TABLE XXII

1982 ACID RAIN GAUGE RESULTS
(all results in ppm)

Week in 1982	pH	Conductivity (μmho/cm)	Ca	Mg	K	Na	NH_4	NO_3	Cℓ	SO_4	PO_4
6/29 - 7/6	6.1	30.0	1.89	0.56	0.15	0.62	0.70	2.89	0.59	2.32	<0.008
7/6 - 7/13	5.1	16.9	0.70	0.09	0.06	0.08	0.27	1.63	0.17	1.90	<0.003
7/13 - 7/20	5.0	17.3	0.64	0.08	0.05	0.07	0.22	1.39	0.11	1.26	<0.003
7/20 - 8/17	4.8	12.8	0.31	0.03	0.02	0.02	0.23	1.58	0.08	1.35	<0.003
8/17 - 8/24	4.9	9.7	0.17	0.01	0.02	0.02	0.23	0.96	0.04	1.26	<0.003
8/24 - 9/7	---	---	---	---	---	---	---	---	---	---	---
9/7 - 9/14	5.0	8.0	0.26	0.03	0.02	0.04	0.19	0.87	0.08	1.18	<0.003
9/14 - 9/21	5.2	5.8	0.17	0.02	0.01	0.03	0.15	0.45	0.04	0.97	<0.003
9/21 - 9/28	4.1	53.4	0.54	0.12	0.46	0.61	<0.02	<0.02	0.14	0.81	<0.003
9/28 - 10/25	6.2	10.8	0.71	0.13	0.05	0.23	0.35	0.72	0.39	1.14	<0.003

C. Meteorology

1. Weather Summary

Weather during 1982 for Los Alamos was wet and cool. The year was in great contrast with the past few years when conditions were warm with normal or less than normal precipitation. Snowfall for the calendar year nearly set a record at about 100 in. Numerous heavy thunderstorms during summer brought heavy rains and some hail. The year was the wettest since 1969 and the coldest since 1976. The 1982 weather is summarized in Fig. 20, Table E-XXXIII, and Table E-XXXIV.

The year began with a 10-in. snowstorm on New Year's Day. January had more than 19 in. of snowfall. However, February had more snow with a total of 36 in. A snowstorm on the 4th dumped 19 in. of snow and paralyzed the Los Alamos area. Over 6 in. of snow fell on the 11th. Low temperature records were set on the 5th and 6th with the heavy snow cover. The mercury rose into the 60s for three consecutive days, however, starting on the 20th. March was free of big snows, but it was rather wet. The storm track moved well north of Los Alamos in April, allowing a respite from heavy precipitation. Typical strong, springtime winds blew on several days with a maximum wind gust of 61 mph occurring on the 1st.

The heavy precipitation returned in May with almost 2 in. of rain. Much of this precipitation fell on the 5th (0.8 in.) when several inches of snow fell on the north side of Los Alamos and the Jemez Mountains. An upper air ridge formed over the southern United States in June causing generally dry and pleasant conditions. There were, however, heavy thunderstorms nearby during the month. For instance, White Rock and the eastern area of Los Alamos had over a half inch of rain and slight hail damage on June 20.

A strong monsoon circulation developed after the first week of July and continued through much of September. Heavy rains fell through this period. Heavy thunderstorms on July 11 produced 3 in. of hail near the airport causing State Road 4 to be closed temporarily. Thundershowers became even more prevalent in August, especially on the north side of Los Alamos. Rainfall totals of 8 in. were recorded in August in the Western and Barranca Mesa areas of Los Alamos with 4.5 in. falling at the Occupational Health Laboratory (TA-59). Heavy thunderstorms developed over the Jemez Mountains and were carried by a persistent weak south-southwesterly wind over the north part of Los Alamos. Another 2.67 in. of rain fell in September at the Occupational Health Laboratory.

A drying trend occurred in October. However, an early snowstorm and cold wave resulted in 5 in. of snow

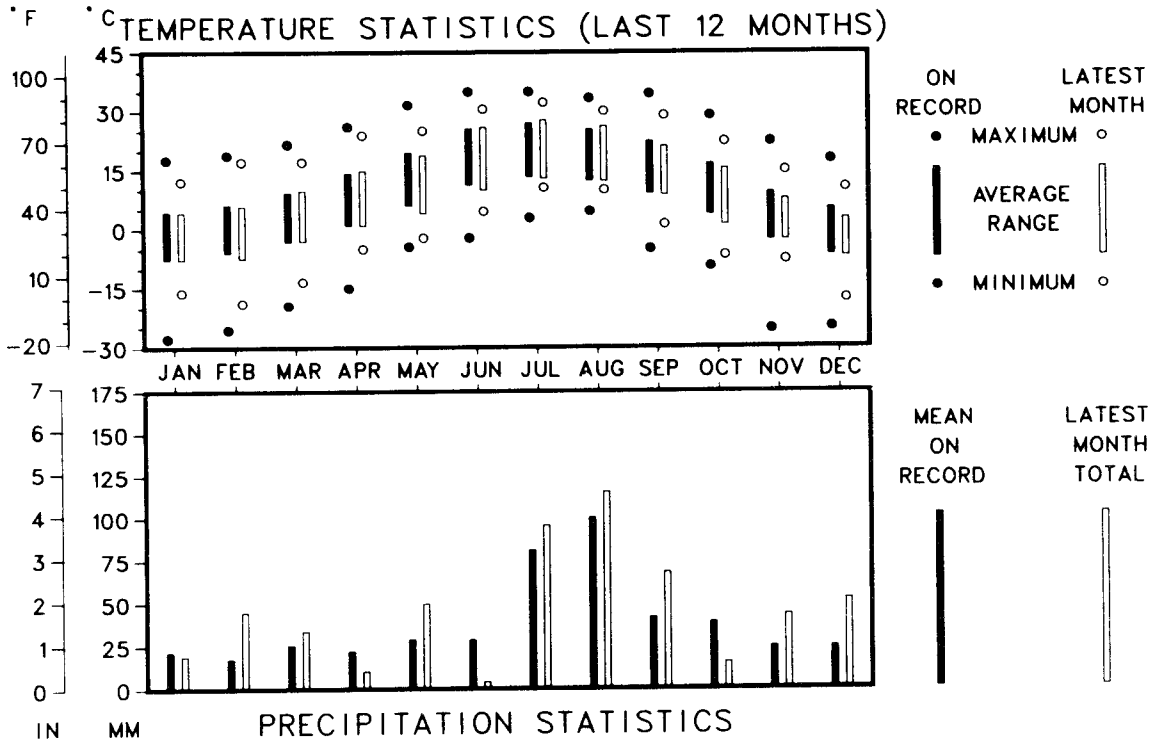


Fig. 20. Summary of 1982 weather in Los Alamos (data from Occupational Health Laboratory, OHL, TA-59).

on the 11th and 12th, and record-breaking temperatures in the 20's on the 9th, 10th, and 13th. Precipitation was again above normal in November, however, less than 4 in. of snow fell. Heavy precipitation continued into December with over 2 in. of precipitation and over 24 in. of snow. A snowstorm from the 8th to the 10th produced nearly a foot of snow. The temperature dipped to 0°F on the 29th, setting a new daily low record.

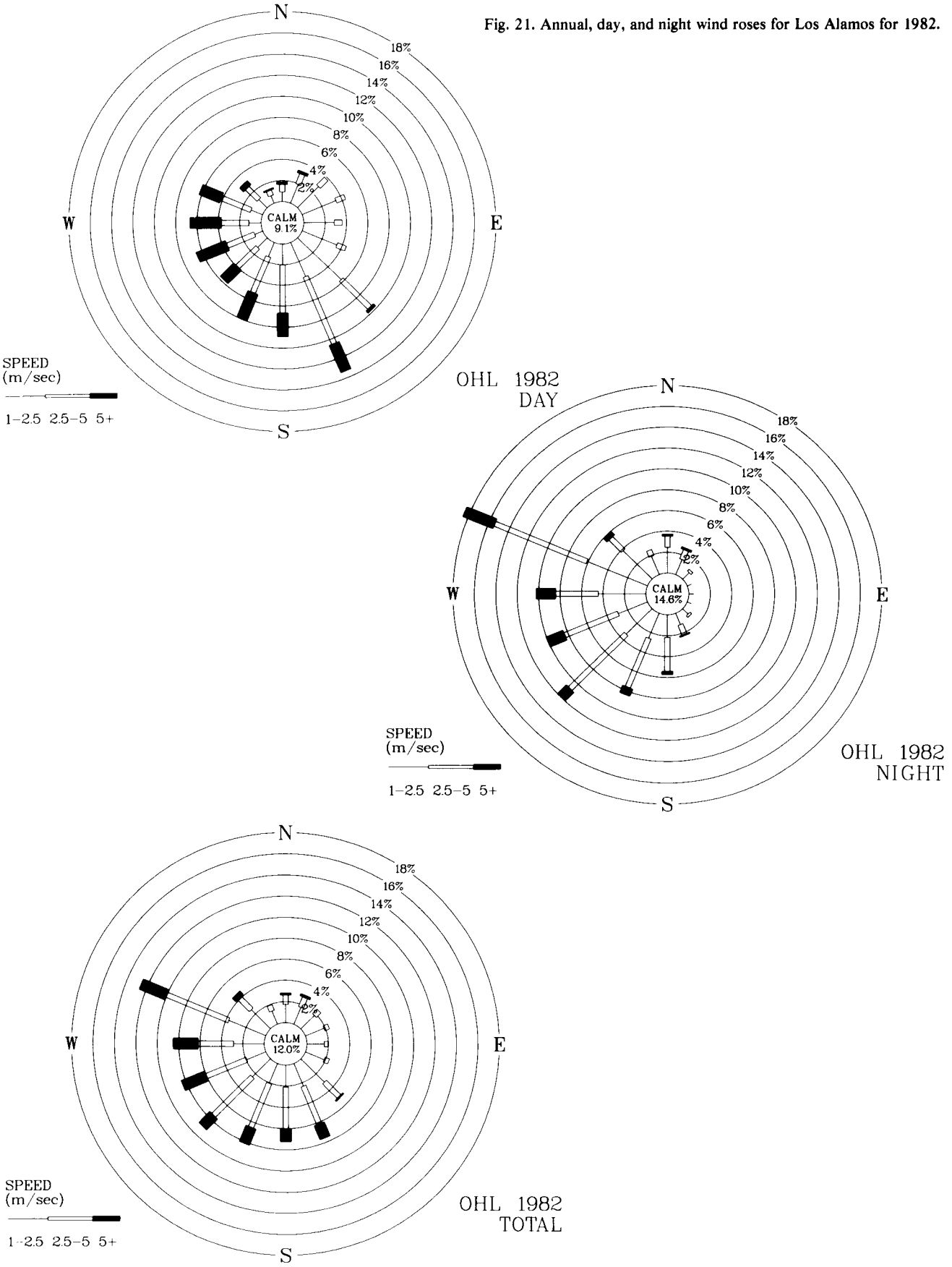
2. Wind Roses

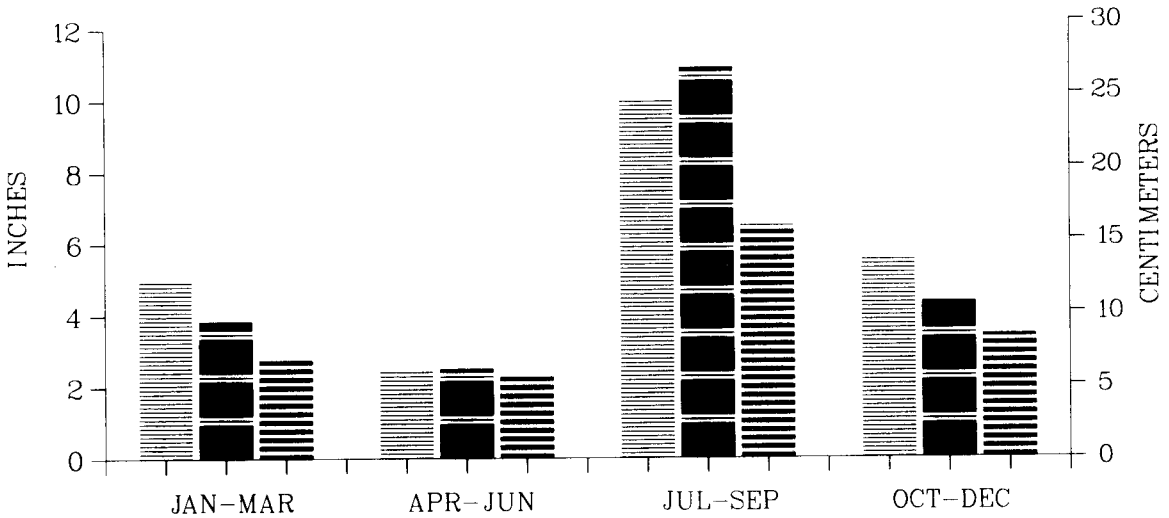
The 1982 wind speed and direction measured at the Occupational Health Laboratory (OHL, TA-59) are plotted in wind roses (see Fig. 21). A wind rose is a circle from the center of which emanate lines representing the direction *from* which the wind blows. The length of each line is proportional to the frequency of the wind speed interval from that particular direction. Each direction is one of the 16 major compass points (N, NNE, etc.) and is centered on a 22.5° sector of the circle. The frequency of the calm winds, defined as those having wind speed of less than 1 m/sec and no direction, is given in the circle's center.

The OHL wind data were measured at a height of 23 m with over 97% data recovery for 1982. The wind roses in Fig. 21 include an annual summary for 1982 and summaries for daytime and nighttime hours. Daylight hours were defined as the hours when measured solar insolation was greater than 0.01 langleys/min. Los Alamos is a generally light wind site with an annual average wind speed of 2.9 m/sec. Only 14% of wind speeds in 1982 were greater than 5 m/sec, while 35% were less than 2.5 m/sec.

The distribution of wind direction reflects (1) the location of Los Alamos on the southern side of the midlatitude westerlies, and (2) the northwest-southeast slope of the Jemez Mountains and Pajarito Plateau. Predominance of winds from NW to SW is produced by "westerlies," which are often as far south as New Mexico. The slope of the terrain produces a distinct daily pattern under weak atmospheric pressure gradients. At night, drainage winds (less than 2.5 m/sec) flow down from the Jemez Mountains out of the NW and WNW. During the day, light upslope winds come up out of the SE to SSE.

Fig. 21. Annual, day, and night wind roses for Los Alamos for 1982.





	ELEV. (m)	TOTAL (in.)
S-SITE (TA-16)	3019	23.10
OHL (TA-59)	2903	21.67
WHITE ROCK	2509	15.00

Fig. 22. Survey of 1982 precipitation at three sites at the Laboratory.

3. Rainfall Summary

Above-normal amounts of precipitation fell on the Los Alamos area in 1982. Figure 22 shows 1982 quarterly and annual precipitation for three sites in Los Alamos County. See Figs. 3 and 5 for locations of the sites. Note that precipitation generally increases with elevation for the three sites. The exception is the third quarter (July-September) when OHL (TA-59) received more rain from thundershowers than did S-Site (TA-16). All quarters show above-normal rainfall at all sites, except during the second quarter (April-June), when only about 2 in. of precipitation fell at all three sites.

V. ENVIRONMENTAL PROTECTION PROGRAMS AT LOS ALAMOS

A. Laboratory Environmental Review Committee

The Laboratory has a Laboratory Environmental Review Committee to provide a critical management overview of environmental concerns. The Laboratory Environmental Review Committee membership consists of representatives from the Associate Director for Technical Support, the Legal Affairs Office, and the Engineering, Budget, and Health Divisions. The Laboratory Environmental Review Committee has responsibility to review environmental documents prepared for the Department of Energy by the Laboratory. Additionally, the Laboratory Environmental Review Committee identifies and reviews items of environmental interest that are generated by Laboratory activities or that affect Laboratory programs and property.

An Environmental Evaluations Coordinator, based in the Environmental Surveillance Group, assists the Laboratory Environmental Review Committee by (a) coordinating with user groups, Health Division, and Engineering Division on environmental documentation and (b) providing input to construction or programmatic project design at the earliest stage for appropriate environmental decision making.

Projects that may require an environmental assessment or environmental impact statement are screened by the Environmental Evaluations Coordinator to determine the necessary preliminary environmental documentation. When needed, various resource people are identified by the Environmental Evaluations Coordinator to assist in preparation of the draft environmental document.

The Environmental Evaluations Coordinator also coordinates input on environmental matters for other official documents and the Quality Assurance program (see next section). The Environmental Evaluations Coordinator and the Environmental Surveillance Group's respresentative to the Quality Assurance program work with those responsible for construction and/or programmatic activities to assure that proper environmental considerations are made during project design and that they are implemented in the Quality Assurance program.

B. Quality Assurance

The Laboratory has a Quality Assurance program[31] for engineering, construction, modification, and maintenance of Department of Energy facilities and installation. The purpose of the program is not only to minimize the chance of deficiencies in construction, but also to improve the cost effectiveness of facility design, construction, and operation, and to protect the environment. The Quality Assurance program is implemented from inception of design through completion of construction by a project team approach. The project team consists of individuals from the Department of Energy's program division, Department of Energy's Albuquerque Operations and Los Alamos Area Offices, Laboratory operating group(s), Laboratory Engineering Divison, design contractor, inspection organization, and construction contractor.

Under the project team approach, each organization having responsibility for some facet of the project is likewise responsible for its respective aspects of the overall Quality Assurance program. For example, it is the inspection organization's responsibility to provide assurance that the structures, systems, and components have been constructed or fabricated in accordance with the approved drawings and specifications.

Laboratory representatives are responsible for coordinating reviews and comments from all groups with a vested interest in the project. In particular, the Environmental Surveillance Group reviews proposed new construction, maintenance activities, and modifications to existing facilities to minimize any environmental degradation. Consideration is given to the present condition of the site (soils, geology, ground water, surface water, air quality, archeology, flora, fauna, drainage features, etc.), environmental consequences of the proposed project (airborne emissions, liquid effluents, industrial waste, solid waste, noise levels, traffic patterns, etc.), and environmental impact assessment (air, water, land, visual, noise, odor, biota, etc.).

C. Archeological and Historical Protection

Protection of archeological and historical sites at the Laboratory (mandated by several Congressional Acts

and Executive Order 11593) is also part of the Environmental Evaluations Coordinator and Quality Assurance programs. A proposed location for a new facility is surveyed for archeological and historical features. If a feature is found, siting is adjusted to preserve it.

The Laboratory has a contract with the Museum of New Mexico to provide archeological surveys, make evaluations of archeologic or historic features, and provide professional expertise for cultural resource management. The Laboratory is currently drafting a Cultural Resources Management Plan to guide protection efforts.

A survey of more than 450 archeological sites at the Laboratory was made between March 1973 and July 1975. This survey of the pre-Columbian Indian ruins is summarized in a Laboratory report.[32] A further report summarizing excavations on the Laboratory between 1975 and 1978 was issued this year.[33] (No further excavations are anticipated pending completion of a Cultural Resource Management Plan.) These surveys are used during construction planning to avoid damage to archeologic or historic sites. Additional surveys of proposed construction sites are undertaken routinely.

Several unique pre-Columbian ruins were recommended for registration as national historic sites, and formal nomination procedures are underway. Registration will ensure their preservation for future generations by establishing formal responsibility for their protection. Nine new sites, both pre-Columbian and historic, were located this year and added to the inventory of sites.

Two public tours of archeological sites within the Laboratory's boundary were conducted in 1982. These tours allow the public to see archeological sites that are normally inaccessible because of security restrictions for the surrounding Laboratory land. This year the tours included an Indian ruin at TA-15 (a large plaza site of major research potential) and Tshirege (the largest pre-Columbian community on Pajarito Plateau). These tours were extremely popular, with more than 600 Laboratory employees and visitors participating in each of the 1982 tours.

VI. RELATED ENVIRONMENTAL STUDIES

The Environmental Sciences Group (LS-6) at the Laboratory conducts research and experimental studies under auspices of the Department of Energy. Some of the research programs conducted by LS-6 complement routine monitoring and research (see Appendix G for list of publicatins) conducted by the Environmental Surveillance Group (H-8) by providing a better understanding of the ecosystem surrounding the Laboratory in relation to its operations. Following are highlights of several of these research programs.

A. Environmental Assessment of Revising the Definition of Transuranic Wastes [L. J. Walker and W. R. Hansen (H-8)]

Transuranic (TRU) wastes containing fewer than 10 nanocuries of TRU per gram of waste (10 nCi/g) may presently be disposed of as low level wastes via Shallow Land Burial. Those TRU wastes exceeding 10 nCi/g must be segregated and stored in a retrievable manner for a minimum of 20 years. Currently, Los Alamos National Laboratory buries radioactive wastes at depths slightly greater than those normally considered as Shallow Land Burial.

The Department of Energy is considering redefining TRU wastes as those containing 100 nCi/g or more. For some TRU wastes, "Greater Confinement" may be a possible way to handle small volumes of special wastes. Greater Confinement denotes disposal of radioactive wastes by land burial at depths greater than Shallow Land Burial, but less than the depths of a geological repository. It also includes other selected technologies such as engineered improvements, greater fixation and immobilization, and decreased mobility of the waste forms.

The Laboratory's Environmental Surveillance Group was selected to:

1. environmentally assess the impact of changing of the limits of TRU waste from 10 to 100 nCi/g,
2. evaluate environmental considerations of Greater Confinement of TRU wastes under local conditions at Los Alamos, and
3. evaluate environmental and dose assessment methodologies used in preparation of the Draft Environmental Impact Statement on 10CFR61, "Licensing Requirements for Land Disposal of Radioactive Wastes," NUREG-0782, September 1981.

Among the results of this study were the following:

1. Deeper burial reduces surface interactions such as human and vegetative intrusion, and erosional effects. However, deeper burial may place wastes in closer proximity to ground water.
2. A paradox is created in that the more reliable a disposal system is, the less predictable are the failure mechanisms (because the system has been engineered to prevent or minimize failures).
3. Existing TRU inventories could be disposed of by Greater Confinement at Los Alamos without a high probability of release of the buried isotopes. However, members of the decay chains from the buried wastes (daughter products), including ^{234}U, ^{235}U, ^{231}Pa, and ^{226}Ra, could be released many years after burial. Over the course of the first few thousand years, the potential hazards are from the TRU wastes. However, in the time frame of a million years, potential hazards from the decay products become more dominant.
4. Additional studies are required to more adequately measure several of the critical parameters required in mathematical models used to predict movement through subterranean soil and ground water.

While Greater Confinement of TRU wastes by deeper burial is possible at Los Alamos, the availability of large land areas required for entry, turnaround, and exit of vehicles may be severely limited at Los Alamos. Under this concept, the burial pits would be deeper so that TRU wastes could be layered into the deepest part of the pits and then covered with subsequent layers of lower concentrated wastes. This would require a much longer pit in order to keep the slope at one end shallow enough to allow vehicular access.

B. Plutonium and Cesium in Soils from Stream Channels and Banks of Los Alamos Liquid Effluent-Receiving Areas [J. W. Nyhan, G. C. White, and G. Trujillo (LS-6)]

Stream channel sediments and adjacent bank soils found in three intermittent streams used for treated liquid effluent disposal at Los Alamos were sampled to determine the distribution of ^{238}Pu, $^{239+240}Pu$, and ^{137}Cs. Radionuclide concentrations and inventories were determined as functions of horizontal distances from the waste outfall and stream channel, samplng depth, a few

physiographic and hydrologic properties of each intensive study area, and the waste use history of three effluent-receiving areas.

Radionuclide concentrations in channel sediments generally decreased with distances up to 10 km from the outfalls, an important observation in waste management practices dealing with control of released contaminants. At sites receiving appreciable amounts of waste effluents, stream bank soils exhibited radionuclide concentrations that decreased with distances greater than 0.38 m from the stream channel and with sampling depths greater than 20-40 cm, probably due to the higher reactivity and lower permeability of these finer-textured soils (loams) relative to the coarser-textured channel sediments (sands).

Radionucide concentrations and inventories were also influenced by stream bank physiographic relationships: concentrations and total amounts of radionuclides were inversely related to bank height within the segment of the stream channel normally exposed to surface flows of effluent discharges and runoff events. Coefficients of variation of radionuclide inventory estimates in channel sediments ranged from 0.41 to 2.6, due largely to the variability in radionuclide concentrations at each site.

The fact that the three liquid effluent-receiving areas had different waste use histories allowed several observations to be made about the long-term deposition of environmental contaminants added to these typical southwestern intermittent streams. Eleven years after the last time Acid-Pueblo Canyon was used as an effluent-receiving area, the major inventory of radionuclides was not found in the stream channel soils, but rather in the soils in the adjacent stream banks. These soils thus appear to be a reservoir of radionuclides long after the effluent-receiving area was decommissioned. This observtion is easily explained by differences in residence times of channel sediments versus adjacent bank soils in watersheds no longer receiving waste discharges: sediments are directly exposed to violent runoff events, which sweep channel sediments and easily eroded bank soils rapidly downstream, eventually leaving less contaminated sediments and contaminated stable bank soils behind.

The other interesting observation related to waste use history had to do with ratios of plutonium isotopes found in stream bank soils and channel sediments relative to the ratios in current effluents. Channel sediments closely reflect the isotopic ratios of plutonium found in current effluents,[34] but bank soils contained plutonium ratios different from either of these types of samples. A period of time greater than 6 years (the period of time corresponding to the initiation of large ^{238}Pu disposals in Mortandad Canyon in 1968 up through our 1974 sample collection date) is evidently required before the plutonium in current liquid wastes is equilibrated with the bank soil plutonium in these intermittent streams. This is an important aspect to keep in mind for waste management clean-up practices, that is, contaminants in liquid wastes currently added to an intermittent stream could be removed by removing only channel sediments and only a small portion of the bank soils from these canyons.

C. Waste Disposal Area Surveillance [D. Mayfield and W. Hansen (H-8)]

Waste disposal area surveillance provides for collection and interpretation of data necessary to guide waste management decisions about potential radiological impacts of solid radioactive waste disposal on the environment. This surveillance program responds to DOE directives developed to assure consistency with federal environmental policy. The program is designed to identify radiological trends at nine radioactive disposal sites at Los Alamos. One of the sites is currently active and the remainder are closed or decommissioned.

Since sampling began in late 1979, surface soil and associated biota have been sampled. Additional sampling started in 1982 has begun to provide data about external penetrating radiatio at disposal site exclusion fences, and about potential subsurface migration of contaminants from Area G (TA-54) repositories.

The thermoluminescent dosimeter data for allsites is in Table XXIII. After deleting results near known sources of radiation (Stations C11, G7, and T3), and after grouping disposal areas that are in close proximity to one another (Areas T, A, and U; and B and V), the data were analyzed (Table XXIV). The results show that background radiation ranged from 27 mrem to about 40 mrem during the fourth quarter of 1982.[35] A few locations were marginally above site background radiation. They will be studied more intensively as Laboratory resources permit. Remedial action will be investigated for the sources near Stations C11, G7, and T3. None of these measurements extrapolated to a full year's exposure would exceed 30% of the permissible annual exposure to the maximally exposed individual of the general public (if that person were in full-time residence at the point of measurement).[36] Actual residence time at the fence is not likely to be more than a few hours.

TABLE XXIII

WASTE DISPOSAL AREAS: THERMOLUMINESCENT DOSIMETER MEASUREMENTS FOR THE 4th QUARTER OF 1982

Station	mrem (x ± 2s)	Station	mrem (x ± 2s)	Station	mrem (x ± 2s)
A1	32 ± 2	C4	34 ± 2	G12	36 ± 2
A2	31 ± 3	C5	37 ± 2	G13	35 ± 2
A3	33 ± 2	C6	37 ± 2	G14	42 ± 2
A4	30 ± 2	C7	35 ± 2	G15	36 ± 2
A5	31 ± 2	C8	32 ± 2	G16	37 ± 2
		C9	35 ± 2	G17	36 ± 2
B1	30 ± 2	C10	32 ± 2	G18	34 ± 2
B2	34 ± 2	C11	68 ± 2	G19	37 ± 2
B3	36 ± 2	C12	28 ± 2	G20	38 ± 2
B4	38 ± 2	C14	32 ± 2	G21	35 ± 2
B5	31 ± 2	C15	32 ± 2	G22	34 ± 2
B6	34 ± 2	C16	29 ± 2	G23	39 ± 2
B7	31 ± 2	C17	34 ± 2	G24	37 ± 2
B8	32 ± 2	C18	29 ± 2	G25	43 ± 2
B9	31 ± 2			G26	35 ± 2
B10	29 ± 2	E1	35 ± 2	G27	36 ± 2
B11	33 ± 2	E2	36 ± 3		
B12	32 ± 2	E3	36 ± 2	T1	33 ± 2
B13	36 ± 2	E4	40 ± 2	T2	33 ± 2
B14	31 ± 3			T3	56 ± 2
B15	33 ± 2	F1	28 ± 2	T4	32 ± 2
B16	37 ± 2	F2	27 ± 2	T5	35 ± 2
B17	37 ± 2			T6	31 ± 2
B18	37 ± 2	G1	35 ± 2	T7	32 ± 2
B19	36 ± 2	G2	37 ± 2		
B20	37 ± 2	G3	36 ± 2	U1	36 ± 2
B21	33 ± 2	G4	41 ± 2	U2	32 ± 2
B22	35 ± 2	G5	43 ± 2		
B23	31 ± 2	G6	36 ± 2	V1	30 ± 2
		G7	50 ± 2	V2	34 ± 2
C1	31 ± 2	G8	36 ± 2	V3	34 ± 2
C2	35 ± 2	G10	38 ± 2		
C3	38 ± 2	G11	35 ± 2		

TABLE XXIV

EXTERNAL PENETRATING RADIATION EXPOSURE AT WASTE DISPOSAL AREAS FOR THE 4th QUARTER OF 1982

Exposure (mrem)	Area(s)					
	T, A, & U	B & V	C	E	F	G
Maximum	56	38	68	40	28	50
Minimum	30	29	28	35	27	34
x ± 2s	34 ± 13	34 ± 5	35 ± 18	37 ± 4	28 ± 2	38 ± 7
Number of samples	14	26	17	4	2	26

Six subsurface monitoring holes were drilled at Area G in 1982. Tuff pulverized by the sampling auger was sampled at 91 cm depth and at 152 cm intervals thereafter to a depth of 1920 cm. Tuff samples were analyzed for ^{3}H, total U, and $^{239+240}Pu$. The empty holes have been capped to prevent intrusion of contaminants prior to backfilling in 1984. Moisture was collected from the sealed test hole atmosphere at a depth of about 13.7 m to indicate vapor phase ^{3}H concentrations, distinct from liquid phase ^{3}H concentrations in soil samples. Vapor phase ^{3}H for each of the holes is in Table XXV. Liquid phase ^{3}H results are not yet available. Total U results for holes H-2 and H-3 are given in Table XXVI. Liquid phase ^{3}H distributions correspond to ^{3}H distribution in surface soil and vegetation.[37] Total uranium measurements in holes H-2 and H-3 are typical of local soils and rock. The $^{239+240}Pu$ analyses have not been completed.

Surface reconnaissance results at Area G (TA-54) through 1981 also indicate migration of low level ^{3}H from waste repositories through soil to biota and to atmosphere by evapotranspiration. Results also show surface redistribution of low-level surface-deposited $^{239+240}Pu$ by wind. Results did not indicate uranium

TABLE XXV

VAPOR PHASE TRITIUM CONCENTRATIONS IN AREA G TEST HOLES AT ABOUT 14 m DEPTH

Location	mℓ H_2O	nCi/ℓ
H-1	16.5	1.0 ± 0.3
H-2	20.0	1.3 ± 0.3
H-3	18.6	0.4 ± 0.3
H-4	15.7	930 ± 14
H-5	17.6	9000 ± 130
H-6	10.9	11 000 ± 150

TABLE XXVI

TOTAL URANIUM IN AREA G TEST HOLES

Depth (cm)	Total Uranium (μg/g)	
	Hole 2	Hole 3
0 - 91	4.9 ± 0.5	4.9 ± 0.5
91 - 243	4.7 ± 0.5	3.9 ± 0.5
243 - 396	4.6 ± 0.5	5.0 ± 0.5
396 - 549	4.4 ± 0.5	4.6 ± 0.5
549 - 701	5.1 ± 0.5	4.9 ± 0.5
701 - 853	4.6 ± 0.5	4.8 ± 0.5
853 - 1006	4.0 ± 0.4	4.5 ± 0.5
1006 - 1158	4.6 ± 0.5	5.0 ± 0.5
1158 - 1311	4.7 ± 0.5	4.6 ± 0.5
1311 - 1463	4.6 ± 0.5	4.9 ± 0.5
1463 - 1615	5.6 ± 0.5	4.8 ± 0.5
1615 - 1768	7.2 ± 0.6	5.6 ± 0.5
1768 - 1920	6.0 ± 0.6	17.1 ± 1.0

concentrations greater than natural background in soil, vegetation, or air. Observed ^{3}H and $^{239+240}Pu$ concentrations were far below health protection standards or guidelines.[36,38]

D. Transport of Radionuclides from the LAMPF Lagoons [G. H. Brooks, Jr., R. W. Ferenbaugh, and W. D. Purtymun (H-8)]

Monitoring of the discharge water from the Los Alamos Meson Physics Facility (LAMPF; TA-53) lagoons continued during 1982 to determine the extent to which activation product radionuclides from the lagoons are transported along the canyon into which the discharge flows. Samples of water and sediment from the stream channel were sampled periodically at the locations shown in Fig. 23. Table E-XXXV shows a data summary for ^{7}Be, ^{3}H, and ^{22}Na for the years 1979-1982.

In 1982, water samples were collected at sample location 5 for the first time. Previously, no water ever was found below sample location 4. Both the water and sediment data show that there has been some radionuclide penetration as far as sample location 5, although most of the activity is above this location. This appears to represent a further penetration of radionuclides along the canyon than was previously found. The increase in radionuclide concentrations below sample location 1 reflects a change in stream channel morphology from a bare-soil trench to a marshy area that acts as a sediment and radionuclide trap.

An effort to determine the uptake and distribution of several radionuclides in the biota surrounding the waste-disposal ponds also was conducted during the summer of 1982. Samples included soil, water, vegetation, mice, and one prairie rattlesnake. Preliminary investigations showed that contamination directly around the pond was relatively nonexistent (believed to be due to the lack of an adequate transfer medium), so the study area was expanded to include the overflow stream that runs east of the ponds. Since the final statistical analysis is still in progress, the following are preliminary interpretations of the "raw" data. Once the final statistical analysis has been completed, definite conclusions can be drawn.

- The first element of interest is cesium (^{134}Cs). Cesium is known to accumulate as trophic levels increase, and the preliminary data confirm this relationship. However, the data here do not show the levels of accumulation seen in other studies. Reasons for the relatively low-accumulation factor could be the high per cent of clay in the soil (complexing the cesium), poor translocation in the plant itself, or the high-potassium content or alkalinity of the soil.
- The second element of interest is beryllium (^{7}Be). There tends to be little, if any, bioaccumulation of this element in the study area. The greatest concentrations tend to be in the soil, where high clay content soils (with high cation exchange capacities) are known to have a great holding capacity for beryllium. Of the little beryllium taken up by the plant, even less will reach the shoots and leaves as beryllium is poorly translocated. If the beryllium does reach the next trophic level, it is known to be

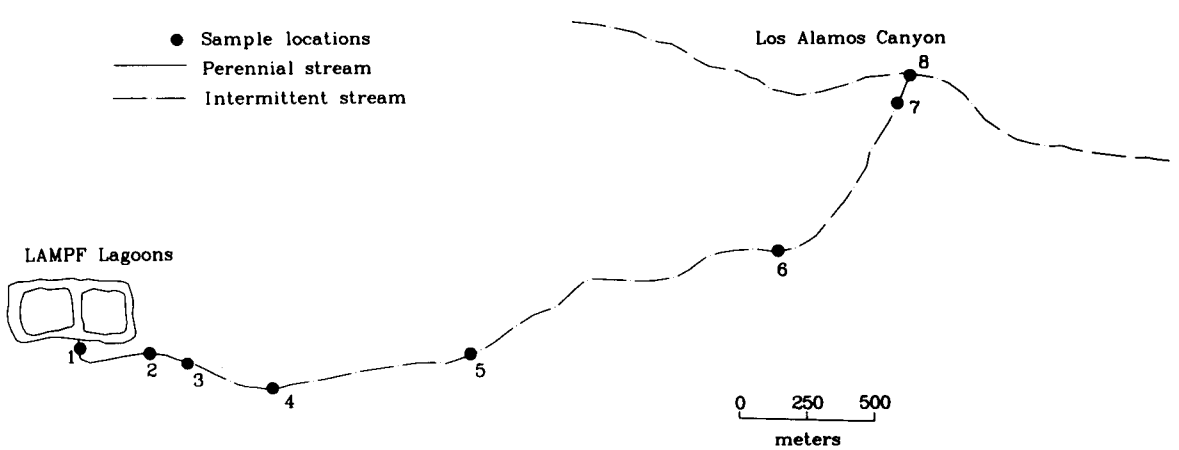


Fig. 23. Sampling locations in vicinity of the Los Alamos Meson Physics Facility's lagoons.

rapidly excreted (short biological half-life) and will pose little threat to organisms of interest.

- Manganese (^{54}Mn), the least biologically toxic of all elements studied, tends to show an increase in concentration through the first two trophic levels. The concentrations then taper off and can almost be seen to reach equilibrium between the soil/plant trophic levels. The path of manganese follows that seen in other studies, showing low accumulation rates due to the high-organic content of the soil. What is interesting to note is that, with movement farther out the transect (away from the stream and soil of high-organic matter), the manganese tends to be in greater proportions in the soil in relation to the other elements at that sample location.
- The next element is cobalt (^{57}Co). Accumulation tends to increase for the water to the soil, but from soil to plants, there seems to be a definite decrease in concentration (with little seen in the fourth and fifth trophic levels). This follows what has been shown in other studies. One reason for the decline could be the extremely short biological half-life of manganese.
- The last element is rubidium (^{83}Rb). Results show that this has accumulated with increasing concentrations to the third trophic level, but then decreases through the next level. This contradicts other studies that have shown rubidium to have a great tendency to biomagnify (10-1000 times) with progression through trophic levels. A possible reason for these results may once again be high clay content, low pH, or competition with high potassium concentrations in the soil.

As previously indicated, these interpretations are preliminary and should be treated as such. When the final statistical analysis has been completed, definite conclusions can be drawn. The statistical analysis should allow definition of exact paths of biomagnification and determination of what, if any, interactions are taking place.

E. Honeybees as Biological Monitors [R. W. Ferenbaugh, M. K. Wallwork-Barber, and E. S. Gladney (H-8)]

Investigations into the use of honeybees as biological monitors continued through 1982.[39] Results obtained from the beehive monitoring network to date are shown in Table E-XXIV. The only consistently high numbers in these data are the tritium analyses in honey obtained from the hive at TA-33. This is not unexpected considering the routine releases from that site.

Preliminary experiments in which uranium-spiked sugar water was fed to bees in cages showed that the uranium could be detected in the various components of the hive (bees, honey, beeswax, larvae, etc.).[40] However, a more sophisticated technique will be required to examine transfer coefficients among these components and to study cycling within the hive. These experiments will be continued in cages built within a new greenhouse facility, which should allow year-round studies instead of restriction to only the summer months.

F. Temperature Regulation and Energetics of Lizards at the Los Alamos National Environmental Research Park [R. G. Bowker (Alma College) and R. W. Ferenbaugh (H-8)]

1. Introduction

Although reptiles are generally most abundant in low elevation habitats, the area around Los Alamos National Laboratory (2225 m elevation) nonetheless has a variety of reptile species. Preliminary surveys of the area indicate the presence of nine lizard species representing three families (Table XXVII). During the summer of 1981, a study of aspects of the physiology and ecology of two lizard species *(Cnemidophorus velox, Sceloporus undulatus)* was begun, and this research was expanded during the summer of 1982 to include three additional species *(C. exanguis, Crotaphytus collaris, Urosaurus ornatus)*. The physiological studies primarily involved a comparison of the abilities of the five species to regulate body temperature (BT). Directly related to this, the energy requirements of the species also were being determined. The ecological studies involved determination of the temporal and spatial distributions of the species.

2. Materials and Methods

A typical thermoregulation study consisted of placing an animal in a temperature gradient (constructed either in the field or in a laboratory), allowing the lizard to move about and thereby regulate BT, and recording the BT continuously. In the energetic studies, resting metabolic rates (mℓ CO_2/g-h) were measured at 25, 30,

TABLE XXVII

LIZARD SPECIES COLLECTED ON OR NEAR LOS ALAMOS NATIONAL LABORATORY PROPERTY

Family Teiidae	
Cnemidophorus exanguis	Chihuahua whiptail
Cnemidophorus neomexicanus[a]	New Mexican whiptail
Cnemidophorus tessalatus	Checkered whiptail
Cnemidophorus velox	Plateau whiptail
Family Iguanidae	
Crotaphytus collaris	Collared lizard
Phrynosoma douglassii	Short-horned lizard
Sceloporus undulatus	Eastern fence lizard
Urosaurus ornatus	Tree lizard
Family Scincidae	
Eumeces multivirgatus	Many-lined skink

[a]Observed at Bandelier National Monument.

35, and 38°C using an infrared CO_2 analyzer. Data on the activity times and distribution of the various species were gathered when the animals were collected for the physiological work.

3. Results and Discussion

The lizards typically regulated BT by shuttling between the sun and shade (or from warm to cool) in the thermal gradient enclosure. This movement resulted in a sine-like fluctuation of BT with time. There were species-specific differences in their behavior in the thermal gradient. Certain species *(C. Velox, C. Exanguis, U. oranatus)* tended to be more active (shuttled more frequently) than did the other species *(Crotaphytus collris, Sceloporus undulatus)*. This typifies the behavior of the species in nature; the three species that were active in the thermal gradient are active-hunters in nature, while the sit-and-wait predators were relatively inactive in the thermal gradient. Regardless of the frequency of movement in the temperature gradient, all of the species maintained relatively high-body temperatures (between 36 and 38°C) and did so with considerable precision (standard deviations less than 2°C). Thus, the five species of lizards examined to date maintain BTs comparable to those of mammalian species.

The energetic studies were designed to complement the thermoregulation experiments and to provide data for a predictive model of the foraging requirements of each species. The general assumption is that the metabolic rate of ectothermal animals follows the Arrhenius relationship; that is, there will be an exponential increase of metabolic rate as BT increases, with metabolic rate doubling approximately every 10°C. A preliminary analysis of the lizard energetic data provides some surprising findings. Although tthe metabolic rate did generally increase as body temperature increased from 20 to 38°C, the relationship was not strongly temperature dependent for any of the species. In fact, most of the species showed either a plateau or a decrease in metabolic rate when their body temperature was near their preferred temperature (for example, for *Urosaurus ornatus* the metabolic rate at 30°C averaged 0.50 mℓ CO_2/g-h and declined to 0.35 mℓ CO_2/g-h at 38°C).

Since all of the species examined to date are relatively precise thermoregulators, they therefore must invest both time and energy to achieve thermal homeostatis. If the

obvious temperature-metabolic relations are not important in this temperature range, then this raises some interesting questions as to the value of precise thermoregulation. These questions are currently being explored.

G. Formerly Utilized Sites Remedial Action Program [R. W. Ferenbaugh, T. E. Buhl, A. K. Stoker, and W. R. Hansen (H-8); J. C. Rodgers (LS-6)]

Under the Formerly Utilized Sites Remedian Action Program, three locations at Los Alamos were selected as potential candidates for remedial action. These sites were the former TA-10 site in Bayo Canyon for conducting experiments with high explosives, the former TA-45 radioactive waste treatment plant site on the east rim of Acid Canyon, and the Acid/Pueblo/Los Alamos Canyon complex into which untreated effluents and subsequently treated effluents from the TA-45 treatment plant were discharged. Radiological surveys of these sites were performed to determine the amount of residual radioactivity remaining.[41,42] Sets of alternatives, ranging from no action to total cleanup, were defined for each site, and engineering and environmental analyses were prepared for each alternative.[43-47]

On the basis of the engineering and environmental analyses, an alternative for each site was selected. At Bayo Canyon, where all residual radioactivity is subsurface at a depth of >5 m, a minimal action alternative was selected. This consisted of demarcating the area of subsurface residual radioactivity to prevent disturbance before the radioactivity has decayed to safer levels. At Acid Canyon an area in the upper reaches of the canyon where residual radioactivity exceeded cleanup criteria was excavated, and the excavated material taken to Area G (TA-54) for disposal. The environmental analysis of lower Pueblo and lower Los Alamos Canyons is incomplete and awaits results from flow models of the canyon system to predict future dispersion patterns.[48-49]

H. Plutonium in Soil near Technical Area 21 [W. D. Purtymun, N. Becker, R. Peters, and M. Maes (H-8)]

Technical Area 21 (TA-21) was used as a plutonium processing area from 1944 until mid-1978. Air exhaust systems at TA-21 contained filters that removed most of the plutonium. Studies were made in 1970 to determine the deposition of plutonium in soil around TA-21.[25] The 13 stations sampled in 1970 were resampled in 1982 (Fig. 24). The same sampling technique was used in collection of both sets of samples. The samples were collected as a sample 8.9 cm in diameter and to a depth of 5.1 cm. Five samples were collected in a square of

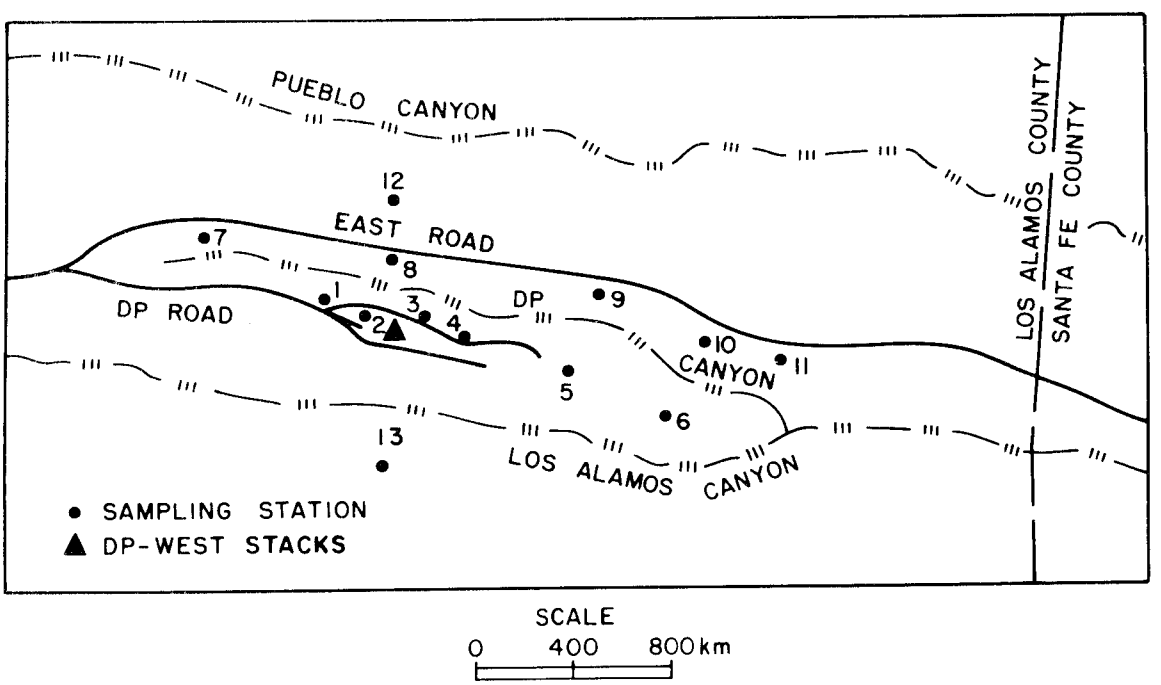


Fig. 24. Soil sampling locations adjacent to Technical Area 21 (TA-21).

about 9 m on a side and one sample collected in the center of the square.

The ^{238}Pu concentrations in 1970 ranged from 0.000 to 0.011 pCi/g with an average of 0.004 pCi/g, while the ^{239}Pu concentrations ranged from 0.021 to 0.51 pCi/g with an average of 0.20 pCi/g. Levels of plutonium based on regional soil samples were 0.004 pCi/g for ^{238}Pu and 0.023 pCi/g for ^{239}Pu in 1970 and were about 0.009 pCi/g for ^{238}Pu and 0.025 pCi/g for ^{239}Pu in 1974-1977.[35] In 1970 regional levels for ^{238}Pu was exceeded only at Location 3, whereas the ^{239}Pu regional level was exceeded at all stations except Location 10 (Fig. 24).

The ^{238}Pu concentrations in 1982 ranged from –0.13 to 0.15 pCi/g with an average of 0.009 pCi/g, whereas ^{239}Pu concentrations ranged from 0.006 to 13 pCi/g with an average of 1.7 pCi/g (Table XXVIII). Regional levels for ^{238}Pu were exceeded at Locations 2, 3, 4, and 5 in 1982. Regional levels of ^{239}Pu were exceeded at all locations except 7, 10 and 11 in 1982.

From 1972 to 1982 the average concentrations of ^{238}Pu about doubled, whereas the average concentration of ^{239}Pu increased about 8 times. The ratio of $^{239}Pu/^{238}Pu$ increased from about 50 to 187 (Table XXVIII). The ratio of $^{239}Pu/^{238}Pu$ shown by regional analyses is about 2.8.

The distribution in both sets of samples shows a nonuniform deposition of plutonium with a general decrease in concentrations with increasing distance from the stacks. The largest concentration and largest increase in concentrations were at Locations 3 and 4, which are adjacent and downwind from the areas of the major stacks.

Plutonium analyses for individual stations is shown in Table E-XXXVI. The soil samples collected in 1982 were also analyzed for ^{137}Cs, gross alpha, gross beta, ^{3}H, ^{90}Sr, and total U. Concentrations of these radionuclides and radioactivity were at normal environmental levels (Table E-XXXVI).

I. Radionuclides in Sediments in Pueblo Canyon [W. D. Purtymun, N. Becker, R. Peters, and M. Maes (H-8)]

Untreated effluents containing radionuclides were released into Acid-Pueblo from 1943 through 1951. Pueblo Canyon is a tributary to Los Alamos Canyon; lower Los Alamos Canyon is, in turn, tributary to the Rio Grande (Fig. 25). To reduce the amounts of radionuclides present in the effluent, a treatment plant (TA-45) began operation in 1951 and was operated until June 1964.

TABLE XXVIII

PLUTONIUM CONCENTRATIONS IN SOILS ADJACENT TO TA-21 IN 1970 AND 1982

	Concentrations in pCi/g			
	November 1970		July 1982	
	^{238}Pu	^{239}Pu	^{238}Pu	^{239}Pu
No. of Analyses	13	13	13	13
Minimum	0.000 ± 0.003	0.021 ± 0.006	–0.13 ± 0.24	0.006 ± 0.004
Maximum	0.011 ± 0.005	0.51 ± 0.11	0.15 ± 0.02	13 ± 1.00
Average	0.004	0.201	0.009	1.7
2s	0.006	0.38	0.12	7.4
$^{239}Pu/^{238}Pu$ Ratio	50		187	
Regional Concentration[a]	0.004	0.023	0.009	0.025

[a]References 25 and 35.

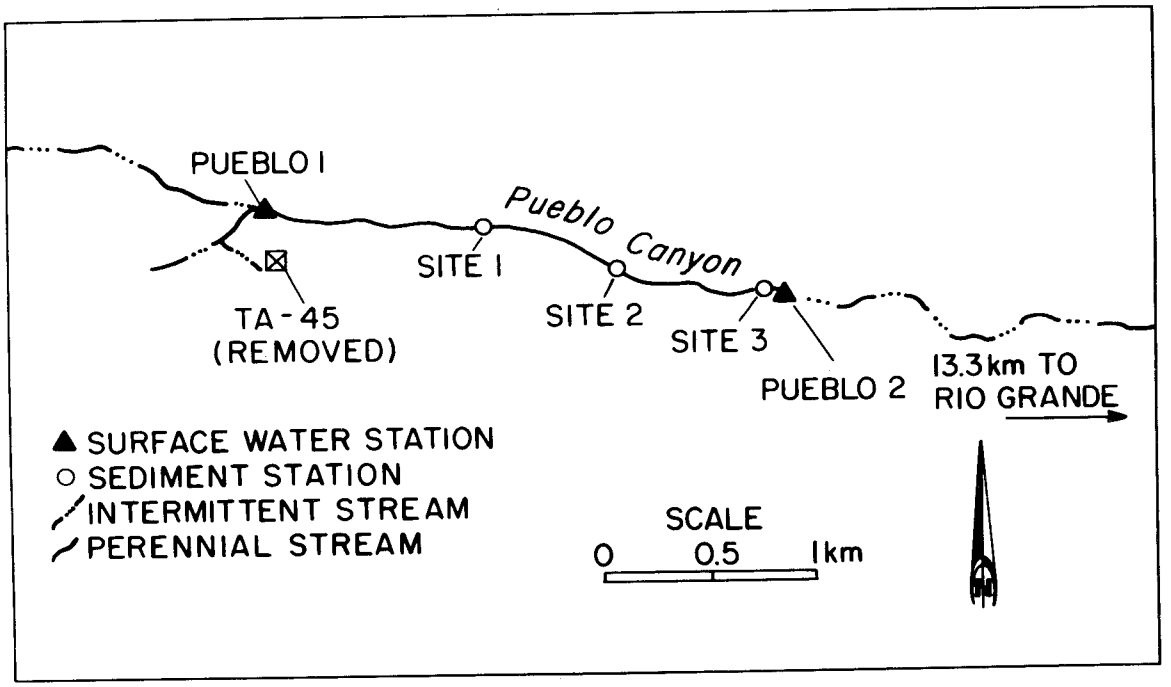


Fig. 25. Sediment sampling stations in Pueblo Canyon.

Radionuclides in the effluent released into the canyon are adsorbed or exchanged with ions in the alluvium, thus reducing the amount of radioactivity in surface flow. Plutonium and cesium in waste effluents are adsorbed or retained with finer sediments in the stream channel. During the fall through spring, concentrations of radionuclides tend to build up at the point of effluent discharge in the stream channel. This buildup is then dispersed by transport during storm runoff, especially during heavy summer showers. In general, the concentrations of radioactivity decrease with increasing distance from effluent outfall.[50]

For general monitoring, samples of sediments in the stream channel are collected across the active stream channel to a depth of 6 cm. Samples for this study were taken during construction of a sanitary sewage line on the floor of Pueblo Canyon. Samples of sediments were collected from the wall of the trench dug for the line. Samples were collected at three locations (Fig. 25) at 20 cm intervals for the total depth of the trench (maximum (160 cm). Analyses were performed on the samples for ^{137}Cs, ^{238}Pu, ^{239}Pu, and total U (Tables XXIX and E-XXXVII).

Concentrations of ^{137}Cs were below regional levels in the environment. Trace amounts of ^{238}Pu were found in almost all of the analyses. The concentrations generally decreased with increasing depth. The average ^{238}Pu concentration increased with increasing distance from the plant outfall (Site 1, 0.016 pCi/g; Site 2, 0.13 pCi/g; and Site 3, 0.55 pCi/g). The concentrations of ^{239}Pu followed the same trend as the ^{238}Pu, with increasing depth the concentrations decreased. The average ^{239}Pu concentration increased downgradient in the channel (Site 1, 0.47 pCi/g; Site 2, 6.5 pCi/g; and Site 3, 150 pCi/g). The average ratio of $^{239}Pu/^{238}Pu$ increased from 29 at Site 1 to 271 at Site 3 (Tables XXIX and E-XXXVII). The bulk of the plutonium release into the canyon was ^{239}Pu.

Total uranium was below regional occurring levels (4.6 μg/g) at Sites 1 and 2. At Site 3 several samples contained total uranium ranging from 6.0 to 6.7 μg/g.[24]

The average concentration of plutonium increased downgradient in the canyon at the three sampling sites. The highest concentrations occurred at Site 3 because of total loss of stream flow that occurs in this reach of the canyon during the late spring, summer, and early fall. Stream flow (sanitary and industrial effluents) during the period of operation of the plant at TA-45 was depleted by evaporation and infiltration into the sediments of the channel. This carried the plutonium in solution deeper into the sediments where they were retained by ion exchange or adsorption with clay minerals in the sediments.

TABLE XXIX

CESIUM, PLUTONIUM, AND TOTAL URANIUM CONCENTRATIONS IN SEDIMENTS IN PUEBLO CANYON

	Number of Analyses	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Total U (μg/g)
Site 1					
Minimum	5	−0.40 ± 0.12	0.001 ± 0.000	0.007 ± 0.000	4.0 ± 0.8
Maximum	5	0.20 ± 0.10	0.035 ± 0.000	2.03 ± 0.060	4.4 ± 0.8
Average	5	−0.02	0.016	0.468	4.2
2s	5	0.45	0.27	1.75	0.4
$^{239}Pu/^{238}Pu$ Ratio			29		
Site 2					
Minimum	8	0.04 ± 0.08	−0.009 ± 0.300	0.140 ± 0.000	3.2 ± 0.6
Maximum	8	0.29 ± 0.06	0.806 ± 0.020	14.3 ± 0.400	4.5 ± 1.0
Average	8	0.15	0.125	6.48	3.8
2s	8	0.16	0.554	11.5	0.9
$^{239}Pu/^{238}Pu$ Ratio			54		
Site 3					
Minimum	8	0.01 ± 0.10	0.005 ± 0.000	0.213 ± 0.020	2.8 ± 0.6
Maximum	8	0.16 ± 0.20	2.51 ± 0.260	615 ± 14	6.7 ± 1.4
Average	8	0.08.0.553	0.553	150	5.6
2s	8	0.12	1.78	444	2.7
$^{239}Pu/^{238}Pu$ Ratio			271		
Natural or Regional Concentrations[a]		1.24	0.009	0.025	4.6

[a]Reference 35.

J. Storm Runoff Transport of Plutonium [W. D. Purtymun, N. Becker, R. Peters, and M. Maes (H-8)]

Untreated effluents containing radionuclides were released into Upper Pueblo Canyon from 1943 through 1951. To reduce the amount of radionuclides present in the effluent, a treatment plant began operation in 1951 and was operated until June 1964. Similarly, a treatment plant has operated from 1950 to the present releasing treated effluents into DP Canyon (a tributary to Los Alamos Canyon) above the junction with Pueblo Canyon.

Radionuclides in the effluents are adsorbed or exchanged with ions in silts and clays of alluvium in the canyon, thus reducing the amount of radioactivity in surface flow. Buildup of radionuclides in alluvium near a treatment plant outfall is dispersed by storm runoff, spring snowmelt, and summer thunderstorms. The major

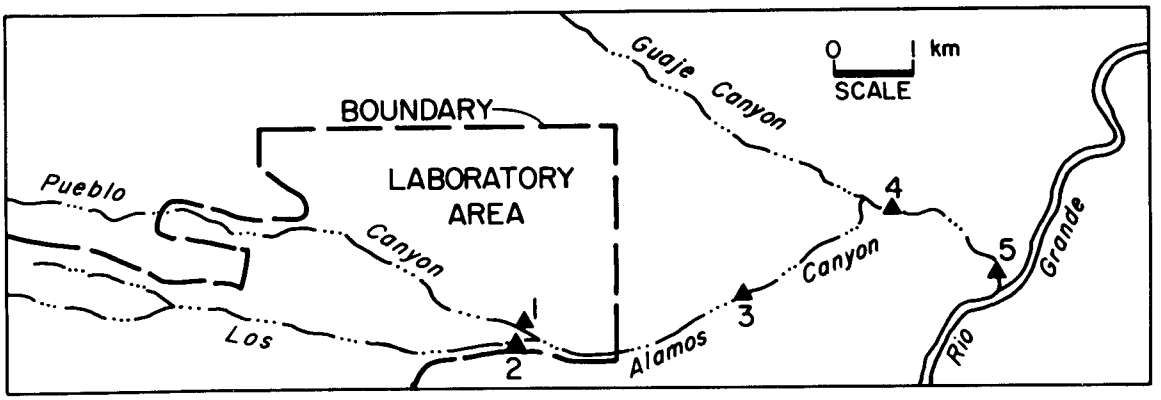


Fig. 26. Surface water sampling stations in Pueblo and Los Alamos Canyons.

transport of radionuclides from these canyons is with storm runoff (solution or suspended sediments).

Samples were collected during spring snowmelt and heavy summer runoff in Pueblo and Los Alamos Canyons. The samples were analyzed for plutonium in solution and suspended sediments. Additional radionuclides were analyzed in solution of the summer runoff. Radioactivity in solution is defined as filtrate passing through a 0.45 μm pore-size filter, whereas radioactivity in suspended sediments is defined as residue on the filter.

During the spring of 1982, snowmelt runoff samples were collected in Los Alamos Canyon at Stations 2 and 3 (Fig. 26). The runoff began at Station 3 on May 4 and ended about May 25. The mean discharge was about 15 ℓ/sec with a mean sediment discharge of about 200 mg/ℓ. The flow extended down the canyon beyond Station 3. Flow loss into the alluvium precluded any water reaching the Rio Grande.

There was very little ^{238}Pu in solution at either Stations 2 or 3 in the spring runoff when compared to concentrations of control analyses (Table XXX). Trace amounts of ^{239}Pu occurred in solution. The major transport of plutonium was in suspended sediments (Table XXX). Concentrations of ^{239}Pu were greater in suspended sediments than were concentrations of ^{238}Pu. In general, concentrations of plutonium in solution and suspended sediments decreased downgradient in the canyon from Station 2 to Station 3.

During 1982, summer runoff was collected at four stations (Table XXX). In contrast with the snowmelt runoff with low discharge and suspended sediment concentrations over a long period of time (21 days in 1982), the summer runoff events occurred with high discharge (as much as 2000 ℓ/sec) and suspended sediment concentrations (20 000 mg/ℓ). The runoff events are of short duration (generally less than 4 h).[8] Runoff from the 10 runoff events reached the Rio Grande during five of those events.

At Station 1 at the mouth of Pueblo Canyon, trace amounts of ^{238}Pu in solution and measurable amount of ^{239}Pu in solution and both ^{238}Pu and ^{239}Pu in suspended sediments occurred in the summer runoff. The bulk of the plutonium was ^{239}Pu. The plutonium concentrations in Pueblo Canyon were higher than what occurred at Stations 2, 4, and 5 in Los Alamos Canyon. There was little, if any, ^{238}Pu in solution in runoff at Stations 2, 4, and 5, whereas measurable amounts of ^{239}Pu in solution and ^{238}Pu and ^{239}Pu were found in the suspended sediment.

In general, concentrations of plutonium in the summer runoff decreased downgradient in the canyon. It is apparent, in both the spring and summer runoff, that there is very little plutonium taken into solution from that which was adsorbed or exchanged with ions in silts and clays in the alluvium. Major transport of the plutonium occurs with the radionuclides fixed in the silts and clays (suspended sediments). Runoff that does reach the Rio Grande carries trace amounts of residual plutonium in the alluvium, which results from release of effluents from the treatment plants.[24]

Individual plutonium analyses from spring and summer runoff are shown in Table E-XXXVIII and E-XXXIX, respectively. The summer runoff was analyzed for ^{137}Cs, gross alpha, gross beta, ^{3}H, total U, and ^{90}Sr in solution. Individual analyses are shown in Table E-XL.

TABLE XXX

AVERAGE PLUTONIUM CONCENTRATIONS IN SOLUTION AND SUSPENDED SEDIMENTS DURING SPRING AND SUMMER RUNOFFS

	Number of Samples	Solution		Suspended Sediments	
		^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)
Spring Runoff					
Station 2	4	0.019 ± 0.330	0.027 ± 0.061	1.39 ± 1.37	9.68 ± 8.88
Station 3	3	0.004 ± 0.016	0.014 ± 0.028	0.840 ± 0.0113	3.51 ± 0.764
Summer Runoff					
Station 1	4	0.012 ± 0.034	0.058 ± 0.119	0.333 ± 0.682	5.71 ± 5.56
Station 2	10	0.008 ± 0.021	0.017 ± 0.045	0.462 ± 1.10	3.81 ± 10.9
Station 4	1	−0.006 ± 0.028	0.020 ± 0.040	0.002 ± 0.002	0.016 ± 0.006
Station 5	5	0.004 ± 0.011	0.035 ± 0.152	0.0744 ± 0.170	2.37 ± 4.24
Control—1980					
Guaje Canyon[a]	2	0.013 ± 0.030	−0.002 ± 0.012	−0.04 ± 0.13	0.10 ± 0.28

[a]Reference 24.

K. Storm Transport of Radionuclides from Area G, Technical Area 54 [W. D. Purtymun, N. Becker, R. Peters, and M. Maes (H-8)]

Area G, Technical Area 54 (TA-54) is used for disposal of solid radioactive wastes. Area G is located on a mesa named Mesita del Buey. Mesita del Buey trends southeast, and is about 3.2 km long and 0.4 km wide. The surface slopes from an elevation about 2100 m near its western end to about 2010 m at its eastern end at Area G. It is bounded on the north and south by canyons cut 15 to 30 m below the mesa surface, and several small side drainages serrate the edge of the mesa.

The surface and underlying rocks of Mesita del Buey are ashflows and ashflows of rhyolite tuff underlain by volcanic basalts interbedded with sediments. The tuff is about 75 m thick. There is no known perched water at Area G between the surface of the mesa and the main aquifer of the Los Alamos area. The main aquifer (capable of municipal and industrial water supply) lies at a depth of 250 m below the surface of the mesa. Movement of water in the aquifer is to the east and southeast where a part is discharged into the Rio Grande.[51]

In 1956, Area G was designated for the disposal of solid radioactive waste (Fig. 27). The wastes range from rubber gloves and glassware to parts of obsolete buildings and equipment that cannot be decontaminated. They are buried in pits ranging in size from 9 to 30 m wide, 45 to 180 m long, and 4 to 10 m deep. The waste is placed in layers 1 to 2 m deep, and each layer is covered with approximately 0.5 m of crush tuff. The pits are filled to within 1 m of the land surface and covered with 1.5 to 2 m of crushed tuff. This final cover is slightly mounded above the original grade to encourage surface runoff. Some wastes are placed in vertical shafts, which range from 0.6 to 1.8 m in diameter and up to 20 m deep.

Containment of the radionuclides is the purpose of their burial of wastes at Area G. Initial containment is accomplished with burial of wastes in pits or shafts. After burial, the major means of potential transport of contaminants to the environment are in the hydrologic cycle. Hydrologic characteristics and conditions of the soil, seal material over the waste, and tuff underlying the

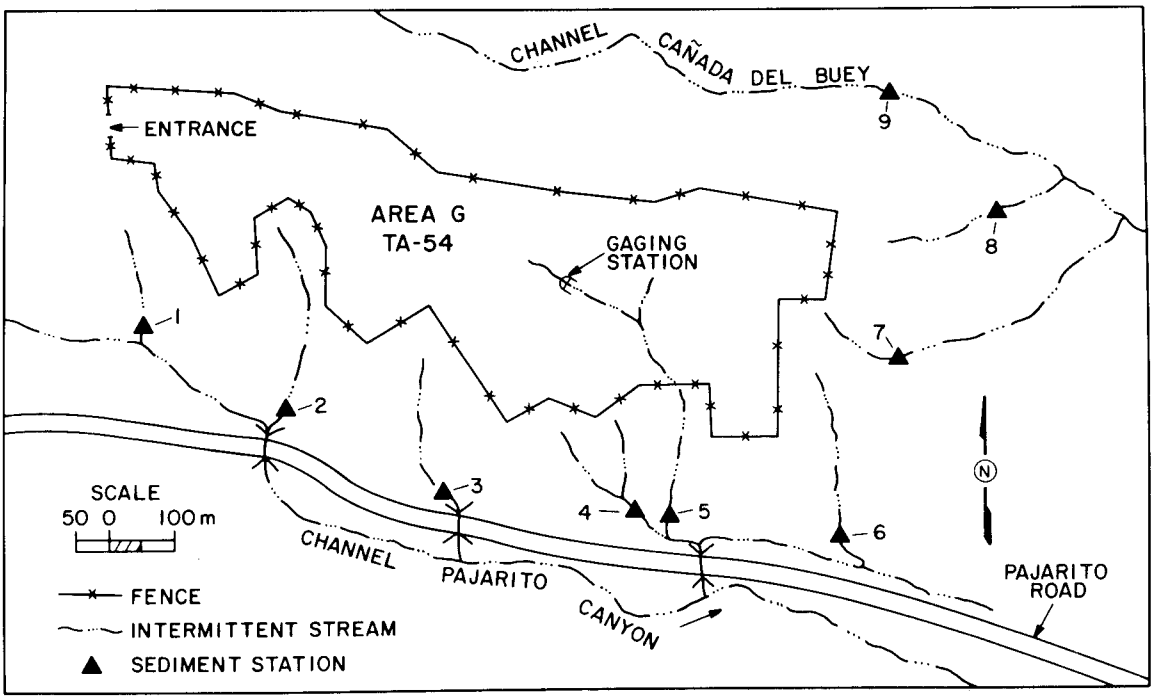


Fig. 27. Surface water gauging station in Area G (TA-54) and sediment sampling stations adjacent to Area G.

wastes indicate no recharge from the mesas to the main aquifer. Transport of radionuclides by surface runoff on the mesa seems unlikely because the wastes are buried. However, transport of wastes to and handling of the wastes at the site could result in surface contamination. This contamination would be subject to transport by storm runoff.

Radionuclides transported by storm runoff have an affinity for attachment to sediment particles by ion-exchange or adsorption. Thus, the surface runoff would be concentrated in sediments of the stream channels that drain Area G. Nine stations were located outside the fence at Area G for collection of sediments that were transported off the area by storm runoff (Fig. 27).

The sediments analyzed for ^{137}Cs, ^{3}H, and total U were within or below concentrations found in the natural environment at all nine stations (Tables XXXI and E-XLI). The ^{3}H concentration at Station 4 was above regional concentrations. The ^{238}Pu concentrations found in sediments from Stations 4, 8, and 9 and ^{239}Pu concentrations at 4 and 6 exceed regional levels, thus indicating transport of surface contamination by runoff from Area G. The maximum ^{239}Pu concentration (0.042 pCi/g) is a factor of about 5 times greater than the regional concentration (0.009 pCi/g). The maximum ^{239}Pu concentration (0.167 pCi/g) is a factor of about 7 times greater than regional concentrations (0.025 pCi/g).[35]

Radiochemical analyses were performed on six summer runoff events from a portion of Area G (Table XXXI). The samples were collected at the gauging station (Fig. 27). The analyses of the runoff were performed on the solution and suspended sediments. Radioactivity in solution is defined as filtrate passing through a 0.45 μm pore-size filter, while radioactivity in suspended sediments is defined as the residue left on the filter. Only the plutonium was analyzed as suspended sediments, since the mass of the sediments collected was not great enough for other analyses.

Trace concentrations of ^{238}Pu and ^{239}Pu were found in solution in the six runoff events. The ^{238}Pu concentrations were slightly greater than the ^{239}Pu concentrations (Table XXXI). Most of the events contained ^{238}Pu and ^{239}Pu concentrations in excess of those found in the control analyses (Table XXXI). As in solution, there was more ^{238}Pu in the suspended sediments than ^{239}Pu.

In summary, there is some transport of surface contamination from Area G. Concentrations of the radionuclides are low and pose no problem. Area G is well within the confines of the Laboratory.

TABLE XXXI

RADIOCHEMICAL ANALYSES OF SEDIMENTS AND RUNOFF AT AREA G, TA-54

Sediments	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/g)
No. of Analyses	9	9	9	9	9
Minimum	0.17 ± 0.06	0.002 ± 0.002	0.002 ± 0.002	2.5 ± 0.6	2.3 ± 0.4
Maximum	0.76 ± 0.14	0.042 ± 0.010	0.167 ± 0.020	22 ± 1.0	4.8 ± 1.0
Average	0.30	0.011	0.032	6.3	3.2
2s	0.41	0.025	0.104	12	1.9
Natural or Regional Concentrations in 1981[a]	1.24	0.009	0.025	6.4	4.6

	Solution		Suspended Sediments	
Runoff	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)
No. of Analyses	6	6	5	5
Minimum	0.004 ± 0.012	0.004 ± 0.026	0.640 ± 0.120	0.010 ± 0.006
Maximum	0.072 ± 0.038	0.070 ± 0.040	1.38 ± 0.080	0.329 ± 0.002
Average	0.027	0.013	1.08	0.133
2s	0.051	0.056	0.282	0.240
Control—1980 Guaje Canyon[b]	0.013 ± 0.030	−0.002 ± 0.012	−0.04 ± 0.13	0.10 ± 0.28

[a]Reference 35.
[b]Reference 24.

L. Fenton Hill Site (TA-57) Surface and Ground Water Quality [W. D. Purtymun, R. W. Ferenbaugh, N. Becker, M. Maes (H-8) and H. Adams (H-7)]

Los Alamos National Laboratory is currently evaluating the feasibility of extracting thermal energy from hot dry rock geothermal reservoirs at this Fenton Hill Site (TA-57). The concept involves drilling two deep holes, connecting these holes by hydraulic fracturing, and bringing thermal energy to the surface by circulating water through the system.

The chemical quality of surface and ground waters in the vicinity of TA-57, about 30-km west of Los Alamos (Fig. 28), has been determined for use in geohydrologic and environmental studies. Results of past studies and detailed data have been reported elsewhere.[52] The chemical quality of water is organized around stations with common chemical properties and total dissolved solids (TDS).

Surface water stations (12 on Jemez River, the Rio Guadalupe, and their tributaries) are divided into 4 general groups based on common chemical properties of

TABLE XXXII

PREDOMINATE IONS IN SURFACE AND GROUND WATERS AND PONDS AT FENTON HILL, 1982

Concentrations in mg/ℓ

	Na	Cℓ	TDS
Surface Water			
Sodium-Chloride			
Redondo Creek (U)	11	13	86
Jemez River (R)	88	110	464
Jemez River (S)	97	135	514

	Ca	HCO_3	TDS
Calcium-Bicarbonate			
San Antonio Creek (N)	18	72	130
Rio Cebolla (T)	18	68	138
Rio Guadalupe (Q)	50	156	216
Lake Fork 2 (LF-2)	20	84	200
Lake Fork 3 (LF-3)	14	60	130
Lake Fork 4 (LF-4)	17	72	146

	Ca	SO_4	TDS
Calcium-Sulfate			
Sulphur Creek (V)	59	280	430
Sulphur Creek (F)	16	31	106

	Na	HCO_3	TDS
Sodium-Bicarbonate			
Jemez River (J)	16	68	140

	Na	Cℓ	TDS
Ground Water			
Sodium-Chloride			
Loc. JF-1 (Hot Spr)	345	540	1568
Loc. JF-5 (Hot Spr)	855	1450	3964

	Ca	HCO_3	TDS
Ground Water (cont)			
Calcium-Bicarbonate			
FH-1 (Supply well)	52	120	326
Loc. 2 (Well)	50	148	252
Loc. 39 (Spr)	13	40	66

	Na	HCO_3	TDS
Sodium-Bicarbonate			
JS-2, 3 (Spr)	18	84	194
JS-4, 5 (Spr)	17	84	194
Loc. 4 (Spr)	33	72	154
Loc. 31 (Spr)	16	64	154
RV-2 (Hot Spr)	25	48	130
RV-4 (Hot Spr)	53	112	218
RV-5 (Hot Spr)	19	72	142

	SO_4	Cℓ	F	TDS
Ponds—Fenton Hill				
Upper GTP-1	112	1188	4.7	5430
Lower GTP-3	89	520	3.9	2238

	As	B	Cd	Li
Upper GTP-1	6.56	40	0.003	9.6
Lower GTP-3	3.13	13	0.003	4.0

predominate ions and TDS (Table XXXII). The predominate ions are (1) sodium and chloride, (2) calcium and bicarbonate, (3) calcium and sulfate, and (4) sodium and bicarbonate.

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

During 1982, the quality of surface and ground water within the drainage area of Fenton Hill (TA-57) varied slightly, which was attributed to normal seasonal fluctuations. The TDS of Supply Well at FH-1 increased slightly when compared to previous years concentrations

of TDS. This is probably due to the decline in water level of about 2.7 m from 1976 through 1982. Chemical quality of water from the well is below primary and secondary standards for use as water supply (see Section IV.b.1.c).

Ponds at the site contain water used in drilling operations and water used in the experimental loop in the dry hot rock about 3000 m below land surface. The water in the ponds is highly mineralized (2238 to 5430 mg/ℓ) in 1982 (Table XXXII). Certain elements in the ponds (sulfate chloride and TDS) are of special interest to investigators. Arsenic, boron, cadmium, fluoride, and lithium concentrations must be monitored as specified in the National Pollutant Discharge Elimination System Permit. Water from the ponds is released into a dry canyon that is tributary to Lake Fork Canyon south of the site (Fig. 28). Monitoring of surface water in Lake Fork Canyon LF-2, LF-3, LF-4, and ground water from springs at Locations 31 and 39 failed to detect any

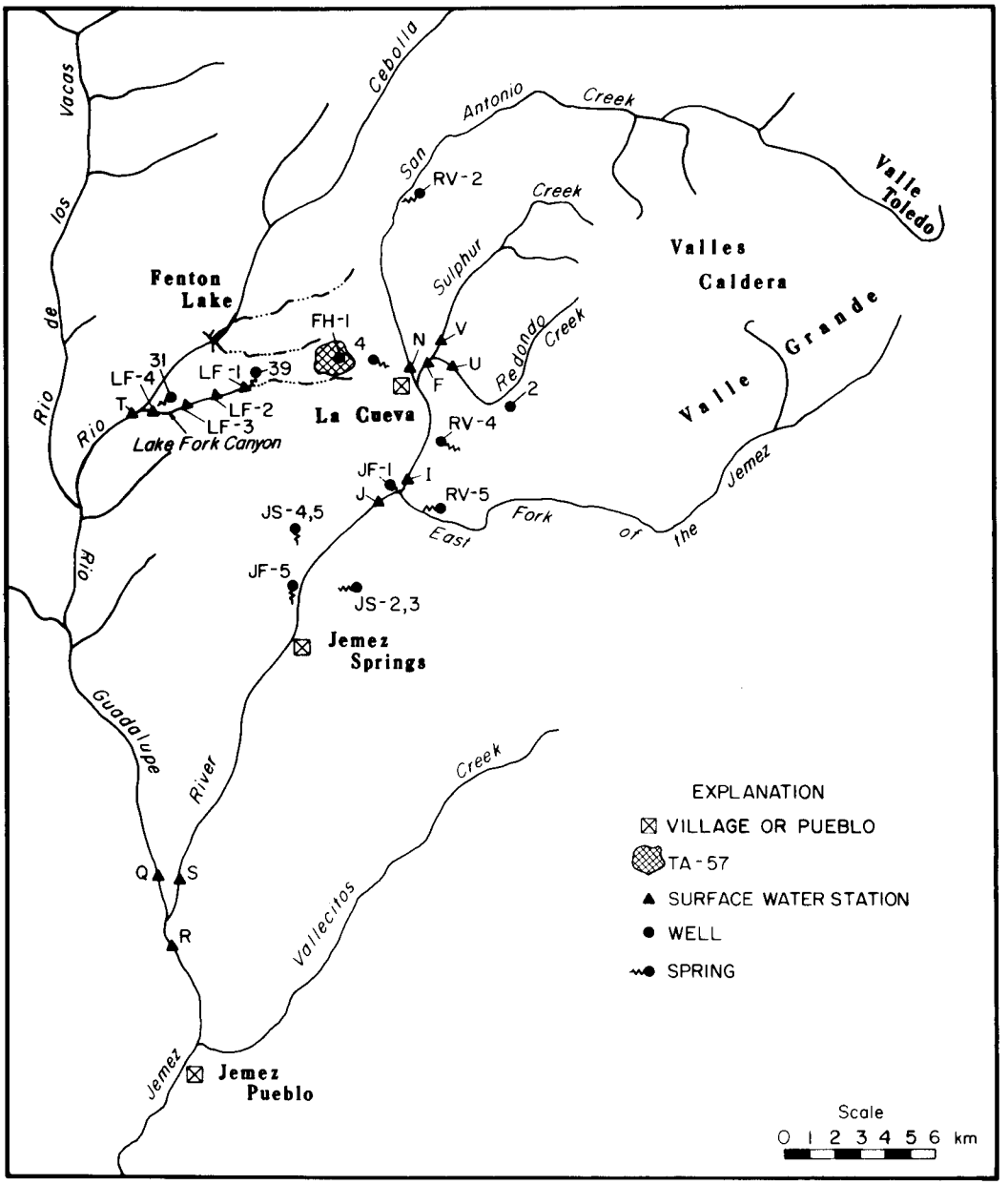


Fig. 28. Water sampling locations in vicinity of Fenton Hill Geothermal Site (TA-57).

change in chemical constituents that could be related to the release of water from the ponds.

Vegetation and soil samples are taken from the canyon below the holding ponds to determine if there is any buildup of arsenic, boron, cadmium, fluoride, or lithium. Samples are taken from the channel at distances of 100 m, 200 m, 400 m, and 1000 m below the discharge point. Control samples are taken from the bank of the canyon at the same distances and from the canyon channel far below the point where the discharge sinks into the alluvium.

Results of the analyses from the past several years are shown in Table E-XLII. The results are mixed. Some, such as boron in foliage and fluoride in soil show a distinct accumulation pattern. Others, such as arsenic in roots and lithium in vegetation, show a less distinct accumulation pattern, and still others, such as cadmium and lithium in soil, show very little pattern at all. This may merely reflect the different soil physiochemical and plant biophysiological properties of these elements.

Direct observation of the vegetation (grass and small aspen) growing in the channel shows no apparent detrimental effect of the discharge.

M. Development of Supply Well PM-4 [W. D. Purtymun, N. Becker, and M. Maes (H-8)]

Construction of supply Well PM-4 began in January 1981 and was completed when the well was put into production in July 1982. The well is about 1200 m north of Well PM-2, on the south rim of Cañada del Buey. The well was located in an area where it was possible to develop a high-yield well (production rate at greater than 63 ℓ/sec with less than 30 m of drawdown).[53,54]

The well was completed at a depth of 890 m. Stratigraphic units penetrated by the well in descending order are the Bandelier Tuff, Basaltic Rocks of Chino Mesa, the Puye Conglomerate, and Tesuque Formation (Table XXXIII). Drilling time log is based on a 38-cm bit using air-foam to about 295 m, drilling mud to 905 m with a bit pressure about 9100 kg. Stratigraphic nomenclature use in Table XXXIII is as described by Griggs.[55]

The top of the Main Aquifer of the Los Alamos area (only aquifer capable of municipal and industrial water supply) was encountered at a depth of about 320 m in the lower part of the Basaltic Rocks of Chino Mesa. The lower part of the Puye Conglomerate and Tesuque Formation are within the zone of saturation at the well. The well was developed (removal of drilling mud, silt, and clay from formation and gravel pack) by jetting the perforated casing with water followed by swabbing, bailing, and pumping.

Step test to determine pumping rate of the permanent pump was made at rates of 52, 63, 76, 85, 95, and 97 ℓ/sec. At a pumping rate of 97 ℓ/sec, the maximum drawdown of water level at the end of 3 h of pumping was 16 m with a specific capacity of 6.0 ℓ/sec/m of drawdown. Based on step tests, the pumping rate of the permanent pump was set at about 95 ℓ/sec.

The well produced about 2.9×10^9 ℓ of water from July through December 1982 at an average pumping rate of about 88 ℓ/sec. The average drawdown has been about 12.5 m, indicating a specific capacity of about 7 ℓ/sec/m of drawdown. Only Well PM-3 of the 16 supply wells has a greater specific capacity than this new well.

Water from the well is a sodium-bicarbonate type (predominate ions) and is similar in chemical quality to water from supply Well PM-2. The total dissolved solids are low at 124 mg/ℓ. The water is soft with a hardness of 42 mg/ℓ. Analyses of the water indicates the chemical quality meets the primary and secondary standards for municipal use as set by the US Environmental Protection Agency.[21,22] Gross alpha activity in water from the well was 20×10^{-9} μCi/mℓ, which exceeded the standard used for screen of 15×10^{-9} μCi/mℓ; however, the mixture of the water from Well PM-4 with water from other wells reduced the concentrations to acceptable levels. The low radium (^{226}Ra, 0.03×10^{-9} μCi/mℓ) of water from Well PM-4 indicates the gross alpha activity may be the result of contamination of the sample after collection.

N. An Environmental Study of Emissions from Testing of Shaped-Charge, Depleted Uranium Munitions [T. Gunderson, T. Buhl, R. Romero, and D. Van Etten (H-8)]

1. Introduction

The US Army Missile Command, Redstone Arsenal, Alabama, requested assistance in an environmenal study of emissions from testing of shaped-charge, depleted uranium munitions. This study was done at Los Alamos National Laboratory in Technical Area 36 at IJ Firing Site. The IJ Firing Site is in a controlled area where public access is restricted. The Laboratory's Environmental Surveillance Group (H-8) and Detonation Physics Group (M-3) participated in the study.

TABLE XXXIII

GENERALIZED GEOLOGIC AND DRILLING TIME LOG OF SUPPLY WELL PM-4

	Thickness (m)	Depth (m)	Drilling Time (min/m)
Bandelier Tuff			
Tshirege member	67	67	4.9
Otowi member	98	165	6.6
Guaje member	18	183	6.6
Basaltic Rock of Chino Mesa			
Basalt (unit 3)	152	335	20
Puye Conglomerate			
Fanglomerate member	85	421	16
Totavi lentil	12	433	20
Tesuque Formation			
Claystone, siltstone, sandstone	162	594	16
Basalt	9	604	33
Siltstone, sandstone	34	637	20
Basalt	18	655	43
Interflow breccia	12	668	26
Basalt	27	695	49
Claystone	12	707	23
Basalt	34	741	46
Claystone, siltstone, sandstone	150	890	16

Note: Top of main aquifer at 323 m.

2. Sampling Methodology

Airborne emissions from seven test shots were sampled using high-volume and virtual-impactor air samplers. These samplers were placed downwind from the test area so the cloud from the munition and resuspended soil caused by the blast could be sampled. In addition to this sampling, surface and core soil samples were taken at the IJ Firing Site to help estimate the degree of uranium soil contamination. Some particulate fallout samples were also taken.

3. Comparison of Measured Airborne Uranium Concentrations with Nuclear Regulatory Commission

The Nuclear Regulatory Commission (NRC) standards for occupational exposure require that no individual be exposed to air concentrations of uranium in soluble form that exceed 200 $\mu g/m^3$ when averaged over a 40-hour week. At IJ Site, exposures to airborne uranium are well within these limits. Individuals at the site remain in a protected bunker for several minutes after the shot until the cloud has passed from the area.

This procedure effectively reduces the exposure to negligible levels.

To evaluate potential uranium hazards that might exist at other sites where observers may be located outside and be directly exposed to the cloud, the 40-hour week average air concentration of uranium resulting from exposure to the highest uranium concentration measured at IJ Site was calculated. That concentration, 16 900 $\mu g/m^3$ averaged over the 17 seconds estimated for passage of the cloud, would be 2 $\mu g/m^3$ if averaged over a 40-hour week, or approximately 1% of the NRC standard. While this calculated average is well below the NRC standard, data indicate that exposure levels from many repeated tests in the same area may cause the standard to be exceeded.

Because of the 5 km distance from IJ Site to the Laboratory boundary, uranium concentrations in air in uncontrolled areas were small. However, at test sites in the country where the boundary may be close to the firing site, offsite concentrations may be of concern. In a calculation similar to that performed above, the highest measured uranium concentration (16 900 $\mu g/m^3$ was used to estimate an annual average to provide an estimate of an upper limit on the uranium concentration resulting from these tests. The one-year average was calculated to be 0.009 $\mu g/m^3$ for a single test, which is 0.1% of the NRC standard. Again, a program involving many tests during a year would require individual evaluation to ensure that this standard would not be exceeded.

4. Uranium Concentrations in Soils Around Firing Site

The soil sampling data show that uranium contamination has been spread widely at IJ Firing Site. This was expected, since IJ Firing Site has been in operation for over 20 years and several hundred tests have been conducted there. Average background uranium concentrations in soil in the Los Alamos area range from 1 to 3 parts per million. All soil samples from IJ Site were above background, ranging from about 2 to 600 times background levels.

5. Radiological Dose Assessment

The 50-year inhalation dose commitments to lung, bone, and kidney, the three organs receiving the highest doses, were 5, 0.8, and 0.2 mrem, respectively. These doses resulted from a single exposure. If the individual were exposed to clouds from several shots, the doses would be additive.

These doses can be compared to the Department of Energy's occupational exposure dose standards of 5000 mrem per quarter (1500 mrem per year) for lung and kidney, and 10 000 mrem per quarter (30 000 mrem per year) for bone. The standards for members of the public are 1500 mrem per year for lung, kidney, and bone.

6. Conclusions

- Based on either radiological or chemical toxicity considerations, measured average airborne concentrations or uranium in clouds resulting from testing of shaped-charge, depleted uranium munitions did not exceed airborne uranium standards at IJ Firing Site.
- Testing hundreds of uranium munitions at one firing site results in extensive soil contamination at that site.
- The radiological dose from exposure to any one test firing of a shaped-charge, depleted uranium munition is relatively insignificant. However, the doses are additive for repeated exposures.

O. Aerial Gamma Radiation Survey of Los Alamos National Laboratory [D. Mayfield (H-8) and A. E. Fritszche (EG&G Aerial Measurements Section)]

The EG&G Company conducted an aerial gamma radiation survey of the Laboratory during September. This gamma radiation survey was the first to cover the entire Laboratory site since 1963, although a limited aerial gamma survey was conducted by EG&G in 1975 as part of a TA-1 cleanup operation. The object of the new gamma survey was to provide an overview of the distribution of gamma radiation in the Laboratory environs from Laboratory sources. This data will supplement point measurements ordinarily taken in the Laboratory's environmental surveillance program.

The aerial survey will be useful in guiding management decisions regarding radiological impacts of Laboratory activities on the environs. The survey will facilitate Laboratory responses to those DOE directives that assure consistency with federal environmental policy. It will also be used to provide public information regarding the degree of public exposure to radiation from Laboratory sources or the impact of Laboratory operations on the environs.

Preliminary results from the 1982 survey show the plume from the Los Alamos Meson Physics Facility stack to be the dominant source of environmental gamma exposure from the Laboratory. No unexpected sources of gamma radiation were observed.

P. Plutonium in Reservoir Sediments [W. D. Purtymun, N. Becker, R. Peters, J. Salazar, R. Romero (H-8)]

Low concentrations of plutonium are found in soils as the result of worldwide fallout from atmospheric nuclear tests. Sheet wash and erosion transports the soil into river systems. The soils, now sediments, eventually become trapped in reservoirs.

Sediment samples were collected from four reservoirs in northern New Mexico. Three of the reservoirs, Heron, El Vado, and Abiquiu are in the drainage above Los Alamos, whereas Cochiti Reservoir is in the drainage below Los Alamos (Fig. 29). The study was made to determine fallout concentrations of plutonium in the sediments and evaluate possible transport of plutonium from the Laboratory.

The samples were collected from a boat using a Eckman dredge. The dredge, about 20 cm long by 10 cm wide, was lowered to the bottom and tripped with a brass messenger. The bottom sample was collected to a depth of about 6 cm, depending on the compaction of the sediments. The sediments were fine-grained silts and clays with some organic material. There were considerably more organic materials in sediments from Cochiti Reservoir than from the other reservoirs (Heron, El Vado, and Abiquiu). A mass of 1 kg was used for each analysis. This is about 100 times the usual mass, which lowers the limit of detection by one significant figure.

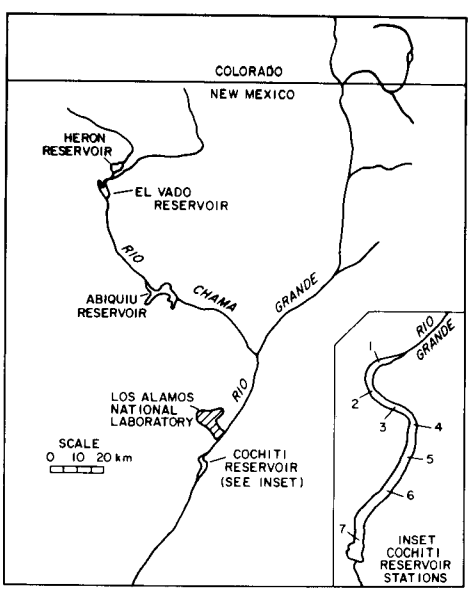


Fig. 29. Reservoirs used in collection of sediments in northern New Mexico.

Samples were collected from the upper, middle, and lower parts (next to dam) of the lakes at Heron and El Vado Reservoir. At Abiquiu the samples were collected in upper and lower parts of the reservoir. Seven samples were collected in Cochiti Reservoir (Fig. 29).

The ^{238}Pu concentrations ranged from 0.0001 to 0.0012 pCi/g, with an average of 0.0007 pCi/g (Table XXXIV). There was no significant difference in plutonium concentrations in the reservoir sediments when compared to the river sediments. However, when plutonium concentrations in reservoir and river sediments were compared to those in the soils, the soil plutonium concentrations were about a factor of 2 times greater than the sediment plutonium concentrations (Table XXXIV).

The ^{239}Pu concentrations in the reservoir sediments ranged from 0.0052 to 0.0257 pCi/g, with an average of 0.0142 pCi/g. The average ^{239}Pu concentrations in reservoir sediments were about a factor of 3 times greater than in the river sediments, and a factor of 1.5 times greater than the concentrations in the soils (Table XXXIV).

In comparing the amounts of the two isotopes of plutonium, the ratio ^{239}Pu/^{238}Pu was about 20 in reservoir sediments. The ratio ^{239}Pu/^{238}Pu decreased to about 6 in river sediments and to about 2.5 in soils.

There was no significant difference in the ^{238}Pu concentration in sediments from the four reservoirs. The ^{239}Pu concentration appeared to be slightly greater in sediments from Cochiti Reservoir than in sediments from the other three reservoirs. However, it was not considered significant, when the uncertainty terms associated with analyses from Heron Reservoir were considered. The ^{239}Pu/^{238}Pu ratio in sediments from the four reservoirs indicated that there was only regional concentrations in the reservoir sediments.

Plutonium analyses from the individual stations are in Table E-XLIII.

TABLE XXXIV

SUMMARY OF PLUTONIUM CONCENTRATIONS IN RESERVOIR SEDIMENTS, 1982
(average of a number of analyses)

	Number of Analyses	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	$^{239}Pu/^{238}Pu$ Ratio
Heron Reservoir	3	0.0006 ± 0.0007	0.0137 ± 0.0122	23
El Vado Reservoir	3	0.0003 ± 0.0006	0.0095 ± 0.0077	32
Abiquiu Reservoir	2	0.0005 ± 0.0003	0.0097 ± 0.0048	20
Cochiti Reservoir	7	0.0009 ± 0.0004	0.0178 ± 0.0072	20
Summary				
Minimum	15	0.0001 ± 0.0000	0.0052 ± 0.0000	52
Maximum	15	0.0012 ± 0.0001	0.0257 ± 0.0012	21
$\bar{x} \pm 2s$	15	0.0007 ± 0.0007	0.0142 ± 0.0105	20
Control ($\bar{x} \pm 2s$) 1981[a]				
Sediments (River)	3	0.0007 ± 0.0013	0.0041 ± 0.0053	6
Soils	6	0.0040 ± 0.0049	0.0093 ± 0.0099	2.5

[a]Reference 35.

Q. Activities of the Los Alamos National Environmental Research Park, 1982 [K. W. Bostick (LS-6)]

The Los Alamos National Environmental Research Park (LA/NERP) was established in 1976 as a field laboratory for ecological research to study the environmental impacts of energy development, and as a source of public information on environmental issues. The emphasis of research on the park is to develop criteria that facilitate energy development in ways that are least harmful to the environment.

The LA/NERP encompasses approximately 111 km^2 of DOE land at Los Alamos. The steep elevation gradient (1500 m in 25 km) and canyon/mesa terrain give the Research Park a wide spectrum of southwestern habitat types in a compact area. A unique feature of the LA/NERP is that some areas within the park have been protected from activities such as agriculture, lumbering, or mining for nearly 40 years.

Studies on the LA/NERP are conducted by Laboratory staff and by graduate and undergraduate students from regional universities. Some of the work is conducted in cooperation with federal and state agencies, such as the National Park Services and the New Mexico Department of Game and Fish. Research projects sponsored by this program are selected by the LA-NERP Advisory Committee. Current research activities include work on forest fire ecology, plant habitat characterization, big game biotelemetry research, lizard physiology, and work with endangered species.

In keeping with the NERP charter to promote public understanding of environmental issues, a significant effort of the LA/NERP staff is devoted to public presentations. During 1982, 25 talks or presentations were given primarily to schools and educational organizations. The Laboratory's display at the 1982 New Mexico State Fair featured the LA/NERP. Over 44 000 people saw this display featuring topics on animal disturbance of waste cover profiles, biotelemetry of deer and elk in areas disturbed by oil shale development and fire, endangered species at the LA/NERP, and the concepts and the need for studies of ecosystem structure and function.

R. Use of Pellet-Group Plots to Measure Trends in Deer and Elk Populations [M. M. Rowland, G. C. White, and E. M. Karlen (LS-6)]

Distribution and abundance of mule deer *(O. hemionus)* and elk *(C. elephus)* were studied from 1976-1981 near Los Alamos, New Mexico, using pellet group counts. Data were shown to fit the negative binomial distribution. One of four models[56] was chosen that best represented distribution and frequency of pellet groups among years and vegetation types, for deer and elk. Mule deer numbers varied among years in all vegetation types; the population trend was generally downward. Elk numbers (winter only) increased in ponderosa pine, but remained unchanged in other areas. Deer pellet groups were distributed similarly from year to year and were nonrandom (that is, clumped). Elk pellet groups were also clumped, but were more randomly distributed in mixed conifer during the latter part of the study. In ponderosa pine, where deer were most abundant, pellet groups were more randomly distributed. Similarly, elk numbers were highest in mixed conifer, where pellets were also most random. Neither weather nor fire appeared to greatly affect deer or elk numbers.

S. Estimating Erosional Losses of Fallout Plutonium [G. R. Foster and T. E. Hakonson (LS-6)]

Fallout from atmospheric testing of nuclear weapons in the 1950s and 1960s deposited plutonium over all of the United States. Soon after fallout, the plutonium became strongly adsorbed on soil particles, especially the fine particles of silt and clay.[57] A major pathway for the movement of plutonium in the environment is the erosion of soil and the transport of sediment from erosional processes, a pathway extending from the landscape to rivers to the oceans.

Major erosive agents are raindrops striking exposed soil, and surface runoff from rainfall at rates greater than water can infiltrate into the soil. Surface runoff is the major transport agent that moves eroded soil particles, sediment, over the landscape. Erosion is a function of climate, soil erodibility, topography, land use, and vegetative cover and can be predicted with the Universal Soil-Loss Equation.[58] We used erosion rates estimated by the US Department of Agriculture Soil Conservation Service[59] at 200 000 locations across the US to estimate removal rates of fallout plutonium by soil erosion.

Erosion does not rapidly remove plutonium. We estimated that after 100 years, about 50% of the originally deposited plutonium will remain in soils in the Southwest, 60% in the Midwest, 70% in the Northwest, and 80% in the Southeast and the Northeast.[60] Plutonium removal rates at a specific site depend on the particular combination of factors controlling erosion at the site. Cropland is especially susceptible to erosion, but sediment eroded from cropland is diluted in plutonium because tillage mixes plutonium over a greater soil depth than plutonium occurring in undisturbed soils. Therefore, sediment eroded from undisturbed land has higher concentrations of plutonium than does sediment eroded from cropland. However, erosion rates on undisturbed land are usually significantly less than those on cropland. Erosion on undisturbed land is closely related to the natural vegetation cover. Even though rainfall is much less in the Southwest than in the Southeast, erosion rates on undisturbed land in the Southwest are greater because of sparse natural vegetation.

Not all eroded sediment (less than 4% on the average) reaches the outlet of major rivers.[59] Ninety-six per cent of eroded sediment is deposited somewhere between the point where erosion produces the sediment and river outlets. Deposition is a selective process causing sand particles to be deposited before clay. Since plutonium is primarily associated with the clay, deposition enriches the concentration of plutonium in the sediment load. Concentration of plutonium in sediment is about 2 to 3 times that in soil.

Based on the enrichment of plutonium (ratio of sediment delivered to that eroded) and estimated erosion rates, we calculate the annual delivery of plutonium in major rivers to range from 0.02% of the initial inventory for the Northeast and Southeast to 0.05% for the Midwest to 0.08% for the semiarid Southwest to 0.04% for the Northwest.[58] If atmospheric deposition of plutonium had been uniform at 1 mCi/km^2, plutonium activity on sediment would range from about 0.01 pCi/g of sediment in the Midwest to 0.02 pCi/g in the Southeast and the Northeast to 0.04 pCi/g in the Southwest and the Northwest.[58] These estimated plutonium delivery rates and concentrations agree well with observed data (see Table XXXIV).

Much of the plutonium on eroded sediment will travel only a short distance from its origin before the host sediment particles are deposited. The deposited sediment is permanently located at least within the time frame of a

few hundred years. Therefore, most of the plutonium initially deposited on the landscape will remain there but will be redistributed in space because of erosion and deposition. Furthermore, in many areas, the delivery rates of plutonium in major rivers would not be expected to decrease greatly in the next 100 to 200 years.

T. Preliminary Results of Measurements and Modeling of Gamma Absorbed Doses Due to Releases from LAMPF [B. M. Bowen, T. E. Buhl, J. M. Dewart, W. R. Hansen, D. Talley, A. I. Chen, W. A. Olsen, and D. M. Van Etten (H-8)]

1. Introduction

During the summer of 1982, three portable, high-pressure ionization chambers (HPICs) were placed in the field to measure short-term gamma radiation levels caused by the Los Alamos Meson Physics Facility's (LAMPF) plume. This was in addition to the thermoluminescent dosimeter (TLD) network that routinely measures long-term gamma radiation levels. Gaussian-type atmospheric dispersion model was used to estimate gamma levels from the plume concentration at the fence line. The model predicts absorbed doses from gamma rays emitted from a passing plume.

2. Preliminary Model Results

Absorbed doses from gamma radiation were measured and predicted for the last 7 months of 1982. Figure 30 shows the measured and predicted gamma absorbed doses. Note that the calculated absorbed doses are higher on the east end of the TLD network, reflecting a greater frequency of SSW and SW winds. The measured external radiation contribution from LAMPF was calculated by subtracting a background external radiation dose (measured by another TLD network unaffected by Laboratory operations) from measured external radiation doses in each of the three sectors along the fence line. The predictions are reasonably close to the measured values except for the NNW sector. The 0 mrad measured contribution for the NNW sector may be due to the high degree of spatial variability of the background external radiation dose. Note that the highest absorbed dose is predicted for the NE sector. For this reason, the four westernmost TLDs have recently been relocated to the east of the network in the NE sector.

Daily model predictions were made for 11 days on which all necessary data was available and measurable absorbed dose was obtained. Figure 31 shows the comparison of predicted and measured daily gamma doses. There is a good correlation between predicted and

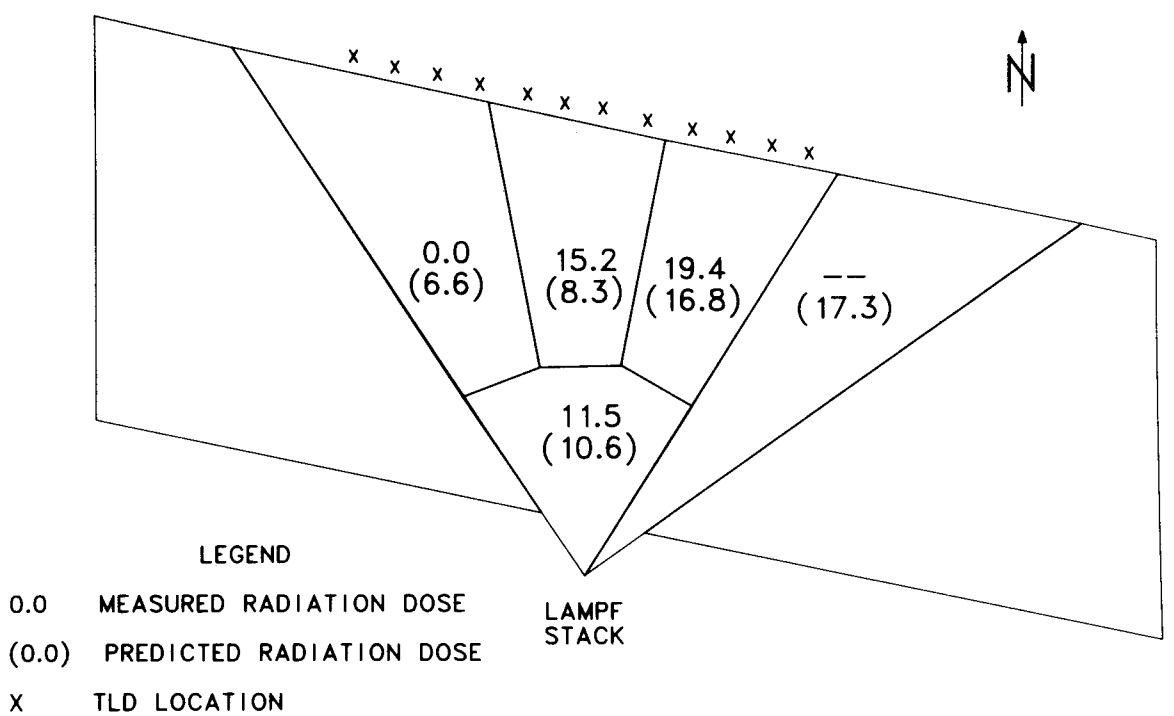


Fig. 30. Predicted versus measured radiation dose (mRad) from the Los Alamos Meson Physics Facility's airborne emissions, by sector, for June through December 1982.

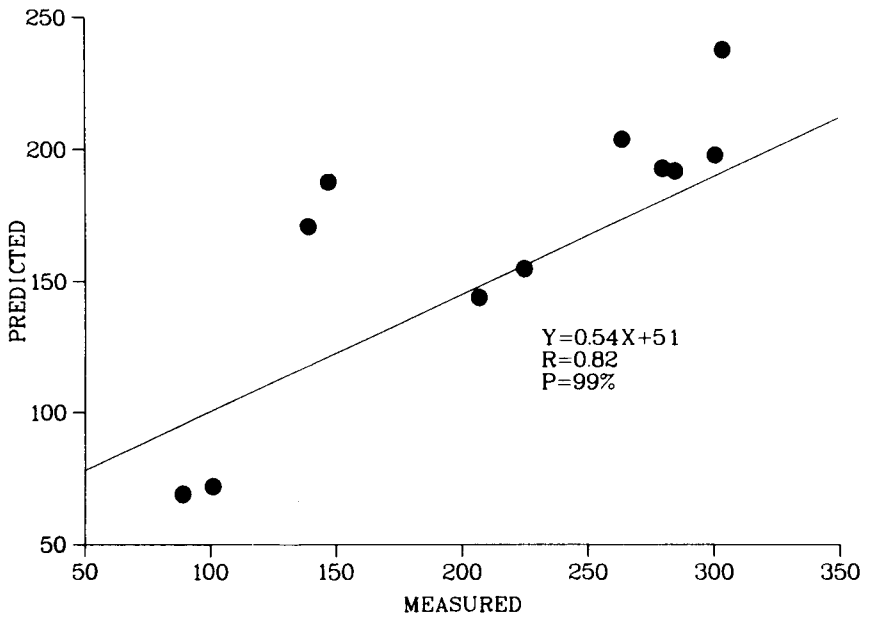


Fig. 31. Predicted versus measured daily gamma doses (μRad).

measured values. Note that the model underpredicts in 9 of the 11 days, so that some refinement of the model may be necessary for application in the irregular terrain at Los Alamos.

3. Summary and Conclusions

A network of monitors measuring gamma radiation for short- and long-time periods were used with meteorological and source-term data to predict gamma radiation emitted by air activation products released from LAMPF. Long-term predictions tend to agree with measurements. However, the spatial variability of background external penetrating radiation is larger than the contribution of the source, thereby putting some uncertainty in the results. The predicted values are shown to be strongly correlated with measured daily values.

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APPENDIX A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

The concentrations of radioactive and chemical contaminants in air and water samples collected throughout the environment are compared with pertinent standards contained in regulations of several federal and state agencies in order to verify the Laboratory's compliance with these standards. Laboratory operations pertaining to the environment are conducted in accordance with directives and procedures contained in DOE Order 5480.1A (Environmental Protection, Safety, and Health Protection Program for DOE Operations), Chapter I (Environmental Protection, Safety, and Health Protection Standards) and Chapter XI (Requirements for Radiation Protection); and DOE Order 5484.1 (Environmental Protection, Safety, and Health Protection Information Reporting Requirements), Chapter III (Effluent and Environmental Monitoring Program Requirements).

In the case of radioactive materials in the environment, guides contained in Chapter XI are used as a basis for evaluation. The standards are listed in Table A-I as Concentration Guides (CGs). A CG is the concentration of radioactivity in air breathed continuously or water constituting all that ingested during 50 years that will result in whole body or organ doses equal to the Radiation Protection Standards in the fiftieth year (RPSs, listed in Table A-II) for internal and external exposures.

Obviously, there are uncertainties in relating CGs to RPSs. Uncontrolled area CGs correspond to RPSs for the general public, whereas controlled area CGs correspond to RPSs for workers. Thus, common practice and stated DOE policy in Chapter XI are that operations shall be "conducted in a manner to assure that radiation exposure to individuals and population groups is limited to the lowest levels reasonably achieveable."

Because some radioisotopes remain in the body and cause exposure long after intake has occurred, the RPSs require consideration of dose commitment caused by inhalation, ingestion, or absorption of such isotopes. For purposes of this report, 50-yr dose commitments were calculated where appropriate using dose factors from reference A1.

For chemical pollutants in water supply, the controlling standards are those promulgated by either the Environmental Protection Agency (EPA) or the New Mexico Environmental Improvement Division (NMEID, see Table A-III). EPA's primary maximum contaminant level (MCL) is the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system.[A2]

The EPA's secondary drinking water regulations control contaminants in drinking water that primarily affect aesthetic qualities relating to public acceptance of drinking water. At considerably higher concentrations of these contaminants, health implications may also exist as well as aesthetic degradations.[A3]

Radioactivity in public water supply is governed by EPA regulations contained in 40CFR141. These regulations provide that combined ^{226}Ra and ^{228}Ra shall not exceed 5×10^{-9} μCi/mℓ (5 pCi/ℓ) and gross alpha activity (including ^{226}Ra, but excluding radon and uranium) shall not exceed 15×10^{-9} μCi/mℓ (15 pCi/ℓ). A screening level of 5×10^{-9} μCi/mℓ (5 pCi/ℓ) is established as part of the monitoring requirements to determine whether specific radium analyses must be performed. Plutonium concentrations are compared to the EPA gross alpha MCL of 15×10^{-9} μCi/mℓ (15 pCi/ℓ).[A2]

For manmade beta and photon emitting radionuclides, the EPA drinking water regulations specify that a concentration be limited to a level that would result in a dose of 4 mrem/yr calculated according to a specified procedure. The EPA calculated value for tritium (^{3}H) is 20×10^{-6} μCi/mℓ and for cesium (^{137}Cs) is 200×10^{-9} μCi/mℓ[A2]

TABLE A-I

DOE CONCENTRATION GUIDES (CGs)

Concentration Guides for Uncontrolled Areas[a,b]

Nuclide	CG for Air (μCi/mℓ)	CG for Water (μCi/mℓ)
^{3}H	2×10^{-7}	3×10^{-3}
^{7}Be	---	2×10^{-3}
$^{11}C, ^{13}N, ^{15}O$	3×10^{-8}	---
^{41}Ar	4×10^{-8}	---
^{89}Sr	3×10^{-10}	3×10^{-6}
^{90}Sr[d]	3×10^{-11}	3×10^{-7}
^{131}I[d]	1×10^{-10}	3×10^{-7}
^{137}Cs	5×10^{-10}	2×10^{-5}
^{238}Pu	7×10^{-14}	5×10^{-6}
^{239}Pu[d]	6×10^{-14}	5×10^{-6}
^{241}Am	2×10^{-13}	4×10^{-6}
	(pg/m^3)[c]	
U, natural[c]	6×10^{6}	6×10^{-7}

Concentration Guides for Controlled Areas[a,b]

Nuclide	CG for Air (μCi/mℓ)	CG for Water (μCi/mℓ)
^{3}H	5×10^{-6}	1×10^{-1}
^{7}Be	---	5×10^{-2}
$^{11}C, ^{13}N, ^{15}O$	1×10^{-6}	---
^{41}Ar	2×10^{-6}	---
^{89}Sr	3×10^{-8}	3×10^{-4}
^{90}Sr	1×10^{-9}	1×10^{-5}
^{131}I[d]	4×10^{-9}	3×10^{-5}
^{137}Cs	1×10^{-8}	4×10^{-4}
^{238}Pu	2×10^{-12}	1×10^{-4}
^{239}Pu[d]	2×10^{-12}	1×10^{-4}
^{241}Am	6×10^{-12}	1×10^{-4}
	(pg/m^3)[c]	
U, natural[c]	1.8×10^{8}	2×10^{-5}

---

[a]This table contains the most restrictive CGs for nuclides of major interest at the Laboratory (DOE Order 5480.1A, Chapter XI).

[b]CGs apply to radionuclide concentrations in excess of that occurring naturally or due to fallout.

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

[d]The CGs of ^{239}Pu and ^{90}Sr are the most appropriate to use for gross alpha and gross beta CGs, respectively.

TABLE A-II

DOE RADIATION PROTECTION STANDARDS FOR EXTERNAL AND INTERNAL EXPOSURES

Individuals and Population Groups in Uncontrolled Areas

Type of Exposure	Annual Dose Equivalent or Dose Commitment[a] (rem): Based on Dose to Individuals at Points of Maximum Probable Exposure	Annual Dose Equivalent or Dose Commitment[a] (rem): Based on an Average Dose to a Suitable Sample of the Exposed Population[b]
Whole body, gonads, or bone marrow	0.5	0.17
Other organs	1.5	0.5

Individuals in Controlled Areas

Type of Exposure	Exposure Period	Dose Equivalent [Dose or Dose Commitment[a] (rem)]
Whole body, head and trunk, gonads, lens of the eyes,[c] red bone marrow, active blood forming organs.	Year	5 [d]
	Calendar Quarter	3
Unlimited areas of the skin (except hands and forearms). Other organs, tissues, and organ systems (except bone).	Year	15
	Calendar Quarter	5
Bone	Year	30
	Calendar Quarter	10
Forearms[e]	Year	30
	Calendar Year	10
Hands[e] and feet	Year	75
	Calendar Quarter	25

[a]In keeping with the DOE policy on lowest practicable exposure, exposures to the public shall be limited to as small a fraction of the respective annual dose limits as is practicable.

[b]See Paragraph 5.4, FRC Report No. 1 (Reference A4) for discussion on concept of suitable sample of exposed population.

[c]A beta exposure below a maximum energy of 700 keV will not penetrate the lens of the eye; therefore, the applicable limit for these energies would be that for the skin (15 rem/year).

[d]In special cases with the approval of the Deputy Assistant Secretary for Environmental Safety and Health, a worker may exceed 5 rem/year provided his or her average exposure per year since age 18 will not exceed 5 rem/year. This does not apply to emergency situations.

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

TABLE A-III

MAXIMUM CONTAMINANT LEVEL (MCL) IN WATER SUPPLY FOR INORGANIC CHEMICALS AND RADIOCHEMICALS[a]

Inorganic Chemical Contaminant	MCL (mg/ℓ)	Radiochemical Contaminant	MCL (μCi/mℓ)
	Primary Standard[a]		
Ag	0.05	^{137}Cs	200×10^{-9}
As	0.05	Gross alpha[d]	5×10^{-9}
Ba	1.0	^{3}H	20×10^{-6}
Cd	0.010	^{238}Pu	15×10^{-9}
Cr	0.05	^{239}Pu	15×10^{-9}
F[b]	2.0		
Hg	0.002		
NO_3	45		
Pb	0.05		
Se	0.01		
	Secondary Standards[c]		
Cℓ	250		
Cu	1.0		
Fe	0.3		
Mn	0.05		
SO_4	250		
Zn	5.0		
TDS	500		
pH	6.5 - 8.5		

[a]Reference A2.
[b]Based on annual average of the maximum daily air temperature of 14.6 to 17.7°C.
[c]Reference A3.
[d]See text for discussion of application of gross alpha MCL and gross alpha screening level of 5×10^{-9} μCi/mℓ.

REFERENCES

A1. US Department of Energy, "A Guide for Environmental Radiological Surveillance at U.S. Department of Energy Installations," US Department of Energy report DOE/EP-0023 (July 1981).

A2. Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," EPA-570/9-76-003, U.S. Govt Printing Office, Washington, DC (1976).

A3. Environmental Protection Agency, "National Secondary Drinking Water Regulations," Federal Register **44** (140) (July 19, 1979).

A4. Federal Radiation Council (FRC), "Background Material for the Development of Radiation Protection Standards," FRC Report No. 1, Washington, DC (1960).

APPENDIX B

SAMPLING PROCEDURES AND STATISTICAL TREATMENT OF DATA

A. Thermoluminescent Dosimeters

Lithium fluoride (LiF) chips, 6.4 mm square by 0.9 mm thick, are used in the environmental and Los Alamos Meson Physics Facility (LAMPF) networks. The chips are annealed at 400°C for 1 h and then cooled rapidly to room temperature. This is followed by annealing at 100°C for 1 h and again cooling rapidly to room temperature. In order for the annealing conditions to be repeatable, the chips are put into rectangular borosilicate glass vials that hold 48 LiF chips each. These vials are slipped into a borosilicate glass rack so they all can be placed at once into the ovens maintained at 400°C and 100°C.

Incandescent lighting is used exclusively during all phases of annealing, dosimeter preparation, and readout to prevent ultraviolet-induced spurious thermoluminescence (TL). Four chips are placed in a molded heat sealable vinyl pouch measuring 1.5 cm diameter by 3 cm long. This assembly constitutes one dosimeter. A calibration set is prepared each time chips are annealed. The calibration set is read at the start of the dosimetry cycle. The number of dosimeters and exposure levels are determined for each calibration in order to efficiently use available TLD chips and personnel. Each set contains from 20 to 50 dosimeters. These are irradiated at levels in the range between 0 mR and 160 mR. using an 8.5 mCi ^{137}Cs source calibrated by the National Bureau of Standards.

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

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

B. Air Sampling

1. Sampling Procedures

Samples are collected monthly at 25 continuously operating stations.[B4] Air pumps with flow rates of approximately 3 ℓ/sec are used. Atmospheric aerosols are collected on 79 mm diameter polystyrene filters. The filters are mounted on a cartridge that contains charcoal. This charcoal is not routinely analyzed for radionuclides. However, if an unplanned release occurs, the charcoal can be analyzed for any ^{131}I it may have collected. Part of the total air flow (2.4 – 3.1 mℓ/sec) is passed through a cartridge containing silica gel to adsorb atmospheric water vapor for tritium analyses. Air flow rates through both sampling cartridges are measured with variable-area flow meters, and sampling times recorded. The entire air sampling train at each station is cleaned, repaired, and calibrated on an as-needed basis.

Gross alpha and gross beta activities on the monthly air filters are measured with a gas-flow proportional counter on collection day and again 7 to 10 days after collection. The first count is used to screen samples for inordinate activity levels. The second count (made after absorbed, naturally-occurring, radon-thoron daughters had reached equilibrium with their long-lived parents) provides a record of long-lived atmospheric radioactivity. Immediately upon being retrieved from the field,

the filters are mounted on counting planchets and covered with mylar. This insures adequate sample preservation.

Two clean, control filters are used to detect any possible contamination of the 25 sampling filters while they are in transit. The control filters accompany the 25 sampling filters when they are placed in the air samplers and when they are retrieved. Then the control filters are analyzed for radioactivity just like the 25 sampling filters. Analytical results for the control filters are subtracted from the appropriate gross analytical results to obtain net analytical results.

At one location (N050-E040) atmospheric radioactivity samples are collected daily (Monday through Friday). Atmospheric particulate matter on each daily filter is counted for gross alpha and gross beta activities on collection day and again 7 to 10 days after collection. The first measurement provides an early indication of any major change in atmospheric radioactivity. The second measurements are used to observe temporal variations in long-lived atmospheric radioactivity.

After being measured for gross alpha and gross beta activities, the monthly filters for each station are cut in half. The first group of filter halves is then combined and dissolved to produce quarterly composite samples for each station. The second group of filter halves is saved for uranium analysis.

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

Silica gel cartridges from the 25 air sampling stations are analyzed monthly for tritiated water. The cartridges contain a small amount of blue "indicating" gel at each end to indicate a desiccant over-saturation. During cold months of low absolute humidity, sampling flow rates are increased to ensure collection of enough water vapor for analysis. To avoid sample preservation problems, water is distilled from each silica gel sample immediately upon being retrieved from the field. This distillation yields a monthly average atmospheric water vapor sample. An aliquot of the distillate is then analyzed for tritium by liquid scintillation counting.

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

2. Statistical Analysis

Measurements of the air particulate samples require that chemical or instrumental backgrounds be subtracted to obtain net values. Thus, net values lower than the minimum detection limit (MDL, Table C-IV) of an analytical technique are sometimes obtained. Consequently, individual measurements result in values of zero or negative numbers because of statistical fluctuations in the measurements. 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[B5] are included in the population.

Uncertainties reported for maximum and minimum concentrations reflect uncertainties introduced both in the field (flow rate and time determinations), and laboratory (counting, pipetting, etc.). These values indicate the precision of the maximums and minimums and represent twice the propagated measurement uncertainties.

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

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

where

$s_{\bar{c}}$ = standard deviation of $\bar{c}$
$\bar{c}$ = annual mean of a station or group of stations
c_i = concentration for station i
N = number of concentrations (sampling periods).

C. Water, Soil, and Sediment Sampling

Surface and ground water sampling points are grouped (regional, perimeter, and onsite) according to location and hydrologic similarity. Surface and ground water grab samples are taken one to two times annually. Samples from wells are collected after sufficient pumpage or bailing to ensure that the sample is representative of the water in the aquifer. Spring samples (ground water) are collected at point of discharge.

The water samples are collected in 4 ℓ (for radiochemical) and 1 ℓ (for chemical) polyethylene bottles. The 4 ℓ bottles are acidified in the field with 5 mℓ of concentrated nitric acid and returned to the laboratory within a few hours for filtration through a 0.45 μm pore membrane filter. The samples are analyzed radiochemically for dissolved cesium (^{137}Cs), plutonium (^{238}Pu and ^{239}Pu), and tritium (as HTO), as well as for total dissolved gross alpha, beta, and gamma activities. Total uranium is measured using the neutron activation method (see Appendix C).

Water is collected for chemical analyses at the same time as for radiochemical analysis and returned to the laboratory for filtration. Samples for trace constituents in the water supply are collected and acidified in the field and returned immediately to the laboratory for filtration.

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

Soil samples are collected by taking five plugs, 75 mm in diameter and 50 mm deep, at the center and corners of a square area 10 m on a side. The five plugs are combined to form a composite sample for radiochemical analyses. Sediment samples are collected from dune buildup behind boulders in the main channels of perennially flowing streams. Samples from the beds of intermittently flowing streams are collected across the main channel. The soil and sediment samples are analyzed for gross alpha and gross beta activities, ^{137}Cs and ^{238}Pu and ^{239}Pu. Moisture distilled from soil samples is analyzed for ^{3}H. A few select samples are analyzed for ^{90}Sr.

The average concentrations of radionuclides and chemical constituents are reported for a number of individual analyses in Tables E-XI through E-XIX and Tables E-XXI through E-XXIII. The minimum and maximum values reported are individual analyses in the groups, while the average is computed from all of the individual analyses in the group. The uncertainty following the primary value represents twice the standard deviation of the distribution of observed values, or the analytical variation for individual results.

REFERENCES

B1. H. E. John and J. R. Cunningham, *The Physics of Radiobiology*, 3rd edition. (C. C. Thomas, Springfield, Illinois, 1974) and International Commission on Radiological Protection (ICRP), "Protection Against Ionizing Radiation from External Sources," ICRP Report No. 15 (Pergamon Press, New York, 1970).

B2. P. R. Bevington, *Data Reduction and Error Analysis for the Physical Sciences* (McGraw-Hill, New York, 1969).

B3. National Bureau of Standards Handbook 91, *Experimental Statistics* (National Bureau of Standards, August 1, 1963).

B4. T. C. Gunderson, "Environmental and Emergency Response Capabilities of Los Alamos Scientific Laboratory's Radiological Air Sampling Program," Los Alamos Scientific Laboratory report LA-8379-MS (May 1980).

B5. R. O. Gilbert, *Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group*, BNWL-B-368, Battelle, Pacific Northwest Laboratories, Richland, Washington, September 1975.

APPENDIX C

ANALYTICAL CHEMISTRY METHODOLOGY

A. Radioactive Constituents

Environmental samples are routinely analyzed for the following radioactive constituents: gross alpha, gross beta, gross gamma, isotopic plutonium, americium, uranium, cesium, tritium, and strontium. The detailed procedures have been published in this appendix in previous years.[C1,C2] Occasionally other radionuclides from specific sources are determined: ^{7}Be, ^{22}Na, ^{40}K, ^{51}Cr, ^{60}Co, ^{65}Zn, ^{83}Rb, ^{106}Ru, ^{134}Cs, ^{140}Ba, and ^{226}Ra. All but ^{226}Ra are determined by gamma-ray spectrometry on large Ge(Li) detectors. Depending upon the concentration and matrix, ^{226}Ra is measured by emanation[C3] or by gamma-ray spectrometry of its ^{214}Bi decay product.[C4] Uranium isotopic ratios ($^{235}U/^{238}U$) are measured by neutron activation analysis where precisions of $\pm 5\%$ are adequate.[C5] More precise work still requires mass spectrometry.

B. Stable Constituents

A number of analytical methods are used for various stable elements. The choice of method is based on many criteria, including the operational state of the instruments, 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, ion selective electrodes, and combustion analysis. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capabilities include flame, graphite, mercury cold vapor, and hydride generation, as well as flame emission spectrophotometry. The methods used and references for determination of various chemical constituents are summarized in Table C-I.

C. Analytical Chemistry Quality Evaluation Program

1. Introduction

Control samples are analyzed in conjunction with the normal analytical chemistry work load. Such samples consist of several general types: calibration standards, reagent blanks, process blanks, matrix blanks, duplicates, and standard reference materials. Analysis of control samples fill two needs in the analytical work. First, they provide quality control over analytical procedures so that problems that might occur can be identified and corrected. Secondly, data obtained from analysis of control samples permit evaluation of the capabilities of a particular analytical technique for determination of a given element or constituent under a certain set of circumstances. The former function is analytical control; the latter is quality assurance.

No attempt is made to make control samples unknown to the analyst. However, they are submitted to the laboratory at regular intervals and analyzed in association with other samples; that is, they are not normally handled as a unique set of samples. We feel it would be difficult for analysts to give the samples special attention, even if they were so inclined. We endeavor to run at least 10% of stable constituent analyses and selected radioactive constituent analyses as quality assurance samples using the materials described above. A detailed description of our Quality Assurance program and a complete listing of our annual results have been published.[C56,C57,C58 C59,C60]

2. Radioactive Constituents

Quality control and quality assurance samples for radioactive constituents are obtained from outside agencies as well as prepared internally. The Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA—Las Vegas) provides water,

TABLE C-I

ANALYTICAL METHODS FOR VARIOUS STABLE CONSTITUENTS

Technique	Stable Constituents Measured	References
Standard Chemical Methods	pH, Total Alkalinity, Hardness, $SO_4^{=}$, TDS, Conductivity,COD	C6
Color Spectrophotometry	NO_3^-,$PO_4^{=}$	C6
Neutron Activation		
Instrumental Thermal	Al,Sb,As,Ba,Br,Ca,Ce,Cs,Cl,Cr, Co,Dy,Eu,Au,Hf,In,I,Fe,La,Lu, Mg,Mn,K,Rb,Sm,Sc,Se,Na,Sr,S, Ta,Tb,Th,Ti,W,V,Yb,Zn	C7,12,13,14,15
Instrumental Epithermal	Al,Sb,As,Ba,Br,Cs,Cr,F,Ga,Au, In,I.La,Mg,Mn,Mo,Ni,K,Sm,Se, Si,Na,Sr,Th,Ti,W,U,Zn,Zr	C7,9,16,17,18,19,20,21
Thermal Neutron Capture Gamma Ray	Al,B,Ca,Cd,C,Gd,H,Fe,Mg N,P,K,Si,Na,S,Ti	C7,22,23,24,25,26,27,28,29
Radiochemical	Sb,As,Cu,Au,Ir,Hg,Mo,Os,Pd Pt,Ru,Se,Ag,Te,Th,W,U,La,Ce, Pr,Nd,Sm,Eu,Gd,Tb,Dy,Ho,Er, Yb,Lu,$^{235}U/^{238}U$, ^{238}Pu, ^{239}Pu	C5,6,7,30,31,32,33,34,35,36, 37,38,51
Delayed Neutron Assay	U	C7,8,10,11,39,40
Atomic Absorption	Sb,As,Ba,Be,Bi,Cd,Ca,Cr,Co,Cu Ga,In,Fe,Pb,Li,Mg,Mn,Hg,Mo, Ni,K,Se,Si,Ag,Na,Sr,Te,Tl,Sn, Ti,V,Zn	C6,41,43,44,45,46,47,48,52, 53,54
Ion Chromatography	F^-,Cl^-,Br^-,NO_2^-, NO_3^-,SO_6^{-2},SO_4^{-2}, PO_4^{-3}	C49
Ion Selective Electrodes	F^-,NH_4^+	C50,C55
Combustion	C,N,H,S	C29

foodstuff, and air filter standards for analysis of gross alpha, gross beta, ^{3}H, ^{40}K, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{106}Ru, ^{134}Cs, ^{137}Cs, ^{226}Ra, and ^{239}Pu as part of an ongoing laboratory intercomparison program. They also distribute reference soil samples that have been characterized for ^{235}U, ^{238}U, ^{228}Th, ^{230}Th, ^{232}U, ^{226}Ra, ^{228}Ra, and ^{210}Pb. The National Bureau of Standards (NBS) provides two soil and sediment Standard Reference Materials (SRM) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{230}Th, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and several other nuclides.

Soil, rock, and ore samples obtained from the Canadian Geological Survey are used for quality assurance of uranium and thorium determinations in silicate matrices.[C61] Our own "in-house" standards are prepared by adding known quantities of liquid NBS radioactivity SRMs to blank matrix materials.

3. Stable Constituents

Quality assurance for the stable constituent analysis program is maintained by analysis of certified or well-characterized environmental materials. The NBS has a large set of silicate, water, and biological SRMs. The EPA distributes mineral analysis and trace analysis water standards. Rock and soil certified standards have been obtained from the CGS and the United States Geological Survey (USGS). Details of this program have also been published.[C56,C57,C58,C59,C60]

The analytical control program for a specific batch of samples is the combination of many factors. These include the "fit of the calibration curve," instrument drift, calibration of the instrument and/or reagents, recovery for SRMs, and precision of results. In addition, there is a need for a program for evaluation of the quality of results for an individual water sample. These individual water sample quality ratios are the sum of the milliequivalent (meq) cations to the sum of meq anions, the meq hardness to the sum of meq Ca^{++} and Mg^{+4}, the observed total dissolved solids (TDS) to the sum of solids, the observed conductivity to the sum of contributing conductivities, as well as the two ratios obtained by multiplying (0.01) × (conductivity) and dividing by the meq cations, and the meq anions. A summary of these ratios is given for 1982 waters by sample set in Table C-II.

A detailed investigation of these individual quality assurance ratios can be suggestive of the need for reanalysis of specific constituents. However, one must realize that obtaining a ratio of 1.00 is not always possible. Reanalysis of a sample is based on these ratios, the presence of constituents not requested, and historical considerations.

4. Indicators of Accuracy and Precision

Accuracy is the degree of difference between average test results and true results, when the latter are known or assumed. Precision is the degree of mutual agreement among replicate measurements (frequently assessed by calculating the standard deviation of a set of data points). Accuracy and precision are evaluated from results of analysis of standards. These results are normalized to the known quantity in the standard to permit comparison between standards containing different quantities 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 samples):

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

The standard deviation (s) of R is calculated assuming a normal distribution of the population of samples (N).

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

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

The standard deviation is a measure of precision. Precision is a function of the quantity of analyte; that is, as the absolute quantity approaches the limit of detection, precision deteriorates. For instance, the precision for some ^{3}H determinations is quite large because many standards approached the limits of detection of a measurement. We are attempting to address this issue by calculating a new quality assurance parameter:

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

TABLE C-II

INDIVIDUAL SAMPLE WATER QUALITY ASSURANCE RATIOS

[meq Cation/meq Anion] Ratio

Sample Set	Number of Samples	Average Ratio	s	Number of Outliers[a]
1	13	0.968	0.0622	1
2	3	0.949	0.0104	0
3	3	0.905	0.0445	1
4	26	0.976	0.0293	0

[Conductivity/Sum of Contributing Conductivities] Ratio

Sample Set	Number of Samples	Average Ratio	s	Number of Outliers[a]
1	13	0.928	0.0593	4
2	3	0.932	0.0366	1
3	3	0.910	0.0491	2
4	26	0.937	0.0242	1

[meq Hardness/Sum meq Ca + Mg] Ratio

Sample Set	Number of Samples	Average Ratio	s	Number of Outliers[a]
1	12	1.008	0.0853	1
2	3	1.022	0.0130	0
3	3	1.031	0.0156	0
4	26	0.979	0.0415	0

[0.01 Conductivity/meq Cations] Ratio

Sample Set	Number of Samples	Average Ratio	s	Number of Outliers[a]
1	13	1.019	0.0730	4
2	3	0.939	0.0344	0
3	3	0.957	0.0270	0
4	26	0.923	0.0265	2

[TDS/Sum of Solids] Ratio

Sample Set	Number of Samples	Average Ratio	s	Number of Outliers[a]
1	13	0.976	0.153	3
2	3	1.052	0.019	0
3	3	1.052	0.109	1
4	26	0.951	0.0766	9

[0.01 Conductivity/meq Anions] Ratio

Sample Set	Number of Samples	Average Ratio	s	Number of Outliers[a]
1	13	0.976	0.153	3
2	3	0.892	0.022	1
3	3	0.866	0.037	2
4	26	0.9013	0.037	16

[a]Outliers are defined as having a ratio outside 1.00 ± 0.10.

TABLE C-III

SUMMARY OF ANALYTICAL QUALITY ASSURANCE RESULTS FOR STABLE CONSTITUENTS AND SELECTED RADIOACTIVE CONSTITUENTS

Analysis	Silicates [R ± s (N)]	Waters [R ± s (N)]	Biologicals and Air Particulates [R ± s (N)]
Ag	---	1.00 ± 0.07 (7)	---
Al	0.98 ± 0.02 (8)	---	0.98 ± 0.07 (17)
As	1.01 ± 0.06 (5)	0.96 ± 0.11 (13)	0.97 ± 0.33 (5)
Ba	1.01 ± 0.12 (37)	1.03 ± 0.13 (5)	---
Br	---	---	0.93 ± 0.08 (21)
Ca	0.98 (2)	1.04 ± 0.03 (6)	1.01 ± 0.16 (12)
Cd	0.92 ± 0.16 (38)	1.05 ± 0.23 (103)	0.91 ± 0.15 (29)
Cl	---	1.01 ± 0.04 (29)	1.03 ± 0.07 (20)
Co	1.04 ± 0.06 (24)	---	---
Cond	---	0.98 ± 0.04 (14)	---
Cr	0.98 ± 0.09 (31)	0.99 ± 0.06 (7)	---
Cs	0.99 ± 0.15 (94)	---	1.12 ± 0.15 (15)
Cu	0.97 ± 0.09 (12)	1.06 ± 0.06 (25)	0.98 ± 0.06 (13)
Eu	0.98 ± 0.06 (31)	---	---
F	0.99 ± 0.10 (8)	1.01 ± 0.05 (5)	1.03 ± 0.22 (27)
Fe	1.00 ± 0.03 (35)	1.00 ± 0.08 (35)	---
Hard	---	1.00 ± 0.03 (4)	---
Hf	0.99 ± 0.11 (35)	---	---
Hg	1.25 (2)	1.06 ± 0.06 (6)	0.70 (2)
I	---	---	1.05 ± 0.13 (6)
K	0.96 ± 0.06 (9)	0.99 ± 0.02 (4)	0.90 ± 0.13 (4)
La	0.98 ± 0.07 (10)	---	---
Li	1.08 ± 0.13 (32)	---	0.96 ± 0.11 (12)
Mg	0.93 ± 0.06 (11)	1.04 ± 0.06 (6)	---
Mn	1.03 ± 0.05 (46)	1.02 ± 0.07 (32)	1.01 ± 0.05 (21)
Na	1.04 ± 0.05 (21)	0.99 ± 0.03 (6)	0.99 ± 0.17 (13)
NO_3	---	1.05 ± 0.12 (17)	---
P	0.92 ± 0.10 (8)	---	---
Pb	---	1.00 ± 0.07 (26)	0.90 ± 0.04 (9)
pH	---	0.98 ± 0.04 (11)	---
PO_4	---	0.78 ± 0.07 (6)	---
Rb	1.06 ± 0.09 (18)	---	---
Sb	1.26 (1)	---	0.99 ± 0.12 (50)
Sc	0.99 ± 0.05 (170)	---	0.95 ± 0.08 (25)
Se	---	0.96 ± 0.09 (8)	---
Si	1.01 ± 0.06 (6)	---	---
Sm	1.01 ± 0.09 (10)	---	---
SO_4	---	1.00 ± 0.14 (11)	---
Sr	1.03 ± 0.08 (33)	0.99 (2)	---
Ta	0.90 ± 0.11 (16)	---	---
Tb	1.07 ± 0.21 (27)	---	---

TABLE C-III

Analysis	Silicates [R ± s (N)]	Waters [R ± s (N)]	Biologicals and Air Particulates [R ± s (N)]
TDS	---	0.95 ± 0.07 (25)	---
Th	1.04 ± 0.06 (19)	---	---
Ti	0.98 ± 0.09 (11)	---	---
Tot alk	---	1.07 ± 0.04 (5)	---
$^{235,238}U$ (natural)	1.01 ± 0.07 (88)	0.99 ± 0.03 (18)	1.01 ± 0.11 (25)
$^{235,238}U$ (depleted)	1.01 ± 0.06 (8)	---	---
V	---	---	1.02 ± 0.06 (11)
Zn	0.99 ± 0.06 (5)	0.95 ± 0.12 (24)	0.94 ± 0.05 (7)
^{3}H (<2000 pCi/ℓ)	---	1.05 ± 0.25 (73)	---
^{3}H (>2000 pCi/ℓ)	---	0.99 ± 0.08 (99)	---
^{7}Be	---	0.95 ± 0.12 (17)	---
^{22}Na	1.07 ± 0.08 (11)	1.11 ± 0.13 (9)	---
^{137}Cs	1.04 ± 0.16 (41)	1.02 ± 0.17 (48)	---
^{230}Th	1.00 (2)	---	---
^{238}Pu	0.77 ± 0.41 (13)	---	---
^{239}Pu	0.90 ± 0.18 (22)	---	---
^{241}Am	1.27 ± 0.55 (7)	---	---

TABLE C-IV

SUMMARY OF RADIOACTIVE CONSTITUENT QUALITY ASSURANCE RESULTS ON EPA PROGRAMS

Constituent	Number of Samples	R ± s
Gross alpha	24	1.14 ± 0.22
Gross beta	24	1.12 ± 0.12
^{3}H (<2000 pCi/ℓ)	15	0.95 ± 0.13
^{90}Sr	6	0.95 ± 0.11
^{137}Cs	15	0.97 ± 0.16
^{226}Ra	12	0.86 ± 0.07
^{239}Pu	6	0.96 ± 0.05
U (natural)	12	0.86 ± 0.23

TABLE C-V

DETECTION LIMITS FOR ANALYSES OF TYPICAL ENVIRONMENTAL SAMPLES

Parameter	Approximate Sample Volume or Weight	Count Time	Detection Limit Concentration
Air Sample			
Tritium	3 m^3	50 min	1×10^{-12} μCi/mℓ
^{238}Pu	2.0×10^4 m^3	8×10^4 sec	2×10^{-18} μCi/mℓ
^{239}Pu	2.0×10^4 m^3	8×10^4 sec	3×10^{-18} μCi/mℓ
^{241}Am	2.0×10^4 m^3	8×10^4 sec	2×10^{-18} μCi/mℓ
Gross alpha	6.5×10^3 m^3	100 min	3×10^{-16} μCi/mℓ
Gross beta	6.5×10^3 m^3	100 min	3×10^{-16} μCi/mℓ
Uranium (Delayed neutron)	2.0×10^4 m^3	60 sec	1 pg/m^3
Water Sample			
Tritium	0.005 ℓ	50 min	7×10^{-7} μCi/mℓ
^{137}Cs	0.5 ℓ	5×10^4 sec	4×10^{-8} μCi/mℓ
^{238}Pu	0.5 ℓ	8×10^4 sec	9×10^{-12} μCi/mℓ
^{239}Pu	0.5 ℓ	8×10^4 sec	3×10^{-11} μCi/mℓ
^{241}Am	0.5 ℓ	8×10^4 sec	2×10^{-10} μCi/mℓ
Gross alpha	0.9 ℓ	100 min	1×10^{-9} μCi/mℓ
Gross beta	0.9 ℓ	100 min	5×10^{-9} μCi/mℓ
Uranium (Delayed neutron)	0.025 ℓ	50 sec	1 μg/ℓ
Soil Sample			
Tritium	1 kg	50 min	0.003 pCi/g
^{137}Cs	100 g	5×10^4 sec	10^{-1} pCi/g
^{238}Pu	10 g	8×10^4 sec	0.003 pCi/g
^{239}Pu	10 g	8×10^4 sec	0.002 pCi/g
^{241}Am	10 g	8×10^4 sec	0.01 pCi/g
Gross alpha	2 g	100 min	0.8 pCi/g
Gross beta	2 g	100 min	0.003 pCi/g
Uranium (Delayed neutron)	2 g	20 sec	0.03 μg/g

where $\overline{X}_E$ and $\overline{X}_c$ are the experimentally determined and certified/consensus mean elemental concentrations, respectively. The S_E and S_c parameters are the standard deviations associated with $\overline{X}_E$ and $\overline{X}_c$, respectively. An analysis will be considered under control when this condition is satisfied for a certain element in a given matrix. An evaluaton of this approach will be presented in the 1982 Quality Assurance Report.[C59]

Data on analytical detector limits are in Table C-V.

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APPENDIX D

METHODS FOR DOSE CALCULATIONS

A. Introduction

Annual radiation doses are evaluated for three principal exposure pathways: inhalation, ingestion, and external exposure (which includes exposure from immersion in air containing radionuclides and direct and scattered penetrating radiation). Results of environmental measurements are used as much as possible. Calculations based on these measurements follow procedures recommended by federal agencies to determine radiation doses.[D1,D2]

Estimates are made of the:

1. Maximum boundary dose to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs. It assumes the individual is at the Laboratory boundary continuously (24 hours a day, 365 days a year).
2. Maximum individual dose to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where there is a person. It takes into account occupancy (for example, 40 hours a week) and shielding (for example, by buildings) factors.
3. Average doses to nearby residents.
4. Whole body person-rem dose for the population living within an 80-km radius of the Laboratory.

Four age groups are considered: infant, child, teen, and adult. Dose calculations utilize parameters such as annual food consumption and breathing rates specific to each age group. Values[D2,D3] provided for these and other parameters used in the calculations are in Table D-I.

Age specific dose conversion factors used for inhalation and ingestion calculations are in Table D-II. These factors give total dose received (in mrem) by an organ during the 50-yr period following intake of a radionuclide (the 50-yr dose commitment) per amount of radionuclide (in pCi) either inhaled or ingested.[D4]

All dose conversion factors (except those for ^{7}Be) were taken from Hoenes and Soldat.[D5] The ^{7}Be dose conversion factors, which were not published by Hoenes and Soldat,[D5] were taken from values recommended by the International Commission on Radiological Protection.[D6]

Table D-III also lists a second set of dose conversion factors based on the dose (in mrem) received in the first year, rather than the 50-yr dose commitment. Procedures for calculating doses using these two sets of dose conversion factors are identical. The first set gives total dose incurred during the 50th year following intake; the second gives dose received in the first year. Dose estimates in the text are identified as to which type of dose they represent.

B. Inhalation Dose

Annual average air concentrations of ^{3}H, ^{238}Pu, ^{239}Pu, ^{241}Am, and total U, determined by H-8's air monitoring network, are corrected for background by subtracting the average concentrations measured at regional stations. These net concentrations are then multiplied by standard breathing rates for the four age groups to determine total annual intake via inhalation, in pCi/yr, for each radionuclide. Each intake is multiplied by appropriate dose conversion factors to convert intake into 50-yr dose commitments for bone, liver, total body, thyroid, kidney, lung, and gastrointestinal (GI) tract. First year dose is estimated for bone, total body, thyroid, lung, and GI tract. Organs chosen for dose calculations include those expected to receive the largest dose from the radionuclides being considered. Parameters used in the calculations are in Tables D-I, D-II, and D-III. As noted in Tables D-II and D-III, dose conversion factors for ^{3}H include an increase of 1.5 over inhalation intake to account for skin absorption.

This procedure for dose calculation conservatively assumes that a hypothetical individual is exposed to the measured air concentration continuously throughout the entire year (8736 h). This assumption is made for the boundary dose, dose to the maximum exposed individual, and dose to the population living within 80 km of the site.

Organ doses are determined at sampling sites for each radionuclide. A final calculation estimates the total inhalation dose to an organ by summing doses to that organ from each radionuclide.

TABLE D-I

PARAMETERS USED IN DOSE ASSESSMENT

Parameter	Infant	Child	Teenager	Adult
Annual breathing rate (m^3/yr)	1400	3700	8000	8000
Food consumption rate				
Fish (kg/yr)	---	6.9	16	21
Fruits (kg/yr)	---	114	139	114
Vegetables (kg/yr)	---	281	340	281
Grain (kg/yr)	---	125	151	125
Meat and poultry (kg/yr)	---	41	65	110
Milk (ℓ/yr)	330	330	400	310
Honey (kg/yr)	---	3	5	5
Shielding factor for residential structures				0.7
Occupancy Factor				
All locations, except where noted in text				1.0
Solubility of inhaled radionuclides				
^{3}H				Soluble
Total U				Insoluble
^{238}Pu				Insoluble
$^{239,240}Pu$				Insoluble
^{241}Am				Insoluble
Number of trips, longer than one day,- taken by Laboratory personnel in 1982				16 695

TABLE D-II

AGE SPECIFIC DOSE CONVERSION FACTORS FOR 50-YR DOSE COMMITMENT

Infant Dose Conversion Factors
(mrem/50 yr per pCi intake in first year)

Radio-nuclide	Pathway	Organ: Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI[b]
^{3}H	Inhalation[a]	0.0	4.62×10^{-7}	4.62×10^{-7}	4.62×10^{-7}	4.62×10^{-7}	4.62×10^{-7}	4.62×10^{-7}
	Ingestion	0.0	3.08×10^{-7}	3.08×10^{-7}	3.08×10^{-7}	3.08×10^{-7}	3.08×10^{-7}	3.08×10^{-7}
^{90}Sr	Ingestion	1.85×10^{-2}	---	4.71×10^{-3}	---	---	---	2.31×10^{-4}
^{137}Cs	Ingestion	5.22×10^{-4}	6.11×10^{-4}	4.33×10^{-5}	0.0	1.64×10^{-4}	6.64×10^{-5}	1.91×10^{-6}
Total U	Inhalation	5.00×10^{-2}	0.0	3.52×10^{-3}	0.0	1.00×10^{-2}	3.27×10^{-1}	3.77×10^{-5}
	Ingestion	4.67×10^{-3}	0.0	3.56×10^{-4}	0.0	9.93×10^{-4}	0.0	6.08×10^{-5}
^{238}Pu	Inhalation	5.02	6.33×10^{-1}	1.27×10^{-1}	0.0	4.64×10^{-1}	9.03×10^{-1}	4.69×10^{-5}
	Ingestion	1.34×10^{-3}	1.69×10^{-4}	3.40×10^{-5}	0.0	1.21×10^{-4}	0.0	7.57×10^{-5}
^{239}Pu	Inhalation	5.50	6.72×10^{-1}	1.34×10^{-1}	0.0	4.95×10^{-1}	8.47×10^{-1}	4.28×10^{-5}
	Ingestion	1.45×10^{-3}	1.77×10^{-4}	3.54×10^{-5}	0.0	1.28×10^{-4}	0.0	6.91×10^{-5}
^{241}Am	Inhalation	1.84	8.44×10^{-1}	1.31×10^{-1}	0.0	7.94×10^{-1}	4.06×10^{-1}	4.78×10^{-5}
	Ingestion	1.53×10^{-3}	7.18×10^{-4}	1.09×10^{-4}	0.0	6.55×10^{-4}	0.0	7.70×10^{-5}

Child Dose Conversion Factors
(mrem/50 yr per pCi intake in first year)

Radio-nuclide	Pathway	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI[b]
^{3}H	Inhalation[a]	0.0	3.04×10^{-7}	3.04×10^{-7}	3.04×10^{-7}	3.04×10^{-7}	3.04×10^{-7}	3.04×10^{-7}
	Ingestion	0.0	2.03×10^{-7}	2.03×10^{-7}	2.03×10^{-7}	2.03×10^{-7}	2.03×10^{-7}	2.03×10^{-7}
^{90}Sr	Ingestion	1.70×10^{-2}	---	4.31×10^{-3}	---	--	---	2.29×10^{-4}
^{137}Cs	Ingestion	3.27×10^{-4}	3.13×10^{-4}	4.62×10^{-5}	0.0	1.02×10^{-4}	3.67×10^{-5}	1.96×10^{-6}
Total U	Inhalation	4.27×10^{-2}	0.0	2.59×10^{-3}	0.0	7.00×10^{-3}	1.63×10^{-1}	3.74×10^{-5}
	Ingestion	3.42×10^{-3}	0.0	2.07×10^{-4}	0.0	5.60×10^{-4}	0.0	6.03×10^{-5}
^{238}Pu	Inhalation	4.74	6.05×10^{-1}	1.21×10^{-1}	0.0	4.47×10^{-1}	6.08×10^{-1}	4.65×10^{-5}
	Ingestion	1.25×10^{-3}	1.56×10^{-4}	3.16×10^{-5}	0.0	1.15×10^{-4}	0.0	7.50×10^{-5}
^{239}Pu	Inhalation	5.24	6.44×10^{-1}	1.28×10^{-1}	0.0	4.78×10^{-1}	5.72×10^{-1}	4.24×10^{-5}
	Ingestion	1.36×10^{-3}	1.65×10^{-4}	3.31×10^{-5}	0.0	1.22×10^{-4}	0.0	6.85×10^{-5}
^{241}Am	Inhalation	1.74	7.85×10^{-1}	1.24×10^{-1}	0.0	7.63×10^{-1}	2.02×10^{-1}	4.73×10^{-5}
	Ingestion	1.43×10^{-3}	6.40×10^{-4}	1.02×10^{-4}	0.0	6.03×10^{-4}	0.0	7.64×10^{-5}

[a]Includes an increase of 50% to account for skin absorption.
[b]Gastrointestinal—Lower large intestine.

Teen Dose Conversion Factors
(mrem/50 yr per pCi intake in first year)

Radio-nuclide	Pathway	Organ: Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI[b]
^{3}H	Inhalation[a]	0.0	1.59×10^{-7}	1.59×10^{-7}	1.59×10^{-7}	1.59×10^{-7}	1.59×10^{-7}	1.59×10^{-7}
	Ingestion	0.0	1.06×10^{-7}	1.06×10^{-7}	1.06×10^{-7}	1.06×10^{-7}	1.06×10^{-7}	1.06×10^{-7}
^{90}Sr	Ingestion	8.30×10^{-3}	---	2.05×10^{-3}	---	---	---	2.33×10^{-4}
^{137}Cs	Ingestion	1.12×10^{-4}	1.49×10^{-4}	5.19×10^{-5}	---	5.07×10^{-5}	1.97×10^{-5}	2.12×10^{-6}
Total U	Inhalation	1.42×10^{-2}	0.0	8.66×10^{-4}	---	3.33×10^{-3}	8.43×10^{-2}	3.85×10^{-5}
	Ingestion	1.14×10^{-3}	0.0	6.93×10^{-5}	---	2.67×10^{-4}	---	6.21×10^{-5}
^{238}Pu	Inhalation	2.86	4.06×10^{-1}	7.22×10^{-2}	--	3.10×10^{-1}	3.12×10^{-1}	4.79×10^{-5}
	Ingestion	7.21×10^{-4}	1.02×10^{-4}	1.82×10^{-5}	---	7.80×10^{-5}	---	7.73×10^{-5}
^{239}Pu	Inhalation	3.31	4.50×10^{-1}	8.05×10^{-2}	---	3.44×10^{-1}	2.93×10^{-1}	4.37×10^{-5}
	Ingestion	8.27×10^{-4}	1.12×10^{-4}	2.01×10^{-5}	---	8.57×10^{-5}	---	7.06×10^{-5}
^{241}Am	Inhalation	1.06	4.07×10^{-1}	7.10×10^{-2}	---	5.32×10^{-1}	1.05×10^{-1}	4.88×10^{-5}
	Ingestion	8.62×10^{-4}	3.29×10^{-4}	5.75×10^{-5}	---	4.31×10^{-4}	---	7.87×10^{-5}

Adult Dose Conversion Factors
(mrem/50 yr per pCi intake in first year)

Radio-nuclide	Pathway	Organ: Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI[b]
^{3}H	Inhalation[a]	0.0	1.58×10^{-7}	1.58×10^{-7}	1.58×10^{-7}	1.58×10^{-7}	1.58×10^{-7}	1.58×10^{-7}
	Ingestion	0.0	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}
^{7}Be	Ingestion	5.7×10^{-9}	6.9×10^{-9}	3.4×10^{-9}	---	6.9×10^{-9}	---	1.0×10^{-6}
^{22}Na	Ingestion	1.74×10^{-5}	1.74×10^{-5}	1.74×10^{-5}	1.74×10^{-5}	1.74×10^{-5}	1.74×10^{-5}	1.74×10^{-5}
^{54}Mn	Ingestion	0.0	4.57×10^{-6}	8.72×10^{-7}	---	1.36×10^{-6}	---	1.40×10^{-5}
^{57}Co	Ingestion	0.0	1.75×10^{-7}	2.91×10^{-7}	---	---	---	4.44×10^{-6}
^{90}Sr	Ingestion	7.58×10^{-3}	---	1.86×10^{-3}	---	---	---	2.19×10^{-4}
^{134}Cs	-Ingestion	6.22×10^{-5}	1.48×10^{-4}	1.21×10^{-4}	---	4.79×10^{-5}	1.59×10^{-5}	2.59×10^{-6}
^{137}Cs	Ingestion	7.97×10^{-5}	1.09×10^{-4}	7.14×10^{-5}	---	3.70×10^{-5}	1.23×10^{-5}	2.11×10^{-6}
Total U	Inhalation	9.93×10^{-3}	0.0	6.06×10^{-4}	---	2.33×10^{-3}	4.90×10^{-2}	3.63×10^{-5}
	Ingestion	8.01×10^{-4}	0.0	4.85×10^{-5}	---	1.87×10^{-4}	---	5.86×10^{-5}
^{238}Pu	Inhalation	2.74	3.87×10^{-1}	6.90×10^{-2}	---	2.96×10^{-1}	1.82×10^{-1}	4.52×10^{-5}
	Ingestion	6.80×10^{-4}	9.58×10^{-5}	1.71×10^{-5}	---	7.32×10^{-5}	---	7.30×10^{-5}
^{239}Pu	Inhalation	3.19	4.31×10^{-1}	7.75×10^{-2}	---	3.30×10^{-1}	1.72×10^{-1}	4.13×10^{-5}
	Ingestion	7.87×10^{-4}	1.06×10^{-4}	1.91×10^{-5}	---	8.11×10^{-5}	---	6.66×10^{-5}
^{242}Am	Inhalation	1.01	3.59×10^{-1}	6.71×10^{-2}	---	5.04×10^{-1}	6.06×10^{-2}	4.60×10^{-5}
	Ingestion	8.19×10^{-4}	2.88×10^{-4}	5.41×10^{-5}	---	4.07×10^{-4}	---	7.42×10^{-5}

[a]Includes an increase of 50% to account for skin absorption.
[b]Gastrointestinal—Lower large intestine.

TABLE D-III

DOSE CONVERSION FACTORS FOR FIRST YEAR DOSE

Adult Dose Conversion Factors
(mrem/first year per pCi intake)

Radio-nuclide	Pathway	Organ						
		Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI[a]
^{3}H	Inhalation[a]	0.0	---	1.5×10^{-7}	1.5×10^{-7}	---	1.5×10^{-7}	1.5×10^{-7}
	Ingestion	0.0	1.0×10^{-7}	1.0×10^{-7}	1.0×10^{-7}	1.0×10^{-7}	---	1.0×10^{-7}
^{137}Cs	Ingestion	4.3×10^{-5}	7.3×10^{-5}	4.3×10^{-5}	0.0	3.1×10^{-5}	---	2.1×10^{-6}
Total U	Inhalation	1.5×10^{-3}	---	1.9×10^{-4}	0.0	---	2.8×10^{-2}	3.6×10^{-5}
	Ingestion	2.6×10^{-4}	0.0	3.1×10^{-5}	0.0	7.8×10^{-5}	---	5.8×10^{-5}
^{238}Pu	Inhalation	7.3×10^{-3}	---	1.9×10^{-4}	0.0	---	5.1×10^{-2}	4.5×10^{-5}
	Ingestion	8.9×10^{-6}	1.4×10^{-6}	2.3×10^{-7}	0.0	1.1×10^{-6}	---	7.3×10^{-5}
^{239}Pu	Inhalation	7.1×10^{-3}	---	1.7×10^{-4}	0.0	---	4.8×10^{-2}	4.1×10^{-5}
	Ingestion	8.6×10^{-6}	1.3×10^{-6}	2.1×10^{-7}	0.0	9.9×10^{-7}	---	6.7×10^{-5}
^{241}Am	Inhalation	5.2×10^{-3}	---	4.2×10^{-4}	0.0	---	3.5×10^{-2}	4.6×10^{-5}
	Ingestion	9.3×10^{-6}	1.1×10^{-5}	7.6×10^{-7}	0.0	5.3×10^{-6}	---	7.4×10^{-5}

[a]Gastointestinal—Lower large intestine.

C. Ingestion Dose

Results from foodstuff sampling, described in Section IV.A.5, are used to calculate doses to the same organs as considered for the inhalation dose. The procedure is similar to that used in the previous section. 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 50-yr dose commitment and first year dose to the organ. Consumption rates and dose conversion factors used in the calculations are in Tables D-I, D-II, and D-III.

Doses are evaluated for ingestion of ^{3}H, ^{90}Sr, ^{137}Cs, total U, ^{238}Pu, and ^{239}Pu in fruits and vegetables; ^{3}H, ^{7}Be, ^{22}Na, ^{54}Mn, ^{57}Co, ^{83}Rb, ^{134}Cs, ^{137}Cs, and total U in honey; and ^{90}Sr, ^{137}Cs, total U, ^{238}Pu, and ^{239}Pu in fish.

Consumption rates in Table D-I correspond to values recommended by the Nuclear Regulatory Commission[D2] for calculation of dose to the maximum exposed individual. The single exception is the honey consumption rate, which, since it has no recommended value, was based on professional judgment.

D. External Radiation

Nuclear reactions with air in the target areas at the Los Alamos Meson Physics Facility (LAMPF, TA-53) cause the air activation products ^{11}C, ^{13}N, and ^{15}O to be formed. These isotopes are all positron emitters and have 20.4-min, 10-min, and 122-sec half-lives, respectively. Neutron reactions with air at the Omega West Reactor (TA-2) and the LAMPF form ^{41}Ar (1.8 h half-life).

The radioisotopes ^{11}C, ^{13}N, and ^{15}O are sources of gamma radiation that are due to formation of two 0.511-MeV photons through positron-electron annihilation. The ^{41}Ar emits a 1.29 MeV gamma with a 99% yield.

External radiation doses are monitored with H-8's thermoluminescent dosimeter network. Measured doses, considered as whole body doses in this report, are in Table E-II. Background estimates at each site, based on historical data, consideration of possible nonbackground contributions, and, if possible, values measured at locations of similar geology and topography, are then subtracted from each measured value. This net dose is assumed to represent the dose due to Laboratory activities that an individual would receive if he or she were to spend 100% of his or her time during an entire year at the monitoring location.

Boundary and maximum individual doses from ^{41}Ar releases from the Omega West Reactor (TA-2) are estimated using standard meteorological models and measured stack releases[D8] (see Table E-I). Procedures used in making the calculations are described in the following section.

At onsite locations at which above background doses were measured, but at which public access is limited, doses based on a more realistic estimate of exposure time are also presented. Assumptions used in these estimates are in the text.

E. Population Dose

Calculation of whole body population dose estimates (in person-rem) are based on measured data to the extent possible. For background radiation, average measured background doses for Los Alamos, White Rock, and regional stations are multiplied by the appropriate population number. Tritium average doses are calculated from average measured concentrations in Los Alamos and White Rock above background (as measured by regional stations).

These doses are multiplied by population data incorporating results of the 1980 census, which is summarized in Table D-IV. The population data has been slightly modified to account for population changes between 1980 and 1982. The modification is based on an extrapolation of the 1970-1980 growth rates.

Radionuclides emitted by Los Alamos Meson Physics Facility and, to a lesser extent, by the Omega West Reactor contribute over 95% of the population dose.

For ^{41}Ar, ^{11}C, ^{13}N, and ^{15}O, atmospheric dispersion models are used to calculate an average dose to individuals living in the area in question. The air concentration of the isotope $[\chi(r,\theta)]$ at a location (r,θ) due to its emission from a particular source is found using the annual average meteorological dispersion coefficient $[\chi(r,\theta)/Q]$ (based on Gaussian plume dispersion models) and the source term Q. Source terms, obtained by stack measurements, are in Table E-I.

Dispersion factors for the LAMPF and Omega West Reactor are given in Table D-V. The dispersion factors were calculated from 1982 meteorological data collected near LAMPF during the actual time periods when

TABLE D-IV

ESTIMATES OF NUMBER OF PEOPLE LIVING WITHIN 80 km OF LABORATORY

A. Cities and towns included in preliminary census results.[a]

Town	No. of People	Town	No. of People
Alcalde	432	San Felipe Pueblo	1 534
Bernalillo	3 310	San Ildefonso Pueblo	1 492
Chama	1 136	San Juan Pueblo	4 291
Chimayo	2 688	San Ysidro	203
Cochiti Pueblo	804	Sandia Pueblo	239
Cuba	666	Santa Ana Pueblo	395
Española	7 487	Santa Clara Pueblo	7 320
Jemez Pueblo	1 542	Santa Fe	50 804
Jemez Springs	312	Santo Domingo Pueblo	2 187
Los Alamos	11 179	Tesuque Pueblo	362
Nambe Pueblo	1 124	Tesuque	1 036
Pecos	970	White Rock	6 980
Ranchos de Taos	1 500	Zia Pueblo	517
		Total	110 510

B. Estimate of number of people not included in 1980 census results. 14 558

C. Estimate of total number of people living within 80 km of Laboratory. 125 068

[a]1980 census counts. Source: US Bureau of the Census.

radionuclides were being released from the stacks. The χ/Q includes the reduction of the source term due to radioactive decay.

The gamma dose rate in a semi-infinite cloud at time t, $\gamma_{\cdot}(r,\theta,t)$, can be represented by the equation[D8]

$$\gamma_{\cdot}(r,\theta,t) = 0.25\ \bar{E}_{\gamma}\ \chi(r,\theta,t)$$

where

$\gamma_{\infty}(r,\theta,t)$ = gamma dose rate (rad/sec) at time t, at a distance r, and angle θ,

$\bar{E}_{\gamma}$ = average gamma energy per decay (MeV) (1.02 MeV for position emitters and 1.29 MeV for ^{41}Ar), and

$\chi(r,\theta,t)$ = plume concentration in Ci/m^3 at time t, at a distance r, and angle θ.

The annual dose is calculated from the dose rate and then multiplied by the appropriate population figure to give the estimated population dose.

Background radiation doses due to airline travel are based on the number of trips taken by Laboratory personnel. It was assumed that 85% of these trips were

TABLE D-V

DISPERSION FACTOR (χ/Q) USED FOR POPULATION DOSE ESTIMATES[a]

Source	Location	Radionuclide	Half-Life (min)	χ/Q (sec/m^3)
TA-2	Boundary	^{41}Ar	109.8	2.6×10^{-6}
TA-2	Maximum individual	^{41}Ar	109.8	2.3×10^{-6}
TA-2	Los Alamos	^{41}Ar	109.8	1.1×10^{-7}
TA-2	White Rock	^{41}Ar	109.8	6.7×10^{-9}
TA-53	Boundary	^{15}O	2.07	2.8×10^{-7}
		^{13}N	10.0	8.1×10^{-7}
		^{11}C	20.4	9.5×10^{-7}
		^{41}Ar	109.8	1.1×10^{-6}
TA-53	Los Alamos	^{15}O	2.07	3.2×10^{-10}
		^{13}N	10.0	1.1×10^{-8}
		^{11}C	20.4	2.3×10^{-8}
		^{41}Ar	109.8	8.0×10^{-8}
TA-53	White Rock	^{15}O	2.07	2.5×10^{-12}
		^{13}N	10.0	2.0×10^{-9}
		^{11}C	20.4	8.0×10^{-9}
		^{41}Ar	109.8	4.0×10^{-8}

[a]Includes correction for radioactive decay.

taken by Laboratory personnel residing in Los Alamos County and that non-Laboratory travel was 10% of the Laboratory trips. Average air time at altitude for each trip was estimated to be 4.5 h, where the average dose rate is 0.22 mrem/h.[D9]

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APPENDIX E

ENVIRONMENTAL DATA TABLES

TABLE E-I

ATMOSPHERIC RADIOACTIVE EFFLUENT TOTALS FOR 1982

Location	^{238}Pu ^{239}Pu (μCi)	^{241}Am (μCi)	^{235}U ^{238}U (μCi)	MFP[a] (μCi)	^{131}I (μCi)	^{41}Ar (Ci)	^{32}P (μCi)	^{3}H (Ci)	G/MAP (Ci)[b]	P/VAP (Ci)[c]
TA-2	---	---	---	---	---	342	---	---	---	---
TA-3	74	---	321	76	785	---	---	1938	---	---
TA-9	---	---	---	---	---	---	---	---	---	---
TA-15	---	---	---	---	---	---	---	---	---	---
TA-18	---	---	---	---	---	---	---	---	---	---
TA-21	16	0.035	1043	0.44	---	---	---	169	---	---
TA-33	---	---	---	---	---	---	---	13 600	---	---
TA-35	1.3	---	---	---	---	---	---	---	---	---
TA-41	---	---	---	---	---	---	---	130	---	---
TA-43	1.4	---	---	---	---	---	4.8	---	---	---
TA-46	---	---	2.0	---	---	---	---	---	---	---
TA-48	9.9	---	7.3	1094	---	---	---	---	---	---
TA-50	6.5	---	---	14	---	---	---	---	---	---
TA-53	---	---	---	---	---	---	---	0.07	251 000	182
TA-54	0.020	---	---	---	---	---	---	---	---	---
TA-55	2.6	---	---	---	---	---	---	19	---	---

---

[a]Mixed fission products.

[b]G/MAP = Gaseous Mixed Activation Products. Main contaminants are ^{11}C, ^{13}N, and ^{15}O. The half-lives of ^{11}C, ^{13}N, and ^{15}O range from about 2 to 20 minutes, so these nuclides decay rapidly.

[c]P/VAP = Particulate or Vapor Activation Products. Thirty-five nuclides were monitored. Main contaminants are ^{195}Hg for vapor and ^{192}Au for particulates.

Note: --- means no discharge of that radionuclide at that location.

TABLE E-II

ANNUAL THERMOLUMINESCENT DOSIMETER MEASUREMENTS

Station Location	Coordinates	Annual Dose: Dose (mrem)	Annual Dose: 95% Conf Interval (mrem)	Annual Dose: 95% Conf Interval (per cent)
Regional Stations (28-44 km)		**Uncontrolled Areas**		
1. Española	---	83.5	± 4.7	± 5.6
2. Pojoaque	---	91.6	± 4.7	± 5.1
3. Santa Fe	---	84.2	± 4.7	± 5.6
4. Fenton Hill	---	122.3	± 5.2	± 4.3
Perimeter Stations (0-4 km)		**Controlled Areas**		
5. Barranca School	N180 E130	101.0	± 4.7	± 4.7
6. Arkansas Avenue	N170 E030	89.5	± 4.7	± 5.3
7. Cumbres School	N150 E090	101.0	± 4.7	± 4.7
8. 48th Street	N110 W010	123.9	± 4.7	± 3.8
9. LA Airport	N110 E170	111.9	± 5.5	± 4.9
10. Bayo Canyon S.T.P.	N120 E250	127.4	± 4.8	± 3.8
11. Gulf Station	N090 E120	118.5	± 4.7	± 4.0
12. Royal Crest	N080 E080	118.0	± 4.7	± 4.0
13. White Rock S.T.P.	S080 E420	106.0	± 4.7	± 4.4
14. Pajarito Acres	N130 W180	92.1	± 4.7	± 5.1
15. Banedlier Lookout	S280 E200	117.2	± 4.7	± 4.0
16. Pajarito Ski Area	N130 W180	101.4	± 4.7	± 4.6

Station Location	Coordinates	Annual Dose: Dose (mrem)	Annual Dose: 95% Conf Interval (mrem)	Annual Dose: 95% Conf Interval (per cent)
Onsite Stations		**Controlled Areas**		
17. TA-21	N095 E140	114.9	± 4.7	± 4.1
18. TA-6	N025 E030	115.4	± 4.7	± 4.1
19. TA-53	N070 E090	138.3	± 4.7	± 3.4
20. Well PM-1	N030 E305	125.2	± 4.8	± 3.8
21. TA-16	S035 W025	112.7	± 4.7	± 4.2
22. Booster P-2	S030 E220	121.1	± 5.1	± 4.2
23. TA-54	S080 E290	116.2	± 4.7	± 4.0
24. State Hwy 4	N070 E350	166.3	± 4.8	± 2.9
25. TA-49	S165 E085	104.9	± 4.7	± 4.5
26. TA-2	N075 E120	117.8	± 4.7	± 4.0
27. TA-2	N085 E120	130.2	± 4.8	± 3.7
28. TA-18	S040 E205	153.5	± 4.8	± 3.1
29. TA-35	N040 E105	118.3	± 4.7	± 4.0
30. TA-36	N040 E110	134.6	± 4.8	± 3.6
31. TA-3	N050 E020	180.2	± 5.1	± 2.8
32. TA-3	N050 E020	180.6	± 4.9	± 2.7
33. TA-3	N050 E020	196.1	± 5.6	± 2.9
34. TA-3	N050 E020	164.5	± 5.8	± 3.5
35. TA-3	N050 E020	133.2	± 4.8	± 3.6
36. TA-3	N050 E040	121.8	± 4.8	± 3.9
37. Pistol Range	N040 E240	111.0	± 4.7	± 4.2

TABLE E-III

LOCATIONS OF AIR SAMPLING STATIONS

Station	Latitude or N-S Coord	Longitude or E-W Coord
Regional (28-44 km)		
1. Española	36°00′	106°06′
2. Pojoaque	35°52′	106°02′
3. Santa Fe	35°40′	106°56′
Perimeter (0-4 km)		
4. Barranca School	N180	E130
5. Arkansas Avenue	N170	E030
6. Cumbres School	N150	E090
7. 48th Street	N110	W010
8. LA Airport	N110	E170
9. Bayo STP	N120	E250
10. Gulf Station	N090	E120
11. Royal Crest	N080	E080
12. White Rock	S080	E420
13. Pajarito Acres	S210	E380
14. Bandelier	S280	E200
Onsite		
15. TA-21	N095	E140
16. TA-6	N025	E030
17. TA-53 (LAMPF)	N070	E090
18. Well PM-1	N030	E305
19. TA-52	N020	E155
20. TA-16	S035	W025
21. Booster P-2	S030	E220
22. TA-54	S080	E290
23. TA-49	S165	E085
24. TA-33	S245	E225
25. TA-39	S190	E230

TABLE E-IV

REGIONAL AVERAGE BACKGROUND ATMOSPHERIC RADIOACTIVITY CONCENTRATIONS

Radioactive Constituent	Units	EPA[a] 1981	Laboratory[b] 1982	Uncontrolled Area Concentration Guide
Gross alpha	10^{-15} μCi/mℓ	Not reported	1.6 ± 0.3	6×10^{1}
Gross beta	10^{-15} μCi/mℓ	15 ± 18	25 ± 2	3×10^{4}
^{241}Am	10^{-18} μCi/mℓ	Not reported	0.7 ± 3.0	2×10^{11}
^{238}Pu	10^{-18} μCi/mℓ	2.4 ± 4.0	−0.6 ± 0.6	7×10^{4}
^{239}Pu	10^{-18} μCi/mℓ	23 ± 31	2.3 ± 1.6	6×10^{4}
^{3}H	10^{-12} μCi/mℓ	Not reported	11 ± 4	2×10^{5}
U	10^{-18} μCi/mℓ	44 ± 38	20 ± 11	2×10^{6}
U	pg/m^{3}	133 ± 49	61 ± 34	6×10^{6}

[a]US Environmental Protection Agency, "Environmental Radiation Data," Report 25-26 (October 1981) and "Environmental Radiation Data," Report 27 (December 1981). Data are from the Santa Fe, New Mexico sampling location and were taken from October 1980 through August 1981.

[b]Data annual averages are from the regional stations (Española, Pojoaque, Santa Fe) and were taken during calendar year 1982.

TABLE E-V

ANNUAL ATMOSPHERIC GROSS ALPHA AND GROSS BETA ACTIVITY CONCENTRATIONS[a]

Station Location	Gross Alpha Concentrations—fCi/m³ (10^{-15} μCi/mℓ)							Gross Beta Concentrations—fCi/m³ (10^{-15} μCi/mℓ)					
	Total Air Volume[b] (m³)	Number of Monthly Samples	Number of Samples <MDL[c]	Max[d]	Min[d]	Mean[d]	Mean as % CG[e]	Number of Monthly Samples	Number of Samples <MDL[c]	Max[d]	Min[d]	Mean[d]	Mean as % CG[e]
Regional Stations (28-44 km)—Uncontrolled Areas													
1. Española	93 024	12	0	4.6 ± 2.0	0.6 ± 0.3	1.4 ± 0.6	2.3	12	0	31 ± 8	18 ± 4	25 ± 2	0.08
2. Pojoaque	73 816	12	0	3.9 ± 1.8	0.6 ± 0.3	1.9 ± 0.6	3.1	12	0	39 ± 10	16 ± 4	25 ± 2	0.08
3. Santa Fe	88 989	12	0	2.2 ± 1.0	0.6 ± 0.3	1.5 ± 0.3	2.6	12	0	36 ± 10	19 ± 4	27 ± 3	0.09
Regional Group Summary	255 829	36	0	4.6 ± 2.0	0.6 ± 0.3	1.6 ± 0.3	2.7	36	0	39 ± 10	16 ± 4	25 ± 2	0.08
Perimeter Stations (0-4 km)—Uncontrolled Areas													
4. Barranca School	90 923	12	0	5.2 ± 2.2	1.4 ± 0.6	3.0 ± 0.7	5.1	12	0	70 ± 18	26 ± 6	46 ± 9	0.15
5. Arkansas School	83 744	12	0	7.0 ± 3.0	2.0 ± 0.8	3.9 ± 0.9	6.5	12	0	103 ± 26	24 ± 6	50 ± 17	0.17
6. Cumbres School	80 626	12	0	5.4 ± 2.4	2.0 ± 0.8	3.9 ± 0.6	6.5	12	0	46 ± 12	23 ± 6	34 ± 4	0.11
7. 48th Street	83 566	12	0	12 ± 6	1.8 ± 0.8	4.8 ± 1.7	8.0	12	0	86 ± 22	16 ± 4	45 ± 14	0.15
8. LA Airport	93 687	12	0	7.0 ± 3.0	1.9 ± 0.8	3.7 ± 0.8	6.1	12	0	41 ± 10	9 ± 2	28 ± 8	0.09
9. Bayo STP	83 388	12	0	4.5 ± 2.0	1.4 ± 0.6	3.0 ± 0.5	5.0	12	0	76 ± 20	29 ± 8	42 ± 11	0.13
10. Gulf Station	88 263	12	3	4.2 ± 1.8	0.0 ± 0.1	1.4 ± 0.9	2.4	12	3	41 ± 10	0.0 ± 0.1	15 ± 10	0.05
11. Royal Crest	84 257	12	0	3.5 ± 1.6	1.0 ± 0.4	2.0 ± 0.4	3.3	12	0	18 ± 4	8 ± 2	12 ± 2	0.04
12. White Rock	84 890	12	0	2.7 ± 1.2	0.5 ± 0.2	1.7 ± 0.4	2.8	12	0	32 ± 8	19 ± 4	26 ± 3	0.09
13. Pajarito Acres	72 821	12	0	5.9 ± 2.6	1.9 ± 0.8	3.5 ± 0.6	5.8	12	0	110 ± 28	39 ± 10	62 ± 16	0.21
14. Bandelier	64 818	12	0	5.6 ± 2.4	1.1 ± 0.4	3.4 ± 0.7	5.6	12	0	78 ± 20	34 ± 8	48 ± 7	0.16
Perimeter Group Summary	910 983	132	3	12 ± 6	0.0 ± 0.1	3.1 ± 0.3	5.2	132	3	110 ± 28	0.0 ± 0.1	37 ± 4	0.12
Onsite Stations—Controlled Areas													
15. TA-21	83 370	12	0	7.9 ± 3.4	1.7 ± 0.8	4.0 ± 1.0	0.20	12	0	94 ± 24	36 ± 10	53 ± 13	0.0053
16. TA-6	82 763	12	0	7.5 ± 3.2	0.6 ± 0.3	3.6 ± 1.2	0.18	12	0	77 ± 20	16 ± 4	41 ± 12	0.0041
17. TA-53 (LAMPF)	84 524	12	0	6.5 ± 2.8	1.8 ± 0.8	3.6 ± 0.8	0.18	12	0	48 ± 12	32 ± 8	40 ± 3	0.0040
18. Well PM-1	84 434	12	0	8.8 ± 3.8	2.4 ± 1.0	4.9 ± 1.0	0.25	12	0	87 ± 22	37 ± 10	53 ± 11	0.0053
19. TA-52	85 137	12	0	6.3 ± 2.8	1.6 ± 0.8	4.0 ± 0.9	0.20	12	0	70 ± 18	13 ± 3	35 ± 14	0.0035
20. TA-16	87 990	12	1	4.0 ± 1.8	0.3 ± 0.2	2.6 ± 0.7	0.13	12	0	35 ± 8	8 ± 2	24 ± 7	0.0024
21. Booster P-2	82 779	12	0	5.7 ± 2.4	2.0 ± 0.8	4.0 ± 0.7	0.20	12	0	59 ± 16	40 ± 10	49 ± 4	0.0049
22. TA-54	92 659	12	0	6.2 ± 2.8	1.0 ± 0.4	2.9 ± 0.9	0.15	12	0	54 ± 14	32 ± 8	40 ± 4	0.0040
23. TA-49	94 814	12	0	13 ± 6	2.7 ± 1.2	5.8 ± 1.7	0.29	12	0	65 ± 16	39 ± 10	52 ± 5	0.0052
24. TA-33	94 814	12	0	6.5 ± 2.8	2.4 ± 1.0	4.5 ± 0.8	0.22	12	0	50 ± 12	42 ± 10	46 ± 2	0.0046
25. TA-39	86 005	12	0	4.8 ± 2.0	1.2 ± 0.6	2.7 ± 0.6	0.14	12	0	38 ± 10	28 ± 8	32 ± 2	0.0032
Onsite Group Summary	954 989	132	1	13 ± 6	0.3 ± 0.2	3.9 ± 0.3	0.19	132	0	94 ± 24	8 ± 2	42 ± 3	0.0042

[a]The filters are held 7-10 days before analysis to allow naturally occurring radon-thoron daughters to reach equilibrium with their long-lived parents.

[b]Air volumes (m³) at average ambient conditions of 77 kPa barometric pressure and 15°C.

[c]Minimum detectable limit = 0.3×10^{-15} μCi/mℓ (α).
= 0.3×10^{-15} μCi/mℓ (β).

[d]Uncertainties are ±2 standard deviations (see Appendix B.2).

[e]The CGs of ^{239}Pu and ^{90}Sr are the most appropriate to use for the gross alpha and gross beta CGs, respectively.

Controlled Area Concentration Guide = 2×10^{-12} μCi/mℓ (α)
1×10^{-9} μCi/mℓ (β)

Uncontrolled Area Concentration Guide = 6×10^{-14} μCi/mℓ (α)
3×10^{-11} μCi/mℓ (β).

TABLE E-VI

ANNUAL ATMOSPHERIC TRITIATED WATER VAPOR CONCENTRATIONS

Station Location	Total Air Volume[a] (m^3)	Number of Monthly Samples	Number of Samples <MDL[b]	Concentrations—pCi/m^3 (10^{-12} μCi/mℓ) Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km)—Uncontrolled Areas							
1. Española	78	12	3	38 ± 12	0.5 ± 0.6	8.9 ± 6.5	0.004
2. Pojoaque	78	12	0	33 ± 10	1.7 ± 0.8	11 ± 6	0.005
3. Santa Fe	78	12	1	45 ± 14	1.7 ± 2.0	12 ± 7	0.006
Regional Group Summary	234	36	4	45 ± 14	0.5 ± 0.6	11 ± 4	0.005
Perimeter Stations (0-4 km)—Uncontrolled Areas							
4. Barranca School	78	12	0	33 ± 10	1.1 ± 0.8	14 ± 6	0.007
5. Arkansas Ave	78	12	0	25 ± 8	1.6 ± 0.2	12 ± 4	0.006
6. Cumbres School	78	12	0	25 ± 8	2.6 ± 1.4	10 ± 4	0.005
7. 48th Street	78	12	0	39 ± 10	2.8 ± 1.0	10 ± 5	0.005
8. LA Airport	78	12	0	69 ± 22	3.4 ± 1.4	19 ± 13	0.009
9. Bayo STP	78	12	0	130 ± 40	3.8 ± 1.8	26 ± 21	0.013
10. Gulf Station	78	12	0	14 ± 4	4.6 ± 1.6	8.7 ± 1.5	0.004
11. Royal Crest	78	12	0	21 ± 6	2.3 ± 0.8	12 ± 4	0.006
12. White Rock	78	12	0	93 ± 30	2.3 ± 0.8	24 ± 19	0.012
13. Pajarito Acres	78	12	0	330 ± 100	2.1 ± 0.8	65 ± 62	0.033
14. Bandelier	78	12	0	109 ± 34	2.3 ± 1.2	31 ± 20	0.016
Perimeter Group Summary	858	132	0	330 ± 100	1.1 ± 0.8	21 ± 7	0.011
Onsite Stations—Controlled Areas							
15. TA-21	78	12	0	77 ± 24	3.1 ± 1.2	16 ± 12	0.0003
16. TA-6	78	12	0	21 ± 8	4.4 ± 1.6	11 ± 3	0.0002
17. TA-53 (LAMPF)	78	12	0	13 ± 4	3.0 ± 1.2	7.3 ± 1.9	0.0001
18. Well PM-1	78	12	0	93 ± 30	2.9 ± 1.0	26 ± 17	0.0005
19. TA-52	78	12	0	45 ± 14	1.9 ± 1.0	25 ± 9	0.0005
20. TA-16	78	12	0	28 ± 8	1.8 ± 1.4	10 ± 6	0.0002
21. Booster P-2	78	12	1	38 ± 12	1.3 ± 1.4	13 ± 6	0.0002
22. TA-54	78	12	0	45 ± 14	3.0 ± 1.4	23 ± 8	0.0005
23. TA-49	78	12	0	23 ± 8	1.6 ± 1.0	6.9 ± 3.8	0.0001
24. TA-33	78	12	0	280 ± 80	1.5 ± 1.0	88 ± 52	0.0018
25. TA-39	78	12	0	690 ± 220	3.6 ± 1.4	149 ± 140	0.0030
Onsite Group Summary	858	132	1	690 ± 220	1.3 ± 1.4	34 ± 15	0.0007

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.
[b]Minimum detectable limit = 1×10^{-12} μCi/mℓ.
[c]Uncertainties are ±2 standard deviations (see Appendix B.2).
[d]Controlled Area Concentration Guide = 5×10^{-6} μCi/mℓ.
Uncontrolled Area Concentration Guide = 2×10^{-7} μCi/mℓ.

TABLE E-VII

ANNUAL ATMOSPHERIC ^{238}Pu AND $^{239+240}Pu$ CONCENTRATIONS

Station Location	Total Air Volume[a] (m^3)	^{238}Pu aCi/m^3 (10^{-18} μCi/mℓ) Number of Samples	Number <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]	$^{239+240}Pu$ aCi/m^3 (10^{-18} μCi/mℓ) Number of Samples	Number <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km)—Uncontrolled Areas													
1. Española	93 024	4	4	0.0 ± 1.8	−1.1 ± 2.1	−0.6 ± 0.5	0.0	4	3	3.0 ± 2.4	−1.3 ± 1.2	1.2 ± 1.9	0.002
2. Pojoaque	73 816	4	4	2.2 ± 6.7	−1.6 ± 1.1	−0.3 ± 1.7	0.0	4	4	9.1 ± 13	−0.5 ± 1.3	3.1 ± 4.3	0.005
3. Santa Fe	88 989	4	4	0.0 ± 5.5	−1.4 ± 1.5	−0.9 ± 0.6	0.0	4	3	4.8 ± 7.3	0.9 ± 1.7	2.8 ± 1.8	0.005
Regional Group Summary	255 829	12	12	2.2 ± 6.7	−1.6 ± 1.1	−0.6 ± 0.6	0.0	12	10	9.1 ± 13	−1.3 ± 1.2	2.3 ± 1.6	0.004
Perimeter Stations (0-4 km)—Uncontrolled Areas													
4. Barranca School	90 923	4	4	−0.3 ± 1.7	−4.5 ± 5.5	−1.8 ± 1.9	0.0	4	2	6.6 ± 9.1	2.6 ± 2.1	4.6 ± 1.7	0.008
5. Arkansas Ave	83 744	4	4	1.6 ± 3.5	−0.6 ± 1.2	0.1 ± 1.0	0.0	4	3	7.1 ± 2.8	0.3 ± 3.8	2.6 ± 3.1	0.004
6. Cumbres School	80 626	4	4	0.0 ± 6.2	−1.5 ± 1.4	−0.7 ± 0.7	0.0	4	1	4.0 ± 2.4	−1.7 ± 6.2	2.2 ± 2.7	0.004
7. 48th Street	83 566	4	4	−0.6 ± 1.9	−1.1 ± 1.1	−0.8 ± 0.2	0.0	4	2	6.9 ± 3.0	−0.3 ± 2.0	2.8 ± 3.1	0.005
8. LA Airport	93 687	4	4	0.9 ± 3.7	−1.0 ± 1.0	−0.4 ± 0.9	0.0	4	4	2.6 ± 3.3	−1.3 ± 1.3	1.2 ± 1.8	0.002
9. Bayo STP	83 388	4	4	−0.7 ± 1.6	−1.6 ± 3.4	−1.1 ± 0.5	0.0	4	1	5.6 ± 3.0	0.3 ± 5.8	3.7 ± 2.4	0.006
10. Gulf Station	88 263	4	3	50 ± 9	−1.9 ± 3.8	12 ± 26	0.02	4	2	11 ± 3.8	−1.0 ± 1.2	4.0 ± 4.7	0.007
11. Royal Crest	84 257	4	3	45 ± 6	−1.5 ± 2.7	10 ± 23	0.02	4	4	2.2 ± 2.1	−0.1 ± 3.4	0.7 ± 1.0	0.001
12. White Rock	84 890	4	4	0.0 ± 4.1	−1.4 ± 1.7	−0.6 ± 0.6	0.0	4	4	2.9 ± 2.9	−1.7 ± 6.1	1.3 ± 2.0	0.002
13. Pajarito Acres	72 821	4	4	0.0 ± 1.5	−1.4 ± 1.7	−0.5 ± 0.7	0.0	4	3	6.8 ± 2.9	0.9 ± 1.9	2.8 ± 2.7	0.005
14. Bandelier	64 818	4	4	−0.8 ± 2.4	−4.6 ± 7.1	−2.0 ± 1.8	0.0	4	3	3.7 ± 2.7	−0.5 ± 1.8	1.4 ± 2.1	0.002
Perimeter Group Summary	910 983	44	42	50 ± 9	−4.6 ± 7.1	1.3 ± 3.1	0.004	44	29	11 ± 3.8	−1.7 ± 6.2	2.5 ± 0.8	0.004
Onsite Stations—Controlled Areas													
15. TA-21	83 370	4	4	0.0 ± 1.7	−1.1 ± 1.3	−0.6 ± 0.5	0.0	4	1	8.0 ± 3.9	1.4 ± 2.1	6.0 ± 3.1	0.0003
16. TA-6	82 763	4	4	−0.3 ± 1.8	−2.0 ± 1.6	−1.0 ± 0.7	0.0	4	4	1.9 ± 2.1	0.4 ± 1.5	1.2 ± 0.7	0.0001
17. TA-53 (LAMPF)	84 524	4	4	−0.1 ± 1.5	−1.2 ± 1.5	−0.9 ± 0.5	0.0	4	3	3.7 ± 2.6	0.2 ± 1.9	2.2 ± 1.5	0.0001
18. Well PM-1	84 434	4	4	0.8 ± 2.1	−0.7 ± 1.8	−0.1 ± 0.7	0.0	4	1	4.4 ± 3.2	−1.0 ± 1.5	2.8 ± 2.5	0.0001
19. TA-52	85 137	4	4	−0.5 ± 1.5	−1.2 ± 2.0	−0.7 ± 0.3	0.0	4	4	2.4 ± 2.2	0.2 ± 2.3	1.5 ± 1.0	0.0001
20. TA-16	87 990	4	4	−0.7 ± 1.5	−1.8 ± 1.6	−1.0 ± 0.6	0.0	4	3	3.9 ± 2.4	−1.6 ± 1.4	1.0 ± 2.5	0.0001
21. Booster P-2	82 779	4	4	−0.5 ± 1.6	−1.2 ± 1.2	−0.8 ± 0.3	0.0	4	2	3.9 ± 2.2	1.0 ± 2.0	2.7 ± 1.3	0.0001
22. TA-54	92 659	4	3	3.2 ± 2.3	−0.1 ± 2.6	1.3 ± 1.4	0.00007	4	1	38 ± 8.8	1.7 ± 1.9	13 ± 17	0.0006
23. TA-49	74 814	4	4	−0.3 ± 1.1	−2.6 ± 3.5	−1.0 ± 1.1	0.0	4	3	4.6 ± 2.3	−0.4 ± 1.3	1.8 ± 2.1	0.0001
24. TA-33	94 814	4	4	0.2 ± 1.8	−1.4 ± 1.3	−0.6 ± 0.7	0.0	4	3	5.0 ± 2.9	0.7 ± 2.3	2.4 ± 1.8	0.0001
25. TA-39	86 005	4	4	0.0 ± 3.9	−2.6 ± 2.1	−0.8 ± 1.2	0.0	4	4	5.0 ± 5.7	1.1 ± 2.9	2.7 ± 1.6	0.0001
Onsite Group Summary	954 989	44	43	3.2 ± 2.3	−2.6 ± 2.1	−0.6 ± 0.3	0.0	44	29	38 ± 8.8	−1.6 ± 1.4	3.4 ± 1.7	0.0002

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.

[b]Minimum detectable limits = 2×10^{-18} μCi/mℓ (^{238}Pu).
= 3×10^{-18} μCi/mℓ ($^{239+240}Pu$).

[c]Uncertainties are ±2 sample standard deviations (see Appendix B.2).

[d]Controlled Area Concentration Guide = 2×10^{-12} μCi/mℓ (^{238}Pu).
= 2×10^{-12} μCi/mℓ ($^{239+240}Pu$).
Uncontrolled Area Concentration Guide = 7×10^{-14} μCi/mℓ (^{238}Pu).
= 6×10^{-14} μCi/mℓ ($^{239+240}Pu$).

TABLE E-VIII

ANNUAL ATMOSPHERIC URANIUM CONCENTRATIONS
(concentrations in pg/m^3)

Station Location	Total Air Volume[a] (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG
Regional Stations (28-44 km)—Uncontrolled Areas							
1. Española	93 024	4	1	77 ± 16	5.7 ± 2.5	50 ± 31	0.0008
2. Pojoaque	73 816	4	1	230 ± 46	13 ± 3.6	98 ± 94	0.0016
3. Santa Fe	88 989	4	0	55 ± 11	25 ± 5.7	37 ± 13	0.0006
Regional Group Summary	255 829	12	2	230 ± 46	5.7 ± 2.5	61 ± 34	0.0010
Perimeter Stations (0-4 km)—Uncontrolled Areas							
4. Barranca	90 923	4	0	57 ± 12	29 ± 6.5	47 ± 13	0.0008
5. Arkansas Ave	83 744	4	0	91 ± 19	21 ± 4.8	44 ± 33	0.0007
6. Cumbres School	80 626	4	0	28 ± 6.4	21 ± 5.0	25 ± 3.6	0.0004
7. 48th Street	83 566	4	1	53 ± 11	11 ± 3.2	33 ± 17	0.0005
8. LA Airport	93 687	4	1	240 ± 49	11 ± 3.1	112 ± 100	0.0018
9. Bayo STP	83 388	4	0	65 ± 14	28 ± 6.3	45 ± 16	0.0007
10. Gulf Station	88 263	4	3	36 ± 7.8	2.6 ± 2.5	14 ± 16	0.0002
11. Royal Crest	84 257	4	3	29 ± 6.5	4.8 ± 2.7	15 ± 10	0.0003
12. White Rock	84 890	4	0	130 ± 26	28 ± 6.4	63 ± 44	0.0011
13. Pajarito Acres	72 821	4	0	77 ± 16	37 ± 8.2	56 ± 22	0.0009
14. Bandelier	64 818	4	1	36 ± 7.9	19 ± 4.8	28 ± 8.8	0.0005
Perimeter Group Summary	910 983	44	9	240 ± 49	26 ± 2.5	44 ± 13	0.0007
Onsite Stations—Controlled Areas							
15. TA-21	83 370	4	0	130 ± 27	59 ± 12	94 ± 31	0.00005
16. TA-6	82 763	4	1	16 ± 9.8	12 ± 3.3	31 ± 15	0.00002
17. TA-53 (LAMPF)	84 524	4	0	74 ± 15	27 ± 6.1	53 ± 22	0.00003
18. Well PM-1	84 434	4	0	65 ± 13	35 ± 7.5	51 ± 13	0.00003
19. TA-52	85 137	4	2	71 ± 15	13 ± 3.6	42 ± 33	0.00002
20. TA-16	87 990	4	2	37 ± 7.9	7.8 ± 2.6	23 ± 15	0.00001
21. Booster P-2	82 779	4	0	63 ± 13	32 ± 7.1	49 ± 13	0.00003
22. TA-54	92 659	4	0	110 ± 23	67 ± 14	86 ± 22	0.00005
23. TA-49	94 814	4	0	56 ± 12	35 ± 7.5	48 ± 9.0	0.00003
24. TA-33	94 814	4	0	49 ± 10	25 ± 5.6	37 ± 13	0.00002
25. TA-39	86 005	4	0	100 ± 23	24 ± 5.6	54 ± 35	0.00003
Onsite Group Summary	954 989	44	5	130 ± 27	7.8 ± 2.6	52 ± 8.4	0.00003

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.
[b]Minimum detectable limit = 1 pg/m^3.
[c]Uncertainties ±2 sample standard deviations (see Appendix B.2).
[d]Controlled Area Concentration Guide = 1.8×10^8 pg/m^3.
Uncontrolled Area Concentration Guide = 6×10^6 pg/m^3.

Note: One curie of natural uranium is equivalent to 3000 kg of natural uranium. Hence, uranium masses can be converted to the DOE "uranium special curie" by using the factor 3.3×10^{-13} μCi/pg.

TABLE E-IX

ANNUAL ATMOSPHERIC $^{241}2Am$ CONCENTRATIONS

Station Location	Total Air Volume (m^3)[a]	Number of Quarterly Samples	Number of Samples <MDL[b]	aCi/m^3 (10^{-18} μCi/mℓ) Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km)—Uncontrolled Areas							
3. Santa Fe	88 989	4	3	11 ± 7.2	−0.5 ± 2.8	0.7 ± 3.0	0.0004
Regional Group Summary	88 989	4	3	11 ± 7.2	−0.5 ± 2.8	0.7 ± 3.0	0.0004
Perimeter Stations (0-4 km)—Uncontrolled Areas							
6. Cumbres	80 626	4	4	2.0 ± 6.0	0.0 ± 2.2	0.2 ± 0.4	0.0001
8. LA Airport	93 687	3	3	1.7 ± 3.4	−1.5 ± 2.7	1.2 ± 8.8	0.0006
9. Bayo STP	83 388	4	4	1.0 ± 3.8	0.0 ± 38	0.1 ± 0.2	0.0001
12. White Rock	84 890	4	4	2.5 ± 3.7	−0.1 ± 3.2	0.2 ± 0.5	0.0001
Perimeter Group Summary	342 591	15	15	2.5 ± 3.7	−1.5 ± 2.7	0.07 ± 0.33	0.0000
Onsite Stations—Controlled Areas							
16. TA-6	82 763	4	4	2.7 ± 3.5	−1.0 ± 6.0	0.2 ± 0.9	0.000003
17. TA-53 (LAMPF)	84 524	4	4	0.7 ± 1.8	−1.0 ± 3.8	0.1 ± 0.4	0.000002
20. TA-16	87 990	4	4	1.0 ± 4.0	0.0 ± 1.8	0.3 ± 0.7	0.000005
21. Booster P-2	82 779	4	4	1.3 ± 3.9	−1.0 ± 4.0	0.0 ± 0.6	0.000000
22. TA-54	92 659	4	3	9.5 ± 3.5	1.1 ± 3.3	0.9 ± 2.0	0.000015
23. TA-39	86 005	4	4	0.9 ± 3.2	−1.4 ± 3.2	0.0 ± 0.5	0.000000
Onsite Group Summary	516 720	24	23	9.5 ± 3.5	−1.4 ± 3.2	0.04 ± 0.20	0.000001

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.
[b]Minimum detectable limit = 2×10^{-18} μCi/mℓ.
[c]Uncertainties are ±2 sample deviations (see Appendix B.2).
[d]Controlled Area Concentration Guide = 6×10^{-12} μCi/mℓ.
Uncontrolled Area Concentration Guide = 2×10^{-13} μCi/mℓ.

TABLE E-X

LOCATIONS OF SURFACE AND GROUND WATER STATIONS

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Regional Surface Water				
Rio Chama at Chamita	36°05′	106°07′	---	SW
Rio Grande at Embudo	36°12′	105°58′	---	SW
Rio Grande at Otowi	35°52′	106°08′	---	SW
Rio Grande at Cochiti	35°37′	106°19′	---	SW
Rio Grande at Bernalillo	35°17′	106°36′	---	SW
Jemez River	35°40′	106°44′	---	SW
Perimeter Stations				
Los Alamos Reservoir	N105°	W090	7	SW
Guaje Canyon	N300	E100	8	SW
Frijoles	S280	E180	9	SW
La Mesita Spring	N080	E550	10	GWD
Sacred Spring	N170	E540	11	GWD
Indian Spring	N140	E530	12	GWD
White Rock Canyon				
Group I				
Sandia Spring	S030	E470	13	SWR
Spring 3	S110	E450	14	SWR
Spring 3A	S120	E445	15	SWR
Spring 3AA	S140	E440	16	SWR
Spring 4	S170	E110	17	SWR
Spring 4A	S150	E395	18	SWR
Spring 5	S220	E390	19	SWR
Spring 5AA	S240	E360	20	SWR
Ancho Spring	S280	E305	21	SWR
Group II				
Spring 5A	S230	E390	22	SWR
Spring 6	S300	E330	23	SWR
Spring 6A	S310	E310	24	SWR
Spring 7	S330	E295	25	SWR
Spring 8	S335	E285	26	SWR

[a]Regional Surface Water sampling locations in Fig. 9, Perimeter, White Rock Canyon, Onsite, and Effluent Release Area sampling locations in Fig. 13.

[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 E-X (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Spring 8A	S315	E280	27	SWR
Spring 9	S270	E270	28	SWR
Spring 9A	S325	E265	29	SWR
Doe Spring	S320	E250	30	SWR
Spring 10	S370	E230	31	SWR
White Rock Canyon Stations				
Group III				
Spring 1	N040	E520	32	SWR
Spring 2	N015	E505	33	SWR
Group IV				
Spring 3B	S150	E465	34	SWR
Streams				
Pajarito	S180	E410	35	SWR
Ancho	S295	E340	36	SWR
Frijoles	S365	E235	37	SWR
Sanitary Effluent				
Mortandad	S070	E480	38	SWR
Onsite				
Test Well 1	N070	E345	39	GWD
Test Well 2	N120	E150	40	GWD
Test Well 3	N080	E215	41	GWD
Test Well DT-5A	S110	E090	42	GWD
Test Well 8	N035	E170	43	GWD
Test Well DT-9	S155	E140	44	GWD
Test Well DT-10	S120	E125	45	GWD
Cañada del Buey	N010	E150	46	SW
Pajarito	S060	E215	47	SW
Water Canyon at Beta	S090	E090	48	SW
Effluent Release Areas				
Acid-Pueblo Canyon				
Acid Weir	N125	E070	49	SW
Pueblo 1	N130	E080	50	SW
Pueblo 2	N120	E155	51	SW
Pueblo 3	N085	E315	52	SW

TABLE E-X (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Hamilton Bend Springs	N110	E250	53	S
Test Well 1A	N070	E335	54	GWS
Test Well 2A	N120	E140	55	GWS
Basalt Spring	N065	E395	56	S
DP-Los Alamos Canyon				
DPS-1	N090	E160	57	SW
DPS-4	N080	E200	58	SW
LAO-C	N085	E070	59	GWS
LAO-1	N080	E120	60	GWS
LAO-2	N080	E210	61	GWS
LAO-3	N080	E220	62	GWS
LAO-4	N070	E245	63	GWS
LAO-4.5	N065	E270	64	GWS
Sandia Canyon				
SCS-1	N080	E040	65	SW
SCS-2	N060	E140	66	SW
SCS-3	N050	E185	67	SW
Mortandad Canyon				
GS-1	N040	E100	68	SW
MCO-3	N040	E110	69	GWS
MCO-4	N035	E150	70	GWS
MCO-5	N030	E160	71	GWS
MCO-6	N030	E175	72	GWS
MCO-7	N025	E180	73	GWS
MCO-7.5	N030	E190	74	GWS
MCO-8				
Water Supply and Distribution				
Los Alamos Well Field				
Well LA-1B	N115	E530	76	GWD
Well LA-2	N125	E505	77	GWD
Well LA-3	N130	E490	78	GWD
Well LA-4	N070	E405	79	GWD
Well LA-5	N076	E435	80	GWD
Well LA-6	N105	E465	81	GWD

TABLE E-X (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
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
Fire Station 1	N080	E015	95	D
Fire Station 2	N100	E120	96	D
Fire Station 3	S085	E375	97	D
Fire Station 4	N185	E070	98	D
Fire Station 5	S010	W065	99	D
Bandelier National Monument Headquarters	S270	E190	100	D
Fenton Hill (TA-57)	35°53′	106°40′	101	D

TABLE E-XI

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE WATER FROM REGIONAL STATIONS

Station	1982 Date	Radiochemical ^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Chamita	3-29	−14 ± 40	−0.013 ± 0.012	−0.026 ± 0.008	3.6 ± 2.6	6.5 ± 2.2	0.6 ± 0.6	2.9 ± 0.8
Chamita	9-13	6 ± 52	0.013 ± 0.030	0.004 ± 0.026	54 ± 22	31 ± 6.0	0.1 ± 0.6	3.2 ± 0.8
Embudo	3-29	−40 ± 40	0.011 ± 0.018	0.005 ± 0.018	1.6 ± 1.4	4.6 ± 1.8	0.3 ± 0.6	2.3 ± 0.8
Embudo	9-13	−21 ± 58	0.005 ± 0.024	0.005 ± 0.028	3.9 ± 2.6	6.8 ± 2.2	0.7 ± 0.6	1.9 ± 0.8
Otowi	9-13	5 ± 44	0.006 ± 0.018	0.006 ± 0.034	7.0 ± 4.0	19 ± 4.0	0.2 ± 0.6	2.6 ± 0.8
Cochiti	3-30	10 ± 40	0.008 ± 0.018	−0.004 ± 0.014	1.2 ± 1.4	2.5 ± 1.6	0.5 ± 0.6	2.2 ± 0.8
Cochiti	9-14	10 ± 28	−0.005 ± 0.022	0.005 ± 0.028	3.3 ± 3.2	20 ± 4.0	0.5 ± 0.6	1.7 ± 0.8
Bernalillo	3-30	−20 ± 20	0.006 ± 0.022	−0.017 ± 0.012	2.8 ± 2.4	7.8 ± 2.4	0.1 ± 0.6	3.8 ± 0.8
Bernalillo	9-14	40 ± 148	0.005 ± 0.018	−0.014 ± 0.028	2.4 ± 3.8	16 ± 4.0	0.3 ± 0.6	4.2 ± 0.8
Jemez	3-30	−30 ± 12	0.013 ± 0.016	−0.013 ± 0.008	6.7 ± 3.4	12 ± 3.0	0.9 ± 0.6	1.4 ± 0.8
Jemez	9-14	−42 ± 90	0.034 ± 0.038	0.006 ± 0.028	7.2 ± 3.8	8.4 ± 2.4	0.1 ± 0.6	0.0 ± 0.8
No. of Analyses		11	11	11	11	11	11	11
Minimum		−42 ± 90	−0.013 ± 0.012	−0.026 ± 0.008	1.2 ± 1.4	2.5 ± 1.6	0.1 ± 0.6	0.0 ± 0.8
Maximum		40 ± 148	0.034 ± 0.038	0.006 ± 0.028	54 ± 22	31 ± 6.0	0.9 ± 0.6	4.2 ± 0.8
Average		−9	0.008	−0.004	8.6	12.2	0.4	2.4
2s		50	0.023	0.023	30.5	17.0	0.5	2.3

Station	1982 Date	Chemical (Concentrations in mg/ℓ) Cℓ	F	NO_3	TDS	pH
Chamita	3-29	7	0.2	<0.5	334	8.1
Embudo	3-29	5	0.4	0.8	162	8.2
Cochiti	3-30	7	0.4	<0.5	208	8.2
Bernalillo	3-30	28	0.5	<0.5	292	8.0
Jemez	3-30	44	0.6	0.9	242	7.8
No. of Analyses		5	5	5	5	5
Minimum		5	0.2	<0.5	162	7.8
Maximum		44	0.6	0.9	334	8.2
Average		18	0.4	0.6	248	8.1
2s		34	0.3	0.4	136	0.3

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XII

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATERS FROM PERIMETER STATIONS

Station	1982 Date	Radiochemical						
		^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Perimeter Stations								
Los Alamos Reservoir	3-24	1 ± 20	−0.006 ± 0.012	−0.006 ± 0.016	0.1 ± 1.0	1.5 ± 1.4	0.8 ± 0.6	0.0 ± 0.8
Guaje Canyon	3-24	−37 ± 24	−0.013 ± 0.000	−0.010 ± 0.040	0.1 ± 1.0	4.6 ± 1.8	1.6 ± 0.6	1.5 ± 0.8
Frijoles Canyon	4-1	95 ± 60	−0.005 ± 0.010	−0.010 ± 0.020	0.2 ± 0.8	1.9 ± 1.4	4.3 ± 0.6	0.0 ± 0.8
La Mesita Spring	3-24	−70 ± 60	−0.020 ± 0.000	0.005 ± 0.020	9.0 ± 4.0	11.0 ± 1.4	2.4 ± 0.6	10 ± 2.0
Indian Spring	10-1	17 ± 58	0.020 ± 0.140	−0.040 ± 0.100	0.3 ± 1.6	5.3 ± 2.0	0.1 ± 0.4	0.8 ± 0.8
Sacred Spring	3-24	−3 ± 34	−0.006 ± 0.012	−0.018 ± 0.012	1.6 ± 1.4	3.5 ± 1.6	3.8 ± 0.6	2.3 ± 0.8
No. of Analyses		6	6	6	6	6	6	6
Minimum		−70 ± 60	−0.013 ± 0.000	−0.040 ± 0.100	0.1 ± 1.0	1.5 ± 1.4	0.1 ± 0.4	0.0 ± 0.8
Maximum		95 ± 60	0.020 ± 0.140	0.005 ± 0.020	9.0 ± 4.0	11.0 ± 1.4	4.3 ± 0.6	10.0 ± 2.0
Average		0	−0.005	−0.013	1.9	4.6	2.2	2.4
2s		112	0.027	0.030	7.1	6.9	3.3	7.6

Station	1982 Date	Chemical (Concentrations in mg/ℓ)				
		Cℓ	F	NO_3	TDS	pH
Los Alamos Reservior	3-24	2	0.1	<0.5	76	7.3
Guaje Canyon	3-24	2	0.2	1.1	110	7.2
Frijoles Canyon	4-1	3	0.2	0.9	105	7.7
La Mesita Spring	3-24	8	0.3	7.5	202	7.7
Indian Spring	10-1	11	0.5	<0.1	251	7.7
Sacred Spring	3-24	2	0.5	<0.5	183	7.5
No. of Analysis		6	6	6	6	6
Minimum		2	0.1	<0.1	76	7.2
Maximum		11	0.5	7.5	251	7.7
Average		5	0.3	1.8	154	7.5
2s		8	0.3	5.7	136	0.5

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XIII

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATERS FROM WHITE ROCK CANYON, OCTOBER 1982

Station	1982 Date	Radiochemical						
		^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Group I								
Sandia Spring	9-27	15 ± 60	0.020 ± 0.060	0.010 ± 0.060	0.3 ± 1.4	3.2 ± 1.8	−0.1 ± 0.4	0.8 ± 0.8
Spring 3	9-27	79 ± 114	0.020 ± 0.120	0.020 ± 0.140	1.3 ± 1.4	4.6 ± 1.8	−0.1 ± 0.4	2.8 ± 0.8
Spring 3A	9-27	−36 ± 96	0.020 ± 0.040	−0.014 ± 0.036	0.0 ± 1.0	3.4 ± 1.6	−0.1 ± 0.4	0.8 ± 0.8
Spring 3AA	9-27	54 ± 100	−0.007 ± 0.036	0.030 ± 0.040	0.1 ± 1.2	3.9 ± 1.8	0.0 ± 0.4	1.4 ± 0.8
Spring 4	9-27	13 ± 32	0.010 ± 0.040	−0.013 ± 0.032	0.0 ± 1.2	3.9 ± 1.8	0.0 ± 0.4	0.9 ± 0.8
Spring 4A	9-27	−20 ± 50	0.010 ± 0.30	0.005 ± 0.032	1.8 ± 1.6	32 ± 6.0	0.2 ± 0.4	0.9 ± 0.8
Spring 5	9-27	−10 ± 32	−0.006 ± 0.016	−0.006 ± 0.038	0.2 ± 1.2	1.4 ± 1.6	0.2 ± 0.4	0.0 ± 0.8
Spring 5AA	9-27	−39 ± 53	0.006 ± 0.028	0.023 ± 0.034	0.3 ± 1.4	4.9 ± 2.0	0.4 ± 0.4	0.6 ± 0.8
Ancho Spring	9-27	23 ± 43	−0.007 ± 0.028	−0.021 ± 0.038	−0.2 ± 1.2	4.3 ± 1.8	0.6 ± 0.4	0.0 ± 0.8
Group II								
Spring 5A	9-27	−5 ± 31	0.006 ± 0.022	0.006 ± 0.028	0.8 ± 1.6	4.6 ± 1.8	0.3 ± 0.4	1.5 ± 0.8
Spring 6	9-28	0 ± 21	0.012 ± 0.032	0.006 ± 0.034	0.0 ± 1.0	3.7 ± 1.6	0.1 ± 0.4	0.0 ± 0.8
Spring 6A	9-28	6 ± 46	−0.008 ± 0.000	0.020 ± 0.040	−0.1 ± 1.0	1.9 ± 1.4	0.2 ± 0.4	0.0 ± 0.8
Spring 7	9-28	−10 ± 44	0.005 ± 0.016	−0.015 ± 0.024	0.6 ± 1.2	1.1 ± 1.4	0.1 ± 0.4	1.6 ± 0.8
Spring 8A	9-28	11 ± 24	0.011 ± 0.030	0.016 ± 0.034	3.7 ± 2.2	5.8 ± 2.0	0.2 ± 0.4	0.9 ± 0.8
Spring 9	9-28	8 ± 14	0.008 ± 0.030	−0.020 ± 0.040	0.2 ± 1.0	2.7 ± 1.6	0.0 ± 0.4	0.8 ± 0.8
Spring 9A	9-28	−10 ± 24	0.020 ± 0.040	−0.030 ± 0.040	6.8 ± 3.2	5.3 ± 2.0	0.2 ± 0.4	0.0 ± 0.8
Doe Spring	9-28	20 ± 38	−0.007 ± 0.022	−0.013 ± 0.015	−0.3 ± 1.0	1.8 ± 1.6	0.2 ± 0.4	0.0 ± 0.8
Spring 10	9-29	−42 ± 36	0.023 ± 0.038	−0.010 ± 0.060	0.2 ± 1.0	1.5 ± 1.4	0.4 ± 0.4	0.0 ± 0.8
Group III								
Spring 1	9-27	14 ± 22	−0.006 ± 0.012	−0.010 ± 0.040	0.8 ± 1.4	4.2 ± 1.8	−0.2 ± 0.4	2.7 ± 0.8
Spring 2	9-27	26 ± 52	−0.005 ± 0.010	−0.010 ± 0.024	3.9 ± 2.8	3.4 ± 1.8	0.0 ± 0.4	5.6 ± 1.2
Group IV								
Spring 3B	9-27	31 ± 78	0.005 ± 0.016	0.005 ± 0.026	14 ± 8.0	14 ± 3.6	0.8 ± 0.4	20 ± 4.0
Streams								
Pajarito	9-27	8 ± 38	0.006 ± 0.020	−0.012 ± 0.032	5.2 ± 2.8	7.9 ± 2.4	0.5 ± 0.4	0.9 ± 0.8
Ancho	9-28	46 ± 60	0.034 ± 0.036	0.030 ± 0.020	−0.5 ± 1.0	3.4 ± 1.6	0.5 ± 0.4	0.0 ± 0.8
Frijoles	9-29	−9 ± 53	0.017 ± 0.030	0.006 ± 0.022	−0.1 ± 1.0	3.3 ± 1.6	0.3 ± 0.4	0.0 ± 0.8
Sanitary Effluent								
Mortendad	9-27	31 ± 52	0.005 ± 0.020	0.005 ± 0.024	2.3 ± 3.2	20 ± 4.0	0.7 ± 0.4	1.4 ± 0.8
No. of Analyses		25	25	25	25	25	25	25
Minimum		−42 ± 36	−0.008 ± 0.000	−0.030 ± 0.040	−0.5 ± 1.0	1.1 ± 1.4	−0.2 ± 0.4	0.0 ± 0.8
Maximum		79 ± 114	0.034 ± 0.036	0.030 ± 0.040	14 ± 8.0	32 ± 6.0	0.8 ± 0.8	20 ± 4.0
Average		8	0.008	0.000	2.8	5.9	0.2	1.7
2s		57	0.023	0.033	9.8	13.6	0.5	8.0

TABLE E-XIII (cont)

Station	Chemical (Concentrations in mg/ℓ)															Cond (mS/m)
	SiO_2	Ca	Mg	K	Na	CO_2	HCO_3	PO_4	SO_4	Cℓ	F	NO_3	TDS	Hard	pH	
Group I																
Sandia Spring	45	34	3.1	3.0	16	0	165	<0.1	5	4	0.6	<0.1	178	98	7.8	25
Spring 3	45	20	1.7	3.0	15	0	104	<0.1	4	3	0.4	1.5	143	58	8.2	17
Spring 3A	49	20	1.8	3.0	15	0	104	<0.1	5	3	0.4	1.4	148	57	8.1	17
Spring 3AA	41	18	0.3	3.1	17	0	101	<0.1	4	3	0.4	0.8	134	46	7.4	16
Spring 4	51	22	4.4	2.8	13	0	93	<0.1	10	6	0.4	3.4	182	74	7.4	21
Spring 4A	66	22	4.8	2.2	12	0	106	<0.1	5	6	0.5	3.1	182	71	7.7	19
Spring 5	64	20	4.8	2.0	12	0	112	<0.1	4	5	0.4	0.5	182	72	8.1	18
Spring 5AA	58	37	6.9	3.0	15	0	187	<0.1	4	5	0.4	0.2	189	117	7.1	29
Ancho Spring	73	16	3.9	2.3	10	0	94	<0.1	2	2	0.4	1.9	137	55	7.3	15
Group II																
Spring 5A	54	30	3.1	3.2	24	0	160	<0.1	8	5	0.4	1.0	174	88	7.4	27
Spring 6	71	19	3.9	2.1	12	0	107	<0.1	3	3	0.4	<0.1	151	65	7.0	17
Spring 6A	73	11	2.9	2.1	10	0	69	<0.1	4	2	0.3	1.3	128	36	7.9	11
Spring 7	73	17	3.8	2.7	18	0	120	<0.1	8	3	0.4	0.4	168	63	6.8	19
Spring 8A	75	14	3.0	2.2	12	0	80	<0.1	2	2	0.4	0.2	142	44	8.5	13
Spring 9	71	12	3.1	1.6	11	0	83	<0.1	2	2	0.4	0.4	134	39	8.1	13
Spring 9A	71	11	3.2	1.5	10	0	79	<0.1	2	2	0.4	1.2	115	38	8.0	12
Doe Spring	71	16	3.6	1.6	11	0	96	<0.1	2	2	0.5	1.0	138	50	8.0	14
Spring 10	66	12	3.2	1.7	11	0	82	<0.1	3	2	0.4	0.9	131	41	7.5	13
Group III																
Spring 1	30	22	1.5	2.2	31	0	152	<0.1	7	3	0.6	2.0	143	61	8.1	24
Spring 2	36	28	1.6	1.9	72	0	273	<0.1	11	6	1.3	2.1	266	77	8.1	41
Group IV																
Spring 3B	45	24	2.1	4.9	125	0	428	<0.1	17	4	0.6	7.5	400	64	7.7	60
Streams																
Pajarito	66	22	4.6	2.6	13	0	116	<0.1	5	5	0.4	5.4	166	76	8.3	19
Ancho	68	17	3.7	2.1	10	6	89	<0.1	3	3	0.4	1.4	126	55	8.4	15
Frijoles	56	10	3.3	2.0	8	0	62	0.1	4	3	0.2	2.4	115	39	7.5	11
Sanitary Effluent																
Mortandad	83	35	7.9	15	90	0	279	44	33	47	1.1	34	460	125	7.5	66
No. of Analyses	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Minimum	30	10	0.3	1.5	8	0	62	<0.1	2	2	0.2	<0.1	115	36	6.8	11
Maximum	83	37	7.9	15	125	6	428	44	33	47	1.3	34	460	125	8.5	66
Average	60	20	3.4	3.0	24	0	134	1.9	6	5	0.5	3.0	177	64	7.8	22
2s	28	15	3.3	5.2	57	2	166	17.6	13	18	0.5	13.4	166	47	0.9	28

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XIV

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATERS FROM ONSITE STATIONS

Station	1982 Date	Radiochemical						
		^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Test Well 1	4-7	−4 ± 40	−0.014 ± 0.000	−0.014 ± 0.014	2.0 ± 2.4	11 ± 3.0	2.2 ± 0.6	1.2 ± 0.8
Test Well 1	9-23	4 ± 38	0.030 ± 0.080	0.010 ± 0.080	1.0±.1.8	5.1 ± 2.0	1.3 ± 0.4	0.7 ± 0.8
Test Well 2	4-8	1 ± 20	0.005 ± 0.016	−0.009 ± 0.010	0.3 ± 0.8	3.7 ± 1.6	1.6 ± 0.6	0.6 ± 0.8
Test Well 2	10-21	116 ± 212	0.005 ± 0.024	−0.005 ± 0.026	0.3 ± 1.2	−0.6 ± 1.4	25 ± 1.0	0.6 ± 0.8
Test Well 3	4-8	---	0.005 ± 0.024	−0.230 ± 0.080	1.4 ± 1.6	2.4 ± 1.6	0.4 ± 0.6	0.9 ± 0.8
Test Well DT-5A	10-6	8 ± 44	−0.004 ± 0.008	−0.008 ± 0.022	−0.2 ± 1.0	0.9 ± 1.4	0.6 ± 0.4	0.0 ± 0.8
Test Well 8	4-8	−2 ± 40	−0.026 ± 0.014	−0.046 ± 0.030	0.6 ± 1.0	1.1 ± 1.4	0.5 ± 0.6	0.6 ± 0.8
Test Well 8	11-1	−35 ± 122	0.010 ± 0.040	0.020 ± 0.080	−0.1 ± 0.8	2.8 ± 1.6	9.1 ± 0.6	0.7 ± 0.8
Test Well 9	10-5	19 ± 28	−0.004 ± 0.014	−0.004 ± 0.018	6.6 ± 3.2	6.5 ± 2.0	5.3 ± 0.6	1.1 ± 0.8
Test Well 10	4-8	−20 ± 40	−0.005 ± 0.010	−0.011 ± 0.016	1.3 ± 1.2	2.2 ± 1.6	4.4 ± 0.6	0.8 ± 0.8
Test Well 10	11-1	53 ± 86	0.030 ± 0.180	0.080 ± 0.160	−0.5 ± 1.4	1.6 ± 1.6	21 ± 1.0	0.0 ± 0.8
Cañada del Buey	4-5	14 ± 38	0.009 ± 0.018	−0.017 ± 0.008	0.9 ± 1.2	4.2 ± 1.8	10 ± 0.8	1.0 ± 0.8
Pajarito	4-7	−30 ± 20	0.011 ± 0.030	−0.033 ± 0.012	3.7 ± 2.6	20 ± 4.0	6.1 ± 0.8	0.7 ± 0.8
Pajarito	9-22	−72 ± 148	−0.003 ± 0.000	0.009 ± 0.020	2.0 ± 2.0	12 ± 3.0	2.8 ± 0.6	0.0 ± 0.8
Water at Beta	4-16	14 ± 40	−0.006 ± 0.032	−0.012 ± 0.038	0.4 ± 1.2	6.9 ± 2.2	6.8 ± 0.8	1.2 ± 0.8
Water at Beta	11-4	−7 ± 50	−0.020 ± 0.180	0.170 ± 0.100	−0.3 ± 1.0	6.4 ± 2.0	8.3 ± 0.6	0.6 ± 0.8
No. of Analyses		15	16	16	16	16	16	16
Minimum		−72 ± 148	−0.026 ± 0.014	−0.046 ± 0.030	−0.5 ± 1.4	−0.6 ± 1.4	0.4 ± 0.6	0.0 ± 0.8
Maximum		116 ± 212	0.030 ± 0.080	0.170 ± 0.000	6.6 ± 3.2	20 ± 4.0	25 ± 1.0	1.2 ± 0.8
Average		3.9	0.001	−0.001	1.2	5.4	6.6	0.7
2s		84	0.031	0.056	3.5	10	14	0.8

Station	1982 Date	Chemical (concentrations in mg/ℓ)				
		Cℓ	F	NO_3	TDS	pH
Test Well 1	4-17	53	0.8	39	345	7.4
Test Well 2	4-8	3	0.5	0.5	80	8.2
Test Well 8	4-8	2	0.2	1.3	32	9.7
Test Well 10	4-8	2	0.2	<0.5	42	9.6
Cañada del Buey	4-5	19	1.9	<0.5	157	7.0
Pajarito	4-7	92	0.1	<0.5	267	6.9
Water at Beta	4-16	7	0.3	0.5	155	7.3
No. of Analyses		7	7	7	7	7
Minimum		2	0.1	<0.5	32	6.9
Maximum		92	1.9	39	345	9.7
Average		25	0.6	6.1	154	8.0
2s		69	1.3	29	234	2.4

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XV

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATERS FROM ACID PUEBLO CANYON, FORMER EFFLUENT RELEASE AREA

		Radiochemical								
Station	1982 Date	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	Total U (μg/ℓ)	^{241}Am (10^{-9} μCi/mℓ)
Acid Weir	4-15	30 ± 60	0.006 ± 0.022	0.028 ± 0.032	0.4 ± 2.8	145 ± 30	3.0 ± 0.6	6.1 ± 2.3	2.0 ± 0.8	0.060 ± 0.086
Acid Weir	10-21	−11 ± 110	0.005 ± 0.022	1.19 ± 0.160	2.4 ± 2.0	44 ± 10	8.8 ± 0.6	---	2.5 ± 0.8	---
Pueblo 1	4-15	8 ± 80	−0.009 ± 0.028	−0.013 ± 0.020	0.5 ± 2.0	10 ± 2.8	6.9 ± 0.8	0.6 ± 1.8	0.6 ± 0.8	0.02 ± 0.060
Pueblo 1	4-21	262 ± 272	0.005 ± 0.018	−0.005 ± 0.018	0.4 ± 1.8	56 ± 12	20 ± 1.0	---	0.0 ± 0.8	---
Pueblo 2	4-15	30 ± 120	0.004 ± 0.032	0.038 ± 0.038	0.9 ± 2.0	22 ± 4.0	3.5 ± 0.6	3.7 ± 2.6	1.4 ± 0.8	0.050 ± 0.060
Pueblo 3	4-15	−10 ± 80	−0.008 ± 0.008	0.039 ± 0.032	6.0 ± 4.0	29 ± 6.0	1.7 ± 0.6	3.6 ± 2.6	5.8 ± 1.2	0.140 ± 0.080
Pueblo 3	10-21	225 ± 252	0.015 ± 0.028	0.290 ± 0.080	10 ± 6.0	33 ± 8.0	97 ± 3.0	---	5.4 ± 0.8	---
Hamilton Bend Spring	4-15	−4 ± 38	−0.013 ± 0.022	−0.004 ± 0.022	4.0 ± 2.6	12 ± 3.2	1.4 ± 0.6	0.2 ± 0.4	3.1 ± 0.8	0.010 ± 0.100
Hamilton Bend Spring	10-21	106 ± 94	0.004 ± 0.018	0.004 ± 0.026	5.6 ± 3.7	21 ± 4.0	38 ± 1.4	---	8.0 ± 1.6	---
Test Well 1A	4-15	---	−0.008 ± 0.016	0.004 ± 0.010	2.0 ± 1.8	4.2 ± 1.8	2.9 ± 0.6	---	1.9 ± 0.8	---
Test Well 1A	9-23	−54 ± 88	0.004 ± 0.024	0.090 ± 0.040	0.8 ± 1.6	8.3 ± 2.4	1.0 ± 0.4	---	0.0 ± 0.8	---
Test Well 2A	4-8	−11 ± 80	−0.006 ± 0.012	0.006 ± 0.016	0.5 ± 1.2	2.1 ± 1.6	17 ± 1.0	0.1 ± 0.4	0.7 ± 0.8	0.080 ± 0.060
Basalt Spring	4-14	−20 ± 100	−0.013 ± 0.026	−0.009 ± 0.022	1.2 ± 1.6	5.3 ± 2.0	1.3 ± 0.6	0.1 ± 0.6	1.4 ± 0.8	0.000 ± 0.060
Basalt Spring	10-25	9 ± 56	0.006 ± 0.018	0.013 ± 0.030	0.1 ± 1.2	4.2 ± 1.8	51 ± 1.8	---	1.4 ± 0.8	---
No. of Analyses		13	14	14	14	14	14	7	14	6
Minimum		−54 ± 88	−0.013 ± 0.022	−0.013 ± 0.020	0.1 ± 1.2	2.1 ± 1.6	1.0 ± 0.4	0.1 ± 0.4	0.0 ± 0.8	0.000 ± 0.060
Maximum		262 ± 272	0.015 ± 0.028	1.19 ± 0.160	10 ± 6.0	145 ± 30	97 ± 3.0	6.1 ± 2.3	8.0 ± 1.6	0.140 ± 0.080
Average		43	−0.001	0.119	2.5	18.9	18.1	2.1	2.4	0.051
2s		193	0.017	0.636	5.8	32.7	54.7	4.8	4.8	0.097

		Chemical (Concentration in mg/ℓ)				
Station	1982 Date	Cℓ	F	NO_3	TDS	pH
Acid Weir	4-15	123	0.4	6.6	350	6.5
Pueblo 1	4-15	61	0.8	76	395	6.9
Pueblo 2	4-15	61	0.8	19	335	7.4
Pueblo 3	4-15	43	1.2	26	353	7.0
Hamilton Bend Spring	4-15	51	1.0	19	312	6.9
Test Well 2A	4-8	36	0.3	<0.5	125	8.1
Basalt Spring	4-14	15	0.7	4.5	178	7.7
No. of Analyses		7	7	7	7	7
Minimum		15	0.3	<0.5	125	6.5
Maximum		123	1.2	76.0	395	8.1
Average		56	0.7	21.7	293	7.2
2s		67	0.6	51.3	201	1.1

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XVI

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATERS FROM SANDIA CANYON, ACTIVE EFFLUENT RELEASE AREA

		Radiochemical								
Station	1982 Date	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	Total U (μg/ℓ)	^{241}Am (10^{-9} μCi/mℓ)
SCS-1	4-14	60 ± 100	−0.004 ± 0.032	−0.013 ± 0.018	12 ± 8.0	46 ± 10	1.8 ± 0.6	1.1 ± 0.4	2.0 ± 0.8	0.180 ± 0.080
SCS-1	9-23	0 ± 28	0.007 ± 0.038	−0.001 ± 0.004	2.4 ± 3.0	17 ± 4.0	9.9 ± 0.6	---	0.8 ± 0.8	---
SCS-2	4-14	1 ± 54	0.007 ± 0.008	−0.007 ± 0.016	18 ± 10	17 ± 4.0	8.4 ± 0.8	0.3 ± 0.4	1.0 ± 0.8	---
SCS-2	9-23	−65 ± 142	0.004 ± 0.018	0.004 ± 0.024	−0.1 ± 2.6	16 ± 3.8	10 ± 0.6	---	0.7 ± 0.8	---
SCS-3	4-14	−8 ± 100	−0.004 ± 0.012	−0.020 ± 0.028	1.1 ± 2.8	15 ± 3.6	4.5 ± 0.6	2.6 ± 0.6	0.9 ± 0.8	0.020 ± 0.030
SCS-3	9-23	−142 ± 82	0.004 ± 0.018	−0.009 ± 0.026	0.7 ± 1.6	14 ± 3.4	9.6 ± 0.6	---	0.0 ± 0.8	---
No. of Analyses		6	6	6	6	6	6	3	6	2
Minimum		−142 ± 82	−0.004 ± 0.032	−0.020 ± 0.028	−0.1 ± 2.6	14 ± 3.2	1.8 ± 0.6	0.3 ± 0.4	0.0 ± 0.8	0.020 ± 0.030
Maximum		60 ± 100	0.007 ± 0.038	0.004 ± 0.024	18 ± 10	46 ± 10	10.0 ± 0.6	2.6 ± 0.6	2.0 ± 0.8	0.180 ± 0.180
Average		−26	0.002	−0.008	5.7	21	7.4	1.3	0.9	0.100
2s		139	0.010	0.017	15.0	25	6.8	2.3	1.3	0.226

		Chemical (Concentration in mg/ℓ)				
Station	1982 Date	Cℓ	F	NO_3	TDS	pH
SCS-1	4-14	187	1.9	7.5	868	7.2
SCS-2	4-14	160	1.9	5.5	758	7.8
SCS-3	4-14	110	1.3	3.9	557	7.8
No. of Analyses		3	3	3	3	3
Minimum		110	1.3	3.9	557	7.2
Maximum		187	1.9	7.5	868	7.8
Average		152	1.7	5.6	728	7.6
2s		78	0.7	3.6	315	0.7

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XVII

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATERS FROM DP—LOS ALAMOS CANYON, ACTIVE EFFLUENT RELEASE AREA

Station	1982 Sampling Date	Radiochemical								
		^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	Total U (μg/ℓ)	^{241}Am (10^{-9} μCi/mℓ)
DPS-1	4-14	6 ± 40	0.310 ± 0.080	0.480 ± 0.100	470 ± 200	2000 ± 400	46 ± 1.8	362 ± 16	270 ± 60	8.00 ± 0.800
DPS-1	10-25	31 ± 60	0.610 ± 0.140	1.11 ± 0.200	67 ± 28	570 ± 120	64 ± 2.2	---	127 ± 26	---
DPS-4	4-14	-50 ± 20	-0.004 ± 0.024	0.043 ± 0.038	4.0 ± 6.0	460 ± 100	41 ± 1.6	138 ± 6.0	4.1 ± 0.8	1.08 ± 140
DPS-4	10-20	11 ± 57	0.039 ± 0.032	0.200 ± 0.080	2.0 ± 2.6	210 ± 40	5.9 ± 0.6	---	2.2 ± 0.8	---
LAO-C	4-14	-2 ± 40	-0.009 ± 0.010	-0.005 ± 0.026	2.2 ± 1.6	7.1 ± 2.2	3.2 ± 0.6	0.9 ± 0.3	1.6 ± 0.8	0.080 ± 0.080
LAO-C	10-20	15 ± 57	0.009 ± 0.016	-0.013 ± 0.024	0.0 ± 1.0	8.0 ± 1.6	0.7 ± 0.4	---	0.0 ± 0.8	---
LAO-1	4-14	-51 ± 40	0.004 ± 0.024	0.013 ± 0.024	0.9 ± 2.6	98 ± 20	23 ± 1.2	30 ± 1.4	1.3 ± 0.8	0.060 ± 0.080
LAO-1	10-20	20 ± 31	0.017 ± 0.026	-0.004 ± 0.030	1.6 ± 2.0	54 ± 12	12 ± 0.8	---	0.5 ± 0.8	---
LAO-2	4-14	3 ± 60	0.004 ± 0.018	0.017 ± 0.028	1.0 ± 4.0	340 ± 60	36 ± 1.4	117 ± 10	1.3 ± 0.8	0.100 ± 0.100
LAO-2	10-20	95 ± 172	0.026 ± 0.030	0.026 ± 0.036	0.6 ± 2.0	175 ± 36	3.5 ± 0.6	---	1.2 ± 0.8	---
LAO-3	4-14	-1 ± 34	0.004 ± 0.014	0.008 ± 0.028	2.3 ± 3.2	126 ± 26	36 ± 1.4	35 ± 2.0	2.6 ± 0.8	0.200 ± 0.080
LAO-3	10-20	-46 ± 100	0.013 ± 0.020	0.013 ± 0.032	1.5 ± 2.0	74 ± 16	6.0 ± 0.6	---	1.9 ± 0.8	---
LAO-4	4-14	13 ± 70	0.030 ± 0.060	10.4 ± 1.00	2.3 ± 2.0	17 ± 4.0	4.0 ± 0.6	2.7 ± 0.8	1.2 ± 0.8	0.350 ± 0.100
LAO-4	10-20	54 ± 68	0.007 ± 0.028	-0.010 ± 0.040	1.8 ± 1.6	21 ± 4.0	3.8 ± 0.6	---	1.1 ± 0.8	---
LAO-4.5	4-14	-40 ± 40	-0.005 ± 0.022	0.014 ± 0.026	1.1 ± 1.6	8.8 ± 2.6	3.2 ± 0.6	0.9 ± 0.4	1.6 ± 0.8	0.090 ± 0.080
LAO-4.5	10-20	20 ± 46	0.009 ± 0.018	0.005 ± 0.030	7.3 ± 3.6	18 ± 4.0	4.4 ± 0.6	---	1.2 ± 0.8	---
No. of Analyses		16	16	16	16	16	16	8	16	8
Minimum		-51 ± 40	-0.009 ± 0.010	-0.013 ± 0.024	0.0 ± 1.0	7.1 ± 2.2	0.7 ± 0.4	0.9 ± 0.3	0.0 ± 0.8	0.060 ± 0.080
Maximum		95 ± 172	0.610 ± 0.140	10.4 ± 1.00	470 ± 200	2000 ± 400	64 ± 2.2	362 ± 16	270 ± 60	8.000 ± 0.800
Average		5	0.066	0.768	35	261	18	85	26	1.24
2s		78	0.327	5.16	234	988	39	247	144	5.501

Station	1982 Date	Chemical (concentrations in mg/ℓ)				
		Cℓ	F	NO_3	TDS	pH
DPS-1	4-14	240	18.5	16	1160	8.2
DPS-4	4-14	84	3.1	124	508	7.1
LAO-C	4-14	47	0.2	0.9	163	6.8
LAO-1	4-14	104	0.8	3.3	325	6.7
LAO-2	4-14	90	2.2	124	502	7.0
LAO-3	4-14	89	1.7	76	372	7.0
LAO-4	4-14	35	2.0	6.5	217	6.6
LAO-4.5	4-14	22	0.8	1.6	197	6.9
No. of Analyses		8	8	8	8	8
Minimum		22	0.2	0.9	163	6.6
Maximum		240	18.5	124	1160	8.2
Average		89	3.7	44	430	7.0
2s		136	12.1	110	646	1.0

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XVIII

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATERS FROM MORTANDAD CANYON, ACTIVE EFFLUENT RELEASE AREA

		Radiochemical								
Station	1982 Date	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	Total U (μg/ℓ)	^{241}Am (10^{-9} μCi/mℓ)
GS-1	4-21	210 ± 140	4.04 ± 0.808	64.9 ± 3.00	260 ± 100	780 ± 160	4.7 ± 0.6	24 ± 2.4	---	23.3 ± 1.20
GS-1	11-15	692 ± 238	143 ± 3.6	1266 ± 26	1500 ± 6000	1760 ± 360	36 ± 1.4	---	2.6 ± 0.8	---
MCO-3	4-21	10 ± 18	123 ± 3.2	1493 ± 30	32 ± 16	260 ± 60	7.6 ± 0.8	32 ± 2.4	---	4.3 ± 0.800
MCO-3	11-15	646 ± 136	19.5 ± 0.800	209 ± 6.00	6700 ± 2600	880 ± 180	46 ± 1.6	---	2.5 ± 0.8	---
MCO-4	4-21	1 ± 10	1.95 ± 0.260	13.6 ± 1.00	9.0 ± 4.0	67 ± 14	20 ± 1.0	52 ± 2.4	3.6 ± 0.8	11.2 ± 2.00
MCO-4	11-15	-35 ± 62	2.49 ± 0.360	12.9 ± 1.20	100 ± 40	880 ± 90	88 ± 2.8	---	4.5 ± 0.8	---
MCO-5	4-21	-7 ± 18	0.580 ± 0.100	3.80 ± 0.280	110 ± 40	220 ± 40	57 ± 2.0	8.2 ± 1.0	3.6 ± 0.8	---
MCO-5	11-15	97 ± 182	0.630 ± 0.140	5.90 ± 0.400	140 ± 60	157 ± 32	53 ± 1.8	---	1.6 ± 0.8	---
MCO-6	4-21	-50 ± 20	0.210 ± 120	0.110 ± 0.064	90 ± 40	310 ± 60	83 ± 2.8	5.0 ± 0.8	4.2 ± 0.8	---
MCO-6	11-15	-31 ± 56	0.130 ± 0.080	0.240 ± 0.100	11 ± 8.0	135 ± 28	99 ± 3.2	---	4.2 ± 0.8	---
MCO-7	4-21	80 ± 80	0.150 ± 0.060	0.049 ± 0.034	10 ± 6.0	25 ± 6.0	83 ± 2.8	0.2 ± 0.4	1.6 ± 0.8	---
MCO-7	11-15	26 ± 116	0.050 ± 0.080	0.030 ± 0.100	9.0 ± 60	53 ± 12	44 ± 1.6	---	1.1 ± 0.8	---
MCO-7.5	11-15	-24 ± 88	0.160 ± 0.180	-0.130 ± 0.160	38 ± 20	63 ± 14	78 ± 2.6	---	2.3 ± 0.8	---
No. of Analyses		13	13	13	13	13	13	6	11	3
Minimum		-50 ± 20	0.050 ± 0.080	0.030 ± 0.100	9.0 ± 60	25 ± 6.0	4.7 ± 0.6	0.2 ± 0.4	1.1 ± 0.8	4.3 ± 0.800
Maximum		692 ± 238	143 ± 3.6	1493 ± 30	15 000 ± 6000	1760 ± 360	99 ± 3.2	52 ± 2.4	4.5 ± 0.8	23.3 ± 1.20
Average		124	23	236	1741	430	54	20	2.9	5.27
2s		504	99	1026	8776	1019	62	39	2.4	11.0

		Chemical (Concentration in mg/ℓ)				
Station	1982 Date	Cℓ	F	NO_3	TDS	pH
GS-1	4-21	21	1.9	181	552	10.5
MCO-3	4-21	33	2.9	261	1648	9.4
MCO-4	4-21	45	7.5	650	1207	9.3
MCO-5	4-21	34	2.3	477	947	7.4
MCO-6	4-21	35	2.9	555	1100	7.3
MCO-7	4-21	22	0.7	85	383	7.0
No. of Analyses		6	6	6	6	6
Minimum		21	0.7	85	383	7.0
Maximum		45	7.5	650	1207	10.5
Average		32	3.0	368	806	8.5
2s		18	4.7	450	655	2.9

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XIX

RADIOCHEMICAL AND CHEMICAL QUALITY OF WATER FROM MUNICIPAL SUPPLY AND DISTRIBUTION

Station	1982 Date	Radiochemical						
		^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Los Alamos Field								
Well LA-1B	3-30	-50 ± 80	-0.004 ± 0.014	-0.004 ± 0.012	11 ± 6.0	6.4 ± 2.4	---	5.0 ± 1.0
Well LA-2	3-30	19 ± 40	0.009 ± 0.020	-0.019 ± 0.000	9.0 ± 4.0	4.1 ± 1.8	0.3 ± 0.6	3.9 ± 0.8
Well LA-3	3-30	-80 ± 40	0.004 ± 0.012	-0.012 ± 0.008	1.5 ± 1.4	6.5 ± 2.0	1.2 ± 0.6	4.6 ± 1.0
Well LA-5	3-30	-10 ± 34	-0.005 ± 0.010	-0.010 ± 0.010	3.3 ± 2.0	3.8 ± 1.8	0.9 ± 0.6	7.0 ± 1.4
Guaje Field								
Well G-1	3-30	40 ± 60	-0.006 ± 0.012	-0.012 ± 0.012	0.1 ± 1.2	2.4 ± 1.6	3.4 ± 0.6	0.9 ± 0.8
Well G-1A	3-30	-2 ± 80	0.007 ± 0.030	-0.007 ± 0.020	0.3 ± 1.0	28 ± 6.0	1.8 ± 0.6	1.0 ± 0.8
Well G-2	3-30	-7 ± 38	0.005 ± 0.016	-0.014 ± 0.012	0.8 ± 1.2	0.8 ± 1.4	0.3 ± 0.6	0.9 ± 0.8
Well G-3	3-30	-40 ± 40	0.004 ± 0.014	-0.013 ± 0.000	1.0 ± 1.2	2.1 ± 1.6	4.1 ± 0.6	1.6 ± 0.8
Well G-4	3-30	40 ± 60	0.014 ± 0.038	0.010 ± 0.600	1.1 ± 1.2	1.2 ± 1.4	0.2 ± 0.6	1.0 ± 0.8
Well G-5	3-30	-40 ± 80	-0.005 ± 0.000	-0.016 ± 0.010	1.0 ± 1.0	3.8 ± 1.6	0.7 ± 0.6	1.3 ± 0.4
Well G-6	3-30	19 ± 40	0.009 ± 0.026	-0.009 ± 0.038	5.9 ± 2.4	7.7 ± 2.2	0.8 ± 0.6	1.7 ± 0.8
Pajarito Field								
Well PM-1	3-30	-50 ± 40	-0.010 ± 0.020	-0.050 ± 0.100	0.7 ± 1.4	8.1 ± 2.4	0.5 ± 0.6	1.8 ± 0.8
Well PM-2	3-30	20 ± 40	0.010 ± 0.040	-0.020 ± 0.040	1.1 ± 1.2	1.9 ± 1.6	0.3 ± 0.6	0.0 ± 0.8
Well PM-3	3-30	30 ± 20	-0.014 ± 0.014	-0.005 ± 0.014	1.0 ± 1.4	13 ± 3.2	4.2 ± 0.6	1.6 ± 0.8
Well PM-4	8-3	10 ± 48	0.012 ± 0.020	-0.012 ± 0.034	20 ± 8.0	18 ± 4.0	0.5 ± 0.6	0.8 ± 0.8
Well PM-5	8-4	36 ± 34	0.018 ± 0.024	0.004 ± 0.024	3.9 ± 2.2	3.2 ± 1.6	0.4 ± 0.6	2.2 ± 0.4
No. of Analyses		16	16	16	16	16	15	16
Minimum		-80 ± 40	-0.014 ± 0.014	-0.050 ± 0.050	0.1 ± 1.2	0.8 ± 1.4	0.2 ± 0.6	0.0 ± 0.8
Maximum		40 ± 60	0.018 ± 0.024	0.010 ± 0.010	20.0 ± 8.0	28.0 ± 6.0	4.2 ± 0.6	7.0 ± 1.4
Average		-4	0.003	-0.012	3.9	6.9	1.3	2.2
2s		75	0.019	0.026	10.8	14.5	2.8	3.8
Distribution								
Fire Station 1	3-31	7 ± 60	0.005 ± 0.016	-0.009 ± 0.014	0.6 ± 1.0	3.6 ± 1.6	1.0 ± 0.6	0.8 ± 0.8
Fire Station 2	3-31	40 ± 80	-0.030 ± 0.040	-0.040 ± 0.060	1.4 ± 1.4	1.5 ± 1.6	1.8 ± 0.6	2.7 ± 0.8
Fire Station 3	3-31	10 ± 60	-0.004 ± 0.014	-0.017 ± 0.008	1.7 ± 1.6	5.1 ± 2.0	-0.1 ± 0.6	1.6 ± 0.8
Fire Station 4	3-31	30 ± 30	0.004 ± 0.026	-0.008 ± 0.018	0.8 ± 1.2	2.7 ± 1.6	2.0 ± 0.6	1.4 ± 0.8
Fire Station 5	3-31	1 ± 34	0.011 ± 0.018	-0.007 ± 0.006	2.2 ± 2.0	3.5 ± 1.8	2.4 ± 0.6	3.4 ± 0.8
Bandelier National Monument	4-1	10 ± 40	-0.004 ± 0.020	-0.017 ± 0.018	1.8 ± 1.6	3.4 ± 1.8	2.1 ± 0.6	3.4 ± 0.8
Fenton Hill (TA-57)	3-31	5 ± 34	-0.024 ± 0.036	-0.063 ± 0.024	5.6 ± 1.5	7.0 ± 2.2	0.5 ± 0.6	2.2 ± 0.8
No. of Analyses		7	7	7	7	7	7	7
Minimum		1 ± 34	-0.030 ± 0.040	-0.063 ± 0.024	0.6 ± 1.0	1.5 ± 1.6	-0.1 ± 0.6	0.8 ± 0.8
Maximum		40 ± 80	0.011 ± 0.018	-0.007 ± 0.008	5.6 ± 1.5	7.0 ± 2.2	2.4 ± 0.6	3.4 ± 0.8
Average		15	-0.006	-0.023	2.0	3.8	1.4	2.2
2s		29	0.031	0.042	3.4	3.5	1.9	2.0
Los Alamos Field								
Well LA-6	3-30	-30 ± 40	-0.005 ± 0.000	-0.015 ± 0.030	2.9 ± 2.2	4.0 ± 1.8	0.5 ± 0.6	3.8 ± 0.8

TABLE E-XIX (cont)

Primary Chemical Quality Required for Municipal Use
(Concentrations in mg/ℓ)

	Ag	As	Ba	Cd	Cr	F	Hg	NO_3	Pb	Se
Los Alamos Field										
Well LA-1B	<0.0005	0.039	0.06	<0.001	0.022	2.6	<0.0002	1.2	<0.003	<0.003
Well LA-2	<0.0005	0.013	0.09	<0.001	0.020	1.9	<0.0002	1.8	<0.003	<0.003
Well LA-3	<0.0005	0.009	0.06	<0.001	0.010	0.7	<0.0002	1.7	<0.003	<0.003
Well LA-5	<0.0005	0.032	0.07	<0.001	0.010	1.0	<0.0002	1.4	<0.003	<0.003
Guaje Field										
Well G-1	<0.0005	<0.005	0.06	<0.001	0.008	0.4	<0.0002	1.2	<0.003	<0.003
Well G-1A	<0.0005	0.009	0.04	<0.001	0.006	0.5	<0.0002	1.2	<0.003	<0.003
Well G-2	<0.0005	0.048	0.03	<0.001	0.011	1.0	<0.0002	0.9	<0.003	<0.003
Well G-3	<0.0005	0.018	0.02	<0.001	0.005	0.4	<0.0002	1.0	0.004	<0.003
Well G-4	<0.0005	<0.005	0.02	<0.001	0.004	0.3	<0.0002	1.5	<0.003	<0.003
Well G-5	<0.0005	<0.005	0.02	<0.001	0.002	0.3	<0.0002	3.0	<0.003	<0.003
Well G-6	<0.0005	<0.005	0.02	<0.001	0.005	0.3	<0.0002	0.6	<0.003	<0.003
Pajarito Field										
Well PM-1	<0.0005	<0.005	0.09	<0.001	0.010	0.3	<0.0002	1.1	<0.003	<0.003
Well PM-2	<0.0005	<0.005	0.02	<0.001	0.004	0.2	<0.0002	0.4	<0.003	<0.003
Well PM-3	<0.0005	<0.005	0.05	<0.001	0.003	0.3	<0.0002	0.7	0.005	<0.003
Well PM-4	<0.0005	<0.005	0.04	<0.001	0.006	0.3	<0.0002	7.6	<0.003	<0.003
Well PM-5	<0.0005	<0.005	0.04	<0.001	0.002	0.4	<0.0002	3.0	<0.003	<0.003
Water Canyon										
Gallery	<0.0005	<0.005	0.02	<0.001	0.002	0.1	<0.0002	0.7	<0.003	<0.003
No. of Analyses	17	17	17	17	17	17	17	17	17	17
Minimum	<0.0005	<0.005	0.02	<0.001	0.002	0.1	<0.0002	0.4	<0.003	<0.003
Maximum	<0.0005	0.048	0.09	<0.001	0.022	2.6	<0.0002	7.6	0.005	<0.003
Average	0.0005	0.013	0.04	0.001	0.008	0.6	<0.0002	1.7	0.003	<0.003
2s	0	0.027	0.05	0.000	0.012	1.3	0.000	3.4	0.001	0
Distribution										
Fire Station 1	<0.0005	<0.005	0.06	<0.001	0.005	0.3	<0.0002	<0.5	<0.003	<0.003
Fire Station 2	<0.0005	0.019	0.09	<0.001	0.011	1.0	<0.0002	2.1	<0.003	<0.003
Fire Station 3	<0.0005	<0.005	0.07	<0.001	0.005	0.7	<0.0002	<0.5	<0.003	<0.003
Fire Station 4	<0.0005	0.009	0.03	<0.001	0.040	0.5	<0.0002	1.7	<0.003	<0.003
Fire Station 5	<0.0005	0.012	0.03	<0.001	0.018	1.2	<0.0002	1.1	0.003	<0.003
Bandelier National Monument	<0.0005	0.013	0.04	<0.001	0.012	1.2	<0.0001	0.7	<0.003	<0.003
Fenton Hill (TA-57)	<0.0005	<0.005	0.02	<0.001	0.001	0.1	<0.0001	<0.5	<0.003	<0.003
No. of Analyses	7	7	7	7	7	7	7	7	7	7
Minimum	<0.0005	<0.005	0.02	<0.001	0.001	0.1	<0.0001	<0.5	<0.003	<0.003
Maximum	<0.0005	0.019	0.09	<0.001	0.040	1.2	<0.0002	2.1	0.003	<0.003
Average	0.0005	0.010	0.05	0.001	0.013	0.7	0.0002	1.0	0.003	0.003
2s	0.0000	0.011	0.05	0.000	0.026	0.9	0.0001	1.3	0.000	0.000
Los Alamos Well LA-6	<0.0005	0.185		<0.001	0.014	2.3	<0.0002	0.4	0.006	<0.003
USEPA Maximum Contaminant Level	0.05	0.05	1.0	0.01	0.05	2.0	0.002	45	0.05	0.01

TABLE E-XIX (cont)

Secondary Chemical Quality For Municipal Use
(Concentrations in mg/ℓ)

	Cℓ	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Los Alamos Field								
Well LA-1B	16	0.003	0.028	<0.002	27	<0.01	408	7.9
Well LA-2	16	0.006	0.100	0.008	12	<0.01	204	8.5
Well LA-3	4	<0.002	0.007	<0.002	5	<0.01	162	8.3
Well LA-5	2	<0.002	<0.005	<0.002	3	<0.01	170	8.6
Guaje Field								
Well G-1	3	0.003	0.007	0.010	<2	0.02	162	7.9
Well G-1A	3	0.013	0.006	<0.002	<2	0.02	152	8.3
Well G-2	3	<0.002	0.010	<0.002	2	<0.01	168	8.3
Well G-3	3	0.010	0.018	<0.002	<2	0.12	120	8.3
Well G-4	3	0.012	0.062	0.002	3	0.09	126	8.2
Well G-5	3	<0.002	0.012	0.002	4	<0.01	160	8.3
Well G-6	3	<0.002	<0.005	<0.002	2	<0.01	134	7.6
Pajarito Field								
Well PM-1	6	<0.002	<0.005	<0.002	2	<0.01	188	7.6
Well PM-2	2	0.003	<0.005	<0.002	2	0.04	134	8.0
Well PM-3	8	0.004	<0.005	<0.002	3	0.01	203	8.0
Well PM-4	2	<0.002	0.020	0.003	4	<0.01	169	8.2
Well PM-5	3	<0.002	0.050	0.055	10	<0.01	211	8.2
Water Canyon								
Gallery	<1	<0.002	0.325	<0.002	2	0.02	114	7.5
No. of Analyses	17	17	17	17	17	17	17	17
Minimum	<1	<0.002	<0.005	<0.002	<2	<0.01	114	7.5
Maximum	16	0.013	0.325	0.055	27	0.12	408	8.6
Average	5	0.004	0.039	0.006	5	0.02	176	8.1
2s	9	0.007	0.156	0.026	13	0.06	133	0.6
Distribution								
Fire Station 1	3	<0.002	0.006	<0.002	<2	0.07	128	8.0
Fire Station 2	6	0.011	0.030	<0.002	8	<0.01	190	8.3
Fire Station 3	7	0.020	<0.005	<0.002	3	<0.01	200	8.1
Fire Station 4	3	0.005	0.016	<0.002	2	<0.01	160	8.2
Fire Station 5	7	0.004	0.056	<0.002	10	<0.01	205	8.3
Bandelier National Monument	7	<0.002	0.021	<0.002	9	0.05	196	8.5
Fenton Hill (TA-57)	41	0.007	0.036	<0.002	8	0.91	274	7.8
No. of Analyses	7	7	7	7	7	7	7	7
Minimum	3	<0.002	<0.005	<0.002	<2	<0.01	128	7.8
Maximum	41	0.020	0.056	<0.002	10	0.91	274	8.5
Average	11	0.007	0.024	0.002	6	0.15	193	8.2
2s	27	0.013	0.036	0.000	7	0.67	90	0.5
Los Alamos Well LA-6	4	0.011	0.908	<0.002	2	0.07	222	8.6
USEPA Maximum Contaminant Level	250	1.0	0.3	0.05	250	5.0	500	6.5 - 8.5

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analyses.

TABLE E-XX

LOCATIONS OF SOIL AND SEDIMENT STATIONS

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]
Regional Soils[b]			
Rio Chama at Chamita	36°05′	106°07′	---
Embudo	36°12′	105°58′	---
Otowi	35°52′	106°08′	---
Near Santa Cruz	35°59′	105°54′	---
Cochiti	35°37′	106°19′	---
Bernalillo	35°17′	106°36′	---
Jemez	35°40′	106°44′	---
Perimeter Soils			
Sportsman's Club	N240	E215	S1
North Mesa	N134	E168	S2
TA-8	N060	W075	S3
TA-49	S165	E085	S4
White Rock (east)	N051	E218	S5
Tsankawi	N020	E310	S6
Onsite Soils			
TA-21	N095	E140	S7
East of TA-53	N051	E218	S8
TA-50	N035	E095	S9
Two Mile Mesa	N025	E030	S10
East of TA-54	S080	E295	S11
R-Site Road East	S042	E103	S12
Potrillo Drive	S065	E195	S13
S-Site	S035	W025	S14
Near Test Well DT-9	S150	E140	S15
Near TA-33	S245	E225	S16

[a]Soil sampling locations in Fig. 14; sediment sampling locations in Fig. 15.

TABLE E-XX (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]
Regional Sediments			
Chamita	36°05′	106°07′	---
Embudo	36°12′	105°58′	---
Otowi	35°52′	106°08′	---
Sandia	S060	E490	---
Pajarito	S185	E410	---
Ancho	S305	E335	---
Frijoles	S375	E235	---
Cochiti	35°37′	106°19′	---
Bernalillo	35°17′	106°36′	---
Jemez River	35°40′	106°44′	---
Perimeter Sediments			
Guaje at SR-4	N135	E480	12
Bayo at SR-4	N100	E455	13
Sandia at SR-4	N025	E315	14
Mortandad at SR-4	S030	E350	15
Cañada del Buey at SR-4	S090	E360	16
Pajarito at SR-4	S105	E320	17
Potrillo at SR-4	S145	E295	18
Water at SR-4	S170	E260	19
Ancho at SR-4	S255	E250	20
Frijoles at National Monument Headquarters	S280	E185	21
Effluent Release Area Sediments			
Acid Pueblo Canyon			
Acid Weir	N125	E070	22
Pueblo 1	N130	E085	23
Pueblo 2	N120	E145	24
Hamilton Bend Spring	N105	E255	25
Pueblo 3	N090	E315	26
Pueblo at SR-4	N070	E350	27

TABLE E-XX (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]
Sediments (cont)			
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
Mortandad Canyon			
Mortandad near CMR	N060	E036	39
Mortandad West of GS-1	N045	E095	40
Mortandad at GS-1	N040	E105	41
Mortandad at MCO-5	N035	E155	42
Mortandad at MCO-7	N025	E190	43
Mortandad at MCO-9	N030	E215	44
Mortandad at MCO-13	N015	E250	45

TABLE E-XXI

RADIOCHEMICAL ANALYSES OF REGIONAL SOILS AND SEDIMENTS

Location	Map Designation	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/g)
Regional Soils								
Chamita	Fig. 1	0.73 ± 0.08	0.001 ± 0.002	0.011 ± 0.006	4.1 ± 2.2	9.1 ± 2.2	2.2 ± 0.6	3.2 ± 0.6
Embudo	Fig. 1	1.37 ± 0.16	0.004 ± 0.002	0.029 ± 0.008	5.6 ± 2.6	9.1 ± 2.0	3.7 ± 0.6	2.2 ± 0.4
Otowi	Fig. 1	1.04 ± 0.12	---	---	7.0 ± 3.0	9.5 ± 0.8	4.6 ± 0.6	3.7 ± 0.6
Near Santa Cruz Lake	Fig. 1	1.27 ± 0.12	0.001 ± 0.002	0.019 ± 0.008	7.1 ± 3.7	8.4 ± 2.0	3.2 ± 0.6	3.4 ± 0.6
Cochiti	Fig. 1	0.52 ± 0.08	0.002 ± 0.004	0.006 ± 0.006	11 ± 6.0	11 ± 2.4	5.0 ± 0.6	2.9 ± 0.6
Bernalillo	Fig. 1	0.28 ± 0.08	0.001 ± 0.000	0.002 ± 0.002	3.7 ± 1.8	4.2 ± 1.2	2.9 ± 0.6	2.2 ± 0.4
Jemez	Fig. 1	0.04 ± 0.03	0.005 ± 0.002	0.001 ± 0.002	9.0 ± 4.0	11 ± 2.6	1.4 ± 0.6	2.2 ± 0.4
No. of Analyses		7	6	6	7	7	7	7
Minimum		0.04 ± 0.03	0.001 ± 0.002	0.001 ± 0.002	3.7 ± 1.8	4.2	1.4 ± 0.6	2.2 ± 0.4
Maximum		1.37 ± 0.16	0.005 ± 0.002	0.029 ± 0.008	11 ± 6.0	11 ± 2.6	5.0 ± 0.6	3.7 ± 0.6
Average		0.75	0.002	0.011	6.8	8.9	3.3	2.8
2s		1.0	0.004	0.022	5.2	4.6	2.5	1.3
Regional Sediments								
Rio Grande at:								
Embudo	Fig. 1	0.23 ± 0.08	0.001 ± 0.000	0.002 ± 0.002	3.8 ± 1.8	4.6 ± 1.2	---	1.9 ± 0.4
Otowi	A	0.16 ± 0.06	0.002 ± 0.002	0.065 ± 0.010	1.9 ± 1.0	2.3 ± 0.8	---	2.4 ± 0.4
Otowi	B	0.19 ± 0.06	0.001 ± 0.000	0.011 ± 0.002	5.9 ± 2.8	6.9 ± 1.8	---	2.4 ± 0.4
Pajarito	C	0.08 ± 0.12	0.023 ± 0.030	0.210 ± 0.260	4.6 ± 2.2	3.8 ± 1.2	---	---
Ancho	D	0.16 ± 0.08	0.000 ± 0.000	0.015 ± 0.002	4.4 ± 2.2	4.0 ± 1.2	---	---
Frijoles	E	0.21 ± 0.14	0.007 ± 0.002	0.093 ± 0.034	4.1 ± 2.0	3.4 ± 1.0	---	---
Bernalillo	Fig. 1	0.39 ± 0.06	0.001 ± 0.002	0.005 ± 0.004	16 ± 8.0	16 ± 3.4	---	3.1 ± 0.6
Jemez	Fig. 1	0.29 ± 0.16	−0.001 ± 0.002	0.002 ± 0.002	12 ± 6.0	18 ± 3.8	---	3.0 ± 0.6
No. of Analyses		8	8	8	8	8	---	5
Minimum		0.08 ± 0.12	−0.001 ± 0.002	0.002 ± 0.002	1.9 ± 1.0	3.4 ± 1.0	---	1.9 ± 0.4
Maximum		0.39 ± 0.06	0.023 ± 0.030	0.210 ± 0.260	16 ± 8.0	18 ± 3.8	---	3.1 ± 0.6
Average		0.21	0.004	0.050	6.6	7.4	---	2.6
2s		0.19	0.016	0.146	9.7	12.2	---	1.0

Note: The ± value represents twice the uncertainty term for the analysis.

TABLE E-XXII

RADIOCHEMICAL ANALYSES OF PERIMETER SOILS AND SEDIMENTS

Location	Map Designation	^{137}Cs (pCi/g)	^{238}Pu (pCi/g	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/g)
Perimeter Soils								
Sportsman Club	S1	1.56 ± 0.16	0.001 ± 0.004	0.082 ± 0.016	8.8 ± 3.8	12 ± 2.6	5.5 ± 0.6	4.3 ± 0.8
North Mesa	S2	0.54 ± 0.06	0.001 ± 0.002	0.049 ± 0.012	10.0 ± 4.0	9.3 ± 2.2	5.9 ± 0.8	4.7 ± 1.0
TA-8	S3	2.69 ± 0.26	0.005 ± 0.002	0.085 ± 0.010	6.8 ± 3.0	15 ± 3.2	2.9 ± 0.6	3.9 ± 0.8
TA-49	S4	0.62 ± 0.10	0.002 ± 0.002	0.014 ± 0.006	7.9 ± 3.6	8.8 ± 2.0	7.2 ± 0.8	4.4 ± 0.8
White Rock (east)	S5	0.70 ± 0.16	0.001 ± 0.002	0.039 ± 0.012	7.2 ± 3.2	7.6 ± 1.8	14 ± 0.8	4.0 ± 0.8
Tsankowi	S6	1.37 ± 0.10	0.000 ± 0.000	0.019 ± 0.006	5.8 ± 2.6	8.7 ± 2.0	12 ± 0.8	6.3 ± 1.2
No. of Analyses		6	6	6	6	6	6	6
Minimum		0.54 ± 0.06	0.000 ± 0.000	0.014 ± 0.006	5.8 ± 2.6	7.6 ± 1.8	2.9 ± 0.6	3.9 ± 0.8
Maximum		2.69 ± 0.26	0.005 ± 0.002	0.085 ± 0.010	10.0 ± 4.0	15.0 ± 3.2	14.0 ± 0.8	6.3 ± 1.2
Average		1.25	0.002	0.048	7.8	10.2	7.9	4.6
2s		1.65	0.004	0.061	3.0	5.5	8.4	1.8
Perimeter Sediments								
Guaje at SR-4	12	0.21 ± 0.08	0.001 ± 0.002	0.002 ± 0.002	1.9 ± 1.0	2.8 ± 1.0	2.5 ± 0.6	2.5 ± 0.6
Bayo at SR-4	13	0.09 ± 0.03	0.000 ± 0.000	0.001 ± 0.000	2.8 ± 1.4	2.8 ± 1.0	2.1 ± 0.4	2.1 ± 0.4
Sandia at SR-4	14	0.05 ± 0.06	0.004 ± 0.004	0.006 ± 0.004	2.1 ± 1.0	2.2 ± 0.8	3.0 ± 0.6	3.0 ± 0.6
Mortandad at SR-4	15	0.07 ± 0.06	0.000 ± 0.000	0.000 ± 0.002	3.2 ± 1.6	5.4 ± 1.4	---	---
Cañada del Buey at SR-4	16	0.18 ± 0.08	0.000 ± 0.000	0.007 ± 0.002	4.7 ± 2.0	3.9 ± 1.0	2.6 ± 0.6	2.6 ± 0.6
Pajarito at SR-4	17	1.27 ± 0.14	0.004 ± 0.004	0.032 ± 0.008	13 ± 6.0	12 ± 2.8	4.5 ± 1.0	4.5 ± 1.0
Potrillo at SR-4	18	0.18 ± 0.04	0.000 ± 0.002	0.008 ± 0.004	4.0 ± 1.8	4.5 ± 1.2	2.6 ± 0.6	2.6 ± 0.6
Water at SR-4	19	0.29 ± 0.12	0.000 ± 0.000	0.003 ± 0.004	3.9 ± 2.0	7.6 ± 1.8	---	---
Ancho at SR-4	20	0.32 ± 0.08	0.000 ± 0.000	0.005 ± 0.002	3.5 ± 1.6	3.8 ± 1.0	4.7 ± 1.0	4.7 ± 1.0
Frijoles	21	0.17 ± 0.6	0.001 ± 0.002	0.003.L0.0.002	1.7 ± 0.8	1.6 ± 0.8	2.3 ± 0.4	2.3 ± 0.4
No. of Analyses		10	10	10	10	10	8	8
Minimum		0.05 ± 0.06	0.000 ± 0.000	0.000 ± 0.002	1.7 ± 0.8	1.6 ± 0.8	2.1 ± 0.4	2.1 ± 0.4
Maximum		1.27 ± 0.14	0.004 ± 0.004	0.032 ± 0.008	13 ± 6.0	12 ± 2.8	4.7 ± 1.0	4.7 ± 1.0
Average		0.28	0.001	0.007	4.1	4.7	3.0	3.0
2s		0.72	0.003	0.019	6.6	6.2	2.0	2.0

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XXIII

RADIOCHEMICAL ANALYSES OF ONSITE SOILS AND SEDIMENTS

Location	Map Designation	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/g)
Onsite Soils								
TA-21	S7	0.18 ± 0.03	0.002 ± 0.002	0.320 ± 0.038	5.6 ± 2.6	5.4 ± 1.4	6.4 ± 0.8	4.2 ± 0.8
East of TA-53	S8	2.13 ± 0.16	0.002 ± 0.002	0.109 ± 0.018	4.5 ± 2.0	9.2 ± 2.0	10 ± 0.8	4.0 ± 0.8
TA-50	S9	0.02 ± 0.06	0.001 ± 0.000	0.002 ± 0.000	3.8 ± 1.8	5.6 ± 1.4	14 ± 1.0	3.9 ± 0.8
Two Mile Mesa	S10	0.81 ± 0.10	0.001 ± 0.004	0.017 ± 0.008	6.9 ± 3.0	8.9 ± 2.0	6.1 ± 0.8	3.9 ± 0.8
East of TA-54	S11	0.13 ± 0.08	0.000 ± 0.000	0.015 ± 0.006	10 ± 4.0	9.9 ± 2.2	3.1 ± 0.6	---
R-Site Road East	S12	0.84 ± 0.10	0.001 ± 0.002	0.017 ± 0.006	12 ± 6.0	17 ± 3.6	5.5 ± 0.6	5.3 ± 0.6
Potrillo Drive	S13	0.66 ± 0.08	0.001 ± 0.002	0.016 ± 0.008	7.1 ± 3.0	7.7 ± 1.8	11 ± 0.8	4.4 ± 0.8
S Site	S14	0.32 ± 0.006	0.002 ± 0.002	0.018 ± 0.006	9.0 ± 4.0	12 ± 2.6	5.6 ± 0.6	3.9 ± 0.8
Near Test Well DT-9	S15	1.04 ± 0.12	0.002 ± 0.002	0.025 ± 0.010	7.7 ± 3.4	9.8 ± 2.2	9.0 ± 0.8	4.0 ± 0.8
Near TA-33	S16	0.47 ± 0.06	0.000 ± 0.000	0.009 ± 0.004	10.0 ± 4.0	13 ± 2.8	93 ± 3.0	3.9 ± 0.8
No. of Analyses		10	10	10	10	10	10	9
Minimum		0.02 ± 0.06	0.000 ± 0.000	0.002 ± 0.000	3.8 ± 1.8	5.4 ± 1.4	3.1 ± 0.6	3.9 ± 0.8
Maximum		2.13 ± 0.16	0.002 ± 0.002	0.320 ± 0.038	12 ± 6.0	17 ± 3.6	93 ± 3.0	5.3 ± 0.6
Average		0.66	0.001	0.055	7.7	9.0	16.4	4.2
2s		1.24	0.002	0.196	5.2	7.0	54.2	0.9

Location	Map Designation	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	^{241}Am (pCi/g)	Total U (μg/g)	^{90}Sr (pCi/g)
Effluent Release Areas Sediments									
Acid-Pueblo Canyon									
Acid Weir	22	1.26 ± 0.12	0.080 ± 0.080	18.5 ± 1.40	17 ± 6.0	9.5 ± 2.2	1.03 ± 0.080	4.0 ± 0.8	1.4 ± 0.16
Acid Weir		0.99 ± 0.08	0.040 ± 0.020	7.60 ± 1.20	8.5 ± 3.6	4.1 ± 1.2	---	2.9 ± 0.6	---
Pueblo 1	23	0.20 ± 0.06	0.002 ± 0.002	0.009 ± 0.006	2.9 ± 1.4		0.004 ± 0.004	2.7 ± 0.6	0.02 ± 0.10
Pueblo 1		0.02 ± 0.14	0.000 ± 0.002	0.002 ± 0.002	1.5 ± 0.8	2.2 ± 0.8	---	2.2 ± 0.6	---
Pueblo 2	24	0.19 ± 0.04	0.024 ± 0.024	4.30 ± 0.800	7.9 ± 3.4	3.6 ± 1.0	0.145 ± 0.018	4.0 ± 0.8	0.12 ± 0.14
Pueblo 2		0.13 ± 0.06	0.026 ± 0.008	4.39 ± 0.120	6.2 ± 2.6	4.0 ± 1.2	---	3.6 ± 0.8	---
Hamilton Bend Spr	25	0.12 ± 0.04	0.002 ± 0.002	0.640 ± 0.040	2.3 ± 1.2	1.5 ± 0.8	0.029 ± 0.010	1.8 ± 0.4	0.09 ± 0.14
Hamilton Bend Spr		0.13 ± 0.10	0.004 ± 0.004	0.488 ± 0.034	1.9 ± 1.0	2.4 ± 0.8	---	1.8 ± 0.4	---
Pueblo 3	26	0.44 ± 0.12	0.060 ± 0.034	15.5 ± 2.40	18 ± 8.0	5.8 ± 1.4	0.241 ± 0.022	4.6 ± 1.0	0.17 ± 0.18
Pueblo 3		0.15 ± 0.11	0.000 ± 0.002	0.002 ± 0.004	2.1 ± 1.0	2.0 ± 0.8	---	2.8 ± 0.6	---
Pueblo at SR-4	27	0.06 ± 0.06	0.004 ± 0.008	0.640 ± 0.120	6.5 ± 2.8	5.9 ± 1.4	0.030 ± 0.008	2.8 ± 0.6	0.41 ± 0.22
Pueblo at SR-4		0.13 ± 0.05	0.004 ± 0.006	0.700	1.5 ± 0.8	0.7 ± 0.6	---	2.6 ± 0.6	---

TABLE E-XXIII (cont)

Location	Map Designation	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	^{241}Am (pCi/g)	Total U (µg/g)	^{90}Sr (pCi/g)
Effluent Release Areas Sediments									
DP-Los Alamos Canyon									
DPS-1	28	0.02 ± 0.01	0.035 ± 0.000	0.203 ± 0.000	2.9 ± 1.4	5.3 ± 1.4	0.492 ± 0.162	2.5 ± 0.6	---
DPS-1		23.9 ± 2.4	0.670 ± 0.040	2.67 ± 0.100	22 ± 10	25 ± 6.0	---	3.3 ± 0.6	---
DPS-4	29	0.14 ± 0.03	0.176 ± 0.000	0.424 ± 0.020	6.7 ± 2.8	21 ± 4.0	3.71 ± 0.206	1.9 ± 0.4	---
DPS-4		19.0 ± 2.0	0.115 ± 0.016	0.440 ± 0.034	3.3 ± 1.4	16 ± 3.2	---	3.0 ± 0.6	---
Los Alamos at Bridge	30	0.23 ± 0.10	0.002 ± 0.002	0.009 ± 0.006	4.2 ± 2.0	4.6 ± 1.2	0.003 ± 0.004	2.8 ± 0.6	0.01 ± 0.14
Los Alamos at Bridge		0.20 ± 0.12	0.390 ± 0.080	0.005 ± 0.022	2.4 ± 1.2	2.1 ± 0.8	---	2.5 ± 0.4	---
Los Alamos at LAO-1	31	0.22 ± 0.12	0.019 ± 0.020	4.10 ± 0.600	6.1 ± 2.6	3.7 ± 1.0	0.051 ± 0.010	4.2 ± 0.8	0.15 ± 0.18
LAO-1		0.13 ± 0.08	0.001 ± 0.002	1.27 ± 0.140	2.9 ± 1.4	2.1 ± 0.8	---	3.2 ± 0.6	---
Los Alamos at GS-1	32	0.15 ± 0.08	0.004 ± 0.003	0.290 ± 0.026	1.8 ± 1.0	1.5 ± 0.8	0.085 ± 0.012	1.7 ± 0.4	0.12 ± 0.12
Los Alamos at GS-1		0.15 ± 0.12	-0.002 ± 0.008	0.220 ± 0.040	1.6 ± 0.8	0.9 ± 0.6	---	1.6 ± 0.4	---
Los Alamos at LAO-3	33	8.3 ± 0.06	0.075 ± 0.010	0.239 ± 0.020	1.3 ± 0.8	4.0 ± 1.0	0.720 ± 0.040	0.9 ± 0.2	0.52 ± 0.12
Los Alamos at LAO-3		1.7 ± 0.14	0.041 ± 0.014	0.340 ± 0.040	3.8 ± 1.6	6.2 ± 1.4	---	3.5 ± 0.6	---
Los Alamos at LAO-4.5	34	4.5 ± 0.40	0.110 ± 0.014	0.437 ± 0.036	5.7 ± 2.6	11 ± 2.4	0.55 ± 0.040	4.8 ± 1.0	0.70 ± 0.22
Los Alamos at LAO-4.5		-0.16 ± 0.01	0.195 ± 0.024	0.810 ± 0.080	8.8 ± 1.9	23 ± 4.0	---	4.1 ± 0.8	---
Los Alamos at SR-4	35	3.89 ± 0.38	0.044 ± 0.010	0.272 ± 0.032	3.5 ± 1.6	8.6 ± 2.0	1.66 ± 0.100	3.3 ± 0.6	1.40 ± 0.14
Los Alamos at SR-4		5.9 ± 0.46	0.050 ± 0.014	0.195 ± 0.030	2.8 ± 1.2	6.2 ± 1.4	---	2.1 ± 0.4	---
Los Alamos at Totavi	36	0.42 ± 0.06	0.001 ± 0.002	0.730 ± 0.060	2.2 ± 1.2	2.2 ± 0.8	0.036 ± 0.008	2.4 ± 0.4	0.09 ± 0.12
Los Alamos at Totavi		0.03 ± 0.02	0.012 ± 0.010	0.290 ± 0.060	1.6 ± 0.8	1.7 ± 0.8	---	2.3 ± 0.4	---
Los Alamos at LA-2	37	0.61 ± 0.10	0.015 ± 0.006	0.254 ± 0.026	3.5 ± 1.6	4.3 ± 1.2	0.225 ± 0.020	2.2 ± 0.4	0.44 ± 0.20
Los Alamos at LA-2		0.55 ± 0.18	0.011 ± 0.012	0.300 ± 0.060	2.5 ± 1.2	3.1 ± 1.0	---	2.4 ± 0.4	---
Los Alamos at Otowi	38	0.25 ± 0.16	0.001 ± 0.000	0.004 ± 0.002	4.2 ± 2.2	6.8 ± 1.6	0.001 ± 0.002	2.7 ± 0.6	0.09 ± 0.10
Los Alamos at Otowi		0.30 ± 0.06	0.005 ± 0.010	0.100 ± 0.040	1.5 ± 0.8	0.8 ± 0.6	---	1.7 ± 0.2	---
Mortandad Canyon									
Mortandad at CMR	39	0.00 ± 0.00	0.015 ± 0.000	0.066 ± 0.000	3.5 ± 1.6	1.4 ± 0.8	0.346 ± 0.084	1.8 ± 0.4	---
Mortandad at CMR		0.12 ± 0.08	0.0260 ± 0.012	0.007 ± 0.008	5.1 ± 2.2	---	2.0 ± 0.4	---	
Mortandad West of GS-1	40	0.00 ± 0.00	0.008 ± 0.006	0.036 ± 0.000	3.8 ± 1.8	3.3 ± 1.0	0.346 ± 0.084	2.6 ± 0.6	---
Mortandad West of GS-1		0.05 ± 0.06	0.001 ± 0.004	0.007 ± 0.006	2.8 ± 1.4	6.5 ± 1.6	---	3.4 ± 0.6	---
Mortandad at GS-1	41	5.9 ± 1.3	17.6 ± 0.400	237 ± 3.40	420 ± 180	950 ± 200	28.0 ± 9.02	3.2 ± 0.6	---
Mortandad at GS-1		312 ± 19	4.75 ± 0.140	33.6 ± 0.800	130 ± 60	310 ± 60	---	2.3 ± 0.4	---
Mortandad at MCO-5	42	0.89 ± 0.20	7.2 ± 0.280	67.0 ± 1.20	150 ± 60	153 ± 30	48.0 ± 1.57	2.5 ± 0.6	---
Mortandad at MCO-5		71 ± 7.8	4.15 ± 0.140	18.5 ± 0.400	37 ± 14	83 ± 16	---	3.1 ± 0.6	---
Mortandad at MCO-7	43	0.55 ± 0.12	2.67 ± 0.080	0.27 ± 0.180	23 ± 10	68 ± 14	5.38 ± 0.358	2.3 ± 0.6	---
Mortandad at MCO-7		66 ± 6.6	9.15 ± 0.600	11.9 ± 0.240	10 ± 4.0	43 ± 8.0	---	2.2 ± 0.4	---
Mortandad at MCO-9	44	0.01 ± 0.00	0.003 ± 0.000	0.039 ± 0.000	5.9 ± 2.8	10 ± 2.4	0.45 ± 0.120	4.0 ± 0.8	---
Mortandad at MCO-9		1.0 ± 0.12	0.090 ± 0.060	8.19 ± 1.64	5.3 ± 2.4	11 ± 2.4	---	3.1 ± 0.4	---
Mortandad at MCO-13	45	0.69 ± 0.08	0.003 ± 0.002	0.019 ± 0.008	24 ± 10	30 ± 6.0	---	3.3 ± 0.4	
No. of Analyses		47	47	47	47	47	23	47	15
Minimum		-0.16 ± 0.01	-0.002 ± 0.008	0.002 ± 0.002	1.3 ± 0.8	0.7 ± 0.6	0.001 ± 0.002	0.9 ± 0.2	0.01 ± 0.14
Maximum		312 ± 19	17.6 ± 0.400	237 ± 3.40	420 ± 180	950 ± 200	48.0 ± 1.57	4.8 ± 1.0	1.40 ± 0.14
Average		11.3	1.0	9.4	21.1	40.0	3.98	3.2	0.38
2s		94.1	6.2	71.5	131.6	289.5	22.45	5.9	0.92

Note: The ± value represents twice the uncertainty term for the analysis.

TABLE E-XXIV

ELEMENTAL ANALYSES OF BEES AND HONEY

Bee Analyses

Sample Location	As (ppm) 1979	As (ppm) 1980	^{7}Be (pCi/g) 1981	^{7}Be (pCi/g) 1982	B (ppm) 1979	B (ppm) 1980	^{134}Cs (pCi/g) 1982	^{137}Cs (pCi/g) 1981	^{137}Cs (pCi/g) 1982
Chimayo	---	<0.02	<0.10	<0.261	---	19	0.046	0.500	<0.029
Barranca Mesa	---	0.07	0.084	0.589	---	14	0.148	0.0002	0.111
Pajarito Acres	---	<0.02	<22	0.288	---	18	0.129	0.117	0.054
Area G	0.07	<0.03	---	1.427	25	20	0.233	---	0.051
DP Canyon	<0.02	<0.02	<20	0.030	20	15	0.104	0.038	0.092
Effluent Canyon	<0.02	0.25	3.23	1.060	11	13	0.112	0.002	0.034
LAMPF	---	---	<41	0.406	---	---	0.100	0.006	0.065
Mortandad Canyon	0.21	<0.02	<80	0.262	24	17	0.076	0.028	0.029
S Site	0.07	0.07	<1.41	0.435	11	11	0.155	0.0004	0.085
TA-33	<0.03	0.12	<62	<0.448	15	17	0.064	<0.109	0.040

Honey Analyses

Sample Location	^{7}Be (pCi/g) 1980	^{7}Be (pCi/g) 1981	^{7}Be (pCi/g) 1982	Cd (ppb) 1979	Cd (ppb) 1980	Cd (ppb) 1981	^{134}Cs (pCi/g) 1982	^{137}Cs (pCi/g) 1979	^{137}Cs (pCi/g) 1980	^{137}Cs (pCi/g) 1981	^{137}Cs (pCi/g) 1982
Chimayo	0.050	0.01	<0.064	10.0	<10	1.4	0.002	<0.008	0.023	<0.014	0.009
Barranca Mesa	<0.143	<0.025	0.049	0.7	<10	12.0	0.019	0.006	0.003	0.050	0.003
Pajarito Acres	<0.095	0.030	0.161	1.3	<10	---	0.004	<0.02	0.003	0.040	<0.016
Area G	0.073	<0.017	0.116	2.2	<10	16.0	0.044	<0.03	<0.015	<0.020	0.031
DP Canyon	<0.143	<0.008	0.019	17.0	<10	3.1	0.034	<0.02	0.009	0.007	0.016
Effluent Canyon	<0.084	<0.012	0.146	11.0	<10	9.0	0.045	0.007	0.007	<0.015	0.034
LAMPF	---	---	0.201	---	---	---	0.019	---	---	---	0.021
Mortandad Canyon	0.111	<0.009	<0.080	7.3	<10	2.8	0.018	<0.02	0.002	0.010	0.015
S Site	<0.105	<0.008	<0.069	0.4	<10	13.0	0.020	0.001	0.033	0.014	0.007
TA-33	---	0.040	0.119	12.0	---	0.9	0.006	<0.018	---	<0.030	0.005

TABLE E-XXIV (cont)

Sample Location	Bee Analyses							
	Cr (ppm)		^{57}Co (pCi/g)	F (ppm)		^{54}Mn (pCi/g)	Hg (ppb)	
	1979	1980	1982	1979	1981	1982	1981	1982
Chimayo	---	0.83	0.070	---	---	<0.028	---	4
Barranca Mesa	---	3.91	<0.059	---	1.1	0.072	<10	<1
Pajarito Acres	---	2.68	0.037	---	4.1	0.029	3	3
Area G	1.22	5.22	0.199	2.9	1.3	0.088	---	<1
DP Canyon	1.33	4.43	0.176	18.0	2.8	0.039	<10	<1
Effluent Canyon	0.96	2.25	1.404	2.6	1.2	1.123	2	2
LAMPF	---	---	0.085	---	0.9	<0.036	2	<1
Mortandad Canyon	1.57	1.08	<0.021	3.9	1.5	0.002	2	<1
S Site	1.04	1.75	<0.048	2.0	0.3	0.015	<10	3
TA-33	1.45	2.52	0.003	3.9	0.4	0.063	3	<1

Sample Location	Honey Analyses									
	^{57}Co (pCi/g)	F (ppm)				^{54}Mn (pCi/g)	Hg (ppb)			
	1982	1979	1980	1981	1982	1982	1979	1980	1981	1982
Chimayo	0.027	0.07	0.2	<0.1	0.1	<0.007	<1	<1	<1	1
Barranca Mesa	<0.014	0.05	0.1	0.07	0.2	0.007	<1	<1	<1	2
Pajarito Acres	0.026	0.10	0.4	---	0.2	0.039	<1	<1	<1	1
Area G	0.002	0.08	0.2	0.07	0.1	0.017	<1	<1	<1	3
DP Canyon	0.031	0.09	0.4	0.26	0.4	0.001	<1	<1	<1	2
Effluent Canyon	0.063	0.05	<0.1	0.08	0.5	0.033	<1	<1	<1	<0.5
LAMPF	<0.013	---	---	---	0.1	<0.013	---	---	---	<0.5
Mortandad Canyon	0.027	0.09	0.1	0.09	0.1	0.009	<1	<1	<1	1
S Site	0.022	0.08	<0.1	0.04	0.1	0.001	<1	<1	<1	<0.5
TA-33	0.036	0.10	---	0.04	0.1	0.026	<1	---	<1	0.5

TABLE E-XXIV (cont)

Bee Analyses

Sample Location	^{83}Rb (pCi/g) 1982	^{22}Na (pCi/g) 1981	^{22}Na (pCi/g) 1982	U (ppb) 1979	U (ppb) 1980	U (ppb) 1981	U (ppb) 1982
Chimayo	0.169	<0.100	0.088	---	20	<1.0	5.5
Barranca Mesa	0.043	<0.0002	<0.062	---	59	7.3	5.5
Pajarito Acres	<0.074	<0.080	0.059	---	<10	<3.0	6.5
Area G	0.175	---	0.001	23	14	<3.0	6.0
DP Canyon	0.105	0.015	0.003	57	99	7.6	20.0
Effluent Canyon	<0.047	0.005	10.877	15	47	39.0	---
LAMPF	0.041	9.827	<0.030	---	---	<3.0	76.0
Mortandad Canyon	0.006	<0.091	0.035	36	96	7.3	9.0
S Site	0.043	<0.003	0.065	18	31	<3.0	5.5
TA-33	0.008	<0.132	0.005	7	44	<3.0	4.0

Honey Analyses

Sample Location	^{83}Rb (pCi/g) 1982	^{22}Na (pCi/g) 1980	^{22}Na (pCi/g) 1981	^{22}Na (pCi/g) 1982	^{3}H (pCi/mℓ) 1979	^{3}H (pCi/mℓ) 1980	^{3}H (pCi/mℓ) 1981	^{3}H (pCi/mℓ) 1982	U (ppb) 1979	U (ppb) 1980	U (ppb) 1981	U (ppb) 1982
Chimayo	0.042	0.044	0.005	<0.007	0.6	3.0	6.3	1.3	<04	<0.4	2.4	2.4
Barranca Mesa	0.012	0.007	<0.025	0.013	3.6	4.0	12.7	12.3	<0.4	<0.4	<1.0	1.9
Pajarito Acres	0.023	<0.011	0.030	0.027	10.5	7.9	---	3.2	<0.4	<0.4	<1.0	<0.5
Area G	0.032	0.013	<0.017	0.007	9.6	21.4	27.0	29.4	<0.4	<0.4	1.1	3.5
DP Canyon	0.015	<0.018	<0.008	0.057	5.8	5.6	18.2	9.0	<0.4	<0.4	<1.0	4.0
Effluent Canyon	0.036	0.014	<0.012	0.206	26.7	17.9	63.5	17.6	<0.4	<0.4	<1.0	4.4
LAMPF	<0.024	---	---	0.014	---	---	---	11.2	---	---	---	3.3
Mortandad Canyon	0.025	<0.009	<0.009	0.032	11.8	27.4	13.6	7.2	<0.4	0.9	<1.0	4.4
S Site	0.031	0.015	<0.008	<0.007	2.8	5.2	3.1	11.0	<0.4	<0.4	<1.0	2.8
TA-33	<0.013	---	0.040	0.095	579	207	156	92.5	<0.4	---	<1.0	2.6

TABLE E-XXV

QUALITY OF EFFLUENTS FROM LIQUID RADIOACTIVE WASTE TREATMENT PLANTS FOR 1982

	Waste Treatment Plant Location			
	TA-50		TA-21	
Radioactive Isotopes	Activity Released (mCi)	Average Concentration (μCi/mℓ)	Activity Released (mCi)	Average Concentration (μCi/mℓ)
^{238}Pu	3.0	7.5×10^{-8}	0.10	2.7×20^{-8}
^{239}Pu	16.6	4.2×10^{-7}	0.22	5.9×10^{-8}
^{241}Am	17.8	4.5×10^{-7}	0.97	2.6×10^{-7}
^{89}Sr	11.8	3.0×10^{-7}	0.03	8.2×10^{-9}
^{90}Sr	12.8	3.2×10^{-7}	0.59	1.6×10^{-7}
^{3}H	14 200	3.6×10^{-4}	1130	3.1×10^{-4}
^{137}Cs	209	5.3×10^{-6}	0.62	1.7×10^{-7}
^{234}U	1.2	3.0×10^{-8}	0.89	2.4×10^{-7}

	Waste Treatment Plant Location	
	TA-50	TA-21
Nonradioactive Constituent	Average Concentration (mg/ℓ)	Average Concentration (mg/ℓ)
Cd[a]	0.029	0.29
Ca	56	34
Cl	82	48
Cr (Total)[a]	0.046	0.15
Cu[a]	0.23	0.13
F	20	117
Hg[a]	0.0007	0.0006
Mg	2.3	3
Na	883	1020
Pb[a]	0.035	0.033
Zn[a]	0.075	0.21
CN	0.086	---
COD[a]	59	209
$NO_3(N)$	335	456
PO_4	0.91	1.2
TDS	3400	3900
pH[a]	10.9 - 12.5	5.2 - 12.5
Total Effluent Volume	3.976×10^7 ℓ	3.671×10^6 ℓ

[a]Constituents regulated by National Pollutant Discharge Elimination System permit.

TABLE E-XXVI

CHEMICAL QUALITY OF SURFACE AND GROUND WATERS FROM INACTIVE AND ACTIVE EFFLUENT RELEASE AREAS

	Acid-Pueblo Canyon		DP-Los Alamos Canyon			Sandia Canyon		Mortandad Canyon	
Analyses (in mg/ℓ)	Pueblo 1	Pueblo 3	DPS-4	LAO-1	LAO-4.5	SCS-1	SCS-3	MCO-4	MCO-7.5
Silica	47	53	21	42	35	132	70	35	29
Calcium	16	15	22	14	12	28	24	14	34
Magnesium	4	3	3	3	4	6	6	2	9
Sodium	77	96	113	48	40	153	95	315	222
CO_3	0	0	0	0 [a]	0	0	0	60	0
HCO_3	84	108	164	74 [b]	78	112	96	216	184
Sulfate	36	48	35	16	19	203	134	60	76
Chloride	37	35	48	39	12	93	56	22	22
Fluoride	1.0	1.2	5.5	0.8	0.7	1.8	1.2	5.6	0.7
Nitrate (N)	8.4	13	26	0.6	0.7	1.5	4.5	132	101
Nitrogen[c]	2.5	3.3	3.4	2.0	1.8	11	5.7	2.1	2.0
Ammonia (N)	0.7	0.7	0.3	0.2	0.4	8.6	0.4	0.5	0.3
Boron	0.3	0.5	0.2	0.1	0.1	0.6	0.2	0.2	0.1
Cadmium	0.001	0.006	0.003	0.003	0.006	0.003	0.002	0.002	0.002
Chromium	<0.005	<0.005	0.100	<0.005	<0.005	0.100	0.033	<0.005	<0.005
Copper	0.040	0.063	0.050	0.073	0.140	0.437	0.100	0.230	0.130
Lithium	0.020	0.027	0.020	0.033	<0.002	0.180	0.073	<0.002	0.013
Lead	0.014	0.013	0.038	0.022	0.038	0.033	0.068	0.031	0.080
Mercury	0.0005	0.0012	0.0007	0.0002	0.0004	0.0012	0.0004	0.0001	0.0005
Phosphate	19	31	3.3	0.52	0.24	18	5.3	1.5	0.24
Potassium	8.0	12	23	2.0	4.0	23	9.0	14	8.0
Zinc	0.204	0.030	0.490	0.208	0.574	0.704	0.702	0.437	0.168
Total Hardness	58	50	66	48	46	96	84	42	122
Total dissolved solids	366	432	546	256	232	788	510	1250	938
Suspended solids	9	36	126	18	250	11	24	45	210
COD	3	66	21	<3	<3	24	<3	24	<3
Conductance (mS/m)	49	58	76	34	30	95	66	171	134
pH	6.9	6.8	7.0	6.7	6.6	7.1	7.2	9.2	6.8

[a] CO_3, 120 mg/ℓ as $CaCO_3$.
[b] HCO_3, 96 mg/ℓ as $CaCO_3$.
[c] Total Kjeldal nitrogen.

Note: Acid-Pueblo Canyon inactive area (former release) for industrial effluents; samples collected June 2, 1982.

TABLE E-XXVII

CHEMICAL QUALITY FROM MISCELLANEOUS AREAS

	1982 Date	mg/ℓ SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	SO_4	Cℓ	F	NO_3	TDS	Hard	Cond (mS/m)	pH
Onsite Noneffluent Area																
Test Well 8	4-8	7	5	0.8	1.8	10	14	22	<1	2.4	0.19	1.3	32	19	8	9.7
Onsite Effluent Release Area																
Acid-Pueblo Canyon																
Acid Weir	4-15	24	25	3.9	6.3	93	0	111	19	123	0.4	6.6	350	75	63	6.5
Pueblo 1	4-15	59	17	3.1	11	78	0	48	31	61	0.8	76	395	51	51	6.9
Pueblo 2	4-15	57	20	4.1	11	82	0	142	21	61	0.8	19	335	63	51	7.4
Pueblo 3	4-15	62	15	2.5	11	95	0	168	39	43	1.2	26	353	45	52	7.0
Sandia Canyon																
SCS-1	4-14	189	40	9.4	27	151	0	94	173	187	1.9	7	868	132	111	7.2
SCS-2	4-14	67	38	8.2	14	188	0	162	203	160	1.9	5	758	126	117	7.8
SCS-3	4-14	70	30	6.9	10	130	0	134	130	110	1.3	4	557	99	85	7.8
Water Supply																
Well LA-6	3-30	26	3	<0.2	1.1	82	13	192	2	4	2.3	0.4	222	17	33	8.6
Well G-1	3-30	88	12	0.5	3.2	21	0	97	<1	3	0.4	1.2	162	34	16	7.9
Well G-5	8-3	60	17	4	2.0	12	0	94	6	3	<0.2	3	160	6	16	8.3
Well G-6	3-30	54	14	2.4	2.3	15	0	97	2	3	0.3	0.6	134	46	16	7.6
Well PM-1	3-30	79	24	6.4	4.1	18	0	154	2	6	0.3	1.1	188	91	25	7.6
Well PM-4	8-3	87	9	3	1.9	11	0	70	4	2	0.3	2	165	36	12	8.2
Well PM-5	8-3	86	14	4	2.4	24	0	106	10	4	0.3	8	211	52	19	8.2
Water Canyon Gallery	3-31	43	6	3	1.7	5	0	51	2	1	<0.2	0.7	114	28	8	7.5

TABLE E-XXVIII

TOTAL SUSPENDED PARTICULATES IN AIR AT LOS ALAMOS AND WHITE ROCK DURING 1982

(Data from New Mexico Environmental Improvement Division. All concentrations in $\mu g/m^3$.)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Los Alamos (Annual Geometric Mean = 48)												
Number of Samples	---	---	4	5	5	6	6	6	6	6	6	6
Maximum	---	---	78	72	122	110	62	95	84	115	40	83
Minimum	---	---	27	42	18	51	25	16	22	31	18	22
Mean	---	---	63	54	62	70	41	56	62	66	29	44
± 1s	---	---	24	15	39	22	13	28	25	31	9	23
White Rock (Annual Geometric Mean = 37)												
Number of Samples	---	---	3	5	6	6	5	7	6	6	6	7
Maximum	---	---	59	86	87	130	134	58	51	135	28	30
Minimum	---	---	29	33	8	40	63	23	10	17	9	6
Mean	---	---	41	59	50	81	91	37	32	57	19	20
± 1s	---	---	16	22	30	40	28	12	16	42	10	10

TABLE E-XXIX

QUANTITIES OF VOLATILE CHEMICALS AND COMPRESSED GASES USED AT LOS ALAMOS
(all amounts in kg)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Acids										
Acetic Acid	---	---	---	---	---	---	410	220	190	230
Hydrochloric Acid	---	---	---	---	---	---	3 700	4 200	5 400	6 500
Hydrofluoric Acid	---	---	---	---	---	---	8 100	6 400	170	420
Nitric Acid	---	---	---	---	---	---	80 000	58 100	71 900	99 500
Perchloric Acid	---	---	---	---	---	---	390	140	290	230
Phosphoric Acid	---	---	---	---	---	---	710	450	320	480
Sulfuric Acid	---	---	---	---	---	---	1 700	2 300	1 800	2 200
Gases										
Ammonia	4 200	2 700	3 200	2 600	2 600	2 900	3 000	2 500	2 600	2 900
Carbon Monoxide	---	---	---	---	4 900	6 200	9 300	5 500	4 800	6 200
Chlorine	---	---	---	---	500	680	500	640	1 100	1 200
Freon 12	---	---	---	---	2 500	3 400	2 800	2 000	2 100	3 300
Hydrogen Fluoride	---	---	---	---	1 300	950	360	500	1 300	1 000
Nitrogen Oxides	---	---	---	---	7 800	6 700	640	1 200	350	440
Sulfur Dioxide	---	---	---	---	120	290	160	110	150	370
Sulfur Hexafluoride	17 400	6 700	10 300	11 400	12 200	13 700	9 200	11 400	6 900	10 600
Inorganic Chemicals										
Ammonium Hydroxide	---	---	---	---	---	---	---	2 200	1 600	1 900
Mercury	---	---	---	---	500	290	180	140	140	200
Organic Chemicals										
Acetone	18 800	9 200	12 400	16 100	15 500	12 700	10 600	8 300	7 900	10 200
Carbon Tetrachloride	300	290	250	100	250	230	200	280	100	180
Chloroform	360	250	500	380	370	190	160	200	310	250
Ethanol	---	---	---	---	---	9 200	10 900	9 900	9 400	11 800
Freons	10 900	13 300	15 000	10 200	12 400	13 800	8 200	9 200	12 800	12 500
Kerosene	8 100	5 000	5 900	4 800	4 600	4 400	3 800	4 100	5 800	5 300
Methanol	590	540	1 500	1 700	6 600	4 300	2 600	3 300	2 400	3 400
Methylene Chloride	820	820	310	1 000	820	2 200	250	170	180	230
Methyl Ethyl Ketone	---	---	---	2 300	9 400	10 600	14 300	22 000	11 400	21 000
Perchloroethylene	3 400	680	1 000	820	680	1 000	1 400	340	1 400	9 100
Toluene	2 300	2 100	1 200	2 700	3 300	1 600	2 100	2 100	650	60
Trichloroethane	25 600	18 300	25 800	22 900	34 000	28 300	24 100	23 800	28 200	39 300
Trichloroethylene	20 400	15 500	16 200	9 400	13 200	10 200	7 400	6 900	3 400	3 200

TABLE E-XXX

ESTIMATED CONCENTRATIONS OF TOXIC ELEMENTS AEROSOLIZED BY DYNAMIC EXPERIMENTS

Element	1982 Total Usage (kg)	Fraction Aerosolized (%)	Annual Average Concentration (ng/m^3)		Applicable Standard (ng/m^3)
			4 km	8 km	
Uranium	1059	10	0.10	0.04	9000[a]
Be	26.0	2	0.0007	0.0002	10[b] (30 day av)
Pb	100.3	100 [c]	0.11	0.04	1500[d] (3 month av)

[a]Department of Energy Order 5480.1A, Chapter XI.
[b]Section 201 of the Ambient Air Quality Standards and Air Quality Control Regulations adopted by the New Mexico Health and Social Services Board, April 19, 1974.
[c]Assumed percentage aerosolization.
[d]40 CFR 50.12.

TABLE E-XXXI

SANITARY SEWAGE TREATMENT FACILITIES EFFLUENT QUALITY SUMMARY[a]

Discharge Location	Permit Constituents	Number of Deviations	Range of: [Deviation / Limiting Standard] or pH
TA-3	BOD[b]	4	1.0 - 1.4
	TSS[c]	1	1.0
	Fecal Coliform[d]	2	TNTC[f]
	pH[e]	0	---
TA-8	BOD	1	1.8
	TSS	1	3.9
	pH	3	9.7 - 10
TA-9	BOD	0	---
	TSS	0	---
	pH	0	---
TA-16	BOD	1	1.2
	TSS	1	2.0
	pH	0	---
TA-18	BOD	0	---
	TSS	0	---
	pH	1	9.5
TA-21	BOD	0	---
	TSS	0	---
	pH	0	---
TA-41	BOD	5	1.1 - 2.1
	TSS	0	---
	Fecal Coliform[d]	12	1.5 - TNTC
	pH	1	5.7
TA-46	BOD	1	1.15
	TSS	2	2.2 - 22
	pH	2	5.5 - 5.8
TA-48	BOD	0	---
	TSS	0	---
	pH	0	---
TA-53	BOD	4	1.1 - 2.0
	TSS	4	1.1 - 1.3
	pH	16	9.1 - 11
TA-35	BOD	11	1.1 - 2.4
	TSS	7	2.1 - 42
	pH	7	9.1 - 9.8

[a]Single NPDES Permit NM 0028355.
[b]The BOD_5 limits are 30 mg/ℓ (20-day avg), 45 mg/ℓ (7 day avg).
[c]The TSS limits are 30 mg/ℓ (20-day avg), 45 mg/ℓ (7 day avg).
[d]Fecal coliform limits are 2000/100 mℓ (daily max) and 1000/100 mℓ (geometric mean).
[e]The pH range limit is not less than 6.0 or greater than 9.0 standard units.
[f]TNTC = Too numerous to count.

TABLE E-XXXII

INDUSTRIAL LIQUID EFFLUENT QUALITY SUMMARY[a]

Discharge Category	Number of Outfalls	Permit Constituents	Number of Deviations	Range of: [Deviation / Limiting Standards] or pH[b]	Number of Outfalls Causing Deviations
Power Plant	2[c]	TSS	0	---	0
		Free Cl	0	---	0
		pH	12	2.2 - 11.0	2
Boiler Blowdown	1	TSS	0	---	0
		Fe	0	---	0
		Cu	9	1.1 - 5.1	1
		P	1	1.6	1
		pH	11	10.4 - 11.9	1
Treated Cooling Water	30	TSS	0	---	0
		Free Cl	4	11.0 - 22.0	2
		P	0	---	0
		pH	1	9.2	1
Noncontact Cooling Water	30	pH	2	5.9 - 9.2	2
Radioactive Waste Treatment Plant Discharges	2	NH_3	0	---	0
		COD	0	---	0
		TSS	1	1.3	1
		Cd	2	2.8 - 12	2
		Cr	3	1.4 - 3.1	1
		Cu	0	---	0
		Fe	0	---	0
		Pb	0	---	0
		Hg	0	---	0
		Zr	0	---	0
		pH	0	---	0
High Explosives Waste Discharges	20	COD	6	1.6 - 21	3
		TSS	4	1.0 - 1.6	4
		pH	3	3.3 - 5.6	3

TABLE E-XXXII (cont)

Discharge Category	Number of Outfalls	Permit Constituents	Number of Deviations	Range of: [Deviation / Limiting Standards] or pH[b]	Number of Outfalls Causing Deviations
Photo Waste Discharges	15 [c]	Cn	0	---	0
		TSS	0	---	0
		pH	0	---	0
		Ag	1	13.4	1
Printed Circuit Board Development Wastes	1	COD	1	2.0	1
		Cu	5	1.4 - 7.8	5
		Fe	5	4.6 - 18	5
		Ni	0	---	0
		P	0	---	0
		pH	4	4.0 - 9.1	
Acid Dip Tank Rinse	1	Cu	0	---	0
		pH	0	---	0
Gas Cylinder Cleaning Waste	1	TSS	0	---	0
		P	0	---	0
		pH	0	---	0

[a]Summary of reports to EPA or NPDES Permit NM 0028355.
[b]The pH range limit on all outfalls is not less than 6.0 or greater than 9.0 standard units.
[c]Increased from 14 outfalls to 15 outfalls in 1982.

TABLE E-XXXIII

MEANS[a] AND EXTREMES OF TEMPERATURE AND PRECIPITATION—
CLIMATOLOGICAL SUMMARY (1911-1982) FOR LOS ALAMOS, NEW MEXICO[b]

	Temperature (°F)										
	Means			Extremes							
Month	Mean Max	Mean Min	Avg	High Mean	Year	Low Mean	Year	High Daily Max	Date	Low Daily Min	Date
Jan	39.7	18.5	29.1	37.5	1953	20.9	1930	64	1/12/53	-18	1/13/63
Feb	43.0	21.5	32.2	37.4	1934	23.0	1939	66	2/24/36	-14	2/1/51 2/8/33
Mar	48.7	26.5	37.6	45.8	1972	32.1	1948	71	3/26/71 3/30/46	-3	3/11/48
Apr	57.6	33.7	45.6	54.3	1954	39.7	1973	79	4/23/38	5	4/9/28
May	67.0	42.8	54.9	60.5	1956	50.1	1957	89	5/29/35	24	4 Dates
Jun	77.8	52.4	65.1	84.5	1980	60.4	1965	95	6/22/81	28	6/3/19
Jul	80.4	56.1	68.2	87.3	1980	63.3	1926	95	7/11/35	37	7/7/24
Aug	77.4	54.3	65.8	70.3	1936	60.9	1929	92	8/10/37	40	8/16/47
Sept	72.1	48.4	60.2	65.8	1956	56.2	1965	94	9/11/34	23	9/29/36
Oct	62.0	38.7	50.3	54.7	1963	44.4	1976	84	10/1/80	15	10/19/76
Nov	48.7	27.1	37.9	44.4	1949	30.5	1972	72	11/1/50	-14	1/28/76
Dec	41.4	20.3	30.8	38.4	1980	24.6	1931	64	12/27/80	-13	12/9/78
Annual	59.6	36.7	48.1	52.0	1954	46.2	1932	95	7/11/35 6/22/81	-18	1/13/63

	Precipitation (in.)											Mean Number of Days		
	Rain[c]					Snow								
Month	Mean	Mo. Max	Year	Daily Max	Date	Mean	Mo. Max	Year	Daily Max	Date		Precip ≥0.10 in.	Max Temp ≥90°F	Min Temp ≤32°F
Jan	0.85	6.75	1916	2.45	1/27/16	9.7	39.3	1949	15.0	1/5/13		2	0	30
Feb	0.68	2.44	1948	1.05	2/20/15	7.3	36.4	1982	19.0	2/4/82		2	0	26
Mar	1.01	4.11	1973	2.25	3/30/16	9.7	36.0	1973	18.0	3/30/16		3	0	24
Apr	0.86	4.64	1915	2.00	4/12/75	5.1	33.6	1958	20.0	4/12/75		2	0	13
May	1.13	4.47	1929	1.80	5/21/29	0.8	17.0	1917	12.0	5/2/78		3	0	2
Jun	1.12	5.57	1913	2.51	6/10/13	0	---	---	---	---		3	1	0
Jul	3.18	7.98	1919	2.47	7/31/68	0	---	---	---	---		8	1	0
Aug	3.93	11.18	1952	2.26	8/1/51	0	---	---	---	---		9	0	0
Sept	1.63	5.79	1941	2.21	9/22/29	0.1	6.0	1913	6.0	9/25/13		4	0	0
Oct	1.52	6.77	1957	3.48	10/5/11	1.7	9.0	1972	9.0	10/31/72		3	0	7
Nov	0.96	6.60	1978	1.77	11/25/78	5.0	26.2	1931	14.0	11/22/31		2	0	22
Dec	0.96	2.85	1965	1.60	12/6/78	11.4	41.3	1967	22.0	12/6/78		3	0	30
Annual	17.83	30.34	1941	3.48	10/5/11	50.8	100.0	1958	22.0	12/6/78		43	2	154

[a]Means based on standard 30-year period: 1951-1980.
[b]Latitude 35° 32' north, longitude 106° 19' west; elevation 2260 m.
[c]Includes liquid water equivalent of frozen precipitation.

TABLE E-XXXIII (cont)

CLIMATOLOGICAL SUMMARY 1982

	Temperature (°F)						
	Means			Extremes			
Month	Mean Max	Mean Min	Avg	High	Date	Low	Date
Jan	39.4	18.3	28.9	54	26	3	8
Feb	42.4	18.9	30.6	63	21	–2	6
Mar	49.7	26.6	38.2	63	10	8	6
Apr	58.8	33.6	46.2	75	29	23	3
May	65.8	39.1	52.4	75	31	28	6
Jun	78.5	50.0	64.2	87	28	40	4
Jul	81.8	55.3	68.6	90	21	51	1
Aug	79.0	54.1	66.5	86	16	50	31
Sept	69.8	47.6	58.7	84	2	34	29
Oct	59.9	33.9	46.9	72	4	20	29
Nov	45.7	27.0	36.4	59	7	18	3
Dec	36.7	19.5	28.1	51	17	0	29
Annual	59.0	35.3	47.1	90	7/21	–2	2/6

	Precipitation (in.)						Number of Days		
	Rain[a]			Snow					
Month	Total	Daily Max	Date	Total	Daily Max	Date	Precip ≥0.10 in.	Max Temp ≥90°F	Min Temp ≤32°F
Jan	0.75	0.38	1	19.3	10.0	1	1	0	31
Feb	1.76	0.61	4	36.4	19.0	4	4	0	27
Mar	1.33	0.43	13	8.2	5.0	5	4	0	29
Apr	0.40	0.20	30	2.0	1.0	23	2	0	14
May	1.95	0.80	5	0.5	0.5	5	7	0	5
Jun	0.15	0.08	20	0	0	---	3	0	0
Jul	3.76	1.15	29	0	0	---	8	1	0
Aug	4.54	1.54	24	0	0	---	10	0	0
Sept	2.67	0.69	18	0	0	---	6	0	0
Oct	0.60	0.20	12	5.0	3.0	12	3	0	12
Nov	1.70	0.74	10	3.8	1.0	2	5	0	26
Dec	2.06	0.84	9	24.2	6.0	9	7	0	30
Annual	21.67	1.54	8/24	99.4	19.0	2/4	54	1	174

TABLE E-XXXIV

HIGHLIGHTS OF WEATHER DURING 1982

January	New Year's Snowstorm. Snowy month: 19.3 in. SMDS on the 1st: 10 in.
February	Snowiest February: 36.4 in. (previous: 24.8 in., 1948). 3rd snowiest any month. Big snowstorm shuts down Laboratory (afternoon) on the 4th. Snow on 4th is 3rd snowiest day on record: 19.0 in. SMDS on the 4th: 19.0 in. SMDP on the 4th: 0.61 in. TMDL on the 5th: 2°F. SMDL on the 6th: –2°F. SMDH on the 21st: 63°F. SMDH on the 22nd: 60°F.
March	SMDP on the 13th: 0.43 in. Windstorm on the 31st: 61 mph peak gust.
April	Dry: only 0.40 in. precipitation. Windstorm on 1st: 61 mph peak gust. Windstorm on 2nd: 53 mph peak gust. Windstorm on 12th: 50 mph peak gust. SMDH on the 29th: 75°F.
May	Wet: 1.95 in. precipitation. SMDP on the 5th: 0.80 in. SMDL on the 14th: 30°F.
June	Dry: only 0.15 in. precipitation.
July	Heavy thunderstorms on the 11th. Heavy rain and 3 in. of hail fell on 11th near Los Alamos Airport. Hail damaged windshields and vegetation near Los Alamos Airport. SMDH on the 21st: 90°F. SMDH on the 29th: 1.15 in.
August	Heavy rains continued, especially over Western Area and Barranca Mesa (where nearly 9 in. of rain fell during month).
September	Another wet month: 2.67 in. (normal: 1.63 in.). TMDH on the 2nd: 84°F. TMDL on the 13th: 40°F.

TABLE E-XXXIV (cont)

October	Cool and dry. Only 0.60 in. precipitation (normal: 1.52 in.). Tied for most snows ≥1.0 in.: 2 (1969). SMDL on the 9th: 27°F. SMDL on the 10th: 25°F. SMDS on the 11th: 2.0 in. TMDS on the 12th: 3.0 in. TMDL on the 13th: 27°F.
November	Cool and wet. 1.70 in. precipitation (normal: 0.96 in.). SMDP on the 10th: 0.74 in.
December	Cold and snowy. Average maximum temperature: 36.7°F (normal: 41.4°F). Snowfall: 24.2 in. (normal: 11.4 in.). SMDP on the 9th: 0.84 in. SMDL on the 29th: 0°F.
Annual	Average temperature = 47.1°F. Mean annual temperature = 48.1°F. Coldest year since 1976 (46.5°F). 1982 precipitation = 21.67 in. Mean annual precipitation = 17.85 in. Wettest year since 1969 (25.67 in.). 1982 snowfall = 99.4 in. Mean annual snowfall = 51.0 in. 2nd snowiest year (highest in 1958 = 100.0 in.).

Key for Abbreviations

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

TABLE E-XXXV

ANALYTICAL RESULTS OF SAMPLES TAKEN BELOW LAMPF LAGOONS

	^{3}H ($\times 10^{5}$)							
	1979		1980		1981		1982	
	Low	High	Low	High	Low	High	Low	High
Water (pCi/ℓ)								
Loc. 1	4.00 ± 0.20	11.8 ± 0.19	5.55 ± 0.09	9.47 ± 0.15	3.62 ± 0.06	6.68 ± 0.10	1.40 ± 0.02	4.88 ± 0.07
Loc. 2	3.90 ± 0.20	11.5 ± 0.18	5.53 ± 0.09	8.30 ± 0.13	3.52 ± 0.06	6.79 ± 0.10	1.36 ± 0.02	4.86 ± 0.07
Loc. 3	4.20 ± 0.20	10.8 ± 0.17	5.49 ± 0.09	9.77 ± 0.15	3.60 ± 0.06	6.70 ± 0.10	1.39 ± 0.02	4.87 ± 0.07
Loc. 4	4.60 ± 0.20	8.01 ± 0.13	5.05 ± 0.03	9.65 ± 0.15	3.60 ± 0.06	6.47 ± 0.09	1.38 ± 0.02	4.78 ± 0.07
Loc. 5	---	---	---	---	---	---	1.37 ± 0.02	4.61 ± 0.07
Loc. 8	0.004 ± 0.003	0.029 ± 0.004	0.02 ± 0.003	0.05 ± 0.004	0.004 ± 0.003	0.14 ± 0.003	0.038 ± 0.003	0.046 ± 0.003
Sediment (pCi/ℓ)								
Loc. 1	5.64 ± 0.09	9.57 ± 0.15	5.87 ± 0.09	9.65 ± 0.15	3.82 ± 0.06	6.41 ± 0.09	1.36 ± 0.02	4.69 ± 0.07
Loc. 2	4.63 ± 0.07	10.4 ± 0.2	2.01 ± 0.03	9.61 ± 0.15	3.72 ± 0.06	6.30 ± 0.09	1.39 ± 0.02	4.80 ± 0.07
Loc. 3	4.85 ± 0.08	10.5 ± 0.2	3.49 ± 0.06	9.61 ± 0.15	3.59 ± 0.06	6.97 ± 0.09	1.28 ± 0.02	4.47 ± 0.06
Loc. 4	1.38 ± 0.03	8.47 ± 0.13	4.29 ± 0.07	8.31 ± 0.13	3.70 ± 0.06	6.54 ± 0.09	1.33 ± 0.02	4.50 ± 0.07
Loc. 5	0.076 ± 0.004	3.27 ± 0.05	0.008 ± 0.0003	0.102 ± 0.0006	0.04 ± 0.004	2.43 ± 0.17	0.478 ± 0.009	3.70 ± 0.05
Loc. 6	0	0.062 ± 0.004	0.006 ± 0.0003	0.079 ± 0.002	0.02 ± 0.004	1.04 ± 0.912	0.031 ± 0.003	0.536 ± 0.009
Loc. 7	0	0.055 ± 0.004	0.011 ± 0.003	0.102 ± 0.016	0.007 ± 0.004	0.280 ± 0.004	0.058 ± 0.003	0.255 ± 0.005
Loc. 8	1.131 ± 0.005	0.140 ± 0.020	0.016 ± 0.003	0.120 ± 0.01	0 ± 0.003	0.209 ± 0.008	0.030 ± 0.003	0.184 ± 0.007

	^{7}Be							
	1979		1980		1981		1982	
	Low	High	Low	High	Low	High	Low	High
Water (pCi/ℓ)								
Loc. 1	11 100 ± 1100	340 000 ± 10 000	40 000 ± 3000	270 000 ± 10 000	220 ± 50	1 090 000 ± 60 000	9700 ± 3000	442 000 ± 12 000
Loc. 2	1050 ± 110	690 000 ± 20 000	37 000 ± 3000	490 000 ± 30 000	590 ± 70	5 800 000 ± 300 000	17 000 ± 8000	559 000 ± 30 000
Loc. 3	140 ± 160	100 000 ± 3000	32 000 ± 2000	220 000 ± 20 000	890 ± 50	710 000 ± 40 000	9900 ± 1500	353 000 ± 27 000
Loc. 4	16 600 ± 600	60 000 ± 2000	13 000 ± 1100	290 000 ± 20 000	719 ± 19	430 000 ± 10 000	12 900 ± 3000	372 000 ± 20 000
Loc. 5	---	---	---	---	---	---	4450 ± 1400	484 000 ± 13 000
Loc. 8	60 ± 50	90 ± 120	<150	900 ± 500	0 ± 160	<500	<60	435 ± 181

TABLE E-XXXV (cont)

	^{7}Be (cont)							
	1979		1980		1981		1982	
	Low	High	Low	High	Low	High	Low	High
Sediment (pCi/g)								
Loc. 1	148 ± 15	5900 ± 600	1180 ± 70	3370 ± 170	950 ± 30	30 000 ± 1600	110 ± 5	2300 ± 70
Loc. 2	340 ± 30	10 200 ± 1000	3.4 ± 1.4	7000 ± 400	5000 ± 300	20 700 ± 900	1200 ± 64	7850 ± 260
Loc. 3	134 ± 4	12 200 ± 1200	2470 ± 100	9000 ± 400	300 ± 10	13 500 ± 600	86 ± 3	9600 ± 300
Loc. 4	21.5 ± 0.7	1180 ± 130	33 ± 3	5700 ± 300	2720 ± 130	50 000 ± 3000	310 ± 17	14 100 ± 1200
Loc. 5	0.07 ± 0.02	740 ± 70	0 ± 1.3	1.7 ± 0.8	0.7 ± 0.7	460 ± 20	175 ± 6	2000 ± 65
Loc. 6	0.04 ± 0.02	1.8 ± 1.7	0.2 ± 0.3	1.1 ± 0.6	0.1 ± 0.7	51.8 ± 1.8	0.6 ± 0.5	24 ± 1
Loc. 7	0.05 ± 0.03	1.3 ± 0.8	0.3 ± 0.5	1.1 ± 0.6	0 ± 0.3	0.7 ± 0.3	0.54 ± 0.1	16 ± 0.8
Loc. 8	0.05 ± 0.02	1.6 ± 0.9	0.2 ± 0.5	2.1 ± 0.8	0 ± 1.17	3.0 ± 0.8	0.01 ± 0.49	0.43 ± 0.30

	^{22}Na							
	1979		1980		1981		1982	
	Low	High	Low	High	Low	High	Low	High
Water (pCi/ℓ)								
Loc. 1	1060 ± 50	3360 ± 150	2550 ± 90	6000 ± 400	530 ± 60	9200 ± 200	3310 ± 50	10 500 ± 310
Loc. 2	930 ± 40	3270 ± 140	2600 ± 190	5700 ± 400	400 ± 60	5000 ± 300	3230 ± 60	8700 ± 490
Loc. 3	970 ± 50	3010 ± 110	2490 ± 160	6500 ± 400	3080 ± 170	7500 ± 400	3180 ± 60	9340 ± 710
Loc. 4	870 ± 40	1940 ± 70	2420 ± 160	5200 ± 400	3340 ± 190	8900 ± 200	3230 ± 60	8620 ± 460
Loc. 5	---	---	---	---	---	---	55 ± 54	3180 ± 60
Loc. 8	3 ± 6	3 ± 6	<3	80 ± 40	12 ± 20	12 ± 20	1 ± 10	<22
Sediment (pCi/g)								
Loc. 1	1.55 ± 0.17	2.8 ± 1.5	1.57 ± 0.11	8.1 ± 0.4	4.5 ± 0.3	8.4 ± 0.6	2.8 ± 0.16	6.9 ± 0.39
Loc. 2	2.00 ± 0.20	8.3 ± 1.3	4.2 ± 0.3	17.1 ± 1.1	11.9 ± 0.6	26 ± 1	7.3 ± 0.5	24 ± 0.9
Loc. 3	0.40 ± 0.06	1.73 ± 0.18	3.4 ± 0.3	4.6 ± 0.4	2.7 ± 0.1	13.3 ± 0.7	0.6 ± 0.06	9.0 ± 0.5
Loc. 4	0.81 ± 0.10	2.6 ± 0.3	4.0 ± 0.3	7.3 ± 0.3	8.5 ± 0.5	52 ± 4	2.3 ± 0.12	39 ± 3
Loc. 5	0.04 ± 0.04	1.55 ± 0.19	0.03 ± 0.19	0.14 ± 0.06	0 ± 0.08	2.19 ± 0.12	1.77 ± 0.15	11 ± 0.4
Loc. 6	0	0.07 ± 0.05	<0.01	0.07 ± 0.09	0 ± 0.04	0.47 ± 0.05	0.08 ± 0.04	1.46 ± 0.08
Loc. 7	0.01 ± 0.04	0.06 ± 0.05	<0.01	0.05 ± 0.06	0.05 ± 0.07	0.1 ± 0.04	0 ± 0.01	0.64 ± 0.05
Loc. 8	0.01 ± 0.04	0.07 ± 0.11	0.04 ± 0.06	0.13 ± 0.06	0 ± 0.03	0.14 ± 0.06	0 ± 0.01	0.08 ± 0.04

TABLE E-XXXVI

PLUTONIUM IN SOILS NEAR TA-21 IN 1970 AND 1982

Sample Location	January-February 1970		November 1970		July 1982	
	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)
1	0.003 ± 0.002	0.496 ± 0.060	0.002 ± 0.000	0.215 ± 0.031	0.008 ± 0.004	0.640 ± 0.060
2	0.004 ± 0.002	0.545 ± 0.049	0.001 ± 0.002	0.507 ± 0.110	0.026 ± 0.008	1.05 ± 0.080
3	0.024 ± 0.006	0.825 ± 0.111	0.011 ± 0.005	0.400 ± 0.056	0.150 ± 0.024	12.9 ± 1.00
4	0.011 ± 0.002	0.008 ± 0.004	0.004 ± 0.003	0.473 ± 0.058	–0.130 ± 0.240	5.80 ± 1.40
5	0.007 ± 0.002	0.725 ± 0.071	0.005 ± 0.003	0.055 ± 0.011	0.002 ± 0.002	0.059 ± 0.014
6	0.002 ± 0.002	0.025 ± 0.005	0.004 ± 0.003	0.115 ± 0.015	0.004 ± 0.002	0.102 ± 0.016
7	0.001 ± 0.001	0.043 ± 0.007	0.004 ± 0.003	0.081 ± 0.015	0.001 ± 0.002	0.006 ± 0.004
8	0.016 ± 0.004	1.32 ± 0.123	0.007 ± 0.003	0.462 ± 0.063	0.030 ± 0.008	1.08 ± 0.120
9	0.005 ± 0.002	0.063 ± 0.007	0.004 ± 0.004	0.061 ± 0.011	0.001 ± 0.000	0.107 ± 0.014
10	0.001 ± 0.001	0.029 ± 0.004	0.005 ± 0.003	0.021 ± 0.006	0.002 ± 0.002	0.025 ± 0.008
11	0.017 ± 0.004	0.019 ± 0.004	0.000 ± 0.003	0.036 ± 0.008	0.001 ± 0.002	0.012 ± 0.006
12	0.003 ± 0.002	0.110 ± 0.015	0.004 ± 0.004	0.098 ± 0.017	0.003 ± 0.002	0.071 ± 0.014
13	---	---	0.001 ± 0.003	0.088 ± 0.018	0.016 ± 0.006	0.072 ± 0.014
No. of Analyses	12	12	13	13	13	13
Minimum	0.001 ± 0.001	0.008 ± 0.004	0.000 ± 0.003	0.021 ± 0.006	–0.130 ± 0.240	0.006 ± 0.004
Maximum	0.024 ± 0.006	1.32 ± 0.123	0.011 ± 0.005	0.507 ± 0.110	0.150 ± 0.024	12.9 ± 1.00
Average	0.008	0.351	0.004	0.201	0.009	1.69
2s	0.015	0.860	0.006	0.375	0.116	7.43
Ratio $^{239}Pu/^{238}Pu$	44		50		187	

RADIOCHEMICAL ANALYSES OF SOILS, JULY 1982

Sample Location	^{137}Cs (pCi/g)	Gross Alpha (pCi/g)	Gross Beta pCi/g)	^{3}H (10^{-6} μCi/mℓ)	^{90}Sr (pCi/g)	Total U μg/g)
1	0.53 ± 0.08	17 ± 8.0	13 ± 2.8	2.7 ± 0.6	0.35 ± 0.10	5.1 ± 1.0
2	1.2 ± 0.14	9.0 ± 2.0	11 ± 2.4	6.9 ± 0.8	0.38 ± 0.08	5.2 ± 1.0
3	0.20 ± 0.12	13 ± 6.0	9.5 ± 2.2	3.0 ± 0.6	0.72 ± 0.20	6.8 ± 1.4
4	0.82 ± 0.14	11 ± 4.0	8.8 ± 2.0	4.0 ± 0.6	0.35 ± 0.18	4.6 ± 1.0
5	0.31 ± 0.08	8.1 ± 3.4	8.0 ± 1.8	2.7 ± 0.6	0.31 ± 0.18	4.2 ± 0.8
6	0.53 ± 0.14	13 ± 6.0	14 ± 3.0	1.1 ± 0.6	0.38 ± 0.10	4.4 ± 0.8
7	0.11 ± 0.04	9.0. ± 4.0	7.8 ± 1.8	3.3 ± 0.6	0.14 ± 0.08	3.6 ± 0.8
8	1.0 ± 0.12	8.4 ± 3.6	11 ± 2.4	3.0 ± 0.6	0.52 ± 0.18	5.9 ± 1.2
9	0.64 ± 0.10	8.2 ± 3.6	9.7 ± 2.2	1.8 ± 0.6	0.57 ± 0.22	4.5 ± 1.0
10	0.65 ± 0.10	7.9 ± 3.4	11 ± 2.4	0.8 ± 0.6	0.37 ± 0.16	4.5 ± 1.0
11	0.49 ± 0.08	9.0 ± 4.0	9.0 ± 1.0	1.8 ± 0.6	0.30 ± 0.16	4.4 ± 1.0
12	0.33 ± 0.12	8.3 ± 1.8	6.3 ± 1.6	3.4 ± 0.6	0.27 ± 0.08	3.8 ± 0.8
13	0.65 ± 0.10	10 ± 4.0	9.1 ± 2.0	6.3 ± 0.6	0.40 ± 0.10	4.3 ± 0.8
No. of Analyses	13	13	13	13	13	13
Minimum	0.11 ± 0.04	7.9 ± 3.4	6.3 ± 1.6	0.8 ± 0.6	0.14 ± 0.08	3.6 ± 0.8
Maximum	1.2 ± 0.14	17 ± 8.0	14 ± 3.0	6.9 ± 0.8	0.72 ± 0.20	6.8 ± 1.4
Average	0.570	10	9.9	3.1	0.39	4.7
2s	0.616	5.4	4.2	3.6	0.29	1.7

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XXXVII

RADIOACTIVITY IN SEDIMENTS—UPPER PUEBLO CANYON

Station	Depth (cm)	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Total U (μg/g)
Site 1	0-20	0.20 ± 0.10	0.024 ± 0.000	2.03 ± 0.060	4.4 ± 0.8
	20-40	0.03 ± 0.08	0.009 ± 0.000	0.187 ± 0.020	4.0 ± 0.8
	40-60	0.03 ± 0.12	0.001 ± 0.000	0.067 ± 0.000	4.2 ± 0.8
	60-80	0.03 ± 0.08	0.011 ± 0.000	0.007 ± 0.000	4.2 ± 0.8
	80-100	−0.40 ± 0.12	0.035 ± 0.000	0.051 ± 0.000	4.0 ± 0.8
No. of Analyses		5	5	5	5
Minimum		−0.40 ± 0.12	0.001 ± 0.000	0.007 ± 0.000	4.0 ± 0.8
Maximum		0.20 ± 0.10	0.035 ± 0.000	2.03.+.0.060	4.4 ± 0.8
Average		−0.02	0.016	0.468	4.2
2s		0.45	0.027	1.75	0.4
$^{239}Pu/^{238}Pu$ Ratio			29		
Site 2	0-20	0.14 ± 0.14	0.806 ± 0.020	11.4 ± 0.200	4.5 ± 1.0
	20-40	0.21 ± 0.09	0.078 ± 0.000	14.3 ± 0.200	4.0 ± 0.8
	40-60	0.29 ± 0.06	0.053 ± 0.000	11.7 ± 0.240	4.0 ± 0.8
	60-80	0.16 ± 0.04	0.038 ± 0.004	8.31 ± 0.840	3.9 ± 0.8
	80-100	0.18 ± 0.12	0.024 ± 0.000	5.28 ± 0.120	3.2 ± 0.6
	100-120	0.11 ± 0.10	−0.009 ± 0.300	0.510 ± 0.140	4.2 ± 0.8
	120-140	0.08 ± 0.14	0.003 ± 0.000	0.230 ± 0.020	4.0 ± 0.8
	140-160	0.04 ± 0.08	0.004 ± 0.000	0.140 ± 0.000	3.2 ± 0.6
No. of Analyses		8	8	8	8
Minimum		0.04 ± 0.08	−0.009 ± 0.300	0.140 ± 0.000	3.2 ± 0.6
Maximum		0.29 ± 0.06	0.806 ± 0.020	14.3 ± 0.400	4.5 ± 1.0
Average		0.15	0.125	6.48	3.8
2s		0.16	0.554	11.5	0.9
$^{239}Pu/^{238}Pu$ Ratio			54		
Site 3	0-20	0.12 ± 0.10	2.51 ± 0.260	625 ± 14.0	6.3 ± 1.2
	20-40	0.04 ± 0.10	0.430 ± 0.280	226 ± 14.0	6.0 ± 1.2
	40-60	0.02 ± 0.08	1.20 ± 0.600	285 ± 24.0	6.7 ± 1.4
	60-80	0.09 ± 0.12	0.161 ± 0.000	42.3 ± 0.800	4.3 ± 0.8
	80-100	0.05 ± 0.08	0.083 ± 0.000	18.0 ± 0.400	2.8 ± 0.6
	100-120	0.16 ± 0.20	0.020 ± 0.000	1.94 ± 0.080	6.1 ± 1.2
	120-140	0.16 ± 0.16	0.005 ± 0.000	1.03 ± 0.040	6.4 ± 1.2
	140-160	0.01 ± 0.10	0.013 ± 0.000	0.213 ± 0.020	6.5 ± 1.4
No. of Analyses		8	8	8	8
Minimum		0.01 ± 0.10	0.005 ± 0.000	0.213 ± 0.020	2.8 ± 0.6
Maximum		0.16 ± 0.20	2.51 ± 0.260	625 ± 14.0	6.7 ± 1.4
Average		0.08	0.553	150	5.6
2s		0.12	1.78	444	2.7
$^{239}Pu/^{238}Pu$ Ratio			271		

Note: The ± value represents twice the standard deviation of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XXXVIII

PLUTONIUM IN SPRING SNOWMELT RUNOFF, 1982

Station	1982 Date	Solution ^{238}Pu (10^{-9} μCi/mℓ)	Solution ^{239}Pu (10^{-} μCi/mℓ)	Suspended Sediments ^{238}Pu (pCi/g)	Suspended Sediments ^{239}Pu (pCi/g)
Site 2	5-6	0.005 ± 0.014	0.005 ± 0.014	2.05 ± 0.260	15.6 ± 0.800
(Los Alamos Canyon)	5-7	0.038 ± 0.034	0.070 ± 0.040	1.70 ± 0.260	10.4 ± 0.800
	5-10	0.026 ± 0.036	0.026 ± 0.036	1.34 ± 0.220	7.20 ± 0.600
	5-19	0.005 ± 0.028	0.005 ± 0.028	0.460 ± 0.180	5.50 ± 0.600
No. of Analyses		4	4	4	4
Minimum		0.005 ± 0.014	0.005 ± 0.014	0.460 ± 0.220	7.20 ± 0.600
Maximum		0.038 ± 0.034	0.070 ± 0.040	2.05 ± 0.260	15.6 ± 0.800
Average		0.019	0.027	1.39	9.68
2s		0.33	0.061	1.37	9.88
$^{239}Pu/^{238}Pu$ Ratio		1.4		6.9	
Site 3	5-7	−0.005 ± 0.000	0.005 ± 0.000	0.800 ± 0.080	3.24 ± 0.260
(Los Alamos Canyon)	5-9	0.010 ± 0.040	0.030 ± 0.040	---	---
	5-10	0.007 ± 0.030	0.007 ± 0.030	0.880 ± 0.140	3.78 ± 0.400
No. of Analyses		3	3	2	2
Minimum		−0.005 ± 0.000	0.005 ± 0.000	0.800 ± 0.080	3.24 ± 0.260
Maximum		0.010 ± 0.040	0.030 ± 0.040	0.880 ± 140	3.78 ± 0.400
Average		0.004	0.014	0.840	3.51
2s		0.016	0.028	0.113	0.764
$^{239}Pu/^{238}Pu$ Ratio		3.5		4.2	

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XXXIX

PLUTONIUM IN SUMMER RUNOFF, 1982

Station	1982 Date	Solution ^{238}Pu (10^{-9} μCi/mℓ)	Solution ^{239}Pu (10^{-9} μCi/mℓ)	Suspended Sediments ^{238}Pu (pCi/g)	Suspended Sediments ^{239}Pu (pCi/g)
Site 1 (Pueblo Canyon)	8-25	0.014 ± 0.032	0.130 ± 0.060	0.115 ± 0.012	9.36 ± 0.460
	8-26	0.012 ± 0.022	0.080 ± 0.040	0.016 ± 0.004	3.33 ± 0.160
	9-20	0.032 ± 0.028	0.024 ± 0.024	0.770 ± 0.074	6.39 ± 0.400
	9-21	–0.009 ± 0.016	–0.004 ± 0.026	0.430 ± 0.060	3.77 ± 0.300
No. of Analyses		4	4	4	4
Minimum		–0.009 ± 0.016	–0.004 ± 0.026	0.016 ± 0.004	3.33 ± 0.160
Maximum		0.032 ± 0.028	0.130 ± 0.060	0.770 ± 0.074	9.36 ± 0.460
Average		0.012	0.058	0.333	5.71
2s		0.034	0.119	0.682	5.56
$^{239}Pu/^{238}Pu$ Ratio		4.8		17.1	
Site 2 (Los Alamos Canyon)	8-25	0.006 ± 0.036	0.080 ± 0.040	0.550 ± 0.040	4.60 ± 0.240
	8-26	0.010 ± 0.026	0.005 ± 0.024	0.103 ± 0.012	0.580 ± 0.040
	8-27	–0.006 ± 0.018	0.019 ± 0.036	0.138 ± 0.018	0.834 ± 0.062
	8-30	0.005 ± 0.024	0.019 ± 0.032	0.098 ± 0.012	0.415 ± 0.034
	8-31	–0.006 ± 0.012	0.006 ± 0.036	0.197 ± 0.034	0.944 ± 0.082
	9-17	0.020 ± 0.030	0.010 ± 0.040	0.236 ± 0.032	1.66 ± 0.120
	9-20	0.027.+0.0.018	0.012 ± 0.016	0.706 ± 0.068	5.39 ± 0.360
	9-21	0.014 ± 0.022	0.005 ± 0.022	0.520 ± 0.080	3.54 ± 0.240
	9-22	0.005 ± 0.012	0.005 ± 0.028	0.174 ± 0.032	1.53 ± 0.120
	9-23	0.005 ± 0.020	0.010 ± 0.034	1.90 ± 0.600	18.6 ± 1.80
No. of Analyses		10	10	10	10
Minimum		–0.006 ± 0.012	0.005 ± 0.022	0.098 ± 0.012	0.415 ± 0.034
Maximum		0.027 ± 0.018	0.080 ± 0.040	1.90 ± 0.600	18.6 ± 1.80
Average		0.008	0.017	0.462	3.81
2s		0.021	0.045	1.10	10.9
$^{239}Pu/^{238}Pu$ Ratio		2.1			8.2
Site 4	8-25	–0.006 ± 0.028	0.020 ± 0.040	0.002 ± 0.002	0.016 ± 0.006
$^{239}Pu/^{238}Pu$ Ratio		3.3		8.0	
Site 5 (Los Alamos Canyon)	8-25	0.005 ± 0.022	0.170 ± 0.060	0.052 ± 0.008	4.55 ± 0.200
	9-17	0.005 ± 0.018	–0.005 ± 0.028	0.003 ± 0.006	0.022 ± 0.016
	9-20	–0.004 ± 0.012	–0.009 ± 0.028	0.038 ± 0.008	0.370 ± 0.004
	9-21	0.011 ± 0.028	0.016 ± 0.034	0.057 ± 0.010	2.64 ± 0.160
	9-22	0.005 ± 0.018	0.005 ± 0.032	0.220 ± 0.014	4.29 ± 0.280
No. of Analyses		5	5	5	5
Minimum		–0.004 ± 0.012	–0.009 ± 0.028	0.003 ± 0.006	0.022 ± 0.016
Maximum		0.011 ± 0.028	0.170 ± 0.060	0.220 ± 0.014	4.55 ± 0.200
Average		0.004	0.035	0.074	2.37
2s		0.011	0.152	0.170	4.24
$^{239}Pu/^{238}Pu$ Ratio		8.8		32.0	

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XL

RADIOCHEMICAL QUALITY OF SUMMER RUNOFF, 1982

Station	1982 Date	^{137}Cs (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)	^{90}Sr (10^{-9} μCi/mℓ)
Site 1 (Pueblo Canyon)	8-25	40 ± 80	0.4 ± 1.2	23 ± 4.0	1.0 ± 0.6	0.8 ± 0.8	3.2 ± 1.0
	8-26	12 ± 76	9.0 ± 2.0	17 ± 4.0	0.9 ± 0.6	1.3 ± 0.8	1.2 ± 0.60
	9-20	-3 ± 108	0.8 ± 1.2	33 ± 6.0	1.9 ± 0.6	0.0 ± 0.8	13.7 ± 1.6
	9-21	48 ± 106	-0.3 ± 1.0	17 ± 3.8	1.5 ± 0.6	0.0 ± 0.8	6.7 ± 1.0
No. of Analyses		4	4	4	4	4	4
Minimum		-3 ± 108	-0.3 ± 1.0	17 ± 4.0	0.9 ± 0.6	0.0 ± 0.8	1.2 ± 0.60
Maximum		48 ± 106	9.0 ± 2.0	33 ± 6.0	1.9 ± 0.6	1.3 ± 0.8	13.7 ± 1.6
Average		24.2	2.5	22	1.3	0.5	6.2
2s		47.7	8.7	15	0.9	1.3	11
Site 2 (Los Alamos Canyon)	8-25	8 ± 80	1.2 ± 1.4	52 ± 10	2.9 ± 0.6	1.4 ± 0.8	18.3 ± 1.4
	8-26	-6 ± 34	0.5 ± 1.0	21 ± 4.0	1.6 ± 0.6	0.7 ± 0.8	6.9 ± 0.60
	8-27	15 ± 40	0.7 ± 1.2	18 ± 4.0	1.1 ± 0.6	0.0 ± 0.8	5.2 ± 1.0
	8-30	34 ± 28	7.4 ± 3.6	41 ± 8.0	2.3 ± 0.6	1.2 ± 0.8	15 ± 1.8
	8-31	16 ± 52	0.4 ± 1.0	20 ± 4.0	2.3 ± 0.6	1.2 ± 0.8	6.2 ± 0.6
	9-17	4 ± 66	0.0 ± 1.2	37 ± 8.0	2.6 ± 0.6	0.0 ± 0.8	11.6 ± 1.0
	9-20	17 ± 32	0.5 ± 1.2	37 ± 8.0	2.6 ± 0.6	0.0 ± 0.8	15.8 ± 0.8
	9-21	16 ± 74	0.5 ± 1.2	18 ± 4.0	1.3 ± 0.4	0.0 ± 0.8	4.6 ± 1.0
	9-22	31 ± 62	-0.1 ± 1.0	20 ± 4.0	3.4 ± 0.6	0.0 ± 0.8	4.4 ± 0.8
	9-23	---	6.2 ± 3.0	27 ± 6.0	---	0.0 ± 0.8	3.6 ± 1.0
No. of Analyses		9	10	10	9	10	10
Minimum		-6 ± 34	-0.1 ± 1.0	18 ± 4.0	1.1 ± 0.6	0.0 ± 0.8	3.6 ± 1.0
Maximum		34 ± 28	7.4 ± 36	52 ± 10	3.4 ± 0.6	1.4 ± 0.8	18.3 ± 1.4
Average		15	1.7	29	2.2	0.4	9.2
2s		25	5.4	24	1.5	1.2	11
Site 4 (Los Alamos Canyon)	8-25	50 ± 50	0.8 ± 1.2	8.6 ± 2.4	1.5 ± 0.6	0.9 ± 0.8	0.78 ± 0.30
Site 5 (Los Alamos Canyon)	8-25	80 ± 100	0.2 ± 1.2	13 ± 3.2	1.5 ± 0.6	1.5 ± 0.8	1.2 ± 0.30
	9-17	7 ± 24	0.4 ± 1.2	7.9 ± 2.4	0.5 ± 0.4	2.9 ± 0.8	3.9 ± 0.40
	9-20	37 ± 36	-0.4 ± 1.2	10 ± 2.8	1.8 ± 0.4	1.1 ± 0.8	1.6 ± 0.80
	9-21	4 ± 32	0.3 ± 1.4	12 ± 3.0	1.3 ± 0.6	0.5 ± 0.8	3.1 ± 0.80
	9-22	24 ± 36	0.5 ± 1.2	13 ± 3.2	1.9 ± 0.6	0.5 ± 0.8	2.9 ± 0.80
No. of Analyses		5	5	5	5	5	5
Minimum		4 ± 32	-0.4 ± 1.2	7.9 ± 2.4	0.5 ± 0.4	0.5 ± 0.8	1.2 ± 0.30
Maximum		80 ± 100	0.5 ± 1.2	13.0 ± 3.2	1.9 ± 0.6	2.9 ± 0.8	3.9 ± 0.40
Average		30	0.2	11.2	1.4	1.3	2.5
2s		62	0.7	4.4	1.1	2.0	2.2

TABLE E-XLI

ENVIRONMENTAL SURVEILLANCE OF AREA G, TA-54

Station	Stream Channel Alluvium						
	^{137}Cs (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/g)
1	0.11 ± 0.04	0.002 ± 0.002	0.008 ± 0.004	3.8 ± 1.8	2.8 ± 1.0	2.5 ± 0.6	3.7 ± 0.8
2	0.31 ± 0.10	0.003 ± 0.002	0.002 ± 0.002	5.1 ± 2.2	4.0 ± 1.0	3.5 ± 0.6	3.0 ± 0.6
3	0.19 ± 0.06	0.004 ± 0.002	0.004 ± 0.004	5.4 ± 2.4	4.9 ± 1.2	7.7 ± 0.8	2.3 ± 0.4
4	0.76 ± 0.14	0.011 ± 0.006	0.033 ± 0.010	11 ± 4.0	12 ± 2.6	22 ± 1.0	4.8 ± 1.0
5	0.19 ± 0.06	0.005 ± 0.002	0.011 ± 0.004	3.8 ± 1.8	2.8 ± 1.0	5.3 ± 0.6	2.0 ± 0.4
6	0.48 ± 0.10	0.015 ± 0.006	0.167 ± 0.020	7.8 ± 3.4	8.4 ± 20	4.2 ± 0.6	3.6 ± 0.8
7	0.31 ± 0.16	0.004 ± 0.010	0.027 ± 0.018	4.4 ± 2.0	4.4 ± 1.2	5.9 ± 0.6	3.9 ± 0.8
8	0.17 ± 0.06	0.016 ± 0.003	0.014 ± 0.006	7.2 ± 3.2	6.4 ± 1.6	2.4 ± 0.6	3.4 ± 0.6
9	0.20 ± 0.06	0.042 ± 0.010	0.019 ± 0.006	4.1 ± 1.8	3.0 ± 1.0	3.0 ± 0.6	2.0 ± 0.4
No. of Analyses	9	9	9	9	9	9	9
Minimum	0.17 ± 0.06	0.002 ± 0.002	0.002 ± 0.002	3.8 ± 1.8	2.8 ± 1.0	2.5 ± 0.6	2.3 ± 0.4
Maximum	0.76 ± 0.14	0.042 ± 0.002	0.167 ± 0.020	11 ± 4.0	12 ± 2.6	22 ± 1.0	4.8 ± 1.0
Average	0.30	0.011	0.032	5.8	5.4	6.3	3.2
2s	0.41	0.025	0.104	4.8	6.2	12	1.9

SUMMER STORM RUNOFF AT GAGING STATION, AREA G

1982 Date	Solution								Suspended Sediments	
	^{137}Cs (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	Total U (μg/ℓ)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)
7-16, 18	40 ± 35	0.072 ± 0.038	0.070 ± 0.040	0.3 ± 1.0	11 ± 2.6	0.5 ± 0.6	1.0 ± 0.60	1.5 ± 0.8	1.38 ± 0.080	0.075 ± 0.012
8-24	8 ± 36	0.031 ± 0.038	0.005 ± 0.032	6.4 ± 3.0	7.4 ± 2.2	0.9 ± 0.6	---	0.6 ± 0.8	1.08 ± 0.080	0.110 ± 0.020
8-31	90 ± 80	0.004 ± 0.012	0.004 ± 0.026	10 ± 4.0	13 ± 3.2	1.3 ± 0.6	0.04 ± 0.26	1.1 ± 0.8	---	---
9-11	17 ± 64	0.009 ± 0.018	0.005 ± 0.032	0.2 ± 1.0	6.1 ± 2.0	3.6 ± 0.6	2.1 ± 0.80	0.0 ± 0.8	1.26 ± 0.080	0.329 ± 0.002
9-17	7 ± 44	0.034 ± 0.028	0.005 ± 0.028	14 ± 6.0	16 ± 3.6	0.7 ± 0.4	−0.40 ± 0.60	0.0 ± 0.8	1.03 ± 0.028	0.140 ± 0.060
9-20	10 ± 18	0.010 ± 0.024	0.005 ± 0.028	0.4 ± 0.8	3.6 ± 1.6	0.8 ± 0.4	−0.20 ± 0.60	0.0 ± 0.8	0.640 ± 0.120	0.010 ± 0.006
No. of Analyses	6	6	6	6	6	6	5	6	5	5
Minimum	7 ± 44	0.004 ± 0.012	0.004 ± 0.026	0.2 ± 1.0	3.6 ± 1.6	0.5 ± 0.6	−0.40 ± 0.60	0.0 ± 0.8	0.640 ± 0.120	0.010 ± 0.006
Maximum	90 ± 80	0.072 ± 0.038	0.070 ± 0.040	14 ± 6.0	16 ± 3.6	3.6 ± 0.6	2.1 ± 0.80	1.5 ± 0.8	1.38 ± 0.080	0.329 ± 0.002
Average	29	0.027	0.013	5.2	9.5	1.3	0.51	0.5	1.08	0.133
2s	65	0.051	12 - 0.056	9.3 - 12	2.3 - 9.3	2.1 - 2.3	1.3 - 2.1	0.649 - 1.3	0.56	0.240

Note: The ± value represents twice the standard deviation of the distribution of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analyses.

TABLE E-XLII

METAL ION ANALYSES OF VEGETATION AND SOILS IN POND RELEASE AREA AT FENTON HILL
(all values in ppm)

Sample Type	Channel														
	100 m			200 m			400 m			1000 m			Lower Canyon		
	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil
Fall 78															
As	0.22	---	---	<0.05	---	---	0.12	---	---	0.34	---	---	0.08	---	---
Cd	<500	---	---	<500	---	---	<500	---	---	<500	---	---	<500	---	---
Li	3.5	---	---	9.1	---	---	13	---	---	1.9	---	---	1.0	---	---
Spring 79															
As	0.44	---	---	0.21	---	---	<0.04	---	---	<0.06	---	---	<0.04	---	---
B	150	---	---	290	---	---	350	---	---	26	---	---	<25	---	---
Cd	0.17	---	---	0.15	---	---	0.15	---	---	0.19	---	---	0.15	---	---
F	3.3	---	---	1.2	---	---	8.8	---	---	0.8	---	---	0.3	---	---
Li	46	---	---	110	---	---	240	---	---	2.6	---	---	2.6	---	---
Fall 79															
As	---	0.97	---	---	5.4	---	---	1.9	---	---	1.6	---	---	0.41	---
B	---	13	---	---	21	---	---	28	---	---	20	---	---	<5	---
F	---	50	---	---	34	---	---	78	---	---	47	---	---	14	---
Spring 80															
As	<0.04	8.4	10	0.31	5.9	43	0.12	2.1	12	<0.03	0.31	2	0.06	0.27	3
B	240	56	22	250	64	44	240	34	25	21	9	18	10	<5	14
Cd	---	---	0.28	---	---	0.24	---	---	0.18	---	---	0.12	---	---	0.90
F	---	---	380	---	---	290	---	---	160	---	---	110	---	---	220
Li	---	---	52	---	---	46	---	---	39	---	---	38	---	---	54
Fall 80															
As	<0.06	---	8.4	<0.06	---	3.4	<0.05	---	5.7	<0.04	---	2.4	<0.04	---	3.2
B	170	---	31	180	---	42	110	---	36	18	---	18	10	---	20
Cd	---	---	0.25	---	---	0.22	---	---	0.29	---	---	0.08	---	---	0.20
F	---	---	420	---	---	140	---	---	180	---	---	105	---	---	210
Li	---	---	58	---	---	36	---	---	39	---	---	29	---	---	40
Spring 81															
As	<0.09	7.2	6.1	<10	1.2	7.3	<0.09	1.8	5.7	---	0.16	3.2	1.8	0.09	4.9
B	25	28	33	23	---	150	28	30	11	28	14	12	26	10	16
Cd	0.45	---	0.22	0.81	---	0.25	0.10	---	0.56	---	0.32	0.24	0.02	---	0.41
F	5	39	360	1.8	32	320	3.2	6.4	120	---	6.3	90	11	9	250
Li	72	---	46	150	---	88	32	---	36	---	1.3	32	1.0	---	40

TABLE E-XLII (cont)

Sample Type	Channel														
	100 m			200 m			400 m			1000 m			Lower Canyon		
	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil
Fall 81															
As	<0.11	13	4.9	0.09	5.7	3.7	0.45	6.5	3.8	0.24	1.9	2.5	0.30	1.1	3.4
B	210	73	38	110	140	51	130	61	17	13	36	15	15	21	19
Cd	---	0.20	0.16	---	0.53	0.17	---	0.26	0.15	---	0.33	0.13	---	0.32	0.14
F	19	92	350	2.7	96	320	11	70	170	6.0	52	160	5.2	34	180
Li	52	43	45	32	16	35	19	6.0	32	---	4.5	31	4.3	3.6	40
Spring 82															
B	670	63	38	700	100	42	110	45	18	33	7	21	10	11	18
Cd	---	---	0.28	---	---	0.18	---	---	0.11	---	---	0.11	---	---	0.15
F	2.1	11	240	2.1	15	200	2.6	15	150	1.2	7.1	190	1.1	29	200
Li	---	---	44	---	---	48	---	---	31	---	---	30	---	---	46
Fall 82															
B	190	110	49	430	140	100	110	130	54	12	30	18	13	32	15
Cd	---	---	0.21	---	---	0.44	---	---	0.22	---	---	0.21	---	---	0.14

Sample Type	Bank											
	100 m			200 m			400 m			1000 m		
	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil
Fall 78												
As	0.13	---	---	0.14	---	---	0.06	---	---	<0.05	---	---
Cd	<500	---	---	<500	---	---	<500	---	---	<500	---	---
Li	1.9	---	---	1.9	---	---	0.69	---	---	1.0	---	---
Spring 79												
As	<0.04	---	---	<0.04	---	---	<0.02	---	---	<0.03	---	---
B	<25	---	---	<25	---	---	<25	---	---	<25	---	---
Cd	0.27	---	---	0.19	---	---	0.14	---	---	0.27	---	---
F	2.4	---	---	13	---	---	0.6	---	---	1.2	---	---
Li	0.8	---	---	0.8	---	---	3.3	---	---	0.8	---	---
Fall 79												
As	---	2.2	---	---	0.67	---	---	0.45	---	---	0.78	---
B	---	14	---	---	<5	---	---	9	---	---	8	---
F	---	66	---	---	28	---	---	25	---	---	23	---

TABLE E-XLII (cont)

Sample Type	Bank											
	100 m			200 m			400 m			1000 m		
	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil
Spring 80												
As	0.07	0.41	12	0.08	0.12	10	<0.05	0.76	3	<0.04	0.35	5
B	21	9	16	14	<5	19	13	13	15	11	<5	25
Cd	---	---	0.18	---	---	0.17	---	---	0.07	---	---	0.50
F	---	---	100	---	---	110	---	---	100	---	---	200
Li	--	---	30	---	---	30	---	---	34	---	---	30
Fall 80												
As	<0.08	---	---	<0.04	---	4.2	<0.06	---	3.3	<0.03	---	4.8
B	32	---	10	30	---	13	9	---	19	9	---	23
Cd	---	---	0.17	---	---	0.17	---	---	0.11	---	---	0.29
F	---	---	---	---	---	80	---	---	95	---	---	160
Li	---	---	35	---	---	32	---	---	29	---	---	33
Spring 81												
As	0.26	0.34	0.5	<10	0.45	7.3	26	0.36	3.1	0.09	0.10	3.3
B	18	22	15	24	18	16	20	19	20	27	15	23
Cd	0.08	---	0.24	0.28	0.23	0.16	0.05	0.33	0.11	0.14	0.66	0.51
F	2.9	19	100	2.3	21	160	7.8	22	130	13	11	170
Li	0.37	2.6	28	1.5	2.7	29	0.92	1.1	31	0.75	6.9	30
Fall 81												
As	0.11	3.8	2.8	0.08	2.2	3.3	0.35	2.9	4.2	<0.06	5.7	3.6
B	15	42	16	14	29	16	20	28	15	12	35	15
Cd	---	0.18	0.13	---	0.10	0.17	---	0.17	0.11	---	---	0.16
F	6.7	45	90	1.8	28	150	6.0	59	130	3.8	46	140
Li	1.2	23	30	0.86	19	30	2.1	20	29	0.75	3.7	26
Spring 82												
B	19	7	14	18	12	16	17	17	19	10	10	21
Cd	---	---	0.12	---	---	0.17	---	---	0.16	---	---	0.11
F	2.1	7.5	80	1.6	12	130	1.9	2.5	200	2.0	10	220
Li	---	---	31	---	---	26	---	---	32	---	---	33
Fall 82												
B	11	29	14	13	37	23	32	30	17	9	34	31
Cd	---	---	0.08	---	---	0.16	---	---	0.08	---	---	0.51

TABLE E-XLIII

PLUTONIUM IN RESERVOIR SEDIMENTS, 1982

	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	$^{239}Pu/^{238}Pu$ Ratio
Heron Reservoir			
Upper	0.0002 ± 0.0000	0.0077 ± 0.0000	38
Middle	0.0007 ± 0.0000	0.0135 ± 0.0000	19
Lower	0.0009 ± 0.0000	0.0199 ± 0.0000	22
$\bar{x}$ ± 2s	0.0006 ± 0.0007	0.0137 ± 0.0122	23
El Vado Reservoir			
Upper	0.0001 ± 0.0000	0.0106 ± 0.0000	106
Middle	0.0001 ± 0.0000	0.0052 ± 0.0000	52
Lower	0.0006 ± 0.0000	0.0126 ± 0.0000	21
$\bar{x}$ ± 2s	0.0003 ± 0.0006	0.0095 ± 0.0077	32
Abiquiu Reservoir			
Upper	0.0004 ± 0.0003	0.0080 ± 0.0006	20
Lower	0.0006 ± 0.0001	0.0114 ± 0.0006	19
$\bar{x}$ ± 2s	0.0005 ± 0.003	0.0097 ± 0.0048	20
Cochiti Reservoir			
Station 1	0.0007 ± 0.0001	0.0151 ± 0.0008	22
Station 2	0.0012 ± 0.0001	0.0257 ± 0.0012	21
Station 3	0.0008 ± 0.0001	0.0156 ± 0.0008	20
Station 4	0.0008 ± 0.0001	0.0156 ± 0.0010	20
Station 5	0.0010 ± 0.0001	0.0174 ± 0.0008	17
Station 6	0.0012 ± 0.0001	0.0179 ± 0.0010	15
Station 7	0.0008 ± 0.0001	0.0171 ± 0.0008	21
$\bar{x}$ ± 2s	0.0009 ± 0.0004	0.0178 ± 0.0072	20
Summary			
$\bar{x}$ ± 2s	0.0007 ± 0.0007	0.0142 ± 0.0105	20

Note: The ± value represents twice the standard deviation of the distribution of a number of observed values. If only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

APPENDIX F

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the 32 active technical areas (TA's) operated by the Laboratory are shown in Fig. 4. The main programs conducted at each are listed in this appendix.

TA-2, Omega Site: Omega West Reactor, an 8 megawatt nuclear research reactor, is located here. It serves as a research tool in providing a source of neutrons for fundamental studies in nuclear physics and associated fields.

TA-3, South Mesa Site: In this main technical area of the Laboratory is the Administration Building that contains the Director's office and administrative offices and laboratories for several divisions. Other buildings house the Central Computing Facility, Administration offices, Materials Department, the science museum, Chemistry and Materials Science Laboratories, Physics Laboratories, technical shops, cryogenics laboratories, a Van de Graaff accelerator, and cafeteria.

TA-6, Two Mile Mesa Site: This is one of three sites (TA-22 and TA-40 are the other two sites) used in development of special detonators for initiation of high explosive systems. Fundamental and applied research in support of this activity includes investigation of phenomena associated with initiation of high explosives, and research in rapid shock-induced reactions with shock tubes.

TA-8, GT Site (or Anchor Site West): This is a nondestructive testing site operated as a service facility for the entire Laboratory, It maintains capability in all modern nondestructive testing techniques for insuring quality of materials, ranging from test weapon components to checking of high pressure dies and molds. Principal tools include radiographic techniques (x-ray machines to 1 million volts, a 24-MeV betatron), radioactive isotopes, ultrasonic testing, penetrant testing, and electromagnetic methods.

TA-9, Anchor Site East: At this site fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K-Site: Facilities are located here for testing explosive components and systems under a variety of extreme physical environments. The facilities are arranged so testing may be controlled and observed remotely, and so devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q-Site: This firing site is used for running various tests on relatively small explosive charges and for fragment impact tests.

TA-15, R-Site: This is the home of PHERMEX—a multiple cavity electron accelerator capable of producing a very large flux of x-rays for certain weapons development problems and tests. This site is also used for the investigation of weapon functioning and weapon system behavior in nonnuclear tests, principally by electronic recording means.

TA-16, S-Site: Investigations at this site include development, engineering design, pilot manufacture, environmental testing, and stockpile production liaison for nuclear weapon warhead systems. Development and testing of high explosives, plastics and adhesives, and process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18, Pajarito Laboratory Site: The fundamental behavior of nuclear chain reactions with simple, low-power reactors called "critical assemblies" is studied here. Experiments are operated by remote control and observed by closed circuit television. The machines are housed in buildings known as "kivas" and are used primarily to provide a controlled means of assembling a critical amount of fissionable materials. This is done to study the effects of various shapes, sizes, and configurations. These machines are also used as sources of fission neutrons in large quantities for experimental purposes.

TA-21, DP-Site: This site has two primary research areas, DP West and DP East. DP West is concerned with chemistry research. DP East is the high temperature chemistry and tritium site.

TA-22, TD Site: See TA-6.

TA-28, Magazine Area "A": Explosives storage area.

TA-33, HP-Site: A major high-pressure tritium handling facility is located here. Laboratory and office space for Geosciences Division related to the Hot Dry Rock Geothermal Project are also here.

TA-35, Ten Site: Nuclear safeguards research and development, which is conducted here, is concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research in reactor safety and laser fusion is also done here.

TA-36, Kappa Site: Various explosive phenomena, such as detonation velocity, are investigated here.

TA-37, Magazine Area "C": Explosives storage area.

TA-39, Ancho Canyon Site: Nonnuclear weapon behavior is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interaction of explosives, and explosions with other materials.

TA-40, DF-Site: See TA-6.

TA-41, W-Site: Personnel at this site are engaged primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.

TA-43, Health Research Laboratory: The Biomedical Research Group does research here in cellular radiobiology, molecular radiobiology, biophysics, mammalian radiobiology, and mammalian metabolism. A large medical library, special counters used to measure radioactivity in humans and animals, and animal quarters for dogs, mice and monkeys are also located in this building.

TA-46, WA Site: Here applied photochemistry, which includes development of technology for laser isotope separation and laser-enchancement of chemical processes, is investigated. Solar energy research, particularly in the area of passive solar heating for residences, is done.

TA-48, Radiochemistry Site: Laboratory scientists and technicians at this site study nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made and "hot cells" are used for remote handling of radioactive materials.

TA-50, Waste Management Site: Personnel at this site have responsibility for treating and disposing of most industrial liquid waste received from Laboratory technical areas, for development of improved methods of folid waste treatment, and for containment of radioactivity removed by treatment. Radioactive liquid waste is piped to this site for treatment from many of the technical areas.

TA-51, Animal Exposure Facility: Here animals are exposed to nonradioactive toxic materials to determine biological effects of high and low exposures.

TA-52, Reactor Development Site: A wide variety of activities related to nuclear reactor performance and safety are done here.

TA-53, Meson Physics Facility: The Los Alamos Meson Physics Facility (LAMPF), a linear particle accelerator, is used to conduct research in the areas of basic physics, cancer treatment, materials studies, and isotope production.

TA-54, Waste Disposal Site: This is a disposal area for solid radioactive and toxic wastes.

TA-55, Plutonium Processing Facilities: Processing of plutonium and research in plutonium metallurgy are done here.

TA-57, Fenton Hill Site: This is the location of the Laboratory's Hot Dry Rock geothermal project. Here scientists are studying the possibility of producing energy by circulating water through hot, dry rock located hundreds of meters below the earth's surface. The water is heated and then brought to the surface to drive electric generators.

TA-58, Two Mile Mesa. Undeveloped technical area.

TA-59, Occupational Health Site: Occupational health and environmental science activities are conducted here.

APPENDIX G

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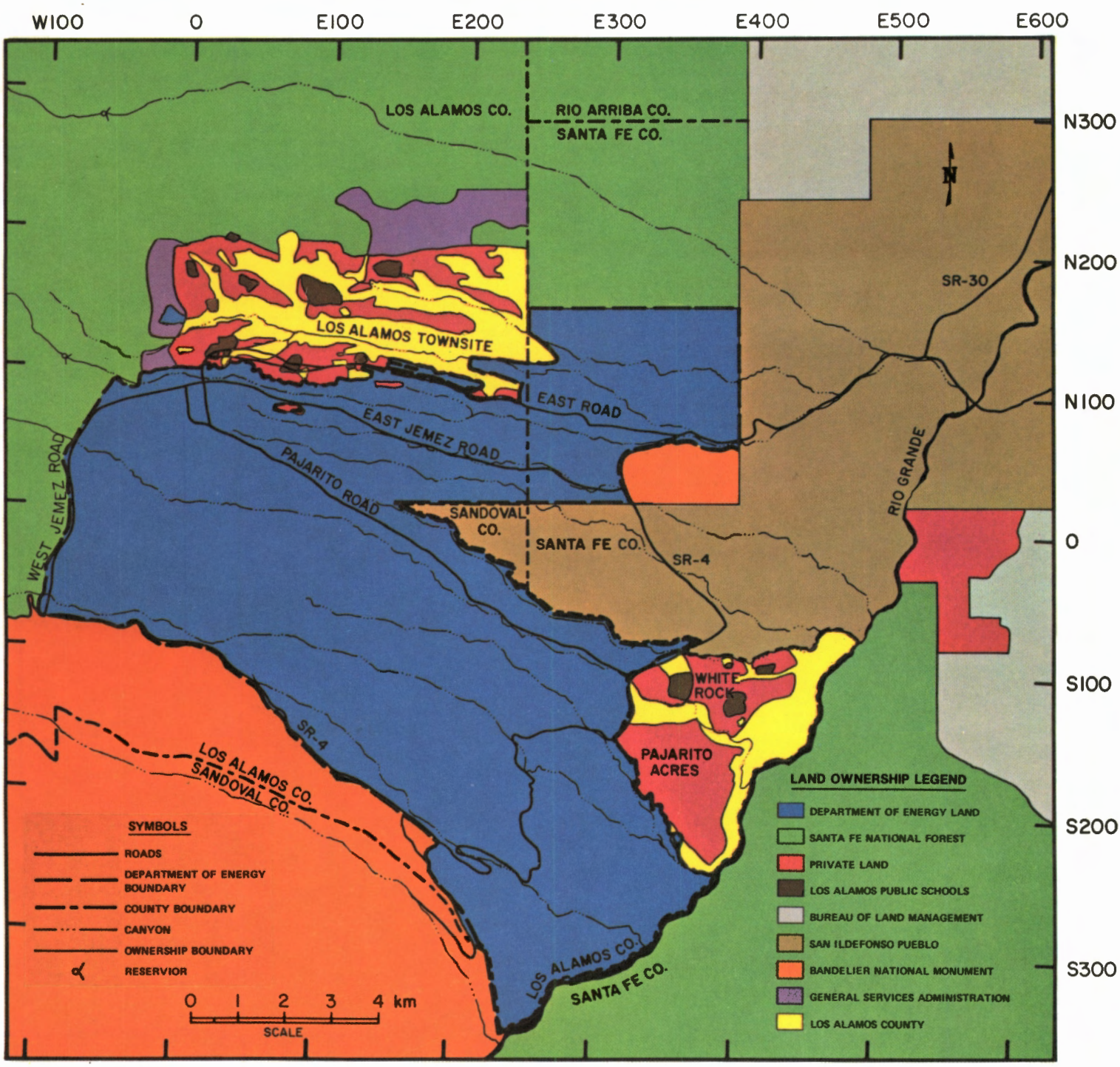
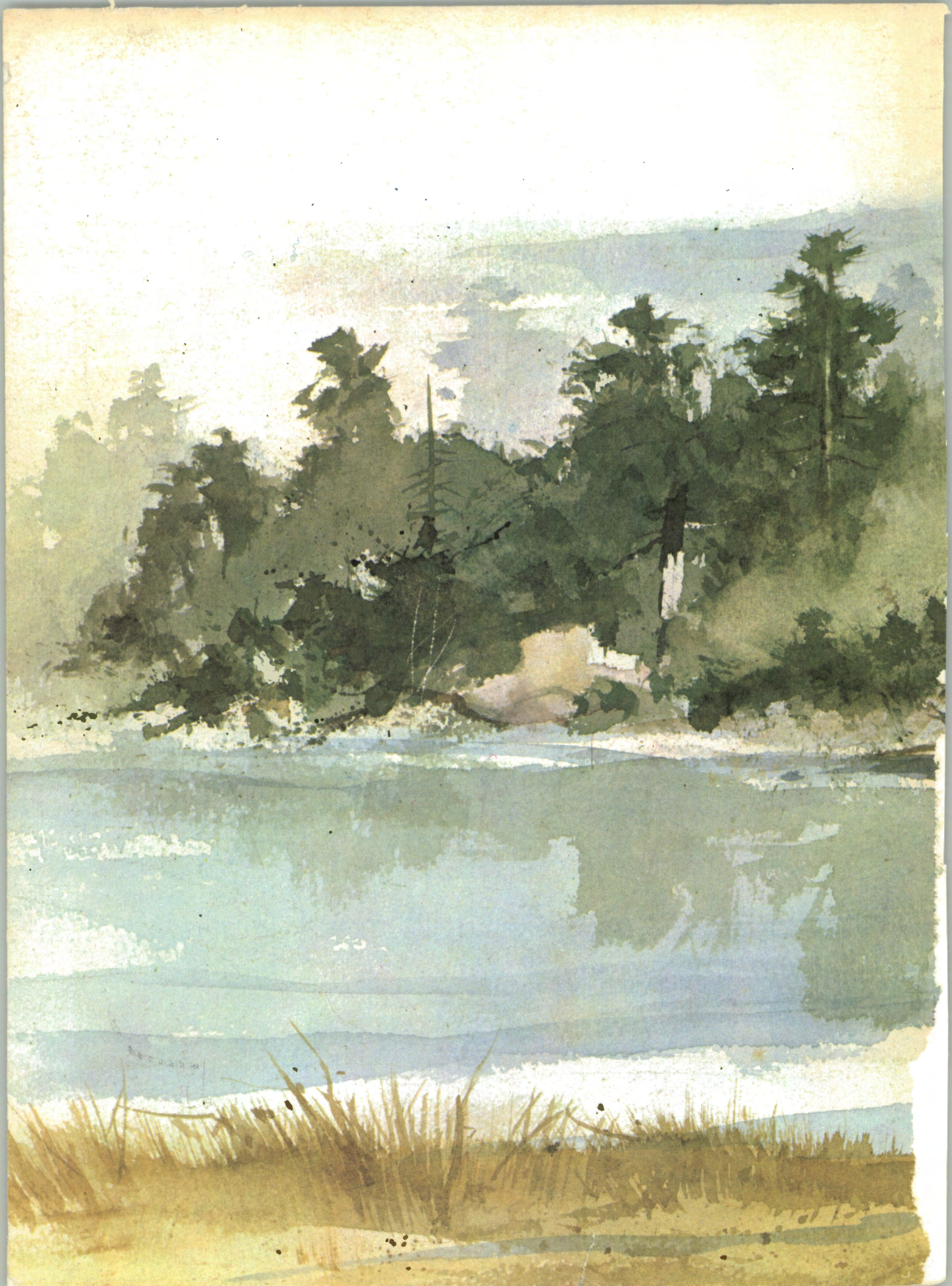
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