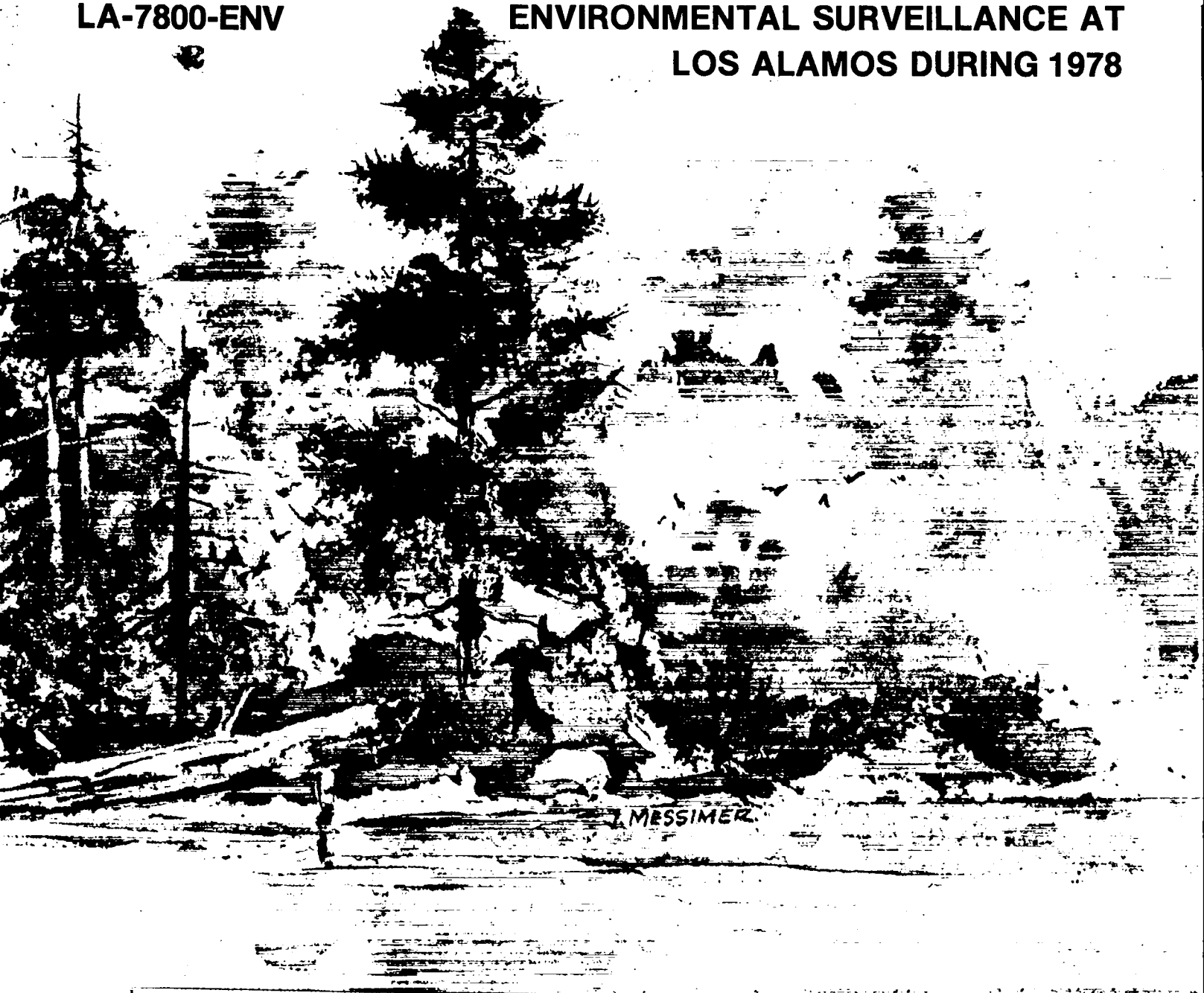
LA-7800-ENV

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1978



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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 1978

Environmental Surveillance Group

The four most recent reports in this series, unclassified, are LA-5977-PR, LA-6321-MS, LA-6801-MS, and LA-7263-MS.

UNITED STATES
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ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1978

Environmental Surveillance Group

ABSTRACT

This report documents the environmental surveillance program conducted by the Los Alamos Scientific Laboratory (LASL) in 1978. 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 the data for 1978 on penetrating radiation, chemical and radiochemical quality of ambient air, surface and ground water, municipal water supply, soils and sediments, food, and airborne and liquid effluents are included. Comparisons with appropriate standards and regulations or with background levels from natural or other non-LASL sources provide a basis for concluding that environmental effects attributable to LASL operations are minor and cannot be considered likely to result in any hazard to the population of the area. Results of several special studies provide documentation of some unique environmental conditions in the LASL environs.

I. INTRODUCTION

This report documents results of the environmental monitoring program conducted at the Los Alamos Scientific Laboratory (LASL) during 1978. In keeping with Department of Energy (DOE) and Laboratory intent to describe and document possible influences of operations on the environment, this report provides data and interpretation of environmental conditions in the vicinity of LASL.

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

Since its inception in 1943, the Laboratory's primary mission has been nuclear weapons research and development. National security programs include weapons development, laser fusion, nuclear materials research, and laser isotope separation, as well as 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, magnetic fusion, and radiobiology and medicine. In more recent years other programs have been added in astrophysics, earth sciences, energy resources, nuclear fuel safeguards, lasers, and biomedical and environmental research.

A unique combination of facilities, which contribute to the various research programs, exists at Los Alamos. These facilities include the 800 MeV proton accelerator, a tandem Van de Graaff accelerator, the Laser Laboratory, the Magnetic Fusion Laboratory, a flash radiographic facility, and a 10 megawatt research reactor. Some of these facilities encourage participation and joint projects by researchers from other laboratories and research facilities.

In August 1977, the LASL site, encompassing 111 km^2, was dedicated as a National Environmental Research Park. The ultimate goal of 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 made available to individuals and organizations outside of LASL for the purpose of facilitating self-supported research on those subjects deemed compatible with the LASL programmatic mission.

A. Physical Setting

The Los Alamos Scientific Laboratory and adjacent residential areas of Los Alamos and White Rock are located in Los Alamos County in north-central New Mexico, about 100 km NNE of Albuquerque and 40 km NW of Santa Fe by air (Fig. 1). The 111 km^2 Laboratory site and adjacent communities are situated on the Pajarito Plateau. The Plateau consists of a series of mesas separated by deep canyons cut by intermittent streams that trend eastward from an altitude of about 2400 m at the flank of the Jemez Mountains to about 1800 m at the eastern margin where it terminates above the Rio Grande valley. Most Laboratory and community developments are confined to the mesa tops (see Fig. 2 and inside front cover). The surrounding land is essentially undeveloped with large tracts of land north, west, and south of the Laboratory site held by the U.S. Forest Service and U.S. Park Service (see land ownership map inside back cover). San Ildefonso Indian lands border the Laboratory to the east.

All Los Alamos County and vicinity locations references in this report are identified by the LASL cartesian coordinate system, which is based on English units of measurement. This system is standard throughout the Laboratory but is independent of the U.S. 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 LASL boundary is a controlled area because DOE has the option to completely restrict access. This control can be instituted when necessary.

B. Geology-Hydrology

The canyons and mesas in the Laboratory area are underlain by the Bandelier Tuff composed of ashfall and ashflow pumice and rhyolite tuff that form the surface of the Pajarito Plateau. The tuff ranges from nonwelded to welded and is in excess of 300 m thick in the western part of the Pajarito Plateau and thins to about 80 m 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—1.4 million years ago.

The tuffs lap onto the older volcanics of the Tschicoma Formation, which form the Jemez Mountains along the western edge of the Plateau and are underlain by the fanglomerate of the Puye Formation in the central and eastern edge along the Rio Grande. The Chino Mesa basalts interfinger with the fanglomerate along the river. These formations overlie the siltstone/sandstone Tesuque Formation, which extends across the Rio Grande Valley, and are in excess of 1000 m thick.

Los Alamos area surface water is primarily intermittent stream flow. Springs on the flanks of the Jemez Mountains supply base flow to the upper reaches of some canyons, but the amount is insufficient to maintain surface flows across the 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 1.5 km.

Ground water occurs in three modes in the Los Alamos area: (1) water in shallow alluvium in the canyons, (2) perched water in basalt, and (3) the main aquifer of the Los Alamos area.

Intermittent stream flows in canyons of the Plateau have deposited alluvium that ranges from less than 1 m to as much as 30 m in thickness. The alluvium is quite permeable in contrast to the underlying volcanic tuff and sediments. The intermittent runoff in the canyons infiltrates the alluvium until its downward movement is impeded by the less permeable tuff and volcanic sediment. This results in a shallow alluvial ground water body that moves

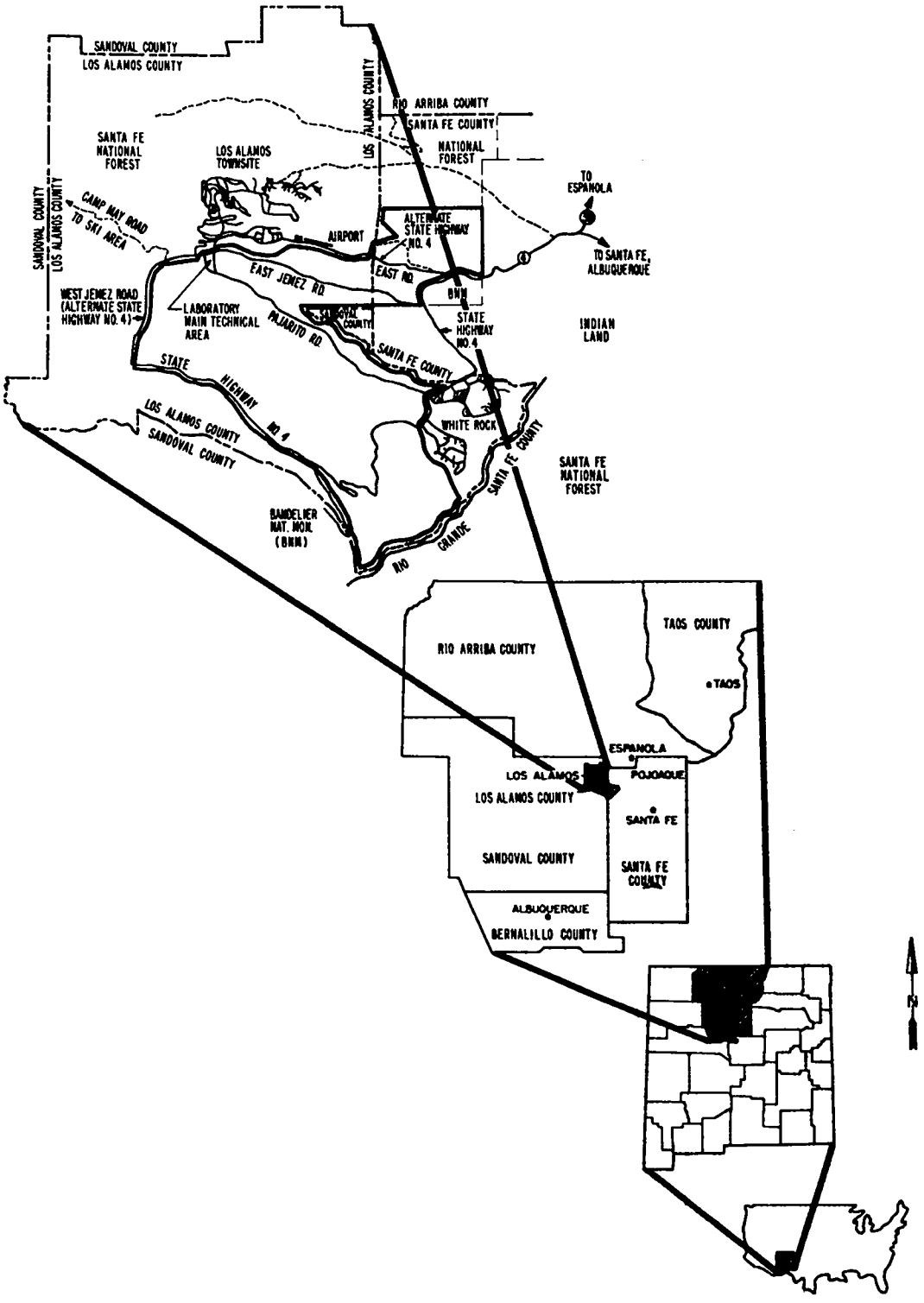


Fig. 1.

Regional location of Los Alamos.

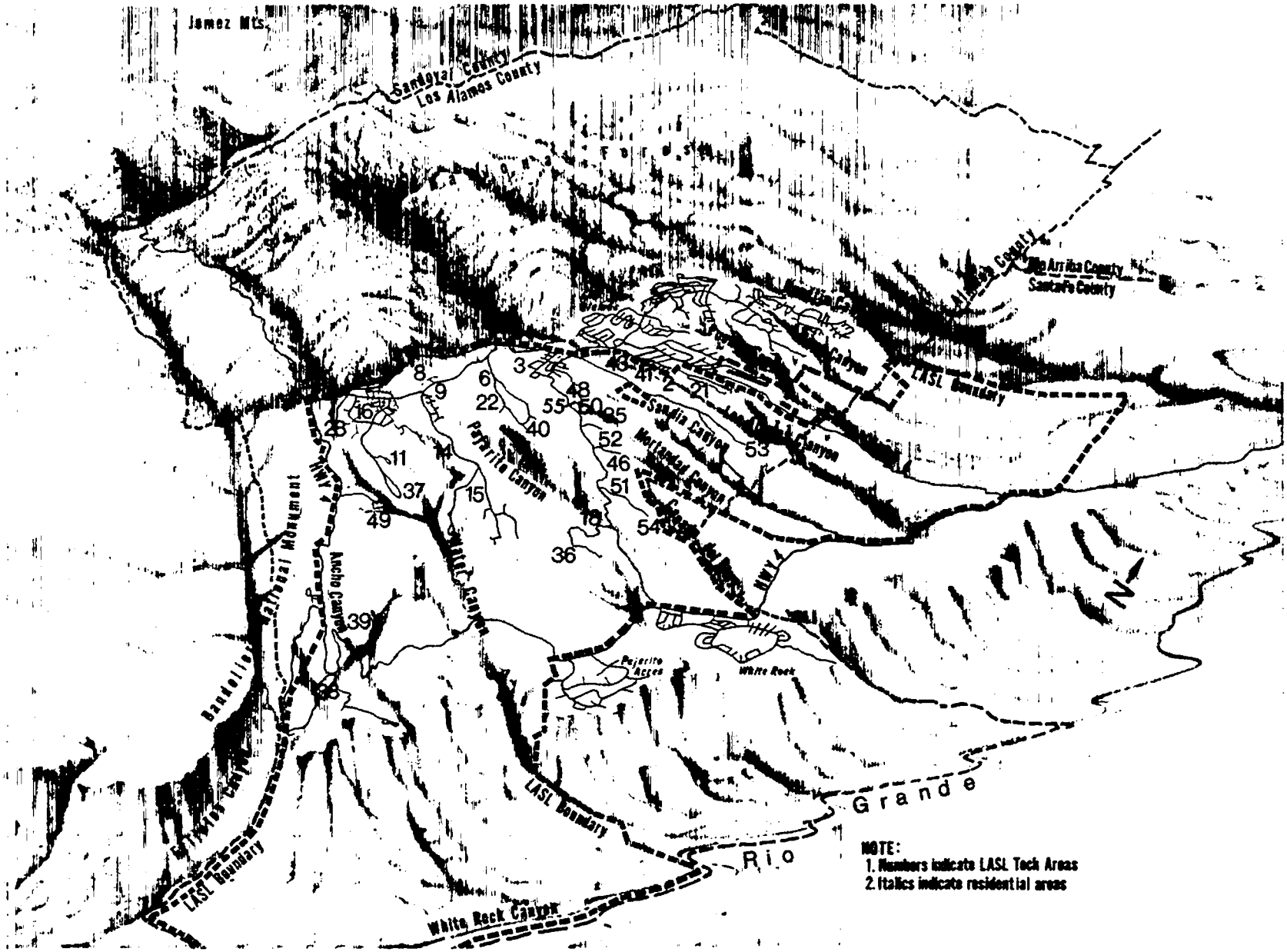


Fig. 2.

Topography of the Los Alamos, New Mexico area.

downgradient in the alluvium. As water in the alluvium moves downgradient, it is depleted by evapotranspiration and movement into underlying volcanics.[1]

In lower Los Alamos and Pueblo Canyons a small local body of perched water is formed in the basalts by water infiltrating from the alluvium into underlying volcanics. This perched water discharges into Los Alamos Canyon west of the Rio Grande. This is the only perched water body beneath the Plateau in the main aquifer.

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 along the western margin of the Plateau to about 180 m at the eastern margin. The water 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 the intermountain basin of the Valles Caldera. 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 and the Tesuque Formation. The Rio Grande receives ground water discharge from springs fed by the main aquifer. The 18.4 km reach of the river between Otowi Bridge and the mouth of Rito de Frijoles receives an estimated 5.3 to 6.8 $\times$ 10^6 m^3 annually from the aquifer.

C. Meteorology

Los Alamos has a semiarid, continental mountain climate. The average annual precipitation of 46 cm is accounted for by warm-season orographic convective rain showers and winter migratory storms. Seventy-five per cent of the annual total moisture falls between May and October, primarily as thunderstorms. Peak shower activity is in August. Winter precipitation falls primarily as snow, with annual accumulations of about 1.3 m.

Summers are cool and pleasant. Maximum temperatures are generally below 32°C, and a large diurnal variation keeps nocturnal temperatures in the 12-15°C range. Winter temperatures are typically in the range from −10°C to 5°C. Many winter days are clear with light winds, and strong solar radiation makes conditions quite comfortable even when air temperatures are cold. A single heating degree day equals 18.3°C minus the average of the daily maximum and minimum temperatures. The average total heating degree days per year between 1951 and 1978 was 3528°C days, with January accounting for over 622°Cdays. Summaries of the 1978 weather and climatological data from 1951 through 1978 are presented in Table E-I and Fig. 3.

Major spatial variation of surface winds in Los Alamos is caused by the unusual terrain. Under moderate and strong atmospheric pressure differences, flow is channeled by the major terrain features. Under weak pressure differences, a distinct daily wind cycle exists. The interaction of these two patterns gives rise to a westerly flow predominance on the western part of the Laboratory site and a southerly component at the east end of the mesas.

Historically, no tornadoes have been reported in Los Alamos County. Lightning, however, is common in the vicinity of the Pajarito Plateau. Local climatological records indicate an average of 62 thunderstorm-days per year. Lightning protection is an important consideration applied to each facility at LASL.

D. Demographics

Los Alamos County is demographically different from the surrounding area. With a population estimated at 19 600, it is characteristically urban in nature, surrounded by more rural communities relying on farming and cattle and sheep herding, primarily in the valley areas. Two residential and related commercial areas exist in the county (see Fig. 4 and inside back cover). Los Alamos, the original area of development, has an estimated population of 13 300, while White Rock has about 6300 residents. Commuting and general traffic are served by State Road 4, which runs through White Rock, and Loop 4, which runs through Los Alamos (see Fig. 4). Two federally owned roads, East Jemez and Pajarito Roads, cross this site and are normally open to public use. About one third of those employed in Los Alamos commute from other counties. Population estimates for 1978 place 105 000 people within an 80 km radius of Los Alamos.

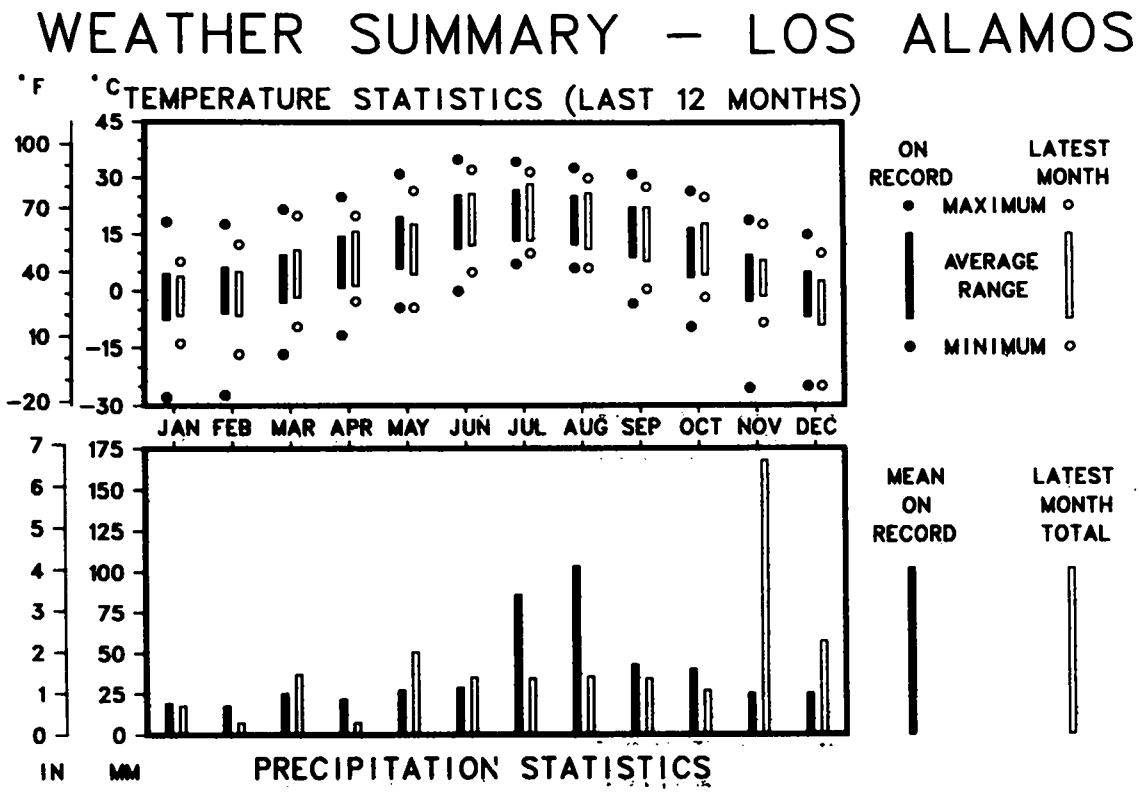


Fig. 3.

Summary of 1978 weather in Los Alamos.

E. Waste Disposal

LASL's activities are carried out in 30 active technical areas (TA) distributed over the site (see Fig. 4). Wastes requiring disposal are generated at virtually all these locations. Sanitary sewage is treated by a number of plants employing conventional secondary treatment processes or by septic tanks. Uncontaminated solid waste is disposed in a County-operated landfill located within the Laboratory boundary. Nonradioactive airborne effluents include combustion products from the power and steam plants, vapors of fumes from numerous local exhaust systems such as chemistry laboratory hoods, and burning of high explosives wastes.

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

Between 90% and 95% of the total radioactively contaminated solid waste volume from the Laboratory is disposed of by burial at the waste disposal area, TA-54. The remaining 5-10% is classed as transuranic waste and stored retrievably. Environmental containment is provided by the dry geologic formations of the burial ground.

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

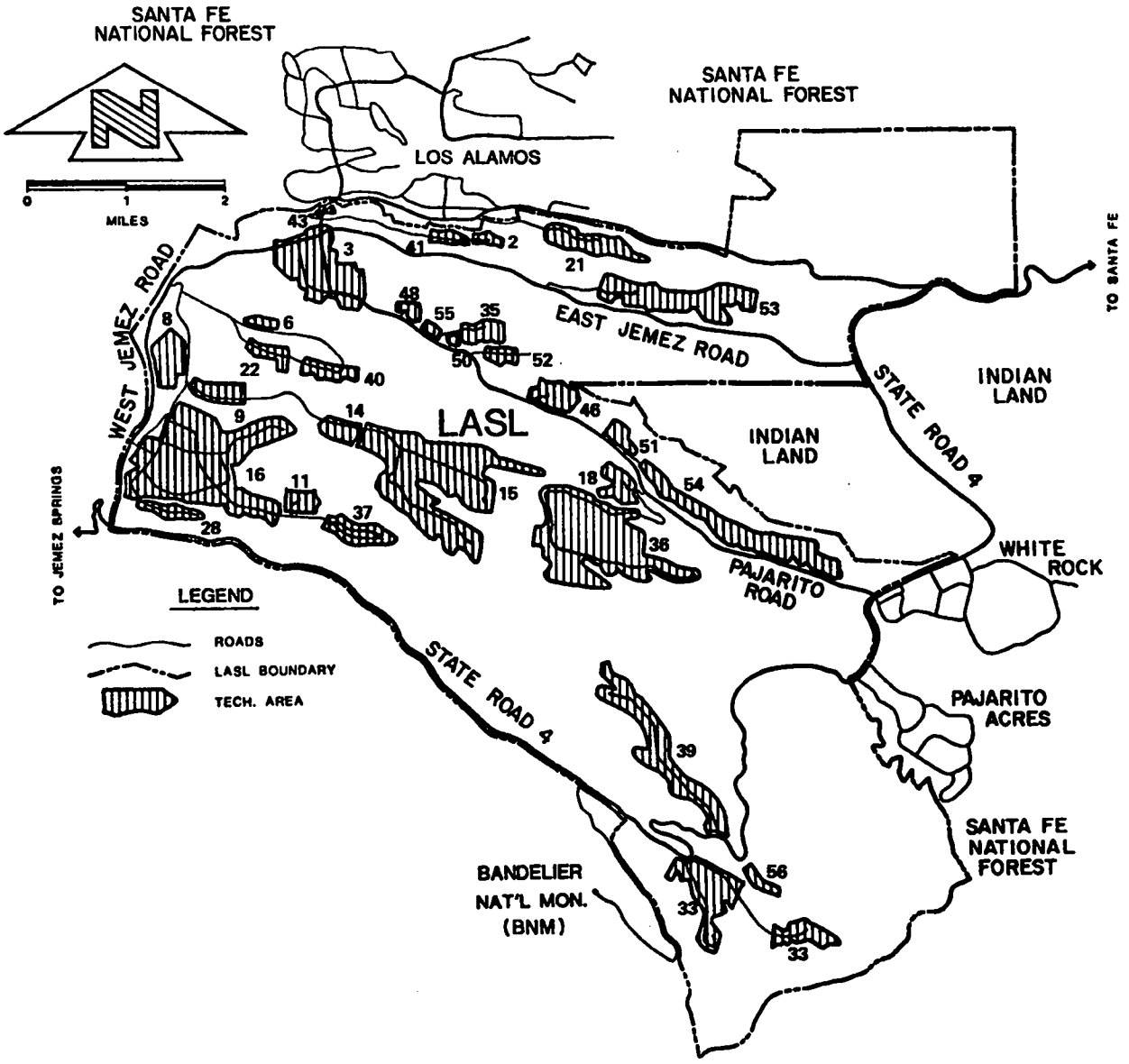


Fig. 4.

LASL technical areas and adjacent community areas.

F. Environmental Monitoring

Routine monitoring of radiation, radioactive materials, and chemical substances is conducted on the Laboratory site and in the surrounding region to assure compliance with appropriate standards, identify possible undesirable trends, inform the public, and contribute to general environmental knowledge. This monitoring in the environment serves as a check on specific effluent release points such as the radioactive waste treatment plants and various stacks at nuclear research facilities.

Exposure from external penetrating radiation (primarily gamma radiation) in the LASL environs is monitored at stations equipped with thermoluminescent dosimeters (TLD). Atmospheric radioactivity samples are collected monthly at continuously operating air sample stations in Los Alamos County and vicinity. Monitoring for surface

and ground water radioactivity provides routine surveillance of the possible dispersion of effluents from LASL operations, while regional surface waters within 75 km of LASL are sampled to ascertain natural levels of radioactivity in water of the area. Soil and sediment samples are also collected from the area for analysis. Sampling stations in Los Alamos County and the Rio Grande Valley are used to monitor locally produced foodstuffs, principally fruits and vegetables.

II. SUMMARY

This report presents the results of LASL environmental monitoring programs for 1978. Data and interpretive comparisons are included for:

- penetrating radiation
- radioactivity in air, water, soil, and foodstuffs
- radioactivity in airborne and liquid effluents
- chemical contaminants in airborne and liquid effluents
- chemical and radiochemical quality of water supply

Several special studies on environmental conditions at Los Alamos are summarized.

Penetrating radiation in the Los Alamos area outside the LASL boundary averaged 108 mrem/yr from multiple sources of natural radiation; LASL operations did not contribute to the total. Penetrating radiation at onsite locations near facilities emitting radiation reached a maximum of about 700 mrem/yr. The annual mean concentration of tritiated water vapor in air at perimeter locations was 13×10^{-12} μ Ci/mℓ, about 9×10^{-12} μCi/mℓ higher than background measured at regional stations, showing some effect of laboratory effluents. The mean concentration at perimeter locations is about 0.007% of the applicable uncontrolled area concentration guide (CG).

Uncontrolled area concentration guides represent levels of radioactivity considered acceptable in air breathed or water consumed by members of the public and were derived to insure that continuous breathing of air or drinking of water containing radioactivity at the CG levels would not cause human radiation doses exceeding the Radiation Protection Standards (see Appendix A). However, the CGs do not account for concentration mechanisms that may exist in environmental media. Consequently, other media such as sediments, soils, and foods are monitored.

Atmospheric long-lived gross alpha and gross beta mean concentrations in the LASL environs were 1.5×10^{-15} and 86×10^{-15} μCi/mℓ, respectively, 2.4% and 0.09% of their respective uncontrolled area CGs. Gross beta activity was elevated during March and December, shortly after detonations of atmospheric nuclear devices by the People's Republic of China. The maximum beta activity concentrations were less than 0.6% of the appropriate CG. The atmospheric ^{239}Pu mean concentration offsite in the LASL environs was about 80×10^{-18} μCi/mℓ, which was 0.13% of the uncontrolled area CG. The airborne radioactive effluents of possible concern were the air activation products ^{41}Ar, ^{11}C, ^{13}N, and ^{15}O, released from the research reactor (TA-2) and the linear accelerator at the Los Alamos Meson Physics Facility (LAMPF, TA-53). Concentrations for these isotopes at occupied locations were theoretically calculated using atmospheric dispersion models in order to estimate doses. Measured doses at the Laboratory boundary north of LAMPF indicate that the theoretically calculated concentrations probably overestimate actual concentrations.

Radiation doses to members of the public (~0.1 mrem/yr or greater) attributable to radioactive airborne effluents from LASL operations were calculated from these measured or theoretically estimated concentrations or from penetrating radiation measurements. Such calculations indicate that maximum doses to people at occupied locations could be as high as 0.7 mrem/yr from ^{41}Ar [0.14% of the DOE Radiation Protection Standard (RPS), see Table A-II], and 3.8 mrem/yr from combined ^{11}C, ^{13}N, and ^{15}O (0.76% of the RPS). The estimated total whole body population dose attributable to LASL operations for residents of Los Alamos County was 10.5 man-rem or about 0.44% of the population dose due to normally present background radiation and about 0.52% of the population dose received from medical radiation (diagnostic x-rays only).

No pathways to humans were identified for radioactivity in treated liquid effluents. All water affected by such effluents contained radioactivity at levels well below appropriate CGs. No pathways for sediments in liquid waste discharge areas were identified. Analyses of fish from the Cochiti Reservoir showed no measurable concentrations of activity attributable to Laboratory operations.

Commuters making 15 round trips a week on one federally owned road (Pajarito Road) crossing the site would have received <0.5 mrem/yr from one technical area where radiation emitting experiments are carried out. Two possible food pathways, involving honey and venison, could have resulted in doses of <4 mrem/yr to a few people.

The water supply met all applicable US Environmental Protection Agency (EPA) and New Mexico Environmental Improvement Division (NMEID) chemical quality and radioactivity standards. The integrity of the geological formations protecting the deep groundwater aquifer was confirmed by the lack of any measurements indicative of non-natural radioactivity or chemical contamination in the municipal water supply sources.

Nonradioactive airborne effluents from sources including a power plant, steam plants, an asphalt plant, a beryllium shop, and experiments utilizing high explosives were well within environmental quality standards. Effluents from 6 of 10 sanitary sewage plants operating under provisions of EPA permits exceeded one or more permit limits during at least one month of the year. Industrial effluents from 104 sources came under provisions of an EPA NPDES permit during October 1978. Data on the quality of these effluents are presented.

III. MONITORING RESULTS

A. Radiation and Radioactivity

1. Penetrating Radiation

Levels of penetrating radiation, including x and gamma rays from cosmic, terrestrial, and man-made sources in the Los Alamos area are monitored with thermoluminescent dosimeters deployed in two independent networks. The environmental network consists of 50 locations divided into three groups (Fig. 5). Three of these locations are 28 to 44 km from the Laboratory boundaries in the neighboring communities of Española, Pojoaque, and Santa Fe, and form the regional group (Fig. 1). The perimeter group consists of 16 dosimeters placed within 4 km of the boundary. Thirty-one locations within LASL boundaries are classed as the onsite group. The dosimeters are changed each calendar quarter. The second network consists of 25 locations, all within LASL boundaries. This network was established to monitor radioactivity of the gaseous effluent from LAMPF at ground level approximately 1 km from the stack. The dosimeters are changed in accordance with the operating schedule of LAMPF. No measurements at regional or perimeter locations in the environmental network for any calendar quarter showed any statistically discernible increase in radiation levels that could be attributed to LASL operations. The LAMPF network showed an increase of 13.7 ± 1.4 mrem/yr at the LASL boundary north of the LAMPF facility. Table I summarizes the annual total doses by the regional, perimeter, onsite, and LAMPF groups for 1978.

Natural penetrating radiation background has two components. The natural terrestrial component results from the decay of ^{40}K and the radioactive daughters from the decay chains of ^{232}Th and ^{238}U. The cosmic component includes both photon radiation and neutrons. The thermoluminescent dosimeters used in the LASL monitoring program (TLD-100®) are insensitive to neutrons so neutron contribution to natural background radiation was not measured and, therefore, will be excluded from this discussion. The cosmic ionizing radiation level increases with elevation because of reduction in the shielding effect of 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 2.1 km at Santa Fe, receive from 50-60 mrem/yr.[3]

In contrast to this fairly constant cosmic component, the dose from the natural terrestrial component in the Los Alamos area is highly variable. The

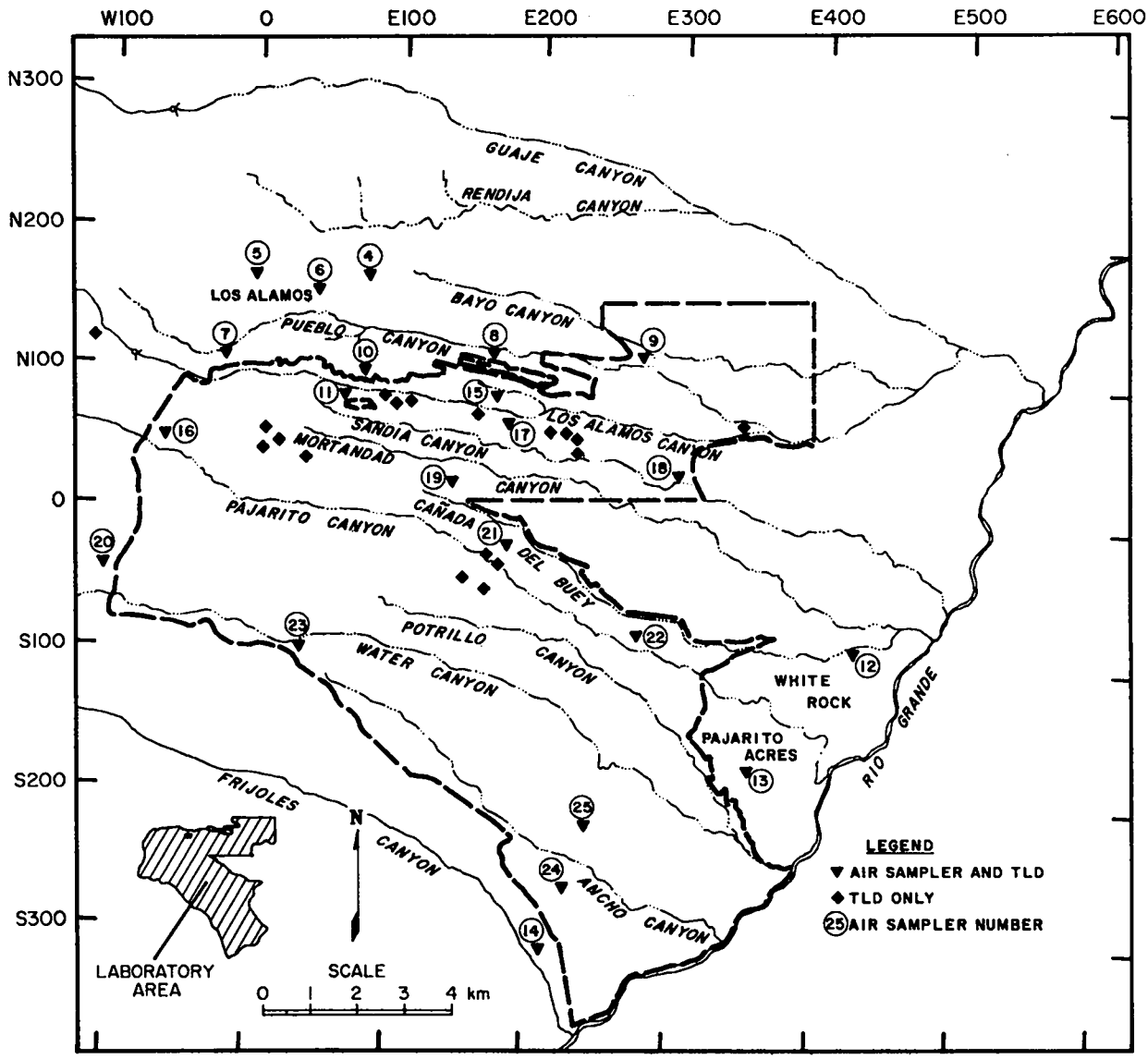


Fig. 5.

Thermoluminescent dosimeter (TLD) and air sampler locations on or near the LASL site.

temporal variation at any particular location (Fig. 5) is about 15-25% because of variations in soil moisture content and snow cover.[3] There is also spatial variation because of different soil and rock types in the area.[4] These natural sources of variation make it difficult to detect any increases in the radiation level from man-made sources, especially if the magnitude of such an increase is small compared to natural fluctuations.

In order to discriminate between these man-made and natural components of variation, data were used from two different dosimeter configurations at each LAMPF network location. One measures total penetrating radiation, both cosmic and terrestrial. The second is shielded from below with enough lead to eliminate about 90% of the direct terrestrial gamma-ray component and from above by enough Lucite to eliminate virtually all beta particles and positrons (whether from natural sources or from LAMPF operations). Gamma rays from annihilation of positrons and electrons can penetrate the Lucite.

TABLE I

EXTERNAL PENETRATING RADIATION DURING 1978

Group	Dose (mrem) Minimum	Maximum	Average
Regional	74.± 5	96.± 6	84.± 22
Perimeter	82.± 6	135.± 6	108.± 29
Onsite	97.± 5	681.± 13	160.± 212
LAMPF[a]	81.± 5	127.± 7	110.± 10

[a]Extrapolated from data obtained during the fourth calendar quarter when the LAMPF network was completed.

Three of the locations in the LAMPF TLD network are 7.5 to 9 km from LAMPF in similar terrain. These three locations are not influenced by any laboratory radiation sources and are used as background locations. By comparing ratios of unshielded to shielded doses recorded during the same period at the background locations and at each field location in the LAMPF network, the component of the total penetrating dose due to LAMPF operations can be determined for each field location.

Because the TLD dosimeters used in the LAMPF network are insensitive to neutrons, independent neutron measurements with sensitive portable equipment were made at the nearest boundary to LAMPF (0.8 km north). With all LAMPF targets in use and a beam current of about 40% of the maximum planned current, the neutron dose rate increase at this location is less than 0.1 mrem/yr. When full power is eventually reached, the dose rate due to LAMPF produced neutrons will be less than 0.2 mrem/yr.

2. Air

Worldwide background atmospheric radioactivity is composed of fallout from atmospheric nuclear weapons 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. During 1978, no statistically significant difference was observed between the atmospheric concentrations of gross alpha, gross beta, americium, plutonium, and uranium measured at sampling locations along the Laboratory perimeter and those measured in distant areas. This indicates Laboratory contributions to concentrations of these contaminants were less than the local variability in background levels. Tritiated water vapor (HTO) concentrations at perimeter and onsite stations were about three and four times higher, respectively, than regional background HTO levels and are attributable to the Laboratory's HTO stack effluents. Elevated levels of airborne activity from short-lived fission products were detected for short periods of time following nuclear atmospheric detonations by the People's Republic of China on March 14 and December 14.

a. General. Atmospheric radioactivity samples were collected at 25 continuously operating air sampling stations in Los Alamos County and vicinity. Onsite and perimeter station locations are shown in Fig. 5 and identified by map coordinates (Table E-VI). Perimeter stations are 0 to 4 km from the Laboratory boundary. The regional monitoring stations, located 28 to 44 km from the Laboratory at Española, Pojoaque, and Santa Fe (Fig. 6), serve as reference points in determining the regional background for atmospheric radioactivity.

When interpreting data from this air sampling program, one must first be aware of natural and fallout radioactivity levels and their fluctuations. Worldwide background atmospheric radioactivity is largely composed of fallout from atmospheric nuclear weapons tests, natural radioactive constituents in dust from the decay chains of ^{232}Th, ^{238}U, and materials resulting from interactions with cosmic radiation, such as tritiated water vapor. Because suspended particulates are mostly from soil resuspension, there are large temporal fluctuations

in radioactivity concentrations as a result of changing meteorological conditions. Periods of high winds, resulting in relatively high suspended particulate concentrations, contrast with periods of heavy precipitation, which remove much of the suspended mass. Spatial variations may be dependent on these same factors. Previous measurements of background atmospheric radioactivity concentrations are summarized in Table E-III and are useful in interpreting the air sampling data.

b. Chinese Fallout Monitoring. Two atmospheric nuclear tests by the People's Republic of China were conducted over their Lop Nor testing area in southwest China. Both tests (March 14 and December 14) were reported to be nuclear devices with explosive power equivalent to approximately 20 000 tons of TNT. Radioactive materials were injected into the troposphere and stratosphere over the mid-latitudes of the northern hemisphere by the above-ground detonations. Prevailing air currents then carried the airborne radioactive materials to the North American continent where the radioactive debris slowly dropped to the earth's surface as fallout.

After each explosion, supplementary sampling was initiated to measure the fallout. Daily particulate samples were taken at the Occupational Health Laboratory (N050 E040) and at the offsite station at Española, 28 km distant from the Laboratory (see Fig. 6). The highest observed long-lived (counted after 7 to 10 days), gross beta concentration for the March 14 test was 570 (±70) $\times 10^{-15}$ μCi/mℓ and for the December 14 test was 190 (±20) $\times$ 10^{-15} μCi/mℓ. These concentrations are 0.6% and 0.2%, respectively, of the uncontrolled area CG for ^{131}I. Qualitative gamma spectral analyses of the atmospheric particulate samples showed the presence of fresh fission products (e.g., ^{141}Ce, ^{131}I, ^{95}Zr) from the detonations. Tables E-IV and E-V contain all data collected during the special Chinese fallout monitoring programs.

c. Annual Gross Alpha and Gross Beta Radioactivity. The annual average 4-wk gross alpha and gross beta concentrations are summarized in Table II and are shown in detail in Table E-VII. Temporal variations in long-lived gross beta concentrations (Fig. 7) were observed during the year. The elevated activity during the spring was typical of that observed during most springs when mixing of the stratosphere with the troposphere causes increased fallout of particulates.

Data plotted in Fig. 7 also show that there were no significant differences in atmospheric gross beta concentrations among the regional, perimeter, and onsite sampling stations this year. There have been no statistically significant differences over the past six years. This lack of statistically significant differences in concentrations indicates that Laboratory operations have negligible influence on the ambient atmospheric radioactivity in the Los Alamos vicinity and suggests that this radioactivity originates from widespread sources—fallout from nuclear test detonations and naturally occurring materials—and not from a localized source such as the Laboratory.

d. Tritium. Atmospheric tritiated water concentrations for each station for 1978 are summarized in Table II and shown in detail in Table E-VIII. The relatively higher levels observed at the Los Alamos airport (station 8) and TA-21 (station 15) are similar to those observed in previous years and are attributable to stack effluents from nearby TA-21. The relatively higher concentrations at TA-54 (station 22) result from evapotranspiration of buried tritium-contaminated wastes at this site. The annual mean for the onsite stations is statistically higher (at a >99% confidence level) than the regional and perimeter means. The higher value reflects tritium releases from Laboratory operations (see Sec. III.A.6). The annual mean atmospheric tritium concentrations for the perimeter and onsite stations are shown in Fig. 8. The highest annual mean of 57 (±74) pCi/m^3 was at TA-54 (station 22).

e. Plutonium. The annual average ^{238}Pu and ^{239}Pu concentrations for each station are summarized in Table II and listed in Table E-IX. Practically all ^{238}Pu concentrations were less than the minimum detectable limit of 2 $\times$ 10^{-18} μCi/mℓ; ^{239}Pu concentrations were comparable to 1977 data and showed no anomolies. The regional, perimeter, and onsite group ^{239}Pu means are statistically indistinguishable from one another, indicating Laboratory contributions of ^{239}Pu to the atmosphere are at background levels.

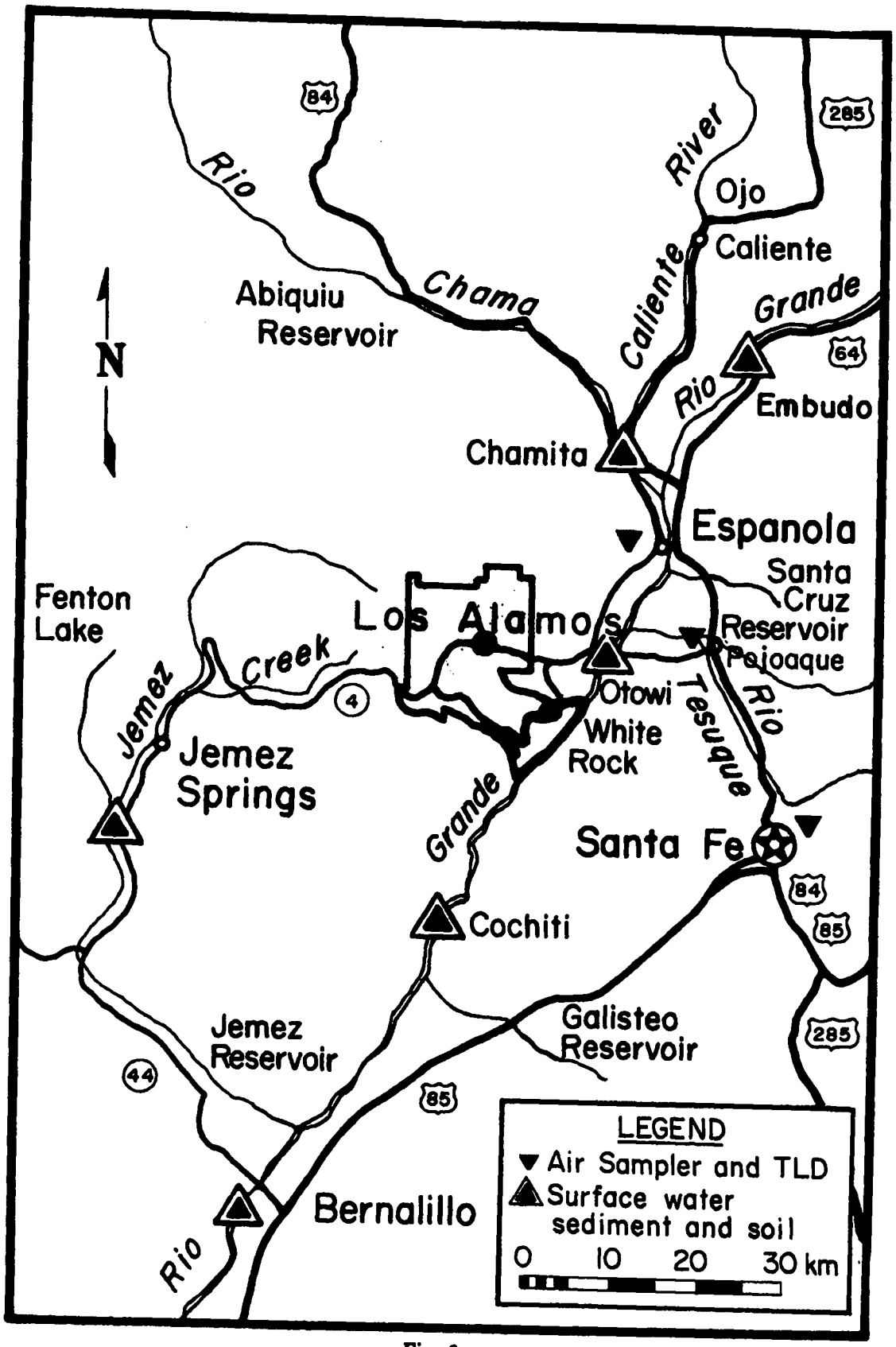
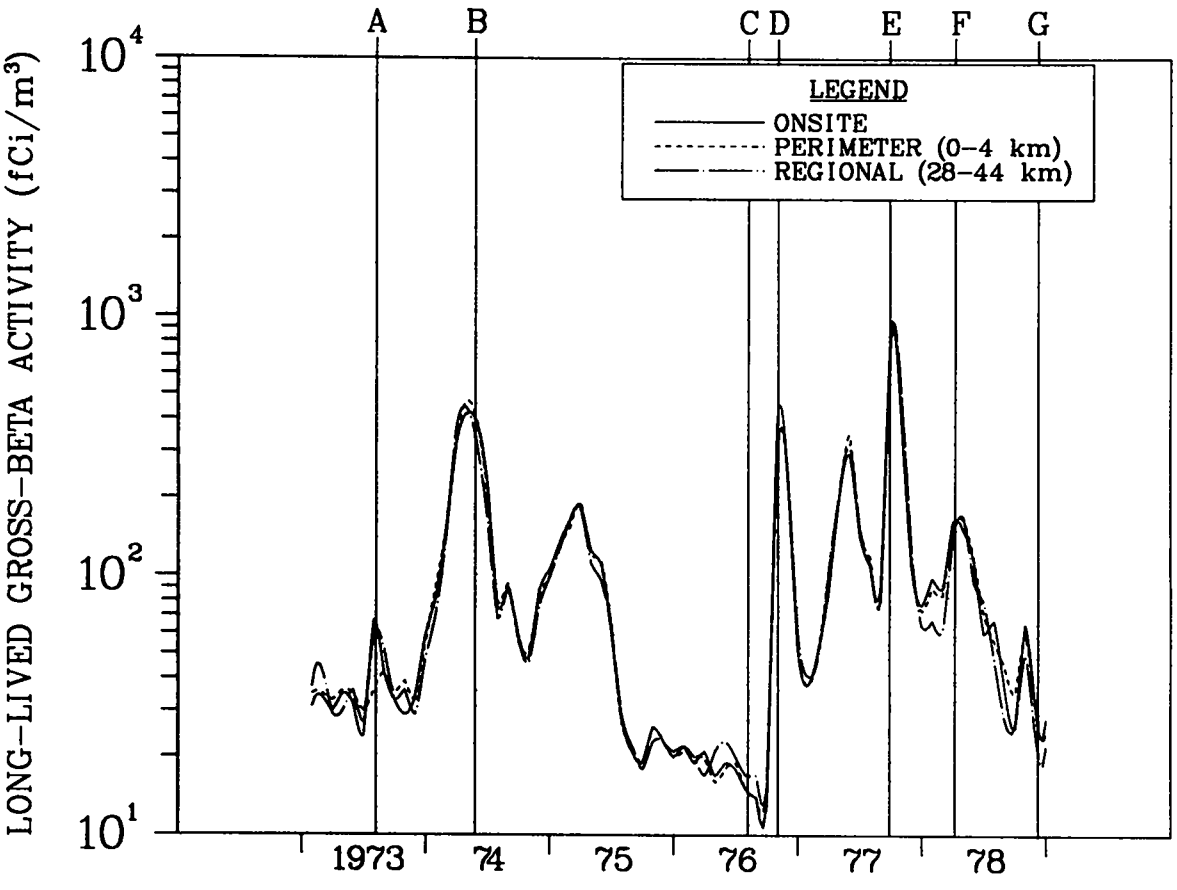


Fig. 6.
Regional surface water, sediments, soil, and air sampling stations.



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

Fig. 7.

Monthly average long-lived gross beta radioactivity, 1973-1978, by sampling station groups.

f. Uranium and Americium. The 1978 atmospheric uranium concentrations are summarized in Table II and listed in Table E-X. The uranium concentrations are dependent on the immediate environment of the sampling station. Those stations with higher annual averages and maximum values were all located in dusty areas where a higher filter dust loading accounts for the collection of more natural crustal-abundance of uranium. The annual averages of the stations are typical of regional average background atmospheric uranium concentrations (Table E-III). There were no statistically significant (at a >99% confidence level) temporal or geographical differences among the regional, perimeter, and onsite station groups.

The 1978 atmospheric americium concentrations are summarized in Table II and listed in Table E-XI. All data were below the analytical detection limit, so no statistical analysis was made. Only 0.034 μCi of ^{241}Am (Table E-XXI) was released to the atmosphere from LASL during 1978.

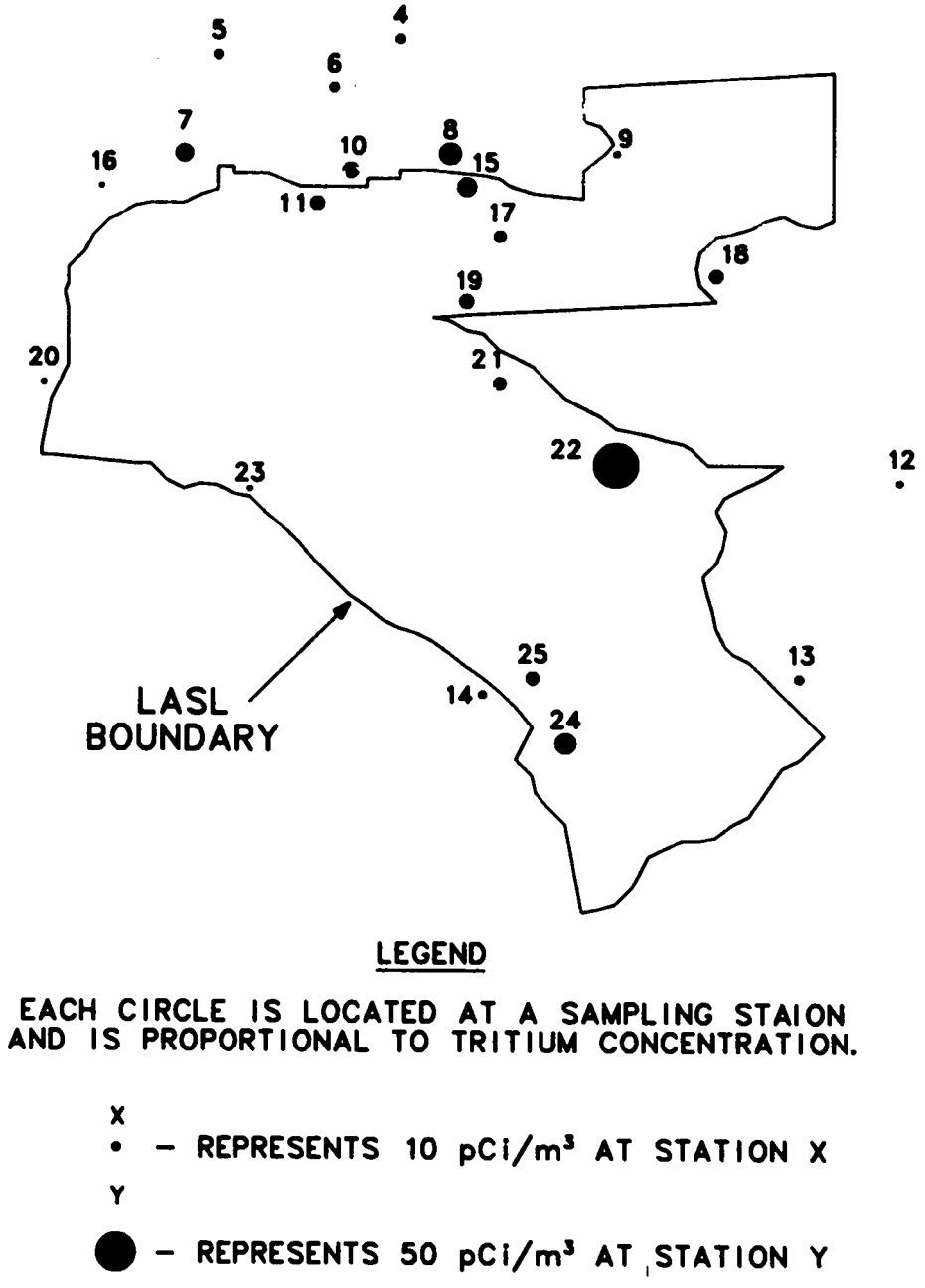


Fig. 8.

Annual mean atmospheric tritiated water vapor concentrations in the vicinity of LASL.

TABLE II

SUMMARY OF ANNUAL ATMOSPHERIC RADIOACTIVITY MONITORING

Analysis	Composite Group	Units	Maximum Observed	Minimum Observed	Annual Mean	Mean As % CG
Gross Alpha	Regional	10^{-15} μCi/mℓ	1.9 ± 0.8	−0.3 ± 0.1	0.9 ± 0.9	1.6
	Perimeter	10^{-15} μCi/mℓ	6.8 ± 3.2	−0.0 ± 0.1	1.5 ± 1.9	2.4
	Onsite	10^{-15} μCi/mℓ	4.6 ± 2.0	−0.1 ± 0.6	1.5 ± 2.0	0.1
Gross Beta	Regional	10^{-15} μCi/mℓ	200 ± 60	9 ± 2	72 ± 102	0.07
	Perimeter	10^{-15} μCi/mℓ	240 ± 60	13 ± 3	86 ± 108	0.09
	Onsite	10^{-15} μCi/mℓ	440 ± 120	4 ± 1	83 ± 109	0.002
Tritiated Water Vapor	Regional	10^{-12} μCi/mℓ	19 ± 6	0.2 ± 0.6	4 ± 9	0.002
	Perimeter	10^{-12} μCi/mℓ	107 ± 34	0.6 ± 0.2	13 ± 33	0.007
	Onsite	10^{-12} μCi/mℓ	118 ± 38	0.1 ± 0.6	18 ± 48	0.0004
^{238}Pu	Regional	10^{-18} μCi/mℓ	−1.1 ± 1.6	−4.5 ± 4.8	−2.3 ± 1.3	0.00
	Perimeter	10^{-18} μCi/mℓ	−0.1 ± 1.9	−4.7 ± 3.9	−1.8 ± 1.3	0.00
	Onsite	10^{-18} μCi/mℓ	8.8 ± 3.2	−4.7 ± 2.3	−1.2 ± 3.7	0.00
^{239}Pu	Regional	10^{-18} μCi/mℓ	44 ± 81	1.2 ± 1.5	20 ± 39	0.034
	Perimeter	10^{-18} μCi/mℓ	79 ± 14	−0.6 ± 1.4	27 ± 43	0.044
	Onsite	10^{-18} μCi/mℓ	153 ± 13	−0.5 ± 1.3	32 ± 67	0.0016
^{241}Am	Regional	10^{-18} μCi/mℓ	0.3 ± 3.6	−2.0 ± 9.1	−0.5 ± 2.2	0.00000
	Perimeter	10^{-18} μCi/mℓ	7.4 ± 15	−2.7 ± 6.4	0.5 ± 6.7	0.00026
	Onsite	10^{-18} μCi/mℓ	4.2 ± 4.8	−3.3 ± 4.8	0.1 ± 4.2	0.000002
Uranium (total)	Regional	pg/m³	184 ± 38	34 ± 18	102 ± 94	0.0011
	Perimeter	pg/m³	238 ± 49	19 ± 22	74 ± 88	0.0008
	Onsite	pg/m³	177 ± 40	16 ± 21	68 ± 66	0.00003

See footnotes in Tables E-VII (gross alpha and beta), E-VIII (tritiated water vapor), E-IX (^{238}Pu and ^{239}Pu), E-X (uranium), and E-XI (^{241}Am) for minimum detectable limits, Concentration Guide values, and other pertinent information.

3. Radioactivity in Surface and Ground Waters

Surface and ground waters are monitored to provide routine surveillance of potential dispersion of radionuclides from LASL operations. The results of these analyses are compared to DOE CGs (see Appendix A) as an indication of the very small amounts of radionuclides in the environment. The results of the 1978 radiochemical quality analyses of water from regional, perimeter, water supply, and onsite non-effluent release areas indicate no effect from effluent releases from LASL. Waters in the 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 the areas outside the LASL boundaries. However, the CGs do not account for concentration mechanisms that may exist in environmental media. Consequently, other media such as sediments, soils, and foods are monitored. Regional surface waters were collected within 75 km of LASL from six stations on the Rio Grande, Rio Chama, and Jemez River (Fig. 6, Table E-XII). Samples were also collected from five perimeter stations located within about 4 km of the LASL boundaries and from 26 stations in White Rock Canyon of the Rio Grande (Fig. 9, Table E-XII). 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. 9). As a known release area and for hydrologic continuity, the monitoring results in Acid-Pueblo Canyon are discussed in the following section concerning onsite surface and ground waters. Detailed data from the regional and

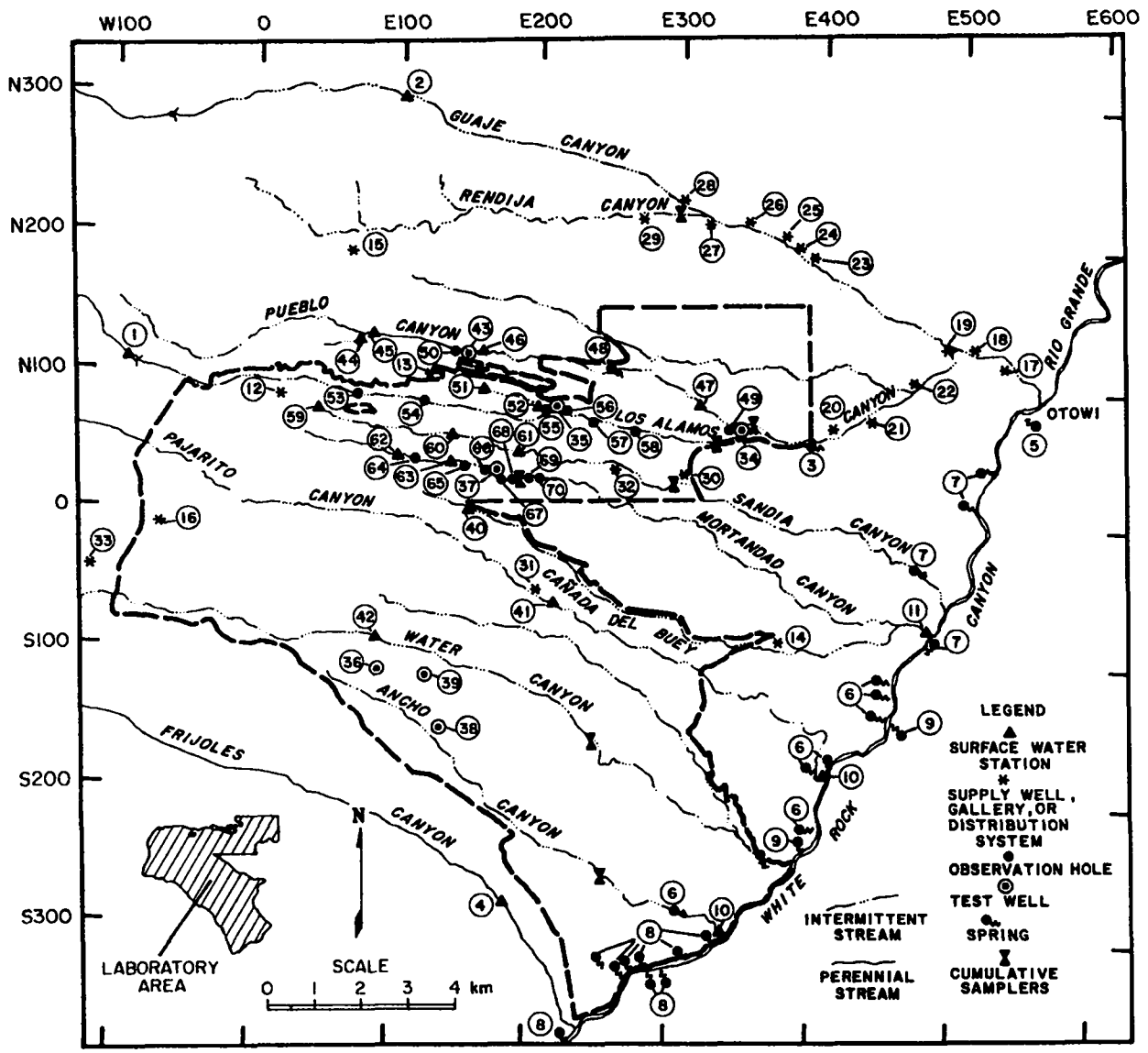


Fig. 9.

Surface and ground water sampling locations on or near the LASL site.

perimeter stations are in Tables E-XIII and E-XIV, respectively (see Appendix B.3 for methods of collection, analyses, and reporting of water data). A comparison of the maximum concentrations found in these waters with CGs for uncontrolled areas is given in Table III.

Radionuclide concentrations in surface and ground waters from the six regional and five perimeter stations are low and have shown no effect from release of liquid effluents at LASL. Plutonium concentrations are near detection limits. The concentrations are well below CGs for uncontrolled areas.

b. Water Supply. The municipal and industrial water supply for the Laboratory and community is from 15 deep wells (in 3 well fields) and one gallery (underground collection basin for spring discharge). The wells are located on the Pajarito Plateau and in canyons east of the Laboratory (Fig. 9). The water is pumped from the main aquifer, which lies at a depth of about 350 m below the surface of the plateau. The gallery discharges from a perched water zone in the volcanics west of the plateau. During 1978 production from the wells and gallery was about $5.6 \times 10^6 m^3$, with the wells furnishing about 97% of the total production and the gallery about 3%. Water samples were collected from the wells and gallery and at 5 stations on the distribution system. The 5 stations on the distribution system are located within the Laboratory and community (Fig. 9, Table E-XII).

Detailed radiochemical analyses from the wells, gallery, and distribution system are presented in Table E-XV. A comparison of maximum concentrations found in these waters with the EPA National Interim Primary Drinking Water Standards[9] is given in Table IV.

Radioactivity occurring in the water supply is low and naturally occurring. Plutonium is below detection limits. Samples from the water distribution system showed gross alpha activity lower than the EPA screening limit (see Appendix A) even though one well (LA-1B, Los Alamos field) contained natural alpha activity about 40% greater than the screening limit. Dilution by water from the wells results in concentrations at points of use that meet the EPA criteria for municipal supply without requiring further detailed analyses.

c. Onsite Surface and Ground Waters. The onsite sampling stations are grouped according to areas that are not located in effluent release areas and those located in areas that receive or have received industrial liquid effluents. The onsite noneffluent release areas consist of seven test wells completed into the main aquifer, and three surface water sources (Fig. 9; Table E-XII). Detailed radiochemical analyses are shown in Table E-XVI. The maximum concentration of radioactivity at the ten stations is in Table V. The concentrations were low, near or below detection limits, and well below CGs for controlled areas.

TABLE III

MAXIMUM RADIOACTIVITY CONCENTRATIONS IN REGIONAL AND PERIMETER WATERS

Analyses	Units $\mu Ci/ml$	Regional	Perimeter		CG for Uncontrolled Areas
			Five Stations	White Rock Canyon	
^3H	10^{-6}	3.6	1.4	1.3	3000
^{137}Cs	10^{-9}	<140	<100	<120	30 000
^{238}Pu	10^{-9}	<0.03	<0.02	<0.02	5000
^{239}Pu	10^{-9}	<0.02	<0.03	<0.02	5000
Gross Alpha	10^{-9}	5.2	6.3	13	5000
Gross Beta	10^{-9}	24	8.7	18.	300
Total U	$\mu g/l$	4.5	14	20	1800

TABLE IV

MAXIMUM RADIOACTIVITY CONCENTRATIONS IN WATER SUPPLY

Analysis	Units μCi/mℓ	Wells and Gallery	Distribution System	EPA NIPDWR[a]
^{3}H	10^{-6}	0.6	1.2	20
^{137}Cs	10^{-9}	<80	<80	200
^{238}Pu	10^{-9}	<0.01	<0.01	7.5
^{239}Pu	10^{-9}	<0.01	<0.01	7.5
Gross Alpha	10^{-9}	7.0	2.9	5
Gross Beta	10^{-9}	5.2	5.9	---
Total U	$\mu g/\ell$	6.3	4.2	1800

[a] Environmental Protection Agency's National Interim Primary Drinking Water Regulations.

TABLE V

MAXIMUM RADIOACTIVITY IN ONSITE WATERS IN AREAS NOT RECEIVING EFFLUENTS

Analysis	Units (μCi/mℓ)	Onsite Non-Effluent Area	CGs for Controlled Areas
^{3}H	10^{-6}	4.2	100 000
^{137}Cs	10^{-9}	70	400 000
^{238}Pu	10^{-9}	<0.01	100 000
^{239}Pu	10^{-9}	0.01	100 000
Gross Alpha	10^{-9}	2.3	100 000
Gross Beta	10^{-9}	17.0	10 000
Total U	$\mu g/\ell$	2.4	60 000

Canyons that receive or have received industrial effluents are Acid-Pueblo, DP-Los Alamos, Sandia, and Mortandad. Samples were collected from surface water stations or shallow observation holes completed in the alluvium. Surface water in these canyons infiltrates into the alluvium before leaving the LASL boundaries (Fig. 9, Table E-XII). The maximum concentration of radioactivity in each of the four canyons is given in Table VI. Radioactivity observed in Acid-Pueblo Canyon (7 stations) results from residuals of treated and untreated radioactive liquid waste effluents released into the canyon before 1964 (Table E-XVI). Radionuclides that were adsorbed by channel sediments are now being resuspended by runoff and municipal sanitary effluents.

Sandia Canyon (3 stations) receives cooling tower blowdown from the TA-3 power plant and some sanitary effluent from the TA-3 areas. Analyses of samples from this canyon show no release of radionuclides to the environment (Table E-XVI).

DP-Los Alamos Canyon (8 stations) receives industrial effluents that contain low levels of

TABLE VI

MAXIMUM RADIOACTIVITY CONCENTRATIONS IN WATERS IN AREAS RECEIVING EFFLUENTS

Analysis	Units μCi/mℓ	Acid-Pueblo	DP-Los Alamos	Sandia	Mortandad	CGs for Controlled Areas
^{3}H	10^{-6}	21.5	93.4	8.4	464	100 000
^{137}Cs	10^{-9}	110	<100	29	960	400 000
^{238}Pu	10^{-9}	0.04	13.1	0.02	8.60	100 000
^{239}Pu	10^{-9}	4.22	5.49	0.01	5.13	100 000
^{90}Sr	10^{-9}	77	197	0.90	137	10 000
Gross Alpha	10^{-9}	15	3100	5.0	560	100 000
Gross Beta	10^{-9}	220	1220	25	1230	10 000
Total U	μg/ℓ	50	1160	7.9	143	60 000

radionuclides and some sanitary effluents from TA-21. Mortandad Canyon (8 stations) receives industrial effluent containing radionuclides (Table E-XVI).

The three areas, Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons, contain surface and ground water with measurable amounts of radioactivity. The concentrations are well below CGs 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 the alluvium of the stream channel within LASL 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 LASL boundary since hydrologic studies in the canyon began in 1960, 3 yr before release of any industrial effluents.

4. Radionuclides in Soil and Sediments

The number of soil and sediment stations was increased this year over the number in 1977. A sample from one soil station in the regional net contained ^{137}Cs and ^{239}Pu in excess of natural fallout. Three soil samples from perimeter stations contained ^{137}Cs and one station contained ^{239}Pu in excess of natural fallout. The concentrations were less than 10 times worldwide fallout levels. Eight other perimeter sediment samples, all from a former release area, contained concentrations of ^{241}Am, ^{238}Pu, and ^{239}Pu above fallout levels. Five onsite soil stations contained activity above normal fallout and are near Laboratory activities. Sediment samples that contained activity greater than fallout were from effluent release areas.

a. Regional Soils and Sediments. Regional soils are collected in the same general locations as the regional waters (Fig. 6). Regional sediments are also collected at the same locations with additional samples collected on the Rio Grande downgradient from the station at Otowi (Fig. 6). The exact locations are presented in Table E-XVII (see Appendix B.3 for methods of collection, analysis, and reporting of soil and sediment data). These samples provide a baseline for comparison with samples collected in and adjacent to the Laboratory. The maximum concentrations of radionuclides in the regional samples

for 1978 were compared with maximum concentrations in soils for 1970 and in soils and sediments for 1974-77 in Table VII. Cesium and ^{239}Pu in soil from Otowi were slightly elevated from previous levels. The remainder of analyses in 1978 were comparable to previous analyses. Four sediment samples collected from the Rio Grande to Otowi (Fig. 6, Table E-XVIII) showed only background concentrations of radionuclides.

b. Perimeter Soils and Sediments. Eight perimeter soil stations were sampled in areas >4 km from the Laboratory. Twenty sediment samples were collected from major intermittent streams that cross the Plateau. Locations of the stations are described in Table E-XVII and mapped in Fig. 10. The maximum concentrations are summarized in Table VIII and are grouped into those above background and background.

Soil analyses indicated ^{137}Cs was above background in three samples and ^{239}Pu in one (see Table E-XIX for detailed analyses). The above background concentrations in soils are due to Laboratory activities. Cesium and ^{239}Pu were only slightly above background. Concentrations of ^{241}Am, ^{238}Pu, and ^{239}Pu were found in sediments from Acid-Pueblo Canyon (offsite), which are due to release of industrial effluents into the canyon before 1964 (Table E-XIX). The concentrations in lower Los Alamos Canyon (Totavi to Rio Grande) reflect transport by intermittent storm runoff from Acid-Pueblo Canyon and from onsite release of liquid effluents into DP-Los Alamos Canyon. The concentrations decrease downgradient in the canyons and are only slightly higher than the regional baseline concentrations (Table E-XVIII).

c. Onsite Soils and Sediments. Onsite soil samples were collected from 19 stations within Laboratory boundaries. Sediment samples were collected from 32 stations within the boundaries (Fig. 10, Table E-XX). Ten of the sediment samples are from areas that receive or have received liquid effluents. The detailed analyses are shown in Table E-XX, while descriptions of locations are noted in Table E-XVII. The maximum concentrations are in Table IX.

Concentrations of ^{3}H (1 station), ^{137}Cs (2 stations), ^{238}Pu (1 station), ^{239}Pu (5 stations), and gross beta (1 station) in the onsite soils were above background levels. These levels are probably due to deposition of airborne effluents from past Laboratory operations. Above background levels of ^{137}Cs, ^{90}Sr, ^{241}Am, ^{238}Pu, ^{239}Pu, gross alpha , and gross beta were found mainly in sediments of canyons that are now receiving treated effluents. They

TABLE VII

MAXIMUM RADIOACTIVITY IN REGIONAL SOIL AND SEDIMENTS
(concentrations in pCi/g, except as noted)

	1978		1970	1974-77
Analysis	**Soils**	**Sediments**	**Soils**	**Soil and Sediments**
^{3}H[a]	29.5	---	---	---
^{137}Cs	1.02[b]	0.26	---	1.00
^{90}Sr	---	---	0.87	1.06
^{238}Pu	<0.016	<0.020	0.004	0.010
^{239}Pu	0.053[b]	<0.014	0.012	0.045
Gross Alpha	4.8	16		18
Gross Beta	7.6	14		13

[a] pCi/mℓ.

[b] Maximum value except for Otowi analyses: 1.73 pCi/g ^{137}Cs; ^{239}Pu 0.15 pCi/g.

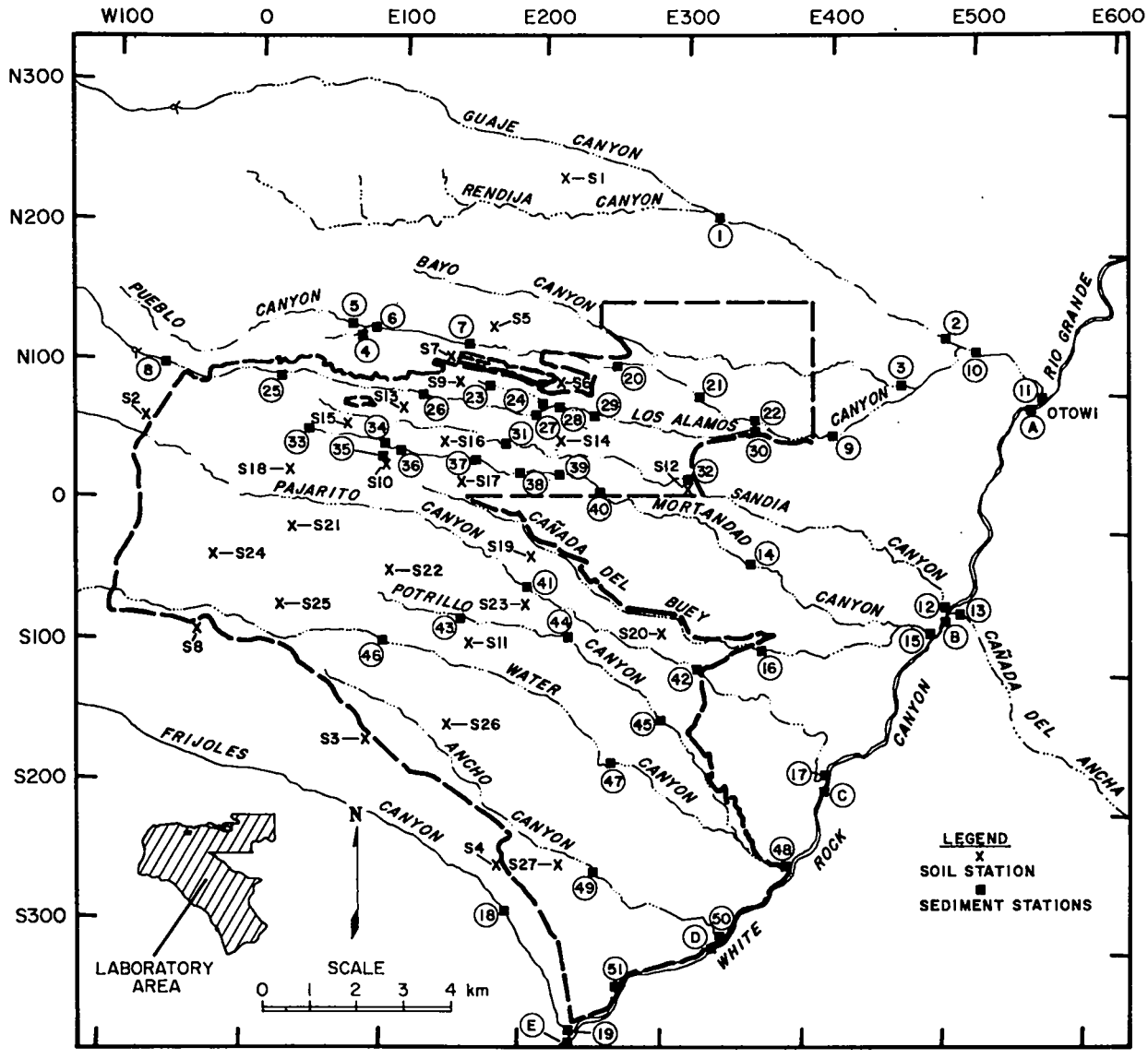


Fig. 10.

Soil and sediment sampling stations on or near the LASL site.

are Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons. The radionuclides in the treated effluents are adsorbed or attached to sediment particles in the alluvium. Concentrations are highest near the effluent outfall and decrease downgradient in the canyon as the sediments and radionuclides are transported and dispersed by other industrial effluents, sanitary effluents, and periodic storm runoff.

The ^{238}Pu in sediments from Mortandad Canyon near the CMR laboratory (station 33, Fig. 10) is from an acid sewer spill in 1974. The bulk of the contamination was removed. Above background levels of ^{137}Cs and ^{239}Pu were reported from two stations in Water Canyon. The ^{137}Cs is slightly above background, while ^{239}Pu is about a factor of 2 above normal levels (Table E-XX).

TABLE VIII

MAXIMUM RADIOACTIVITY IN PERIMETER SOILS AND SEDIMENTS[a]
(concentrations in pCi/g, except as noted)

	Soil		Sediments	
Analysis	Above Background	Background	Above Background	Background
$^{3}H^{6}$	---	12.2(8)	---	---
^{137}Cs	1.6(3)	1.08(5)	---	0.81(25)
^{90}Sr	---	0.92(4)	---	0.90(6)
^{241}Am	---	---	0.590(3)	<0.024(8)
^{238}Pu	---	<0.020(8)	0.040(2)	<0.009(17)
^{239}Pu	0.460(1)	0.041(7)	6.46(6)	<0.022(13)
Gross Alpha	---	6.2(8)	---	7.4(23)
Gross Beta	---	8.9(8)	---	74(19)

[a]Parentheses indicate number of stations in group with the maximum value noted. See Table E-XVII and Fig. 11 for description of location.
[b]10^{-6} μCi/mℓ.

TABLE IX

MAXIMUM RADIOACTIVITY IN ONSITE SOILS AND SEDIMENTS[a]
(concentrations in pCi/g, except as noted)

	Soil		Sediments	
Analysis	Above Background	Background	Above Background	Background
$^{3}H^{b}$	157(1)	29.7(18)	---	---
^{137}Cs	1.50(2)	1.10(17)	1260(12)	1.15(20)
^{90}Sr	---	0.83(7)	17(6)	1.05(8)
^{241}Am	---	0.003(1)	---	0.016(12)
^{238}Pu	0.700(1)	0.015(18)	35.2(8)	<0.027(24)
^{239}Pu	2.52(5)	0.026(14)	11.6(14)	0.056(18)
Gross Alpha	---	11(19)	52(3)	8.5(29)
Gross Beta	22(1)	14(8)	1710(8)	12(24)

[a]Parentheses indicate number of stations in group with the maximum value noted. See Table E-XVII and Fig. 11 for description of location.
[b]10^{-6} μCi/mℓ.

d. Study of Radionuclide Transport in Storm Runoff. The major transport mechanism for radionuclides from canyons receiving treated liquid radioactive effluent is in storm runoff (solution and suspended sediments). Cumulative samplers were set up in intermittent streams to collect samples of runoff for analyses (see Appendix B.3 for methods of collection, analyses, and reporting of data). Rendija Canyon was used as a control. Pueblo, Los Alamos, and Mortandad Canyons receive liquid waste effluent, while Sandia Canyon receives sanitary effluents. Water and Ancho Canyons drain small areas that were burned during the June 1977 La Mesa fire (Fig. 10). All sampler locations were within Laboratory boundaries except for the control sampler in Rendija Canyon.

Analyses were performed for ^{137}Cs, ^{238}Pu, and ^{239}Pu in solution and for ^{238}Pu and ^{239}Pu in the suspended sediments. In addition, chemical analyses were performed for Ca, Mg, Cl, F, and total dissolved solids (TDS) when enough sample was collected. The runoff volume of each event varied, so if there was low volume, the sample collected may have been too small for particular analyses. In addition, due to localized rainfall on the Plateau, one stream might run, while the adjacent stream might not. All streams sampled are tributary to the Rio Grande; however, in Mortandad Canyon, storm runoff infiltrates into the alluvium within the Laboratory boundary. The average radiochemical and chemical concentrations for a number of flow events are in Table X.

Runoff from Rendija Canyon (used as a control) shows little radioactivity, while runoff from Pueblo, Los Alamos, and Mortandad Canyons contains plutonium both in solution and suspended sediments. The plutonium in Pueblo Canyon is mainly ^{239}Pu, while that in Los Alamos and Mortandad Canyons is both ^{238}Pu and ^{239}Pu. The $^{239}Pu/^{238}Pu$ ratios are 742, 3, and 0.3, respectively, in the suspended sediment. The three canyons have or are now receiving treated effluents. Trace amounts of

TABLE X

RADIOCHEMICAL AND CHEMICAL ANALYSES OF STORM RUNOFF
(average concentrations)

Canyon	No. of Events	Radiochemical: Solution (pCi/ℓ) ^{137}Cs	Solution (pCi/ℓ) ^{238}Pu	Solution (pCi/ℓ) ^{239}Pu	Suspended Sediments (pCi/g) ^{238}Pu	Suspended Sediments (pCi/g) ^{239}Pu
Rendija near G-6	3	12 ± 29	−0.003 ± 0.004	−0.004 ± 0.015	−0.042 ± 0.053	−0.012 ± 0.023
Pueblo near SR-4	4	12 ± 12	0.002 ± 0.013	0.051 ± 0.046	−0.014 ± 0.069	10.4 ± 8.8
Los Alamos near SR-4	7	7 ± 16	0.026 ± 0.058	0.074 ± 0.104	1.38 ± 1.05	4.59 ± 2.28
Sandia near SR-4	3	128 ± 186	−0.012 ± 0.006	−0.001 ± 0.005	−0.004 ± 0.012	0.079 ± 0.044
Mortandad near MCO-7	2	25 ± 35	0.521 ± 0.578	0.092 ± 0.124	31.6 ± 37.3	8.9 ± 10.0
Water at SR-4	7	6 ± 21	−0.008 ± 0.008	0.011 ± 0.003	0.003 ± 0.164	0.119 ± 0.298
Ancho at SR-4	3	20 ± 28	−0.021 ± 0.034	−0.019 ± 0.028	0.001 ± 0.001	0.075 ± 0.042

Canyon	No. of Events	Chemical (solution concentrations in mg/ℓ) Ca	Mg	Cl	F	TDS
Rendija near G-6	3	16 ± 2	4.4 ± 3.1	4 ± 3	0.4 ± 0.1	184 ± 84
Pueblo near SR-4	4	11 ± 2	2.1 ± 0.6	10 ± 10	0.7 ± 0.4	242 ± 83
Los Alamos near SR-4	8	10 ± 2	1.4 ± 0.9	7 ± 3	3.4 ± 3.6	277 ± 86
Sandia near SR-4	3	14 ± 6	3.0 ± 1.8	20 ± 28	0.4 ± 0.2	265 ± 217
Mortandad near MCO-7	2	8 ± 1	1.8 ± 0.5	5 ± 1	0.9 ± 0.1	172 ± 54
Water at SR-4	8	14 ± 9	3.9 ± 1.8	3 ± 3	0.2 ± 0.1	164 ± 64
Ancho at SR-4	4	14 ± 6	2.6 ± 0.7	3 ± 1	0.3 ± 0.1	132 ± 99

Note: ± value is standard deviation of the distribution of a number of analyses.

^{239}Pu are found in suspended sediments of Sandia, Water, and Ancho Canyons, which may be from Laboratory operations or fallout.

The calcium, magnesium, and chloride analyses of runoff show no trends. Fluorides are high (3.4 ± 3.6 mg/ℓ) in runoff from Los Alamos Canyon, while the remainder shows no particular trends. The relatively higher TDS in runoff from Pueblo, Los Alamos, and Sandia Canyons may reflect the release of sanitary effluents into the canyons.

The seven canyons contain intermittent streams that flow only during storm runoff. It is evident that in three canyons—Pueblo, Los Alamos, and Mortandad—transport of radionuclides occurs during storm runoff events both in solution and in suspended sediments.

5. Radioactivity in Foodstuffs

Fruit and vegetable samples collected in the vicinity of LASL showed no apparent influence from Laboratory operations except for peach tree leaves collected at an onsite location near a facility that emits tritium.

Fruit and vegetable samples were collected during the fall to monitor foodstuffs for possible radioactive contamination from Laboratory operations. Collection was made in the Los Alamos area and in the Rio Grande Valley above and below the confluences of intermittent streams crossing the Laboratory and the Rio Grande. Samples were cleaned but not washed. Moisture was distilled from them for HTO analyses and the remaining fraction dried, ashed, and chemically digested for ^{238}Pu, ^{239}Pu, total uranium and ^{90}Sr analyses. A study completed in 1978 analyzed the 1977 piñon nut crop for radioactivity. Additionally, fish muscle samples from a 1976 ecological research project were analyzed for ^{137}Cs, ^{238,239}Pu, and total uranium.

The data presented in Table XI summarize the tritium content in fruit and vegetable samples from the 1978 harvest according to different water supplies. Sample moisture ranged from 64 to 96% of the total sample weight. With the exception of the TA-35 sample, there is no significant difference in HTO content between any batches of samples analyzed. Observed concentrations are within the range of values measured in local surface water and atmospheric water vapor. Thus, there is no indication of any measurable offsite contribution from Laboratory operations. The peach trees of TA-35 produced a small crop, which was gone before we were able to sample, so leaves were analyzed as being representative of the HTO content of peaches.

TABLE XI

TRITIATED WATER CONTENT OF FOODSTUFFS

Location	Irrigation Water Source	No. of Samples	Tritium Concentration (pCi/mℓ) Averge (± 1σ)	Range
Española	Rio Chama[a]	5	1.3 ± 1.5	−0.8 to 3.1
Española, San Juan	Rio Grande[a]	6	1.2 ± 0.8	0.4 to 2.2
Peña Blanca	Rio Grande[b]	4	0.4 ± 0.5	−0.3 to 1.0
White Rock	LA County	4	−0.7 ± 0.1	−0.8 to 0.6
Los Alamos	LA County	5	−0.1 ± 0.4	−0.6 to 0.3
TA-35	LA County	1	17	---

[a] Upstream from Laboratory stream confluence.
[b] Downstream from Laboratory stream confluence.

As expected, there was some Laboratory contribution to the tritium content of those leaves because the trees are within 20 m of a 23 m high stack where tritium is released. The few peaches do not represent a significant pathway to man because they are within a Laboratory fence, represent a very small volume of ingestible water, and have considerably less tritium than the uncontrolled area CG (3000 pCi/mℓ) for water.

As can be seen in Table XII, uranium concentrations in all cases are low and consistent with results reported earlier. The three highest values, 247, 184, and 20 pCi/g, are from samples of lettuce (LA County), peach leaves (TA-35), and spinach (White Rock), respectively. Samples of non-leafy vegetables from the Los Alamos and White Rock areas did not show such concentrations of uranium, which indicates the uranium was from soil on the leaf surface and not from the water supply.

Plutonium 238 and 239 analyses were made on all the samples. Only four samples had detectable activity, as indicated in Table XIII. Ingestion of 1 kg of lettuce contaminated to 1.2×10^{-3} pCi/g would result in a 50 yr dose commitment of 1.4×10^{-4} mrem to the critical organ (bone). Contamination and doses of this magnitude indicate they are due to fallout or soil contamination on the plant surface and not to Laboratory related effluents.

Results of ^{90}Sr analyses (Table XIV) show two samples with slightly elevated ^{90}Sr concentrations—lettuce leaves in Los Alamos and peach leaves from TA-35. The lettuce (which has a high surface to volume ratio) had the highest uranium and plutonium concentrations. The contamination was likely due to external contamination from fallout, which would be removed by washing. Eating 1 kg of unwashed lettuce would give a 50 yr dose commitment to the bone of 0.56 mrem. Contamination at TA-35 is likely due to elevated concentrations of ^{90}Sr in the vicinity, caused by early work at TA-35 on radioactive lanthanum sources in which ^{90}Sr is a contaminant. Obviously, the peach leaves are not a route of ingestion for man and ingestion of peaches from TA-35 would not have as much ^{90}Sr contamination as the leaves because of the lower surface to volume ratio of the peaches.

Analysis of bees and honey for radioactive contamination was established in 1972 (phased out in 1974) as part of the ongoing environmental research program at the Laboratory. Results were reported elsewhere.[5-8] Three stations from this network (DP outfall; Effluent Canyon, and Mortandad Canyon) were reestablished and a new station (TA-54) added in September 1978 to monitor radioactive and nonradioactive contaminants in waste disposal areas.

TABLE XII

URANIUM CONCENTRATIONS IN FOODSTUFFS

Location	Irrigation Water Source	No. of Samples	Uranium Concentration (ng/g)[c] Average (± 1σ)	Range
Española	Rio Chama[a]	5	8.0 ± 4.6	4.1 to 13
Española, San Juan	Rio Grande[a]	6	1.4 ± 2.2	0 to 4.5
Peña Blanca	Rio Grande[b]	4	6.1 ± 6.6	0 to 15
White Rock	LA County	4	5.4 ± 9.6	0 to 20
Los Alamos	LA County	5	49.4 ± 110	0 to 247
TA-35	LA County	1	184	---

[a] Upstream from Laboratory stream confluence.

[b] Downstream from Laboratory stream confluence.

[c] Concentrations are given in ng/g of dry weight. After collecting water for tritium analysis, samples were dried at 100°C for 48-72 h.

TABLE XIII

^{238}Pu and ^{239}Pu CONCENTRATIONS IN FOODSTUFFS

Location	Foodstuff	pCi/g (dry weight) ^{238}Pu	pCi/g (dry weight) ^{239}Pu
Peña Blanca	Cucumbers	---	3.6×10^{-4}
Los Alamos	Lettuce	---	1.2×10^{-3}
Los Alamos	Squash	3.2×10^{-4}	---
TA-35	Peach Leaves	---	8.5×10^{-4}

TABLE XIV

^{90}Sr CONTENT IN FOODSTUFFS

Location	Irrigation Water Source	No. of Samples	^{90}Sr Concentration (pCi/g)[c] Average (± 1σ)	^{90}Sr Concentration (pCi/g)[c] Range
Española	Rio Chama[a]	5	0.021 ± 0.015	0.005 to 0.040
Española, San Juan	Rio Grande[a]	6	0.028 ± 0.032	0.0016 to 0.077
Peña Blanca	Rio Grande[b]	4	0.020 ± 0.009	0.008 to 0.031
White Rock	LA County	4	0.029 ± 0.039	0.007 to 0.086
Los Alamos	LA County	5	0.058 ± 0.088	0.008 to 0.215
TA-35	LA County	1	1.58 ± 0.06	---

[a] Upstream from Laboratory stream confluence.
[b] Downstream from Laboratory stream confluence.
[c] Dry weight.

Several of these disposal areas could be readily accessible to bees from privately-owned hives that might be placed near Laboratory boundaries. Because the honey producing season was over at the time hives were placed by the Laboratory, no samples were available for 1978. However, the hives should be well established and productive for samples during 1979. Estimates of the maximum exposure to an individual from eating honey were made from data collected during the research portion of this program. The maximum individual dose was calculated to be 0.12 mrem/yr from eating honey slightly contaminated with tritium, which theoretically would come from nectar made from clover growing over a contaminated solid waste disposal site.

Over half the Laboratory land area of 111 km^2 is covered with the piñon pine tree (*pinus edulis*), which yields a southwestern speciality food—the piñon nut. A study was made of the 1977 crop to determine possible radionuclide intake through piñon nut consumption, because many employees and some of the public harvest nuts on Laboratory lands. In this initial study, unwashed whole nuts were analyzed because some people eat unwashed, whole nuts (although most people prefer to remove the shell). Nuts were harvested by picking them off the ground. Results are summarized in Table XV.

Slightly elevated concentrations (above background sample concentrations) of ^{90}Sr, total uranium, and tritium occurred in several technical

TABLE XV

RADIOACTIVITY CONTENT OF PIÑON NUTS

	Units[a]	Background Composite[b]	Six Technical Areas	
			Average	Range
^{90}Sr	fCi/g	3.0 ± 1.1	13.5 ± 15.6	0.2 to 42
^{238}Pu	fCi/g	0.12 ± 0.18	−1.3 ± 1.2	−3.2 to −0.056
^{239}Pu	fCi/g	0.051 ± 0.18	0.11 ± 2.9	−4.8 to 4.4
U	ng/g	1.4 ± 0.35	14.± 28	1.6 to 71
^{137}Cs	fCi/g	0.070 ± 0.28	0.30 ± 0.41	0.00 to 1.1
^{7}Be	fCi/g	0.40 ± 0.21	0.57 ± 0.47	0.09 to 1.1
^{3}H	pCi/mℓ	4.9 ± 0.4	12.6 ± 7.7	5.6 to 24.2

[a] Units are per gram of wet weight.
[b] Collected from Nambe, Santa Fe, and Abiquiu.

areas. For ^{90}Sr and total uranium we believe this increase is due to greater external soil contamination that contains fallout ^{90}Sr and to naturally occurring uranium, because the nuts were harvested in areas with no record of contamination and no noticed increase of these contaminants in the soil. The sample with elevated tritium concentrations comes from a waste disposal area where there is known tritium contamination. We plan to study this pathway further by examining whether contamination is internal or external and by analyzing the soil from which the nuts are removed.

If one were to eat 1.5 kg of whole, unwashed nuts from the areas with maximum concentrations, one would receive a 50 yr dose commitment to bone from ^{90}Sr of 0.45 mrem and a whole body dose of 2×10^{-3} mrem from HTO.

As part of the environmental research program, fish samples were collected from three locations at Cochiti Reservoir on the Rio Grande in 1976, and at Heron and Costilla Lakes in northern New Mexico in 1976 and 1973, respectively. These samples (muscle only) were analyzed in 1978 for ^{137}Cs, total uranium, and $^{238,239}Pu$. Results are summarized in Table XVI.

As can be seen from the data, there are no significant differences between Cochiti and the background stations at Heron and Costilla Lakes. Species chosen for analysis were mostly bottom feeders (e.g., suckers), which are more likely to ingest any contamination present in sediments than species of higher trophic levels.

6. Radioactive Effluents

Airborne radioactive effluents released from LASL operations in 1978 were typical of releases during the last several years. The greatest change was an increase in activation products from higher power operation of the linear accelerator at LAMPF. Liquid effluents from three waste treatment plants contained radioactivity at levels well below controlled area concentration guides.

Effluents containing radioactivity are discharged at LASL in the form of airborne materials in stack exhausts at twelve of the technical areas and as liquid discharges from two industrial waste treatment plants and one sanitary sewage lagoon. The airborne effluents consist principally of filtered ventilation exhausts from gloveboxes, other experimental

TABLE XVI

RADIOACTIVITY IN FISH

Location	No. of Samples	^{137}Cs (pCi/g[a]) Average	^{137}Cs (pCi/g[a]) Range	U(ng/g[a]) Average	U(ng/g[a]) Range
Cochiti[b]	5	−0.0082 ± 0.049	−0.067 to 0.056	2.0 ± 2.1	0.0 to 4.5
Herron	2	0.0040 ± 0.078	−0.051 to 0.059	1.5 ± 2.1	0.0 too 3.0
Costilla	2	0.013 ± 0.11	−0.065 to 0.091	2.6 ± 3.6	0.0 to 5.1

Location	No. of Samples	^{238}Pu (fCi/g[a]) Average	^{238}Pu (fCi/g[a]) Range	^{239}Pu (fCi/g[a]) Average	^{239}Pu (fCi/g[a]) Range
Cochiti[b]	5	−0.064 ± 0.067	−0.16 to 0.010	−0.044 ± 0.028	−0.090 to 0.020
Herron	2	−0.075 ± 0.120	−0.16 to 0.010	−0.060 ± 0.11	−0.14 to 0.020
Costilla	2	−1.0 ± 1.4	−2.0 to −0.06	−1.2 ± 1.7	−2.4 to 0.040

[a]Radionuclide concentration in muscle tissue based on tissue weight after oven drying.
[b]Below confluence of the Rio Grande with intermittent Laboratory streams.

facilities, and some process facilities such as the liquid waste treatment plants; exhausts from the research reactor (TA-2); and exhausts from the linear accelerator at LAMPF (TA-53). The releases of various isotopes from the technical areas are detailed in Table E-XXI. The quantities of radioactivity released depend on the research programs conducted and result in significant year-to-year variations. For example, the amount of air activation products, especially ^{11}C, ^{13}N, and ^{15}O, was higher by a factor of about 2 in 1978 compared to 1977 (Fig. 11) because the linear accelerator was operating at higher power levels in 1978. However, these short-lived (2 to 20 min) isotopes decay rapidly. For instance, 4 h after a release of a quantity of ^{11}C (half-life of 20 min), <0.1% of the original amount discharged would remain. A Task Force on Radioactive Air at LAMPF has been formed to explore ways to reduce radioactive airborne effluents from LAMPF. Airborne tritium releases at TA-33 in 1978 were higher by a factor of about 30 compared to 1977 releases (Fig. 12) because of increased research activity. Other releases showed variation expectable from programmatic differences (Figs. 13 and 14).

Treated liquid effluents containing low levels of radioactivity are released from the Central Liquid Waste Treatment Plant (TA-50), a smaller plant serving the old plutonium processing facility (TA-21), and the sanitary sewage lagoon serving LAMPF. Detailed results of the effluent radioactivity monitoring are presented in Table E-XXII and Figs. 12-14. A total of 1.3×10^7 ℓ of effluent was discharged from the TA-53 sanitary lagoon containing 0.05 Ci of ^{7}Be and 2.4 Ci of ^{3}H. The source of the radioactivity was leaks of activated beam stop cooling water. None of the isotopes were at concentrations higher than about 2.6% of CGs for water in controlled areas. The amount of radioactive liquid waste processed at the smaller plant (TA-21) has declined through the year as research operations have moved to the new plutonium facility (TA-55) and is expected to continue to decline in 1979. Design work is underway for an upgrading of the larger plant (TA-50), which will further reduce the amount of contaminants released in the effluent.

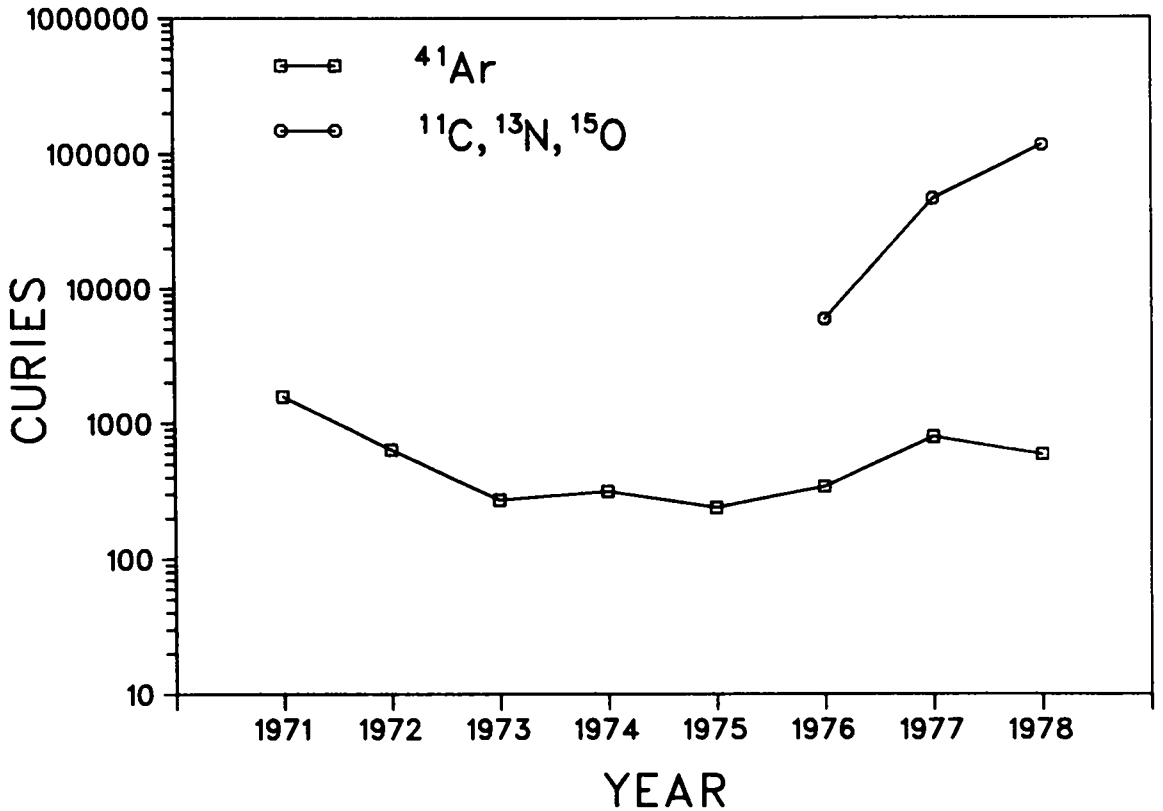
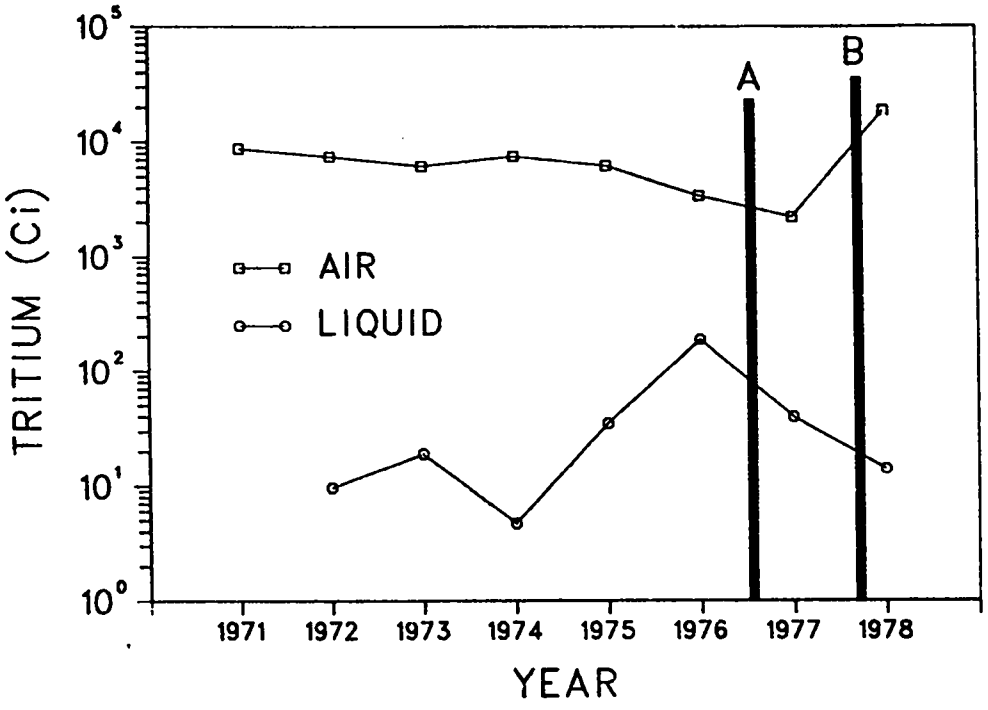


Fig. 11.

Summary of atmospheric releases of ^{41}Ar, ^{11}C, ^{13}N, and ^{15}O.

The releases from the large plant (TA-50) are discharged into a normally dry stream channel (Mortandad Canyon) in which surface flow has not passed beyond the Laboratory boundary since before the plant began operation. The discharges from the smaller plant (TA-21) are made into DP Canyon, a tributary of Los Alamos Canyon where runoff does at times flow past the boundary and transports some residual activity adsorbed on sediments.

In addition to the airborne releases from stacks, some depleted uranium (uranium consisting almost entirely of ^{238}U) is dispersed by experiments employing conventional high explosives. In 1978 about 1371 kg of depleted uranium were used in such experiments. Based on known isotopic composition, this mass is estimated to contain approximately 0.51 Ci of activity. Most of the debris from these experiments is deposited on the ground in the vicinity of the firing point. Limited experimental information indicates that no more than about 10% of the depleted uranium is aerosolized. Approximate dispersion calculations indicate that resulting airborne concentrations at site boundaries 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 continuous air sampling network (see Sec. III.A.2). Estimates of nonradioactive releases from these experiments are discussed in Sec. III.B.3.



A. Accidental airborne tritium release of 22 000 Ci from TA-3-34 on July 15, 1976.
B. Accidental airborne tritium release of 30 800 Ci from TA-33-86 on October 6, 1977.

Fig. 12.
Summary of tritium effluents (air and liquid).

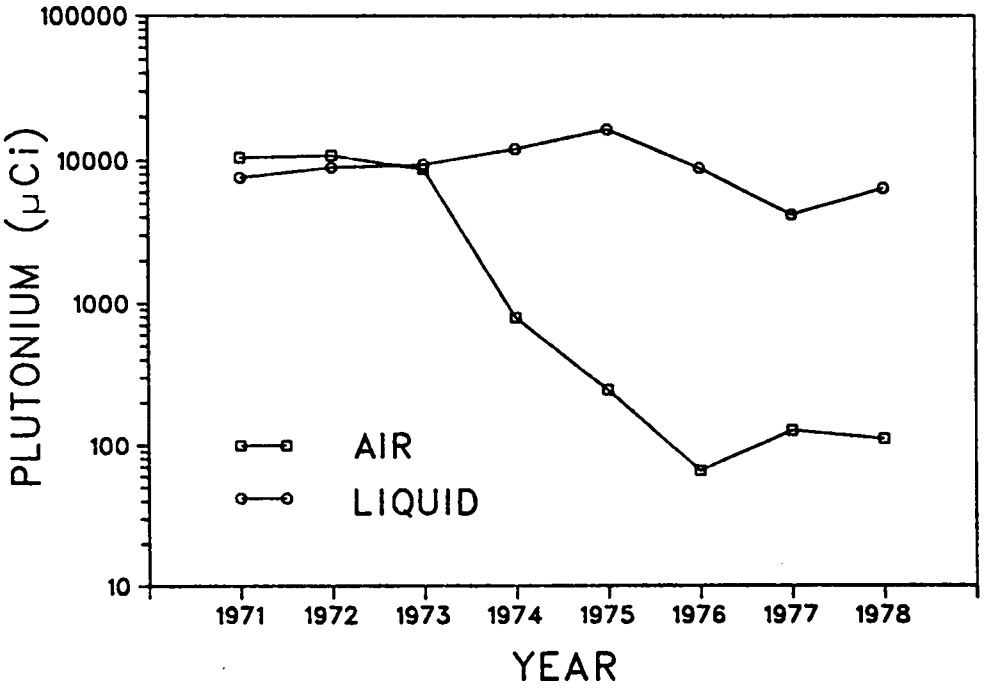


Fig. 13.
Summary of plutonium effluents (air and liquid).

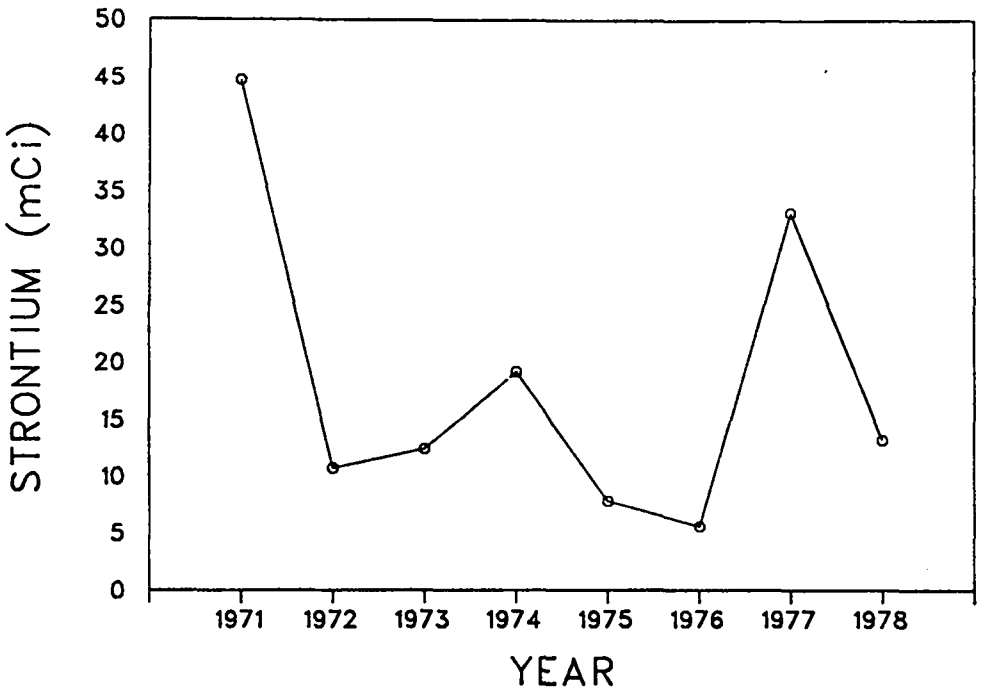


Fig. 14.
Summary of strontium liquid effluents.

B. Chemical Constituents

1. Chemical Quality of Surface and Ground Waters

Chemical analyses of surface and ground waters from regional, perimeter, and onsite non-effluent release areas varied slightly from previous years, but showed no significant change. The chemical quality of water from the municipal supply for the Laboratory and community meets the standards set by the EPA and NMEID. Analyses 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. Analyses were performed for 33 parameters related to water quality.

a. Regional and Perimeter. Regional and perimeter surface and ground waters were sampled at the same locations as were used for radioactivity monitoring (Table E-XII). The regional surface waters were sampled at six stations, with perimeter waters sampled at seven stations plus 26 stations in White Rock Canyon (Fig. 9). Detailed analyses from the regional and perimeter stations are presented in Tables E-XIII and E-XIV, respectively. (See Appendix B.3 for methods of collection, analyses, and reporting of water data). The maximum concentrations for 12 parameters are in Table XVII.

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 the quality of water from previous analyses.

TABLE XVII

MAXIMUM CHEMICAL CONCENTRATIONS IN REGIONAL AND PERIMETER WATERS
(concentrations in mg/ℓ)

Analysis	Regional	Perimeter		Standard or Criteria
		Five Stations	White Rock Canyon	
Ag	0.02	<0.01	---	0.05
As	0.08	<0.01	---	0.05
Ba	0.4	0.49	---	1.0
Cd	<0.010	0.010	---	0.010
Cl	82	9	29	250
Cr	<0.01	<0.01	---	0.05
F	0.9	0.6	1.0	2.0
Hg	<0.001	<0.001	---	0.002
NO_3	<2.	8	60	45
Pb	<0.01	<0.01	---	0.05
Se	<0.005	<0.005	---	0.01
TDS	540	286	552	1000

b. Onsite Surface and Ground Waters. Water samples were collected from three surface water stations and seven wells completed in the main aquifer (Table E-XII). They are located in onsite areas that do not receive industrial effluents (Fig. 9). Detailed results of analyses are given in Table E-XVI. The maximum concentrations for selected constituents are in Table XVIII.

Water quality at the surface water stations also varies slightly as base flow is diluted with varying amounts of storm runoff. Two surface water stations contained above normal amounts of barium (Water Canyon) and fluorides (Cañada del Buey), which may result from release of cooling or process water at sites upgradient from the stations. The quality of surface and ground waters has not changed significantly from previous analyses.

Table E-XVI details the chemical quality analyses of surface and ground water from 21 stations located in canyons that receive sanitary and/or industrial effluent (Fig. 10, Table E-XII). The maximum concentrations of selected constituents found in each canyon are summarized in Table XIX.

Acid-Pueblo Canyon received industrial effluents from 1943 to 1964 and currently is receiving treated sanitary effluents, which are now the major part of the flow. 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 process. The high TDS and chlorides reflect effluents released into the canyons. Cadmium in Acid-Pueblo; chromates in Sandia and DP-Los Alamos; fluorides in DP-Los Alamos and Mortandad; and nitrates in the four canyons were above drinking water standards;[9] however, these onsite waters are not a source of municipal, industrial, or agricultural supply (Table XIX). The maximum concentrations occurred near the effluent outfalls. The chemical quality of the water improves downgradient from the outfall. There is no surface flow to the Rio Grande in these canyons except during periods of heavy precipitation.

Baseline data were collected from the main aquifer upgradient (location 41, Fig. 9) and at the discharge from the aquifer (location 6, Fig. 9) downgradient from a solid waste disposal site, which has been proposed to be used for disposal of organic wastes. The analyses are compared to EPA drinking water standards[9] and are in Table XX.

TABLE XVIII

MAXIMUM CHEMICAL CONCENTRATIONS IN ONSITE NON-EFFLUENT WATER
(concentrations in mg/ℓ)

Analysis	Surface Water	Ground Water	Standard or Criteria
Ag	0.03	<0.01	0.05
As	<0.01	0.01	0.05
Ba	8.15	0.72	1.0
Cd	<0.010	<0.010	0.010
Cl	95	6	250
Cr	<0.01	<0.01	0.05
F	4.2	1.2	2.0
Hg	<0.001	<0.001	0.002
NO_3	<2	<2	45
Pb	<0.01	<0.01	0.05
Se	<0.005	<0.005	0.01
TDS	440	290	1000

TABLE XIX

MAXIMUM CHEMICAL CONCENTRATIONS IN EFFLUENT AREA WATERS
(concentrations in mg/ℓ)

Analysis	Acid-Pueblo	Sandia	DP-Los Alamos	Mortandad	Standard or Criteria
Ag	<0.01	0.07	0.01	0.02	0.05
As	0.01	<0.01	<0.01	<0.01	0.05
Ba	<0.3	<0.3	<0.2	<0.3	1.0
Cd	0.240	0.017	0.007	0.014	0.010
Cl	102	62	104	44	250
Cr	<0.01	5.38	0.11	0.04	0.05
F	0.9	1.9	25	2.7	2.0
Hg	<0.001	<0.001	<0.001	<0.001	0.002
NO_3	46	33	68	276	45
Pb	<0.01	<0.01	<0.01	<0.01	0.05
Se	<0.005	0.005	0.005	<0.005	0.01
TDS	558	916	1908	1340	1000

TABLE XX

BASELINE DATA FOR ORGANIC CHEMICALS
(concentrations in mg/ℓ)

Analysis	Location 41 PM-2	6 Spr 3	6 Spr 4A	Standard
PCBs	<0.0001	<0.0001	<0.0001	---
Chlordane	<0.003	<0.003	<0.003	---
Endrin	<0.0002	<0.0002	<0.0002	0.0002
Heptachlor	<0.0001	<0.0001	<0.0001	---
Heptachlor Epoxide	<0.0001	<0.0001	<0.0001	---
Lindane	<0.004	<0.004	<0.004	0.004
Methoxychlor	<0.1	<0.1	<0.1	0.1
Toxaphene	<0.005	<0.005	<0.005	0.005
2,4-D (acid)	<0.1	<0.1	<0.1	0.1
2,4,5-TP Silver (acid)	<0.01	<0.01	<0.01	0.01

2. Water Supply

The federally-owned well field produced water for the Laboratory and County, which met all applicable EPA standards.

Municipal and industrial water supplies for the Laboratory and community were sampled at 15 deep wells, one gallery, and at five stations on the distribution system (Table E-XII, Fig. 9). Detailed analyses are in Table E-XV. Appendix A gives the federal and state standards and criteria for municipal water supplies. The maximum concentrations of chemical constituents from wells, gallery, and distribution system stations are compared to criteria in Table XXI. The concentrations of naturally-occurring arsenic in the Guaje Well Field (G-2), and fluoride and silver in the Los Alamos Well Field (LA-1B and LA-5, respectively) were slightly above standards[9] for drinking water; however, dilution in the distribution system reduces the concentrations to acceptable levels. All constituents met the criteria for water supply in the distribution system. There has been no significant change in chemical constituents from individual wells from previous years.

TABLE XXI

MAXIMUM CHEMICAL CONCENTRATIONS IN WATER SUPPLY
(concentrations in mg/ℓ)

Analysis	Supply Wells and Gallery	Distribution	Standard or Criteria
Ag	0.07	0.02	0.05
As	0.08	0.01	0.05
Ba	0.1	0.1	1.0
Cd	0.008	0.006	0.010
Cl	13	7	250
Cr	0.03	0.02	0.05
F	2.2	1.1	2.0
Hg	<0.001	<0.001	0.002
NO_3	<2	1	45
Pb	0.02	0.01	0.05
Se	0.001	0.001	0.01
TDS	624	274	1000

3. Nonradioactive Effluents

Nonradioactive effluents include airborne and liquid discharges. Airborne effluents from the asphalt plant; beryllium shop; gasoline storage and combustion; power plant; gases and volatile chemicals; waste explosive burning; lead pouring; and dynamic testing did not result in any measurable or theoretically calculable degradation of air quality. A single NPDES permit for 104 industrial discharge points and 10 sanitary sewage treatment facilities took effect in mid-October. After the new permit took effect, 6 of the 10 sanitary sewage treatment facilities exceeded one or more of the EPA permit limits in one or more months and 18 of the 104 industrial outfalls exceeded one or more limit.

a. Airborne Discharges. Particulate concentrations in the Los Alamos and White Rock areas are routinely measured by the state. Table E-XXIII summarizes these data for 1978. The highest 24 h averages and the annual averages are compared to the New Mexico Ambient Air Quality Standards for particulates in Table XXII. Both the 24 h averages and annual geometric means 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.

The state does not routinely monitor the Los Alamos area for any air contaminants other than particulate matter. As reported last year, a series of SO_2 (sulfur dioxide) measurements was made by the state in October and November of 1976 to establish background levels. None of the hourly SO_2 measurements were above the minimum detectable level of 0.01 ppm. The state standard for SO_2 is a 24 h average of 0.10 ppm and an annual arithmetic average of 0.02 ppm.

During 1978 the Laboratory was surveyed to identify air pollution sources and quantify amounts of materials emitted from these sources. Sources investigated to date include the asphalt plant operated by the Zia Company, beryllium shop, gasoline storage and combustion, TA-3 power plant, volatile chemical and gas emissions, waste explosive burning, and dynamic experiments. These sources are discussed separately in the following paragraphs.

As reported last year,[4] a consultant evaluated the emissions from the asphalt plant operated by the Zia

TABLE XXII

SUMMARY OF ATMOSPHERIC PARTICULATE CONCENTRATIONS IN LOS ALAMOS AND WHITE ROCK DURING 1978

	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 hour average	150	111	172
Maximum 7 day average	110	---	---
Maximum 30 day average	90	---	---
Annual Geometric Mean	60	36	22

Company in 1977. The state particulate emission standard for asphalt plants specifies a maximum allowable particulate emission rate as a function of the aggregate process rate of the plant. At the time of the study, the aggregate production rate of the asphalt plant was 68 metric tons per h. The allowable particulate emission rate for a plant of this size is 16 kg/h. The measured emission rate of 0.8 kg/h was only about 5% of the standard.[10]

Beryllium emissions from the beryllium shop are continuously monitored. A total of about 20 mg of beryllium were emitted during 1978, and measured stack gas concentrations ranged from 0.000 to 0.009 $\mu g/m^3$. All stack gas concentrations were below the state ambient air standard of 0.01 $\mu g/m^3$.

A large fleet of cars and trucks is maintained for the Laboratory complex by the Zia Company. During fiscal year 1978, a total of $2.4 \times 10^6 \ell$ of gasoline were used by this fleet. Carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides, and particulates are emitted during automobile operation. There are also 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 EPA emissions factors[11] to these data, air pollution emissions associated with maintenance and operation of the vehicle fleet (Table XXIII) were estimated.

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/year/unit. The heat input for the TA-3 power plant boilers during 1978 were 0.82×10^{12} Btu (Boiler No. 1), 0.77×10^{12} Btu, (Boiler No. 2), and 0.86×10^{12} Btu (Boiler No. 3). Total heat input for the power plant is 2.45×10^{12} Btu, but inputs for the individual boilers are below the exemption threshold. Measured NO_x (nitrogen oxide) concentrations in the stack gases range from 30 to 50 ppm, or no more than about 20% of the limit that would apply were the heat input threshold exceeded. Using EPA emission factors[11] and volume of natural gas burned, the following estimates of stack gas emissions were made (Table XXIV).

The Laboratory complex uses large quantities of various volatile chemicals and gases that are released into the atmosphere by evaporation or exhaust. Using data from stock records and estimates of actual losses to the atmosphere by large users (>680 kg/yr) of these chemicals, a preliminary estimate of total releases during 1978 was compiled and is given in Table XXV. There are also many small users of chemicals throughout the Laboratory, and other chemicals released to the atmosphere will be added to this list as the smaller users are inventoried.

During 1978 about 26 480 kg of high explosives wastes were disposed by open burning at the Laboratory. Estimates of emissions (Table XXVI) were made by using data from experimental work carried out by Mason & Hangar-Silar Mason Co., Inc.[12] Open burning of high explosives wastes is permitted by the New Mexico Air Quality Control regulations.

TABLE XXIII

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

Pollutant	Estimated Amount (metric tons)
Gasoline Evaporative Losses	28.3
Carbon Monoxide	213
Hydrocarbons	21
Nitrogen Oxides	29
Sulfur Oxides	1.1
Particulates, Exhaust	0.6
Particulates, Tires	1.2

TABLE XXIV

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

Pollutant	Estimated Amount (metric tons)
Sulfur oxides	0.6
Hydrocarbons	1.1
Carbon monoxide	17.9
Particulates	10.5
Nitrogen oxides	739

TABLE XXV

ESTIMATED LOSSES OF GASES AND VOLATILE CHEMICALS

Chemical	Estimated Amount (kg)
Acetone	2700
Carbon Monoxide	4100
Ethyl Acetate	1600
Freons	3300
Helium	6800 - 13 600
Methyl Ethyl Ketone	3500
Methylene Chloride	800
Sulfur Hexafluoride	8200
Trichloroethane	13 700
Trichloroethylene	2000

TABLE XXVI

ESTIMATED EMISSIONS FROM BURNING OF EXPLOSIVE WASTES

(Using data from Mason & Hanger-Silas Mason Co., Inc.[12])

Pollutant	Estimated Amount (kg)
Carbon Monoxide	205
Particulates	477
Nitrogen Oxides	800
Total Waste Burned	26 480 kg

Dynamic experiments employing conventional explosives are routinely conducted in certain test areas at LASL and may contain quantities of potentially toxic metals, including beryllium, lead, and uranium. 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 concentrations at the LASL boundary based on the current year's utilization of the elements of interest. The results are presented in Table E-XXIV along with comparisons to applicable air quality regulations. The average concentrations are all less than 5×10^{-4}% of applicable standards.

b. Liquid Discharges. Nonradioactive liquid wastes are released from 104 industrial discharge points and 10 sanitary sewage treatment facilities subject to NPDES requirements. A single NPDES permit issued by the EPA took effect in mid-October 1978, placing specific effluent limits for the first time on 10 categories of industrial waste outfalls. Ten sanitary sewage treatment facilities, 9 of which previously had separate NPDES permits, were also included in the new permit. Under the new permit only two of the sanitary outfalls were assigned fecal coliform limits; all other parameters, including 5-day biochemical oxygen demand total suspended solids, and pH, were the same as in the individual permits. Tables E-XXV and E-XXVI summarize the effluent quality and compliance status of the sanitary sewage and industrial waste outfalls, respectively.

After the new permit took effect, four of the sanitary sewage outfalls met all limits, and two others (lagoons) exceeded only flow limits because of far above normal precipitation during the last three months of 1978. Eighteen of the 104 industrial outfalls exceeded one or more limit during the period the permit was in effect. Eight of those responsible for the largest number of deviations are scheduled for already-funded corrective measures to be carried out in 1979-80. The two radioactive waste treatment plants have the largest number of limits with which to comply, and only one of those plants exceeded one limit by about 5% on one day. Details of the effluent quality from these two plants are given in Table E-XXII for both non-radioactive (including several not regulated by the NPDES permit), and for radioactive parameters.

4. Herbicide Damage

During the spring and summer of 1978, many reports of dead and dying trees along Laboratory roads were received by the Environmental Surveillance Group. An initial estimate placed the damage at about 2400 dead and dying trees. The most probable causes of damage were insects, road salt, herbicides, or some combination of these factors. To check for the possibility of salt damage, samples of both healthy and damaged needles were analyzed for chloride content. Although the chloride content of the damaged needles was slightly higher than that of the healthy needles, both were within the range of concentrations previously associated with healthy needles. The damage symptoms also were not characteristic of salt damage. Forest Service specialists were called in to assess the possibilities of insect and herbicide damage. No evidence of insect damage was found, but the symptoms were characteristic of damage from bromacil, an herbicide which was applied to the roadsides in the fall of 1977 to control roadside vegetation. Subsequent gas chromatographic analyses established the presence of bromacil residues in the needles from damaged trees. These residues were not present in the needles from healthy trees. As the incident was reconstructed, bromacil, which was applied in the fall, was washed laterally away from the roadside by unusually heavy rains in the spring following a winter with little snowfall. Normally, the herbicide is leached into lower soil horizons by melting snow. Some trees may have been weakened somewhat by road salt, but the herbicide was ultimately responsible for their death.[13]

To prevent future recurrences of this problem, the Laboratory has formed two committees to review its policies and procedures regarding use and application of herbicides. The Vegetation Control Policy Committee will formulate guidelines for herbicide use, while the Vegetation Control Procedure Committee will determine how to implement these guidelines.

IV. ENVIRONMENTAL EVALUATION

A. Radiation Doses

Some increments of radiation doses above natural and worldwide fallout background levels are received by Los Alamos County residents as a result of LASL operations. The largest estimated dose at an occupied location was 3.8 mrem or 0.76% of the radiation protection standard. This estimate is based on boundary dose measurements of airborne effluents from the proton accelerator at TA-53. Other minor exposure pathways such as direct radiation from an experimental facility and two unlikely food pathways may result in doses to several mrem/yr. No significant exposure pathways are believed to exist for radioactivity released in treated liquid waste effluents. The radioactivity is absorbed in the alluvium before leaving the LASL boundaries and some is transported offsite with stream channel sediments during heavy runoff. The total population dose received by residents of Los Alamos County in 1978 was estimated to be 10.5 man-rem or about 0.4% of the 2400 man-rem to the same population from background radiation and 0.5% of the population dose due to medical exposure. As no significant pathways could be identified outside the County, the 10.5 man-rem dose also represents the population dose to the inhabitants living within an 80 km radius of LASL who receive an estimated 11 900 man-rem dose from background radiation.

One means of evaluating the significance of environmental releases of radioactivity is to interpret the exposures received by the public in terms of doses that can be compared to appropriate standards and naturally present background. The critical exposure pathways considered for the Los Alamos area were atmospheric transport of airborne radioactive effluents, 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 for some airborne and waterborne contaminants and external penetrating radiation, and by theoretical calculation based on atmospheric dispersion for other airborne contaminants. Doses were calculated from measured or derived exposures utilizing models based on recommendations of the International Council on Radiation Protection (see Appendix D for details) for each of the three following categories:

1. Maximum dose at a site boundary,
2. dose to individual or population groups where highest dose rates occur, and
3. the whole body cumulative dose for the population within an 80 km radius of the site.

Exposure to airborne ^{3}H (as HTO) was determined by actual measurements with background correction based on the assumption that natural and worldwide fallout activity was represented by the average 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 LAMPF were inferred from direct radiation measurements (see Sec. III.A.1). Exposure from ^{41}Ar released from the TA-2 stack was theoretically calculated from measured stack releases and standard atmospheric dispersion models.

Estimates of a maximum lung exposure to plutonium were calculated by subtracting the average concentration at the regional stations from the average concentration from the perimeter station with the highest measured plutonium concentration (Table XXVII).

The maximum boundary and individual doses attributable to these exposures are summarized in Table XXVII with a comparison to DOE Radiation Protection Standards (RPS) for the individual doses.

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

TABLE XXVII

CALCULATED BOUNDARY AND MAXIMUM INDIVIDUAL DOSES FROM AIRBORNE RADIOACTIVITY

Isotope	Critical Organ	Maximum Boundary Dose		Maximum Individual Dose		
		Location	Dose (mrem/yr)	Location	Dose (mrem/yr)	% RPS
^{3}H (HTO)	Whole Body	TA-54	0.071	Airport	0.029	0.0058
^{11}C, ^{13}N, ^{15}O	Whole Body	Restaurant N. of TA-53	14 [a]	Restaurant N. of TA-53	3.8	0.76
^{41}Ar	Whole Body	Boundary N. of TA-2 Stack	1.2	Apts. N. of TA-2 Stack	0.7	0.14
^{239}Pu	Lung	TA-54	0.024	Bandelier	0.0079[b]	0.00053

[a]Estimated from TLD measurements June-Dec 1978.
[b]For a 50 yr dose commitment, bone becomes the critical organ. A maximum individual would receive a 50 yr dose commitment to bone of 0.53 mrem.

Liquid effluents, as such, do not flow beyond the LASL boundary but are absorbed in the alluvium of the receiving canyons; excess moisture is lost primarily by evapotranspiration. These effluents are monitored at their point of discharge and their behavior in the alluvium of the canyons below outfalls has been studied.[14-17] Small quantities of radioactive contaminants transported during periods of heavy runoff have been measured in canyon sediments beyond the LASL boundary. However, no significant exposure pathways from the sediments to humans have been identified.

No radioactivity in excess of normal background concentrations was detected in drinking water, perennial surface water, or ground water at any offsite location.

There are no known significant aquatic pathways or food chains to humans in the local area. Two minor potential foodstuff pathways involving venison and honey have been identified and were discussed previously.[4] They have been estimated to result in a maximum of <4 mrem/yr to an individual and are unlikely to actually occur.

Measurements of external penetrating radiation showed no statistically distinguishable doses at any offsite locations that could be attributed to LASL operations. Variations among stations or over time were all within expectable ranges.

As was stated in Sec. III.A.1, no measurements of external penetrating radiation at regional and perimeter stations in the environmental network indicated any discernable increase in radiation levels that could be attributed to LASL operations. The special network at the Laboratory boundary north of TA-53 indicated a 13.7 mrem increase above background due to ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar emissions from LAMPF. The increase is considerably less than the 126 mrem dose theoretically estimated for that location from concentrations and cloud size calculated from standard atmospheric dispersion models. To reach the boundary, the effluent must cross a large canyon, which has a pronounced effect on plume dispersion, and for which there are no adequate theoretical models to predict cloud concentrations and size, which are the basis of dose calculations.

Onsite measurements of above background doses were expected and do not represent potential exposure to the public except in the vicinity of TA-18. Members of the public regularly utilizing the DOE-controlled road passing by TA-18 would likely receive no more than 0.5 mrem/yr of direct gamma and neutron radiation. This value was derived from 1975 data[18] on total dose rates using 1978 gamma doses measured by TLDs and estimating exposure time by assuming a person made 15 round trips per week at an average speed of 40 mph past TA-18 while tests were being conducted. The onsite station near the Laboratory boundary at State Highway 4 recorded a dose of 216 mrem/yr. This is caused by a localized accumulation of ^{137}Cs on sediments transported from a treated effluent release point upstream.

Cumulative 1978 whole body doses to Los Alamos County residents from LASL operations with comparison to exposure from natural radiation and medical radiation are indicated in Table XXVIII. Population data are based on Los Alamos County Planning Department figures of 13 300 residents in the Los Alamos townsite and 6300 in White Rock.

The calculated 8.4 man-rem from atmospheric ^{11}C, ^{13}N, and ^{15}O is probably high because it is subject to many of the same uncertainties that caused boundary dose calculations to overestimate actual doses from these isotopes by a factor of 9. The whole-body population dose to the estimated 105 000 inhabitants[21] of the 80 km circle around Los Alamos because of LASL operations is estimated to be 10.5 man-rem, which is 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 exposure undetectable and theoretically a very small fraction of the estimated 10.5 man-rem. By contrast, natural radiation exposure to the inhabitants within the 80 km circle is 11 900 man-rem.

Thus, doses potentially attributable to releases of effluents contribute about 0.44% of the total dose received by Los Alamos County residents from

TABLE XXVIII

1978 WHOLE BODY POPULATION DOSES TO LOS ALAMOS COUNTY RESIDENTS

Exposure Mechanism	Whole-Body Population Dose (man-rem)
Atmospheric Tritium (as HTO)	0.23
Atmospheric ^{11}C, ^{13}N, ^{15}O	8.4
Atmospheric ^{41}Ar	1.9
Total Due to LASL Atmospheric Releases	10.5
Cosmic and Terrestrial Gamma Radiation[a]	1570
Cosmic Neutron Radiation (~17 mrem/yr/person[19])	330
Self Irradiation from Natural Isotopes in the Body (~24 mrem/yr/person[3])	470
Average Due to Airline Travel (0.22 mrem/hr at 9 km[3])	13
Total Due to Natural Sources of Radiation	2383
Medical Exposure (~103 mrem/yr/person[20])	2020

[a]Calculations are based on measured (TLD) data. The indicate a 10% reduction in cosmic radiation due to shielding by structures and a 40% reduction in terrestrial radiation due to shielding by structures and self-shielding by the body.

natural radiation, about 0.52% to the same residents from medical radiation (diagnostic x-rays only), and about 0.088% of the dose from natural radiation received by the population within an 80 km radius of the Laboratory.

B. Environmental Protection Programs at LASL

1. LERC/EEC Program

In order to assist DOE to comply with requirements of the National Environmental Policy Act (NEPA), LASL has an official Laboratory Environmental Review Committee (LERC). The membership consists of representatives from several Assistant and Associate Directors offices, Financial Management, the Engineering Department, and the Health Division and has the responsibility to review all environmental assessments (EAs) and environmental impact statements (EISs) prepared for DOE by the Laboratory. Additionally, LERC identifies and reviews items of environmental interest that are generated by Laboratory activities or that affect the Laboratory programs and property. An Environmental Evaluations Coordinator (EEC), based in the Environmental Surveillance Group, assists LERC by coordinating with user groups, Health Division and the Engineering Department on development of environmental documents and providing input to project design at the earliest stage for appropriate environmental decision making.

Projects that may require an EA or EIS are screened by the EEC to determine level of data needed for the report. Various resource persons are identified to assist in preparation of the draft environmental document for the proposed construction or programmatic project. High-visibility or high-risk projects that may require added attention are passed through an *ad hoc* committee, chaired by the EEC and comprised of representatives of the Engineering Department, Health Division, the user group(s), and other expert members as needed.

The EEC also coordinates input on environmental matters for other official documents and the Quality Assurance (QA) program (see next section). The EEC works with those responsible for construction or programs and the Environmental Surveillance Group representative to the QA program to assure that the environmental considerations are included in the assessments and that they are implemented in the QA program.

2. Quality Assurance Program

In compliance with DOE Manual Chapter 0820, LASL has a QA program[22] for engineering, construction, modification, and maintenance of DOE-owned facilities and installations. The purpose of the program is not only to minimize chance of deficiencies in construction, but also to improve cost effectiveness of facilities' design, construction, and operation, and to protect the environment. QA is implemented from inception of design through completion of construction by a project team approach. The project team consists of individuals from the DOE program division, the DOE Albuquerque Operations Office and Los Alamos Area Office, the LASL operating group(s), the LASL Engineering Department, the design contractor, the inspection organization, and the 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 QA 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, archeological resources, etc.), the environmental consequences of the proposed project (airborne effluents, liquid effluents, industrial waste, solid waste, noise levels, traffic patterns, etc.), and an environmental impact assessment (air, water, land, visual, noise, odor, biota, etc.).

3. Archeology

Protection of archeological sites at LASL (mandated by several Congressional acts and Executive Order 11593) is also part of the QA program. A proposed location for a new facility is checked to determine if there are any archeological sites in the area. An attempt is first made to adjust siting so as

to preserve the site. If alternative siting is not feasible, then the site is excavated to gain knowledge about it and recover artifacts before it is destroyed. The decision as to which course to follow is based on the value of the archeological site, on the availability of alternative locations for the new facility, and on the programmatic impact if the new facility were not built at that location.

A survey of more than 450 archeological sites in LASL environs was made between March 1973 and July 1975. This survey of the pre-Columbian Indian ruins is summarized in a report,[23] which is used during construction planning to avoid damage to such sites if possible, or to provide the lead time necessary to conduct required salvage archeology. Several unique sites were recommended for registration as national historic sites and formal nomination procedures are underway. This will ensure their preservation for future generations by establishing formal responsibility and authority to protect the sites.

Ten additional archeological sites were located and added to the map of all archeological sites at LASL in 1978. Also, four sites were salvaged. One site was salvaged after it was uncovered by the La Mesa fire and found to have been damaged many years ago. Three others were excavated in advance of construction activity. Research now underway includes analysis and identification of food plant remains recovered in archeological salvage activities; plant pollen identification in mesa-top soils to ascertain farming practices of ancient civilizations associated with the archeological sites; identification of ancient crop field locations via analysis of trace soil minerals; a study of minerals in pottery to determine the pottery's origin; and a study of ancient food preparation methods.

4. Decontamination and Decommissioning Work

During the spring and summer of 1978, all facilities at a small abandoned site (TA-42) built to incinerate plutonium contaminated waste were demolished. To monitor for possible airborne release of radioactive contaminants during operations, filters at two special air sampling stations (TA-50 and TA-55) were collected weekly. There was no indication of airborne contamination from these operations. After the facilities were removed, the soil in the vicinity was decontaminated to levels determined to be as low as practicable. Final sampling results will be available in a forthcoming comprehensive report on the decontamination and decommissioning of TA-42.

An ^{227}Ac-contaminated filter building at TA-21 (TA-21-153) was demolished in the summer and fall of 1978. Routine airnet sampling stations located at the airport, DP-East, and LAMPF and a special station established at Acorn Street provided documentation of any possible release of airborne material during demolition operations. Air samples were changed weekly. There was no indication of any airborne radioactivity from these operations.

C. Related Environmental Studies

The Environmental Studies Group (H-12) at LASL conducts research and experimental studies under auspices of the DOE. Some of the research programs conducted by H-12 complement routine monitoring carried out by the Environmental Surveillance Group (H-8) in providing a better understanding of the ecosystem surrounding LASL in relation to the Laboratory's operations. Following are highlights of several of these research programs.

1. Ecological Investigation of Dry Geothermal Energy at Fenton Hill

[Ken Rea (H-12)]

LASL is currently evaluating the feasibility of extracting thermal energy from hot dry rock (HDR) geothermal reservoirs. The concept involves drilling two deep holes into HDR, connecting these holes by hydraulic fracture, and bringing thermal energy to the surface by circulating water through the system.[24]

LASL's HDR project provides an opportunity to study the environmental impact of this new energy resource from its infancy. This study is designed to describe quantitatively the ecosystem surrounding the HDR site, to identify the types and amounts of chemicals and/or materials released during the various phases of development, and to evaluate potential impacts from site operations and effluents. Specific objectives include (a) development and maintenance of an environmental resource data base at the site, (b) periodic examination of permanent transects adjacent to the facility and at nearby control sites to determine changes in composition and

quantity of ecosystem components, and (c) identification and evaluations of chemicals in effluent waste waters and stored residues.[25]

Biological investigations include biomass, relative cover, and relative density measurements on the plant species of the three vegetative complexes surrounding the HDR site. Within each vegetative type, relative densities of small mammal populations are examined by live trapping techniques, and, within the grass forb complex, pellet group counting transects have been established to determine change in utilization patterns of the resident Rocky Mountain elk (*Cervus canadensis*) population.

Table XXIX is a brief summary of the small mammal trapping program for the 1967-1977 field seasons. The 1978 data have not been analyzed; however, the deermouse (*Peromyscus maniculatus*) was the most trappable species encountered in all vegetative types. Variations between trapping locations within and/or between vegetative complexes fall within the bounds of natural variability and are not considered significant for the two years of analyzed data. Examination of the 1978 data shows no unexpected deviations from these previous collections.

The first extensive (10 000 h) run of the HDR system was accomplished during the summer of 1978. Though the system is a closed loop with no apparent releases to the atmosphere, the gaseous component of the fluid was examined to determine what problems might arise during an accidental venting of the system. Minute quantities of H_2S were detected. This was the only toxic gas detected, and at the levels found, it should pose no environmental hazard, even for major releases of the fluid under emergency venting.[26]

Noise pollution has been considered one of the major problems of geothermal energy development. The major source of noise at the HDR site is the heat exchanger, and during the 10 000 h test, noise levels at the heat exchanger under full load conditions averaged less than 95 dB(A), with frequencies less than 1000 Hz.

2. Fenton Hill Site (TA-57) Surface and Ground Waters

[R. Ferenbaugh and W. D. Purtymun (H-8)]

Studies have been carried out to determine the extent to which water discharged from geothermal holding ponds at the Fenton Hill site (LASL's HDR Project) penetrates into the canyon below the site. A series of 1-2 m holes were drilled down-canyon of the site, and soil samples from these holes analyzed for fluoride, chloride, and uranium. Four of the holes at distances of 20, 60 295, and 915 m from the point of discharge were cased. Water samples obtained from these holes after holding pond discharge were collected and analyzed for several chemical constituents in which the water from the geothermal

TABLE XXIX

RELATIVE TRAPPING DENSITIES AND TRAPPING SUCCESS FOR SMALL MAMMALS IN VARIOUS VEGETATIVE COMPLEXES
(expressed in per cent)

	Grass Forb		Aspen		Mixed Conifer	
Species	1976	1977	1976	1977	1976	1977
Deermouse *Peromyscus maniculatus*	99	100	51	65	63	83
Chipmunk *Eutamias minimus*	1	0	44	35	28	17
Other species	0	0	5	0	9	0
	100	100	100	100	100	100
Trapping Success %[a]	72	28	23	63	41	33

[a] Calculated as total captures vs total traps.

pond is enriched. Fluoride concentration, chloride concentration, and strontium isotope ratio were investigated as tracers to determine the extent of penetration of discharged water down the canyon. Chloride concentration proved to be the most informative, and the results of these analyses indicate that the discharged water is completely absorbed into the alluvium by the time it has moved 295 m down the canyon. Wells have been drilled around the holding ponds themselves to determine the extent to which water infiltrates the soil surrounding the ponds. Samples from these wells indicate that most water movement from the ponds is vertical; there is little if any horizontal movement.

Certain elements, which are present in the holding pond discharge, are of particular interest because of the low allowable levels specified in the proposed National Pollution Discharge Elimination System permit. These are arsenic, boron, cadmium, fluoride, and lithium. Soils and vegetation in the canyon into which the water is being discharged consequently are being monitored to determine if these elements are accumulating in the canyon. Plant growth studies and soil adsorption studies also are being carried out using water from the holding ponds.

The canyon below the geothermal site into which water is discharged ultimately opens into Lake Fork Canyon (Fig. 15). Although there is no flow of geothermal water into Lake Fork Canyon, wells and streams in the canyon are monitored for water quality. Other water sources in the vicinity of Fenton Hill are also monitored (Fig. 15). Table E-XXVII summarizes the results of this monitoring during 1978. There has been no significant change in the quality of these waters from previous analyses.

3. The Comparative Distribution of Stable Mercury, Cesium-137, and Plutonium in an Intermittent Stream at Los Alamos

[T. E. Hakonson (H-12), G. C. White (H-12), E. S. Gladney (H-8), and Mona Driecer (H-12)]

Mortandad Canyon has been used for disposal of liquid wastes since 1963. Past studies in this canyon have emphasized the distribution and transport of ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$. Stable mercury is also a component of the waste released to Mortandad Canyon as a result of loss of the metal from chemical laboratories into drain systems. Records maintained over the past few years show that a few tens to hundreds of grams of mercury are released annually to this canyon.[27] The quantity of plutonium and cesium released annually to the canyon averages about 10 and 100 mCi, respectively. Although long term records are not available, we suspect that the isotopic composition of the waste has been varied considerably.

Core samples were collected from 10 stream channel and 10 stream bank locations randomly selected along a 100 m segment of Mortandad Canyon about 500 m below the effluent outfall. A total of 10 stream channel cores and 40 stream bank cores (four per location) were collected. Frozen core samples were sectioned into 0-2.5, 2.5-7.5, and 7.5-30 cm segments; 142 aliquots were then taken for Hg analysis. The remaining sample was oven-dried and counted for ^{137}Cs on a NaI detector coupled to a multichannel analyzer. Sample aliquots were analyzed for ^{238}Pu, ^{239}Pu, and Hg using wet chemistry followed by instrumental analysis.[28] Elemental concentrations in all cases were sufficient to limit instrumental uncertainties to less than 10% ($p<0.05$).

The results of this study demonstrate the importance of stream banks as deposition locations for stable mercury, cesium, and plutonium continuously released to an intermittent stream channel over a 13 yr period. The movement of contaminants from channel to bank results in concentrations that are generally equivalent or exceed those measured in the channel sediments (Table XXX). These findings have implications on the long term distribution of contaminants in intermittent streams because stream banks not only retard downstream movement of the contaminants but may be a source of these materials to biota.

4. Mule Deer Movement

[G. White and L. Eberhardt (H-12)]

Studies continue on the populations of elk and deer that inhabit the Los Alamos National Environmental Research Park (LA/NERP), and cross its boundaries into other protected and/or unprotected areas in Bandelier National Monument, Santa Fe National Forest, and on private lands. Movements of mule deer (*Odocoileus hemionus*) have been studied on the site since January 1975 in an effort to obtain baseline data on this species and to define important deer habitats within the

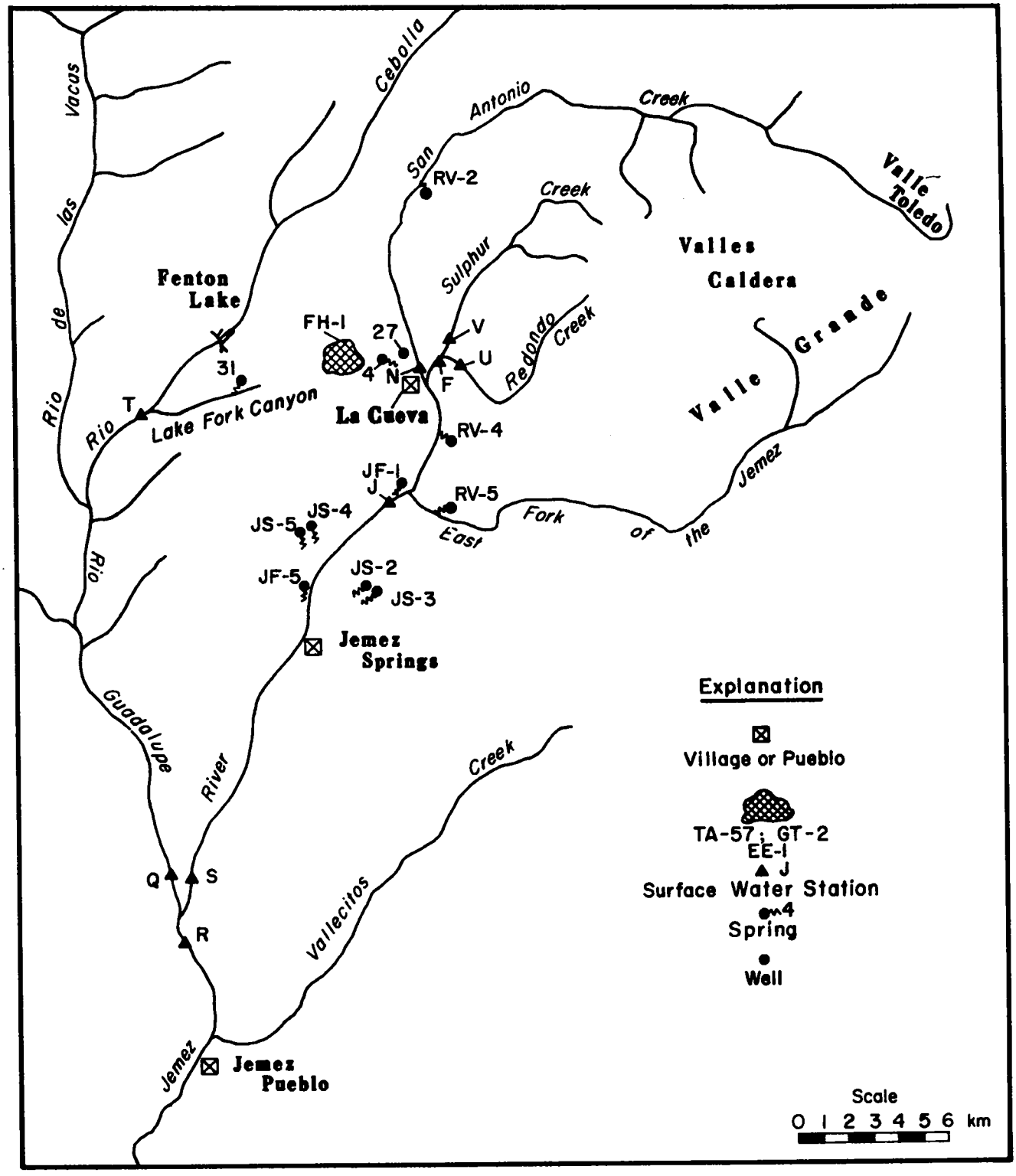


Fig. 15.

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

TABLE XXX

ARITHMETIC MEAN CONCENTRATIONS AND COEFFICIENTS OF VARIATION OF MERCURY, CESIUM, AND PLUTONIUM AS A FUNCTION OF LOCATION IN MORTANDAD CANYON SOILS[a]

	Stream Channel			Stream Bank		
	Number of Samples	Mean	Coefficient of Variation	Number of Samples	Mean	Coefficient of Variation
Hg (ppb)	27	79	1.0	115	160	1.6
^{137}Cs (pCi/g)	28	370	0.35	120	197	1.7
^{238}Pu (pCi/g)	29	26	0.32	120	23	1.9
^{239}Pu (pCi/g)	30	5.2	1.5	119	5.8	1.7

[a]Background concentrations in soils averaged about 10 ppb Hg, 0.5 pCi ^{137}Cs/g and 0.05 pCi Pu/g.

LA/NERP. A total of 34 deer have been live-trapped (Fig. 16), marked with collars and ear tags, and released.[29] Both visual and radiotelemetry techniques have been used to determine deer movements. A total of 254 resightings have been made on 20 of the marked deer since their release. In addition, weekly locations of six radio equipped deer have been determined since March 1977.

Deer movements generally paralleled the east-west oriented canyon systems. A few deer moved to lower elevations on the LA/NERP during the winters, but this was not a consistent trait in all deer studied. Adult female deer generally tended to concentrate their activities in specific areas, while both adult and juvenile male movements were usually more scattered. Longest movement observed during this study was made by an adult female captured at TA-16 in the LA/NERP and relocated one year later 21.4 km to the east across the Rio Grande. Average home range of the six radio collared deer was ~14 km^2 (standard deviation = 5 km^2), which is considerably larger than that reported for mule deer elsewhere.

Security fences on the LA/NERP probably affect deer movements, but several marked animals successfully circumvented the western boundary fence by moving around it or by passing through manned security gates. Specific individual deer consistently walked in and out of the unmanned security gate at TA-9.

Pellet group plots are being used as an index to deer and elk densities, as well as indicators of distribution. A summary of the LA/NERP pellet group data for deer and elk is presented in Tables XXXI and XXXII. For deer, there is a decline in pellet group counts since 1975 in the ponderosa pine and piñon-juniper habitats. There does not appear to have been a significant decline in deer in the mixed conifer habitat type. Not enough data are available to test for time differences in the other three habitats. No significant changes in elk density have occurred in the mixed conifer habitat type. Not enough data are available to test for differences in the other three habitats.

5. Botanical Survey for Critical Habitats in the LA/NERP

[T. Foxx and G. Tierney, Consulting Botanists (H-12)]

Presently, there are 37 candidate plant species on the federal Threatened and Endangered Species list for New Mexico. Examination of the list provided by the New Mexico Heritage Program of the State Fish and Game Department showed only one species, grama grass cactus (*Pediocactus paprycanthus*), that was likely to be found within the LA/NERP. This species was located and photographed in various stages, including the reproductive stage.[30]

Fig. 16.

Capture of a mule deer at LASL.

TABLE XXXI

SUMMARY OF LA/NERP PELLET GROUP DATA FOR DEER

Period	Habitat					
	Conifer	Burn	Meadow	Alfalfa	Ponderosa Pine	Piñon Juniper
Winter 75-76	0.73	---	---	---	3.80	1.81
Summer 76	1.38	---	---	---	1.45	0.94
Winter 76-77	1.00	---	---	---	1.49	0.76
Summer 77	0.46	---	---	---	1.04	0.39
Winter 77-78	0.53	0.38	0.31	0.75	0.51	0.73
Summer 78	0.58	0.76	0.54	3.13	0.51	0.12
Probability level of test for changes with time	0.34	---	---	---	<0.01	0.03

TABLE XXXII

SUMMARY OF LA/NERP PELLET GROUP DATA FOR ELK

Period	Habitat			
	Mixed Conifer	Burn	Meadow	Alfalfa
Winter 75-76	0.60	---	---	---
Summer 76	0.50	---	---	---
Winter 76-77	0.96	---	---	---
Summer 77	0.21	---	---	---
Winter 77-78	0.94	3.76	2.77	12.63
Summer 78	0.89	0.43	1.23	6.88
Probability level of test for change with time	0.23	---	---	---

Although the site location is outside the LA/NERP boundaries *per se*, the species is very likely to occur within undisturbed sites where grama grass predominates.

Most of the species presently on the list occur in the southern part of the state. This is due, in large part, to the paucity of floristic studies in the northern part of the state. Our survey was designed to identify any of the listed species and to locate other species that were rare to the area or perhaps endemic. During the course of the floristic search, several species were located that had not been noted by other LASL studies, by the present investigators, or by previous investigators. They are not necessarily rare, threatened, or endangered at the present time, but in areas sampled, they have a very low population number. An example of such a plant is the larkspur violet (*Viola pedatifida*).

The federal list consists only of candidate species; the list is not yet static. Species are being added and deleted. A number of species are very loosely protected under New Mexico Statute 45-11. Special attention was given to the occurrence of these latter plants within the area. An annotated list of species

ennumerated under the Statute and which are known to be found within the LA/NERP or adjacent areas has been compiled. If these species are subsequently added to the federal list or the New Mexico law becomes more stringent, this information will be readily available to DOE managers.

Because the federal list is not yet static, we realized that a comprehensive plant survey would be the most useful. Therefore, a more complete collection was made than originally anticipated. As of May 1, 1978, 160 plants had been identified; 65 of these had not been reported previously. This indicates that, at the completion of the 1978 field season, the number of newly recorded species can be expected to increase considerably.

From previous experience through contracts for the Museum of New Mexico, the University of New Mexico, and the National Park Service, a number of species have been found that are known to be of ethnobotanical significance. They were possibly utilized by the prehistoric inhabitants of the Pajarito Plateau as food, clothing, medicine, or for ceremonial purposes. Such species as white stem stickleaf (*Mentzelia albicaulis*) are of special ethnobotanical significance and have been located in the study area. These observations have been useful in seed analysis studies done for archeological salvage studies at LASL.

Finally, an unanticipated by-product of the study is a checklist of over 1000 plants compiled by Foxx and Tierney.[30] This checklist is to be published as a LASL report and will give information such as plant distribution, synonyms, and references. Because no such publication now exists for the area, this report will be valuable to the Park Service, Forest Service, Department of Energy, naturalists, teachers, students, and interested laymen.

6. La Mesa Fire

[T. Foxx, Consulting Botanist (H-12)]

The La Mesa fire burned from June 16-23, 1977, ultimately consuming 62 km^2 of Santa Fe National Forest, Bandelier National Monument, and LASL land (10.6 km^2).

Subsequent to the fire 9.9 km^2 of LASL land were reseeded with a mixture of native grass species (slender wheatgrass, western wheatgrass, hard fescue, blue grama, spiked muhley, and sand dropseed) and 0.7 km^2 were set aside for natural succession studies.

In October 1978, paired 20 by 50 m plots with fifty 1 m by 2 m shrub plots and one hundred 5 decimeter by 5 decimeter plots were established in the seeded and unseeded area of the ponderosa pine zone. Relative foliage cover for herbaceous plants and shrubs was determined for each plot. Plots in the seeded area had 6.7% total foliage cover. Grass comprised 56.5% of the total foliage cover; 41.5% was the reseeded grass species *Agropyron trachycaulum* (slender wheatgrass). In the unseeded plots there was 5.2% coverage. Less than 1% was grass and over 99% was forbs. *Chenopodium* (lambsquarters) species made up 78.5% of the total foliage cover.

Biomass was based on ten 1 m by 1 m plots. The biomass in the seeded area was 850.1 g/m^2 and in the unseeded area 10 g/m^2. Grass represented 31.3% of the total biomass on the seeded side, whereas only 5.8% on the unseeded side. Forbs made up 94.2% of the total biomass on the unseeded side and only 68.7% on the seeded side. Reseeded grasses made up 69.3% of the total biomass on the seeded side and 0% on the unseeded side.

7. Long-Term Ecological Effects of Exposure to Uranium

[G. C. White and T. E. Hakonson (H-12)]

An estimated 75 000 to 100 000 kg of uranium were expended during conventional explosive tests at several LASL testing areas during 1949-1970. Of this, about 35 000 to 45 000 kg of natural uranium were used during 1949-1954, and 40 000 to 50 000 kg of depleted uranium (depleted of ^{235}U) were used during 1955-1970. The principal concern about depeleted uranium is the effect of its chemical toxicity and pyrophoric properties on terrestrial ecosystems. Methods to ascertain environmental transport are necessary. Also, rapid analysis for uranium in various matrices has become increasingly important with the advent of the energy crisis. Decontamination of uranium contaminated areas may be necessary because of the chemical toxicity aspects of that element. A fourth year of study of the transport of depleted uranium in the terrestrial ecosystem at LASL was completed, with emphasis on evaluation of the portable phoswich survey instrument as a uranium field survey instrument.

A firing site at LASL was resampled with the phoswich survey instrument at the same locations that were sampled in the 1976 soil uranium field survey.[31] The initial sampling grid was systematically

placed on a polar coordinate system radiating from the detonation point every 45° with concentric circles at 10, 20, 30, 40, and 50 m from the detonation point.

Soil samples collected on the grid system during the 1976 uranium survey at the firing site were obtained with a polyvinylchloride coring tube with a 2.5 cm inside diameter. Field instrument measurements from the grid were compared with the uranium concentration in the 0 to 2.5 cm depth segment of each core.

Correlation between the phoswich measurements and previous soil samples taken in 1976 at the site was excellent (Fig. 17), with $r = 0.95$ ($p<0.0001$), even though the respective measurements were taken two years apart. Changes in the distribution of uranium during the interval between samplings must have been minor relative to the total inventory of uranium in the soil.

D. Resurvey Program

For the past two years LASL's Environmental Surveillance Group has conducted some intensive radiological surveys as part of DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). The results of these surveys will be utilized by DOE to determine whether any remedial measures are desirable to further reduce any residual effects from previous uses of the areas. In the Los Alamos Area, Bayo Canyon and the Acid-Pueblo Canyon system were investigated. A final report on the radiological survey of Bayo Canyon has been completed and is expected to be published by DOE's Division of Environmental Control Technology in 1979. The summary from that report is included in this section. A draft report on Acid-Pueblo Canyon is expected to be submitted to DOE for review in 1979. A brief summary of the status of that work follows the Bayo Canyon summary.

1. Bayo Canyon

A portion of Bayo Canyon (Fig. 5) was used between 1944 and 1961 as a site for experiments employing conventional high explosives in conjunction with research on nuclear weapons development initially under auspices of the US Army Manhattan Engineer District and later the Atomic Energy Commission (AEC). The explosive test assemblies usually included components made from natural or depleted uranium and a radiation source for blast diagnostics. The sources contained several hundred to several thousand curies of ^{140}La (half-life 40.2 h) and a small proportion of ^{90}Sr (half-life 28.1 yr). The explosive detonation resulted in the dispersion of radioactive materials—uranium, ^{140}La and ^{90}Sr—in the form of aerosols and debris to the atmosphere and onto the ground around the firing points. Radiochemistry operations conducted at the site resulted in the generation of liquid and solid radioactive wastes, which were disposed into the subsurface pits and leaching fields.

The site was decommissioned by 1963 with the removal or demolition of structures, cleanup of surface debris, and excavation of contaminated waste disposal facilities. Radiological surveys resulted in the conclusion that the site was sufficiently free of contamination to permit the land to be released from Federal government control. The land was transferred to Los Alamos County by quit claim deed on July 1, 1967.

In 1976 the Energy Research and Development Administration (ERDA) identified the Bayo Canyon Site as one of the locations to be reevaluated as part of the FUSRAP using modern instrumentation and analytical methods as a basis for determining whether any further corrective measures would be desirable.

The resurvey utilized information from a number of routine and special environmental surveillance studies conducted previously by LASL as well as extensive new instrumental measurements, soil sampling, and radiochemical analyses. Results showed that residual surface contamination due to ^{90}Sr averaged about 1.4 pCi/g or approximately 3 times the level attributable to worldwide fallout. Surface uranium averaged about 4.9 μg/g or about 1.5 times the amount naturally present in the volcanic-derived soils of the area. Subsurface contamination associated with the former waste disposal locations is largely confined within a total area of about 10 000 m^2 and down to depths of about 5 m. Of 378 subsurface samples, fewer than 12% exceeded 13 pCi/g of gross beta activity, which is comparable to the upper range of activities for uncontaminated local soils.

Health physics interpretation of the data indicates that the present population of Los Alamos living on mesas adjacent to Bayo Canyon is not receiving any incremental radiation doses due to the

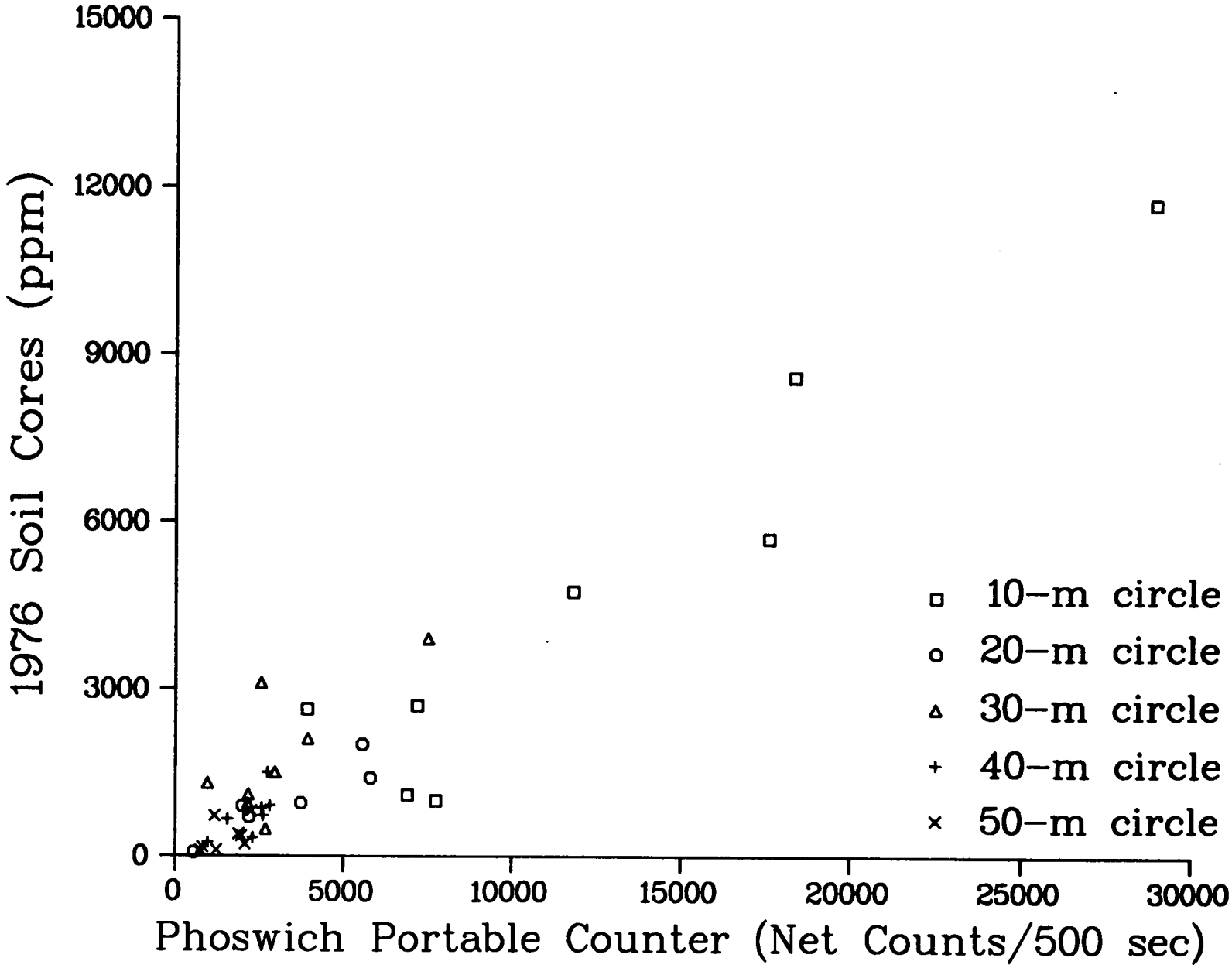


Fig. 17.

Graph of the 1976 0-2.5 cm depth segment soil uranium concentration and the phoswich portable survey instrument counts in 1978.

residual contamination. Potential future land uses of Bayo Canyon include development of a residential area.

Theoretical evaluation of such potential uses by means of exposure scenarios (including inhalation of contamination with dust by construction workers or residents) indicates that increments of radiation exposure due to residual contamination attributable to Bayo test operations would be small in comparison with either radiation protection guidelines or natural background.

The worst case evaluations for maximum individual exposures under these hypothetical conditions were calculated as 50 yr dose commitments, which represent the dose accumulated over 50 yr from exposure to radioactive material in the first year. Only several radionuclides are capable of irradiating an individual for years after exposure to that radionuclide. This occurs when these long-lived radioactive materials are inhaled or ingested and are incorporated into body tissues where they remain, such as incorporation of ^{90}Sr into bone. These dose commitments are compared to the current DOE Radiation Protection Standards for annual doses to individuals in the general public and to average doses of radiation received from natural radiation in the area. Comparing 50 yr dose commitments to annual exposure guidelines is considered conservative because the actual dose received in any one year from a radioisotope capable of irradiating the individual for years after exposure is considerably less than the 50 yr dose commitment.

The largest dose an average resident of Bayo Canyon would receive from present contamination levels would be 0.43 mrem/yr due to external penetrating radiation, which is 0.086% of DOE Guidelines and 0.24% of the dose received from natural radiation in Bayo Canyon. For maximum exposure it is assumed an individual consumes 50 kg/yr of vegetables and fruits produced from garden plots located in contaminated soil in Bayo Canyon. This individual could receive a 50 yr dose commitment of 45.6 mrem to the bone, which is 3.0% of the guidelines for annual exposure and 25% of annual exposure from natural radiation in the Canyon. Another exposure pathway is inhalation of contaminated dust due to construction activity in contaminated soil. The maximum postulated 50 yr dose commitment to a construction worker is 23 mrem to the bone from installation of underground structures or utilities. This would likely by a one-time exposure and would be only 1.5% of the DOE guidelines for annual exposure and 13% of the annual dose due to background radiation in the Canyon.

2. Acid-Pueblo Canyon System

These deep canyons (Fig. 5) were the discharge area for untreated radioactive liquid wastes between 1943 and 1951 resulting from research and processing at LASL. Starting in 1951, treated radioactive effluents were discharged into the canyon from TA-45, the liquid waste treatment facility which operated until 1964. The TA-45 waste treatment plant was sited on the mesa forming the south side of Acid Canyon. Acid Canyon is a deep canyon cut into soft volcanic rock, and is tributary to Pueblo Canyon. Intermittent stream flow is ultimately tributary to the Rio Grande.

Acid Canyon and part of Pueblo Canyon were transferred to the incorporated County of Los Alamos subject to recognition of an easement with AEC. This easement was generally a strip along the stream channel. The right of access was to permit the construction and operation of test wells and to permit the collection of earth and water samples. The property was transferred by a quit claim deed on July 1, 1967.

Plutonium, americium, and fission products were discharged into the canyons in liquid effluents from 1943 to 1964. The first survey of Acid Canyon, for purposes of cleanup, was made on August 31, 1965. On October 4, 1966, work commenced on removing the TA-45 structures. Five hundred truckloads of demolition debris and dirt from this location were removed to the dump. Ninety-four loads of debris from Acid Canyon were placed in a solid waste disposal area within the currently operational LASL site. This decontamination activity included the removal of all drain pipes, wires, rocks, tuff, and other debris found contaminated in Acid and Pueblo Canyons. This work was completed in 1967, and it was reported that a small amount of contamination remained in inaccessible places.

Some radioecological and environmental surveillance evaluations have been completed and documented for Pueblo Canyon as reported in previous surveillance reports.[4-6,27] Several hundred soil and sediment samples were collected for the present detailed radiological survey during 1977. Data

show some limited areas at the TA-45 site and in the canyons that exceed EPA proposed soil screening guides for plutonium concentrations. Measurements of penetrating radiation showed no areas that exceed radiation protection standards. A draft report will be completed in 1979.

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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 the regulations of several Federal and State agencies in order to verify the Laboratory's compliance with these standards. LASL operations pertaining to environmental quality control are conducted in accordance with the directives and procedures contained in DOE's Health and Safety Manual, Chapters 0510, 0511, 0513, 0524, and 0550.

In the case of radioactive materials in the environment, the guides contained in Manual Chapter 0524 are used as a basis for evaluation. However, the DOE standard for uranium in water (1500 and 60 mg/ℓ for controlled and uncontrolled areas, respectively) does not consider chemical toxicity. Therefore, for the purposes of this report, the more restrictive standards[A1] of the International Commission on Radiological Protection (ICRP) for uranium in water (60 mg/ℓ for an occupational 40-h week) are were used as a point of comparison. For atmospheric uranium, the DOE and ICRP standards are in agreement. The standards are listed in Table A-I in the form of a Radioactivity Concentration Guide (CG). A CG is the concentration of radioactivity in the environment that is determined to result in whole body or organ doses equal to the Radiation Protection Standards (listed in Table A-II) for internal and external exposures. Obviously, there are uncertainties in relating the CG to the Radiation Protection Standards. Thus, common practice and stated DOE policy in Manual Chapter 0524 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 technically and economically practicable."

Because some radioisotopes remain in the body and cause exposure long after intake has occurred, it is common practice to consider the 50 yr dose commitment caused by ingestion of such isotopes. At present, there are no standards for 50 yr dose commitments.

For chemical pollutants in water supply, the controlling standards are those promulgated by either the EPA or the NMEID (Table A-III).

Radioactivity in public water supply is governed by EPA regulations contained in 40CFR141. These regulations provide that combined radium-226 and radium-228 shall not exceed 5 pCi/ℓ and gross alpha activity (including radium-226, but excluding radon and uranium) shall not exceed 15 pCi/ℓ. A screening level of 5 pCi/ℓ is established as part of the monitoring requirements to determine whether specific radium analyses must be performed.

For man-made radionuclides the EPA drinking water regulations specify that concentration be limited to levels that would result in doses of 4 mrem/yr calculated according to a specified procedure. The EPA calculated value for tritum (^{3}H) is 20×10^{-6} μCi/mℓ and for cesium (^{137}Cs) is 200×10^{-9} μCi/mℓ.[A2] The calculated concentration using bone as the critical organ and the EPA prescribed methods[A2] for ^{238}Pu or ^{239}Pu is 7.5×10^{-9} μCi/mℓ.

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TABLE A-I

DOE RADIOACTIVITY CONCENTRATION GUIDES (CGs)

CONCENTRATION GUIDES FOR UNCONTROLLED AREAS[a,b]

Nuclide	CG for Air (μCi/mℓ)	CG for Water (μCi/mℓ)	(nCi/ℓ)
^{3}H	2×10^{-7}	3×10^{-3}	3000
^{7}Be	---	2×10^{-3}	2000
^{11}C, ^{13}N, ^{15}O	3×10^{-8}	---	---
^{41}Ar	4×10^{-8}	---	---
^{89}Sr	3×10^{-10}	3×10^{-6}	3
^{90}Sr[d]	3×10^{-11}	3×10^{-7}	0.3
^{131}I[d]	1×10^{-10}	3×10^{-7}	0.3
^{137}Cs	5×10^{-10}	2×10^{-5}	20
^{238}Pu	7×10^{-14}	5×10^{-6}	5
^{239}Pu[d]	6×10^{-14}	5×10^{-6}	5
^{241}Am	2×10^{-13}	4×10^{-6}	4
	(pg/m^3)[c]		(mg/ℓ)
U, natural[c]	6.1×10^{6}	2×10^{-5}	60
			1.8 (ICRP[e])

CONCENTRATION GUIDE FOR CONTROLLED AREAS[a,b]

Nuclide	CG for Air (μCi/mℓ)	CG for Water (μCi/mℓ)	(nCi/ℓ)
^{3}H	5×10^{-6}	1×10^{-1}	1×10^{5}
^{7}Be	---	5×10^{-2}	5×10^{4}
^{11}C, ^{13}N, ^{15}O	1×10^{-6}	---	---
^{41}Ar	2×10^{-6}	---	---
^{89}Sr	3×10^{-8}	3×10^{-4}	300
^{90}Sr	1×10^{-9}	1×10^{-5}	10
^{131}I[d]	4×10^{-9}	3×10^{-5}MM	30
^{137}Cs	1×10^{-8}	4×10^{-4}	400
^{238}Pu	2×10^{-12}	1×10^{-4}	100
^{239}Pu[d]	2×10^{-12}	1×10^{-4}	100
^{241}Am	6×10^{-12}	1×10^{-4}	100
	(pg/m^3)[c]		(mg/ℓ)
U, natural[c]	1.8×10^{6}	5×10^{-4}	1500
			60 (ICRP[e])

[a]This table contains the most restrictive CGs for nuclides of major interest at LASL (DOE Manual Chap. 0524, Annex A).

[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]Of the possible alpha and beta emitting radionuclides released at LASL, ^{239}Pu and ^{131}I, respectively, have the most restrictive CGs. The CGs for these species are used for the gross-alpha and gross-beta CGs, respectively.

[e]For purposes of this report, concentrations of total uranium in water are compared to the ICRP recommended values which consider chemical toxicity.

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 (rem)[a]	
	Based on dose to individuals at points of maximum probable exposure	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 eye,[b] red bone marrow, active blood forming organs.	Year	5 [c]
	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[d]	Year	30
	Calendar Year	10
Hands[d] and feet	Year	75
	Calendar Quarter	25

[a]To meet the above dose commitment standards, operations must be conducted in such a manner that it would be unlikely that an individual would assimilate in a critical organ, by inhalation, ingestion, or absorption, a quantity of a radionuclide(s) that would commit the individual to an organ dose which exceeds the limits specified in the above table.

[b]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).

[c]In special cases with the approval of the Director, Division of Safety, Standards, and Compliance, a worker may exceed 5 rem/year provided his/her average exposure per year since age 18 will not exceed 5 rem per year.

[d]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)
As	0.05
Ba	1.0
Cd	0.010
Cl	250
Cr	0.05
F[b]	2.0
Pb	0.05
Hg	0.002
NO_3	45
Se	0.01
Ag	0.05
TDS	1000

Radiochemical Contaminant	MCL (μCi/mℓ)
^{137}Cs	200×10^{-9}
Gross Alpha	5×10^{-9}
^{3}H	20×10^{-6}
^{238}Pu	7.5×10^{-9}
^{239}Pu	7.5×10^{-9}

[a]USEPA National Interim Primary Drinking Water Regulations (EPA-570/9-76-003), EPA, Office of Water Supply (1976) and NMEID Water Supply Regulations (Regulations Governing Water Supply, N.M. Environmental Improvement Agency, Santa Fe, N.M., Dec. 9 1977).
[b]Based on annual average of the maximum daily air temperature of 14.6 to 17.7°C.

APPENDIX B

SAMPLING PROCEDURES AND STATISTICAL TREATMENT OF DATA

1. Thermoluminescent Dosimeters

Harshaw High Sensitivity TLD-100® LiF (lithium fluoride) chips, 6.4 mm square by 0.9 mm thick, are used in both the environmental and LAMPF networks. The chips are annealed at 400°C for 1 h and then cooled 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 rectangular holes formed by stacking machined stainless steel blocks inside an oven maintained at 400°C. After 1 h the vials are removed from the oven and placed between massive copper blocks at room temperature.

The TLD reader is an Eberline model TLR-5 set for 15s, 140°C preheat and 15s, 240°C integration cycles. Incandescent lighting is used exclusively during all phases of annealing, dosimeter preparation, and readout to prevent ultraviolet-induced spurious TL (thermoluminescence). Four chips are placed in a molded nylon acorn nut, size 3/8-16, then closed with a 3/8-16 × 1/4 in. nylon set screw. This assembly constitutes one dosimeter.

For each annealed batch, two calibration sets are exposed. One set is read at the beginning of the dosimetry cycle along with field and calibration sets from the previous cycle. The second is read at the end of the cycle to detect possible sensitivity drift. Each calibration set consists of 20 dosimeters irradiated at the following levels: 3 at 0 mR are stored as laboratory controls, 3 at 0 mR accompany the set to the irradiation facility and serve as calibration controls, 3 at 0 mR accompany the field set as transit controls, 4 at 10 mR, 4 at 20 mR, 1 each at 40, 80, and 160 mR. A factor of 1 rem (tissue) = 1.061 R is used in evaluating the dosimeter data. This factor is the reciprocal of the product of the roentgen to rad conversion factor of 0.957 for muscle for ^{60}Co (the isotope used for TLD calibrations) and the factor 0.985, 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 units and dose (weighting factor is the reciprocal of 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 10 R exposure. At the end of each field cycle, whether calendar quarter or 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 the square root of the sum of squares of the individual standard deviation by assuming that the 95% confidence interval closely approximates the same interval as ±2 standard deviations. The dose at the LASL boundary north of LAMPF is calculated differently. Here 12 locations are in close proximity and the dose at the end of each cycle is calculated as the mean for these locations. Because there is a dosimeter containing four chips at each location, this is actually a grand mean (or mean of means) and the standard deviation is therefore smaller by a factor of almost a third ($1/\sqrt{12}$) than that of any of the individual dosimeters.

In order to calculate the magnitude of the component of the total dose caused by LAMPF operations, three locations along the south boundary of LASL are used for background values. These locations are distant from and unaffected by LAMPF or any other laboratory source of radiation. They are close enough in elevation to the LAMPF site to experience similar climatic conditions such as rain and snowfall. The geologic formation along the south boundary is different from that near the north boundary and has a smaller terrestrial gamma component. However this causes an overestimate of the LAMPF contribution so that the calculated values are conservative.

The rationale for this calculation is based on the ratio of the dose recorded by the unshielded dosimeter to that for the lead and Lucite-shielded dosimeter. This ratio should be the same for dosimeters at both the north and south boundaries because the cosmic gamma component is quite

stable (and is responsible for nearly 90% of the dose recorded by the shielded dosimeters) and because the terrestrial conditions are nearly the same. Any decrease in the ratio at the north boundary is assumed to be caused by LAMPF operations. The actual method of calculation follows. Let z be the dose component from LAMPF, u and v be the unshielded and shielded dose means, respectively, at the north boundary, u' and v' be their counterparts at the south boundary, and S_u, S_v, $S_{u'}$, $S_{v'}$ be the standard deviation of these means. Then

$$z = u-(v[u'/v']).$$

The uncertainty associated with this value can be determined from the relationship

$$S_z^2 = (\partial_z/\partial_u)^2 S_u^2 + (\partial_z/\partial_v)^2 S_v^2 + (\partial_z/\partial_{u'})^2 S_{u'}^2 + (\partial_z/\partial_{v'})^2 S_{v'}^2.$$

The doses at the other 10 locations in the LAMPF network are reported in the same manner as those in the environmental network. The ratios of unshielded to shielded doses are calculated for comparison purposes only. They serve as a check on the ratios at the north boundary and background locations.

An independent comparison study between an integrating high-pressure ionization chamber and the TLD system was also made to try to verify the ability of the TLD network to measure the north boundary dose. The ion chamber and TLDs were placed on top of a 10 m tower located on the boundary north of LAMPF from 16 Nov 1978 through 15 Jan 1979. The integrated total dose recorded by the ion chamber for this period was 23.7 mrem. The TLDs recorded 22.7 ± 0.4 (2σ) mrem. An estimated dose of 2.1 mrem due to LAMPF activities using data from the ion chamber compares with 3.6 ± 2.4 (2σ) mrem measured by the LAMPF network TLDs placed 1 m above ground in the vicinity of the tower. This close agreement between the two methods of dose measurement indicates that the TLD system is capable of measuring the boundary dose due to LAMPF activities with reasonable accuracy.

2. Air Sampling

Samples are collected monthly at 25 continuously operating stations during 1978. High volume positive displacement air pumps with flow rates of approximately 3 ℓ/s are used. Atmospheric aerosols are collected on 79 mm diam polystyrene filters. Part of the total air flow (~2 mℓ/s) 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.

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 adsorbed, naturally-occurring, radon-thoron daughters had reached equilibrium with the long-lived parents) provides a record of long-lived atmospheric radioactivity.

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.

Plutonium is separated from the 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 plutonum and americium samples are separately electro-deposited 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. Water is distilled from each silica gel sample, yielding a monthly average atmospheric water vapor sample. An aliquot of the distillate is then analyzed for tritium by liquid scintillation counting.

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) of the system were sometimes obtained (see Table C-IV). Individual measurements often 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 or negative values are included in the population. For this reason, the primary value given in the tables of air sampling results is the actual value obtained from an individual measurement or group of measurements. These primary values are those used in making subsequent statistical analyses and in evaluating the real environmental impact of Laboratory operations.

Station and group means are weighted for the length of each sampling period and for the air volume sampled. The means were calculated using the following equation.[B4]

$$\bar{c} = \frac{\sum_{i=1}^{N} v_i t_i c_i}{\sum_{i=1}^{N} v_i t_i}$$

where

$\bar{c}$ = annual mean station or group atmospheric radioactive species concentration.

c_i = atmospheric radioactive species concentration for station or group i during t_i,

N = total number of samples during 1978 for a station or group,

t_i = length of routine sampling period for station or group i, and

v_i = air volume sampled for station or group i during t_i.

Standard deviations for station and group means are similarly weighted by using the following equation.

$$\sigma_{\bar{c}} = \left\{ \frac{\left[N \sum_{i=1}^{N} (v_i t_i c_i)^2 \right] \left[\frac{\sum_{i=1}^{N} (v_i t_i c_i)^2}{\left(\sum_{i=1}^{N} v_i t_i \right)^2} \right] - 1}{N-1} \right\}^{1/2},$$

where

$\sigma_{\bar{c}}$ = standard deviation of $\bar{c}$.

To indicate the precision of the maximum and minimums, an uncertainty term representing twice the propogated measurement uncertainty (2σ) associated with the reported maximum or minimum value is included in the data tables.

3. Water, Soil, and Sediment Sampling

Surface and ground water sampling points are grouped according to location and hydrologic similarity; i.e., regional, perimeter, and onsite stations. 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.

Water is collected for chemical analyses at the same time as for radiochemical analysis and returned to the laboratory for filtration through a Whatman #2 filter. Samples for trace constituents in the water supply are collected and acidified in the field and returned immediately to the laboratory for filtration.

Soil and sediment stations are also grouped according to location and hydrologic similarity; i.e., regional, perimeter, and onsite stations.

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.

Cumulative samplers are set in a dry stream to collect samples of intermittent storm runoff. The sampler consists of a heavy angle iron driven into the channel with a heavy polyethylene bottle attached by a strap. The intake nozzle to the bottle, consisting of a 1 cm diam copper tube fitted through the plastic bottle cap, faces upstream and is placed about 4 cm above the channel. A vent hole (0.4 cm diam) is drilled into the bottle neck to vent air during initial filling of the sampler and to allow some continuous circulation of water and sediments into the bottle. The average time to fill the sampler is about 3 min; however, this can vary considerably, depending on the volume and velocity of flow.

The samples are filtered through a 0.45 μm filter. The radioactivity and chemical composition of the solution is defined as filtrate passing through the filter, while the radioactivity in suspended sediments is defined as the residue on the filter.

The average concentrations of radionuclides and chemical constituents are reported for a number of individual analyses in Tables E-XIII through E-XVI and Tables E-XVIII and E-XX. 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.

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APPENDIX C

ANALYTICAL CHEMISTRY METHODS

1. Procedures

a. Plutonium and Americium. Soil and sediment samples are dried, sieved through a No. 12 screen (<1.7 mm), and split into 10 g aliquots. Each aliquot is leached with HF - HNO_3.

Waters are acidified to ~1% HNO_3 in the field. Immediately upon arrival in the laboratory, they are filtered through 0.45 μm pore membrane filters, split into 500 mℓ aliquots, and evaporated to dryness with HNO_3. The residue is treated with HF to dissolve silica.

Air filters are ignited in platinum dishes, treated with HF-HNO_3 to dissolve silica, wet ashed with HNO_3 - H_2O_2 to decompose the organic residue and treated with HNO_3-HCl to ensure isotopic equilibrium.

Vegetation samples are ashed in a high temperature oven and then treated like soil samples. All samples are spiked with standardized ^{242}Pu and ^{243}Am during dissolution to serve as a chemical recovery tracer.

Dissolved samples are thoroughly digested in 7.2 N HNO_3, and 1N $NaNO_2$ added to ensure that Pu is in the tetravalent state. The solution is passed through a pre-conditioned anion exchange column. The initial eluate and the first 20 mℓ of a 7.2 N HNO_3 wash is saved for ^{241}Am analysis. The column is then washed with 7.2 N HNO_3 and 8 N HCl. Plutonium is eluted with a freshly prepared solution of 1 g/ℓ NH_4I in 1 N HCl. The eluate is appropriately conditioned and Pu is electrodeposited from a 4% solution of $(NH_4)_2C_2O_4$. The plated Pu is counted on an alpha spectrometer.

For water and air filter samples, the eluate from the Pu column is conditioned to ensure the removal of HNO_3 and adjusted to 0.5 N HCl. This solution is loaded on a cation exchange column, rinsed with 0.5 N HCl followed by 2.0 N HCl, and Am is eluted with 4 N HCl. The eluate is converted to the nitrate, made 6 N with HNO_3, then mixed with ethanol in the proportion 40% 6 N HNO_3-60% ethanol, and loaded on a preconditioned anion exchange column. The column is washed with 75% methanol-25% 6N HNO_3, and 60% methanol-40%6N HNO_3. Americium is eluted with 60% methanol-40% 2.5 N HNO_3. This non-aqueous solvent-anion exchange step separates the rare earth elements, other actinides, and Ra from Am.

For soil and vegetation samples the eluate from the Pu column is converted to 6 N HCl. Americium is extracted into 0.015 N DEHPP and then back extracted with $(NH_4)_2CO_3$. The back extract is decomposed with HCl, HNO_3, and $HClO_4$, dissolved in 3 N HCl. The solution is brought to 3 N in HF and Am is coprecipitated with YF_3. The YF_3 is dissolved with H_3BO_3 in 6 N HNO_3, then mixed with ethanol in the proportion 40% 6 N HNO_3-60% ethanol, and loaded on a preconditioned anion exchange column. The column is washed with 75% methanol-25% 6 N HNO_3 and 60% methanol-40% 6 N HNO_3. Americium is eluted with 60% methanol-40% 2.5 N HNO_3. This non-aqueous solvent-anion exchange step separates the rare earth elements, other actinides, and Ra from Am. The Am effluent is evaporated and dissolved in 2 mℓ HCl and 2 mℓ 6 N NH_4SCN. The pH is adjusted to ~3 with NH_4OH. The adjusted sample is loaded on a preconditioned anion exchange column. The column is washed with 2 N NH_4SCN to separate rare earth elements. Americium is eluted with 2 N HCl.

Air and water sample eluates from the methanol-HNO_3 column and soil and vegetation sample eluates from the SCN^- column are conditioned and Am electrodeposited from 5 N NH_4Cl adjusted to the methyl red endpoint. Electrodeposited Am is counted on an alpha spectrometer.

b. Gross Alpha and Beta. Two g of soil or sediment are leached in hot HNO_3-HCl, and the supernate is transferred to a stainless steel planchet and dried for counting.

Nine hundred mℓ of water are acidified with 5 mℓ of HNO_3 and evaporated to dryness. The residue is treated with HF-HNO_3 to dissolve silica, and H_2O_2 and HNO_3 to destroy organics. Residue is dissolved in 7.2 N HNO_3, and then transferred to a counting planchet.

Air filters are mounted directly on counting planchets.

Samples appropriately loaded on the planchets are counted on a thin window, dual channel gas proportional counter. Activity is calculated with appropriate corrections for cross talk between the two channels and the effect of mass loading on the counting efficiency.

c. Tritium. Soils are heated to evaporate the soil moisture, the condensate is trapped, and 5 mℓ aliquots are transferred to scintillation vials.

Water samples are acidified to ~1% HNO_3 in the field and filtered through 0.45 μm pore membrane filters immediately upon arrival in the laboratory. Five mℓ of the water are transferred into a scintillation counting vial.

Atmospheric water is trapped in a desiccator in the field. Moisture is removed from the desiccant in the laboratory, and appropriate aliquots taken for scintillation counting. Fifteen mℓ of scintillation liquid are added to each sample, which is then vigorously shaken.

Samples are counted in a Beckman LS-200 liquid scintillation counter for 50 min or 10 000 counts, whichever comes first. Standards and blanks are counted in conjunction with each set of samples.

d. ^{137}Cs and Gross Gamma. Soils and sediments are sieved through a No. 12 (< 1.7 mm) screen. One hundred grams of the sieved soils are weighed into polyethylene bottles.

Water samples are acidified in the field to ~1% HNO_3 and filtered through 0.45 μm pore membrane filters. Five hundred mℓ of each sample are transferred to a standard 500 mℓ polyethylene bottle for counting.

The radionuclide ^{137}Cs is determined by counting on a Ge(Li) detector coupled to a multichannel analyzer. The activity is calculated by direct comparison with standards prepared in the same geometrical configuration as the samples. Gross gamma is measured by counting in an NaI(Tl) well counter, which accommodates the 500 mℓ bottles. A single channel analyzer adjusted to register gamma radiation between 0 and 2 MeV is interfaced to the detector. Gross gamma determinations are reported as net counts per unit time and unit weight.

e. ^{90}Sr. Sample preparation and dissolutions are similar to those described in the section on Pu. After dissolution, the residue is dissolved in HCl, the pH is adjusted to 2, and Y is separated from Sr by extraction into 20% HDEHP in toluene. The isolated ^{90}Sr is left undisturbed for two weeks to allow the daughter ^{90}Y to attain radioactive equilibrium. After that period, inactive Y carrier is added and ^{90}Y is again extracted from ^{90}Sr by solvent extraction into 5% HDEHP in toluene. Yttrium is back extracted into 3 N HNO_3 and precipitated as the hydroxide. Yttrium hydroxide is redissolved and the oxalate is precipitated. This precipitate is oven fired to the oxide which is filtered and weighed to determine the chemical yield. Yttrium oxide precipitate is counted on a gas proportional counter to measure the activity. Samples are recounted after three days to verify the separation of ^{90}Y from other beta-emitting nuclides.

f. Uranium. Analyses for U were performed in one of two ways—instrumental epithermal neutron activation analysis or delayed neutron activation analysis. In the first method, two gram samples are irradiated in the epithermal neutron port at the Los Alamos Omega West Reactor. A period of two to four days is allowed to pass after the irradiation, and the samples are counted on a Ge(Li) gamma-ray spectrometer. The 228 and 278 keV transitions from ^{239}Np are used for the quantitative determination. The nuclear reaction is $^{238}U\ (n,\gamma)\ ^{239}U \rightarrow {}^{239}Np + \beta$. Obviously the ratio measures the major isotope of U and calculates total U assuming ^{238}U is >99% of the total U. This assumed value will probably not vary significantly in environmental samples.

For samples with U concentrations greater than 100 ppm, another epithermal irradiation may be used. Following a 5 min irradiation and 10 min decay, the 75 keV gamma ray from ^{239}U may be observed directly rather than waiting for the total decay to ^{239}Np. Results from both epithermal methods have been reported in the literature.[C1]

In the second method, samples are irradiated in a thermal neutron port and pneumatically transferred to a neutron counter where the delayed neutrons produced by the fission of ^{235}U are measured.[C2] The technique is very manpower efficient and has a lower limit of detection than does the epithermal irradiation method. However, total U is calculated assuming a $^{235}U/^{238}U$ ratio of 0.0072. Variations in this ratio will produce inaccuracies in the result, hence samples likely to contain depleted U were not analyzed by this method because of the lower limits

of detection. Most of our U analyses are done by this method because it is the more sensitive.

An advantage to having both U techniques available is that samples containing enriched U may be measured. The ^{235}U content may be determined by delayed neutrons and the ^{238}U content by epithermal activation. Total U is the sum of these, and a rough indication of the isotope ratio may also be given.

A comparison of these methods with the more traditional fluorometric technique for U analysis in soils has been published.[C3]

2. Stable Elements

Four instrumental methods are used for a wide variety of stable element determinations. Neutron activation and atomic absorption are the principal techniques with ion chromatography and ion selective electrodes used in a supplementary role. Elements and anions determined by the various methods are summarized in Table CI. In addition, standard chemical methods are used for HCO_3^{-2}, total dissolved solids (TDS), and total hardness. It should be noted that our Hg method of choice is cold vapor atomic absorption using the standard Perkin-Elmer technique.

3. Analytical Chemistry Quality Evaluation Program

Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of two general types. Blanks are matrix materials containing quantities of analyte below the detection limit of the analytical procedure. Standards are materials containing known quantities of the analyte. Analyses of control samples fill two needs in the analytical work. First, they provide quality control over the analytical procedures so that problems that might occur can be identified and corrected. Secondly, data obtained

TABLE C-I

ANALYTICAL METHODS FOR VARIOUS ELEMENTS AND ANIONS

Technique	Elements/Anions Measured	References
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	C4,5,6,7
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	C8,9,10,11
Thermal Neutron Capture–Gamma Ray	Al,B,Ca,Cd,C,Gd,H,Fe,Mg N,P,K,Si,Na,S,ti	C12,13,14
Radiochemical	Sb,As,Bi,Cu,Au,Ir,Hg,Mo,Os,Pd P,Pt,Ru,Se,Ag,Te,Th,W,U	C15,16,17,18 19,20
Atomic Absorption	Sb,As,Ba,Be,Bi,Cd,Ca,Cr,Co,Cu F,Ga,In,Fe,Pb,Li,Mg,Mn,Hg,Mo, Ni,K,Se,Si,Ag,Na,Sr,Te,Tl,Sn, Ti,V,Zn	C21,22,23,24, 25,26,27
Ion Chromatography	F^-,Cl^-,Br^-,NO_3^-, NO_2^-,SO_3^{-2},SO_4^{-2},PO_4^{-3},NH_4^+	C28
Ion Selective Electrodes	F^-,NO_3^-,NH_4^+	C29

from the analysis of control samples permits the evaluation of the capabilities of a particular analytical technique under a certain set of circumstances. The former function is one of analytical control, the latter is called quality assurance.

Quality control samples are obtained from outside agencies and prepared internally. The EPA provides water, foodstuff, and air filter standards for analysis of gross alpha, gross beta, ^{3}H, ^{137}Cs, and ^{239}Pu as part of the ongoing laboratory intercomparison program. The Environmental Measurements Laboratory (EML) provides soil, water, bone, tissue, vegetation, and air filter samples each containing a wide variety of radionuclides. These are part of a laboratory intercomparison of DOE-supported facilities. Uranium standards obtained from the Canadian Geological Survey (CGS) and the International Atomic Energy Agency (IAEA) are used to evaluate the uranium analysis procedures. Internal standards are prepared by adding known quantities of analyte to blank matrix materials.

Quality assurance for the stable element analysis program is maintained by the analysis of certified or well-characterized environmental materials. The National Bureau of Standards (NBS) has a large set of silicate, water, and biological Standard Reference Materials (SRM). 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). Other trace elemental standards have been purchased from Kodak.

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; i.e., they are not normally handled as a unique set of samples. We feel that it would be difficult for the analyst to give the samples special attention even if they were so inclined. We endeavor to run at least 10% of the stable element analyses as quality assurance samples using the materials described above. A more detailed description of our Quality Assurance Program using SRM is in preparation.

The capabilities of the analytical procedures are evaluated from the quality control samples. 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 of ($\bar{x}$) of R for all analyses of a given type is calculated by weighting each value (x_i) by the uncertainty associated with it (σ_i).

$$\bar{x} = \frac{\Sigma_i \, x_i/\sigma_i^2}{\Sigma_i 1/\sigma_i^2} .$$

The standard deviation (σ) of the weighted mean is calculated assuming a normal distribution.

$$\sigma = \sqrt{\frac{\Sigma_i \, (\bar{x} - x_i)^2}{N - 1}} .$$

These calculated values are presented in Table C-II. The weighted mean of the R is a measure of the accuracy of the 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 the precision. The precision is a function of the quantity of analyte; i.e., as the absolute quantity approaches the limit of detection, the precision increases. For instance, the precision for ^{137}Cs determinations is quite large because many of the standards approached the limits of detection of the measurement. Conversely, the precision for the uranium analyses is unrealistically small because the standards contained quantities of uranium significantly above the detection limits.

Analysis of blanks provides a criterion to judge the probability that samples were contaminated during the analysis. Table C-III presented weighted means and standard deviations of the absolute quantity of analyte reported in blank materials analyzed during 1978.

4. Limits of Detection

Data from the analysis of blanks also provide a means of calculating limits of detection for the various procedures. Table C-III presents detection limits for analyses of various constituents in several environmental matrices. The limits for $^{238,239}Pu$, ^{241}Am, ^{137}Cs, and U are calculated from the

TABLE C-II

ANALYTICAL CAPABILITIES EVALUATED FROM QUALITY CONTROL AND QUALITY ASSURANCE STANDARDS

Analysis	No. of Samples	R (Weighted Mean) $\bar{x} \pm \sigma$[a]	Analysis	No. of Samples	R (Weighted Mean) $\bar{x} \pm \sigma$[a]
^{90}Sr	9	1.53 ± 0.57	F	43	1.06 ± 0.20
^{3}H	30	0.70 ± 0.39	Hf	4	1.19 ± 0.12
^{226}Ra	6	1.09 ± 0.13	Hg	15	1.03 ± 0.04
^{137}Cs	14	0.92 ± 0.61	Fe	6	0.96 ± 0.07
^{238}Pu	23	0.84 ± 0.23	La	9	0.91 ± 0.04
^{239}Pu	37	0.90 ± 0.19	Lu	2	1.12
^{241}Am	25	0.96 ± 0.14	Mg	4	0.91 ± 0.08
Gross alpha	21	0.86 ± 0.23	Mn	12	1.07 ± 0.23
Gross beta	21	1.07 ± 0.08	K	15	1.01 ± 0.04
U	87	0.99 ± 0.06	Rb	2	0.94
Al	17	1.11 ± 0.27	Sm	7	1.18 ± 0.02
Sb	1	0.90	Sc	2	0.98
As	10	0.97 ± 0.05	Se	15	0.91 ± 0.20
Ba	12	0.98 ± 0.13	Na	22	1.02 ± 0.10
Br	2	0.87	Sr	5	0.91 ± 0.10
Ca	7	1.08 ± 0.12	Ta	3	0.98 ± 0.07
Ce	2	1.05	Th	9	0.98 ± 0.04
Cs	1	0.99	Ti	3	1.02 ± 0.02
Cl	35	0.99 ± 0.11	W	6	0.99 ± 0.01
Cr	2	1.08	V	12	0.94 ± 0.12
Co	1	1.00	Yb	5	1.09 ± 0.08
Eu	5	1.11 ± 0.07			

[a]Three or more samples are required to calculate σ.

weighted mean plus two standard deviations of the analysis of blanks (Table C-IV). For tritium, the detection limit is merely 2σ of repetitive determinations of the instrumental blank. Gross alpha and gross beta are measured simultaneously by counting on a gas proportional counter and electronically discriminating the output pulses. As there is crosstalk generated by the detection of the two types of emissions, the detection limit of one is a function of the counting rate of the other. Detection limits in Table C-III are calculated assuming that counting rates for both alpha and beta are at background levels. The detection limit for alpha increases 10% above the limit for every count per minute (cpm) of beta activity emitted by the sample. Similarly, the detection limit for beta increases 40% for every 10 cpm of alpha.

For most routine water samples, concentrations of ^{137}Cs were determined with a NaI(Tl) well counter. An automatic sample changer used in conjunction with the system significantly reduced the cost of the analyses. However, the smaller volume and higher background associated with the NaI(Tl) detector significantly degraded the limit of sensitivity for this analysis. No blanks were measured to assess these limits, but they are estimated to be an order of magnitude greater than that given in Table C-IV, which was determined by counting 500 mℓ samples on a Ge(Li) detector.

Results greater than the defined detection limits indicate the presence of the constituent at the 95% confidence level. However, results less than the detection limit do not necessarily indicate its absence.

TABLE C-III

QUANTITY OF CONSTITUENT REPORTED IN BLANKS

Analyses	No. of Samples	Quantity (Weighted Mean) $\bar{x} \pm \sigma$	Units
^{90}Sr	15	0.0055 ± 0.06	pCi
^{137}Cs	26	1.2 ± 11	pCi
^{238}Pu	23	−0.0064 ± 0.069	pCi
^{239}Pu	23	0.0010 ± 0.029	pCi
^{241}Am	18	0.021 ± 0.020	pCi
Uranium (Delayed neutron)	4	15 ± 6	ng
Uranium (Epithermal activation)	153	25 ± 12	ng
Gross α	9	0.032 ± 0.35	pCi
Gross β	9	0.57 ± 0.93	pCi

TABLE C-IV

DETECTION LIMITS FOR ANALYSES OF TYPICAL ENVIRONMENTAL SAMPLES

Parameter	Approximate Sample Volume or Weight	Count Time	Concentration
Air Sample			
Tritium	3 m	100 min	10^{-12} μCi/mℓ
^{238}Pu	1.2×10^{4} m³	8×10^{4} sec	2×10^{-12} μCi/mℓ
^{239}Pu	1.2×10^{4} m³	8×10^{4} sec	10^{-12} μCi/mℓ
^{241}Am	2.5×10^{4} m³	8×10^{4} sec	2×10^{-12} μCi/mℓ
Gross-alpha	3.8×10^{3} m³	100 min	3×10^{-16} μCi/mℓ
Gross-beta	3.8×10^{3} m³	100 min	3×10^{-16} μCi/mℓ
Uranium (Delayed neutron)	2.5×10^{4} m³		1 pg/m³
Water Sample			
Tritium	0.005 ℓ	100 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		1 μg/ℓ
Soil Sample			
Tritium	1 kg	100 min	0.003 pCi/g
^{137}Cs	100 g	5×10^{4} sec	10^{-1} pCi/g
^{238}Pu	10	8×10^{4} sec	0.003 pCi/g
^{239}Pu	10	8×10^{4} sec	0.002 pCi/g
^{241}Am	10	8×10^{4} sec	0.01 pCi/g
Gross-alpha	2	100 min	0.8 pCi/g
Gross-beta	2	100 min	0.003 pCi/g
Uranium (Epithermal activation)	2		0.03 μg/g

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APPENDIX D

METHODS FOR DOSE CALCULATIONS

A. Airborne Tritium and Actinides

Measured annual average concentrations in air, after subtracting background, are multiplied by standard breathing rates[D1] to determine annual intake via inhalation. This intake is then multiplied by appropriate dose conversion factors[D2] to convert intake into annual dose and 50 year dose commitments for various organs. Dose commitment factors for tritium include an increase by a factor of 2 over inhalation intake to account for skin absorption of tritium.

B. Airborne Air Activation Products

Nuclear reactions with air in the target areas at LAMPF 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 and LAMPF form ^{41}Ar (1.8 h half-life). The concentrations of these isotopes at the appropriate site boundary are calculated using the annual average meteorological dispersion coefficient

$$X(r,\theta)/Q$$

and the source term $Q\ X(r,\theta)$ is determined from Gaussian plume dispersion models. The dose calculated using semi-infinite cloud assumptions and then corrected for cloud size. The gamma dose rate in a semi-infinite cloud can be represented by the equation[D3]

$$\gamma_\infty\ (x,y,o,t) = 0.25\,\overline{E}\gamma X(x,y,o,t),$$

where

$\gamma_\infty\ (x,y,o,t)$ = gamma dose rate (rad/sec) to a person located at point x,y at ground level and time t,

$\overline{E}\gamma$ = average gamma energy per decay (MeV), and

$X(x,y,o,t)$ = plume concentration in curies/m^3 at time t.

Dose rate corrections for estimated plume size (if the cloud cannot be construed to be semi-infinite) is taken from standard graphical compilations.[D3] $\overline{E}\gamma$ is 1.02 MeV for the positron emitters (two 0.511 MeV gammas are produced in the positron annihilation process) and 1.29 MeV for ^{41}Ar. For maximum individual doses, a shielding factor (because of structure shielding) of 0.7 is used.[D4]

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APPENDIX E

ENVIRONMENTAL DATA TABLES

TABLE E-I

MEANS AND EXTREMES OF TEMPERATURE AND PRECIPITATION

CLIMATOLOGICAL SUMMARY 1951-1978[a]

	Temperature (°C)							Precipitation (mm)										Mean No. of Days		
	Means			Extremes				Rain[b]					Snow/Frozen Precipitation							
Month	Max	Min	Mo. Mean	High	Year	Low	Year	Mean	Daily Max	Year	Mo. Max	Year	Mean	Daily Max	Year	Mo. Max	Year	Precip ≥2.5 mm	Max Temp ≥32°C	Min Temp ≤0°C
Jan	4.4	−7.5	−1.6	18.3	1953	−27.8	1963	19.0	24.9	1952	47.8	1952	230	360	1974	590	1974	2	0	30
Feb	6.1	−5.9	0.1	17.8	1962	−27.2	1951	17.6	24.4	1975	47.5	1964	200	270	1975	490	1964	2	0	26
March	9.4	−3.0	3.2	21.7	1971	−16.7	1971	25.1	41.7	1973	104.4	1973	250	410	1973	910	1973	3	0	23
April	14.4	1.0	7.7	25.0	1965	−11.7	1973	21.4	50.8	1975	82.0	1975	130	510	1975	850	1958	2	0	13
May	19.7	6.1	12.9	31.1	1956	−4.4	1976	26.9	34.3	1952	88.9	1952	20	300	1978	410	1978	3	0	2
June	25.4	11.3	18.4	35.0	1952	0.0	1975	28.7	29.7	1969	86.4	1960	0	0	---	0	---	3	0	0
July	26.8	13.3	20.1	34.4	1952	7.2	1961	85.6	62.7	1968	167.6	1968	0	0	---	0	---	8	1	0
Aug	25.2	12.4	18.8	32.8	1977	6.1	1957	103.1	57.4	1951	284.0	1952	0	0	---	0	---	9	0	0
Sept	22.3	9.0	20.7	31.1	1952	−3.3	1971	42.5	47.2	1973	115.6	1975	2	40	1971	40	1971	4	0	0
Oct	16.7	3.7	10.2	26.7	1952	−9.4	1976	39.8	52.3	1957	172.0	1957	40	180	1972	230	1959	3	0	7
Nov	9.5	−2.6	3.5	18.9	1952	−25.6	1976	25.0	45.0	1978	167.6	1978	130	300	1976	880	1957	2	0	22
Dec	4.9	−6.8	−1.0	15.0	1965	−25.0	1978	25.2	40.6	1978	72.4	1965	300	560	1978	1050	1967	2	0	30

CLIMATOLOGICAL SUMMARY 1978[a]

	Temperature (°C)					Precipitation (mm)				No. of Days		
	Means			Extremes		Rain[b]		Snow/Frozen Precipitation				
Month	Max	Min	Mo. Mean	High	Low	Total	Daily Max	Total	Daily Max	Precip ≥2.5 mm	Max Temp ≥32°C	Min Temp ≤0°C
Jan	3.7	−6.5	−1.4	7.8	−13.9	17.5	8.4	150	50	2	0	31
Feb	5.1	−6.5	−0.7	12.2	−16.7	7.1	2.8	50	50	1	0	28
March	10.8	−1.7	4.6	20.0	−9.4	36.8	12.2	130	130	6	0	22
April	15.8	1.4	8.6	20.0	−2.8	7.1	4.3	0	0	1	0	10
May	17.8	4.4	11.1	26.7	−4.4	50.5	31.5	410	300	3	0	7
June	25.9	12.1	19.0	32.2	5.0	35.1	19.6	0	0	4	1	0
July	28.5	13.4	21.0	31.7	10.0	34.3	17.0	0	0	5	0	0
Aug	26.0	11.1	18.6	30.0	6.1	35.3	12.7	0	0	6	0	0
Sept	22.3	8.0	15.2	27.8	0.6	34.3	19.8	0.	0	3	0	0
Oct	18.0	4.4	11.2	25.0	−1.7	26.7	13.2	30	30	4	0	6
Nov	8.1	−1.4	3.4	17.8	−8.3	167.6	45.0	180	150	7	0	18
Dec	2.6	−9.1	−3.3	10.0	−25.0	57.1	40.6	640	560	4	0	31

[a]Los Alamos, New Mexico; latitude 35°32' north, longitude 106°19' west; elevation 2260 m.
[b]Includes liquid water equivalent of frozen precipitation.

TABLE E-II

ANNUAL THERMOLUMINESCENT DOSIMETER MEASUREMENTS

Station Location	Coordinates	Annual Dose Dose (mrem)	95% Conf Interval (mrem)	95% Conf Interval (per cent)
Regional Stations	**(28-44 km)**	**Uncontrolled Areas**		
Española		74.3	5.2	7.0
Pojoaque		81.7	5.2	6.4
Santa Fe		95.5	5.7	5.9
Regional Average		83.8 ± 21.5		
Perimeter Stations	**(0-4 km)**	**Uncontrolled Areas**		
Barranca School	N180 E130	111.8	5.6	5.0
Cumbres School	N150 E090	106.8	5.5	5.1
Golf Course	N160 E060	109.6	5.5	5.0
Arkansas Avenue	N170 E020	135.4	5.4	4.1
Diamond Drive	N130 E020	104.9	5.5	5.2
48th Street	N110 E000	128.2	5.5	4.2
Fuller Lodge	N110 E090	128.5	5.5	4.2
Acorn Street	N100 E110	102.6	5.6	5.5
LA Airport	N110 E160	113.7	5.5	4.8
Bayo Canyon S.T.P.	N110 E260	98.6	3.8	3.8
Bandelier Lookout	S270 E200	105.5	5.6	5.3
Pajarito Acres	S210 E370	82.4	5.6	6.8
White Rock S.T.P.	S090 E430	87.7	5.2	6.0
Pajarito Ski Area	N130 W180	111.2	5.2	4.7
Gulf Station	N100 E100	101.0	5.2	5.2
Royal Crest	N080 E080	91.3	5.2	5.7
Perimeter Average		107.5 ± 29.1		

Station Location	Coordinates	Annual Dose Dose (mrem)	95% Conf Interval (mrem)	95% Conf Interval (per cent)
Onsite Stations	**(28-44 km)**	**Controlled Areas**		
TA-21	N090 E170	111.4	5.5	4.9
State Hwy 4	N070 E350	217.1	5.6	2.6
Well PM-1	N030 E310	120.6	5.4	4.5
TA-53	N040 E230	113.9	5.5	4.8
TA-53	N070 E160	121.0	5.5	4.5
TA-53	N060 E190	143.4	5.5	3.8
TA-53	N060 E200	185.7	5.4	2.9
TA-53	N060 E220	680.8	13.3	2.0
TA-53	N050 E230	159.3	5.5	3.4
TA-2	N080 E100	119.7	5.4	4.6
TA-2	N080 E110	138.0	5.5	4.0
TA-2	N080 E120	153.3	5.5	3.6
TA-6	N060 W050	106.7	5.2	4.9
TA-16	S030 W080	117.9	5.5	4.7
TA-49	S100 E040	115.6	5.4	4.7
TA-33	S250 E230	105.8	5.7	5.3
Booster P-1	S100 E300	121.0	5.6	4.6
TA-18	S040 E190	173.6	5.2	3.0
TA-18	S030 E190	251.7	5.7	2.3
TA-18	S040 E200	207.1	5.3	2.6
TA-18	S060 E190	161.4	5.3	3.3
TA-18	S050 E170	114.9	5.2	4.5
TA-52	N020 E170	105.8	5.2	4.9
TA-35	N040 E110	123.4	5.1	4.2
TA-35	N030 E110	119.2	5.2	4.4
TA-39	N030 E100	132.5	4.0	3.0
TA-3	N040 E010	117.0	5.2	4.4
TA-3	N060 E010	219.5	5.4	2.5
TA-3	N050 E020	142.6	5.2	3.6
TA-3	N050 E040	97.2	5.0	5.2
TA-54	S080 E260	112.2	5.2	4.7
Onsite Average		159.9 ± 211.9		

TABLE E-III

REGIONAL AVERAGE BACKGROUNDS ATMOSPHERIC RADIOACTIVITY CONCENTRATIONS

Radioactive Constituent	Activity (10^{-15} μCi/mℓ) EPA[a]	LASL[b]	CG[c]
Gross α[d]	Not reported	1.4 ± 0.2	60
Gross β[e]	83	105 ± 25	1×10^5
^{241}Am	Not reported	0.004 ± 0.004	2×10^2
^{238}Pu	0.0018 ± 0.0018	0.0012 ± 0.0026	70
^{239}Pu	0.0199 ± 0.0100	0.014 ± 0.007	60
Tritium	Not reported	11 000. ± 3500	2×10^8
Uranium	0.0408 ± 0.0300 (120 ± 88)[f]	0.034 ± 0.017 (105 ± 54)[f]	7×10^4

[a] "Radiological Quality of the Environment," (EPA-520/1-76-010), US EPA, Office of Radiation Programs, Washington, DC (1976).

[b] Annual averages for 1973-1977.

[c] Concentration Guide for uncontrolled areas.

[d] Gross alpha activity compares to CG for ^{239}Pu.

[e] Gross beta activity compared to CG for ^{131}I.

[f] pg/m^3.

TABLE E-IV

LONG-LIVED ATMOSPHERIC GROSS BETA CONCENTRATIONS FOLLOWING CHINESE NUCLEAR TEST ON MARCH 14, 1978

Sampling Period	Gross Beta (10^{-15} μCi/mℓ) OHL (Onsite)	Española (28 km from LASL)
3/13 - 3/17	---	180 ± 20
3/7 - 3/20	100 ± 10	114 ± 15
3/20 - 3/21	310 ± 40	170 ± 20
3/21 - 3/22	830 ± 110	500 ± 60[a]
3/22 - 3/23	200 ± 30	170 ± 20
3/23 - 3/24	150 ± 20	170 ± 20
3/24 - 3/27	430 ± 50	460 ± 60
3/27 - 3/28	320 ± 40	260 ± 30
3/28 - 3/29	400 ± 50	240 ± 30
3/29 - 3/30	460 ± 60	330 ± 40
3/30 - 3/31	590 ± 80	570 ± 70[b]
3/31 - 4/3	190 ± 20	190 ± 20
4/3 - 4/4	320 ± 40	230 ± 30

[a] First pass of the fallout cloud.
[b] Second pass of the fallout cloud.

TABLE E-V

LONG-LIVED ATMOSPHERIC GROSS BETA CONCENTATIONS FOLLOWING CHINESE NUCLEAR TEST ON DECEMBER 14, 1978

Sampling Period	Gross Beta (10^{-15} μCi/mℓ) OHL (Onsite)	Española (28 km from LASL)
12/15 - 12/18	48 ± 6	77 ± 10
12/18 - 12/19	16 ± 3	37 ± 5
12/19 - 12/20	83 ± 14	39 ± 5
12/20 - 12/21	45 ± 6	40 ± 6
12/21 - 12/22	53 ± 7	20 ± 3
12/22 - 12/26	148 ± 19	190 ± 20[a]
12/26 - 12/27	91 ± 12	78 ± 11
12/27 - 12/28	80 ± 11	95 ± 13
12/28 - 12/29	63 ± 8	55 ± 8
12/29 - 1/2/79	37 ± 5	44 ± 6
1/2 - 1/3	74 ± 10	77 ± 10

[a] Peak.

TABLE E-VI

LOCATION 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	E020
6. Cumbres School	N150	E090
7. 48th Street	N110	E000
8. LA Airport	N110	E160
9. Bayo STP	N110	E260
10. Gulf Station	N100	E100
11. Royal Crest	N080	E080
12. White Rock	S090	E430
13. Pajarito Acres	S210	E370
14. Bandelier	S270	E200
Onsite		
15. TA-21	N090	E170
16. TA-6	N060	W050
17. TA-53 (LAMPF)	N060	E190
18. Well PM-1	N030	E310
19. TA-52	N020	E170
20. TA-16	S030	W080
21. Booster P-2	S030	E190
22. TA-54	S080	E260
23. TA-49	S100	E040
24. TA-33	S250	E230
25. TA-39	S210	E210

TABLE E-VII

ANNUAL ATMOSPHERIC LONG-LIVED[a] GROSS ALPHA AND GROSS BETA ACTIVITY CONCENTRATIONS

Station Location	Total Air[b] Volume (m^3)	Gross Alpha Concentrations-fCi/m^3 (10^{-15} μCi/mℓ) No. 4-wk Samples	No. Samples <MDL[c]	Max[d]	Min[d]	Mean[d]	Mean as % CG[e]	Gross Beta Concentrations-fCi/m^3 (10^{-15} μCi/mℓ) No: 4-wk Samples	No: Samples <MDL[c]	Max[d]	Min[d]	Mean[d]	Mean as % CG[e]
Regional Stations (28-44 km) - Uncontrolled Areas													
1. Española	81 596	13	3	1.9 ± 0.9	0.3 ± 0.1	0.6 ± 0.7	0.9	13	0	145 ± 38	9 ± 2	64 ± 10	0.06
2. Pojoaque	66 352	13	0	1.9 ± 0.8	0.6 ± 0.3	1.3 ± 1.0	2.2	13	0	200 ± 60	23 ± 6	81 ± 9	0.08
3. Santa Fe	88 083	13	0	1.7 ± 0.8	0.5 ± 0.3	1.0 ± 0.8	1.6	13	0	160 ± 40	13 ± 3	73 ± 104	0.07
Regional Group Summary	236 391	39	3	1.9 ± 0.8	0.3 ± 0.1	0.9 ± 0.9	1.6	39	0	200 ± 60	9 ± 2	72 ± 102	0.07
Perimeter Stations (-04 km) - Uncontrolled Areas													
4. Barranca School	94 684	13	2	2.9 ± 1.2	0.0 ± 0.1	1.4 ± 1.7	2.3	13	0	200 ± 60	24 ± 6	84 ± 113	0.08
5. Arkansas Avenue	83 139	13	0	3.2 ± 1.4	0.5 ± 0.3	1.8 ± 1.9	2.9	13	0	180 ± 40	23 ± 6	91 ± 86	0.09
6. Cumbres School	79 786	13	0	2.8 ± 1.2	0.5 ± 0.3	1.4 ± 1.4	2.3	13	0	180 ± 40	24 ± 6	79 ± 101	0.08
7. 48th Street	79 472	13	2	2.7 ± 1.2	0.2 ± 0.1	1.2 ± 1.6	2.0	13	0	190 ± 40	15 ± 4	71 ± 119	0.07
8. LA Airport	89 099	13	2	3.2 ± 1.4	0.0 ± 0.1	1.5 ± 2.2	2.5	13	0	160 ± 40	21 ± 6	75 ± 102	0.07
9. Bayo Stp	86 190	13	3	3.0 ± 1.4	0.0 ± 0.1	1.1 ± 2.0	1.9	13	0	190 ± 40	21 ± 6	86 ± 114	0.09
10. Gulf Station	91 868	13	1	4.3 ± 1.8	0.3 ± 0.2	1.4 ± 2.1	2.3	13	0	147 ± 38	22 ± 6	81 ± 77	0.08
11. Royal Crest	89 726	13	0	2.6 ± 1.2	0.4 ± 0.2	1.5 ± 1.5	2.5	13	0	190 ± 40	24 ± 6	94 ± 119	0.09
12. White Rock	81 501	13	4	3.5 ± 1.6	0.1 ± 0.2	1.1 ± 2.1	1.8	13	0	180 ± 40	13 ± 3	76 ± 111	0.08
13. Pajarito Acres	82 750	13	1	3.3 ± 1.4	0.1 ± 0.2	1.6 ± 2.0	2.7	13	0	220 ± 60	31 ± 8	99 ± 125	0.10
14. Bandelier	67 895	13	0	6.8 ± 3.2	0.6 ± 0.3	2.3 ± 2.7	3.8	13	0	240 ± 60	40 ± 10	116 ± 145	0.11
Perimeter Group Summary	926 110	143	15	6.8 ± 3.2	0.0 ± 0.1	1.5 ± 1.9	2.4	143	0	240 ± 60	13 ± 3	86 ± 108	0.09
Onsite Stations - Controlled Areas													
15. TA-21	63 527	13	2	3.2 ± 1.4	-0.1 ± 0.6	1.8 ± 2.3	0.09	13	0	440 ± 120	4 ± 1	80 ± 133	0.002
16. TA-6	92 343	13	2	3.1 ± 1.4	0.2 ± 0.2	1.5 ± 1.7	0.08	13	0	160 ± 40	26 ± 6	81 ± 85	0.002
17. TA-53 (LAMPF)	81 513	13	2	2.2 ± 1.0	0.0 ± 0.4	1.1 ± 1.7	0.06	13	0	160 ± 40	4 ± 1	59 ± 114	0.001
18. Well PM-1	92 388	13	2	3.2 ± 1.4	0.3 ± 0.2	1.5 ± 1.8	0.07	13	0	170 ± 40	25 ± 6	89 ± 111	0.002
19. TA-52	94 496	13	1	3.4 ± 1.6	0.2 ± 0.1	1.3 ± 1.8	0.06	13	0	200 ± 60	6 ± 2	85 ± 122	0.002
20. TA-16	94 899	13	2	2.4 ± 1.0	0.1 ± 0.1	1.1 ± 1.5	0.05	13	0	135 ± 34	6 ± 1	69 ± 82	0.002
21. Booster P-2	95 138	13	1	3.1 ± 1.4	0.2 ± 0.2	1.4 ± 1.9	0.07	13	0	160 ± 40	21 ± 6	83 ± 102	0.002
22. TA-54	97 610	13	3	3.5 ± 1.6	0.2 ± 0.2	1.6 ± 2.1	0.08	13	0	190 ± 40	31 ± 8	87 ± 109	0.002
23. TA-49	94 556	13	2	2.6 ± 1.2	0.1 ± 0.1	1.4 ± 1.8	0.07	13	0	190 ± 40	27 ± 6	81 ± 93	0.002
24. TA-33	93 452	13	0	3.9 ± 1.6	0.3 ± 0.3	1.9 ± 2.3	0.09	13	0	220 ± 60	35 ± 8	103 ± 125	0.003
25. TA-39	94 665	13	1	4.6 ± 2.0	0.3 ± 0.2	1.8 ± 2.5	0.09	13	0	210 ± 60	33 ± 8	91 ± 116	0.002
Onsite Group Summary	994 587	143	18	4.6 ± 2.0	-0.1 ± 0.6	1.5 ± 2.0	0.07	143	0	440 ± 120	4 ± 1	83 ± 109	0.002

[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 (m^3) 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 for maximum and minimum concentrations are counting uncertainties at the 95% confidence level (±2 sample standard deviations). Uncertainties for station and groups means are ±2 standard deviations.

[e]Of the possible radionuclides released at LASL, ^{239}Pu and ^{131}I are the most restrictive. The CGs for these species are used for the gross alpha and gross beta CGs, respectively.
Controlled Area Radioactivity Concentration Guide = 2×10^{-12} μCi/mℓ (α)
= 4×10^{-9} μCi/mℓ (β)
Uncontrolled Area Radioactivity Concentration Guide = 6×10^{-14} μCi/mℓ (α)
= 1×10^{-10} μCi/mℓ (β)

TABLE E-VIII

ANNUAL ATMOSPHERIC TRITIATED WATER VAPOR CONCENTRATIONS

Station Location	Total Air Volume (m^3)[a]	No. 4-wk Samples	No. 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	113	13	3	18 ± 6	0.9 ± 0.8	5 ± 11	0.003
2. Pojoaque	121	13	0	9 ± 3	1.1 ± 1.0	4 ± 4	0.002
3. Santa Fe	121	13	2	19 ± 6	0.2 ± 0.6	5 ± 10	0.002
Regional Group Summary	356	39	5	19 ± 6	0.2 ± 0.6	4 ± 9	0.002
Perimeter Stations (0-4 km) - Uncontrolled Areas							
4. Barranca School	121	13	1	26 ± 8	0.7 ± 0.6	10 ± 15	0.005
5. Arkansas Ave	121	13	1	36 ± 14	0.6 ± 0.2	10 ± 21	0.005
6. Cumbres School	120	13	0	27 ± 8	2.0 ± 1.0	10 ± 15	0.005
7. 48th Street	113	13	0	106 ± 34	1.9 ± 1.0	21 ± 60	0.010
8. LA Airport	113	13	0	107 ± 34	3.5 ± 1.2	26 ± 63	0.013
9. Bayo STP	113	13	0	23 ± 8	1.4 ± 0.8	7 ± 14	0.003
10. Gulf Station	121	13	0	43 ± 14	4.2 ± 1.6	18 ± 27	0.009
11. Royal Crest	121	13	0	67 ± 22	4.0 ± 1.4	16 ± 35	0.008
12. White Rock	121	13	0	25 ± 8	1.9 ± 1.8	7 ± 14	0.004
13. Pajarito Acres	120	13	0	36 ± 12	2.6 ± 1.2	10.± 20	0.005
14. Bandelier	111	13	0	26 ± 8	2.6 ± 1.4	9 ± 15	0.004
Perimeter Group Summary	1300.	143	2	107 ± 34	0.6 ± 0.2	13 ± 33	0.007
Onsite Stations - Controlled Areas							
15. TA-21	114	13	0	118 ± 38	1.5 ± 1.0	23 ± 40	0.0005
16. TA-6	117	13	1	15 ± 4	0.5 ± 0.4	5 ± 10	0.0001
17. TA-53 (LAMPF)	114	13	0	33 ± 10	1.9 ± 0.8	13 ± 21	0.0003
18. Well PM-1	115	13	1	95 ± 30	1.2 ± 1.6	15 ± 53	0.0003
19. TA-52	121	13	0	39 ± 12	3.1 ± 1.2	16 ± 21	0.0003
20. TA-16	121	13	1	24 ± 8	0.6 ± 0.6	6 ± 15	0.0001
21. Booster P-2	121	13	0	85 ± 28	2.3 ± 1.0	14 ± 45	0.0003
22. TA-54	123	13	0	114 ± 36	9.1 ± 3.0	57 ± 74	0.0011
23. TA-49	120	13	1	19 ± 6	0.1 ± 0.6	5 ± 10	0.0001
24. TA-33	120	13	0	92 ± 30	6.5 ± 2.2	25 ± 54	0.0005
25. TA-39	122	13	0	68 ± 22	2.7 ± 1.0	15 ± 38	0.0003
Onsite Group Summary	1311	143	4	118 ± 38	0.1 ± 0.6	18 ± 48	0.0004

[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 for maximum and minimum concentrations are counting uncertainties at the 95% confidence level (±2 sample standard deviations). Uncertainties for station and group means are ±2 standard deviations.
[d]Controlled area radioactivity concentration guide = 5×10^{-6} μCi/mℓ.
Uncontrolled area radioactivity concentration guide = 2×10^{-7} μCi/mℓ.

TABLE E-IX

ANNUAL ATMOSPHERIC ^{238}Pu AND ^{239}PU CONCENTRATIONS

Station Location	Total Air[a] Volume (m^3)	^{238}Pu (10^{-18} $\mu Ci/m\ell$[a]) Number of Quarterly Samples	No. <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]	^{239}Pu (10^{-18} $\mu Ci/m\ell$[a]) Number of Quarterly Samples	No. Samples <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km) - Uncontrolled Areas													
1. Española	89 457	4	4	−1.1 ± 1.6	−2.4 ± 3.0	−1.9 ± 0.9	0.00	4	1	26 ± 7.7	1.2 ± 1.5	15 ± 30	0.025
2. Pojoaque	65 350	4	4	−2.0 ± 1.9	−4.5 ± 4.8	−3.0 ± 1.8	0.00	4	0	41 ± 6.3	7.0 ± 3.9	21 ± 47	0.035
3. Santa Fe	93 421	4	4	−1.1 ± 1.3	−3.4 ± 2.2	−2.2 ± 1.3	0.00	4	0	44 ± 8.1	6.2 ± 2.1	24 ± 46	0.040
Regional Group Summary	248 228	12	12	−1.1 ± 1.6	−4.5 ± 4.8	−2.3 ± 1.3	0.00	12	1	44 ± 8.1	1.2 ± 1.5	20 ± 39	0.034
Perimeter Stations (0-4 km) - Uncontrolled Areas													
4. Barranca School	95 009	4	4	−0.7 ± 2.0	−3.0 ± 2.4	−1.8 ± 1.6	0.00	4	0	37 ± 8.1	6.5 ± 2.3	25 ± 44	0.041
5. Arkansas Avenue	80 130	4	4	−1.2 ± 1.8	−2.4 ± 1.7	−1.9 ± 0.5	0.00	4	0	40 ± 5.2	8.6 ± 3.7	27 ± 43	0.045
6. Cumbres School	80 511	4	4	−1.0 ± 1.5	−4.0 ± 2.3	−2.1 ± 2.2	0.00	4	1	49 ± 10	2.0 ± 2.3	24 ± 47	0.040
7. 48th Street	78 886	4	4	−0.8 ± 2.1	−4.2 ± 5.0	−1.7 ± 1.5	0.00	4	0	79 ± 14	4.9 ± 2.3	28 ± 52	0.046
8. LA Airport	92 171	4	4	−0.9 ± 1.3	−3.7 ± 3.4	−2.0 ± 1.9	0.00	4	0	33 ± 10	5.9 ± 2.9	20 ± 41	0.034
9. Bayo STP	100 456	4	4	−1.2 ± 1.4	−2.5 ± 1.8	−1.8 ± 0.4	0.00	4	1	62 ± 7.6	−0.6 ± 1.4	27 ± 61	0.045
10. Gulf Station	112 845	4	4	−1.2 ± 1.3	−2.3 ± 1.7	−1.6 ± 0.3	0.00	4	0	46 ± 7.7	10 ± 3.5	22 ± 33	0.037
11. Royal Crest	89 941	4	4	−0.9 ± 1.3	−1.8 ± 1.8	−1.3 ± 0.4	0.00	4	0	56 ± 9.9	11 ± 3.9	32 ± 52	0.053
12. White Rock	74 695	4	4	−1.0 ± 2.7	−4.7 ± 3.9	−1.9 ± 1.8	0.00	4	0	26 ± 4.6	6.9 ± 4.3	19 ± 35	0.031
13. Pajarito Acres	82 758	4	4	−0.1 ± 1.9	−2.8 ± 2.1	−1.4 ± 1.9	0.00	4	0	52 ± 8.6	7.3 ± 3.0	31 ± 53	0.052
14. Bandelier	67 406	4	4	−1.2 ± 2.0	−3.6 ± 2.4	−2.1 ± 1.1	0.00	4	0	67 ± 10	14 ± 3.7	40 ± 66	0.066
Perimeter Group Summary	954 808	44	44	−0.1 ± 1.9	−4.7 ± 3.9	−1.8 ± 1.3	0.00	44	2	79 ± 14	−0.6 ± 1.4	27 ± 43	0.044
Onsite Stations - Controlled Areas													
15. TA-21	72 942	4	4	−0.2 ± 2.5	−4.7 ± 2.3	−2.0 ± 2.5	0.00	4	0	44 ± 5.7	3.6 ± 2.9	23 ± 51	0.0011
16. TA-6	95 604	4	4	−1.5 ± 1.7	−2.3 ± 1.7	−1.8 ± 1.4	0.00	4	1	43 ± 6.6	−0.5 ± 1.3	27 ± 53	0.0013
17. TA-53 (LAMPF)	81 191	4	4	−1.2 ± 1.4	−2.6 ± 3.5	−1.7 ± 0.5	0.00	4	0	33 ± 5.5	4.2 ± 2.7	17 ± 51	0.0009
18. Well PM-1	92 806	4	4	−2.3 ± 1.9	−3.1 ± 2.6	−2.6 ± 2.8	0.00	4	0	40 ± 5.8	7.4 ± 2.9	26 ± 42	0.0013
19. TA-52	94 693	4	4	−1.2 ± 1.6	−2.8 ± 1.7	−1.7 ± 1.5	0.00	4	0	55 ± 7.5	5.7 ± 2.7	29 ± 58	0.0015
20. TA-16	94 752	4	4	−1.2 ± 1.7	−1.6 ± 1.8	−1.4 ± 0.7	0.00	4	0	59 ± 6.7	7.9 ± 2.8	36 ± 77	0.0018
21. Booster P-2	96 446	4	4	−1.1 ± 1.5	−2.6 ± 1.8	−1.6 ± 0.6	0.00	4	0	37 ± 5.3	7.1 ± 2.6	24 ± 41	0.0012
22. TA-54	99 251	4	3	8.8 ± 3.2	0.3 ± 1.8	3.0 ± 6.8	0.0002	4	0	153 ± 13	15 ± 3.6	80 ± 120	0.0040
23. TA-49	94 524	4	4	−1.0 ± 2.7	−2.2 ± 1.6	−1.5 ± 1.2	0.00	4	0	50 ± 9.7	7.1 ± 2.9	26 ± 41	0.0013
24. TA-33	102 442	4	4	−0.6 ± 1.3	−2.2 ± 2.0	−1.2 ± 1.1	0.00	4	0	41 ± 5.4	8.9 ± 2.9	28 ± 46	0.0014
25. TA-39	95 298	4	4	−0.6 ± 1.7	−2.5 ± 1.5	−1.4 ± 1.3	0.00	4	0	54 ± 6.6	6.4 ± 2.5	35 ± 70	0.0018
Onsite Group Summary	1 019 949	44	43	8.8 ± 3.2	−4.7 ± 2.3	−1.2 ± 3.7	0.00	44	1	153 ± 13	−0.5 ± 1.3	32 ± 67	0.0016

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

[b] Minimum Detectable Limits = 2×10^{-18} $\mu Ci/m\ell$ (^{238}Pu)
= 3×10^{-18} $\mu Ci/m\ell$ (^{239}Pu)

[c] Uncertainties for maximum and minimum concentrations ae counting uncertainties at the 95% confidence level (±2 sample standard deviations). Uncertainties for station and group means are ±2 standard devations.

[d] Controlled Area Radioactivity Concentration Guide = 2×10^{-12} $\mu Ci/m\ell$ (^{238}Pu)
= 2×10^{-12} $\mu Ci/m\ell$ (^{239}Pu)

Uncontrolled Area Radioctivity Concentration Guide = 7×10^{-14} $\mu Ci/m\ell$ (^{238}Pu)
= 6×10^{-14} $\mu Ci/m\ell$ (^{239}Pu)

TABLE E-X

ANNUAL ATMOSPHERIC URANIUM CONCENTRATIONS

Station Location	Total Air[a] Volume (m^3)	Number of Quarterly Samples	No. Samples <MDL[b]	Uranium - pg/m^3 Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km) - Uncontrolled Areas							
1. Española	89 457	4	0	147 ± 29	34 ± 18	105 ± 138	0.0012
2. Pojoaque	65 350	4	0	184 ± 38	128 ± 25	155 ± 38	0.0017
3. Santa Fe	93 421	4	0	91 ± 18	44 ± 16	63 ± 34	0.0007
Regional Group Summary	248 228	12	0	184 ± 38	34 ± 18	102 ± 94	0.0011
Perimeter Stations (0-4 km) - Uncontrolled Areas							
4. Barranca School	95 009	4	0	92 ± 19	59 ± 18	73 ± 36	0.0008
5. Arkansas Ave	80 130	4	0	134 ± 21	43 ± 9	73 ± 59	0.0008
6. Cumbres School	80 611	4	1	69 ± 15	19 ± 22	42 ± 51	0.0005
7. 48th Street	78 886	4	0	159 ± 21	28 ± 6	74 ± 80	0.0008
8. LA Airport	92 171	4	0	107 ± 22	37 ± 18	73 ± 133	0.0008
9. Bayo STP	84 605	4	1	120 ± 23	20 ± 21	58 ± 60	0.0006
10. Gulf Station	91 940	4	0	177.± 40	30 ± 20	84 ± 93	0.0009
11. Royal Crest	89 941	4	0	236.± 40	44 ± 20	101 ± 127	0.0011
12. White Rock	74 695	4	0	238.± 49	56 ± 12	115 ± 145	0.0013
13. Pajarito Acres	82 758	4	0	79 ± 17	45 ± 9	58 ± 28	0.0006
14. Bandelier	67 406	4	0	113 ± 33	38 ± 24	61 ± 37	0.0007
Perimeter Group Summary	918 052	44	2	238 ± 49	19 ± 22	74 ± 88	0.0008
Onsite Stations - Controlled Areas							
15. TA-21	72 942	4	1	149 ± 30	23 ± 27	96 ± 159	0.00005
16. TA-6	95 604	4	0	177 ± 40	36 ± 19	72 ± 89	0.00003
17. TA-53 (LAMPF)	81 191	4	1	61 ± 21	16 ± 21	40 ± 58	0.00002
18. Well PM-1	92 806	4	0	103 ± 21	40 ± 8	59 ± 45	0.00003
19. TA-52	94 693	4	1	94 ± 18	19 ± 19	61 ± 61	0.00003
20. TA-16	94 752	4	1	80 ± 18	20 ± 19	48 ± 45	0.00002
21. Booster P-2	96 446	4	0	86 ± 19	59 ± 12	72 ± 21	0.00003
22. TA-54	99 251	4	0	134 ± 18	78 ± 16	103 ± 42	0.00005
23. TA-49	94 524	4	0	78 ± 18	32 ± 18	61 ± 54	0.00003
24. TA-33	102 442	4	0	81 ± 19	43 ± 10	61 ± 29	0.00003
25. TA-39	95 298	4	0	135 ± 19	52 ± 11	82 ± 40	0.00004
Onsite Group Summary	101 994	44	4	177 ± 40	16 ± 21	68 ± 66	0.00003

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

[b]Minimum detectable limit = 2 pg/m^3.

[c]Uncertainties for maximum and minimum concentrations are counting uncertainties at the 95% confidence level (±2 sample standard deviations). Uncertainties for station and group means are ±2 standard deviations.

[d]Controlled area radioactivity concentration guide = 2.1×10^8 pg/m^3.
Uncontrolled area radioactivity concentration guide = 9×10^6 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} $\mu Ci/pg$.

TABLE E-XI

ANNUAL ATMOSPHERIC ^{241}Am CONCENTRATIONS

Station Location	Total Air Volume (m^3)[a]	Number of Quarterly Samples	No. Samples <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km) - Uncontrolled Areas							
3. Santa Fe	73 671	3	3	0.3 ± 3.6	−2.0 ± 9.1	−0.5 ± 2.2	0.00000
Regional Group Summary	73 671	3	3	0.3 ± 3.6	−2.0 ± 9.1	−0.5 ± 2.2	0.00000
Perimeter Stations (0-4 km) - Uncontrolled Areas							
6. Cumbres	61 855	3	3	7.4 ± 15	−1.0 ± 5.9	3.1 ± 13	0.00156
8. LA Airport	76 020	3	3	2.6 ± 3.6	−2.7 ± 6.4	0.3 ± 5.9	0.00014
9. Bayo STP	68 754	3	3	0.6 ± 3.8	−1.9 ± 5.5	−0.3 ± 2.8	0.00017
12. White Rock	74 695	4	4	1.9 ± 6.0	−2.0 ± 5.9	−0.6 ± 4.0	0.00029
Perimeter Group Summary	281 324	13	13	7.4 ± 15	−2.7 ± 6.4	0.5 ± 6.7	0.00026
Onsite Stations - Controlled Areas							
16. TA-6	71 249	3	3	1.4 ± 3.5	−1.2 ± 5.2	0.3 ± 2.8	0.000006
17. TA-53 (LAMPF)	67 161	3	3	1.1 ± 6.0	−0.7 ± 3.8	0.0 ± 1.9	0.000000
20. TA-16	94 752	4	4	1.3 ± 5.2	−2.0 ± 4.8	−0.4 ± 2.7	0.000000
21. Booster P-2	96 446	4	4	1.6 ± 4.7	−3.3 ± 4.8	−1.5 ± 5.1	0.000000
22. TA-54	99 251	4	4	4.2 ± 4.8	−0.9 ± 5.0	2.2 ± 4.1	0.000036
23. TA-49	73 746	3	3	2.4 ± 3.8	−2.7 ± 5.2	0.0 ± 5.4	0.000000
Onsite Group Summary	502 605	21	21	4.2 ± 4.8	−3.3 ± 4.8	0.1 ± 4.2	0.000002

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.
[b]Minimum detectable limit = 2×10^{-12} μCi/mℓ.
[c]Uncertainties for maximum and minimum concentrations are counting uncertainties at the 95% confidence level (±2 sample deviations). Uncertainties for station and group means are ±2 standard deviations.
[d]Controlled area radioactivity concentration guide = 5×10^{-6} μCi/mℓ.
Uncontrolled area radioactivity concentration guide = 2×10^{-7} μCi/mℓ.

TABLE E-XII

LOCATIONS OF SURFACE AND GROUND WATER STATIONS

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Regional[c]				
Chamita—Rio Chama	36°05'	106°07	---	SW
Embudo—Rio Grande	36°12'	105°58'	---	SW
Otowi—Rio Grande	35°52'	106°08'	---	SW
Cochiti—Rio Grande	35°37'	106°19'	---	SW
Bernalillo—Rio Grande	35°17'	106°36'	---	SW
Jemez River	35°40'	106°44'	---	SW
Perimeter				
Los Alamos Reservoir	N105	W090	1	SW
Guaje Canyon	N300	E100	2	SW
Basalt Spring	N060	E395	3	GWS
Frijoles Canyon	S280	E180	4	SW
La Mesita Spring	N080	E550	5	GWD
White Rock Canyon[d]				
Puye Formation	---	---	6	GWD
Tesuque Fm (F.G. Sed)	---	---	7	GWD
Tesuque Fm (C.G. Sed)	----	---	8	GWD
Tesuque Fm (Basalts)	---	---	9	GWD
Surface Water	---	---	10	SW
Surface Water (Sanitary effluents)	---	---	11	SW
Water Supply				
Distribution				
Fire Station 1	N080	E015	12	D
Fire Station 2	N100	E120	13	D
Fire Station 3	S085	E375	14	D
Fire Station 4	N185	E070	15	D
Fire Station 5	S010	W065	16	D
Los Alamos Field				
LA-1B	N115	E530	17	GWD
LA-2	N125	E505	18	GWD
LA-3	N130	E490	19	GWD
LA-4	N070	E405	20	GWD
LA-5	N076	E435	21	GWD
LA-6	N105	E465	22	GWD
Guaje Field				
G-1	N190	E385	23	GWD
G-1A	N197	E380	24	GWD
G-2	N205	E365	25	GWD
G-3	N215	E350	26	GWD
G-4	N213	E315	27	GWD
G-5	N228	E295	28	GWD
G-6	N215	E270	29	GWD

TABLE E-XII (continued)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Pajarito Field				
PM-1	N030	E305	30	GWD
PM-2	S055	E202	31	GWD
PM-3	N040	E255	32	GWD
Water Canyon Gallery	S040	W125	33	GWD
Noneffluent Areas				
Test Well 1	N070	E345	34	GWD
Test Well 3	N080	E215	35	GWD
Deep Test-5A	S110	E090	36	GWD
Test Well-8	N035	E170	37	GWD
Deep Test-9	S155	E140	38	GWD
Deep Test-10	S120	E125	39	GWD
Cañada del Buey	N010	E150	40	SW
Pajarito Canyon	S060	E215	41	SW
Water Canyon	S090	E090	42	SW
Test Well 2	N120	E150	43	GWD
Effluent Release Area				
Acid-Pueblo Canyon (Former Release Area)				
Acid Weir	N125	E070	44	SW
Pueblo 1	N130	E080	45	SW
Pueblo 2	N120	E155	46	SW
Pueblo 3	N085	E315	47	SW
Hamilton Bend Spring	N110	E255	48	GW
Test Well 1A	N070	E335	49	GWS
Test Well 2A	N120	E140	50	GWS
DP-Los Alamos Canyon				
DPS-1	N090	E160	51	SW
DPS-4	N080	E200	52	SW
Obs. Hole LAO-C	N085	E070	53	GWS
Obs. Hole LAO-1	N080	E120	54	GWS
Obs. Hole LAO-2	N080	E210	55	GWS
Obs. Hole LAO-3	N080	E220	56	GWS
Obs. Hole LAO-4	N070	E245	57	GWS
Obs. Hole LAO-4.5	N065	E270	58	GWS
Sandia Canyon				
SCS-1	N080	E040	59	SW
SCS-2	N060	E140	60	SW
SCS-3	N050	E185	61	SW

TABLE E-XII (continued)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Mortandad Canyon				
GS-1	N040	E200	62	SW
MCS-3.9	N040	E140	63	SW
Obs. Hole MCO-3	N040	E110	64	GWS
Obs. Hole MCO-4	N035	E150	65	GWS
Obs. Hole MCO-5	N030	E160	66	GWS
Obs. Hole MCO-6	N030	E175	67	GWS
Obs. Hole MCO-7	N025	E180	68	GWS
Obs. Hole MCO-7.5	N030	E190	69	GWS
Obs. Hole MCO-8	N030	E205	70	GWS

[a]See Fig. 9 for numbered locations.
[b]SW = surface water; GWD = deep or main aquifer; GWS = shallow or alluvial aquifer; D = water supply distribution system.
[c]See Fig. 8 for regional locations.
[d]Puye Formation 7 stations; Tesuque Fm (F.G. Sed) 4 stations; Tesuque Fm (C.G. Sed) 9 stations; Tesuque (basalts) 3 stations; surface water 2 stations; surface water (sanitary effluents) 1 station.

TABLE E-XIII

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE WATER FROM REGIONAL STATIONS

Station	No. of Analyses	Radiochemical (average of a number of analyses) ^{3}H $10^{-6}\mu Ci/ml$	^{137}Cs $10^{-9}\mu Ci/ml$	^{238}Pu $10^{-9}\mu Ci/ml$	^{239}Pu $10^{-9}\mu Ci/ml$	Gross α $10^{-9}\mu Ci/ml$	Gross β $10^{-9}\mu Ci/ml$	Total U $\mu g/l$
Chamita	2	2.4 ± 3.5	25 ± 42	−0:01 ± 0.000	−0.01 0.07	1.7.± 0.3	6.4 ± 6.9	2.1 ± 3.5
Embudo	2	2.0 ± 3.5	66 ± 156	0.01 ± 0.02	−0:01 ± 0.00	2.2.± 6.3	2.8 ± 8.9	2.1 ± 0.4
Otowi	2	1.4 ± 1.8	15 ± 99	−0.01 ± 0.02	0.01 ± 0.03	0:9 ± 1.0	5.2 ± 3.5	3.0 ± 1.8
Cochiti	2	0.8.± 0.8	10 ± 28	−0:02 ± 0.03	−0.00 ± 0.02	1.5 ± 0.9	5.9 ± 1.1	3.0 ± 3.5
Bernalillo	2	1.1 ± 8.5	−5 ± 14	−0.02 ± 0.03	−0.01.± 0.01	3.4 ± 0.1	7.7 ± 4.7	3.3.± 3.4
Jemez River	2	0.9 ± 0.0	−5 ± 14	−0.01 ± 0.04	−0.02 ± 0.05	4.6 ± 1.7	20 ± 11	0.9 ± 0.4
No. of Analyses		12	12	12	12	12	12	12
Minimum		0.5 ± 0.6	−20 ± 160	−0.01 ± 0:02	−0:04 ± 0.02	−0.8 ± 1,0	−0.3 ± 1.0	0.7 ± 0.2
Maximum		3.6 ± 0.6	120 ± 140	0.02 ± 0.03	0:02 ± 0.02	5.2 ± 3.0	24 ± 6.0	4.5 ± 0.8
Average		1.4 ± 2.0	18 ± 77	−0.01 ± 0.02	−0.01 ± 0.03	2.3 ± 3.5	8.0 ± 12.7	2.4 ± 2.6

Stations	Chemical (one analysis) Si_2O	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond mS/m
Chamita	13	55	13	3	33	4	149	<2	133	10	0.4	<2	508	191	8.5	52
Embudo	21	26	6	3	19	4	112	<2	35	4	0.5	<2	314	91	8.5	27
Otowi	18	38	9	3	24	0	139	<2	68	6.	0.5	<2	394	131	8.5	35
Cochiti	27	36	8	3	25	5	156	<2	53	2	0.5	<2	410	123	8.3	35
Bernalillo	25	41	8	4	41	3	144	<2	70	9	0.6	<2	400	137	8.6	45
Jemez River	39	38	5	12	61	0	178	<2	28	82	0.9	<2	540	116	8.6	52
No. of Analyses	6	6.	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Minimum	13	26.	5	3	19	0	112	<2	28	2	0.4	<2	314	91	8.3	27
Maximum	39	55	13	12	61	5	178	---	133	82	0.9	---	540	191	8.6	52
Average	24 ± 18	39.± 18	8 ± 6	5 ± 8	34 ± 30	3 ± 4	146 ± 44	<2	65 ± 75	19 ± 62	0.6 ± 0.4	<2	428 ± 165	132 ± 66	8.5 ± 0.2	41 ± 20

Stations	Metal Ion (concentrations in $\mu g/l$, one analysis) Ag	Al	As	Ba	Br	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pd	Se	Zn
Chamita	19	33	<5	420	<2	3	<5	<3	<300	<300	<0.2	<300	<10	7	5	<5	<300
Embudo	24	<10	<5	190	<2	3	<5	<3	<300	<300	<0.2	<300	15	7	<3	<5	<300
Otowi	20	20	<5	320	<2.	6	<5	<3	<300	<300	<0.2	<300	13	8'	4	<5	<300
Cochiti	16	16	<5	270	<2.	3	<5	<3	<300	<300	<0.2	<300	12	8	4	<5	<300
Bernalillo	20	11	<5	260	<2.	3	<5	<3	<300.	<300	<0.2	<300	27	9	7	<5	<300
Jemez River	18	49	75	210	<2	4	<5	<3	<300	<300	<0.2	<300	25	10.	8	<5	<300
No. of Analyses	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Minimum	16	<10	1	190	<2	3	<5	<3	<300	<300	<0.2	<300	<10	7	<3	<5	<300
Maximum	24	49	75	420	---	6	---	---	---	---	---	---	27	10	8	---	---
Average	20 ± 5	23 ± 30	17 ± 57	278 ± 167	<2	4 ± 2	<5	<3	<300	<300	<0.2	<300	17 ± 14	8 ± 2	5 ± 4	<5	<300

Note: ± value represents twice the standard deviation of the distributions of observed values unless only one analysis is reported. Then the value represents twice the error term for that analysis. One sample used for chemical and metal ion analysis.

TABLE E-XIV

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

Stations	No. of Analyses	Radiochemical (average of a number of analyses)						
		^{3}H 10^{-6} μCi/mℓ	^{137}Cs 10^{-9} μCi/mℓ	^{238}Pu 10^{-9} μCi/mℓ	^{239}Pu 10^{-9} μCi/mℓ	Gross α 10^{-9} μCi/mℓ	Gross β 10^{-9} μCi/mℓ	Total U μg/ℓ
Los Alamos Reservoir	2	1.2 ± 0.5	1 ± 31	−0.02 ± 0.00	0.01 ± 0.03	−0.3 ± 0.7	4.7 ± 0.0	<0.1 ± 0.2
Guaje Canyon	2	0.9 ± 1.0	59 ± 88	−0.02 ± 0.06	0.00.± 0.01	0.7 ± 1.8	5.7 ± 7.2	0.3 ± 0.8
Basalt Spring	2	0.8 ± 1.0	−1 ± 55	−0.01 ± 0.02	−0.02 ± 0.02	0.8 ± 2.1	4.1 ± 0.4	1.7 ± 0.3
Frijoles Canyon	2	1.1 ± 0.3	13 ± 20	−0.01 ± 0.00	−0.01 ± 0.04	0.9 ± 2.7	6.0 ± 7.6	0.1 ± 0.3
La Mesita Spring	2	1.0 ± 0.3	−6 ± 16	0.00 ± 0.02	0.00 ± 0.02	5.6 ± 2.1	6.9 ± 0.3	14 ± 1.0
No. of Analyses		10	10	10	10	10	10	10
Minimum		0.4 ± 0.6	−20 ± 80	−0.04 ± 0.03	−0.03 ± 0.04	−0.5 ± 1.0	3.1 ± 1.6	<0.1 ± 0.2
Maximum		1.4 ± 0.6	90 ± 100	0.01 ± 0.02	0.03 ± 0.03	6.3 ± 3.0	8.7 ± 2.0	14 ± 2.0
Average		1.0 ± 0.6	13 ± 62	−0.01 ± 0.02	0.00 ± 0.03	1.5 ± 4.6	5.5 ± 4.1	3.2 ± 11
White Rock Canyon								
Puye Formation		0.2 ± 0.6	14 ± 21	0.00 ± 0.01	−0.01 ± 0.02	1.4 ± 2.1	2.7 ± 2.3	0.8 ± 1.4
Tesuque Fm (F.G. Sed)	4	0.1 ± 0.8	8 ± 38	−0.01 ± 0.02	−0.00 ± 0.01	1.8 ± 5.2	3.6 ± 2.4	3.3 ± 6.4
Tesuque Fm (C.G. Sed)	9	0.3 ± 0.8	5 ± 51	0.00 ± 0.02	−0.01 ± 0.01	0.6 ± 1.9	2.3 ± 2.2	0.4 ± 1.1
Tesuque Fm (basalt)	3	<0.1 ± 0.2	7 ± 28	−0.01 ± 0.03	−0.01 ± 0.02	5.3 ± 14	6.6 ± 7.5	7.2 ± 23
Surface Water (2 stations)	2	<0.1 ± 0.8	−20 ± 84	−0.01 ± 0.03	−0.01 ± 0.04	1.1 ± 4.0	3.3 ± 3.0	0.3 ± 0.4
Surface Water (sanitary eff)	1	0.1 ± 0.3	10 ± 80	0.00 ± 0.02	0.00 ± 0.02	−0.2 ± 2.0	18 ± 4.0	0.5 ± 0.2
No. of Analyses		26	26	26	26	26	26	26
Minimum		<0.1 ± 0.6	−50 ± 120	−0.01 ± 0.02	−0.03 ± 0.03	−0.5 ± 0.8	0.2 ± 1.4	<0.1 ± 0.2
Maximum		1.3 ± 0.6	60 ± 120	0.01 ± 0.02	0.00 ± 0.02	13 ± 6.0	18 ± 4.0	20 ± 4.0
Average		0.1 ± 0.7	6 ± 42	−0.01 ± 0.03	−0.01 ± 0.03	1.5 ± 5.4	3.8 ± 7.0	1.7 ± 8.2

TABLE E-XIV (continued)

Chemical
(concentrations in mg/l, one analysis)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond mS/m
Los Alamos Reservoir	50	4	3	3	9	4	61	<2	2	1	0.2	<2	182	18	8.3	8.0
Guaje Canyon	44	3	2	2	6	5	54	<2	2	1	0.3	<2	122	16	7.7	8.0
Basalt Spring	36	17	7	3	14	2	98	<2	18	9	0.6	7	250	72	8.2	24.0
Frijoles Canyon	48	5	3	2	10	2	185	<2	18	9	0.6	7	182	27	8.2	12.0
La Mesita Spring	19	27	<1	3	29	4	222	<2	12	6	0.3	8	286	70	8.1	27.0
No. of Analyses	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Minimum	19	3	<1	2	6	2	54	<2	2	1	0.2	<2	122	16	7.7	8.0
Maximum	50	27	7	3	29	5	222	---	18	9	0.6	8	286	72	8.3	24.0
Average	39 ± 25	11 ± 21	3 ± 5	3 ± 1	14 ± 18	3 ± 3	124 ± 161	<2	10 ± 16	5 ± 8	0.4 ± 0.4	5 ± 6	200 ± 133	41 ± 56	8.1 ± 0.5	15.8 ± 18.2
White Rock Canyon					15	0	94	<2	5	3	0.4	<2	159	60	---	19.0
Puye Formation	55	13	3	---	38	0	150	<2	7	3	0.7	<2	228	63	---	28.5
Tesuque Fm (F.G. Sed)	37	19	2	---	12	0	90	<2	3	2	0.4	<2	173	53	---	14.0
Tesuque Fm (C.G. Sed)	57	8	3	---	52	0	198	<2	9	4	0.4	3	296	71	---	35.0
Tesuque Fm (Basalts)	50	18	3	---	12	0	98	<2	4	4	0.4	<2	173	67	---	17.0
Surface Water (2 stations)	66	12	4	---	75	5	132	40	37	29	0.9	60	562	95	---	60.0
Surface Water (sanitary eff)	88	16	8	---												
No. of Analyses	26	26	26	---	26	26	26	26	26	26	26	26	26	26	---	26
Minimum	30	3	<1	---	10	0	63	<2	2	2	0.2	<2	112	20	---	12.0
Maximum	88	36	5	---	126	5	388	40	37	29	1.0	60	552	105	---	62.0
Average	54 ± 32	13 ± 13	3 ± 3	---	24 ± 52	1 ± 8	115 ± 128	8 ± 18	6 ± 14	4 ± 10	0.4 ± 0.4	5 ± 22	206 ± 210	61 ± 8	---	22.0 ± 25.3

Metal Ions
(concentrations in μg/l, one analysis

Station	Ag	Al	As	Ba	Br	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Zn
Los Alamos Reservoir	<10	32	<5	30	<2000	5	<5	<3	<300	<300	---	<300	<10	8	5	<5	<300
Guaje Canyon	<10	71	<5	30	<2000	7	<5	<3	<300	500	---	<300	<10	8	4	<5	<300
Basalt Spring	<10	<10	<5	110	<2000	5	<5	4	<300	<300	<0.2	<300	15	8	<3	<5	<300
Frijoles Canyon	<10	48	<5	60	<2000	4	<5	<3	<300	<300	<0.2	<300	<10	8	3	<5	<300
La Mesita Spring	<10	<10	<5	490	<2000	10	<5	4	<300	<300	<0.2	<300	13	8	4	<5	<300
No. of Analyses	5	5	5	5	5	5	5	5	5	5	3.	5	5	5	5	5	5
Minimum	<10	<10	<5	30	<2000	4	<5	<3	<300	<300	<0.2	<300	<10	8	<3	<5	<300
Maximum	---	71	---	490	---	10	---	4	---	500	---	---	15	8	5	---	---
Average	<10	34 ± 51	<5	144 ± 392	<2000	6 ± 5	<5	3 ± 1	<300	340 ± 180	<0.2	<300	12 ± 4	8 ± 8	4 ± 2	<5	<300

Note: ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported. Then the value represents twice the error term for that analysis. One sample chemical and metal ion analysis.

TABLE E-XV

RADIOCHEMICAL AND CHEMICAL QUALITY OF WATER FROM MUNICIPAL SUPPLY AND DISTRIBUTION

Station	No. of Analyses	Radiochemical (average of a number of analyses) ^{3}H 10^{-6} μCi/mℓ	^{137}Cs 10^{-9} μCi/mℓ	^{238}Pu 10^{-9} μCi/mℓ	^{239}Pu 10^{-9} μCi/mℓ	Gross α 10^{-9} μCi/mℓ	Gross β 10^{-9} μCi/mℓ	Total U μg/ℓ
Los Alamos Field (5 wells)	5	0.3 ± 0.4	40 ± 48	−0.02 ± 0.04	−0.01 ± 0.03	2.5 ± 5.3	3.3 ± 1.7	3.8 ± 4.7
Guaje Field (7 wells)	7	0.3 ± 0.5	17 ± 70	−0.01 ± 0.02	0.2 ± 0.4	2.4 ± 1.7	0.6 ± 0.5	
Pajarito Field (3 wells)	3	0.4 ± 0.3	−34 ± 116	−0.01 ± 0.01	−0.01 ± 0.02	1.0 ± 1.2	3.7 ± 4.0	1.2 ± 1.7
Water Canyon (gallery)	1	0.5 ± 0.7	−10 ± 40	−0.03 ± 0.02	−0.02 ± 0.02	−0.1 ± 1.0	1.9 ± 1.6	<0.1 ± 0.2
Distribution (5 stations)	10	0.6 ± 0.8	1 ± 54	−0.01 ± 0.03	0.00 ± 0.2	0.8 ± 2.4	3.5 ± 2.6	1.2 ± 2.3
No. of Analyses		26	26	26	26	26	26	26
Minimum		<0.2 ± 0.6	−100 ± 80	−0.04 ± 0.03	−0.03 ± 0.03	−0.4 ± 1.4	1.0 ± 1.4	<0.1 ± 0.2
Maximum		1.2 ± 0.6	80 ± 80	0.01 ± 0.02	0.01 ± 0.02	7.0 ± 4.0	5.9 ± 2.0	6.3 ± 1.2
Average		0.4 ± 0.7	19 ± 117	−0.02 ± 0.03	−0.01 ± 0.02	0.9 ± 3.1	3.1 ± 2.4	1.5 ± 3.4
Los Alamos Well LA-6[a]	1	0.2 ± 0.6	50 ± 80	−0.02 ± 0.03	−0.02 ± 0.02	1.6 ± 1.6	4.6 ± 1.8	1.6 ± 0.4

Station	Quality Required for Municipal Use (average concentrations in mg/ℓ) Ag	As	Ba	Cd	Cr	F	Hg	NO_3	Pb	Se
Los Alamos Field (5 wells)	0.031	0.017	0.100	0.004	0.018	1.0	<0.2	<2	0.010	0.005
Guaje Field (7 wells)	0.011	0.014	0.059	0.005	0.007	0.5	<0.2	<2	0.005	0.005
Pajarito Field (3 wells)	<0.010	0.001	0.097	0.004	0.005	0.4	<0.2	<2	0.004	0.005
Water Canyon (gallery)	<0.010	0.001	0.030	0.007	0.002	0.2	<0.2	<2	0.005	0.005
Distribution (5 stations)	0.018	0.004	0.090	0.004	0.008	0.6	<0.2	<2	0.007	0.005
No. of Analyses	21	21	21	21	21	21	19	21	21	21
Minimum	<0.010	<0.005	0.020	0.003	0.002	0.2	<0.2	<2	0.003	---
Maximum	0.074	0.078	0.150	0.008	0.032	2.2	---	---	0.020	<0.005
Average	0.017 ± 0.030	0.010 ± 0.037	0.080 ± 0.080	0.004 ± 0.003	0.009 ± 0.015	0.6 ± 0.8	<0.2	<2	0.006 ± 0.007	---
USEPA and NMEIA MPL	0.05	0.05	1.0	0.010	0.05	2.0	0.002	45	0.05	0.01
Los Alamos Well LA-6[a]	0.007	0.211	0.040	<0.003	0.019	1.8	<0.2	<2	0.010	<0.005

TABLE E-XV (continued)

Stations	Chemical (average concentrations in mg/ℓ)													
	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	TDS	Hard	pH	Cond mS/m
Los Alamos Field (5 wells)	27	7	<1	1.8	65	0	178	<2	12	6	318	19	8.7	30.6
Guaje Field (7 wells)	65	9	1	2.3	23	0	100	<2	4	2	229	29	8.6	17.0
Pajarito Field (3 wells)	7.5	12	6	3.0	17	4	124	<2	4	4	314	54	8.2	20.3
Water Canyon (gallery)	34	5	3	1.8	6	2	54	<2	2	<1	176	25	8.1	12.0
Distribution (5 stations)	55	9	3	2.5	24	2	141	<2	5	3	249	35	8.2	19.0
No. of Analyses	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Minimum	26	5	<1	1.3	6	0	49	<2	<1	166	14	8.0	8.0	10.0
Maximum	84	16	8	3.8	152	5	376	---	34	13	624	71	8.8	64.0
Average	54 ± 40	9 ± 7	2 ± 5	2.3 ± 1.5	32 ± 66	1 ± 3	130 ± 148	<2	6 ± 14	4 ± 7	265 ± 206	31 ± 34	8.4 ± 0.5	21.0 ± 12.0
													9.1	30.0
Los Alamos Well LA-6[a]	29	3	<3	1.1	74	0	163	<2	4	2	324	7		

Station	Metal Ions (average concentrations in μg/ℓ)								
	Al	Be	Co	Cu	Fe	Mn	Mo	Ni	Zn
Los Alamos Field (5 wells)	<10	<2000	<5	<300	<300	<300	<10	8	<300
Guaje Field (7 wells)	<10	<2000	<5	<300	<300	<300	<10	7	<300
Pajarito Field (3 wells)	11	<2000	<5	<300	<300	<300	40	7	<300
Water Canyon (gallery)	35	<2000	<5	<300	<300	<300	<10	8	<300
Distribution (5 stations)	26	<2000	<5	<300	<300	<300	<10	11	<300
No. of Analyses	21	21	21	21	21	21	21	21	21
Minimum	<10	<2000	<5	<300	<300	<300	<10	6	<300
Maximum	83	---	---	---	---	--	---	12	---
Average	14 ± 34	<2000	<5	<300	<300	<300	<10	8 ± 4	<300
Los Alamos Well LA-6[a]	10	<2000	<5	<300	<300	<300	<10	8	<300

Note: ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported. Then the value represents twice the error term for that analysis. One sample for chemical and metal ion analysis from each well and distribution station.

[a]Los Alamos Well LA-6 on standby; not used (see LA-7012-MS).

TABLE E-XVI

RADIOCHEMICAL AND CHEMICAL QUALTY OF WATER FROM ONSITE STATIONS

Station	No. of Analyses	Radiochemical (average of a number of analyses) ^{3}H 10^{-6} μCi/mℓ	^{137}Cs 10^{-9} μCi/mℓ	^{238}Pu 10^{-9} μCi/mℓ	^{239}Pu 10^{-9} μCi/mℓ	^{90}Sr 10^{-9} μCi/mℓ	Gross α 10^{-9} μCi/mℓ	Gross β 10^{-9} μCi/mℓ	Total U μCi/ℓ
Noneffluent Areas									
Test Well 1	1	1.3 ± 0.3	−19 ± 16	−0.1 ± 0.02	0.00 ± 0.01	---	0.0 ± 1.6	5.2 ± 2.0	0.1 ± 0.2
Test Well 3	2	1.0 ± 0.1	30 ± 57	−0.1 ± 0.02	−0.1 ± 0.06	---	0.7 ± 0.7	1.8 ± 0.6	0.2 ± 0.2
Deep Test-5A	2	0.7 ± 0.3	32 ± 52	−0.2 ± 0.02	−0.01 ± 0.04	---	1.3 ± 3.0	3.0 ± 3.0	0.5 ± 0.2
Test Well 8	2	1.6 ± 0.6	25 ± 14	−0.02 ± 0.04	0.00 ± 0.03	---	0.9 ± 1.0	2.5 ± 0.1	0.1 ± 0.1
Deep Test-9	2	1.9 ± 1.8	15 ±14	−0.03 ± 0.06	0.00 ± 0.02	---	0.9 ± 0.0	3.6 ± 2.6	1.0 ± 0.7
Deep Test-10	1	0.5 ± 0.6	50 ± 40	−0.03 ± 0.02	0.00 ± 0.03	---	0.4 ± 1.2	4.5 ± 1.8	0.4 ± 0.2
Cañada del Buey	1	3.6 ± 0.8	50 ± 32	−0.04 ± 0.03	−0.05 ± 0.04	---	1.8 ± 1.6	6.4 ± 2.2	2.4 ± 0.4
Pajarito Canyon	1	4.2 ± 0.8	60 ± 100	−0.04 ± 0.04	0.00 ± 0.03	—	0.0 ± 2.2	17.0 ± 4.0	0.4 ± 0.2
Water Canyon	1	1.3 ± 0.6	−3 ± 32	−0.02 ± 0.03	−0.01 ± 0.03	—	0.4 ± 1.6	13.0 ± 3.2	1.5 ± 0.2
Test Well 2	2	0.6 ± 0.3	12 ± 20	−0.03 ± 0.02	−0.01 ± 0.01	---	0.1 ± 1.8	1.5 ± 0.9	0.2 ± 0.3
No. of Analyses		14	15	15	16	---	15	15	13
Minimum		4.2 ± 0.8	−19 ± 16	−0.05 ± 0.03	−0.05 ± 0.04	---	−0.6 ± 0.5	1.2 ± 1.6	<0.1 ± 0.2
Maximum		4.2 ± 0.8	70 ± 40	−0.00 ± 0.02	0.01 ± 0.03	—	2.3 ± 0.9	17.0 ± 4.0	2.4 ± 0.4
Average		4.2 ± 2.3	27 ± 50	−0.02 ± 0.02	−0.02 ± 0.04	---	0.7 ± 1.6	4.7 ± 9.0	0.6 ± 1.4
Effluent Release Area									
Acid Pueblo Canyon (former release area)									
Acid Weir	2	1.3 ± 0.4	16 ± 71	0.02 ± 0.06	2.11 ± 5.96	77 ± 6.0	3.2 ± 5.1	118 ± 290	0.4 ± 0.7
Pueblo 1	2	1.8 ± 0.8	1 ± 3	−0.00 ± 0.03	0.10 ± 0.26	3.70 ± 0.80	1.1 ± 1.8	56 ± 102	0.9 ± 1.4
Pueblo 2	2	1.1 ± 0.0	69 ± 117	−0.01 ± 0.06	0.04 ± 0.01	4.60 ± 0.80	2.5 ± 3.4	24 ± 1.4	0.2 ± 0.4
Pueblo 3	2	0.9 ± 0.4	20 ± 57	−0.03 ± 0.04	0.03 ± 0.06	1.70 ± 1.00	12 ± 31	85 ± 112	2.1 ± 5.8
Hamilton Bend Spr	1	1.6 ± 0.6	40 ± 60	−0.03 ± 0.02	−0.01 ± 0.02	−0.70 ± 0.80	15 ± 6.0	25 ± 6.0	50 ± 10
Test Well 1A	1	0.9 ± 0.6	30 ± 40	−0.08 ± 0.03	−0.03 ± 0.02	−0.30 ± 0.80	0.1 ± 1.8	7.1 ± 2.4	0.9 ± 0.2
Test Well 2A	2	18.9 ± 4.4	−10 ± 14	−0.02 ± 0.02	0.00 ± 0.00	0.30 ± 1.00	0.7 ± 1.4	3.3 ± 0.0	0.1 ± 0.3
No. of Analyses		12	12	12	12	7	12	12	12
Minimum		0.8 ± 0.6	−20 ± 60	−0.08 ±0.03	−0.02 ± 0.02	−0.07 ± 0.80	0.1 ± 0.9	3.3 ± 1.6	<0.1 ± 0.2
Maximum		21.5 ± 1.1	110 ± 80	0.04 ± 0.04	4.22 ± 0.32	77 ± 6.0	15 ± 6.0	220 ± 40	50 ± 10
Average		4.2 ± 13.9	22 ± 70	−0.01 ± 0.06	0.38 ± 2.42	12 ± 67	45 ± 14	45 ± 126	4.9 ± 29
DP-Los Alamos Canyon									
DPS-1	2	81.2 ± 34.5	35 ± 42	6.81 ± 18	3.26 ± 6.29	197 ± 12	1885 ± 3450	845 ± 1090	698 ± 1400
DPS-4	2	21.4 ± 16.7	1 ± 116	0.14 ± 0.19	0.42 ± 0.86	185 ± 14	11 ± 27	675 ± 71	4.3 ± 4.0
LAO-C	2	1.0 ± 1.8	10 ± 57	−0.01 ± 0.04	0.02 ± 0.07	1.0 ± 0.6	5.3 ± 7.8	9.1 ± 6.4	3.5 ± 7.5
LAO-1	2	21.3 ± 10.5	4 ± 44	−0.01 ± 0.01	0.08 ± 0.20	73 ± 6.0	3.0 ± 5.8	184 ± 74	0.4 ± 0.8
LAO-2	2	14.8 ± 26.9	21 ± 25	0.00 ± 0.07	0.17 ± 0.42	111 ± 8.0	3.5 ± 4.1	222 ± 249	1.5 ± 1.4
LAO-3	2	12.9 ± 26.2	13 ± 14	0.01 ± 0.07	0.15 ± 0.40	22 ± 2.2	6.6 ± 9.8	84 ± 35	4.2 ± 4.2
LAO-4	2	10.3 ± 1.7	40 ± 57	−0.01 ± 0.03	0.26 ± 0.72	2.0 ± 0.4	5.5 ± 3.5	18 ± 11	0.4 ± 0.8
LAO-4.5	1	10.8± 0.8	40 ± 40	−0.01 ± 0.03	0.00 ± 0.02	1.0 ± 1.2	2.2 ± 2.0	8.9 ± 2.6	2.9 ± 0.6
No. of Analyses		16	16	16	16	15	15	15	15
Minimum		0.4 ± 0.6	−40 ± 40	−0.02 ± 0.02	0.01 ± 0.02	1.0 ± 0.6	1.0 ± 6.0	8.9 ± 2.6	<0.1 ± 0.2
Maximum		93.4 ± 3.2	60 ± 100	13.1 ± 0.80	5.49 ± 0.34	197 ± 6.0	3100 ± 1200	1220 ± 240	1160 ± 232
Average		22.4 ± 51.6	19 ± 51	0.92 ± 6.74	0.58 ± 2.79	74 ± 164	256 ± 1600	271 ± 690	95.1 ± 600
Sandia Canyon			−35 ± 156	−0.02 ± 0.03	−0.01 ± 0.00	0.30 ± 0.40	2.2 ± 7.9	23 ± 7	3.1 ± 46
SCS-1	2	8.1 ± 0.8	15 ± 41	0.00 ± 0.04	−0.01 ± 0.01	0.60 ± 1.2	0.9 ± 5.9	22 ± 6	2.2 ± 0.9
SCS-2	2	7.3 ± 1.7	6 ± 7	−0.01 ± 0.03	0.00 ± 0.00	0.90 ± 1.2	2.5 ± 1.4	24 ± 0	5.3 ± 7.3
SCS-3	2	6.9 ± 2.7							
No. of Analyses		6	6	6	6	3	6	6	6
Minimum		6.0 ± 0.8	−90 ± 100	−0.03 ± 0.02	−0.01 ± 0.02	0.30 ± 0.40	−1.2 3.4	20 ± 4	1.4 ± 0.2
Maximum		8.4 ± 0.8	29 ± 16	0.02 ± 0.02	0.01 ± 0.02	0.90 ± 1.2	5.0 ± 6.0	25 ± 6	7.9 ± 1.6
Average		7 4 ± 1.8	−5 ± 86	0.00. ± 0.02	−0.01 ± 0.01	0.60 ± 0.60	1.9 ± 4.7	23 ± 4	3.5 ± 4.9
Mortandad Canyon									
GS-1	2	8.8 ± 3.0	845 ± 325	4.94 ± 5.18	2.24 ± 4.84	137 ± 12	48 ± 113	1135 ± 212	0.8 ± 0.3
MCS-3.9	1	22.0 ± 1.2	319 ± 38	8.60 ± 0.40	2.37 ± 0.20	---	14 ± 8.0	600 ± 120	1.6 ± 0.4
MCO-3	2	95.4 ± 33.6	35 ± 41	5.37 ± 2.07	0.59 ± 0.54	36 ± 3.0	20 ± 7.0	303 ± 413	4.3 ± 2.0
MCO-4	2	303 ± 114	75 ± 42	19.10 ± 18.10	3.76 ± 3.89	80 ± 6.0	325 ± 665	790 ± 1200	10.4 ± 4.7
MCO-5	2	239 ± 164	−50 ± 15	0.78 ± 1.10	0.19 ± 0.38	2.6 ± 1.0	14 ± 17	66 ± 21	13.6 ± 12.2
MCO-6	2	303 ± 455	21 ± 18	2.16 ± 2.81	0.28 ± 0.63	2.8 ± 1.2	17 ± 29	58 ± 27	32 ± 90
MCO-7	2	105 ± 28	15 ± 14	0.06 ± 0.07	0.02 ± 0.06	0.2 ± 1.4	12 ± 24	18 ± 18	8.2 ± 18
MCO-7.5	1	388 ± 12	−40 ± 140	0.29 ± 0.08	0.06 ± 0.04	1.6 ± 0.8	22 ± 14	42 ± 10	143 ± 14
No. of Analyses		14	14	14	14	7	14	14	14
Minimum		7.8 ± 0.8	−60 ± 80	0.03 ± 0.02	0.00 ± 0.02	0.2 ± 1.4	2.9 ± 2.8	11 ± 3.0	0.7 ± 0.2
Maximum		464 ± 14	960 ± 80	8.60 ± 0.40	5.13 ± 0.34	137 ± 12	660 ± 240	1230 ± 240	143 ± 14
Average		180 ± 295	154 ± 619	5.26 ± 13.8	1.19 ± 3.28	37 ± 106	65 ± 290	387 ± 929	20 ± 78

TABLE E-XVI (continued)

Station	No. Analyses	Chemical (concentrations in mg/l) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	pH	mS/m
Noneffluent Areas																	
Test Well 1	1	44	32	2	5.0	21	14	115	<2	2	6	0.8	<2	290	88	8.3	27.0
Test Well 3	1	70	9	6	2.3	12	2	107	<2	2	3	0.5	<2	268	46	8.1	18.0
Deep Test-5A	1	60	4	2	1.8	11	3	73	<2	<2	1	0.3	<2	200	20	8.1	11.0
Test Well 8	1	46	6	4	1.8	11	0	88	<2	<2	1	0.3	<2	221	32	8.5	13.0
Deep Test-9	1	56	5	3	1.2	11	5	66	<2	<2	1	0.4	<2	180	24	8.2	12.0
Deep Test-10	1	50	6	4	1.6	11	0	110	<2	<2	1	1.2	<2	206	30	8.3	12.0
Cañada del Buey	1	48	3	2	3.1	20	4	56	<2	13	7	4.2	<2	228	31	7.5	16.0
Pajarito Canyon	1	39	25	11	6.6	27	4	61	<2	18	95	0.3	<2	440	111	7.4	41.0
Water Canyon	1	19	17	6	5.2	21	0	122	<2	12	5	0.3	<2	322	69	8.3	23.0
Test Well 2	2	47	9	3	1.2	9	4	106	<2	6	6	0.4	<2	163	67	7.9	16.5
No. of Analyses		11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Minimum		19	3	2	1.2	9	0	56	<2	<2	1	0.3	<2	160	20	7.4	11.0
Maximum		70	32	11	6.6	27	14	122	...	18	95	4.2	8	440	111	8.5	41.0
Average		48 ± 26	12 ± 20	4 ± 6	3.0 ± 3.8	16 ± 12	4 ± 8	90 ± 50	<2	<6 ± 12	13 ± 58	0.9 ± 2.4	<4 ± 6	260 ± 170	82 ± 62	8.1 ± 0.8	19.0 ± 18.0
Effluent Areas																	
Acid-Pueblo Canyon (former release area)																	
Acid-Weir	2	27	117	3	7.9	63	5	116	4	16	60	0.3	13	393	410	7.3	43.0
Pueblo 1	2	60	8	3	14	75	7	79	30	34	43	0.6	40	463	85	8.4	48.5
Pueblo 2	2	49	9	3	13	73	12	96	24	33	30	0.6	36	472	65	8.0	45.0
Pueblo 3	2	47	10	3	14	81	3	157	24	14	3	0.8	20	471	64	8.0	48.0
Hamilton Bend Spr	1	50	7	4	9.3	74	5	120	22	29	40	0.9	28	484	256	8.1	44.0
Test Well 1A	1	44	10	5	7.9	69	7	137	17	27	33	0.9	26	482	96	7.8	44.0
Test Well 2A	2	4	14	3	2.4	18	3	62	<2	22	19	0.3	<2	184	89	8.7	20.5
No. of Analyses		12	12	12	7	12	12	12	12	12	12	12	12	12	12	12	12
Minimum		4	7	2	2.4	18	2	56	<2	<2	<1	0.2	<2	182	34	7.3	19.0
Maximum		66	223	5	14	82	12	190	32	37	102	0.9	46	558	656	8.8	54.0
Average		42 ± 35	28 ± 123	3 ± 2	9.9 ± 8.7	63 ± 46	6 ± 7	106 ± 75	17 ± 24	24 ± 21	32 ± 56	0.6 ± 0.5	23 ± 33	409 ± 252	107 ± 182	8.1 ± 1.0	41.5 ± 22.9
DP-Los Alamos Canyon																	
DPS-1	2	22	11	2	60	407	1	514	237	42	68	21	11	1739	4048	9.6	198.0
DPS-4	1	17	18	3	31	131	2	206	2	24	64	2.8	<2	694	1148	8.3	76.0
LAO-C	2	32	14	5	4.4	51	2	79	<2	9	51	0.2	<2	329	146	8.2	39.0
LAO-1	2	40	16	6	7.2	83	6	146	<2	18	45	0.6	5	454	90	8.1	51.0
LAO-2	2	32	9	2	34	90	3	134	<2	19	40	3.2	3	507	154	7.8	54.0
LAO-3	2	23	9	3	29	78	2	177	<2	18	24	2.6	39	452	190	7.8	48.0
LAO-4	1	36	16	6	...	51	7	124	<2	18	25	1.4	31	320	76	7.6	38.0
LAO-4.5	1	32	9	5	4.3	40	2	73	<2	18	28	0.4	4	280	336	8.1	30.0
No. of Analyses		13	13	13	7	13	13	13	13	13	13	13	13	13	13	13	13
Minimum		17	4	1	4.4	40	0	73	<2	7	12	0.1	<2	258	20	7.1	30.0
Maximum		44	18	6	60	429	7	600	474	49	404	25	68	1908	8057	10.3	200.0
Average		29 ± 18	13 ± 8	4 ± 3	24 ± 41	126 ± 256	3 ± 5	192 ± 305	<89 ± 260	21 ± 22	43 ± 58	4.5 ± 15	<12 ± 38	636 ± 1030	834 ± 4380	8.2 ± 1.7	706 ± 1040
Sandia Canyon																	
SCS-1	2	107	13	5	18	94	2	189	12	50	44	1.3	28	676	136	8.7	59.0
SCS-2	2	96	18	6	17	149	2	241	11	119	62	1.5	10	882	236	8.6	85.0
SCS-3	2	89	17	5	15	134	1	213	12	114	57	1.5	8	761	107	8.8	76.0
No. of Analyses		6	6	6	3	6	6	6	6	6	6	6	6	6	6	6	6
Minimum		74	11	4	15	68	0	134	10	39	36	0.8	2	656	78	8.6	50.0
Maximum		134	22	6	18	150	5	275	13	138	62	1.9	33	916	29.2	8.9	86.0
Average		97 ± 44	16 ± 8	5 ± 2	16 ± 3.0	125 ± 121	2 ± 4	214 ± 96	12 ± 2	94 ± 75	54 ± 19	1.4 ± 0.9	16 ± 24	756 ± 179	160 ± 158	8.6 ± 0.1	73.0 ± 27.0
Mortandad Canyon																	
GS-1	2	80	9	2	3.5	181	0	165	<2	14	9	1.3	28	407	144	8.5	38.0
MCS-3.9	1	42	23	2	...	321	0	400	<2	82	23	1.8	276	1258	68	8.1	140.0
MCO-3	2	43	12	1	3.7	203	1	326	<2	41	18	2.0	112	836	1010	8.7	94.0
MCO-4	2	31	15	2	6.5	271	20	403	<2	61	29	2.6	12	1087	437	8.5	135.0
MCO-5	2	25	19	5	7.5	188	4	287	<2	61	34	0.9	68	861	140	8.0	90.0
MCO-6	6	23	20	6	9.8	264	0	393	<2	76	39	1.6	96	1109	240	8.4	120.0
MCO-7	2	31	11	4	4.6	87	6	15	4	17	12	0.3	32	482	155	8.0	48.5
MCO-7.5	1	25	26	8	8.7	229	9	390	<2	83	29	0.6	<2	1340	333	8.7	54.0
No. of Analyses		14	14	14	7	14	14	14	14	14	14	14	14	14	14	14	14
Minimum		21	4	2	3.5	49	0	107	<2	10	6	0.3	<2	390	34	7.2	34.0
Maximum		62	25	8	9.8	321	9	468	8	84	44	2.7	276	1340	1961	8.8	140.0
Average		35 ± 27	16 ± 13	4 ± 4	6.3 ± 5.0	209 ± 179	6 ± 3	303 ± 238	<2	50 ± 54	24 ± 23	1.5 ± 1.5	<70 ± 192	864 ± 697	332 ± 1032	8.4 ± 0.9	89.0 ± 80.4

TABLE E-XVI (continued)

Station	Metal Ions (concentrations in μg/l, one analysis)																
	Ag	Al	As	Ba	Br	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Zn
DP-Los Alamos Canyon																	
DPS-1	<10	1440	7	160	<2000	6	<5	16	<300	1600	<0.2	<300	56	19	6	<5	<300
DPS-4	<10	196	7	160	<2000	5	<5	<3	<300	<300	<0.2	<300	17	12	6	5	<300
LAO-C	<10	32	<5	110	<2000	4	<5	<3	<300	<300	<0.2	<300	<10	10	6	5	<300
LAO-1	<10	<10	<5	110	<2000	7	<5	113	<300	<300	<0.2	<300	24	13	6	5	<300
LAO-2	11	43	<5	140	<2000	5	<5	<3	<300	<300	<0.2	<300	<10	16	6	<5	<300
LAO-3	<10	55	<5	130	<2000	4	<5	5	<300	<300	<0.2	<300	<10	11	6	5	<300
LAO-4.5	12	53	<5	40	<2000	7	<5	<3	<300	<300	---	<300	<10	9	4	<5	<300
No. of Analyses	7	7	7	7	7	7	7	7	7	7	6	7	7	7	7	7	7
Minimum	2	9	<5	40	<2000	4	<5	1	<300	<300	<0.2	<300	<10	9	4	<5	<300
Maximum	12	1440	7	160	---	7	---	113	---	1600	---	---	56	19	6	5	---
Average	<10 ± 2	261 ± 1047	3 ± 6	121 ± 83	<2000	5 ± 3	<5	21 ± 82	<300	<486 ± 983	<0.2	<300	<20 ± 34	13 ± 7	6 ± 2	<5	<300
Sandia Canyon																	
SCS-1	14	25	5	30	<2000	17	<5	5380	<300	800	<0.2	<300	<10	34	6	<5	<300
SCS-2	21	41	9	30	<2000	13	<5	34	<300	700	<0.2	<300	<10	27	4	<5	<300
SCS-3	74	10	6	20	<2000	11	<5	21	<300	400	<0.2	<300	11	25	3	5	<300
No. of Analyses	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Minimum	14	10	5	20	<2000	11	<5	21	<300	400	<0.2	<300	10	25	3	<5	<300
Maximum	74	41	9	30	---	17	---	5380	---	800	---	---	11	34	6	---	---
Average	36 ± 66	25 ± 31	7 ± 4	27 ± 12	<2000	14 ± 6	<5	1812 ± 6181	<300	633 ± 416	<0.2	<300	<10 ± 1	29 ± 9	4 ± 3	<5	<300
Mortandad Canyon																	
GS-1	10	39	<5	<20	<2000	9	<5	6	<300	800	0.6	<300	<10	13	3	<5	<300
MCO-3	14	360	<5	<20	9700	6	<5	4	<300	500	0.2	<300	30	18	6	<5	<300
MCO-4	14	140	<5	20	180 000	9	<5	13	<300	400	0.3	<300	73	26	8	<5	<300
MCO-5	20	25	<5	120	173 000	6	<5	11	<300	<300	0.2	<300	96	8	6	<5	<300
MCO-6	12	59	<5	100	234 000	9	<5	21	<300	<300	<0.2	<300	196	9	6	<5	<300
MCO-7	<10	40	<5	70	21 000	14	<5	8	<300	<300	<0.2	<300	16	14	7	<5	<300
MCO-7.5	17	43	<5	220	173 000	8	<5	41	<300	<300	<0.2	<300	51	18	7	<5	<300
No. of Analyses	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Minimum	<10	25	<5	<20	<2000	6	<5	4	<300	<300	<0.2	<300	<10	8	3	<5	<300
Maximum	20	360	---	220	234 000	14	---	41	---	800	0.6	---	196	26	7	---	---
Average	14 ± 7	99 ± 234	<5	81 ± 147	113 000 ± 196 000	9 ± 5	<5	15 ± 26	<300	<414 ± 373	0.3 ± 0.3	<300.	67 ± 129	15 ± 12	6 ± 3	<5.	<300.
Noneffluent Areas																	
Test Well 1	10	<10	<5	720	<2000	4	<5	<3	<300	<300	---	500	<10	12	4	<5	<300
Test Well 3	<10	12	<5	90	<2000	6	<5	3	<300	<300	---	<300	<10	9	4	<5	<300
DT-54	<10	11	<5	70	<2000	6	<5	3	<300	<300	<0.2	<300	<10	8	8	<5	400
Test Well 8	<10	<10	<5	40	<2000	4	<5	<3	<300	<300	---	<300	<10	8	9	<5	400
DT-9	<10	11	<5	70	<2000	4	<5	3	<300	<300	---	<300	<10	8	7	<5	<300
DT-10	<10	10	<5	20	<2000	8	<5	<3	<300	<300	---	<300	<10	9	5	<5	<300
Cañada del Buey	29	1700	<5	130	<2000	5	<5	4	<300	2400	---	<300	<10	14	<3	<5	<300
Pajarito Canyon	<10	10	<5	1890	<2000	7	<5	<3	<300	900	<0.2	1110	<10	9	5	<5	<300
Water Canyon	<10	20	<5	8150	<2000	3	<5	<3	<300	<300	---	<300	<10	8	4	<5	<300
Test Well 2	<10	11	10	50	<2000	6	<5	5	<300	<300	---	<300	<10	9	7	<5	<300
No. of Analyses	10	10	10	10	10	10	10	10	10	10	2.	10	10	10	10	10	10
Minimum	<10	<10	<5	20	<2000	3	<5	<3	<300	<300	<0.2	6300	<10	8	<3	<5	<300
Maximum	29	1700	10	8150	---	8	---	5	---	2400	---	1100	---	14	9	---	400
Average	<12 ± 12	<180 ± 1040	<5 ± 4	1120 ± 5070	<2000	5 ± 4	<5	<3 ± 2	<300	<570 ± 1340	<0.2	<370 ± 570	<10	9 ± 4	6 ± 4	<5	<320 ± 84
Effluent Areas																	
Acid-Pueblo Canyon (former release area)																	
Acid Weir	<10	18	<5	110	17 500	240	2	<3	<300	<300	<0.2	<300	<10	7	5	<5	<300
Pueblo 1	<10	18	11	60	<2000	4	<1	4	<300	<300	<0.2	<300	<10	10	4	<5	<300
Pueblo 2	<10	10	10	60	<2000	9	1	3	<300	<300	<0.2	<300	<10	10	3	<5	<300
Pueblo 3	<10	10	8	30	<2000	7	<1	4	<300	<300	<0.2	<300	<10	9	5	<5	<300
Hamilton Bend Spr	<10	56	7	250	<2000	12	1	<3	<300	<300	---	<300	<10	6	3	<5	<300
Test Well 1A	<10	11	10	120	<2000	90	<5	<3	<300	<300	<0.2	<300	<10	11	7	<5	<300
Test Well 2A	<10	16	<5	200	<2000	11	<5	<3	<300	<300	---	<300	<10	10	6	<5	<300
No. of Analyses	7	7	7	7	7	7	7	7	7	7	5	7	7	7	7	7	7
Minimum	<10	10	<5	30	<2000	4	<1	<3	<300	<300	<0.2	<300	<10	5	3	<5	<300
Maximum	---	56	11	250	---	240	<5	4	---	---	---	---	---	11	7	---	---
Average	<10	20 ± 32	8 ± 4	119 ± 160	<2000	53 ± 175	2 ± 4	<3 ± 1	<300	<300	<0.2	<300	<10	9 ± 4	5 ± 4	<5	<300

TABLE E-XVII

LOCATION OF SOIL AND SEDIMENT STATIONS

Station	Latitude or N-S Coordinate	Longtiude or E-W Coordinate	Map Designation (Figure 10)[a]
Regional Soils[b]			
Regional Sediments			
Rio Chama			
Chamita	36°05'	106°07	---
Rio Grande			
Embudo	36°12'	105°58'	---
Otowi	N085	E550	A
Sandia	S060	E490	B
Pajarito	S185	E410	C
Ancho	S305	E335	D
Frijoles	S375	E235	E
Cochiti	35°37'	106°19'	---
Bernalillo	35°17'	106°36'	---
Jemez River	35°40'	106°44'	---
Perimeter Soils			
Sportsman's Club	N240	E215	S1
TA-8	N060	W075	S2
TA-49	S165	E085	S3
Frijoles	S245	E180	S4
North Mesa	N135	E165	S5
East of Airport	N095	E220	S6
West of Airport	N115	E135	S7
South SR-4 near S-Site	S085	W035	S8
Perimeter Sediments			
Guaje near G-4	N215	E325	1
Guaje at SR-4	N135	E480	2
Bayo at SR-4	N100	E455	3
Pueblo at Acid Weir	N125	E070	4
Pueblo at PC-1	N130	E070	5
Pueblo at Pueblo 1	N130	E085	6
Pueblo at Pueblo 2	N120	E145	7
Los Alamos at Reservoir	N100	W065	8
Los Alamos at Totatvi	N065	E405	9
Los Alamos at LA-2	N125	E510	10
Los Alamos at Rio Grande	N095	E555	11
Sandia at Rio Grande	S055	E490	12
Cañada del Ancha	S060	E505	13
Mortandad at SR-4	S030	E350	14
Mortandad at Rio Grande	S075	E480	15
Cañada del Buey at SR-4	S090	E360	16
Pajarito at Rio Grande	S175	E410	17
Frijoles at Park Hdq	S280	E185	18
Frijoles at Rio Grande	S365	E235	19

TABLE E-XVII (continued)

LOCATION OF SOIL AND SEDIMENT STATIONS

Station	Latitude or N-S Coordinate	Longtiude or E-W Coordinate	Map Designation (Figure 10)[a]
Onsite Soils			
TA-21	N095	E140	S9
TA-50	N035	E095	S10
TA-36	S090	E150	S11
PM-1	N020	E310	S12
West of TA-53	N070	E105	S13
East of TA-53	N050	E220	S14
East of New Sigma	N060	E065	S15
Sigma Mesa	N050	E135	S16
East of TA-52	N020	E145	S17
2-Mile Mesa	N025	E030	S18
Near TA-51	S030	E200	S19
East of TA-54	S080	E295	S20
R-Site Road	S015	E030	S21
R-Site Road East	S040	E100	S22
Potrillo Drive	S065	E195	S23
S-Site	S035	W025	S24
Near TA-11	S070	E020	S25
Near DT-9	S150	E140	S26
TA-33	S245	E225	S27
Onsite Sediments			
Pueblo at Hamilton Bend Spr	N105	E255	20
Pueblo at Pueblo 3	N090	E315	21
Pueblo at SR-4	N070	E350	22
DP Canyon at DPS-1	N090	E160	23
DP Canyon at DPS-4	N075	E205	24
Los Alamos Canyon at Bridge	N095	E020	25
Los Alamos at LAO-1	N080	E120	26
Los Alamos at GS-1	N075	E200	27
Los Alamos at TW-3	N075	E215	28
Los Alamos at LAO-4	N075	E240	29
Los Alamos at SR-4	N065	E355	30
Sandia at SCS-2	N050	E175	31
Sandia at SR-4	N025	E315	32
Mortandad near CMR	N060	E035	33
Mortandad West of GS-1	N045	E095	34
Mortandad near MCO-2	N035	E090	35
Mortandad at GS-1	N040	E105	36
Mortandad at MCO-5	N035	E155	37
Mortandad at MCO-7	N025	E190	38
Mortandad at MCO-9	N030	E215	39
Mortandad at MCO-13	N015	E250	40
Pajarito at TA-18	S055	E195	41
Pajarito at SR-4	S105	E320	42

TABLE E-XVII (continued)

LOCATION OF SOIL AND SEDIMENT STATIONS

Station	Latitude or N-S Coordinate	Longtiude or E-W Coordinate	Map Designation (Figure 10)[a]
Potrillo at TA-36	S075	E150	43
Potrillo East of TA-36	S085	E225	44
Potrillo at SR-4	S145	E295	45
Water at Beta Hole	S090	E095	46
Water at SR-4	S170	E260	47
Water at Rio Grande	S240	E385	48
Ancho at SR-4	S255	E250	49
Ancho at Rio Grande	S295	E340	50
Chaquihui at Rio Grande	S335	E265	51

[a]See Fig. 10 for numbered locations.
[b]Locations are the same as for surface water stations (Table E-XII).

TABLE E-XVIII

RADIOCHEMICAL ANALYSES OF REGIONAL SOILS AND SEDIMENTS

	^{3}H 10^{-6} μCi/mℓ	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Gross α pCi/g	Gross β pCi/g
Regional Soils						
Chamita	5.8 ± 0.8	0.68 ± 0.12	0.000 ± 0.002	0.013 ± 0.004	3.4 ± 1.6	4.9 ± 1.4
Embudo[a]	144 ±42.7	1.17 ±0.40	0.001 ± 0.010	0.061 ± 0.129	3.9 ± 1.8	5.8 ± 1.4
Otowi[a,b]	4.9 ± 3.4	1.35 ± 1.07	0.001 ± 0.003	0.102 ± 0.137	4.8 ± 2.2	7.6 ± 1.8
Cochiti	4.9 ± 0.8	0.62 ± 0.16	0.000 ± 0.003	0.004 ± 0.004	3.6 ± 1.8	5.4 ± 1.4
Bernalillo	4.7 ± 0.8	0.15 ± 0.10	−0.001 ± 0.002	0.000 ± 0.003	3.1 ± 1.6	3.4 ± 1.0
Jemez	13.6 ± 1.0	0.06 ± 0.28	−0.002 ± 0.002	0.001 ± 0.002	4.4 ± 2.2	5.7 ± 1.4
No. of Analyses	7	7	7	7	6	6
Minimum	4.8 ± 0.8	0.06 ± 0.28	−0.001 ± 0.02	0.000 ± 0.003	3.1 ± 1.6	3.4.± 1.0
Maximum	29.5 ± 1.4	1.73 ± 0.32	0.005 ± 0.016	0.150 ± 0.040	4.8 ± 2.2	7.6.± 1.8
Average	8.1 ± 9.3	0.67 ± 1.04	0.000 ± 0.002	0.03 ± 0.084	3.9 ± 1.3	5.5.± 2.7
Regional Sediments						
Rio Chama						
Chamita	---	0.00 ± 0.06	0.000 ± 0.002	−0.002 ± 0.004	2.4 ± 1.2	2.8 ± 1.0
Rio Grande						
Embudo[a]	---	0.26 ± 0.16	−0.002 ± 0.002	−0.006 ± 0.004	1.9 ± 1.0	1.7 ±0.8
Otowi	---	0.08 ± 0.03	0.000 ± 0.001	0.000 ± 0.003	1.4 ± 0.8	0.9 ± 0.6
Sandia	---	0.13 ± 0.06	−0.005 ± 0.016	−0.013 ± 0.016	11 ± 2	8.5 ± 1.2
Pajarito	---	0.07 ± 0.06	−0.005 ± 0.016	0.009 ± 0.014	10 ± 2	8.6 ± 1.3
Ancho	---	0.13 ± 0.06	−0.006 ± 0.026	0.003 ± 0.020	16 ± 3	14 ± 1.7
Frijoles	---	0.15 ± 0.06	0.012 ± 0.020	−0.003 ± 0.020	7.3 ± 1.7	6.0 ± 1.0
Cochiti	---	0.03 ± 0.10	−0.001 ± 0.003	0.001 ± 0.004	1.5 ± 0.8	1.5 ± 0.8
Bernalillo	---	0.24 ± 0.06	−0.001 ± 0.003	−0.001 ± 0.003	2.4 ± 1.4	4.9 ±1.4
Jemez River						
Jemez Pueblo	---	0.26 ± 0.14	0.000 ± 0.003	0.002 ± 0.003	4.6 ± 1.2	4.6 ± 2.2
No. of Analyses	---	10	10	10	10	10
Minimum	---	0.00 ± 0.06	−0.001 ± 0.003	−0.001 ± 0.030	1.4 ± 0.8	0.9 ± 0.6
Maximum	---	0.26 ± 0.16	0.012 ± 0.020	0.009 ± 0.014	16 ± 3.0	14 ± 1.7
Average	---	0.14 ± 0.19	0.000 ± 0.00	−0.001 ± 0.012	5.8 ± 10	5.4 ± 8.2

[a]Two analyses for ^{137}Cs, ^{238}Pu, and ^{239}Pu.

[b]^{137}Cs and ^{239}Pu slightly above background.

Note: ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported; then the value represents twice the uncertainty term for that analysis.

TABLE XIX

RADIOCHEMICAL ANALYSES OF PERIMETER SOILS AND SEDIMENTS

	^{3}H 10^{-6} μCi/mℓ	^{137}Cs pCi/g	^{90}Sr pCi/g	^{241}Am pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Gross α pCi/g	Gross β pCi/g
Soils								
Sportsmen's Club	3.0 ± 0.8	1.08 ± 0.18	0.87 ± 0.26	---	0.000 ± 0.006	0.021 ± 0.008	6.2 ± 2.8	7.9 ± 1.8
TA-8[b]	9.0 ± 0.8	1.56 ± 0.26	---	---	0.001 ± 0.006	0.041 ± 0:016	5.1 ± 2.4	8.9 ± 2.0
TA-49	5.9 ± 0.8	0.53 ± 0.10	---	---	−0.001 ± 0.004	0.008 ± 0.006	5.2 ± 2.4	6.2 ± 1.6
Frijoles	4.0.± 0.8	1.37 ± 0.34	---	---	0.000 ± 0.002	0.029 ± 0.006	5.7 ± 2.4	7.1 ± 1.6
North Mesa	8.6 ± 0.8	0.51 ± 0.10	0.87 ± 0.26	---	−0.002 ± 0.003	0.015 ± 0.010	4.3 ± 2.0	6.1 ± 1.4
East of Airport	12.2 ± 1.0	0.59 ± 0.05	0.92 ± 0.26	---	0.000 ± 0.003	0.030 ± 0.001	5.1 ± 2.2	6.2 ± 1.6
West of Airport[a,b]	10.5 ± 3.1	1.44 ± 0.51	---	---	0.010 ± 0.026	0.284 ± 0:498	4.5 ± 2.0	7.9 ± 1.8
South SR-4 & Near S-site[b]	3.4 ± 0.8	1.32 ± 0.20	0.85 ± 0.26	---	0.002 ± 0.004	0.018 ± 0:008	5.1 ± 2.2	6.9 ± 1.6
No. of Analyses	8	9	4		9	9	8	8
Minimum	3.0 ± 0.8	0.51 ± 0.10	0.85 ± 0.26		−0.002 ± 0.003	0.008 ± 0.006	4.3 ± 2.0	6.1 ± 1.6
Maximum	12.2 ± 1.0	1.6 ± 0.24	0.92 ± 0.26		0.019 ± 0.020	0.460 ± 0.080	6.2 ± 2.8	8.9 ± 2.0
Average	7.1 ± 7.0	1.5 ± 0.88	0.88 ± 0.06	---	0.001 ± 0.007	0.056 ± 0.19	5.1 ± 1.2	7.2 ± 2.0
Sediments								
Guaje near G-4	---	0.09 ± 0.12	---	0.002 ± 0.014	0.000 ± 0.002	0.003 ± 0.003	2.3 ± 0.8	1.4 ± 0.8
Guaje at SR-4	---	0.22 ± 0.08	0.17 ± 0.12	0.002 ± 0.014	0.001 ± 0.002	0.000 ± 0.002	2.2 ± 1.2	2.5 ± 0.8
Bayo at SR-4	---	0.10 ± 0.04	0.10 ± 0.11	0.002 ± 0.012	0.001 ± 0.002	0.006 ± 0.002	3.0 ± 1.4	2.3 ± 0.8
Pueblo at Acid Weir[a,b]	---	0.68 ± 0.06	---	0.351 ± 0.024	0.034 ± 0.018	5.62 ± 2.39	7.5 ± 3.2	4.5 ± 1.2
Pueblo at PC-1[a]	---	0.19 ± 0.10	---	0.001 ± 0.012	0.001 ± 0.001	0.026 ± 0.068	1.2 ± 0.8	1.0 ± 0.6
Pueblo at Pueblo 1[a,b]	---	0.50 ± 0.30	---	---	0.022 ± 0.011	3.72 ± 1.30	4.1 ± 2.0	2.1 ± 0.8
Pueblo at Pueblo 2[a,b]	---	0.18 ± 0.03	---	0.590 ± 0.016	0.007 ± 0.009	1.07 ±1.93	3.1 ± 1.4	2.9 ± 1.0
Los Alamos at Reservoir	---	0.80 ± 0.18	---	0.003 ± 0.012	−0.001 ± 0.002	0.011 ± 0.006	10.0 ± 4.0	13.3 ± 3.0
Los Alamos at Totavi[a,b]	---	0.35 ± 0.34	---	---	0.002 ± 0.005	0.053 ± 0.041	2.9 ± 1.4	2.7 ± 1.0
Los Alamos at LA-2[a,b]	---	0.52 ± 0.82	---	---	0.001 ± 0.002	0.068 ± 0.076	2.6 ± 1.2	3.3 ± 1.0
Los Alamos at Rio Grande[a,b]	---	0.36 ± 0.50	0.30 ± 0.11	0.005 ± 0.012	−0.000 ± 0.001	0.062 ± 0.02	2.5 ± 1.2	3.3 ± 1.0
Sandia at Rio Grande	---	0.12 ± 0.04	---	---	0.002 ± 0.020	0.012 ± 0.008	7.4 ± 1.7	7.4 ± 1.1
Cañada del Ancha	---	0.09 ± 0.06	---	---	0.003 ± 0.022	0.007 ± 0.028	6.6 ± 1.6	5.6 ± 1.0
Mortandad at SR-4	---	0.10 ± 0.04	0.90 ± 0.40	0.001 ± 0.012	0.000 ± 0.002	0.001 ± 0.004	5.0 ± 2.2	4.4 ± 1.2
Mortandad at Rio Grande	---	0.11 ± 0.06	---	---	0.000 ± 0.006	0.002 ± 0.008	2.7 ± 0.8	2.9 ± 0.8
Cañada del Buey at SR-4	---	0.06 ± 0.24	0.41 ± 0.38	---	−0.002 ± 0.002	0.003 ± 0.004	4.7 ± 2.2	4.3 ± 1.2
Pajarito at Rio Grande	---	0.17 ± 0.06	---	---	−0.003 ± 0.010	0.007 ± 0.008	3.4 ± 0.9	6.0 ± 1.0
Frijoles at Park Hdq	---	0.35 ± 0.12	−0.15 ± 0.22	0.006 ± 0.012	−0.002 ± 0.003	0.003 ± 0:004	2.5 ± 1.2	1.8 ± 0.8
Frijoles at Rio Grande	---	0.33 ± 0.08	---	---	0.002 ± 0.018	0.020 ± 0.022	6.9 ± 1.6	6.1 ± 1.0
No. of Analyses		25	6	10	25	25	19	19
Minimum		0.09 ± 0.12	−0.15 ± 0.22	0.001 ± 0.012	−0.003 ± 0.010	0.000 ± 0.002	2.5 ± 1.2	2.7 ± 1.0
Maximum		0.81 ± 0.26	0.90 ± 0.40	0.590 ± 0.016	0.040 ± 0.006	6.46 ± 0.28	7.4 ± 1.7	7.4 ± 1.1
Average		0.28 ± 0.43	0.12 ± 0.71	0.096 ± 0.41	0.003 ± 0.018	0.56 ± 3.0	4.2 ± 4.7	4.1 ± 5.7

Note: ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported; then the value represents twice the uncertainty term for that analysis.

[a]Two analyses for ^{137}Cs, ^{238}Pu, and ^{239}Pu.

[b]^{137}Cs, ^{241}Am, ^{238}Pu, or ^{239}Pu slightly above background.

TABLE E-XX

RADIOCHEMICAL ANALYSES OF ONSITE SOILS AND SEDIMENTS
(pCi/g and one analysis except as noted)

Soils	^{3}H[a] 10^{-6} μCi/mℓ	^{137}Cs pCi/g	^{90}Sr pCi/g	^{241}Am pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Gross α pCi/g	Gross β pCi/g
Soils								
TA-21[a]	15.6 ± 31.1	0.07 ± 0.00	---	---	−0.003 ± 0.008	0.022 ± 0.052	4.1 ± 1.8	6.0 ± 1.2
TA-50[a,b]	29.9 ± 69.3	0.49 ± 0.72	---	---	0.008 ± .025	0.085 ± 0.004	6.2 ± 1.4	9.4 ± 2.2
TA-36	22.3 ± 1.2	0.36 ± 0.10	---	---	−0.001 ± 0.004	0.006 ± 0.006	4.4 ± 2.0	5.3 ± 1.4
PM-1	29.7 ± 1.4	0.41 ± 0.12	---	---	−0.002 ± 0.003	0.011 ± 0.006	5.8 ± 2.6	7.5 ± 1.8
West of TA-53	17.6 ± 1.0	1.03 ± 0.20	---	---	−0.001 ± 0.004	0.02 ± 0.008	6.0 ± 2.6	8.0 ± 1.8
East of TA-53[a,b]	8.2 ± 14.6	1.29 ± 0.39	0.82 ± 0.28	---	0.013 ± 0.034	0.15 ± 0.385	4.5 ± 2.0	6.7 ± 1.6
East of New Sigma I	22.2 ± 1.2	0.50 ± 0.14	---	---	0.000 ± 0.003	0.008 ± 0.003	4.5 ± 2.0	5.8 ± 1.4
East of New Sigma II	17.7 ± 1.0	0.50 ± 0.14	0.42 ± 0.22	---	0.000 ± 0.006	0.012 ± 0.006	5.3 ± 2.4	7.5 ± 1.8
East of TA-52	17.7 ± 1.0	−0.11 ± 0.12	−0.05 ± 0.20	---	−0.002 ± 0.002	−0.001 ± 0.002	4.6 ± 2.2	5.7 ± 1.4
2-Mile Mesa	7.1 ± 0.8	0.90 ± 0.16	0.61 ± 0.34	---	−0.002 ± 0.010	0.023 ± 0.010	5.8 ± 2.6	7.9 ± 1.8
Near TA-51[a,b]	7.4 ± 13.3	0.87 ± 1.75	---	---	−0.004 ± 0.017	0.118 ± 0.262	5.8 ± 2.6	12.3 ± 2.6
East of TA-54[a,b]	157 ± 374	0.26 ± 0.36	---	---	0.448 ± 0.714	1.35 ± 3.32	5.5 ± 2.4	6.3 ± 1.6
R-Site Road	6.2 ± 0.8	0.73 ± 0.20	0.63 ± 0.22	---	−0.002 ± 0.003	0.013 ± 0.006	6.1 ± 2.6	7.5 ± 1.8
R-Site Road East[b]	10.5 ± 0.8	0.84 ± 0.18	0.83 ± 0.14	---	0.001 ± 0.003	0.020 ± 0.001	11 ± 4.0	22 ± 4.0
Potrillo Drive	6.8 ± 0.8	0.57 ± 0.12	---	---	−0.003 ± 0.002	0.010 ± 0.006	3.8 ± 1.8	14 ± 1.6
S-Site[a,b]	4.0 ± 4.2	1.46 ± 0.11	---	---	0.015 ± 0.044	0.066 ± 0.181	5.3 ± 2.4	8.6 ± 2.0
Near TA-11	5.3 ± 0.8	0.56 ± 0.28	---	0.003 ± 0.012	−0.002 ± 0.002	0.008 ± 0.006	5.3 ± 2.4	6.6 ± 1.6
Near DT-9	3.8 ± 0.8	1.10 ± 0.22	0.27 ± 0.28	---	−0.001 ± 0.002	−0.021 ± 0.006	7.1 ± 3.0	9.1 ± 2.0
TA-33	28.6 ± 1.4	0.51 ± 0.10	---	---	−0.002 ± 0.004	0.003 ± 0.006	6.5 ± 2.8	8.5 ± 2.0
No. of Analyses	19	24	7.	1	24	24	19	19
Minimum	3.8 ± 0.8	−0.11 ± 0.12	−0.05 ± 0.20	0.003 ± 0.012	−0.003 ± 0.008	−0.001 ± 0.002	3.8 ± 1.8	5.0 ± 1.2
Maximum	157 ± 374	1.50 ± 0.40	0.83 ± 0.14	---	0.700 ± 0.100	2.62 ± 0.220	11 ± 4.0	22 ± 4.0
Average	22 ± 68	0.65 ± 0.80	0.50 ± 0.63	0.003 ± 0.0	0.025 ± 0.21	0.10 ± 0.61	5.7 ± 3.1	8.6 ± 7.9
Sediments								
Pueblo at Hamilton bend Spr[b,c]		0.12 ± 0.01	---	0.016 ± 0.014	0.001 ± 0.002	0.432 ± 0.133	2.6 ± 1.2	1.5 ± 0.8
Pueblo at Pueblo 3[b,c]		0.14 ± 0.17	---	0.015 ± 0.014	0.001 ± 0.001	0.440 ± 0.177	2.1 ± 1.0	1.1 ± 0.8
Pueblo at SR-4[a,b]		0.16 ± 0.11	1.05 ± 0.32	---	0.001 ± 0.001	0.521 ± 0.421	2.7 ± 1.4	3.1 ± 1.0
DP Canyon at DPS-1[b,c]		20 ± 1.8	8.7 ± 0.80	---	6.71 ± 17..8	1.72 ± 2.80	9.1 ± 3.8	30 ± 6.0
DP Canyon at DPS-4[b,c]		12 ± 7.8	2.4 ± 0.30	---	0.092 ± 0.064	0.304 ± 0.204	1.6 ± 0.8	12 ± 2.4
Los Alamos at Bridge		0.07 ± 7.8	2.4 ± 0.30	0.009 ± 0.014	−0.002 ± 0.004	−0.003 ± 0.003	3.1 ± 1.4	1.9 ± 0.8
Los Alamos at LAO-1[b,c]		1.16 ± 0.20	---	---	0.001 ± 0.004	0.490 ± 0.040	2.0 ± 1.2	3.0 ± 1.0
Los Alamos at GS-1[b,c]		0.22 ± 0.04	---	---	0.000 ± 0.002	0.237 ± 0.091	2.3 ± 1.2	2.5 ± 0.8
Los Alamos at TW-2[b,c]		14 ± 9.5	---	---	0.091 ± 0.066	0.323 ± 0.303	2.6 ± 1.2	16 ± 3.4
Los Alamos at LAO-4[b,c]		17 ± 9.2	---	0.008 ± 0.012	0.104 ± 0.018	0.35 ± 0.127	2.7 ± 1.2	17.± 3.6
Los Alamos at SR-4[c]		21 ± 2.8	0.71 ± 0.26	0.001 ± 0.012	0.010 ± 0.027	0.056 ± 0.065	2.4 ± 1.2	2.9 ± 1.0
Sandia at SCS-2		0.42 ± 0.32	---	0.005 ± 0.012	−0.001 ± 0.002	0.003 ± 0.004	1.6 ± 0.8	1.6 ± 0.8
Sandia at SR-4		0.05 ± 0.06	---	---	0.001 ± 0.002	0.001 ± 0.004	2.8 ± 1.4	1.7 ± 0.8
Mortandad near CMR6		0.23 ± 0.12	0.22 ± 0.14	---	0.101 ± 0.020	0.025 ± 0.012	2.0 ± 1.0	2.5 ± 0.8
Mortandad West of GS-1[b,c]		0.24 ± 0.40	0.06 ± 0.14	---	0.008 ± 0.014	0.023 ± 0.034	3.3 ± 1.4	3.7 ± 0.8
Mortandad near MCO-2[b]		1260 ± 180	9.9 ± 0.8	---	3.52 ± 1.20	11.6 ± 0.400	52 ± 22	1710 ± 340
Mortandad at GS-1[b,c]		755 ± 1090	17 ± 1.2	---	17.6 ± 15.3	5.69 ± 4.43	39 ± 16	450 ± 100
Mortandad at MCO-5[b,c]		76.5 ± 26.9	8.9 ± 0.8	---	2.71 ± 3.44	4.14 ± 9.42	11 ± 4	105 ± 22
Mortandad at MCO-7[b,c]		62.5 ± 12.7	4.2 ± 0.4	---	3.27 ± 0.25	0.76 ± 0.01	7.6 ± 3.2	67 ± 14
Mortandad at NCO-9[c]		0.96 ± 1.4	---	0.004 ± 0.012	0.002 ± 0.007	0.018 ± 0.008	6.3 ± 2.8	8.9 ± 2.0
Mortandad at MCO-13[c]		1.32 ± 0.24	0.46 ± 0.26	0.001 ± 0.012	0.002 ± 0.001	0.020 ± 0.044	4.4 ± 2.0	7.1 ± 1.6
Pajarito at TA-18		−0.03 ± 0.10	---	---	0.000 ± 0.001	0.000 ± 0.004	3.3 ± 1.6	2.8 ± 1.0
Pajarito at SR-4		0.90 ± 0.34	−0.11 ± 0.22	−0.001 ± 0.012	−0.002 ± 0.004	0.009 ± 0.008	8.5 ± 3.8	7.3 ± 1.8
Potrillo at TA-36		0.14 ± 0.06	---	0.001 ± 0.012	−0.001 ± 0.002	−0.001 ± 0.002	2.6 ± 1.2	3.2 ± 1.0
Potrillo East of TA-36		0.17 ± 0.08	---	0.004 ± 0.014	0.001 ± 0.002	0.002 ± 0.004	2.7 ± 1.4	4.3 ± 1.2
Potrillo at SR-4		−0.08 ± 0.20	−0.10 ± 0.24	---	−0.001 ± 0.002	0.003 ± 0.004	2.7 ± 1.2	2.3 ± 0.8
Water at Beta Hole[c]		3.4 ± 0.99	---	0.006 ± 0.012	0.002 ± 0.004	0.056 ± 0.027	6.6 ± 2.8	12 ± 2.6
Water at SR-4		0.36 ± 0.16	0.85 ± 0.34	---	−0.001 ± 0.001	0.006 ± 0.004	3.2 ± 1.4	3.3 ± 1.0
Water at Rio Grande[c]		1.39 ± 0.20	---	---	0.007 ± 0.018	0.109 ± 0.038	17.0 ± 4.0	21 ± 2
Ancho at SR-4		0.54 ± 0.08	---	---	0.001 ± 0.002	0.009 ± 0.004	3.9 ± 1.8	5.3 ± 1.4
Ancho at Rio Grande		0.29 ± 0.06	---	---	0.008 ± 0.018	0.018 ± 0.024	7.8 ± 1.9	11 ± 1.4
Chaquihuí at Rio Grande		0.11 ± 0.04	---		−0.002 ± 0.008	0.012 ± 0.010	3.7 ± 1.0	4.4 ± 0.9
No. of Analyses		47	14	12	47	47	32	32
Minimum		−0.08 ± 0.20	−0.11 ± 0.22	−0.001 ± 0.012	−0.002 ± 0.004	−0.003 ± 0.003	1.6 ± 0.8	1.1 ± 0.8
Maximum		1260 ± 180	17 ± 1.2	0.016 ± 0.014	35.2 ± 1.20	11.6 ± 0.400	52 ± 22	1710 ± 340
Average		70 ± 610	3.9 ± 11	0.006 ± 0.011	2.1 ± 14	0.86 ± 4.6	7.1 ± 22	79 ± 620

Note: ± value represents twice the standard deviation of the distribution of observed values unless only one analyses is reported. Then the value represents twice the error term for that analyses.

[a] 10^{-6} μCi/mℓ.
[b] ^{3}H, ^{137}Cs, ^{238}Pu, ^{239}Pu, Gross α, or Gross β above background.
[c] Two analyses for ^{137}Cs, ^{238}Pu, and ^{239}Pu.

TABLE E-XXI

ATMOSPHERIC RADIOACTIVE EFFLUENT TOTAL FOR 1978

Location	^{238}Pu ^{239}Pu (μCi)	^{241}Am (μCi)	^{235}U ^{238}U (μCi)	^{234}Th (mCi)	MFP[a] (μCi)	^{131}I (μCi)	^{41}Ar (Ci)	^{32}P (μCi)	^{3}H (Ci)	$^{11}C, ^{13}N, ^{15}O$[b] (Ci)	^{7}Be (μCi)
TA-2	---	---	---	---	---	---	239	---	---	---	---
TA-3	58.3	---	185	1.9	403	81	---	---	100	---	---
TA-9	---	---	---	---	---	---	---	---	2.6	---	---
TA-15	---	---	---	---	---	---	---	---	---	---	---
TA-21	30.8	0.034	305	---	1.0	---	---	---	72	---	---
TA-33	---	---	---	---	---	---	---	---	17 780	---	---
TA-35	2.0	---	---	---	---	---	---	---	676	---	---
TA-43	1.5	---	---	---	---	---	---	85	---	---	---
TA-46	---	---	25	---	---	---	---	---	---	---	---
TA-48	1.9	---	11.2	---	1169	---	---	---	---	---	---
TA-50	17.4	---	---	---	39	---	---	---	---	---	---
TA-53	---	---	---	---	---	---	350	---	---	116 449	0.19
TA-54	0.026	---	---	---	---	---	---	---	---	---	---
TA-55	0.40	---	---	---	---	---	---	---	---	---	---

[a]Mixed fission products.

[b]The half-lives of ^{11}C, ^{13}N, and ^{15}O range from about 2 to 20 minutes, so these nuclides decay rapidly.

TABLE E-XXII

QUALITY OF EFFLUENTS FROM LIQUID RADIOACTIVE WASTE TREATMENT PLANTS

	Waste Treatment Plant Location			
	TA-50		TA-21	
Radioactive Isotopes	Activity Released (mCi)	Average Concentration (μCi/mℓ)	Activity Released (mCi)	Average Concentration (μCi/mℓ)
^{239}Pu	4.05	0.099×10^{-6}	0.313	0.10×10^{-6}
^{238}Pu	1.83	0.045×10^{-6}	0.223	0.072×10^{-6}
^{241}Am	1.73	0.043×10^{-6}	2.30	0.738×10^{-6}
^{89}Sr	2.64	0.065×10^{-6}	0.026	0.008×10^{-6}
^{90}Sr	10.4	2.57×10^{-7}	0.10	0.321×10^{-7}
^{3}H	12 300	0.30×10^{-3}	1780	0.57×10^{-3}
^{137}Cs	317	0.78×10^{-5}	1.40	0.045×10^{-5}
U-Total	176 grams	4.34×10^{-3} mg/ℓ	10.8 grams	3.46×10^{-3} mg/ℓ
Nonradioactive Constituents		**Average Concentration (mg/ℓ)**		**Average Concentration (mg/ℓ)**
Cd[a]		0.003		0.06
Ca		26.0		10.1
Cl		48.4		70.5
Cr[a]		0.04		0.49
Cu[a]		0.27		0.11
F		3.8		345
Hg[a]		0.009		0.002
Mg		1.4		2.0
Na		354		1650
Pb[a]		0.044		0.064
Zn[a]		0.46		0.26
CN		0.04		---
COD[a]		51		73
NO_3 (N)		90		423
PO_4		0.44		1.96
TDS[a]		1345		5440
pH[a]		6.8-12.3		6.3-13.1
Total Effluent Volume		4.058×10^{7} ℓ		3.118×10^{6} ℓ

[a]Constituents regulated by NPDES permit.

TABLE E-XXIII

ESTIMATED CONCENTRATIONS OF TOXIC ELEMENTS AEROSOLIZED BY DYNAMIC EXPERIMENTS

Element	1978 Total Usage (kg)	Percent Aerosolized (%)	Annual Avg. Concentration (ng/m³) 4 km	8 km	Applicable Standard (ng/m³)
Uranium	1371	10	0.1	0.05	9000[a]
Be	29.4	2	0.0008	0.0002	10[b] (30 day avg)
Pb	16.5	100 [c]	0.03	0.008	10 000 [b] (for total heavy metals, N>21)

[a]DOE Manual Chapter 0524.
[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.

TABLE E-XXIV

TOTAL SUSPENDED PARTICULATES AT LOS ALAMOS AND WHITE ROCK DURING 1978
(Data from New Mexico Environmental Improvement Agency)
All Concentrations in $\mu g/m^3$

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
				Los Alamos (Annual Geometric Mean = 36)								
No. of Samples	5	4	6	5	4	5	5	5	5	2	2	2
Maximum	63	47	63	111	40	60	45	58	98	30	38	29
Minimum	13	35	18	10	14	33	27	25	33	7	34	20
Mean ± 1 Standard Deviation	25 ± 21	42 ± 6	38 ± 15	61 ± 40	30 ± 13	51 ± 11	37 ± 7	46 ± 15	69 ± 37	18 ± 16	36 ± 3	25 ± 6
				White Rock (Annual Geometric Mean = 22)								
No. of Samples	5	5	4	0	0	0	0	0	2	5	4	
Maximum	32	24	172	---	---	---	---	---	---	23	38	32
Minimum	10	15	18	---	---	---	---	---	---	20	13	21
Mean ± 1 Standard Deviation	21 ± 9	20 ± 3	59 ± 76	---	---	---	---	---	---	21 ± 2	21 ± 11	26 ± 6

TABLE E-XXV

SANITARY SEWAGE TREATMENT FACILITIES
EFFLUENT QUALITY SUMMARY

Facility Location	NPDES Identification		Biochemical Oxygen Demand (BOD_5)[c]		Total Suspended Solids[d]		Fecal Coliform Bacteria[e]		pH[f]	
	Permit Number[a]	Outfall Serial No.[b]	Observed Range (mg/ℓ)	No. of Months Limits Exceeded	Observed Range (mg/ℓ)	No. of Months Limits Exceeded	Observed Range (mg/ℓ)	No. of Months Limits Exceeded	Observed Range	No. of Months Limits Exceeded
TA-3	NM0024210	01S	10-84	5	5-46	5	0-430000[g]	7	6.3-8.1	0
TA-9	NM0024295	02S	1-22	0	1-16	0	0-100[h]	0	6.7-8.8	0
TA-16	NM0024236	03S	4-22	0	3-44	1	40-15000[h]	3	6.6-8.3	0
TA-18	NM0024244	04S[i]	21-68	6	28-204	6	0-120[h]	0	6.8-10.3	6
TA-21	NM0024252	05S	9-103	7	9-137	6	0-37600[g]	5	6.1-7.8	0
TA-41	NM0024261	06S	1-28	0	7-43	1	0[h]	0	6.0-8.4	0
TA-46	NM0024341	07S[i]	3-26	0	1-14	0	0-640[h]	1	6.7-7.8	0
TA-48	NM0024741	08S	3-25	0	1-20	0	0-1200[h]	2	6.0-7.8	0
TA-53	NM0024279	09S[i]	37-67	4	28-143	4	1-1500[h]	1	8.9-10.5	5
TA-35	---	010S[i]	52	1	56	1	---[h]	---	9.2-9.7	3

[a]Individual permits effective 1/1/78 - 10/15/78.
[b]Single permit, NM 0028355, with separately designated outfalls effective 10/16/78.
[c]BOD_5 limits 30 mg/ℓ (20-day avg), 45 mg/ℓ (7-day avg).
[d]TSS limits 30 mg/ℓ (20-day avg), 45 mg/ℓ (7-day ave).
[e]Fecal coliform limits 200/100 mℓ for all individual permits through 10/15/78. Starting 10/16/78 limits of 2000/100 mℓ (daily max. and 1000/100 mℓ (geometric mean) apply only to outfall 01S (TA-3) and 05S (TA-21).
[f]pH limits not less than 6.0 or greater than 9.0 standard units.
[g]See footnote e for change in limit as of 10/16/78, new limit exceeded only by outfall 05S during one month.
[h]No fecal coliform limit for these outfalls after 10/15/78.
[i]Flow limits exceeded by these outfalls from lagoons during last quarter when far above average precipitation occurred.

TABLE XXVI

INDUSTRIAL LIQUID EFFLUENT QUALITY SUMMARY[a]

Dischage Category	No. of Outfalls	Permit Constituents	No. of Deviations	Range of Deviation/Limit Ratios or pH[b]	No. of Outfalls Causing Deviations
Power Plant	6	TSS	4	1.5.- 55	2[c]
		Free Cl	0	---	0
		pH	4	9.6.- 11.9	2[c]
Boiler Blowdown	4	TSS	0	---	0
		Fe	0	---	0
		Cu	2	1.3.- 42	1[c]
		P	0	---	0
		pH	10	10.4.- 12.4	3[c]
Treated Cooling Water	32	TSS	2	1.3.- 1.34	2
		Free Cl	0	---	0
		P	0	---	0
		pH	5	9.1.- 9.8	3
Non-contact Cooling Water	23	pH	0	---	0
Radioactive Waste Treatment Plant Discharges	2	NH_3	0	---	0
		COD	0	---	0
		TSS	0	---	0
		Cd	0	---	0
		Cr	0	---	0
		Cu	1	1.05	1
		Fe	0	---	0
		Pb	0	---	0
		Hg	0	---	0
		Zn	0	---	0
		pH	0	---	0
High Explosives Waste Discharges	20	COD	4	1.2.- 87	3[d]
		TSS	0	---	0
		pH	1	4.8	1
Photo Waste Discharges	14	CN	0	---	0
		Ag	0	---	0
		pH	1	9.6	1
Printed Circuit Board Development Wastes	1	COD	0	---	0
		Cu	0	---	0
		Fe	1	1.1	1
		Ni	0	---	0
		P	0	---	0
		pH	0	---	0
Acid Dip Tank Rinse	1	Cu	1	1.01	1[c]
		pH	1	5.3	1[c]
Gas Cylinder Cleaning Waste	1	TSS	0	---	0
		P	0	---	0
		pH	0	---	0

[a]Summary of reports to EPA or NPDES Permit NM0028355, which was effective starting 10/16/78.

[b]pH range limit on all outfalls is not less than 6.0 or greater than 9.0 standard units.

[c]Outfalls responsible for deviations to be corrected during 1979-80 by funded projects.

[d]One of the 3 outfalls scheduled for funded corrective measures.

TABLE E-XXVII

CHEMICAL QUALITY OF WATER IN VICINITY OF FENTON HILL
(average of a number of analyses)

	Surface Water	Water Supply	Springs (Jemez Fault)	Springs (Volcanics)	Abandoned Well	Fenton Hill (Pond Fluids)
No. of Stations[a]	9	4	2	1	1	2
No. of Analyses	9	4	2	1	1	2
Chemical (mg/ℓ)						
SiO_2	33 ± 9	66 ± 15	47 ± 0.7	52	67	115 ± 13
Ca^{2+}	17 ± 5	17 ± 9	137 ± 59	12	26	64 ± 30
Mg^{2+}	3 ± 0.7	3 ± 1	12 ± 0	4	9	6 ± 1
Na^{+}	13 ± 8	14 ± 1	595 ± 494	10	120	411 ± 267
CO_3^{2-}	0 ± 0	0 ± 0	0 ± 0	0	0	0 ± 0
HCO_3^{-}	40 ± 28	78 ± 21	633 ± 284	58	370	337 ± 120
SO_4	20 ± 23	9 ± 9	32 ± 3	<1	5	120 ± 109
Cl^{-}	11 ± 13	6 ± 3	921 ± 785	4	9	657 ± 655
F^{-}	0.4 ± 0.2	0.4 ± 0.1	2.9 ± 0.2	0.9	1.2	8 ± 14
NO_3^{-}	0.4 ± 0.0	0.5 ± 0.3	0.4 ± 0	0.2	0.4	0.4 ± 0
TDS	143 ± 45	226 ± 76	2234 ± 1646	114	480	2013 ± 1322
Hard	55 ± 14	56 ± 27	392 ± 146	44	102	184 ± 82
pH	6.7 ± 1.2	7.4 ± 0.2	7.2.± 0.2	7.2	7.8	7.8 ± 0.1
Conductance mS/m	20.1 ± 7.5	24.5 ± 13.7	384.0 ± 255.3	12.0	74.0	333.0 ± 248.3
Total U μg/ℓ	0.9 ± 0.7	1.0 ± 0.9	1.3 ± 0.1	1.2	<0.1	1.2 ± 0.2

[a]Sampling locations key on Fig. 15 as follows:

Surface Water—Locations F, J, N, Q, R, S, T, U, V.
Water Supply—Locations JS 2-3, JS 4-5, FH-1, 4.
Spring (Jemez Fault)—Locations JF-1, JF-5.
Spring (Volcanics)—Location 31.
Abandoned Well—Location 27.
Fenton Hill (pond fluids)—Two ponds TA-57.

Note: ± value is standard deviation of the distribution of a number of analyses.

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- E. P. Forest

Lawrence Livermore Laboratory
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- V. Noshkin

Mound Laboratory
- A. G. Barnett
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Oak Ridge National Laboratory
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Pantex Plant
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Sandia Laboratories, Albuquerque
- L. W. Brewer
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- J. L. Crandall
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- D. T. Wruble, EMSL, Las Vegas, NV
- A. W. Bush, Region 6, Dallas, TX
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Local Media
Los Alamos Monitor, Los Alamos, NM
Santa Fe New Mexican, Santa Fe, NM
Albuquerque Journal, Albuquerque, NM
KRSN Radio, Los Alamos, NM
KGGM TV, Albuquerque, NM
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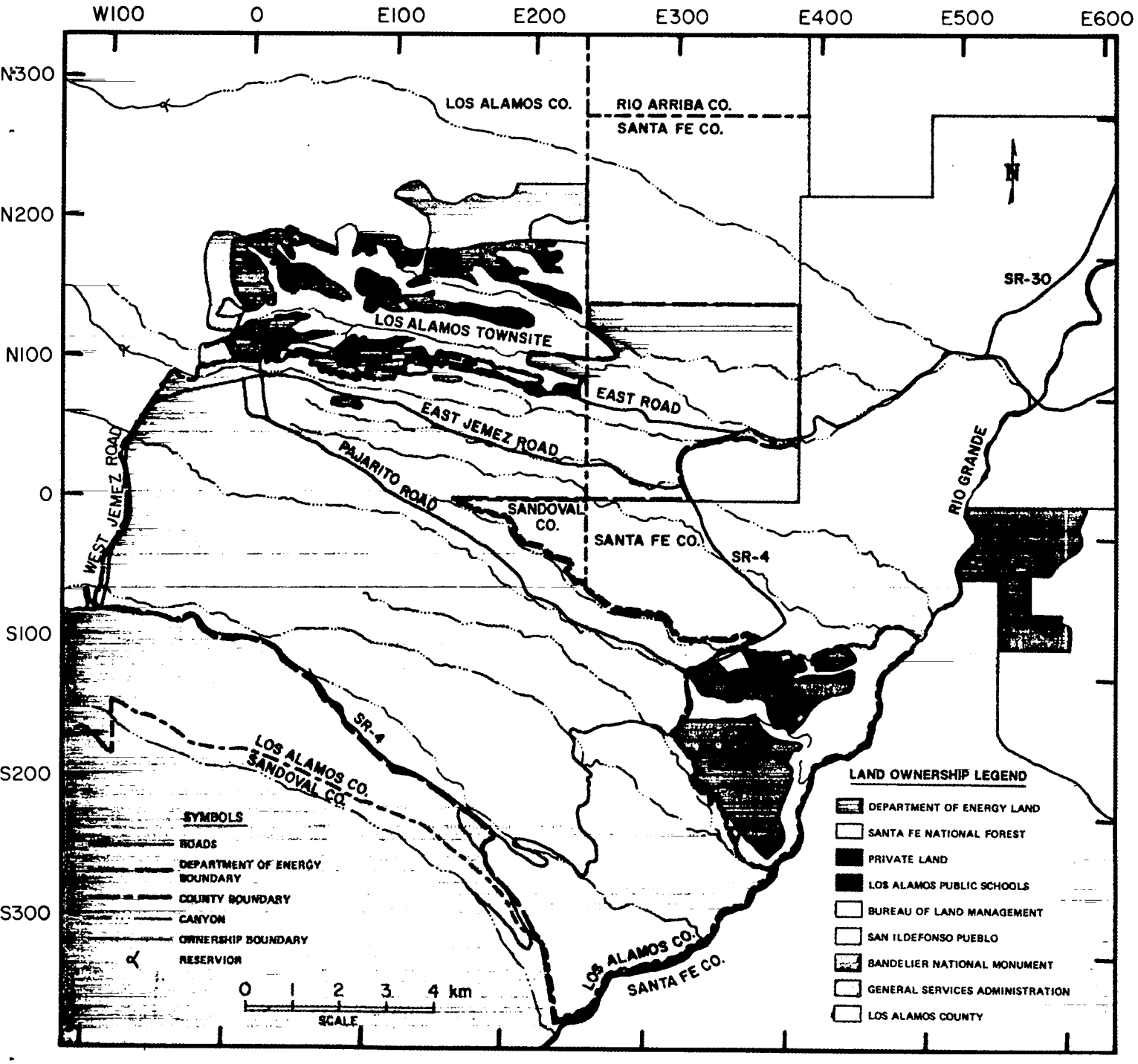

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