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QUALITY ASSURANCE PLAN FOR

WATER, SOIL, SEDIMENTS, AND WATER SUPPLY SAMPLING

AT LOS ALAMOS NATIONAL LABORATORY

prepared by:

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1.1 Introduction

This Quality Assurance Project Plan is being prepared in accordance with US Department of Energy's (DOE) Order 5700.6A ("Quality Assurance," August 1981). The purpose of the plan is to identify procedures for water, soil and sediment sampling and processing, for data reduction, and for ensuring the accuracy of the conclusions drawn from this monitoring program. The content of the plan conforms with the requirements of DOE report DOE/EH/XXXX ("DOE Requirements for Radiological Effluent Monitoring and Environmental Surveillance," Draft 1986), and US Environmental Protection Agency (EPA) report EPA-600-83-004 ("Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," February 1983).

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3. PROJECT DESCRIPTION

3.1 Routine Surveillance

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

This project presents Quality Assurance for monitoring radiochemical and chemical quality of water from Regional, Perimeter, and onsite stations. The section also includes radiochemical quality of soil and sediments.

Routine surveillance and sampling locations for various types of measurements are organized into three groups: (1) Regional stations are located within the five counties surrounding Los Alamos County (Fig. 1) at distances up to 80 km (50 mi) from the Laboratory. They provide a basis for determining conditions beyond the range of potential influence from Laboratory operations. (2) Perimeter stations are located within 4 km (2.5 mi) of the Laboratory boundary, and many are in residential

and community areas. They document conditions in areas regularly occupied by the public and potentially affected by Laboratory operations. (3) Onsite stations are within the Laboratory boundary, and most are in areas accessible only to employees during normal working hours. They document environmental conditions at the Laboratory where the public has limited access.

3.2 Water Supply Surveillance

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

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

The water supply surveillance also include documentation of hydrologic characteristics of the main aquifer in the supply wells and the well fields. The documentation is to ensure of continuing historical record and provide guidance for management

of water resources and long-range planning for the water supply system.

This report also presents the Quality Control Assurance of monitoring the radiochemical and chemical quality of water from supply wells, gallery, and hydrologic characteristics of wells and gallery in the distribution system.

4. PROJECT ORGANIZATION

The following presents an outline of the Los Alamos National Laboratory from the director to personnel engaged in the monitoring.

Director's Office

S. Hecker, Director

A. Tiedman, Environmental Compliance Management Office

Health, Safety, and Environment Division

J. Aragon, Division Leader

W. Hansen, Associate Division Leader, Environment

T. Gunderson, Group Leader, Environmental Surveillance Group, HSE-8

T. Buhl, Associate Group Leader, Environmental Surveillance Group, HSE-8

W. D. Purtymun, Staff Member, HSE-8

M. N. Maes, Technician, HSE-8

5. QUALITY ASSURANCE OBJECTIVES

Representative sampling locations have been chosen to monitor the effects of the Laboratory's operation on surface and ground water, soil, and sediments in offsite locations (Regional and Perimeter stations) and onsite locations (none effluent and effluent release areas).

As to completeness, all sample results are reported. If outliers occur, they are either explained or station or stations resampled to confirm or reject outlier analyses. Completeness and accuracy can not be established without a continuous sample of the entire system; however, the sampling schedule (time of collection) has been established to encompass the two extremes in the hydrologic conditions, spring and fall.

The quality assessment objective is to provide control in preparing quality, accurate, conformity of data to evaluate the Laboratory's impact on the hydrologic environment. This is accomplished by documentation of methods of collection, analyses data reduction, interpretation, and reporting.

6. SAMPLING PROCEDURES

6.1 Routine Surveillance (Selection, Location, and Description)

Station selection and location are based on waste disposal location and geohydrology up and down gradient from the point of effluent discharge. Major means of transport is hydrological, principally in surface water, sheet erosion of soil, and runoff as suspended sediments or bedload. The physiographic setting of the Laboratory is presented in Appendix A. The geology and hydrology discussed in Appendix A is the basis for the selection and location of monitoring stations. A list of reports dealing with the geohydrology of the area and disposal systems which factor into location of monitoring stations are found in Appendix B.

6.2 Water Supply Surveillance (Selection, Location, and Description)

Well location and spacing was developed to insure a maximum water supply from each individual well and well field. The location of the wells were developed upon the best possible geohydrologic information at the time the well was located. Spacing between wells was developed to insure minimum effect on the aquifer as the wells were being pumped. Reports that are related to well locations and development of water supply are found in Appendix C. All wells are sampled in the surveillance program.

Pan Am World Services, Inc., Utilities Department is the utility support contractor to the Los Alamos National Laboratory. Pan Am maintains and operates the water supply system. Water is pumped from wells through distribution lines, and lifted by booster pumps through chlorination stations into reservoirs for storage and distribution to the community and Laboratory areas. Water from the gallery flows by gravity through microfilter and chlorination stations and is pumped into one of the system reservoirs for distribution. The Utilities Department maintains

monthly records of hours of operation on each well, along with records of daily and monthly production. Monthly average nonpumping and pumping water levels are computed from air-line pressure or transducer data recorded continuously at each well. These data provide input for calculating pumping rates, drawdown (difference between nonpumping and pumping water levels), and other well-field statistics that are included in this report.

Hydrologic characteristics of wells, well fields, and gallery that furnishes water to Los Alamos is compiled annually. The reports are published as Laboratory reports (Appendix D). The reports (Appendix D) also contains annual pumping and production information for each supply well and the gallery for the period of record which extends back to the life of the well.

6.3 Past Surveillance History

The past monitoring history is an important factor in Quality Control. Long periods of record from a station establish particular radiochemical and/or chemical type of water, soil, or sediment. Any derivation from that type indicates 1) a change related to outside influences or 2) problems in sample collection, preparation or analyses. In either case the sample will have to be recollected and analyzed to see if change is real or if collection and analyses is the problem.

Los Alamos has a record of radiochemical and chemical data that extends back to 1949. The series of reports presenting this data are found in Appendix E. Many of the stations reported data have remained at the same location since they were established.

6.4 Surveillance Station Locations

The most effective monitoring net has evolved over the year with the collection data. Stations are located to provide background data, the most effective locations to intercept any

contamination from the Laboratory, and data required by state and federal agencies.

6.4.1 Surface and Ground Water

A discussion of the surface water, ground water, soil, and sediment stations with reference to purpose, location, and geohydrology is found in Appendix F. They are documented according to location, water from regional, perimeter, onsite and water supply station.

6.4.2 Soil and Sediments

The soil and sediment stations are also located to provide background data and to intercept and follow any contamination related to Laboratory operations. Location and description of station is found in Appendix G. The documentation is also based on location, regional, perimeter, onsite, and reservoir sediment stations.

6.4.3 Miscellaneous Investigations

Transport of radionuclides and chemicals in storm runoff are monitored in waste disposal areas (TA-54, solid waste disposal area; Pueblo and Los Alamos Canyon, industrial liquid effluent release area). The monitoring is performed to determine the concentrations of contaminates and if contaminates are being carried from these waste areas. Description and location of stations are found in Appendix H.

6.4.4 Water Supply

Water supply at Los Alamos is from 17 wells located in three well fields and a gallery (spring) on the flanks of the mountain west of Los Alamos. Water from these sources are for municipal and industrial use. A small amount of water from two reservoirs furnishes is used for irrigation of lawns at Laboratory or County

buildings. Locations and descriptions of supply wells and test wells completed into the main aquifer and found in Appendix I.

The main aquifer is the only aquifer in the area capable of municipal and industrial supply. Supply wells and test wells are used to monitor any effect the Laboratory's operation may have on the main aquifer.

6.5 Sample Collection Methods

6.5.1 Water Samples

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

Storm runoff samples are collected about 6 cm above the stream channel. The runoff sample collected above the channel contains suspended sediments which are in some cases analyzed for radionuclides or chemical constituents.

6.5.2 Soil Samples

The soil sampling procedure is used to take surface composite samples. Soils samples are collected by taking 5 plugs, 75 mm (3.0 in.) in diameter and 50 mm (2.0 in.) deep from a 10 m square. Plugs of soil are taken from the four corners and one in the center. The five plugs are combined to form a composite sample for radiochemical analysis.

6.5.3 Sediment Samples

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

the beds of intermittently flowing streams are collected in the main channel. The samples are collected to a depth of about 4 cm across the main channel of a intermittent stream. The samples are placed in a polyethene zip lock bag.

Suspended sediments are collected in runoff sample 4 cm above the channel along with water to be analyzed for specific constituents or suspended sediment concentrations.

6.6 Sample Containers

This section deals with sample bottle or container preparation, and analyses requirements.

6.6.1 Radiochemical

The water samples are collected in 4-ℓ (for radiochemical) polyethylene bottles. The 4-ℓ bottles are acidified in the field with 5 ml of concentrated nitric acid and returned to the laboratory within a few hours of sample collection for filtration through a 0.45-μm pore membrane filter. The filtrate portion of the samples then are prepared by chemist for analyses.

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

6.6.2 Chemical (inorganic)

Water samples are collected in a 1-ℓ polyethylene bottle for routine chemical analyses. For mercury analyses, the sample is collected in a 0.5-ℓ polyethylene bottle with 40 ml of nitrate acid and 25 mg of potassium dichromate added. The samples are returned to the laboratory within 4 to 6 hours and filtered

through 0.45-μm pore membrane filters. The chemist then completes preparation of the filtrate for analyses.

Soil and sediment samples for inorganic analyses are placed in a polyethyene zip lock bag.

6.6.3 Chemical (organic)

Water samples are semivolatile organic analyses are collected in a 1-ℓ glass bottle with a teflon seal cap. Water samples for volatile organic analyses are taken in a special 50 ml bottle with teflon cap so that water can be extracted with a hypodermic needle. Bottles are filled so that there is no air spaces between fluid and cap.

Soil and sediment samples for semivolatile analyses are collected in a wide mouth 1-ℓ glass bottle with a teflon seal cap. They are filled so that no air space occurs between soil or sediments and cap.

All samples for organic analyses are placed in an ice chest at collection for transport and receiving at the analytical laboratory. The temperature is 1 to 2°C.

6.7 Analyses Requested

The analyses requested depends on the location of the area monitored.

6.7.1 Radiochemical

Water from regional, perimeter, onsite, and water supply (wells and distribution) are analyzed for ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, total ^{3}H, and gross gamma activity. Water samples from former and active effluent release areas may also be analyzed for ^{241}Am and ^{90}Sr.

Soil and sediments from regional, perimeter, and onsite stations are analyzed for ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, total U, and gross gamma. Water from soil samples is extracted and analyzed for ^{3}H. In addition, sediments from former and active effluent release areas may be analyzed for ^{241}Am and ^{90}Sr.

Water samples from supply wells and distribution are analyzed for gross alpha and gross beta radioactivity as well as ^{226}Ra if necessary.

The frequency of water sample collection and analyses is twice during the years from the regional, perimeter, onsite, and water supply stations. Soil and sediment samples are collected annually.

6.7.2 Chemical (inorganic)

Routine chemical analyses are performed on all water samples from the regional, perimeter, onsite, and water supply stations. Routine analyses are for sixteen parameters:

SiO_2	SO_4
Ca	Cl
Mg	F
K	N
Na	TDS (total dissolved solids)
CO_3	Total hardness
HCO_3	pH
P	Specific conductance

Water supply from wells and distribution systems are analyzed for the parameters regulated by the federal Primary Drinking Water Standards (USEPA 1976, see Appendix J for standards).

Ag	F
As	Hg
Ba	N
Cd	Pb
Cr	Se

Water supply from the wells and distribution systems are also analyzed for the parameters regulated by the Federal Secondary Drinking Water Standards (USEPA 1979, see Appendix J for standards).

Cl	SO_4
Cu	Zn
Fe	TDS (total dissolved solids)
Mn	pH

The standards require collection and analyses for primary and secondary standards once every three years. As the supply

wells and distribution serve as part of the monitoring network of station, sample collection and analyses are performed annually.

6.7.3 Chemical (organic water)

Chemical organic analyses are performed for volatile and semivolatile organics. Type of organic analyses varies from the 129 priority pollutants as described by the USEPA to specific herbicides, pesticides, polychlorinated biphenols, and various oils and solvents. These samples are collected as deemed necessary. There are no USEPA standards. The presence of organics in any concentration above limits of detection may be classes as a toxic concentration (see Appendix K for Limits of Detection).

6.7.4 Chemical (soil and sediments)

Soil and sediment samples may be collected for metal ion analyses and organic analyses. Metal ions may include:

As	Ni
Ba	Be
Cd	Cy
Cr	SO_4
Pb	N
Se	pH
Ag	

Organic analyses of soil and sediments range from volatile to semivolatile organic compounds, the 129 priority pollutants, individual herbicides, pesticides, PCB, oils or solvents. Samples are collected to monitor specific operations within the laboratory (see Appendix J for standards for soil and sediments).

7. SAMPLE CUSTODY

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

7.1 Pre-Sampling Conference

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

The discussion includes:

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

7.2 Documentation and Chain of Custody

The HSE-9 Chemistry Group issues to the collector a block of sample numbers (i.e., 86.0071) with individual numbers assigned by the collector to individual stations. These sample numbers follow the sample from collection through analyses and posting of individual results.

Each number is assigned to a particular sample and is entered into the collector's log book. After the sample is collected, the date, time, temperature (if water), other pertinent

information, and remarks are entered opposite sample number and station previously listed in the log book.

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

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

The analytical request form contains the following information related to ownership and sample program (1) requestor (i.e., sample collector), (2) program code, (3) sample owner (i.e., program manager), (4) date, and (5) total number of samples. The second part of the request form contains (1) sample number or numbers, (2) matrix (i.e., water), (3) type of analyses (i.e., specific radionuclide and/or chemical constituent), (4) technique (i.e., analytical method to be used for individual constituents), (5) analyst (i.e., chemist to perform analyses), (6) priority of sample or samples, and (7) remarks. One copy of the form goes to the collector for his file and the other copies follow the sample. The analytical results from HSE-9 are returned to the sample collector through computer printout "keyed" to sample number.

The collector post the data according to sample number, location (regional, perimeter, etc.) and station on a recap table (rough). The table is typed, (finished) for inclusion as an appendix for the surveillance report. Data from the table is used to compile a recap table for the report.

Examples of the collectors log book, HSE-9 Analytical Chemical Request Form, HSE-9 analyses results, recap table (rough), table (finished) and recap table used in report is found in Appendix L.

8. CALIBRATION PROCEDURES AND FREQUENCY

Equipment used in routine collection of water, soils, and sediments requires no calibration. Discharge from supply wells is metered, meters are checked when anomolies occur. Water levels in supply wells are monitored either by air-lines or transducers. They are calibrated (measured with electric probes or engineers tape) when installed. They are checked and recalibrated if anomolies of water levels are reported.

9. ANALYTICAL PROCEDURES

Radiochemical and chemical analyses are performed by HSE-9 (Chemistry Group). A description of analytical procedures, methods used, and limit of detection for radionuclides and chemicals are presented in Appendix K.

10. DATA REDUCTION, VALIDATION, AND REPORTING

Analytical results from HSE-9 (Chemistry) section are compiled into tables according to (1) location (regional, perimeter, or onsite); (2) matrix (water, soil, or sediment); and (3) location (ascending gradient in hydrologic system).

Data is then reduced to produce each section a minimum maximum, and mean value with one standard deviation. Maximum values are compared to standards, i.e. DOE concentration guides for radioactivity in controlled (onsite) and uncontrolled (offsite) areas or federal drinking water standards.

Soil and sediment data is reduced similarly and the results are compared to regional values compiled over a previous five year period.

Anomolies in analytical results are evaluated to possible cause, health effects, or if necessary reevaluation of analytical results by resampling and analyses.

Hydrologic data related to the supply wells is compiled over and reported annually. Trends or anomolies if they occur are investigated and causes determined and reported.

Radiochemical and chemical data from regional, perimeter, onsite, water supply, and miscellaneous study stations is reported in the annual environmental surveillance report (see Appendix E). Hydrologic characteristics of supply wells, well fields, gallery, and distribution are reported annually in the water supply for Los Alamos (see Appendix C).

As an example, summary of the annual surveillance report for 1985 is found in Appendix M while a summary of the Water Supply report is included as Appendix N.

11. INTERNAL QUALITY CONTROL CHECKS

Internal quality control checks on the radiochemical and chemical analyses are maintained by HSE-9 (Chemistry Group). Informal checks are maintained by HSE-8 Surveillance Operation Section by comparison of analytical results to previous results. If anomolies occur, they are investigating to determine the cause.

In the same manner all hydrologic data received from Pan Am World Services is informally reviewed and if anomolies occur, cause of anomaly is determined.

The annual surveillance report is reviewed internally within the HSE-8 Group, HSE Division Office, and Department of Energy offices in Los Alamos and Albuquerque.

The annual water supply report is reviewed internally by the group, the Division Office, the Laboratory Engineering Division Office, Pan Am World Services Engineering Section, and Los Alamos Department of Energy Engineering Section.

The review of the annual surveillance and water supply reports provide internal quality control checks for the programs.

12. PERFORMANCE AND AUDIT SYSTEMS

Periodically, Department of Energy representatives provide onsite review of monitoring activities, quality assurance, and accountability related to the surveillance and water supply programs.

13. PREVENTATIVE MAINTENANCE

Sampling procedures and equipment to be used are discussed, equipment evaluated, and additional supplies obtained prior to field work. Pumps on test wells are inspected and maintained by the Laboratory's ENG-4 Group. Pumps on supply wells and at booster stations are maintained by Pan Am World Services. Any anomaly of well performance or pumps on wells as determined by HSE-8 by evaluation of hydrologic data are discussed with Pan Am. The rehabilitation or repair, if necessary, will be scheduled, if possible, to a period of low demand for water supply.

14. SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

As discussed previously as to radiochemical and chemical analyses, quality control is maintained by HSE-9 (Chemistry Group). The sample locations are chosen by best available hydrologic and geologic data to assess possible transport of contaminants. Results of analyses are reviewed to evaluate transport and health effects if contaminants have moved and are present. The interpretation of the data is based on geohydraulic conditions as well as past accumulation of data at each station.

Thus the specific routine procedures used to access data precision, accuracy, and completeness is not a procedure discussed in a formal since but is a built in informal evaluation that has been in use for years.

15. CORRECTIVE ACTION

Corrective action may become necessary when unexplained anomolies occur in the radiochemical, chemical, or hydrologic data. The action may consist or resample and analyses of samples, recalibration of airline or transducers or in the case of well failure examination of the casing with a down hole TV camera.

As new radiochemical, chemical, or hydrologic data becomes available it may become necessary to relocate sampling stations to obtain the best possible data to evaluate the Laboratory's operation in relation to release, disposal, or storage of wastes.

16. QUALITY ASSURANCE REPORTS TO MANAGEMENT

There are no formal Quality Assurance reports to management; however, informal reports in the form of the "Environmental Surveillance at Los Alamos" (ESG 1986) and "Water Supply at Los Alamos" (Purtymun 1986) are submitted annually. Other forms of informal reports, not necessary quality assurance, are memos and conferences with section leaders, group, and division personnel or Pan Am personnel when problems do occur in general monitoring and water supply studies.

REFERENCES

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

DOE 1981B: U.S. Department of Energy Order 5481.1A, Chapter XI, "Requirements for Radiation Protection" (April 1981).

DOE 1981C: U.S. Department of Energy Order 5700.6A, "Quality Assurance" (August 1981).

DOE 1986: U.S. Department of Energy "Department of Energy Requirements for Radiological Effluent Monitoring and Environmental Surveillance," DOE Draft Report (1986).

ESG 1986: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1985," Los Alamos National Laboratory Report LA-10721-ENV (April 1986).

Purtymun 1986: W. D. Purtymun, N. M. Becker, and M. N. Maes, "Water Supply at Los Alamos During 1985," Los Alamos National Laboratory Report LA-10835-PR (October 1986).

USEPA 1976: U.S. Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," USEPA Report EPA-570/9-70-003 (1976).

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

APPENDIX A

PHYSIOGRAPHIC SETTING OF THE LOS ALAMOS NATIONAL LABORATORY

A. Geographic Setting

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

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

B. Land Use

Most Laboratory land is used for building sites, test areas, waste disposal locations, roads, and utility rights-of-way (Fig. 3). However, these account for only a small fraction of the total land area. Most land provides isolation for security and safety and is a reserve for future structure locations. The Long Range Site Development Plan assures adequate planning for the best possible future uses of available Laboratory lands.

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

C. Geology-Hydrology

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

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

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

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

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

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

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

Water in the main aquifer is under water table conditions in the western and central part of the Plateau and under artesian conditions in the eastern part and along the Rio Grande. The major recharge area to the main aquifer is from the intermountain basin of the Valles Caldera in the Jemez Mountains west of Los Alamos. The water table in the caldera is near land surface. The underlying lake sediment and volcanics are highly permeable and recharge the aquifer through Tschicoma Formation interflow breccias (rock consisting of sharp fragments embedded in a fine-grained matrix) and the Tesuque Formation. The Rio Grande receives groundwater discharge from springs fed by the main aquifer. The 18.4 km (11.5 mi) reach of the river in

White Rock Canyon between Otowi Bridge and t he 6.8 x 10^3 m^3 (4300 to 5500 acre-feet) annually from the aquifer.

D. Climatology

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

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

F. Population Distribution

Los Alamos County has an estimated 1985 population of approximately 19,200 (based on the 1980 census adjusted for 1985). Two residential and related commercial areas exist in the county (Fig. 3). The Los Alamos townsite, the original area of development (and now including residential areas known as the Eastern Area, and Western Area, North Community, Barranca Mesa, and North Mesa), has an estimated population of 12,050. The White Rock area (including the residential areas of white Rock, La Senda, and Pajarito Acres) has about 7160 residents. About one-third of those employed in Los Alamos commute from other counties. Population estimates for 1985 place about 170,000 people within an 80 km (50 mi) radius of Los Alamos.

F. Programs at Los Alamos National Laboratory

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

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

In August 1977, the Laboratory site, encompassing 111 km^2 (43 mi^2), was dedicated as a National Environmental Research Park. The ultimate goal of programs associated with this regional facility is to encourage environmental research that will contribute understanding of how man can best live in balance with nature while enjoying the benefits of technology. Park resources are available to individuals and organizations outside of the Laboratory to facilitate self-supported research on these subjects deemed compatible with the Laboratory programmatic mission.

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

Source: Environmental Surveillance at Los Alamos during 1985, Los Alamos National Laboratory report LA-10721-ENV (1986).

Table I

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the 32 active technical areas (TA) operated by the Laboratory are shown in Fig. 4. The main programs conducted at each are listed in this appendix.

TA-2, Omega Site: Omega West Reactor, an 8 megawatt nuclear research reactor, is located here. It serves as a research tool in providing a source of neutrons for fundamental studies in nuclear physics and associated fields.

TA-3, South Mesa Site: In this main technical area of the Laboratory is the Administration Building that contains the Director's office and administrative offices and laboratories for several divisions. Other buildings house the Central Computing Facility, Administration offices, Materials Department, the science museum, Chemistry and Materials Science Laboratories, Physics Laboratories, technical shops, cryogencis laboratories, a Van de Graaf accelerator, and cafeteria.

TA-6, Two Mile Mesa Site: This is one of three sites (TA-22 and TA-40 are the other two sites) used in development of special detonators for initiation of high explosive systems. Fundamental and applied research in support of this activity includes investigation of phenomena associated with initiation of high explosives, and research in rapid shock-induced reactions with shock tubes.

TA-8, GT Site (or Anchor Site West): This is a nondestructive testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapon components to checking of high pressure dies and molds. Principal tools include radiographic techniques (x-ray machines to 1 million volts, a 24-MeV betatron), radioactive isotopes, ultrasonic testing, penetrant testing, and electromagnetic methods.

TA-9, Anchor Site East: At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K-Site: Facilities are located here for testing explosive components and systems under a variety of extreme physical environments. The facilities are arranged so testing may be controlled and observed remotely, and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q-Site: This firing site is used for running various tests on relatively small explosive charges and for fragment impact tests.

TA-15, R-Site: This is the home of PHERMEX—a multiple cavity electron accelerator capable of producing a very large flux of x-rays for certain weapons development problems and tests. This site is also used for the investigation of weapon functioning and weapon system behavior in nonnuclear tests, principally by electronic recording means.

TA-16, S-Site: Investigations at this site include development, engineering design, pilot manufacture, environmental testing, and stockpile production liaison for nuclear weapon warhead systems. Development and testing of high explosives, plastics and adhesives, and process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18, Pajarito Laboratory Site: The fundamental behavior of nuclear chain reactions with simple, low-power reactors called "critical assemblies" is studied here. Experiments are operated by remote control and observed by closed circuit television. The machines are housed in buildings known as "kivas" and are used primarily to provide a controlled means of assembling a critical amount of fissionable materials. This is done to study the effects of various shapes, sizes, and configurations. These machines are also used as source of fission neutrons in large quantities for experimental purposes.

TA-21, DP-Site: This site has two primary research areas, DP West and DP East. DP West is concerned with chemistry research. DP East is the high temperature chemistry and tritium site.

Table I (cont)

TA-22, TD Site: See TA-6.

TA-28, Magazine Area "A": Explosives storage area.

TA-33, HP-Site: A major high-pressure tritium handling facility is located here. Laboratory and office space for Geosciences Division related to the Hot Dry Rock Geothermal Project are also here.

TA-35, Ten Site: Nuclear safeguards research and development, which is conducted here, is concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research in reactor safety and laser fusion is also done here.

TA-36, Kappa Site: Various explosive phenomena, such as detonation velocity, are investigated here.

TA-37, Magazine Area "C": Explosives storage area.

TA-39, Ancho Canyon Site: Nonnuclear weapon behavior is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interaction of explosives, and explosions with other materials.

TA-40, DF-Site: See TA-6.

TA-41, W-Site: Personnel at this site are engaged primarily in engineering design and development of nuclear components, including fabrications and evaluation of test materials for weapons.

TA-43, Health Research Laboratory: The Biomedical Research Group does research here in cellular radiobiology, molecular radiobiology, biophysics, mammalian radiobiology, and mammalian metabolism. A large medical library, special counters used to measure radioactivity in humans and animals, and animal quarters for dogs, mice and monkeys are also located in this building.

TA-46, WA-Site: Here, applied photochemistry, which includes development of technology for laser isotope separation and laser-enhancement of chemical processes, is investigated. Solar energy research, particularly in the area of passive solar heating for residences, is done.

TA-48, Radiochemistry Site: Laboratory scientists and technicians at this site study nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made and "hot cells" are used for remote handling of radioactive materials.

TA-50, Waste Management Site: Personnel at this site have responsibility for treating and disposing of most industrial liquid waste received from Laboratory technical areas, for development of improved methods of solid waste treatment, and for containment of radioactivity removed by treatment. Radioactive liquid waste is piped to this site for treatment from many of the technical areas.

TA-51, Animal Exposure Facility: Here, animals are exposed to nonradioactive toxic materials to determine biological effects of high and low exposures.

TA-52, Reactor Development Site: A wide variety of activities related to nuclear reactor performance and safety are done here.

TA-53, Meson Physics Facility: The Los Alamos Meson Physics Facility (LAMPF), a linear particle accelerator, is used to conduct research in the areas of basic physics, cancer treatment, material studies, and isotope production.

TA-54, Waste Disposal Site: This is a disposal area for solid radioactive and toxic wastes.

TA-55, Plutonium Processing Facilities: Processing of plutonium and research in plutonium metallurgy are done here.

TA-57, Fenton Hill Site: This is the location of the Laboratory's Hot Dry Rock geothermal project. Here scientists are studying the possibility of producing energy by circulating water through hot, dry rock located hundreds of meters below the earth's surface. The water is heated and then brought to the surface to drive electric generators.

TA-58, Two Mile Mesa. Undeveloped technical area.

TA-59, Occupational Health Site: Occupational health and environmental science activities are conducted here.

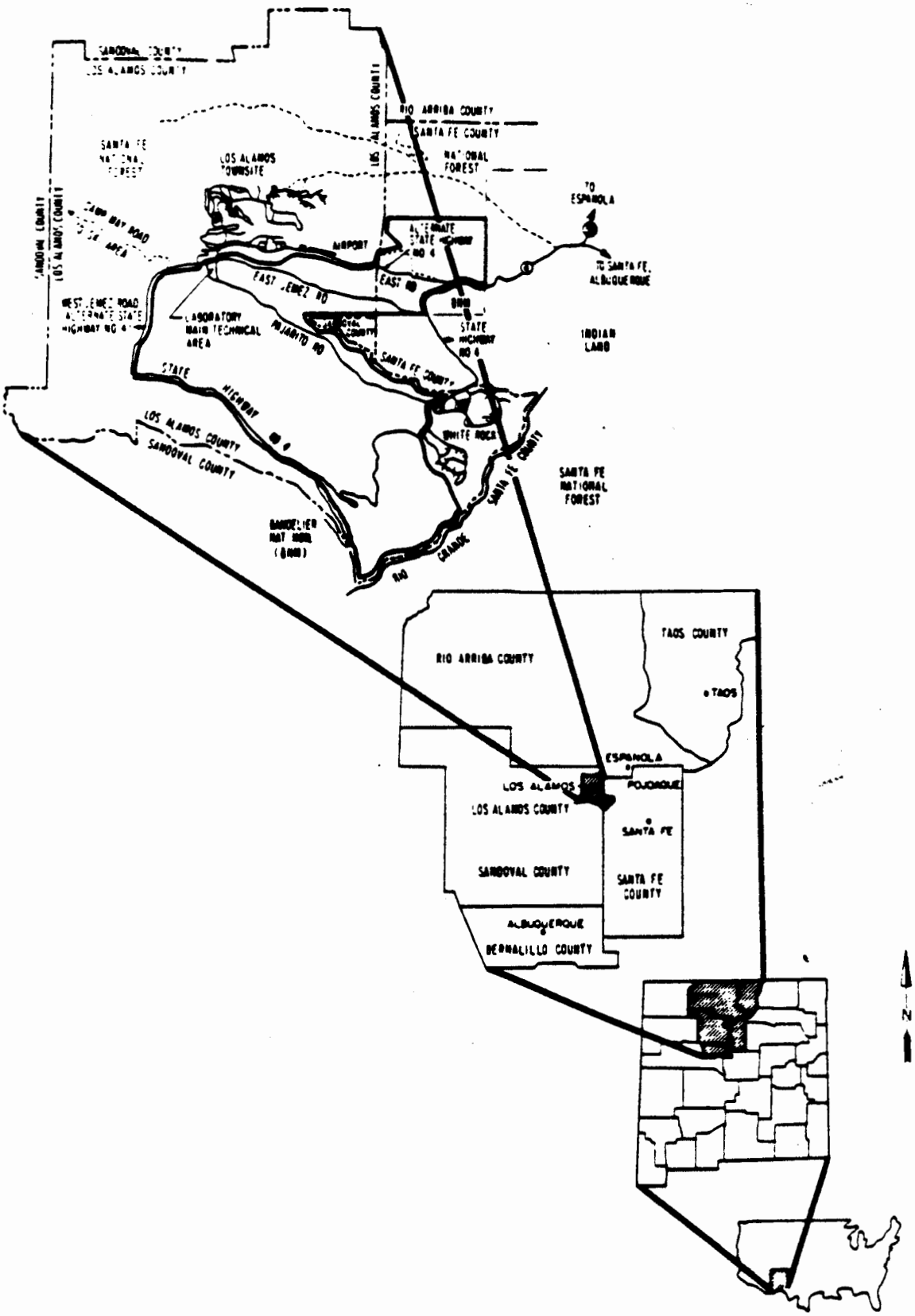


Fig. 1. Regional location at Los Alamos.

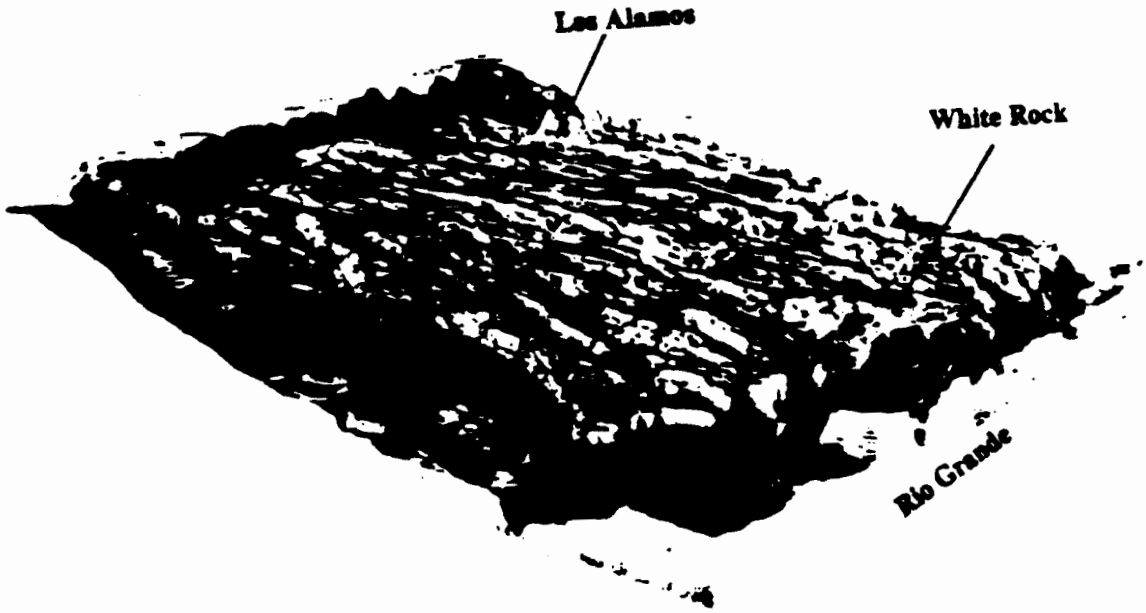


Fig. 2. Topography of the Los Alamos area.

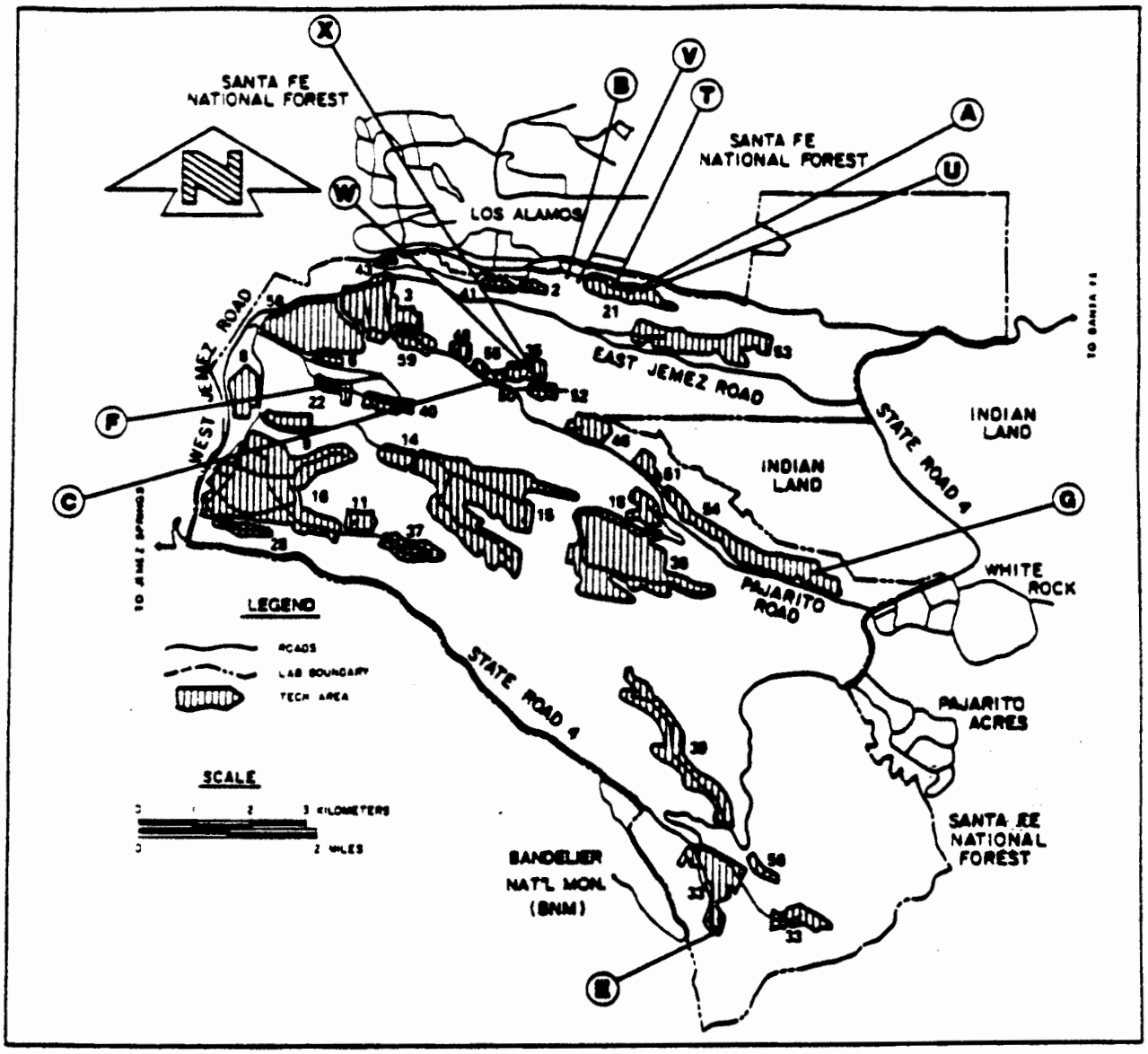


Fig. 3. Los Alamos National Laboratory's technical areas (TAs) and adjacent communities.

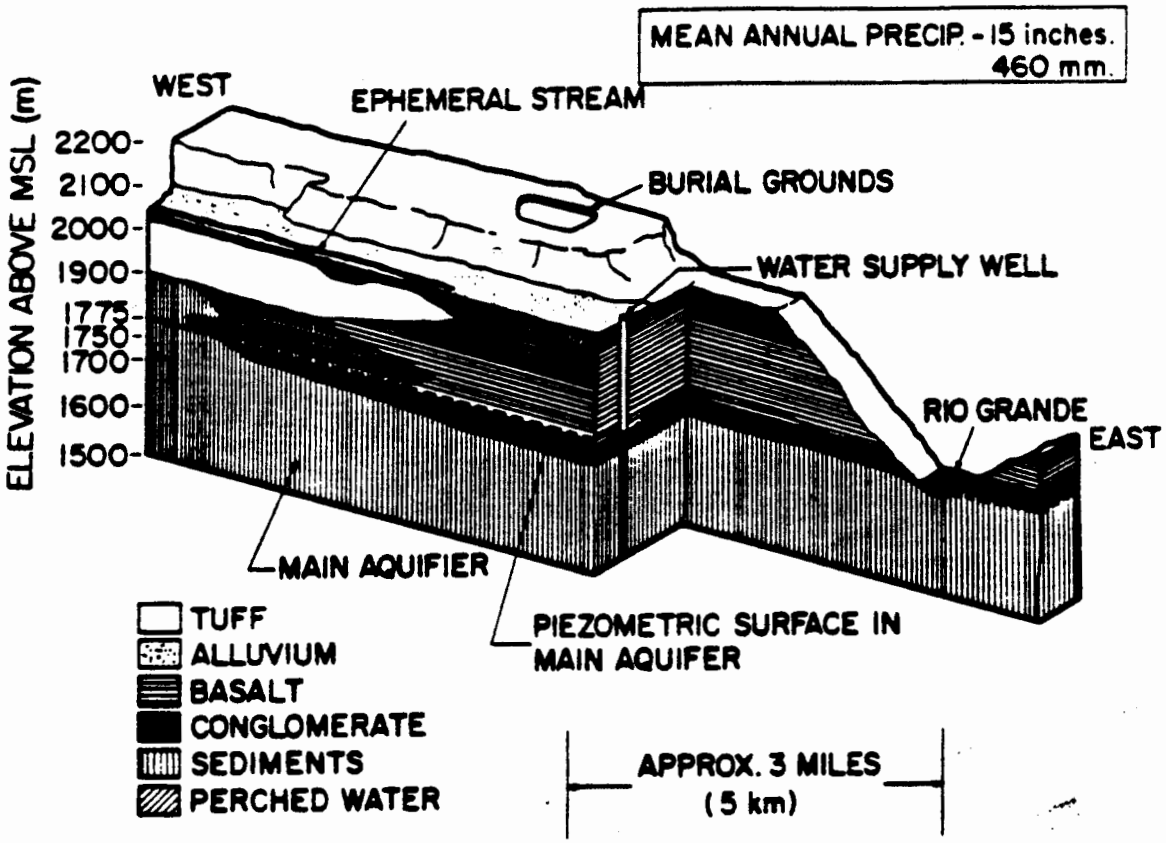


Fig. 4. Conceptual illustration of geologic-hydrologic relationships in the Los Alamos area.

APPENDIX B

LIST OF GEOLOGIC, HYDROLOGIC, AND WASTE DISPOSAL REPORTS OF THE LOS ALAMOS AREA

J. H. Abrahams, J. E. Weir, and W. D. Purtymun, "Distribution of Moisture in Soil and Near-Surface Tuff on the Pajarito Plateau, Los Alamos County, New Mexico." U.S. Geol. Survey Prof. Paper 424-D, p. D142 - D145 (1961).

J. H. Abrahams, E. H. Baltz, and W. D. Purtymun, "Movement of Perched Groundwater in Alluvium Near Los Alamos, New Mexico," U.S. Geol. Survey Prof. Paper 450-B (1962).

E. H. Baltz , J. H. Abrahams, and W. D. Purtymun, "Preliminary Report on the Geology and Hydrology of Mortandad Canyon Near Los Alamos, New Mexico, With Reference to Disposal of Liquid Low-level Radioactive Waste," U.S. Geol. Survey open-file report (1962).

W. D. Purtymun, "The Distribution of Moisture in the Soil and Underlying Tuff at Technical Area 49, Frijoles Mesa, Los Alamos County, New Mexico," U.S. Geol. Survey open-file report (1962).

J. E. Weir and W. D. Purtymun, "Geology and Hydrology of Technical Area 49, Frijoles Mesa, Los Alamos County, New Mexico," U.S. Geol. Survey open-file report (1962).

J. H. Abrahams, "Physical Properties and Movement of Water in the Bandelier Tuff, Los Alamos and Santa Fe Counties, New Mexico," U.S. Geol. Survey open-file report (1963).

C. S. Conover, C. V. Theis, and R. L. Griggs, "Geology and Hydrology of the Valle Grande and Valle Toledo, Sandoval County, New Mexico," U.S. Geol. Survey Water-Supply Paper 1619-Y (1963).

F. C. Koopman and W. D. Purtymun, "Hydrologic Characteristics of the Tshirege Member of the Bandelier Tuff with Reference to the Injection of Treated Low-level Radioactive Liquids," U.S. Geol. Survey open-file report (1964).

W. D. Purtymun, "Progress Report on the Hydrology of Mortandad Canyon, Disposal System for Treated Low-level Liquid Radioactive Wastes; July 1961 to June 1983," U.S. Geol. Survey open-file report (1964).

W. D. Purtymun, J. H. Abrahams, and J. R. Avrett, James R., "Hydrology of Waste Disposal Systems, Los Alamos, New Mexico, 194 through 1961:" U.S. Geol. Survey open-file report (1964).

W. D. Purtymun, "Geology and Hydrology of Area "G" Mesita del Buey, Los Alamos County, New Mexico:" U.S. Geol. Survey open-file report (1963).

Z. E. Spiegel, "Geology and Water Resources of the Santa Fe Area, New Mexico," U.S. Geol. Survey Water-Supply Paper 525 (1963).

R. L. Griggs, "Geology and Ground-Water Resources of the Los Alamos Area, New Mexico," U.S. Geol. Survey Water-Supply Paper 1753 (1964).

W. D. Purtymun and F. C. Koopman, "Physical Properties of the Tshirege Member of the Bandelier Tuff With Reference to Use as A Building and Ornamental Stone:" U.S. Geol. Survey open-file report (1965).

W.D. Purtymun, "Geology and Hydrology of White Rock Canyon from Otowi to the Confluence of Frijoles Canyon, Los Alamos and Santa Fe Counties, New Mexico:" U.S. Geol. Survey open-file report (1965).

W. D. Purtymun and W. R. Kennedy, "Distribution of Moisture and Radioactivity in the Soil and Tuff at the Contaminated Waste-pit Near Technical Area 21, Los Alamos, New Mexico:" U.S. Geol. Survey open-file report, 28 p., 15 figs.

E. C. John. E. Enyart, and W. D. Purtymun, "Records of Wells, Test Holes, Springs and Surface-water Stations in the Los Alamos Area, New Mexico:" U.S. Geol. Survey open-file report, 131 p., 10 figs.

W. D. Purtymun, G. L. Johnson, and E. C. John, "Distribution of Radioactivity in the Alluvium of a Disposal Area at Los Alamos, New Mexico," U.S. Geol. Survey Prof. Paper 550-D (1966).

W. D. Purtymun, J. H. Abrahams, and J. R. Arrett, "Hydrology of Waste Disposal Systems at Los Alamos, New Mexico, 1949 through 1961," U.S. Geol. Survey open-file report (1966).

W. D. Purtymun, "Disposal of Industrial Effluents into Mortandad Canyon, Los Alamos County, New Mexico," U.S. Geol. Survey open-file report (1966).

W. D. Purtymun, G. L. Johnson, and E. C. John, "Distribution of Radioactivity in the Alluvium of a Disposal Area at Los Alamos, New Mexico:" U.S. Geol. Survey Prof. Paper 550-D, p. D250 - D252 (1966).

W. D. Purtymun and E. Enyart, "Test on and Design of Disposal Wells at Los Alamos, New Mexico:" U.S. Geol. Survey open-file report (1967).

W. D. Purtymun, "Geology and Physical Properties of the Near-surface Rocks at Mesita de Los Alamos, Los Alamos County, New Mexico:" U.S. Geol. Survey open-file report (1967).

W. R. Kennedy and W. D. Purtymun, "Plutonium and Strontium in Soil Near Technical Area 21, Los Alamos Scientific Laboratory, Los Alamos, New Mexico." Los Alamos Scientific Laboratory report LA-4563 (1970).

W. R. Kennedy and W. D. Purtymun, "Geology and Hydrology of Mesita del Buey," Los Alamos Scientific Laboratory report LA-4660 (1971).

W. D. Purtymun, "Plutonium in Stream Channel Alluvium in the Los Alamos Area, New Mexico," Los Alamos Scientific Laboratory report LA-4561 (1971).

W. D. Purtymun, "Underground Movement of Tritium from Solid-Waste Storage Shafts," Los Alamos Scientific Laboratory report LA-5286-MS (1973).

W. D. Purtymun, "Dispersion and Movement of Tritium in a Shallow Aquifer in Mortandad Canyon at the Los Alamos Scientific Laboratory," Los Alamos Scientific Laboratory report LA-5716-MS (September 1974).

W. D. Purtymun, "Storm Runoff and Transport of Radionuclide in DP Canyon, Los Alamos County, New Mexico," Los Alamos Scientific Laboratory report LA-5744 (1974).

W. D. Purtymun and S. Johansen, "General Geohydrology of the Pajarito Plateau," New Mexico Geol. Society Guidebook, Ghost Ranch (Central-Northern, New Mexico), 25th Field Conf. (1974).

T. W. Hakonson, J. W. Nyhan, and W. D. Purtymun, "Accumulation and Transport of Soil Plutonium in Liquid Waste Disposal Areas as Los Alamos," in Transuranium Nuclides in the Environment, IAEA/ERDA Symp., IAEA-SM-199/99; Vienna, pp. 175-189 (1976).

W. D. Purtymun, J. R.Buchholz, and T. E. Hakonson, "Chemical Quality of Effluents and Their Influence on Water Quality in a Shallow Aquifer," J. of Environmental Quality 6 (1) (January-March 1977).

M. L. Wheeler, W. J. Smith, A. F. Gallegos, "A Preliminary Evaluation of the Potential for Plutonium Release from Burial Grounds at Los Alamos Scientific Laboratory," Los Alamos Scientific Laboratory report LA-6694-MS (1977).

M. A. Rogers, "History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T)," Los Alamos Scientific Laboratory report LA-6848-MS, Vols 1 and 2 (1977).

W. D. Purtymun, M. L. Wheeler, and M. A. Rogers, "Geologic Description of Cores from Holes P-3 MH-1 through P-3 MH-5, Area G, Technical Area 54," Los Alamos Scientific Laboratory report LA-7308-MS (1978).

W. D. Purtymun, M. A. Rogers, M. W. Wheeler, "Radiochemical Analyses of Samples from Beneath a Solid Radioactive Waste Disposal Pit at Los Alamos, New Mexico," Los Alamos National Laboratory report LA-8422-MS (June 1980).

W. D. Purtymun, R. J. Peters, and J. W. Owens, "Geohydrology of White Rock Canyon of the Rio Grande from Otowi to Frijoles Canyon," Los Alamos Scientific Laboratory report LA-8635-MS (1980).

W. D. Purtymun and H. Adams, "Geohydrology of Bandelier National Monument, New Mexico," Los Alamos Scientific Laboratory report LA-8461-MS (1980).

W. D. Purtymun, R. J. Peters, and A. K. Stoker, "Radioactivity in Soil and Sediments in and Adjacent to the Los Alamos Area, 1974-77," Los Alamos Scientific Laboratory report LA-8234-MS (1980).

Environmental Surveillance Group, "Radiological Survey of the Site of a Former Radioactive Liquid Waste Treatment Plant (TA-45) and the Effluent Receiving Areas of acid, Pueblo, and Los Alamos Canyons, Los Alamos, New Mexico, Final Report," Los Alamos National Laboratory report LA-8890-ENV/US Department of Energy report DOE/EV-0005/30 (May 1981).

W. D. Purtymun, W. R. Hansen, and R. J. Peters, "Radiochemical Quality of Water in the Shallow Aquifer in Mortandad Canyon 1967-1978," Los Alamos National Laboratory report LA-9675-MS (March 1983).

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

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

L. J. Lane, W. D. Purtymun, and N. M. Becker, "New Estimating Procedures for Surface Runoff, Sediment Yield, and Contaminant Transport in Los Alamos County, New Mexico," Los Alamos National Laboratory report LA-10335-MS (1985).

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

APPENDIX C

LIST OF WATER SUPPLY DEVELOPMENT REPORTS

Black and Veatch, Consulting Engineers, "Report on Water Supply, Los Alamos Project, Los Alamos, New Mexico," Kansas City, Mo., Admin. report prepared for US Atomic Energy Commission (1946).

W. D. Purtymun and R. L. Cushman, "Site Location for a Los Alamos Supply Well Near the 10-inch Water Main That Parallels State Highway 4 Between Pueblo Canyon and White Rock," U.S. Geol. Survey open-file report (1961).

C. V. Theis and C. S. Conover, "Plumbing Test in the Los Alamos Canyon Well Field near Los Alamos, New Mexico," U.S. Geol. Survey Water-Supply Paper 1619-I (1962).

W. D. Purtymun and R. L. Cushman, "Site for a Municipal Supply Well in Guaje Canyon or Rendija Canyon near Los Alamos, New Mexico," U.S. Geol. Survey open-file report (1963).

W. D. Purtymun and E. C. John, "Site for Municipal Supply Well in Pajarito Canyon Near Los Alamos, New Mexico:" U.S. Geol. Survey open-file report (1964).

R. L. Cushman, "An Evaluation of Aquifer and Well Characteristics of Municipal Well Fields in Los Alamos and Guaje Canyons Near Los Alamos, New Mexico," U.S. Geol. Survey Water-Supply Paper 1809-D (1965).

J. B. Cooper, W. D. Purtymun, and E. C. John, "Records of Water-Supply Wells Guaje Canyon 6, Pajarito Mesa 1, and Pajarito Mesa 2, Los Alamos, New Mexico, basic data report," U.S. Geol. Survey open-file report (1965).

W. D. Purtymun and J. B. Cooper, "Locations for Five Water-Supply Wells at Los Alamos, New Mexico," U.S. Geol. Survey open-file report (1965).

W. D. Purtymun, "Record of Water-Supply Well PM-3, Los Alamos, New Mexico," U.S. Geol. Survey open-file report (1967).

W. D. Purtymun and J. B. Cooper, "Development of Ground-Water Supplies on the Pajarito Plateau, Los Alamos County, New Mexico," U.S. Geol. Survey Prof. Paper 650-B (1969), B149-B153.

R. L. Cushman and W. D. Purtymun, "An Evaluation of the Yield and Water-Level Relationships," Los Alamos Scientific Laboratory report LA-6086-MS (1975).

W. D. Purtymun, "Hydrologic Characteristics of the Los Alamos Well Field with Reference to the Occurrence of Arsenic in Well LA-6," Los Alamos Scientific Laboratory report LA-7012-MS (1977).

Purtymun 1984: W. D. Purtymun, "Hydrologic Characteristics of the Main Aquifer in the Los Alamos Area: Development of Groundwater Supplies," Los Alamos National Laboratory report LA-9957-MS (1984).

Betty H. Olsen, " Los Alamos Bacterioiogical Studies of Groundwater," Programs in Social Ecology, University of California, Irvine, California (1984).

Raymond Kaiser Engineers and Kentron International, "Los Alamos National Laboratory Long-Range Utilities Development Plan," Preliminary Conceptual Plan, Los Alamos, New Mexico, (September 1984).

Corp of Engineers, "Los Alamos Water Supply Study," U.S. Army Corp of Engineers, Albuquerque District, Albuquerque, New Mexico (October 1984).

APPENDIX D

LIST OF ANNUAL WATER SUPPLY REPORTS

1. W. D. Purtymun and J. E. Herceg, Compilers, "Summary of Los Alamos Municipal Well-Field Characteristics, 1947-1971," Los Alamos Scientific Laboratory report LA-5040-MS (1972).

2. W. D. Purtymun and J. E. Herceg, "Water Supply at Los Alamos During 1971," Los Alamos Scientific Laboratory report LA-5039-MS (1972).

3. W. D. Purtymun and J. E. Herceg, "Water Supply at Los Alamos During 1972," Los Alamos Scientific Laboratory report LA-5296-MS (1973).

4. W. D. Purtymun and J. E. Herceg, "Water Supply at Los Alamos During 1973," Los Alamos Scientific Laboratory report LA-5636-MS (1974).

5. W. D. Purtymun, "Water Supply at Los Alamos During 1974," Los Alamos Scientific Laboratory report LA-5998-MS (1975).

6. W. D. Purtymun, "Water Supply at Los Alamos During 1985," Los Alamos Scientific Laboratory report LA-6461-PR (1976).

7. W. D. Purtymun, "Water Supply at Los Alamos During 1976," Los Alamos Scientific Laboratory report LA-6814-PR (1977).

8. W. D. Purtymun, "Water Supply at Los Alamos During 1977," Los Alamos Scientific Laboratory report LA-7436-MS (1978).

9. W. D. Purtymun, "Water Supply at Los Alamos During 1978," Los Alamos Scientific Laboratory report LA-8074-PR (1979).

10. W. D. Purtymun, "Water Supply at Los alamos During 1979," Los Alamos During 1979," Los Alamos Scientific Laboratory report LA-8504-PR (1980).

11. W. D. Purtymun and Max Maes, "Water Supply at Los Alamos During 1980," Los Alamos National Laboratory report LA-8977-PR (1981).

12. W. D. Purtymun, N. M. Becker, and Max Maes, "Water Supply at Los Alamos During 1981," Los Alamos National Laboratory report LA-9734-PR (1983).

13. W. D. Purtymun, N. M. Becker, and Max Maes, "Water Supply at Los Alamos During 1982," Los Alamos National Laboratory report LA-9896-PR (1984).

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

15. W. D. Purtymun, N. M. Becker, and M. N. Maes, "Water Supply at Los Alamos During 1984," Los Alamos National Laboratory report LA-10584-PR (1986).

16. W. D. Purtymun, N. M. Becker, and M. Maes, "Water Supply at Los Alamos During 1985," Los Alamos National Laboratory report LA-10835-PR (1986).

APPENDIX E

LIST OF PAST SURVEILLANCE REPORTS

J. E. Weir, J. H. Abrahams, J. R. Waldron, and W. D. Purtymun, "The Hydrology and the Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, 1945-55," US Geol. Survey open-file report (1962).

J. H. Abrahams, "Geologic and Hydrologic environment of Radioactive Waste-Disposal Sites at Los Alamos, New Mexico," US Geol. Survey open-file report (1963).

J. H. Abrahams, "Hydrology and the Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, January 1956 through June 1957," US Geol. Survey open-file report (1966).

J. H. Abrahams and W. D. Purtymun, "Hydrology and Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1957 through June 1961," US Geol. Survey open-file report (1963).

W. D. Purtymun, "The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1961 through June 1962," US Geol. Survey open-file report (1963).

W. D. Purtymun, "The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1962 through June 1963," US Geol. Survey open-file report (1963).

W. D. Purtymun, "The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1963 through June 1964," US Geol. Survey open-file report (1965).

W. D. Purtymun, "The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1963 through June 1974," US Geol. Survey open-file report (1966).

W. D. Purtymun and E. A. Enyart, "The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1964 through June 1965," US Geol. Survey open-file report (1966).

W. D. Purtymun and J. L. Kunkler, "The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1965 to June 1966," US Geol. Survey open-file report (1967).

W. D. Purtymun, Chemical and Radiochemical Analyses of Water in the Los Alamos Area, New Mexico, Made by the U.S. Geological Survey, 1960 through 1968," US Geol. Survey open-file report (1969).

W. R. Kennedy, "Los Alamos Environmental Monitoring Program," Los Alamos Scientific Laboratory report LA-3639-MS (1970).

W. R. Kennedy, W. D. Purtymun, and H. F. Schulte, "Los Alamos Environmental Monitoring Program, July through December, 1970," Los Alamos Scientific Laboratory report LA-4672-MS (1971).

Environmental Surveillance Group, "Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, January through June 1971," Los Alamos Scientific Laboratory report LA-4871-MS (1972).

Environmental Surveillance Group, "Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, July through December 1971," Los Alamos Scientific Laboratory report LA-4970 (1972).

Environmental Surveillance Group, "Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, Calendar Year 1972," Los Alamos Scientific report LA-5184 (1973).

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1973," Los Alamos Scientific Laboratory report LA-5586 (1974).

Environmental Surveillance Group, "Environmental Surveillance at Los alamos During 1974," Los Alamos Scientific Laboratory report LA-5977-PR (1975).

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1975," Los Alamos Scientific Laboratory report LA-6321-MS (1976).

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1976," Los Alamos Scientific Laboratory report LA-6801-MS (1977).

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1977," Los Alamos Scientific Laboratory report LA-7263-MS (1978).

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1978," Los Alamos Scientific Laboratory report LA-7800-ENV (1979).

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

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

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1981," Los Alamos National Laboratory report LA-9349-ENV (1982).

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1982," Los Alamos National Laboratory report LA-9762-ENV (1983).

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

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

Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1985," Los Alamos National Laboratory report LA-10721-ENV (1986).

APPENDIX F

DESCRIPTION AND LOCATION OF SURFACE AND GROUNDWATER SURVEILLANCE STATIONS

I. SURFACE AND GROUNDWATER

A. Introduction

Surface and groundwaters from regional, perimeter, and onsite stations are monitored to provide routine surveillance of Laboratory operations (Figs. 1 and 2, Table I). If a sample from a particular station was not taken this year, it was because the station was dry or a water pump was broken. Concentrations of radionuclides in water samples are compared with concentration guides derived from DOE's Radiation Protection Standard (RPS) (Table II). Regional and perimeter stations are in Uncontrolled Areas (RPS), while onsite stations are within Controlled Areas occupational (RPSs). Concentration guides do not account for concentrating mechanisms that may exist in environmental media. Consequently, other media such as sediments and soils are also monitored (see discussion in subsequent sections).

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

II. REGIONAL STATIONS

Regional surface water samples were collected within 75 km (47 mi) of the Laboratory from 6 stations on the Rio Grande, Rio Chama, and Jemez River (Fig. 1). The six sampling stations were located at US Geological Survey Gaging Stations. These waters provided baseline data for radiochemical and chemical analyses in areas beyond the Laboratory boundary. Stations on the Rio Grande were: Embudo, Otowi, Cochiti, and Bernalillo. The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 37,040 km^2 (14,300 mi^2) in southern Colorado and northern New Mexico. Discharge for the period of record (1895-1905, 1909-1984) has ranged from a

minimum of 1.7 m^3/sec (60 ft^3/sec) in 1902 to 691 m^3/sec (24,400 ft^3/sec) in 1920. The discharge for water year 1984 ranged from 9.7 m^3/sec (340 ft^3/sec) on October 27 to 277 m^3/sec (9770 ft^3/sec) on May 17 (USGS 1985).

The Rio Chama is tributary to the Rio Grande north of Los Alamos (Fig. 1). At Chamita on the Rio Chama, the drainage area above the station is 8143 km^2 (3143 mi^2) in northern New Mexico and a small part in southern Colorado. Since 1971, some flow has resulted from transmountain diversion water from the San Juan Drainage. Flow at the gage is governed by release from several reservoirs. Discharge at Chamita during water year 1984 ranged from 0.99 m^3/sec (35 ft^3/sec) in July to 137 m^3/sec (4840 ft^3/sec) in June.

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

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

III. PERIMETER STATIONS

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

Los Alamos Reservoir in upper Los Alamos Canyon on the flanks of the mountains, west of Los Alamos, has a capacity of 51 x 10^3 m^3 (41 acre-ft) and a drainage area of 16.6 km^2 (6.4 mi^2) above the intake. The reservoir is used for storage and recreation. Water flows by gravity through about 10.2 km (6.4 mi) of water lines for

irrigation of lawns and shrubs at the Laboratory's Health Research Building, the Los Alamos High School, and University of New Mexico's Los Alamos Branch.

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

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

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

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

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

Part of the heavy runoff in the Rio Grande in 1985 was stored in Cochiti Reservoir. In September, when the springs were sampled, six springs were below the reservoir level.

Three streams that flow to the Rio Grande were also sampled. Streams in Pajarito and Ancho Canyons are fed from Group I springs. The stream in Frijoles Canyon at the Rio Grande is fed by a spring on the flanks of the mountains west of Pajarito Plateau and flows through Bandelier National Monument to the Rio Grande.

Treated sanitary effluent from the community of White Rock was also sampled in Mortandad Canyon at its confluence with the Rio Grande. The perimeter springs, streams, and sanitary effluents, as well as the Rio Grande, are not sources of municipal water supply downstream from Los Alamos.

IV. ONSITE STATIONS

Onsite sampling stations are grouped according to those that are not located in effluent release areas (noneffluent release areas) and those that are located in areas receiving or that have received treated industrial effluents (Fig. 2, Table I).

A. Onsite Noneffluent Release Areas

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

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

all water above the main aquifer. The wells monitor any possible effect that the Laboratory's operations may have on water quality int he main aquifer.

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

Three shallow observation wells were drilled in 1985 and cased through the alluvium (thickness about 4 m (12 ft) in Pajarito Canyon (Fig. 2 and Table I). Water in the alluvium is perched on the underlying tuff and is recharged through storm runoff. The observation wells were constructed to determine if technical areas in the canyon or adjacent mesas were affecting the quality of shallow groundwater.

Groundwaters from test wells and surface water sources were not a source of municipal, industrial, or irrigation supply.

B. Onsite Effluent Release Areas

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

Water occurs seasonally in the alluvium dependent on the volume of surface flow from sanitary effluents and storm runoff. Three observation wells in the alluvium of Pueblo Canyon were not used as part of the monitoring network because they were dry most of the year. Hamilton Bend Springs discharges from alluvium in the lower reach of Pueblo Canyon and is dry part of the year. The primary sampling stations are surface water stations at Acid Weir, Pueblo 1, Pueblo 2, and Pueblo 3. Other sampling stations are Test Well T-2A [drilled to a depth of 40.5 m (133 ft)], which

penetrates the alluvium and Bandelier Tuff and is completed into the Puye Conglomerate). Aquifer tests indicated the perched aquifer is of limited extent. Water level measurements over a period of time indicate the perched aquifer is hydrologically connected to the stream in Pueblo Canyon.

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

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

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

three surface water sampling stations in the reach of the canyon that contain perennial flow (Table I).

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

surface flows in Acid-Pueblo and DP-Los Alamos canyons reach the Rio Grande only during spring snowmelt or heavy summer thunderstorms. There has been no surface runoff to Laboratory boundaries recorded in Mortandad Canyon since 1960, when hydrologic observations began.

V. WATER SUPPLY AND DISTRIBUTION

The main aquifer is the only aquifer in the area capable of municipal and industrial water supply. Water for the Laboratory and community is supplied from 16 deep wells in 3 well fields and 1 gallery. The well fields are on Pajarito Plateau and in canyons east of the Laboratory (fig. 3). The gallery is west of the Laboratory on the flanks of the mountains. Locations of supply wells and gallery are found in Table I. Production from the wells and gallery for 1985 was 6.1 x 10^9 L (1.6 x 10^9 gal).

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

A. Supply Wells

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

The Guaje well field is composed of seven producing wells. Wells in the field range indepth from 463 to 610 m (1530 to 2000 ft). Movement of water in the upper 430 m (1410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

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

B. Gallery

The Water Canyon gallery collects spring discharge from a perched water zone in the volcanics on the flanks of the mountains west of Los Alamos and Pajarito Plateau (Fig. 3). The canyon supplies a small but important part of the production with use of very little energy.

C. Distribution

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

Water in the distribution systems was sampled at five community and laboratory locations (fire stations), Bandelier National monument, and Fenton Hill (Fig. 3

and Table I). Though federal and state standards require analyses every 3 years, the Laboratory performs the analyses on an annual basis (Table III).

REFERENCES

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

ESG 1981: Environmental Surveillance Group, "Radiological Survey of the Site of a Former Radioactive Liquid Waste Treatment plant (TA-45) and the Effluent Receiving Areas of Acid, Pueblo, and Los alamos Canyons, Los Alamos, New Mexico, Final Report," Los Alamos National Laboratory report LA-8890-ENV/US Department of Energy report DOE/EV-0005/30 (May 1981).

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

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

EPA 1980: Environmental Protection Agency, "Part 261--Identification and Listing of Hazardous Waste. Table 1--Maximum Concentration of Contaminants for Characteristics of EP Toxicity," Federal Register 45:33122 (May 19, 1980).

Purtymun 1974: W. D. Purtymun, "Dispersion and Movement of Tritium in a Shallow Aquifer in Mortandad Canyon," Los Alamos Scientific Laboratory report LA-5716-MS (September 1974).

Purtymun 1977: W. D. Purtymun, "Hydrologic Characteristics of the Los Alamos Well Field with Reference to the Occurrence of Arsenic in Well LA-6," Los Alamos Scientific Laboratory report LA-7012-MS (1977).

Purtymun 1980A: W. D. Purtymun and H. Adams, "Geohydrology of Bandelier national Monument," Los Alamos Scientific Laboratory report LA-8461-MS (July 1980).

Purtymun 1980B: W. D. Purtymun, R. J. Peters, and J. W. Owens, "Geohydrology of White Rock Canyon of the Rio Grande from Otowi to Frijoles Canyon," Los Alamos Scientific Laboratory report LA-8635-MS (December 1980).

Purtymun 1984: W. D. Purtymun, "Hydrologic Characteristics of the Main Aquifer in the Los Alamos Area: Development of Ground Water Supplies," Los Alamos National Laboratory report LA-9957-MS (January 1984).

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

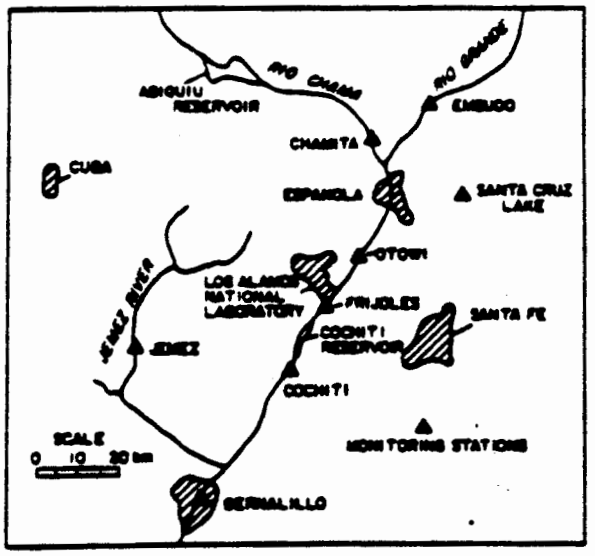


Fig. 1. Regional surface water, sediment, and soil sampling locations.

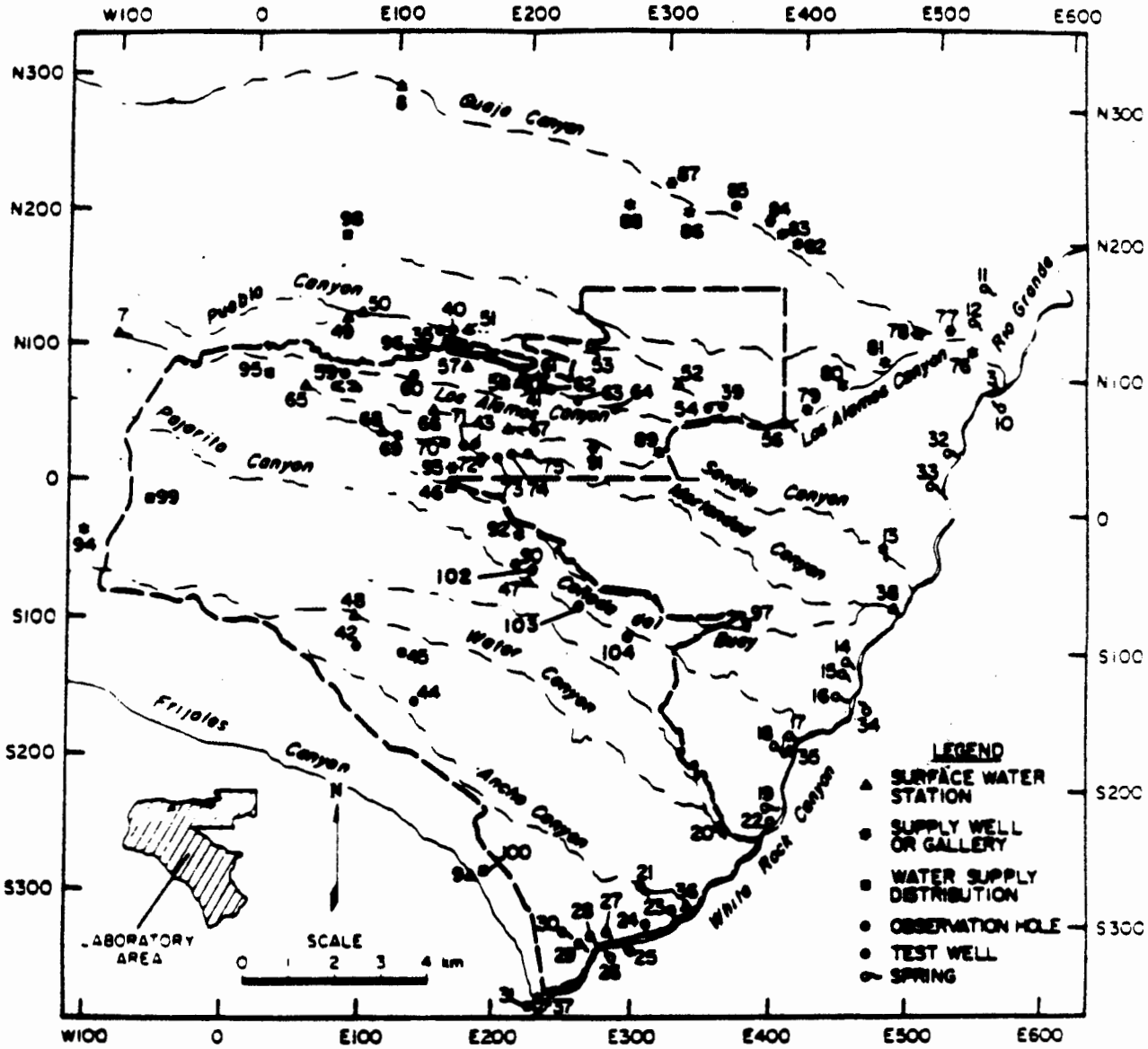


Fig. 2. Surface and groundwater sampling locations on or near the Laboratory site.

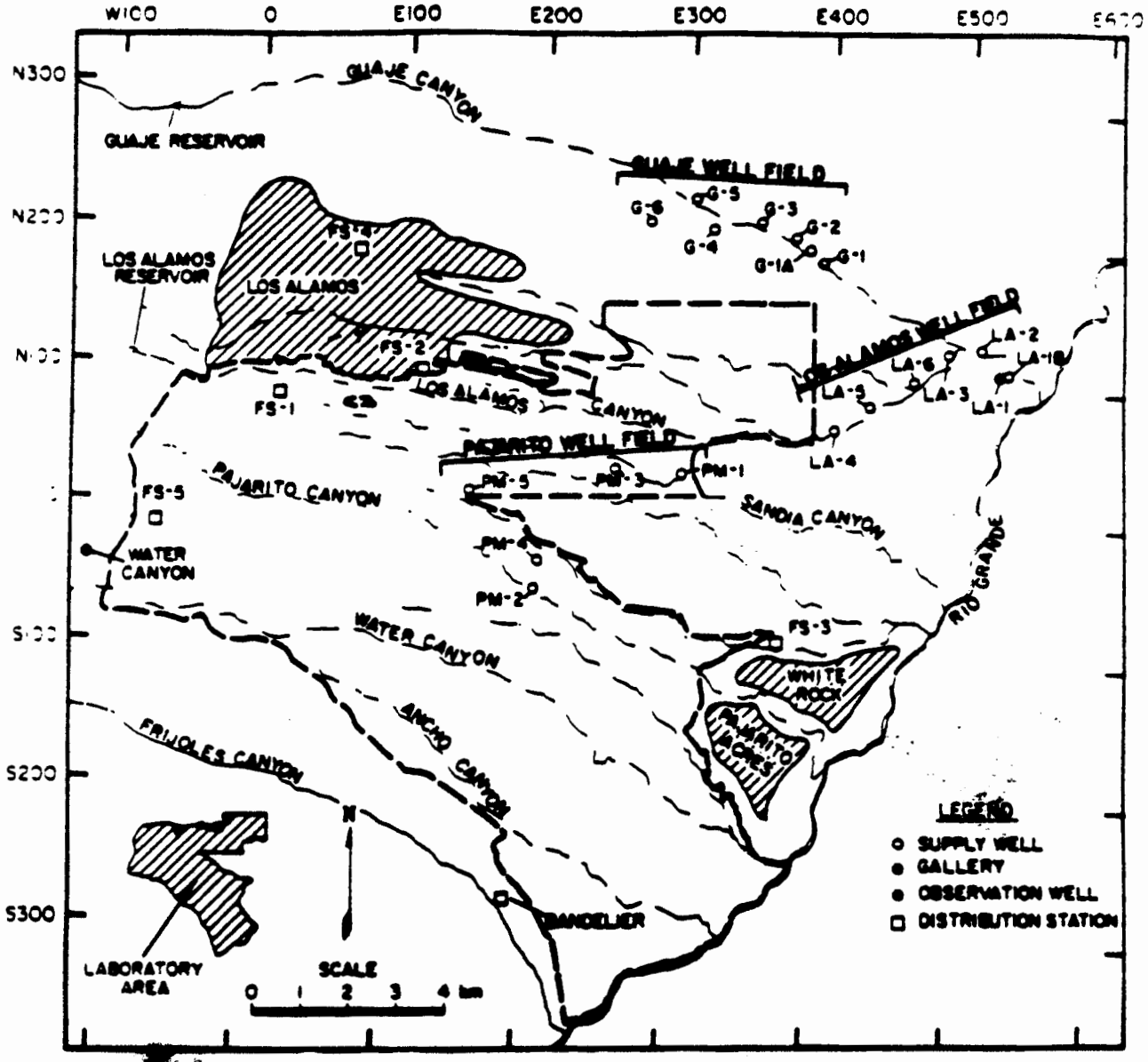


Fig. 3. [illegible]ions of reservoirs, well fields, supply wells, and gallery water supply.

Table I. Location of Surface and Groundwater Sampling Stations

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Regional Surface Water				
Rio Chama at Chamita	36°05′	106°07′	—	SW
Rio Grande at Embudo	36°12′	105°58′	—	SW
Rio Grande at Otowi	35°52′	106°08′	—	SW
Rio Grande at Cochiti	35°37′	106°19′	—	SW
Rio Grande at Bernalillo	35°17′	106°36′	—	SW
Jemez River	35°40′	106°44′	—	SW
Perimeter Stations				
Los Alamos Reservoir	N105	W090	7	SW
Guaje Canyon	N300	E100	8	SW
Frijoles	S280	E180	9	SW
La Mesita Spring	N080	E550	10	GWD
Sacred Spring	N170	E540	11	GWD
Indian Spring	N140	530	12	GWD
White Rock Canyon				
Group I				
Sandia Spring	S030	E470	13	SWR
Spring 3	S110	E450	14	SWR
Spring 3A	S120	E445	15	SWR
Spring 3AA	S140	E440	16	SWR
Spring 4	S170	E110	17	SWR
Spring 4A	S150	E395	18	SWR
Spring 5	S220	E390	19	SWR
Spring 5AA	S240	E360	20	SWR
Ancho Spring	S280	E305	21	SWR
Group II				
Spring 5A	S230	E390	22	SWR
Spring 6	S300	E330	23	SWR
Spring 6A	S310	E310	24	SWR
Spring 7	S330	E295	25	SWR
Spring 8	S335	E285	26	SWR
Spring 8A	S315	E280	27	SWR
Spring 9	S270	E270	28	SWR
Spring 9A	S325	E265	29	SWR
Doe Spring	S320	E250	30	SWR
Spring 10	S370	E230	31	SWR

[a]Regional surface water sampling locations in Fig. 1, Perimeter, White Rock Canyon, Onsite, and Effluent Release Area sampling locations in Fig. 2, water supply and distribution, Fig. 3.

[b]SW = surface water, GWD = deep or main aquifer, GWS = shallow or alluvial aquifer, SWR = spring at White Rock Canyon, and D = water supply distribution system.

Table I (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
White Rock Canyon				
Group III				
Spring 1	N040	E520	32	SWR
Spring 2	N015	E505	33	SWR
Group IV				
Spring 3B	S150	E465	34	SWR
Streams				
Pajarito	S180	E410	35	SWR
Ancho	S295	E340	36	SWR
Frijoles	S365	E235	37	SWR
Sanitary Effluent				
Mortandad	S070	E480	38	SWR
Onsite Stations				
Test Well 1	N070	E345	39	GWD
Test Well 2	N120	E150	40	GWD
Test Well 3	N080	E215	41	GWD
Test Well DT-5A	S110	E090	42	GWD
Test Well 8	N035	E170	43	GWD
Test Well DT-9	S155	E140	44	GWD
Test Well DT-10	S120	E125	45	GWD
Cañada del Buey	N010	E150	46	SW
Pajarito	S060	E215	47	SW
Water Canyon at Beta	S090	E090	48	SW
Pajarito Canyon (Onsite)				
PCO-1	S054	E212	102	GWS
PCO-2	S081	E255	103	GWS
PCO-3	S098	E293	104	GWS
Effluent Release Areas				
Acid-Pueblo Canyon				
Acid Weir	N125	E070	49	SW
Pueblo 1	N130	E080	50	SW
Pueblo 2	N120	E155	51	SW
Pueblo 3	N085	E315	52	SW
Hamilton Bend Springs	N110	E250	53	S
Test Well 1A	N070	E335	54	GWS
Test Well 2A	N120	E140	55	GWS
Basalt Spring	N065	E395	56	S

Table I (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
DP-Los Alamos Canyon				
DPS-1	N090	E160	57	SW
DPS-4	N080	E200	58	SW
LAO-C	N085	E070	59	GWS
LAO-1	N080	E120	60	GWS
LAO-2	N080	E210	61	GWS
LAO-3	N080	E220	62	GWS
LAO-4	N070	E245	63	GWS
LAO-4.5	N065	E270	64	GWS
Sandia Canyon				
SCS-1	N080	E040	65	SW
SCS-2	N060	E140	66	SW
SCS-3	N050	E185	67	SW
Mortandad Canyon				
GS-1	N040	E100	68	SW
MCO-3	N040	E110	69	GWS
MCO-4	N035	E150	70	GWS
MCO-5	N030	E160	71	GWS
MCO-6	N030	E175	72	GWS
MCO-7	N025	E180	73	GWS
MCO-7.5	N030	E190	74	GWS
MCO-8				
Water Supply and Distribution				
Los Alamos Well Field				
Well LA-1B	N115	E530	76	GWD
Well LA-2	N125	E505	77	GWD
Well LA-3	N130	E490	78	GWD
Well LA-4	N070	E405	79	GWD
Well LA-5	N076	E435	80	GWD
Well LA-6	N105	E465	81	GWD
Guaje Well Field				
Well G-1	N190	E385	82	GWD
Well G-1A	N197	E380	83	GWD
Well G-2	N205	E365	84	GWD
Well G-3	N215	E350	85	GWD
Well G-4	N213	E315	86	GWD
Well G-5	N228	E295	87	GWD
Well G-6	N215	E270	88	GWD

Table I (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Pajarito Well Field				
Well PM-1	N030	E305	89	GWD
Well PM-2	S055	E202	90	GWD
Well PM-3	N040	E255	91	GWD
Well PM-4	S030	E205	92	GWD
Well PM-5	N015	E155	93	GWD
Water Canyon Gallery	S040	W125	94	GWD
Fire Station 1	N080	E015	95	D
Fire Station 2	N100	E120	96	D
Fire Station 3	S085	E375	97	D
Fire Station 4	N185	E070	98	D
Fire Station 5	S010	W065	99	D
Bandelier National Monument Headquarters	S270	E190	100	D
Fenton Hill (TA-57)	35°53′	106°40′	101	D

Table II. DOE's Derived Concentration Guides (DCG) for Uncontrolled Areas and Concentration Guides (CG) for Controlled Areas (μCi/mL)[a]
(Radiation Protection Standards)

Nuclide	DCGs for Uncontrolled Areas		CGs for Controlled Areas	
	Air	Water	Air	Water
^{3}H	1×10^{-7}	2×10^{-3}	5×10^{-6}	1×10^{-1}
^{7}Be	5×10^{-8}	1×10^{-3}	1×10^{-6}	5×10^{-2}
^{89}Sr	3×10^{-10}	2×10^{-5}	3×10^{-8}	3×10^{-4}
^{90}Sr[b]	9×10^{-12}	1×10^{-6}	1×10^{-9}	1×10^{-5}
^{137}Cs	4×10^{-10}	3×10^{-6}	1×10^{-8}	4×10^{-4}
^{234}U	9×10^{-14}	5×10^{-2}	1×10^{-10}	1×10^{-4}
^{235}U	1×10^{-13}	6×10^{-7}	1×10^{-10}	1×10^{-4}
^{238}U	1×10^{-13}	6×10^{-7}	7×10^{-11}	2×10^{-5}
^{238}Pu	3×10^{-14}	4×10^{-7}	2×10^{-12}	1×10^{-4}
^{239}Pu[b]	2×10^{-14}	3×10^{-7}	2×10^{-12}	1×10^{-4}
^{240}Pu	2×10^{-14}	3×10^{-7}	2×10^{-12}	1×10^{-4}
^{241}Am	2×10^{-14}	6×10^{-8}	6×10^{-12}	1×10^{-4}
	(pg/m³)	(mg/ℓ)	(pg/m³)	(mg/ℓ)
U, natural[c]	$1 \times 10^{+5}$	8×10^{-1}	$2 \times 10^{+6}$	$6 \times 10^{+1}$

[a]Guides for uncontrolled areas are based upon DOE's Radiation Protection Standard (RPS) for the general public (DOE 1986); those for controlled areas are based upon occupational RPSs from DOE Order 5480.1, Chapter XI. Guides apply to concentrations in excess of that occurring naturally or due to fallout.

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

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

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

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

[a]Source: Reference A9.

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

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

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

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

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

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

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

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

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

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

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141.[A8] These regulations provide that combined ^{226}Ra and ^{228}Ra may not exceed 5×10^{-9} μCi/mℓ. Gross alpha activity (including ^{226}Ra, but excluding radon and uranium) may not exceed 15×10^{-9} μCi/mℓ. A screening level of 5×10^{-9} μCi/mℓ is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with the gross alpha standard for drinking water (Table A-3). For manmade beta and photon emitting radionuclides, drinking water concentrations are limited to concentrations that would result in doses not exceeding 4 mrem/yr, calculated according to a specified procedure.

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

REFERENCES

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

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

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

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

[a]Guides for uncontrolled areas are based upon DOE's Radiation Protection Standard (RPS) for the general public;[A3] those for controlled areas are based upon occupational RPSs from DOE Order 5480.1, Chapter XI. Guides apply to concentrations in excess of that occurring naturally or due to fallout.

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

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

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

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

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

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

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

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

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

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

Exposure of Any Member of the Public[a]

1. All pathways

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

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

2. Air pathway only[d]

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

Occupational Exposures[a]

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

[a]In keeping with DOE policy, exposures shall be limited to as small a fraction of the respective annual dose limits as practicable. These Radiation Protection Standards apply to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, global fallout, self-irradiation, and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from Reference A3. Limits for occupational exposure are taken from DOE Order 5480.1, Chapter XI.
[b]As used by DOE, effective dose equivalent includes both the effective dose equivalent from external radiation and the committed effective dose equivalent to individual tissues from ingestion and inhalation during the calendar year.
[c]For the purposes of DOE's Radiation Protection Standard, a prolonged exposure will be one that lasts, or is predicted to last, longer than 5 years.
[d]These levels are from EPA's regulations promulgated under the Clean Air Act (40 CFR 61, Subpart H).
[e]Beta exposure below 700 keV will not penetrate the lens of the eye; therefore, the applicable limit for beta radiation of these energies would be that for skin, 15 000 mrem/year.
[f]All reasonable effort should be made to keep exposure of forearms and hands within the general limit for skin.

APPENDIX J

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

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

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

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

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

For each radionuclide, the DCG was calculated by

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

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

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

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

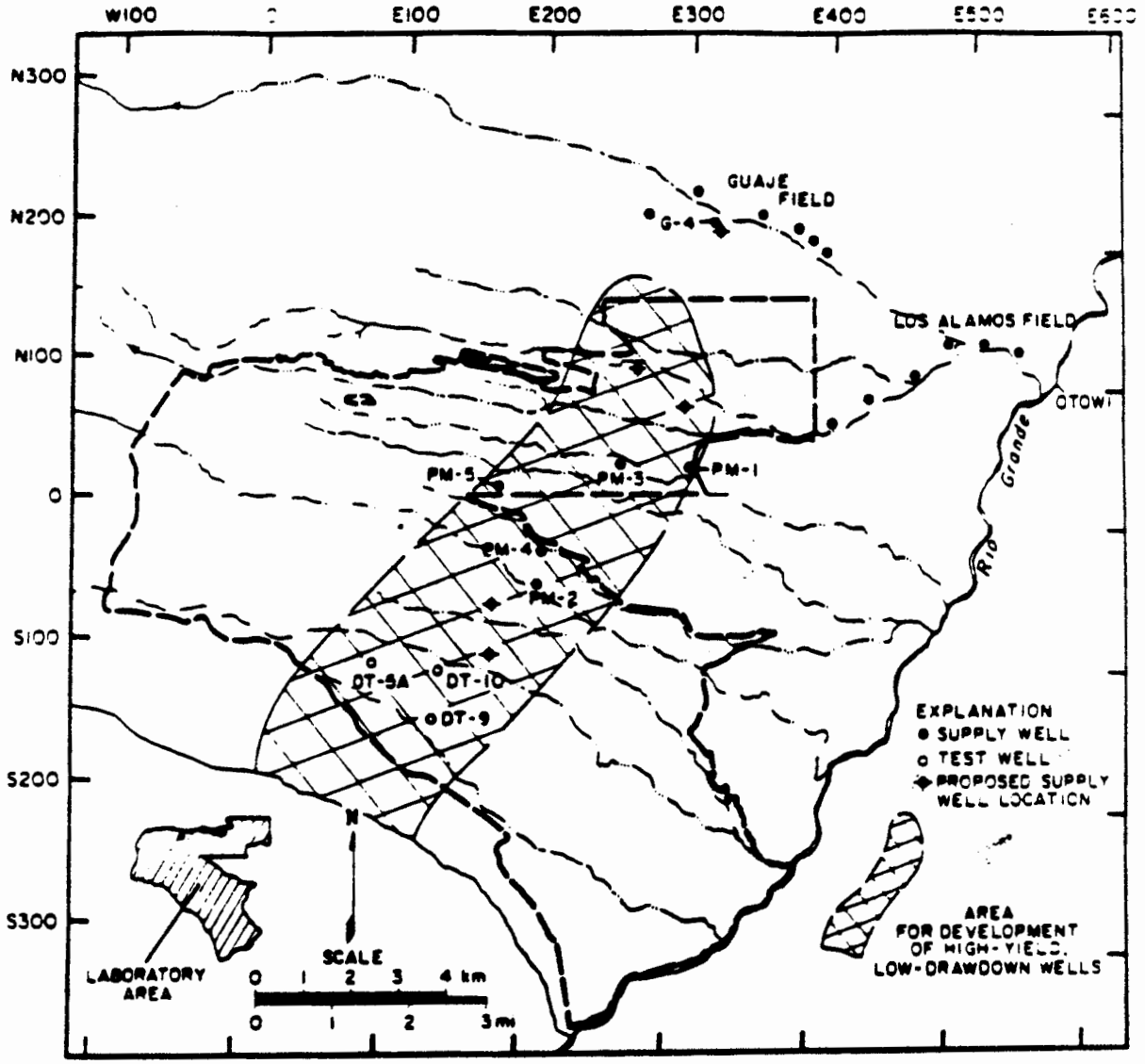


Fig. I-9. **Proposed locations for additional supply wells and area for development of high-yield, low-drawdown wells.**

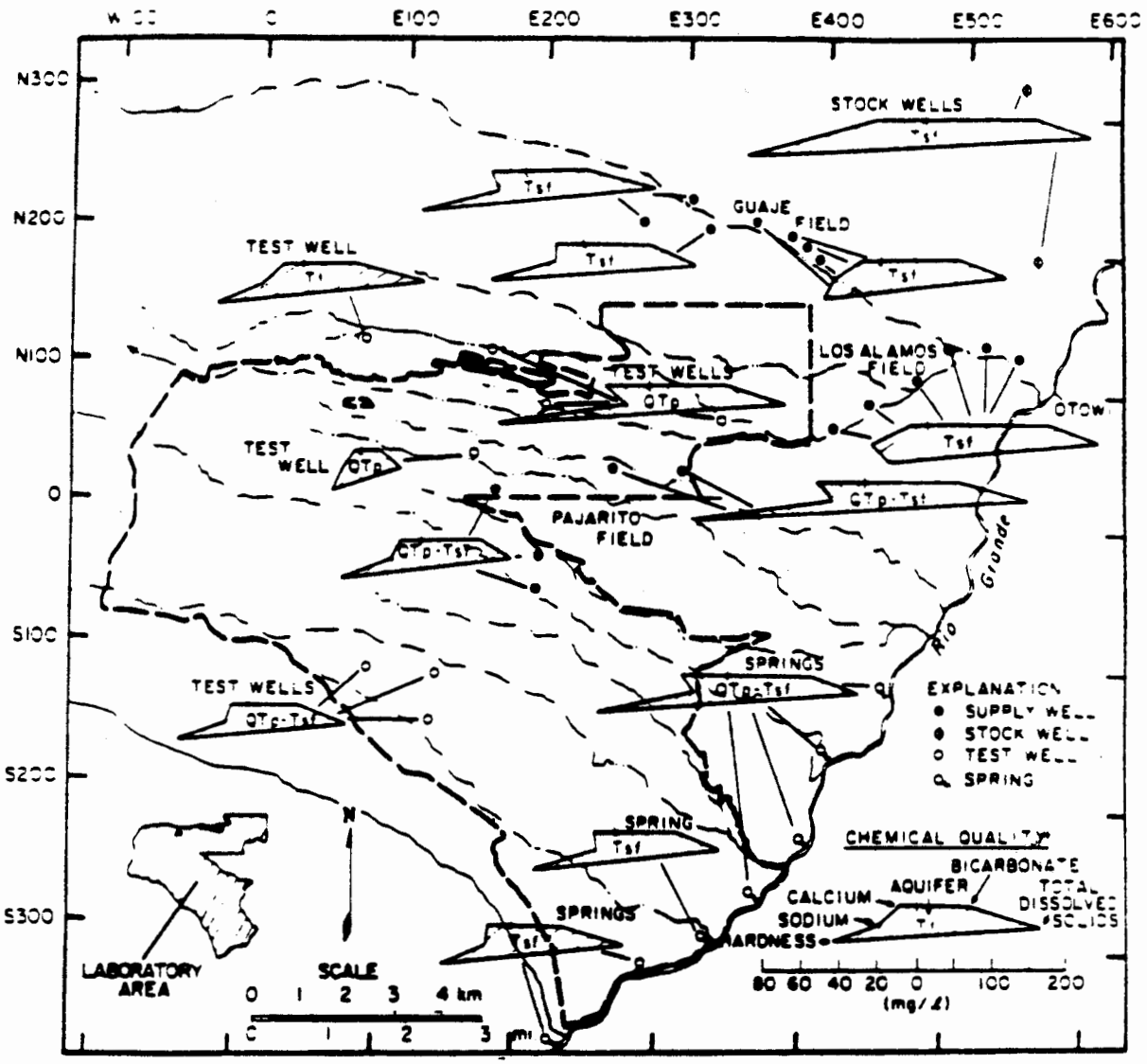


Fig. I-8. **Graphic comparison of chemical constituents in water from supply, test, and stock wells.**

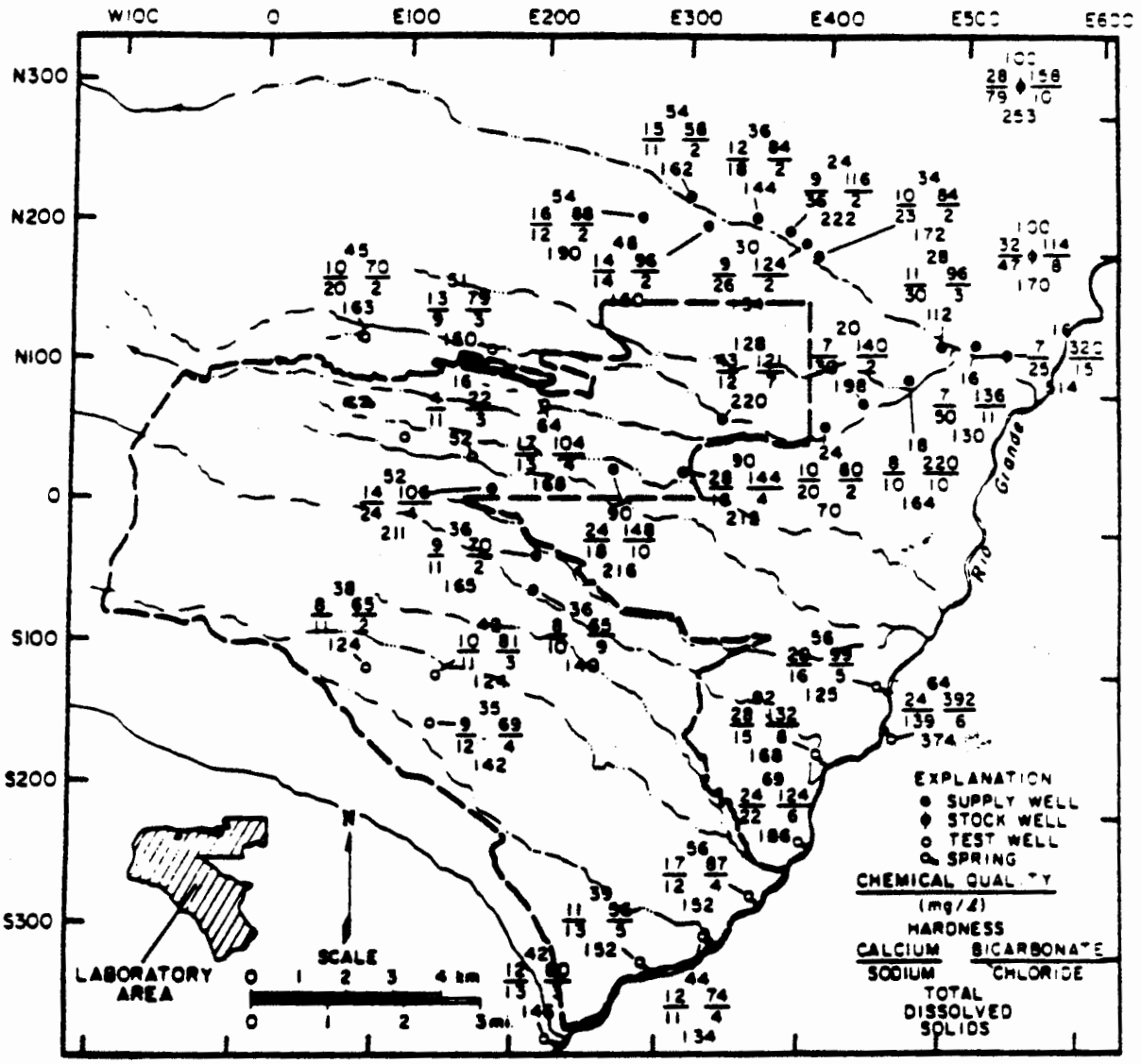


Fig. I-7. Chemical quality of water from supply, test, and stock wells.

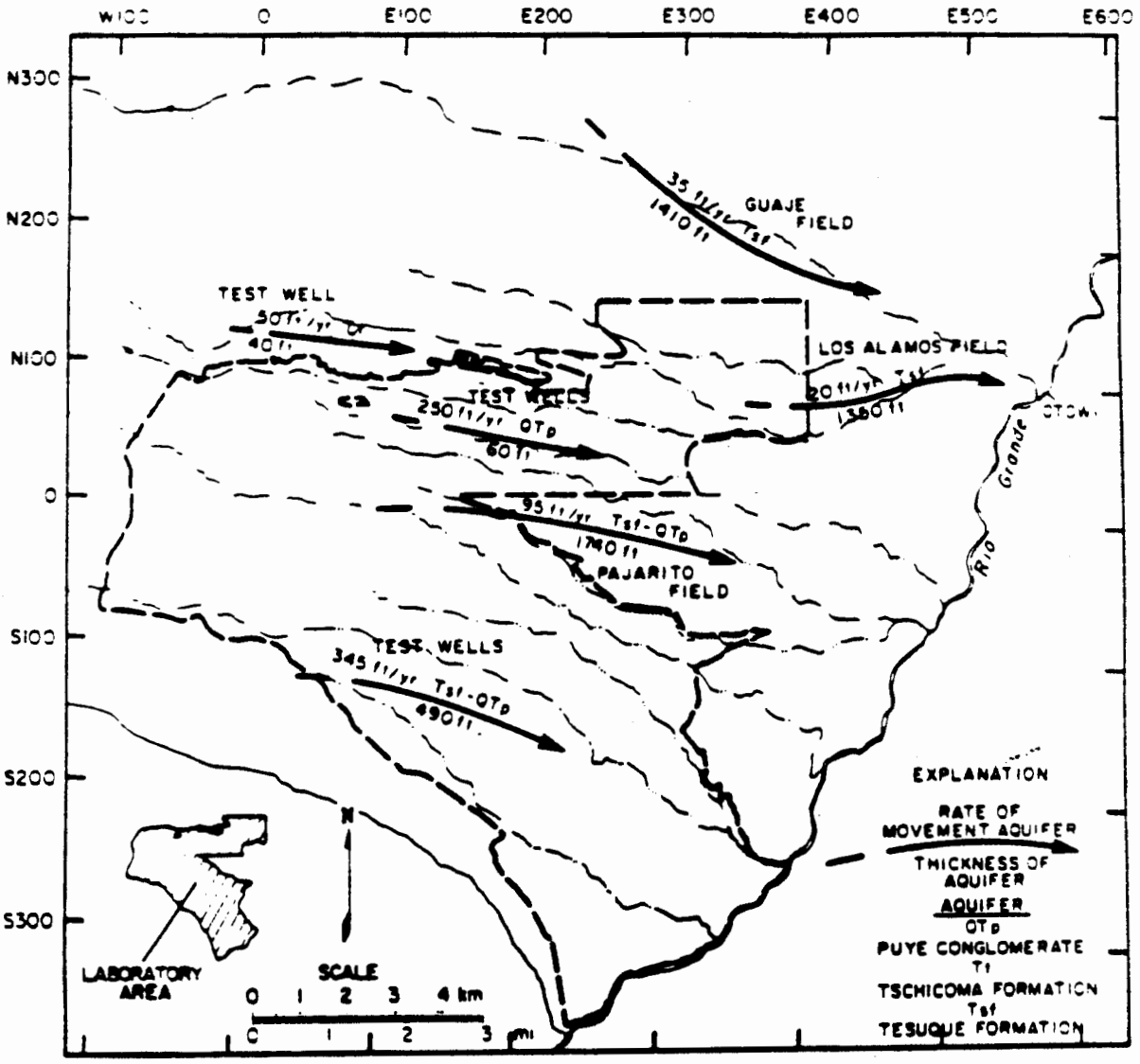


Fig. I-6. Rate of movement of water in the main aquifer.

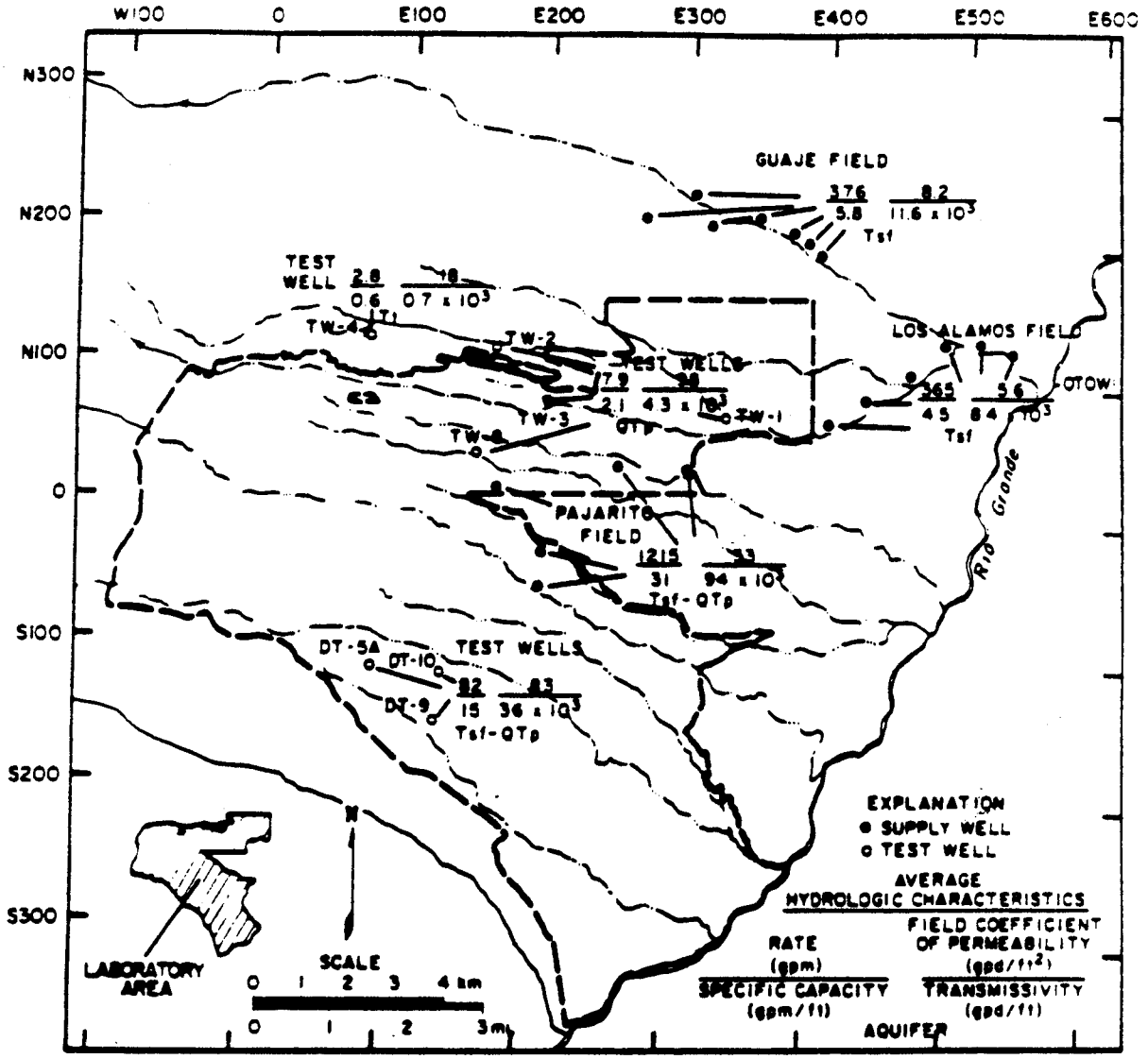


Fig. I-5. Hydrologic characteristics of the main aquifer.

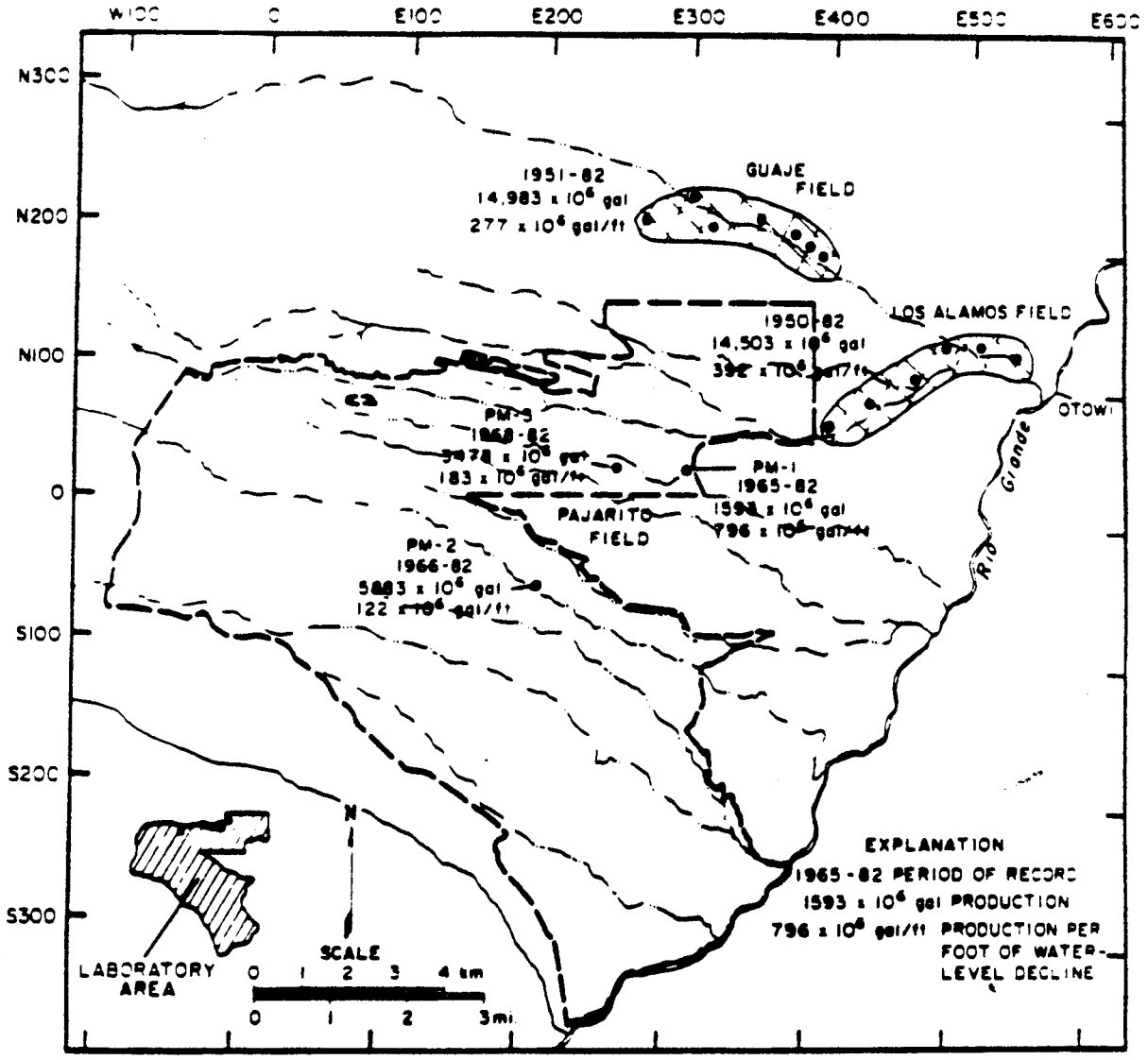


Fig. I-4. Water-level declines related to production from well fields and supply wells.

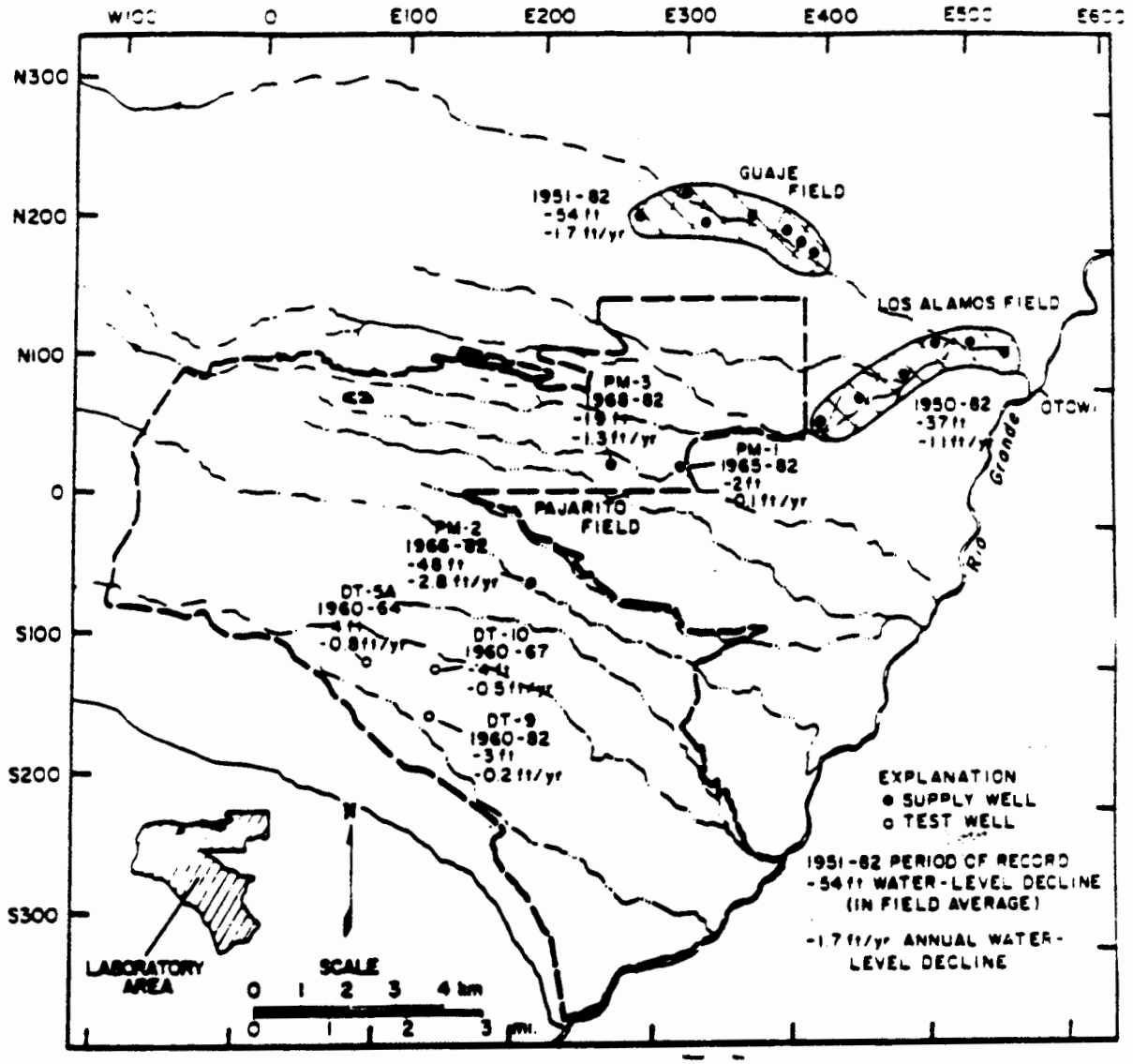


Fig. I-3. Water-level declines in well fields and supply and test wells.

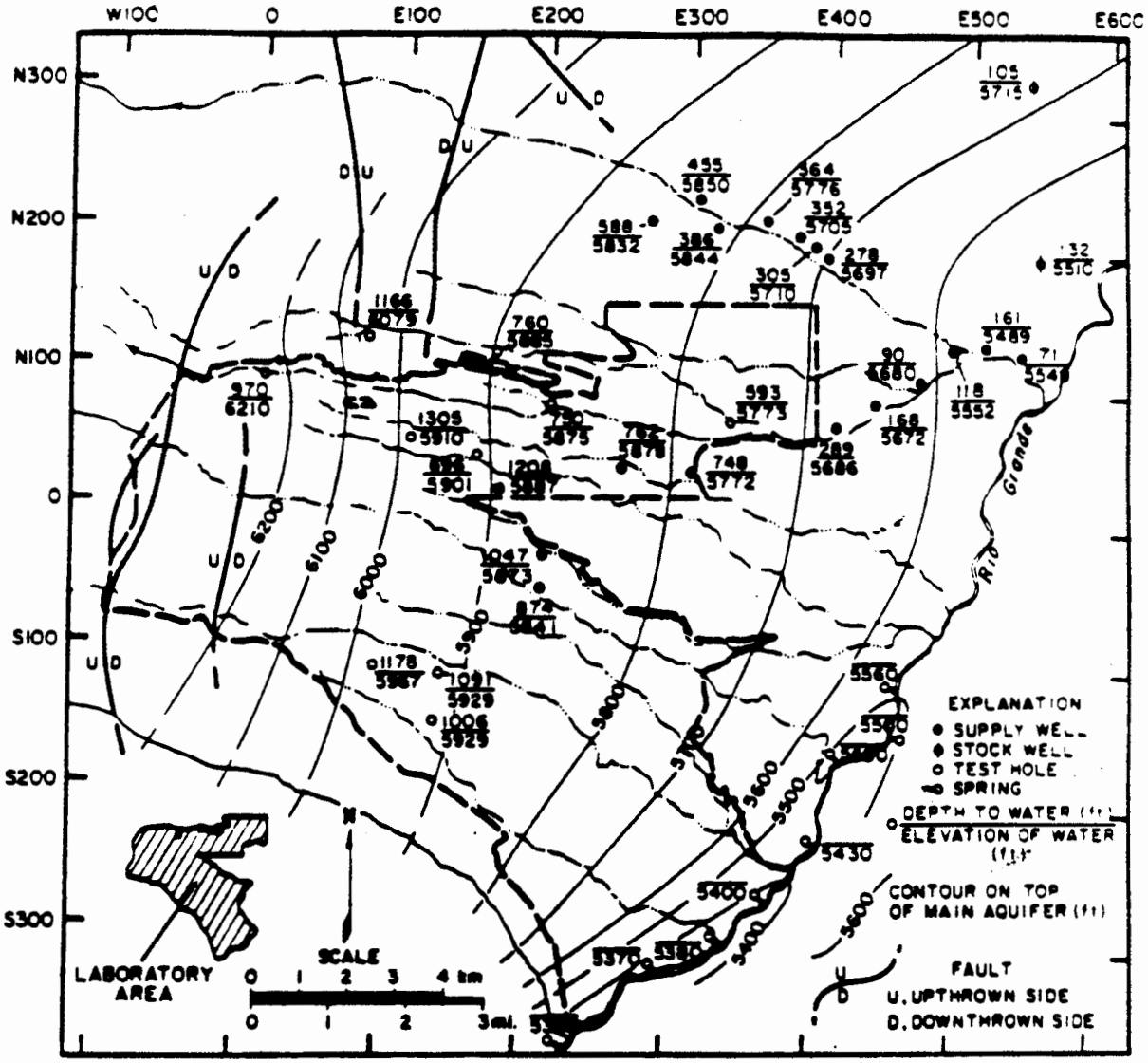


Fig. I-2. Generalized contours on the surface of the main aquifer.

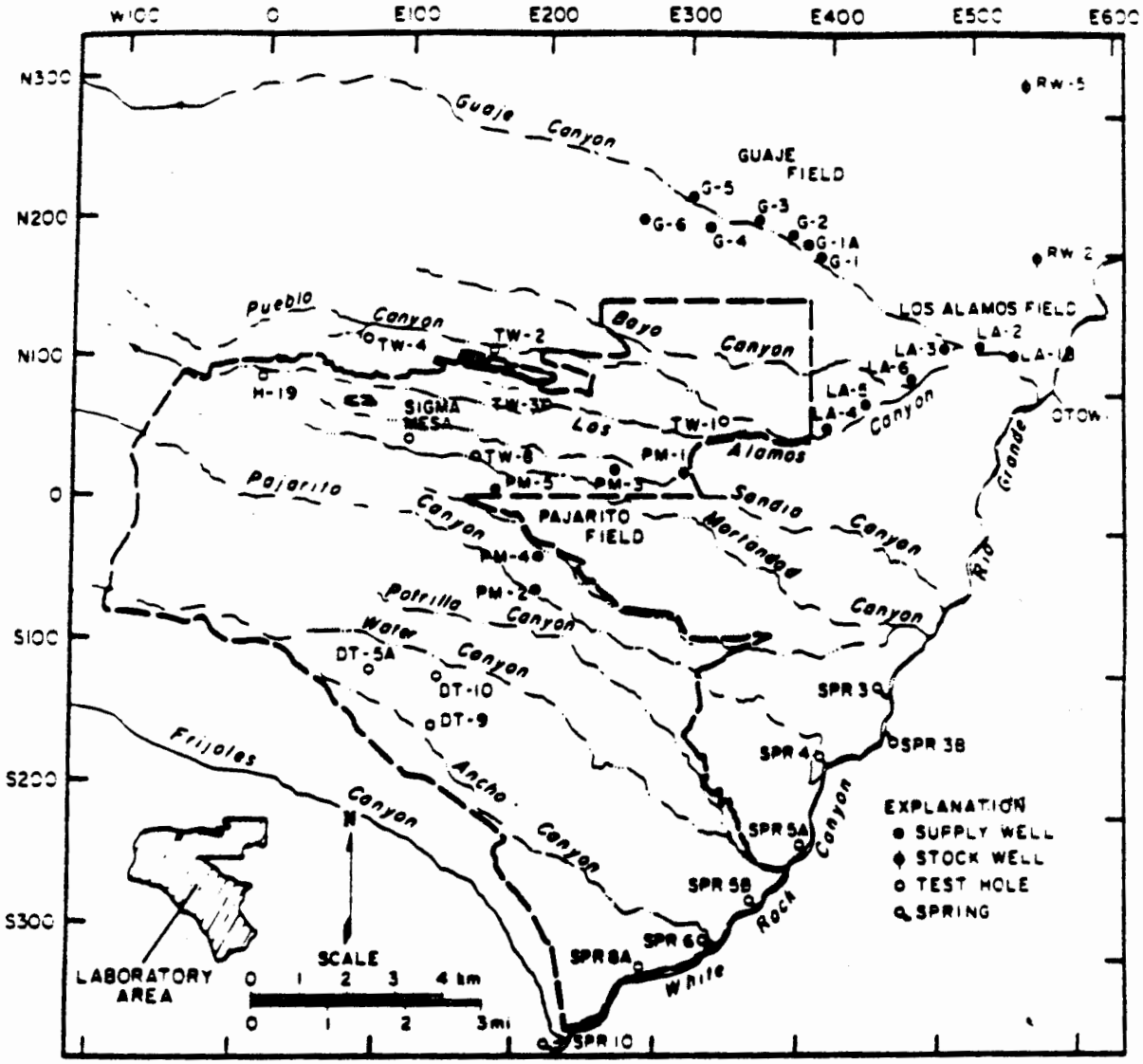


Fig. I-1. Location of supply, test, and stock wells and springs in the Los Alamos area.

Table I-III

HYDROLOGIC DATA FOR SPRINGS IN WHITE ROCK CANYON

	Spring 3	Spring 3B	Spring 4	Spring 5A	Spring 5B	Spring 6	Spring 8A	Spring 10
Elevation of LSD (ft)	5560	5500	5500	5430	5400	5380	5370	5360
Aquifer	QTp	Tsf	QTp	Tsf	Tsf	Tsf	Tsf	Tsf
Discharge at Rio Grande (gpm)	20	10	80	30	10	60	30	20
Quality of Water								
Date	10 13 81	10 13 81	10 13 81	10 13 81	10-14-81	10 14-81	10 14-81	10 15 81
Chemical (mg/ℓ)								
SiO_2	52	46	60	60	64	74	75	69
Ca	20	24	28	24	17	12	11	12
Mg	1.6	2.0	5.7	2.7	4.4	3.6	2.8	3.2
Na	16	139	15	22	12	11	13	13
CO_3	0	0	0	0	0	0	0	0
HCO_3	99	392	132	124	87	74	56	80
SO_4	4	4	6	7	2	2	3	3
Cl	5	6	8	6	4	4	5	4
F	0.4	0.6	0.5	0.3	0.5	0.3	0.4	0.4
NO_3	2.6	8.4	<0.4	1.7	2.0	<0.4	<0.4	1.7
TDS	125	374	168	186	152	134	152	146
Hardness	56	64	92	69	56	44	39	42
Specific conductance (μmho)	210	610	220	240	150	140	130	120
pH	8.1	7.5	7.0	7.4	7.4	7.0	9.0	7.8
Radiochemical								
Total uranium (μg/ℓ)	2.3 ± 0.8	19 ± 4.0	1.5 ± 0.8	2.2 ± 0.8	1.9 ± 0.8	1.0 ± 0.8	1.7 ± 0.8	1.7 ± 0.8
Temperature (°F)	72	68	66	70	61	73	72	66

Note: Tsf = Tesuque Formation and QTp = Puye Conglomerate.

Table I-II (cont)

	Test Wells					Stock Wells	
	TW-8	DT-9	DT-10	Sigma Mesa	H-19	RW-2	RW-[illegible]
Date of Completion	1960	1960	1960	1979	1949	1954	1955
Elevation of LSD (ft)	6870	6935	7020	7215	7180	5642	5820
Construction							
Depth drilled (ft)	1065	1501	1409	2292	2000	161	132
Depth completed (ft)	1065	1501	1408	...	2000[a]	161	132
Diameter (in.)	8	12	12	...	...	...	...
Water Levels							
Date	1965	1982	1967	1979	1949	1954	1955
Depth below LSD (ft)	969	1006	1091	1305[b]	970	132	105
Elevation (ft)	5901	5929	5929	5910	6210	5510	5715
Water Level Fluctuations							
Period	1960-1965	1960-1982	1960-1967	...	...	...	...
Change (ft)	-1	-3	-4	...	...	...	...
Annual rate (ft/yr)	-0.2	-0.2	-0.5	...	...	...	
Aquifer							
Formations	QTp	QTp-Tsf	QTp-Tsf	QTp-Tsf	Tt-QTp	Tsf	Tsf
Saturated thickness (ft)	97	498	324	987	1030	...	
Yield							
Date	1960	1960	1960	...	...	...	...
Rate (gpm)	16	88	78	...	...	...	
Drawdown (ft)	8.0	4.0	4.9	...	...	...	
Specific capacity (gpm/ft)	2	22	16	...	...	...	...
Transmissivity (gpd/ft)	2400	61 000	36 100	...	...	...	...
Field coefficient of permeability (gpd/ft²)	25	122	111	...	...	...	
Quality of Water							
Date	4-6-81	4-10-81	4-2-81	—	—	12-[illegible]-67	[illegible]-67
Chemical (mg/ℓ)							
SiO_2	50	72	58	...	...	...	...
Ca	4	9	10	...	...	32	28
Mg	0.9	3.1	3.5	...	...	5	[illegible]
Na	11	12	11	...	...	[illegible]	79
CO_3	7	0	0	...	...	0	0
HCO_3	22	69	81	...	...	114	158
SO_4	<1	2	1	...	...	...	...
Cl	3	4	3	...	...	8	10
F	0.2	<0.2	0.3	...	...	0.1	0.2
NO_3	4.4	4.3	<0.4	...	...	0.9	3.[illegible]
TDS	52	142	124	...	...	170	253
Hardness	16	35	42	...	...	100	100
Specific conductance (μmho)	90	150	130	...	...	200	270
pH	9.8	8.0	8.3	...	—	8.1	7.6
Radiochemical							
Total uranium (μg/ℓ)	0.0 ± 0.8	0.8 ± 0.8	0.8 ± 0.8	...	...	1.8 ± 0.4	2.3 ± 0.6
Temperature (°F)	67	70	67	—	—	67	66

[a] Now abandoned.
[b] Water level estimated from geophysical logs.

Note: Tsf = Tesuque Formation, QTp = Puye Conglomerate, and Tt = Tesuque Formation.

Table I-II (cont)

	Pajarito Field				
	PM-1	PM-2	PM-3	PM-4	PM-5
Date of Completion	1965	1965	1966	1981	1982
Elevation of LSD (ft)	6520	6715	6640	6920	7095
Construction					
Depth drilled (ft)	2501	2600	2552	2920	3120
Depth completed (ft)	2499	2300	2552	2875	3093
Diameter (in.)[b]	12	14	14	16	16
Water Levels					
Date	1982	1982	1982	1982	1982
Depth below LSD (ft)	748	874	762	1047	1208
Elevation (ft)	5772	5841	5878	5873	5887
Water Level Fluctuations					
Period (yr)	1965-1982	1966-1982	1968-1982	1981-1982	
Change (ft)	-2	-48	-19	5	...
Annual rate (ft/yr)	-0.1	-2.8	-1.3	...	
Aquifer					
Formation	QTp-Tsf	QTp-Tsf	QTp-Tsf	QTp-Tsf	QTp-Tsf
Saturated thickness (ft)	1751	1426	1790	1828	1885
Yield					
Date	1982	1982	1982	1982	1982
Rate (gpm)	589	1386	1402	1473	1225
Drawdown (ft)	22	60	23	40	144
Specific capacity (gpm/ft)	26.8	23.1	60.9	36.8	[illegible]
Transmissivity (gpd/ft)	55 000	40 000	320 000	44 000	10 000
Field coefficient of permeability (gpd/ft^2)	31	28	179	24	5.3
Production					
Period (yr)	1965-1982	1966-1982	1968-1982	1982	...
Pumpage (10^6 gal.)	1593	5863	3478	76	...
Quality of Water					
Date	3-18-81	3-18-81	3-18-81	8-3-81	8-4-81
Chemical (mg/ℓ)					
SiO_2	77	81	88	87	84
Ca	28	8	24	9	14
Mg	6.9	3.1	8.4	3	4
Na	18	10	18	11	24
CO_3	0	0	0	0	0
HCO_3	144	65	148	70	106
SO_4	5	3	7	4	10
Cl	4	9	10	2	4
F	0.3	0.3	0.4	0.3	0.3
NO_3	2.0	<0.1	1.8	2	8
TDS	212	140	216	165	211
Hard	90	36	90	36	52
Specific conductance (μmho)	260	130	250	120	190
pH	8.0	7.8	8.3	8.2	8.2
Radiochemical					
Total uranium (μg/ℓ)	2.4 ± 0.8	0.0 ± 0.8	1.0 ± 0.8	0.8 ± 0.8	2.2 ± 0.4
Temperature (°F)	71	69	71	69	73

[a]Well was abandoned in 1956; data were not used in the average hydrologic characteristics. It is located 150 ft SW of well LA-1B.

[b]Wells have two different diameter sizes of casing; i.e., 12 (650 ft) 10 reads: 12-in. diameter to 650 ft, then 10-in. diameter to completed depth of well.

Note: QTp = Puye Conglomerate; Tsf = Tesuque Formation.

Table I-II

CONSTRUCTION AND HYDROLOGIC DATA FOR TEST AND STOCK WELLS

	Test Wells				
	TW-1	TW-2	TW-3	TW-4	TW-5A
Date of Completion	1950	1949	1949	1950	1960
Elevation of LSD (ft)	6370	6645	6625	7245	7145
Construction					
Depth drilled (ft)	642	789	815	1205	1821
Depth completed (ft)	642	789	815	1205	1821
Diameter (in.)	8	8	10	6	8
Water levels					
Date	1951	1951	1951	1951	1964
Depth below LSD (ft)	593	760	750	1166	11[illegible]8
Elevation (ft)	5773	5885	5875	6079	596[illegible]
Water-Level Fluctuations					
Period	—	—	—	—	1960-1964
Changes (ft)	—	—	—	—	-4
Annual rate (ft/yr)	—	—	—	—	-0.8
Aquifer					
Formations	QTp	QTp	QTp	Tt	QTp Tsf
Saturated thickness (ft)	49	29	65	39	543
Yield					
Date	1951	1951	1951	1951	1960
Rate (gpm)	2.4	6.7	6.6	2.8	81
Drawdown (ft)	38.9	7.5	15.0	4.8	14.2
Specific capacity (gpm/ft)	<0.1	1.0	0.5	0.6	5.[illegible]
Transmissivity (gpd/ft)	200	7000	7800	750	11 000
Field coefficient of permeability (gpd/ft²)	4	241	120	19	1.[illegible]
Quality of Water					
Date	2-28-81	9-17-81	3-31-81	6-8-65	9-16-81
Chemical (mg/ℓ)					
SiO_2	49	79	84	—	72
Ca	43	13	17	10	8
Mg	7.7	3.8	6.0	5	2.5
Na	12	9	13	20	11
CO_3	0	0	0	0	0
HCO_3	121	79	104	70	65
SO_4	3	3	3	—	1
Cl	7	3	4	2	2
F	0.4	0.5	0.4	<0.4	0.2
NO_3	2.4	6.2	4.1	0.4	3.9
TDS	220	150	168	163	124
Hardness	128	51	64	45	38
Specific conductance (μmho)	320	150	190	150	120
pH	8.0	8.0	7.9	7.9	7.9
Radiochemical					
Total uranium (μg/ℓ)	6.1 ± 1.2	0.1 ± 0.8	0.7 ± 0.8	0.5 ± 0.5	0.0 ± 0.8
Temperature (°F)	70	71	74	70	70

Table I-I (cont)

	Gusie Field						
	G 1	G 1A	G 2	G 3	G 4	G 5	G 6
Date of Completion (yr)	1950	1954	1951	1951	1951	1951	1964
Elevation of LSD (ft)	5975	6015	6055	6140	6230	6305	6420
Construction							
Depth drilled (ft)	2100	2071	2006	1996	2002	1997	2005
Depth completed (ft)	2000	1519	1996	1792	1930	1840	1530
Diameter (in ϕ	10 (490 ft) 10	12 (663 ft) 10	12 (600 ft) 10	12 (695 ft) 10	12 (720 ft) 10	12 (739 ft) 10	12
Water Levels							
Depth below LSD (ft)	278	305	352	364	386	455	588
Elevation (ft)	5697	5710	5703	5776	5844	5850	5832
Water Level Fluctuations							
Period (yr)	1951 1982	1955-1982	1951 1982	1951-1982	1951 1982	1951 1982	1964 1982
Change (ft)	-83	-40	-93	-83	-29	-41	-7
Annual rate (ft/yr)	-2.6	-1.4	-2.9	-2.6	-0.9	-1.3	-0.4
Aquifer							
Formation	Tsf	Tsf	Tsf	Tsf	Tsf	Tsf	Tsf
Saturated thickness (ft)	1722	1214	1644	1428	1544	1385	942
Yield							
Date	1982	1982	1982	1982	1982	1982	1982
Rate (gpm)	313	505	476	239	297	522	281
Drawdown (ft)	165	42	47	112	192	55	81
Specific capacity (gpm/ft)	1.9	12.0	10.1	2.1	1.5	9.5	3.5
Transmissivity (gpd/ft)	12 000	11 000	15 000	7500	17 500	12 000	6300
Coefficient of permeability (gpd/ft^2)	7.0	9.1	9.1	5.3	11.3	8.7	6.7
Production							
Period (yr)	1950 1982	1954 1982	1951 1982	1951 1982	1951 1982	1951 1982	1952 1982
Pumpage (10^6 gal)	2386	2921	2504	2084	1202	2774	1062

	Gusie Field						
	G 1	G 1A	G 2	G 3	G 4	G 5	G 6
Quality of water							
Date	2 28 80	2 28 80	2 28 80	2 28 80	2 28 80	2 28 80	2 24 80
Chemical (mg/ℓ)							
SiO_2	86	78	78	54	52	64	70
Ca	10	9	9	12	14	15	16
Mg	0.5	0.5	0.6	1.5	2.5	3.7	3.6
Na	23	26	36	18	14	11	12
CO_3	0	0	0	0	0	0	0
HCO_3	84	124	116	84	96	88	88
SO_4	4	4	4	4	3	4	3
Cl	2	2	2	2	2	2	2
F	0.5	0.5	0.8	0.3	0.2	0.2	0.2
NO_3	2.1	2.1	1.9	2.5	2.7	2.9	1.8
TDS	172	134	222	144	150	162	190
Hardness	34	30	24	36	48	54	54
Specific conductance (μmho)	130	200	200	300	160	130	200
pH	8.3	8.4	8.5	8.3	8.2	8.2	7.9
Radiochemical							
Total uranium (μg/ℓ)	1.0 ± 0.8	0.7 ± 0.8	0.9 ± 0.8	0.8 ± 0.8	1.0 ± 0.8	0.8 ± 0.8	2.4 ± 0.8
Temperature (°F)	78	84	85	82	79	78	83

Table I-I

CONSTRUCTION AND HYDROLOGIC DATA FOR WELLS IN LOS ALAMOS, GUAJE, AND PAJARITO FIELDS

	Los Alamos Field						
	LA 1[a]	LA 1B	LA 2	LA 3	LA 4	LA 5	LA 6
Date of Completion (yr)	1946	1960	1946	1947	1948	1948	1948
Elevation of LSD (ft)	5625	5620	5650	5670	5975	5840	5770
Construction							
Depth drilled (ft)	1001	2256	882	910	2019	2084	2030
Depth completed (ft)	870	1750	870	870	1965	1750	1700
Diameter (in.)[b]	10	12 (650 ft) 10	10	10	12 (754 ft) 10	12 (630 ft) 10	12 (597
Water Levels							
Date	1982	1982	1982	1982	1981	1982	1982
Depth below LSD (ft)	40	71	161	118	289	168	90
Elevation (ft)	5585	5549	5489	5552	5686	5672	5680
Water Level Fluctuations							
Period	1950-1982	1960-1982	1950-1982	1950-1982	1950-1981	1950-1982	1950-1982
Change (ft)	-79	-64	-72	-21	-11	-45	-7
Annual rate (ft/yr)	-2.4	-2.8	-2.2	-0.6	-0.3	-1.4	-0
Aquifer							
Formation	Tsf	Tsf	Tsf	Tsf	Tsf	Tsf	Tsf
Saturated thickness (ft)	830	1679	709	752	1676	1582	1700
Yield							
Date	1950	1982	1982	1982	1981	1982	1981
Rate (gpm)	366	486	269	247	579	467	580
Drawdown (ft)	293	109	187	128	104	136	57
Specific capacity (gpm/ft)	0.8	4.5	1.4	1.9	5.6	3.4	[illegible]
Transmissivity (gpd/ft)		15,700	2500	2500	9600	4800	15,500
Field coefficient of permeability (gpd/ft²)		9.3	3.5	3.1	5.7	3.0	[illegible]
Production							
Period (yr)	1947-1956	1960-1982	1947-1982	1948-1982	1948-1982	1948-1982	1948-[illegible]
Pumpage (10^6 gal.)	353	1964	1305	1644	1503	1049	2884

	Los Alamos Field						
	LA 1[a]	LA 1B	LA 2	LA 3	LA 4	LA 5	LA 6
Quality of Water							
Date	1952	2-28-80	2-28-80	2-28-0	2-28-80	2-28-80	2-28-80
Chemical (mg/ℓ)							
SiO_2	29	40	26	24	30	36	26
Ca	7	7	7	1	10	7	8
Mg	1	0.4	0.2	0.2	0.2	0.2	0.2
Na	80	25	50	30	20	30	10
CO_3	0	0	0	0	0	0	0
HCO_3	177	320	136	96	80	140	220
SO_4	20	37	13	7	3	5	22
Cl	18	15	11	3	2	2	10
F	1.3	2.5	1.2	0.5	0.4	0.9	1.6
NO_3	1.8	2.3	2.5	2.4	2.0	2.3	2.3
TDS	...	514	130	112	70	198	364
Hardness	22	16	16	28	24	20	18
Specific conductance (μmho)	385	330	270	550	200	200	300
pH		8.4	8.5	8.4	8.5	8.7	8.7
Radiochemical							
Total uranium (μg/ℓ)		5.7 ± 1.2	4.5 ± 1.0	3.5 ± 0.8	0.9 ± 0.8	4.8 ± 0.8	3.1 ± [illegible]
Temperature (°F)	63	83	75	67	83	77	84

APPENDIX I

DESCRIPTION AND LOCATION OF SUPPLY WELLS AND TEST WELLS COMPLETED INTO THE MAIN AQUIFER

Location of wells completed into the main aquifer are shown on Figure I-1. Hydrologic characteristics of the main aquifer are shown in Figures I-2 through I-6. Chemical characteristics are shown on Figures I-7 and I-8. Proposed location for additional supply wells are shown on Figure I-9. Construction and hydrologic data for wells in the Los Alamos, Guaje, and Pajarito Well Fields is presented on Table I-I. The construction and hydrologic data for the test and stock wells is shown on Table I-II while hydrologic data for springs that discharge from the main aquifer in White Rock Canyon are shown on Table I-III.

These figures and tables are taken from the report "Hydrologic Characteristics of the Main Aquifer in the Los Alamos Area, Development of Ground Water Supplies" (LA-9957-MS).

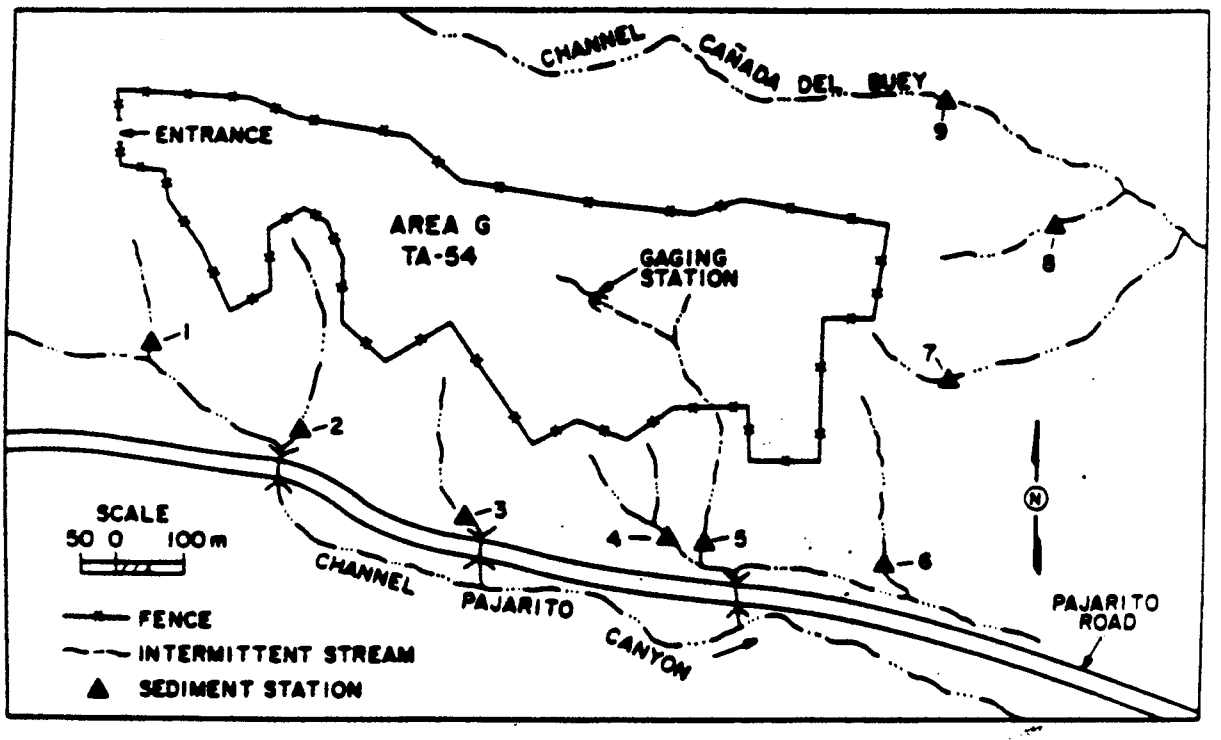


Fig. 3. Surface water gaging station in Area G (TA-54) and sediment sampling stations adjacent to Area G.

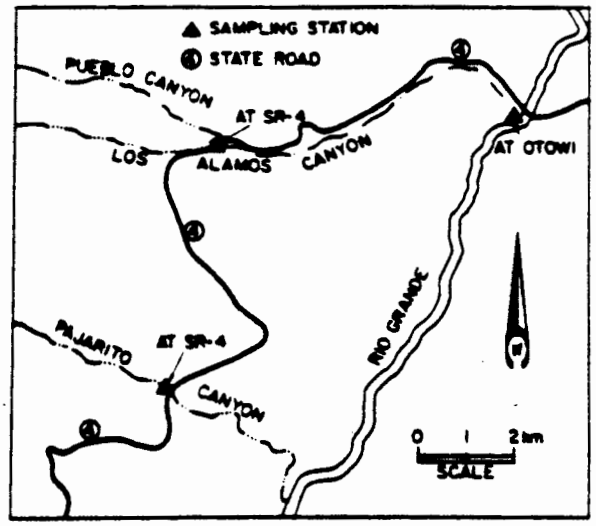


Fig. 2. Locations of surface runoff sampling stations at State Road 4 (SR-4).

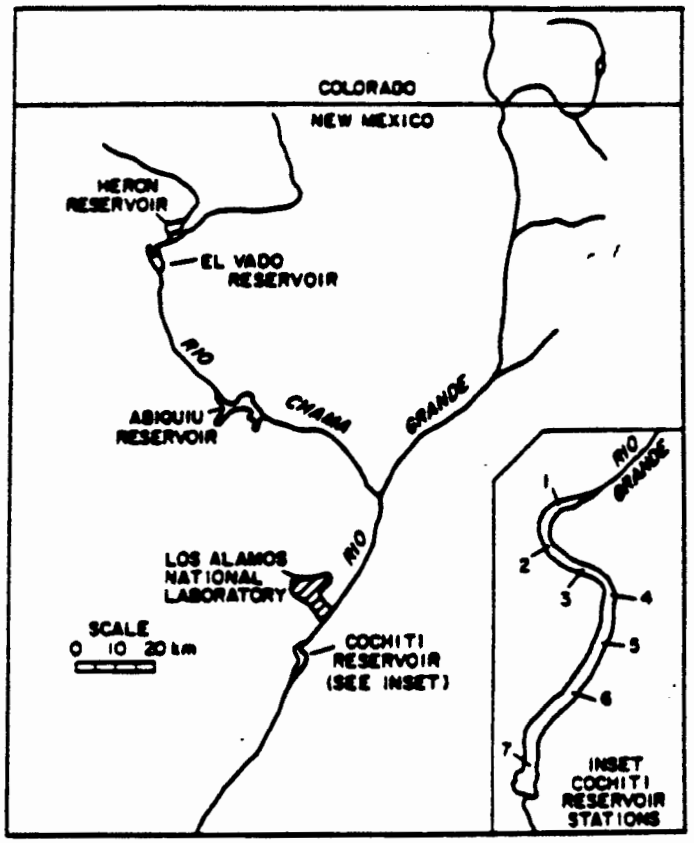


Fig. 1. Special regional sediment sampling locations.

Table I

Minimum Concentrations of Inorganic Contaminants for Meeting EPA's Extraction Procedure Toxicity Characteristic for Hazardous Waste

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

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

V. TRANSPORT OF CHEMICALS IN SEDIMENTS FROM AREAS G AND L

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

Stations at Area G were sampled (4,5,6 combined and sampled as one--a road culvert) with one station added in Canada del Buey in the channel about 300 m below Area L (Fig. 3). All surface runoff from Area L is in Canada del Buey. Sediment samples are analyzed for a number of inorganics (Table I). Eight constituents have limits set for EP toxic concentrations, while the remaining five constituents and pH have no limits but were analyzed as the others.

III. TRANSPORT OF RADIONUCLIDES IN SURFACE RUNOFF

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

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

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

Samples of snowmelt and summer runoff were collected in Los Alamos Canyon at State Road 4 (SR-4) and at the Rio Grande. Also sampled at SR-4 were Pueblo and Guaje canyons, which are tributary to Los Alamos Canyon. Samples were also collected at Pajarito and Water canyons at SR-4 and on the Rio Grande above Otowi (Fig. 2.).

IV. RADIONUCLIDE TRANSPORT IN SEDIMENTS AND RUNOFF AT AREA G

Radionuclides transported by surface runoff have an affinity for attachment to sediment particles by ion exchange or adsorption. Thus, radionuclides in surface runoff tend to concentrate on sediments in stream channels. Nine sampling stations were established in 1982 outside the perimeter fence at Area G to monitor any possible transport of radionuclides by storm runoff (Fig. 3). These stations are sampled annually. Area G is a storage and disposal area for solid radioactive wastes.

APPENDIX H

DESCRIPTION AND LOCATION OF MISCELLANEOUS SURVEILLANCE STATIONS

I. INTRODUCTION

Special Sampling stations are used to evaluate the certain aspects of the Laboratory effect on the environment. This special sampling includes collection of reservoir sediments upstream and downstream from Los Alamos.

Other factors evaluated are transport of radionuclides in summer or snowmelt runoff in disposal area and monitoring the possible transport of radionuclides and chemicals from radioactive and chemical solid waste disposal areas.

II. SEDIMENTS IN REGIONAL RESERVOIRS

The reservoir sediments were collected from Heron, El Vado, and Abiquiu Reservoirs on the Rio Chama. Drainage occurs along the Continental Divide in southern Colorado and northern New Mexico, northwest of Los Alamos. Sediments were sampled from Cochiti Reservoir, which is on the Rio Grande, below the confluence with Rio Chama, and south of Los Alamos (Fig. 1).

Three samples were taken from each reservoir. Sediments were collected in the upper, middle, and lower (near dam) parts of the reservoirs. A boat and Eckman dredge were used to collect bottom samples to a depth of about 6 cm (2 in.). Samples were collected in water depths ranging from 6 to 20 m (0 to 65 ft). The sediments consisted of fine-grained silts, clays, and some organic material (there were considerably more organic materials in sediments from Cochiti Reservoir than from the other reservoirs). The samples were analyzed only for ^{238}Pu and $^{239,240}Pu$. Analyses for plutonium were performed in 1 kg (2 lb) samples (100 times the usual mass used for analyses) of reservoir sediments. These large samples increase the sensitivity of the plutonium analyses, which is necessary to effectively evaluate background plutonium concentrations in fallout from atmospheric nuclear tests.

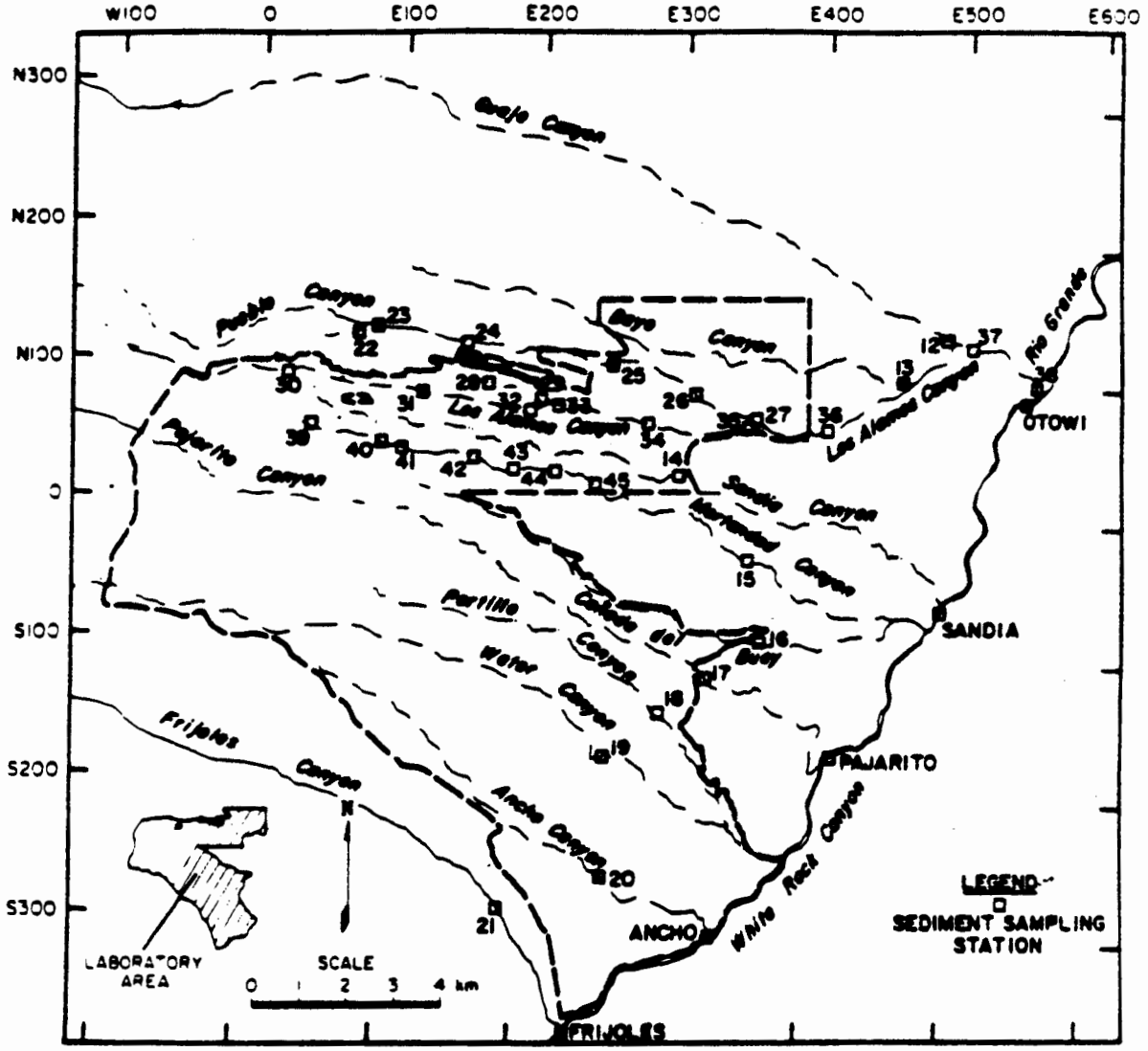


Fig. 3. Sediment sampling locations on or near the Laboratory site.

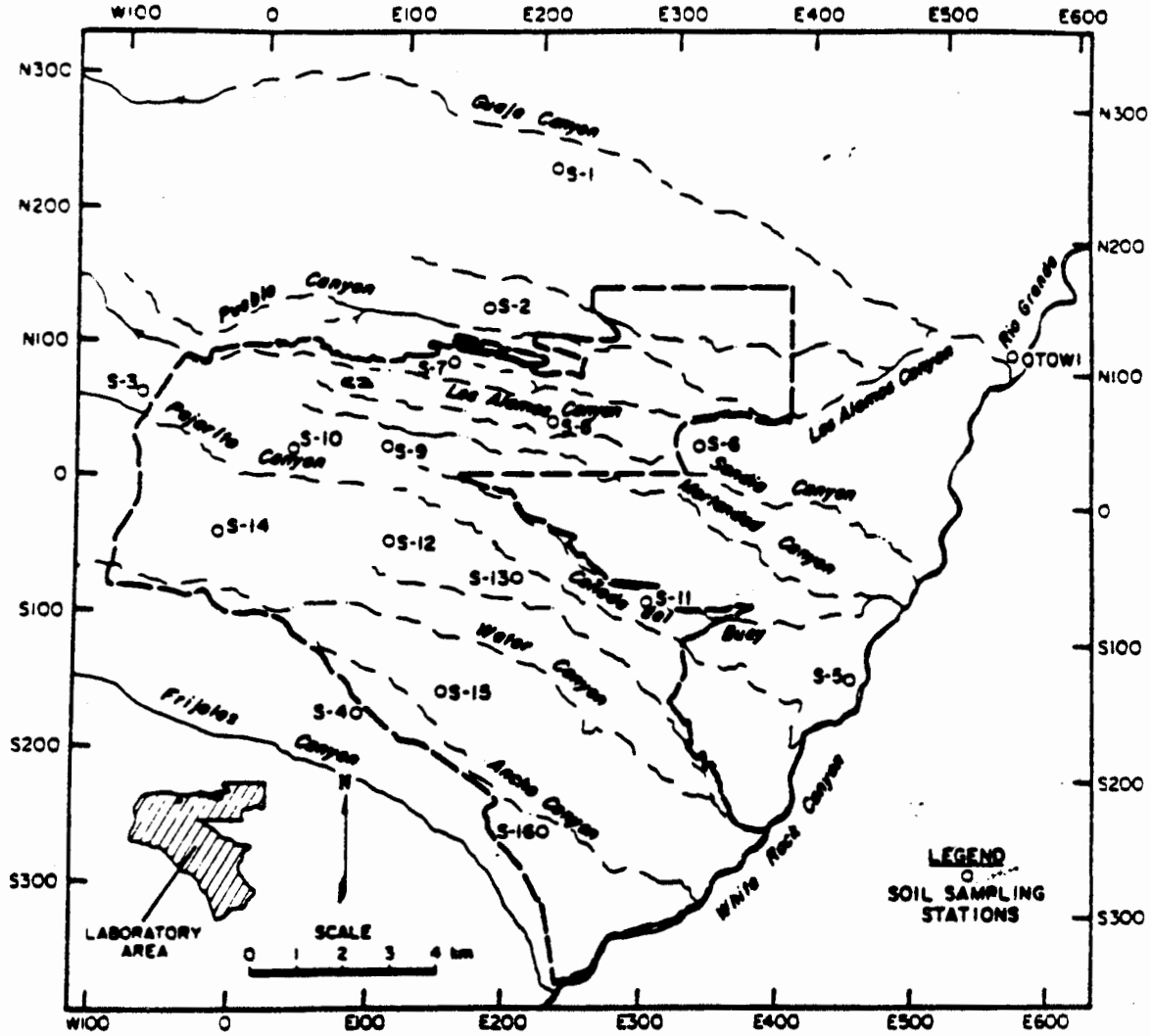


Fig. 2. Soil sampling locations on or near the Laboratory site.

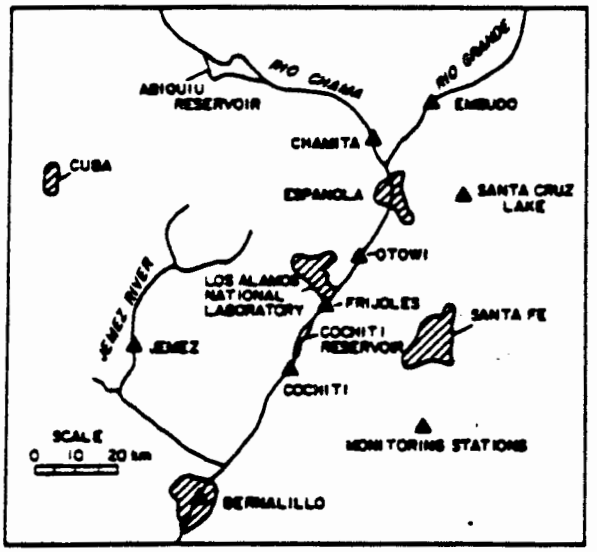


Fig. 1. Regional surface water, sediment, and soil sampling locations.

Table II (cont)

Station	Latitude or N-S Coord	Longitude or E-W Coord	Map Designation[a]
Mortandad Canyon			
Mortandad near CMR	N060	E036	39
Mortandad west of GS-1	N045	E095	40
Mortandad at GS-1	N040	E105	41
Mortandad at MCO-5	N035	E155	42
Mortandad at MCO-7	N025	E190	43
Mortandad at MCO-9	N030	E215	44
Mortandad at MCO-13	N015	E250	45
Regional Soils			
Rio Chama at Chamita	36°05′	106°07′	—
Embudo	36°12′	105°58′	—
Otowi	35°52′	106°08′	—
Near Santa Cruz	35°59′	105°54′	—
Cochiti	35°37′	106°19′	—
Bernalillo	35°17′	106°36′	—
Jemez	35°40′	106°44′	—
Perimeter Soils			
Sportsman's Club	N240	E215	S1
North Mesa	N134	E168	S2
TA-8	N060	W075	S3
TA-49	S165	E085	S4
White Rock (east)	N051	E218	S5
Tsankawi	N020	E310	S6
Onsite Soils			
TA-21	N095	E140	S7
East of TA-53	N051	E218	S8
TA-50	N035	E095	S9
Two Mile Mesa	N025	E030	S10
East of TA-54	S080	E295	S11
R-Site Road East	S042	E103	S12
Portillo Drive	S065	E195	S13
S-Site	S035	W025	S14
Near Test Well DT-9	S150	E140	S15
Near TA-33	S245	E225	S16

[a]Soil sampling locations in Figs. 1 and 2, sediment sampling locations in Fig. 1 and 3

Table II

Locations of Soil and Sediment Sampling Stations

Station	Latitude or N-S Coord	Longitude or E-W Coord	Map Designation[a]
Regional Sediments			
Chamita	36°05′	106°07′	—
Embudo	36°12′	105°58′	—
Otowi	35°52′	106°08′	—
Sandia	S060	E490	—
Pajarito	S185	E410	—
Ancho	S305	E335	—
Frijoles	S375	E235	—
Cochiti	35°37′	106°19′	—
Bernalillo	35°17′	106°36′	—
Jemez River	35°40′	106°44′	—
Perimeter Sediments			
Guaje at SR-4	N135	E480	12
Bayo at SR-4	N100	E455	13
Sandia at SR-4	N025	E315	14
Mortandad at SR-4	S030	E350	15
Cañada del Buey at SR-4	S090	E360	16
Pajarito at SR-4	S105	E320	17
Potrillo at SR-4	S145	E295	18
Water at SR-4	S170	E260	19
Ancho at SR-4	S255	E250	20
Frijoles at National Monument Headquarters	S280	E185	21
Effluent Release Area Sediments			
Acid Pueblo Canyon			
Acid Weir	N125	E070	22
Pueblo 1	N130	E085	23
Pueblo 2	N120	E145	24
Hamilton Bend Spring	N105	E255	25
Pueblo 3	N090	E315	26
Pueblo at SR-4	N070	E350	27
DP-Los Alamos Canyon			
DPS-1	N090	E160	28
DPS-4	N075	E205	29
Los Alamos at Bridge	N095	E020	30
Los Alamos at LAO-1	N080	E120	31
Los Alamos at GS-1	N075	E200	32
Los Alamos at LAO-3	N075	E215	33
Los Alamos at LAO-4.5	N065	E270	34
Los Alamos at SR-4	N065	E355	35
Los Alamos at Totavi	N065	E405	36
Los Alamos at LA-2	N125	E510	37
Los Alamos at Otowi	N100	E560	38

Table I

Background or Control Levels for Comparison of Radiochemical Results for Environmental Surveillance Analyses

	Units	$\bar{x} + 2s$
Soil		
^{137}Cs	pCi/g	1.18
^{238}Pu	pCi/g	0.005
$^{239,240}Pu$	pCi/g	0.036
^{90}Sr	pCi/g	0.68
Total U	µg/g	3.5
Gross Gamma	counts/min/g	6.6
Tritium	10^{-6}µCi/mℓ	7.1
Sediments		
^{137}Cs	pCi/g	0.52
^{238}Pu	pCi/g	0.002
$^{239,240}Pu$	pCi/g	0.011
^{90}Sr	pCi/g	1.15
Total U	µg/g	4.8
Gross Gamma	counts/min/g	8.1

V. REFERENCES

Purtymun 1971: W. D. Purtymun, "Plutonium in Stream Channel Alluvium in the Los Alamos Area, New Mexico," Los Alamos Scientific Laboratory report LA-4561 (1971).

Purtymun 1974a: W. D. Purtymun, "Storm Runoff and Transport of Radionuclides in DP Canyon, Los Alamos County, New Mexico," Los Alamos Scientific Laboratory report LA-5744 (1974).

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

IV. ONSITE SOILS AND SEDIMENTS

Onsite soil samples were collected from 10 stations within the Laboratory boundaries. Onsite sediment samples were collected from 21 stations within liquid effluent release areas (Table II, Figs. 2 and 3).

Sediment samples from stations in Acid-Pueblo, DP-Los Alamos, and Mortandad canyons have radionuclide concentrations above background levels. These canyons have received or are now receiving treated industrial effluents containing trace amounts of radioactivity.

Acid-Pueblo Canyon received effluents from about 1944 through 1964. The major radionuclide released in treated effluents inito Acid-Pueblo Canyon was $^{239,240}Pu$.

DP-Los Alamos and Mortandad canyons are now receiving treated industrial effluents. Major radionuclides above background levels collected from DP-Los Alamos Canyon Are ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, total uranium ^{3}H and gross gamma. The largest concentrations occur in DP Canyon, which received effluent, and below the junction of DP Canyon into Los Alamos Canyon. Concentrations decreased from the outfall downgradient in the canyon.

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

In the canyons that receive or have received treated radioactive wastes, concentrations decrease downgradient in the canyon. Radionuclides are adsorbed or attached to sediment particles in the canyon stream channels (Purtymun 1971, 1974a). This reduces the amount of radionuclides available to be in solution. Radionuclide concentrations are generally highest near the points of effluent discharge and decrease downstream as sediments and radionuclides are dispersed by surface runoff.

APPENDIX G

DESCRIPTION AND LOCATION OF SOIL AND SEDIMENT SURVEILLANCE STATIONS

I. BACKGROUND LEVELS OF RADIOACTIVITY IN SOIL AND SEDIMENTS

Routine samples collected and analyzed for radionuclides from Regional Stations from 1978 through 1985 (Purtymun 1986c) were used to establish background levels of ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, total U, ^{3}H, and gross gamma radioactivity in soils and sediments (Table I). Average concentrations plus twice the standard deviation ($x + 2s$) were used to establish the upper limits of the background concentrations. The number of analyses used to establish background ranged from 115 (^{90}Sr) to 40 (^{137}Cs) for soils and 9 (^{90}Sr) to 30 (^{137}Cs, ^{238}Pu, and $^{239,240}Pu$) for sediments. Samples were collected from five regional soil stations and four regional sediment stations. Location of soil and sediment sampling stations are found in Table II.

II. REGIONAL SOILS AND SEDIMENTS

Regional soil and sediment samples were collected in the same general locations as the regional water samples (Figs. 1, 2 and 3). Additional regional sediment samples were collected from the Rio Grande and tributary streams entering the Rio Grande from Otowi Bridge to Cochiti Reservoir (Fig. 3). The locations are listed in Table II. Soil samples were collected for seven stations and analyzed for six types of radioactivity. Sediments were collected from 15 regional sediment stations and analyzed for 5 types of radioactivity.

III. PERIMETER SOILS AND SEDIMENTS

Six perimeter soil stations were sampled within 4 km (2.5 mi) of the Laboratory. Nine sediment stations near the Laboratory's boundary and on intermittent streams that cross Pajarito Plateau were sampled. Perimeter soil and sediment sampling stations are listed in Table I and Figs. 2 and 3).

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

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

[a]Source: References EPA 1976 and EPA 1979.

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

[c]Based on annual average of the maximum daily air temperature of 14.6 to 17.7°C.

APPENDIX K

ANALYTICAL CHEMISTRY METHODOLOGY

INTRODUCTION

All analytical chemistry is provided by Group HSE-9.

A. Radioactive Constituents

Environmental samples are routinely analyzed for the following radioactive constituents: gross alpha, gross beta, gross gamma, isotopic plutonium, americium, uranium, cesium, tritium, and strontium. The detailed procedures have been published in this appendix in previous years.[C1,C2] Occasionally other radionuclides from specific sources are determined: ^{7}Be, ^{22}Na, ^{40}K, ^{51}Cr, ^{60}Co, ^{65}Zn, ^{83}Rb, ^{106}Ru, ^{134}Cs, ^{140}Ba, ^{152}Eu, ^{154}Eu, and ^{226}Ra. All but ^{226}Ra are determined by gamma-ray spectrometry on large Ge(Li) detectors. Depending upon the concentration and matrix, ^{226}Ra is measured by emanation[C3] or by gamma-ray spectrometry of its ^{214}Bi decay product.[C4] Uranium isotopic ratios ($^{235}U/^{238}U$) are measured by neutron activation analysis where precisions of ±5% are adequate.[C5] More precise work requires mass spectrometry.

B. Stable Constituents

A number of analytical methods are used for various stable isotopes. The choice of method is based on many criteria, including the operational state of the instruments, time limitations, expected concentrations in samples, quantity of sample available, sample matrix, and Environmental Protection Agency (EPA) regulations.

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

C. Organic Constituents

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

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

D. Analytical Chemistry Quality Evaluation Program

1. Introduction. Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of several general types: calibration standards, reagent blanks, process

Table C-1. Analytical Methods for Various Stable Constituents

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

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

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

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

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

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

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

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

Table C-3. Volatiles Determined by EPA Method 601

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

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

quantities of liquid NBS radioactivity SRMs to blank matric materials.

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

Table C-4. Volatiles Determined by EPA Method 602

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

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

The analytical quality control program for a specific batch of samples is the combination of many factors. These include the "fit of the calibration," instrument drift, calibration of the instrument and/or reagents, recovery for SRMs, and precision of results. In addition, there is a program for evaluation of the quality of results for an individual water sample.[C75] These individual water sample quality ratios are the sum of the milliequivalent (meq) cations to the sum of meq anions, the meq hardness to the sum of meq Ca^{+2} and Mg^{+2}, the observed total dissolved solids (TDS) to the sum of solids, the observed conductivity to the sum of contributing conductivities, as well as the two ratios obtained by multiplying (0.01) × (conductivity) and dividing by the meq cations, and the meq anions.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table C-7. Volatiles Determined in Air

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

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

Table C-8. EP Toxicity Organic Contaminants

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

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

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

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

Table C-9 (cont)

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

Table C-10. Detection Limits for Analyses of Typical Environmental Samples

Parameter	Approximate Sample Volume or Weight	Count Time	Detection Limit Concentration
Air Sample			
Tritium	3 m^3	50 min	1×10^{-12} µCi/mℓ
^{238}Pu	2.0×10^6 m^3	8×10^6 sec	2×10^{-18} µCi/mℓ
$^{239,240}Pu$	2.0×10^6 m^3	8×10^6 sec	3×10^{-18} µCi/mℓ
^{241}Am	2.0×10^6 m^3	8×10^6 sec	2×10^{-18} µCi/mℓ
Gross alpha	6.5×10^3 m^3	100 min	4×10^{-16} µCi/mℓ
Gross beta	6.5×10^3 m^3	100 min	4×10^{-16} µCi/mℓ
Uranium (delayed neutron)	2.0×10^6 m^3	60 sec	1 pg/m^3
Water Sample			
Tritium	0.005 ℓ	50 min	7×10^{-7} µCi/mℓ
^{137}Cs	0.5 ℓ	5×10^6 sec	4×10^{-8} µCi/mℓ
^{238}Pu	0.5 ℓ	8×10^6 sec	9×10^{-12} µCi/mℓ
$^{239,240}Pu$	0.5 ℓ	8×10^6 sec	3×10^{-11} µCi/mℓ
^{241}Am	0.5 ℓ	8×10^6 sec	2×10^{-10} µCi/mℓ
Gross alpha	0.9 ℓ	100 min	3×10^{-9} µCi/mℓ
Gross beta	0.9 ℓ	100 min	3×10^{-9} µCi/mℓ
Uranium (Delayed neutron)	0.025 ℓ	50 sec	1 µ/ℓ
Soil Sample			
Tritium	1 kg	50 min	0.003 pCi/g
^{137}Cs	100 g	5×10^6 sec	10^{-1} pCi/g
^{238}Pu	10 g	8×10^6 sec	0.003 pCi/g
$^{239,240}Pu$	10 g	8×10^6 sec	0.002 pCi/g
^{241}Am	10 g	8×10^6 sec	0.01 pCi/g
Gross alpha	2 g	100 min	1.4 pCi/g
Gross beta	2 g	100 min	1.3 pCi/g
Uranium (Delayed neutron)	2 g	20 sec	0.03 µg/g

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

C39. E. S. Gladney, D. R. Perrin, W. K. Hensley, and M. E. Bunker, "Uranium Content of 25 Silicate Standard Materials," Geostandards Newsletter **4**, 243 (1980).

C40. E. S. Gladney, D. R. Perrin, and W. K. Hensley, "Determination of Uranium in NBS Biological Standard Reference Materials by Delayed Neutron Assay," J. Radioanal. Chem. **59**, 249 (1980).

C41. Perkin-Elmer Corporation, "Analytical Methods Using the HGA Graphite Furnace," Perkin-Elmer, Norwalk, Connecticut (1977).

C42. R. D. Ediger, "Atomic Absorption Analysis with the Graphite Furnace Using Matrix Modification," Atomic Absorption Newslett. **14**, 127 (1975).

C43. J. W. Owens and E. S. Gladney, "Determination of Beryllium in Environmental Materials by Flameless Atomic Absorption Spectrometry," Atomic Absorption Newslett. **15**, 95 (1976).

C44. J. W. Owens and E. S. Gladney, "Lithium Metaborate Fusion and the Determination of Trace Metals in Fly Ash by Flameless Atomic Absorption," Atomic Absorption Newslett. **15**, 95 (1976).

C45. J. W. Owens and E. S. Gladney, "The Determination of Arsenic in Natural Waters by Flameless Atomic Absorption," Atomic Absorption Newslett. **15**, 47 (1976).

C46. E. S. Gladney, "Matrix Modification for the Determination of Bi by Flameless Atomic Absorption," Atomic Absorption Newslett. **16**, 114 (1977).

C47. E. S. Gladney and J. W. Owens, "Determination of Hg Using a Carrier-Free Combustion Separation and Flameless Atomic Absorption," Anal. Chim. Acta **90**, 271 (1977).

C48. E. S. Gladney, J. W. Owens, and D. R. Perrin, "The Determination of Mercury in Environmental Materials," Los Alamos National Laboratory report LA-7865-MS (June 1979).

C49. F. C. Smith and R. A. Wetzel, "Operation and Maintenance Manual for Dionex Model 10 and Model 14 Ion Chromatographs," Dionex Corp., Sunnyvale, California (1978).

C50. American Society for Testing and Materials, *1977 Annual Book of ASTM Standards: Part 31: Water*, ASTM, Philadelphia, Pennsylvania (1977).

C51. E. S. Gladney and D. Knab, "Determination of 13 Rare Earth Elements in Geological Materials via Thermal and Epithermal Neutron Activation with Pre-irradiation Chemical Separation," (in preparation).

C52. F. J. Fernandez, M. M. Beaty, and W. B. Barnett, "Use of L'Vov Platform for Furnace Atomic Absorption Applications," Atomic Spectroscopy **2**, 16 (1981).

C53. T. C. Rains, M. S. Epstein, and S. R. Koirtyohann, "Atomic Absorption Spectroscopy," American Chemical Society—A Short Course.

C54. C. R. Parker, "Water Analysis by Atomic Spectroscopy," Varian Techtron Ltd, Springvale, Australia (1972).

C55. D. Knab, "An Investigation of the Analysis of Environmental Samples for Fluoride" (in preparation).

C56. Code of Federal Regulations, Protection of Environment 40 Parts 190-399, Office of the Federal Register, National Archives and Record Service, General Services Administration (1983).

C57. NACE Standard TM-01-67, "Laboratory Corrosion Testing of Metals for the Process Industries," National Association of Corrosion Engineers, Houston, Texas (1972).

C58. ASTM Method 093-77 or D93-80, American Society for Testing Materials, Philadelphia, Pa.

C59. Methods for Chemical Analysis of Water and Waste, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio (1983).

C60. Industrial Methods for Technician Auto Analyzer II, Technicon Industrial Systems, Tarrytown, NY (1977-1982).

61. M. C. Williams, "Automated Method for the Determination of Cyanide" (in preparation).

C62. B. B. Bernard and D. L. Vann, "Model 700: Total Organic Carbon Analyzer Operating Procedures and Service Manual," OIC Corp. (1984).

C63. N. W. Bower, E. S. Gladney, and R. W. Ferenbaugh, "Critical Comparison of X-Ray Fluorescence and Combustion-Infrared Methods for the Determination of Sulfur in Biological Matrices," Analyst, 110: (in press, 1985).

C64. Federal Register, Part III (Dec. 3, 1979).

C65. M. A. Gautier and E. S. Gladney, "Health and Environmental Chemistry at Los Alamos: Analytical Methods, Sample and Data Management," LA-10300 (in press, 1985).

C66. USEPA, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846 Second Edition (July 1982).

C67. E. S. Gladney, J. W. Owens, T. C. Gunderson, and W. E. Goode, "Quality Assurance for Environmental analytical Chemistry: 1976-1979," Los Alamos Scientific Laboratory report LA-8730-MS (1981).

C68. E. S. Gladney, W. E. Goode, D. R. Perrin, and C. E. Burns, "Quality Assurance for Environmental Analytical Chemistry: 1980," Los Alamos National Laboratory report LA-8966-MS (1981).

C69. E. S. Gladney, C. E. Burns, D. R. Perrin, and R. D. Robinson, "Quality Assurance for Environmental Analytical Chemistry: 1981," Los Alamos National Laboratory report LA-9579-MS (1982).

C70. E. S. Gladney, C. E. Burns, D. R. Perrin, R. D. Robinson, and D. Knab, "Quality Assurance for Environmental Analytical Chemistry: 1982," Los Alamos National Laboratory report LA-9950-MS (1984).

C71. E. S. Gladney, D. R. Perrin, and W. E. Goode, "Quality Assurance for Environmental Analytical Chemistry at Los Alamos," Proceedings of the 4th DOE Environmental Protection Information Meeting, Denver, Co., Dec. 7-9, 1982, CONF-821215, pp. 107-118 (1983).

C72. E. S. Gladney, C. E. Burns, D. R. Perrin, R. D. Robinson, and N. A. Raybold, "Quality Assurance for Environmental Analytical Chemistry: 1983," Los Alamos National Laboratory report LA-10115-MS (1984).

C73. M. A. Gautier, E. S. Gladney, and D. R. Perrin, "Quality Assurance for Health and Environmental Chemistry: 1984," Los Alamos National Laboratory report LA-10508-MS (1985).

C74. M. A. Gautier, E. S. Gladney, and B. O'Malley, "Quality Assurance for Health and Environmental Chemistry: 1985, Los Alamos National Laboratory report (in press).

C75. R. D. Robinson, D. Knab, and D. R. Perrin, "An Individual Water Sample Quality Assurance Program," Los Alamos National Laboratory report LA-10163-MS (1985).

Source:

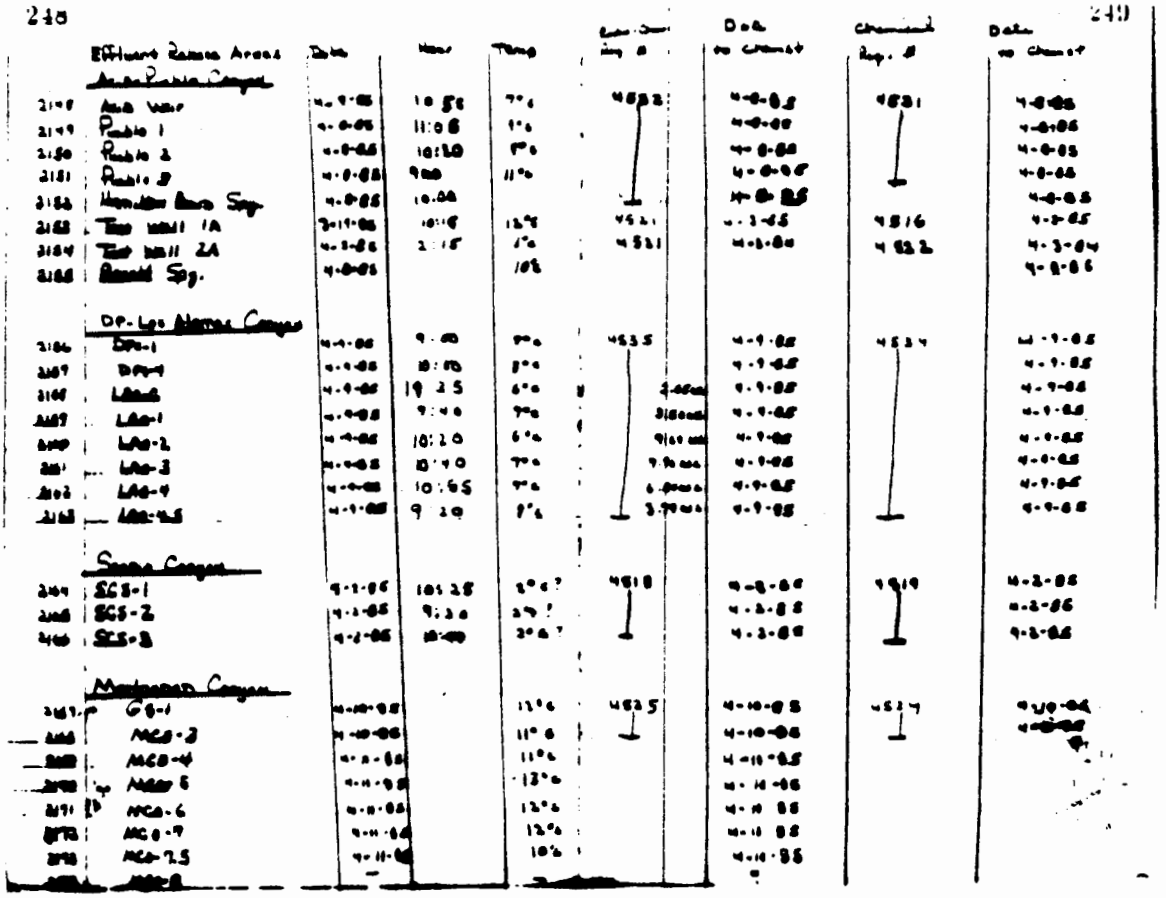
"Environmental Surveillance at Los Alamos During 1985," Los Alamos National Laboratory report LA-10721-ENV (1986)

APPENDIX L

EXAMPLES OF DOCUMENTATION

Examples of documentation of samples collected from analyses to completion are presented in the following pages of Appendix J. These examples (stations in onsite effluent release areas; Acid-Pueblo and DP-Los Alamos Canyon) were prepared for the routine surveillance report 1985 (LA-10721-ENV).

Appendix L (cont)



Example of Collector's Log Book

Los Alamos
Los Alamos National Laboratory

H-9 ANALYTICAL CHEMISTRY REQUEST

4532

REQUESTOR	MM	SAMPLE NUMBERS:
PROJECT NUMBER	W578	
SAMPLE OWNER ID	WP	85.02148 → 52
DATE	4-8-85	
TOTAL No. of SAMPLES	5	
MATERIAL TYPE	W	

Analysis	Technique	Projected Completion Date	Analyst	Priority	Weight or Volume Aliquoted	Date completed and reported	Remarks
γ	G		ESG				
Cs137	G		"				
U	DNA		"				
H-3	LS		RJP				
Pu 238	RAS		"				
Pu 239	"		"				
							Radiochem
							Acid-Public
							4-8-85

Example of HSE9 Radiochemical Request Sheet (Informal Chain of Custody)

SPECIAL INFORMATION:

Is sample dissolution required? *(check one)* ☐ Yes ☐ No

Other sample preparation required? *(if so, specify)*

Other information:

Form No. 991 (8/81)

Los Alamos
Los Alamos National Laboratory

H-~~8~~9 ANALYTICAL CHEMISTRY REQUEST

4531

REQUESTOR	MM	SAMPLE NUMBERS:
PROJECT NUMBER	W578	
SAMPLE OWNER ID	WP	85.02148 → 52
DATE	4-8-85	
TOTAL No. of SAMPLES	5	
MATERIAL TYPE	W	

Analyses	Technique	Projected Completion Date	Analyst	Priority	Weight or Volume Aliquoted	Date completed and reported	Remarks
SiO_2	color		DK				
Ca	AA		RDR				
Mg	"						
Na	"						
K	"						
CO_3	TiTr						
HCO_3	"						
Hard	"						
P	IC						
SO_4	"						
Cl	"						Chemical Acid-Filter Carpon
N	"						
F	"						
TDS	Grav						
PH	ISE						
Cond	"						

Example of HSE-9 Chemical request sheet (Informal chain of Custody)

SPECIAL INFORMATION:

Is sample dissolution required? (check one) ☐ Yes ☐ No

Other sample preparation required? (if so, specify)

Other information:

Form No. 991 (8/81)

Appendix L (cont)

Page 1

****

HSE-9 ANALYTICAL RESULTS

PU-238 24-Jun-1985 WDF

****

SAMPLE NUMBER	REQ NUM	RESULT	UNCERTAINTY	UNITS	COMPLETION DATE
85.02105	04526 -	0.0131	0.0098	PCI/L	6/24/85
85.02106	04526	0.0000	0.0100	PCI/L	6/24/85
85.02107	04526 -	0.0047	0.0123	PCI/L	6/24/85
85.02147	04538 -	0.0069	0.0069	PCI/L	6/24/85
85.02148	04532 -	0.0054	0.0122	PCI/L	6/24/85
85.02149	04532	0.0105	0.0149	PCI/L	6/24/85
85.02150	04532	0.0000	0.0100	PCI/L	6/24/85
85.02151	04532 -	0.0041	0.0072	PCI/L	6/24/85
85.02152	04532 -	0.0043	0.0074	PCI/L	6/24/85
85.02156	04535	0.1620	0.0274	PCI/L	6/24/85
85.02157	04535	0.0678	0.0187	PCI/L	6/24/85
85.02158	04535 -	0.0045	0.0079	PCI/L	6/24/85
85.02159	04535 -	0.0088	0.0088	PCI/L	6/24/85
85.02160	04535	0.0153	0.0135	PCI/L	6/24/85
85.02161	04535	0.0132	0.0146	PCI/L	6/24/85
85.02200	04526 -	0.0051	0.0114	PCI/L	6/24/85

Terry Permenter
RSI
Pueblo Canyon
DP-LOS
W. [illegible]
EHL

THESE DATA MEET ESTABLISHED HSE9 GROUP QUALITY ASSURANCE STANDARDS

DK
SECTION LEADER

mcg 10/11/85
QUALITY ASSURANCE OFFICER

DK 7/1

Example of radiochemical Analytical Results

Rejected WP

Regional
Formaty
Onsite
Acid Punto
DP-
Los Alamos
Sandia
MDPT

TDS

Example of Chemical Analytical results

Appendix V

Appendix L (cont)

Station		Month Date	(10⁻⁶ μCi/ml)			(10⁻⁶ μCi/ml)	Total U (μg/l)		
Acid Wash	1	4-8	41 ± 53	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50 ± 50
Acid Wash	11	1-19	[illegible]	[illegible]	0.011 ± 0.012	2.7 ± 0.5	2.7 ± 0.2	[illegible]	30 ± 60
Pueblo 1	30	4-8	99 ± 39	0.011 ± 0.012	0.011 ± 0.012	[illegible]	1.1 ± 0.4		60 ± 50
Pueblo 1	30	9-18	47 ± 40	0.005 ± 0.012	[illegible]	0.7 ± 0.4	0.4 ± 0.2		40 ± 60
Pueblo 2	31	4-8	21 ± 46	[illegible]	0.05 ± 0.011	0.5 ± 0.3	0.5 ± 0.2		60 ± 50
Pueblo 2	31	10-2	66 ± 44	[illegible]	0.207 ± 0.081	[illegible]	1.4 ± 0.2		120 ± 60
Pueblo 3	32	4-8	56 ± 37	0.004 ± 0.011	0.035 ± 0.13	0.7 ± 0.3	0.9 ± 0.4		70 ± 50
Pueblo 3	32	1-18	-41 ± 52	0.002 ± 0.018	[illegible]	[illegible]	1.7 ± 0.2		40 ± 60
Hamilton Bend Spring	53	4-8	62 ± 38	0.004 ± 0.017	[illegible]	-0.6 ± 0.3	1.5 ± 0.5		[illegible] ± 60
Hamilton Bend Spring	53	1-18	-56 ± 36	[illegible]	[illegible]	0.4 ± 0.4	1.3 ± 0.2		30 ± 60
Test Well 1A	54	2-19	47 ± 56	0.003 ± 0.011	[illegible]	-0.6 ± 0.3	1.6 ± 0.5		50 ± 50
Test Well 1A	54	9-17	-37 ± 36	[illegible]	0.023 ± 0.013	[illegible]	1.1 ± 0.2		90 ± 60
Test Well 2A	55	4-3	93 ± 47	0.002 ± 0.010	[illegible]	1.6 ± 0.4	0.4 ± 0.4		90 ± 50
Test Well 2A	55	10-3	207 ± 46	0.032 ± 0.013	0.038 ± 0.014	-0.31 ± 0.3	0.9 ± 0.1		-110 ± 60
Rasell Spring	56	9-18	91 ± 39	0.000 ± 0.010	0.012 ± 0.010	0.4 ± 0.4	1.1 ± 0.1		-90 ± 60
No. of Analyses			15	15	15	15	15	15	15
Minimum			-37 ± 6	0.000 ± 0.007	-0.007 ± 0.007	-0.99 ± 0.3	0.4 ± 0.4		12 ± 60
Maximum			93 ± 47	0.033 ± 0.013	0.496 ± 0.052	2.9 ± 0.5	1.7 ± 0.2		90 ± 50
Average			11	0.002	0.060	0.5	1.0		21
S			66	0.013	0.148	1.1	0.3		47
Limits of Detection			40	0.009	0.03	0.2	1		50

Example of Recap Table (Rough)

Chemical

Station	Month	SiO_2	Ca	Mg	K	Na	CO_3	HCO	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond. Index
Acid Wash	4-8	18	17	2.4	4.0	110	0	42	<0.5	11	153	0.6	0.3	386	48	7.5	67
Pueblo 1	4-8	42	16	3.0	8.1	56	0	60	6.0	21	35	0.6	8.3	270	48	6.5	40
Pueblo 2	4-8	49	14	2.8	8.5	53	0	51	8.5	19	54	0.6	3.8	242	44	7.3	35
Pueblo 3	4-8	50	14	3.3	9.5	66	0	73	8.3	21	52	0.7	7.0	259	54	7.1	46
Hamilton Bend Spring	4-8	58	16	4.9	9.1	77	0	96	8.2	24	66	0.9	3.6	314	58	7.3	51
Test Well 1A	3-19	56	23	6.8	7.9	71	0	105	1.4	27	49	0.8	12	339	92	7.7	52
Test Well 2A	4-3	20	29	6.4	8.2	26	0	76	<0.5	21	37	0.3	<0.2	183	94	7.5	33
No. of Analyses		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Minimum		14	16	2.4	4.0	22		21	[illegible]	11	35	0.2	[illegible]	183	44	[illegible]	[illegible]
Maximum		58	21	6.8	9.5	110	0	105	[illegible]	27	153	0.9	12	339	94	7.7	67
Average		41	19	4.6	7.0	60		72	4.6	21	69	0.6	5.0	236	67	7.3	46
		17	5	1.8	2.2	26		23	3.2	5	41	0.2	4.4	60	17	0.4	12

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Radiochemical and Chemical [illegible] surface water from DP-[illegible] Canyon, [illegible] Cañada [illegible] release area.

Station	1985 Date (Month-Day)	^{137}Cs (10^{-9} uCi/ml)	^{238}Pu (10^{-9} uCi/ml)	$^{239,240}Pu$ (10^{-9} uCi/ml)	^{3}H (10^{-9} uCi/ml)	Total U (ug/l)	Gross α (counts/min/l)	Chemistry
DPS-1	4-9	[illegible] ± 42	0.010 ± 0.009	0.162 ± 0.127	1.3 ± 0.4	[illegible] ± 3.0	70 ± 50	21[illegible]
DPS-1	9-14	-14 ± 39	0.006 ± 0.011	0.002 ± 0.009	0.0 ± 0.4	0.0 ± 0.2	10 ± 60	5379
DPS-4	4-9	10[illegible] ± 43	0.066 ± 0.016	0.276 ± 0.037	20 ± 2.0	12 ± 2.0	10 ± 50	21[illegible]
DPS-4	9-14	6[illegible] ± 51	0.079 ± 0.021	0.110 ± 0.025	2.9 ± 0.5	29 ± 0.3	20 ± 60	5254
LAO-C	4-9	02 ± 40	-0.006 ± 0.006	0.006 ± 0.010	0.3 ± 0.3	3 ± 0.4	60 ± 50	215[illegible]
LAO-C	9-14	-16 ± 42	0.010 ± 0.018	0.009 ± 0.011	0.9 ± 0.4	1.5 ± 0.2	110 ± 60	538[illegible]
LAO-1	4-9	47 ± 46	-0.009 ± 0.009	0.022 ± 0.012	19 ± 2.0	1[illegible] ± 0.4	80 ± 50	21[illegible]
LAO-1	9-14	-17 ± 36	-0.005 ± 0.0[illegible]	0.024 ± 0.014	0.[illegible] ± 0.4	1.6 ± 0.2	40 ± 60	5382
LAO-2	4-9	[illegible] ± 49	0.015 ± 0.013	0.153 ± 0.029	19 ± 2.0	6.4 ± 1.1	100 ± 50	2160
LAO-2	9-14	19 ± 36	0.030 ± 0.017	0.14 ± 0.023	0.7 ± 0.4	2.9 ± 0.2	20 ± 60	5383
LAO-3	4-9	43 ± 38	0.013 ± 0.014	0.04 ± 0.010	2.6 ± 3.0	2.5 ± 0.8	2[illegible] ± 50	2161
LAO-3	[illegible]	-8 ± 34	0.091 ± 0.017	0.092 ± 0.022	2.3 ± 0.4	2.8 ± 0.3	-5[illegible] ± 60	2284
LAO-4	4-9	[illegible] ± 41	0.004 ± 0.009	0.013 ± 0.010	3.3 ± 0.5	0.6 ± 0.4	40 ± 50	2162
LAO-4	9-14	-33 ± 51	0.040 ± 0.013	0.011 ± 0.025	0.9 ± 0.4	2.4 ± 0.2	40 ± 60	5385
LAO-4.5	4-9	-21 ± 36	-0.016 ± 0.009	0.023 ± 0.011	2.3 ± 0.5	2.2 ± 0.7	70 ± 50	2163
LAO-4.5	9-14	17 ± 51	0.024 ± 0.016	0.007 ± 0.026	0.[illegible] ± 0.4	3.0 ± 0.3	-3[illegible] ± 60	5[illegible]
No. of Analyses		16	16	16	16	16	16	
Minimum		-33 ± 51	-0.016 ± 0.009	0.002 ± 0.010	-0.3 ± 0.3	0.0 ± 0.2	-3[illegible] ± 60	
Maximum		106 ± 43	0.190 ± 0.009	0.276 ± 0.037	26 ± 3.0	31 ± 3.0	110 ± 60	
Average		29	0.528	0.081	6.2	4.4	41	
S		39	0.122	0.080	9.0	8	45	
Limits of detections		40	0.009	0.03	0.7	1	50	

Example of Recap Table (Rough)

Chemical

Station	Date (Month-Day)	Sp. Cond. (µmhos/cm)	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Hard	pH	Cond (µmhos/cm)	Chemistry
DPS-1	4-9	20	30	3.0	9.1	132	0	133	<0.[illegible]	22	154	1.6	<0.2	431	96	7.8	78	21[illegible]
DPS-4	9-14	14	12	1.9	14	132	0	127	<0.[illegible]	23	125	6.0	3.4	407	38	7.8	72	[illegible]
LAO-C	4-9	35	13	3.7	3.9	69	0	51	<0.[illegible]	8	99	0.2	<0.2	269	46	7.4	46	[illegible]
LAO-1	4-9	40	27	6.6	5.5	77	0	59	<0.[illegible]	18	137	0.6	0.6	363	92	7.4	61	[illegible]
LAO-2	4-9	18	12	2.3	14	122	0	120	<0.[illegible]	21	108	5.5	2.3	346	38	7.9	70	[illegible]
LAO-3	4-9	35	20	4.3	13	117	0	116	<0.[illegible]	21	133	3.0	2.5	417	65	7.3	74	[illegible]
LAO-4	4-9	33	14	4.4	7.6	44	0	56	<0.[illegible]	12	68	1.1	<0.2	212	52	7.4	35	[illegible]
LAO-4.5	4-9	62	16	5.4	5.3	46	0	55	<0.[illegible]	11	56	0.7	<0.2	237	58	7.4	36	[illegible]
No. of Analyses		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	

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Appendix L (cont)

Table G-19. Radiochemical and Chemical Quality of Surface and Ground Waters from Acid-Pueblo Canyon, A Former Effluent Release Area

Station	Map Designation	1986 (month-day)	Radiochemical ^{137}Cs (10^{-9} µCi/ml)	^{238}Pu (10^{-9} µCi/ml)	$^{239,240}Pu$ (10^{-9} µCi/ml)	^{3}H (10^{-6} µCi/ml)	Total U (µg/l)	Gross Gamma (counts/min/l)
Acid Weir	49	4-8	−47 ± 53	−0.005 ± 0.012	0.446 ± 0.052	−0.2 ± 0.3	1.1 ± 0.4	80 ± 50
Acid Weir	49	9-18	23 ± 37	−0.006 ± 0.010	0.017 ± 0.012	2.7 ± 0.5	0.7 ± 0.2	−30 ± 60
Pueblo 1	50	4-8	89 ± 39	0.011 ± 0.012	0.011 ± 0.012	−0.9 ± 0.3	1.1 ± 0.4	60 ± 50
Pueblo 1	50	9-18	−47 ± 40	0.008 ± 0.012	−0.008 ± 0.007	0.7 ± 0.4	0.8 ± 0.2	40 ± 60
Pueblo 2	51	4-8	21 ± 48	0.000 ± 0.010	0.056 ± 0.017	0.5 ± 0.3	0.5 ± 0.2	60 ± 50
Pueblo 2	51	10-2	66 ± 44	−0.017 ± 0.010	0.207 ± 0.031	0.2 ± 0.4	1.4 ± 0.2	−120 ± 60
Pueblo 3	52	4-8	56 ± 37	−0.004 ± 0.001	0.033 ± 0.013	0.7 ± 0.3	0.9 ± 0.4	70 ± 50
Pueblo 3	52	9-18	−94 ± 52	0.008 ± 0.015	0.000 ± 0.010	0.0 ± 0.4	1.7 ± 0.2	40 ± 60
Hamilton Bend Spring	53	4-8	62 ± 35	−0.004 ± 0.007	−0.009 ± 0.006	−0.6 ± 0.3	1.5 ± 0.5	10 ± 50
Hamilton Bend Spring	53	9-18	−86 ± 36	−0.005 ± 0.014	0.038 ± 0.015	0.4 ± 0.4	1.3 ± 0.2	30 ± 60
Test Well 1A	54	3-19	−47 ± 56	0.032 ± 0.013	0.014 ± 0.010	−0.6 ± 0.3	1.0 ± 0.5	50 ± 50
Test Well 1A	54	9-17	−37 ± 36	−0.014 ± 0.012	0.028 ± 0.013	2.9 ± 0.5	1.1 ± 0.2	90 ± 60
Test Well 2A	55	4-3	93 ± 47	0.000 ± 0.010	0.012 ± 0.009	1.8 ± 0.4	0.4 ± 0.4	90 ± 50
Test Well 2A	55	10-3	20 ± 48	0.026 ± 0.013	0.038 ± 0.014	−0.3 ± 0.3	0.9 ± 0.1	−110 ± 60
Beaver Spring	56	9-18	91 ± 39	0.000 ± 0.010	0.012 ± 0.010	0.4 ± 0.4	1.1 ± 0.1	−40 ± 60
No. of Analyses			15	15	15	15	15	15
Minimum			−94 ± 52	−0.017 ± 0.010	−0.009 ± 0.006	−0.9 ± 0.3	0.4 ± 0.4	−120 ± 60
Maximum			93 ± 47	0.032 ± 0.013	0.446 ± 0.052	2.9 ± 0.5	1.7 ± 0.2	90 ± 60
Average			11	0.002	0.060	0.5	1.0	21
s			66	0.013	0.148	1.1	0.3	67
Limits of Detection			40	0.009	0.03	0.7	1	50

Table G-19 (cont)

Station	Map (month-day)	HCO3	Ca	Mg	K	Na	CO3	SO4	P	SiO2	Cl	F	N	TDS	Sand	pH	Cond (µmhos)
		Chemical (concentration in mg/l)															
Acid Weir	4-8	18	17	2.4	4.0	110	0	42	<0.5	11	153	0.6	0.3	296	48	7.3	67
Pueblo 1	4-8	43	16	3.0	8.1	96	0	60	6.0	21	35	0.6	0.3	270	40	6.5	40
Pueblo 2	4-8	48	14	2.0	6.5	33	0	31	4.5	19	36	0.6	3.0	262	40	7.3	35
Pueblo 3	4-8	36	18	3.3	9.5	66	0	73	8.3	21	52	0.7	7.0	299	38	7.1	46
Hamilton Bend Spring	4-8	38	16	4.9	9.1	77	0	98	8.3	36	66	0.9	3.6	314	[illegible]	7.3	51
Test Well 1A	3-19	36	23	6.0	7.9	71	0	100	4.4	27	40	0.8	12	339	82	7.7	52
Test Well 2A	4-3	20	20	6.4	4.2	22	0	76	<0.5	21	37	0.5	<0.2	163	96	7.5	33
No. of Analyses		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Minimum		18	16	2.4	4.0	22	—	31	<0.5	11	35	0.3	<0.2	163	40	6.5	33
Maximum		50	20	6.0	9.5	110	0	100	8.3	27	153	0.9	12	296	96	7.7	67
Average		41	19	4.2	7.0	68	—	72	<4.6	21	66	0.6	<3.0	286	61	7.3	46
s		17	3	1.0	2.2	36	—	23	3.2	5	41	0.2	4.4	60	19	0.6	12

Example of Recap table (finished) used in Appendix of report

Table G-23. Radiochemical and Chemical Quality of Surface and Ground Waters from DP-Los Alamos Canyon, an Active Effluent Release Area

Station	1986 (month-day)	Radiochemical: ^{137}Cs (10^{-9} µCi/ml)	^{238}Pu (10^{-9} µCi/ml)	$^{239,240}Pu$ (10^{-9} µCi/ml)	^{3}H (10^{-6} µCi/ml)	Total U (µg/l)	Gross Gamma (counts/min/l)
DP5-1	4-9	72 ± 42	0.494 ± 0.049	0.162 ± 0.027	1.5 ± 0.4	31 ± 3.0	70 ± 50
DP5-1	9-19	−14 ± 39	0.008 ± 0.011	0.012 ± 0.009	0.8 ± 0.4	0.0 ± 0.2	10 ± 60
DP5-4	4-9	106 ± 43	0.068 ± 0.018	0.276 ± 0.037	20 ± 2.0	9.2 ± 2.0	10 ± 50
DP5-4	9-19	68 ± 51	0.079 ± 0.021	0.150 ± 0.025	2.9 ± 0.5	2.9 ± 0.3	20 ± 60
LAO-C	4-9	62 ± 40	−0.004 ± 0.008	0.000 ± 0.010	−0.3 ± 0.3	0.9 ± 0.4	60 ± 50
LAO-C	9-19	−16 ± 42	0.023 ± 0.018	0.009 ± 0.011	0.9 ± 0.4	1.5 ± 0.2	110 ± 60
LAO-1	4-9	47 ± 46	−0.009 ± 0.008	0.022 ± 0.012	19 ± 2.0	1.2 ± 0.4	80 ± 50
LAO-1	9-19	−12 ± 36	−0.005 ± 0.011	0.024 ± 0.014	0.2 ± 0.4	1.6 ± 0.2	40 ± 60
LAO-2	4-9	55 ± 49	0.015 ± 0.013	0.153 ± 0.029	19 ± 2.0	6.4 ± 1.1	100 ± 50
LAO-2	9-19	19 ± 36	0.030 ± 0.017	0.114 ± 0.023	0.7 ± 0.4	2.4 ± 0.2	20 ± 60
LAO-3	4-9	43 ± 38	0.013 ± 0.014	0.004 ± 0.010	26 ± 3.0	2.5 ± 0.8	20 ± 50
LAO-3	9-19	−8 ± 34	0.041 ± 0.017	0.092 ± 0.022	0.5 ± 0.4	2.4 ± 0.3	−50 ± 60
LAO-4	4-9	32 ± 41	0.004 ± 0.009	0.025 ± 0.010	3.3 ± 0.5	0.6 ± 0.4	90 ± 50
LAO-4	9-19	−33 ± 51	0.080 ± 0.013	0.081 ± 0.025	0.9 ± 0.4	2.4 ± 0.2	40 ± 60
LAO-4.5	4-9	−22 ± 36	−0.016 ± 0.009	0.023 ± 0.011	3.5 ± 0.5	2.2 ± 0.7	70 ± 50
LAO-4.5	9-19	17 ± 41	0.034 ± 0.016	0.150 ± 0.028	0.8 ± 0.4	3.0 ± 0.3	30 ± 60
No. of Analyses		16	16	16	16	16	16
Minimum		−33 ± 51	−0.016 ± 0.009	0.000 ± 0.010	−0.3 ± 0.3	0.0 ± 0.2	−50 ± 60
Maximum		106 ± 43	0.494 ± 0.049	0.276 ± 0.037	26 ± 3.0	31 ± 3.0	110 ± 60
Average		29	0.130	0.081	6.2	4.4	41
s		39	0.122	0.080	9.0	8	45
Limits of Detection		40	0.009	0.03	0.7	1	50

Table G-23 (cont)

Station	1986 (month-day)	Chemical (concentration in mg/l): [illegible]	Ca	Mg	K	Na	CO_3	HCO_3	F	SO_4	Cl	F	N	TDS	Hard	pH	Cond (µmhos)
DP5-1	4-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DP5-1	9-19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DP5-4	4-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DP5-4	9-19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-C	4-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-C	9-19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-1	4-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-1	9-19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-2	4-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-2	9-19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-3	4-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-3	9-19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-4	4-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-4	9-19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-4.5	4-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAO-4.5	9-19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
No. of Analyses		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Minimum		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Maximum		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
s		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Example of Recap Table (Finished) used in appendix of report

Appendix L (cont)

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

	Number of Stations[a]	^{137}Cs (10^{-9} µCi/ml)	^{238}Pu (10^{-9} µCi/ml)	$^{239,240}Pu$ (10^{-9} µCi/ml)	^{3}H (10^{-6} µCi/ml)	Total U (µg/l)	Gross Gamma (counts/min/l)
Analytical Limits of Detection		40	0.009	0.03	0.7	1.0	50
Offsite Stations (Uncontrolled Areas)							
Derived Concentration Guide (DCG) for Uncontrolled Areas[b]		3 000	400	300	2 000	800	—
Regional	6	140 ± 60	0.015 ± 0.013	0.035 ± 0.025	5.1 ± 0.7	3.6 ± 0.6	140 ± 60
Perimeter							
Adjacent	7	121 ± 58	0.014 ± 0.016	0.021 ± 0.015	2.8 ± 0.5	28 ± 2.0	110 ± 60
White Rock	21	108 ± 41	0.014 ± 0.001	0.010 ± 0.010	1.0 ± 0.4	19 ± 1.0	250 ± 70
Offsite Station Group Summary:							
Maximum Concentration	—	140 ± 60	0.015 ± 913	0.035 ± 0.025	5.1 ± 0.7	28 ± 2.0	—
Maximum Concentration as % DCG for Uncontrolled Areas	—	5	<1	<1	<1	4	—
Onsite Stations (Controlled Areas)							
Concentration Guide (CG) for Controlled Areas[b]		400 000	100 000	100 000	100 000	60 000	—
Nonaffluent Areas							
Ground Water (Main Aquifer)	6	66 ± 38	0.016 ± 0.016	0.055 ± 0.017	3.4 ± 0.5	3.4 ± 0.6	40 ± 60
Surface Water	3	47 ± 40	0.000 ± 0.010	0.019 ± 0.013	2.4 ± 0.5	1.2 ± 0.4	140 ± 60
Pajarito Canyon	3	74 ± 49	0.024 ± 0.015	0.016 ± 0.011	1.3 ± 0.4	3.8 ± 0.8	60 ± 60
Effluent Areas							
Acid-Pueblo Canyon	8	93 ± 47	0.032 ± 0.013	0.446 ± 0.092	2.9 ± 0.5	1.7 ± 0.2	90 ± 60
DP-Los Alamos Canyon	8	106 ± 43	0.494 ± 0.049	0.276 ± 0.037	26 ± 3.0	31 ± 3.0	110 ± 60
Sandia Canyon	3	98 ± 53	0.022 ± 0.017	0.012 ± 0.009	3.7 ± 0.5	2.9 ± 0.3	70 ± 60
Mortandad Canyon	7	95 ± 45	1.23 ± 0.084	5.76 ± 0.223	48 ± 5.0	8.1 ± 0.8	560 ± 50
Onsite Group Summary:							
Maximum Concentration	—	106 ± 43	1.23 ± 0.084	5.76 ± 0.223	48 ± 5.0	31 ± 3.0	560 ± 50
Maximum Concentration as % CG for Controlled Areas	—	<1	<1	<1	<1	<1	—

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

Example of Recap Table used in Text of Report

Appendix L (cont)

Table 13. Maximum Chemical Concentrations in Surface and Ground Waters

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

[a]EPA (1976, 1979B).

Example of Recap Table used in Text of Report

APPENDIX M

WATER, SOIL, AND SEDIMENT SURVEILLANCE (1985)

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

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

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

Measurements of radioactivity in samples of soils and sediments provide data on less direct pathways of exposure. Measurements of radioactivity in soils and sediments are also useful for monitoring and understanding hydrological transport of radioactivity that occurs in intermittent stream channels in and adjacent to low-level radioactive waste management areas. Pueblo, Los alamos, and Mortandad Canyons all

have concentrations of radioactivity on sediments at levels higher than those attributable to natural terrestrial sources or worldwide fallout. The low levels of cesium, plutonium, and strontium in Mortandad Canyon are from treated liquid effluents from a waste treatment plant. No radioactivity on sediments or in water has been measured in sampling locations beyond the Laboratory boundary in Mortandad Canyon. However, small amounts of radioactivity on sediments in Pueblo Canyon (from pre-1964 effluents) and upper Los Alamos Canyon (from 1952 to current treated effluents) have probably been transported during runoff events to the Rio Grande. Theoretical estimates, confirmed by measurements, show the incremental effect on Rio grande sediments from this transported radioactivity is insignificant when compared with concentrations of radioactivity in soils and sediments attributable to worldwide fallout and natural sources.

Examples of documentation of samples collected from analyses to completion are presented in the following pages of Appendix J. These examples (stations in onsite effluent release areas; Acid-Pueblo and DP-Los Alamos Canyon) were prepared for the routine surveillance report 1985 (LA-10721-ENV).

REFERENCES

"Environmental Surveillance at Los Alamos During 1985," Los Alamos National Laboratory report LA-10721-ENV (1986).

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

Airborne Stack Emissions

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

Liquid Effluents

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

APPENDIX N

SUMMARY OF WATER SUPPLY FOR 1985

Well field operations during 1985 were satisfactory with municipal and industrial supply consisting of 1587 x 10^6 gal from wells in three well fields and 37 x 10^6 gal from the gallery in Water Canyon. About 2.8 x 10^6 gal of water from Guaje Reservoir and 0.9 x 10^6 gal from Los Alamos Reservoir were used for irrigation; thus the total water use in 1985 was about 1628 x 10^6 gal. Primary and secondary chemical quality of water in the distribution system is in compliance with federal regulations.

Pumpage has not been excessive. Projected water demand can be handled through increased operation of the wells in the three well fields. Water-level fluctuations (recovery and declines) are as anticipated with current pumpage. The declines have not been excessive. Water levels have risen (PM-2) where pumpage has decreased. Pumping rate and specific capacities have remained fairly constant for the past few years, showing very little deterioration of wells or pumping equipment. Based on this data, no recommendations are necessary for specific well rehabilitation. Recommendations are that future operations be carried out as in the past year. Hydrologic data collected as in 1985 should continue with an annual evaluation prepared at the beginning of 1987.

REFERENCE

"Water Supply at Los Alamos During 1985," Los Alamos National Laboratory report (in preparation).