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

OCT 11 1994

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SOLID WASTE BUREAU

David Duran, Program Manager
Permitting Section
Solid Waste Bureau
New Mexico Environment Department
P. O. Box 26110
Santa Fe, NM 87502

Dear Mr. Duran:

This letter is in regard to a request for Part VIII, Section 801.C, suspension and submission of a Vadose Zone Monitoring Plan. In response to a letter issued on September 9, 1994, by the New Mexico Environment Department (NMED) to the Los Alamos National Laboratory (LANL), the Department of Energy and the University of California are seeking a suspension from the groundwater monitoring requirements of Part VIII, Sections 802 through 806 of the New Mexico Solid Waste Management Regulations (SWMR) as provided in SWMR Section 801.C. The suspension is for LANL's industrial (special waste) landfill located in Technical Area 54, Area J.

The suspension requires a demonstration that there is no potential for migration of hazardous constituents from the landfill to the uppermost aquifer during the active life of the landfill and the post-closure care period. This demonstration is being made by LANL through submission of the following: Enclosure A, "Documentation for Suspension Request and Vadose Zone Monitoring Plan, TA-54, Area J;" and Enclosure B, "Potential Transport of PCBs Through Fractured Tuff at Area G."

The Vadose Zone Monitoring Plan, which is part of the documentation for the suspension request, is proposed in lieu of a groundwater monitoring plan. The plan is for LANL's industrial landfill and is designed to detect key indicator hazardous constituents in the unsaturated zone and is transmitted herewith.

Enclosure C contains the certification of suspension request form signed by Bruce Gallaher along with his resume.

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If there are questions regarding the request for a Section 801.C suspension or regarding the Vadose Zone Monitoring Plan, please contact Jon Mack of my staff at (505) 665-5026.

Sincerely,

Joseph C. Vozella
Acting Asst. Area Manager
Office of Environment and Projects

LAAMEP:7JM-272

Enclosures:
A - Documentation for Suspension Request and Vadose Zone Monitoring Plan, TA-54, Area J
B - Potential Transport of PCBs Through Fractured Tuff at Area G) in References 54
C - Signed Certification of Suspension Request Form

ENCLOSURE A

DOCUMENTATION FOR SUSPENSION REQUEST AND VADOSE ZONE MONITORING PLAN, TA-54, AREA J

Documentation for Suspension Request and Vadose Zone Monitoring Plan TA-54, Area J

Los Alamos National Laboratory

Date Issued: October 11, 1994
Revision 0

Project Officer: Joseph Vozella
Los Alamos Area Office
Department of Energy
528 36th Street
Los Alamos, NM 87544

Prepared by: Hazardous and
Solid Waste Group (ESH-19)
Los Alamos National Laboratory
Mail Stop K498
Los Alamos, NM 87545

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1. Introduction

Los Alamos National Laboratory (LANL) operates a Class-D Industrial Solid Waste Landfill at Area J of Technical Area 54 (TA-54). This landfill comes under the purview of the New Mexico Solid Waste Management Regulations (EIB/SWMR-4) which became effective on August 17, 1994. These regulations require groundwater monitoring for all operating landfills but provide options to avoid this monitoring by the specified deadline. One of these options which LANL (the Laboratory) chooses to apply to the Area J landfill is to request a partial or full suspension of the requirements under section 801.C of these regulations. This request for suspension must (per J. David Duran, written communication, September 9, 1994):

> "include a demonstration that there is no potential for migration of hazardous constituents from their landfill to the uppermost aquifer during the active life of the landfill and the post-closure care period.
>
> The demonstration shall be based upon:
>
> 1. Site-specific field measurements, sampling, and analysis of physical, chemical, and biological processes affecting contaminant fate and transport, and
> 2. Contaminant fate and transport predictions that maximize contaminant migration and consider impacts on public health, welfare and environment (a conservative code such as EPA's "MULTIMED" may be used for these predictions of Appendix K contaminant fate and transport)."

LANL will demonstrate no potential for migration of hazardous constituents to the uppermost aquifer during the active life of the landfill and the postclosure care period in the following way:

- through presentation of results of various hydrogeologic studies performed at the Laboratory facility both site-wide and TA-54 site-specific
- through use of a conservative modeling code (HELP)
- through the installation of a limited term vadose zone monitoring system.

1.1 Regulation Compliance

1.1.1 Compliance with EIB/SWMR-4 Requirements

New Mexico Solid Waste Management Regulations (SWMR-4) became effective on August 17, 1994. These regulations require groundwater monitoring for all operating solid waste landfills, but allow for two options: 1) "part or all of the groundwater monitoring requirements of Sections 803 through 806 may be suspended by the Secretary if the owner or operator can demonstrate that there is no potential for migration of hazardous constituents from their landfill to the uppermost aquifer during the active life of the landfill and the post-closure care period" (§801.C), and 2) Owners or operators of municipal landfills may request exemptions as small landfills under §110.A. The regulations require all solid waste landfill operators to submit a Groundwater Monitoring System Plan).

This document presents LANL's documentation for a Suspension Request under §801.C of SWMR-4 Regulations.

1.1.2 Compliance with NMED-SWB Requirements

The letter of September 9, 1994 from Mr. J. David Duran of the Solid Waste Bureau to all solid waste landfill operators requested submission of a Groundwater Monitoring System Plan. In that letter eleven specific provisions of SWMR-4, in §801, §802, §803, and §804, were required to be addressed. Those were predicated on a groundwater monitoring system requirement. Since we are requesting a suspension, most of these provisions are not applicable. Only the following three provisions will still apply as a consequence of a proposed limited-term vadose zone monitoring system:

- A description of proposed vadose zone monitoring or leak detection systems (section 8.0)
- A sampling and analysis program, including procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, chain of custody control, and quality assurance and quality control (section 8.1.4)
- An indication the plan will be placed in the operating record within 14 days of approval by the Secretary (section 8.2)

1.2 Background

The Area J Landfill at TA-54 sits atop Mesita del Buey, a narrow finger mesa on the Pajarito Plateau. It is bounded on the north by a tributary stringer canyon to Cañada del Buey and on the south by the Pajarito Canyon. This area is part of the Resource Conservation and Recovery Act (RCRA) Facilities Investigation (LANL) as an Operable Unit (OU 1148) under the Laboratory's Environmental Restoration (ER) Program. TA-54 is being studied together with its neighbor, TA-51 to the west.

TA-54 contains several material disposal areas (MDAs) other than Area J. These are discussed later in the Site Overview of TA-54 section. The importance of these other MDAs is that their operations included hazardous or radioactive materials. In order to protect the uppermost aquifer these MDAs have required extensive evaluation of the vadose zone. This site-specific data, for an area contiguous to Area J with the same geologic and hydrologic constraints, will be described in later sections.

The site-wide geology and hydrology of the finger mesas and the intervening canyons has been studied for many years and is still intensely studied due to the nature of the operations at the Laboratory. The results of these studies have been reported in many places including the annual Environmental Surveillance Reports (LANL 1993, LANL 1992) and the annual Water Supply at Los Alamos report. One of the better summaries of these studies is found in the Installation Work Plan (LANL LA-UR-93-3987 1993) for the ER program. These studies provide a substantial amount of information on the main aquifer (i.e., the uppermost aquifer) which underlies all of the Laboratory. An excerpt from the IWP on the hydrology of the facility is included in Appendix A.

1.3 Geographic Location

1.3.1 Location of LANL

The Laboratory is located in Los Alamos County in north central New Mexico. It is situated approximately 100 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe (Figure 1). The 111-km^2 (43 mi^2) Laboratory site and Los Alamos and White Rock

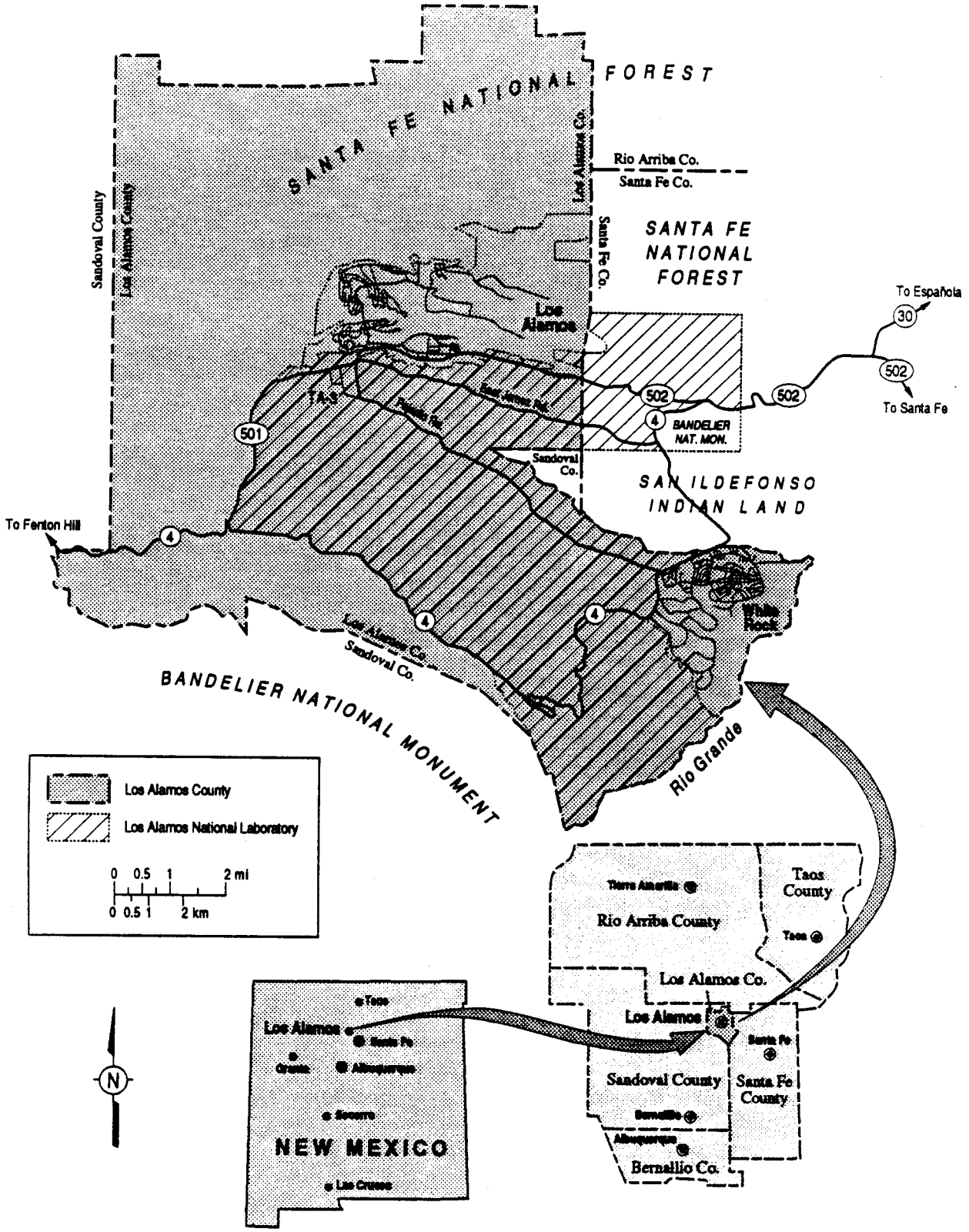


Figure 1. Regional location of Los Alamos.

communities are situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep, west-to-east canyons cut by intermittent streams. Mesa tops range in elevations from approximately 2400 m (7800 ft) on the flanks of the Jemez Mountains to about 1900 m (6200 ft) at their eastern termination above the Rio Grande Valley. Most of the Laboratory and community developments are confined to mesa tops. The surrounding land is largely undeveloped with large tracts of land north, west, and south of the Laboratory site held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County. San Ildefonso Pueblo borders the Laboratory to the east.

1.3.2 Location of TA-54

TA-54 is located on an east-west oriented mesa, Mesita del Buey, that is bounded by Cañada del Buey on the north and Pajarito Canyon on the south. About 100 m (300 ft) to the north of Area J is a small unnamed canyon that feeds into Cañada del Buey. About 130 m (400 ft) to the south of Area J is a small unnamed canyon that feeds into Pajarito Canyon (Figure 2).

2. Hydrogeologic Overview of Pajarito Plateau

2.1 Geology

The geology of the Pajarito Plateau has been studied extensively for over 40 yrs. Results of many of those studies have been described in documents by Griggs (1964), Purtymun (1984), and Dransfield and Gardner (1985). A detailed summary of the geology from the IWP is included in Appendix A; and a brief overview is presented below.

The mesas in the area are made up of the Bandelier Tuff Formation which consists of ash fall, ash fall pumice, and rhyolite tuff. The tuff, ranging from nonwelded to welded, is more than 300 m (1000 ft) thick in the western part of the plateau and thins to about 80 m (260 ft) eastward above the Rio Grande. It was deposited as a result of major volcanic eruptions in the Jemez Mountains about 1.1 to 1.4 million years ago (Conover et al. 1963).

The tuff overlaps onto the Tschicoma Formation, which consists of older volcanic substances that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central and eastern edge along the Rio Grande. Totavi Formation sediments and Cerros del Rio basalts interfinger with the conglomerate. These formations overlay the sediments of the Tesuque and Chamita Formations, which make up the Santa Fe Group. The Santa Fe Group of sediments extends across the Rio Grande Valley and is more than 1000 m (3300 ft) thick. (See Figure 3.) The Laboratory is bordered on the east by the Rio Grande, within the Rio Grande rift. Because the rift is slowly widening, the area experiences minor seismic disturbances.

2.2 Hydrology

Water in the Pajarito Plateau occurs as surface water, groundwater, and soil moisture. Surface water occurs mainly in streams which are ephemeral or interrupted (streams with some reaches that are perennial and some that are ephemeral). Most of the streams are ephemeral (flow briefly in response to rainfall and snowmelt) and flow down the various canyons, but do not reach the Rio Grande. Much of the surface water flow is lost to evapotranspiration and infiltration into alluvial fill in canyon bottoms.

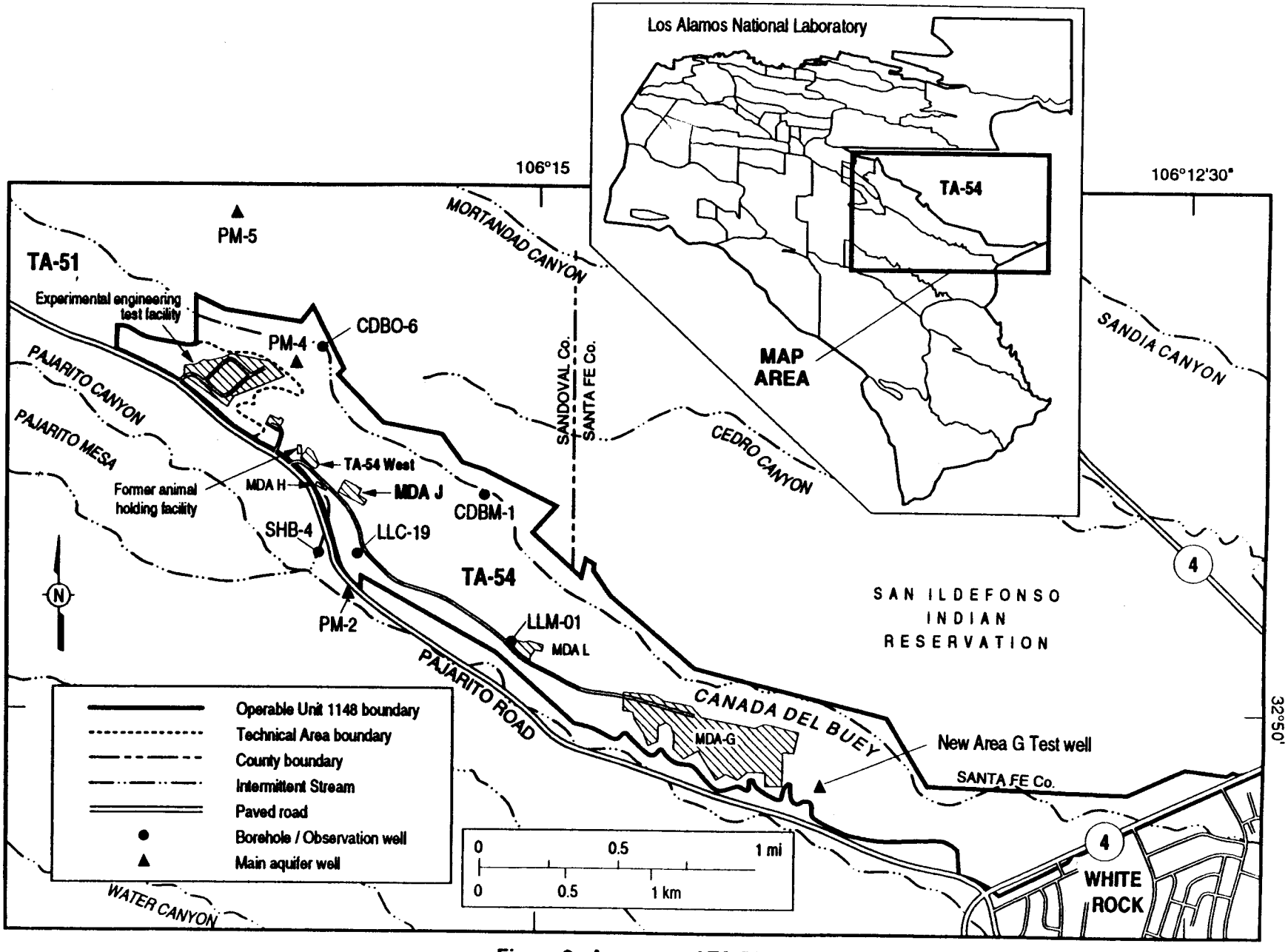


Figure 2. Area map of TA-54.

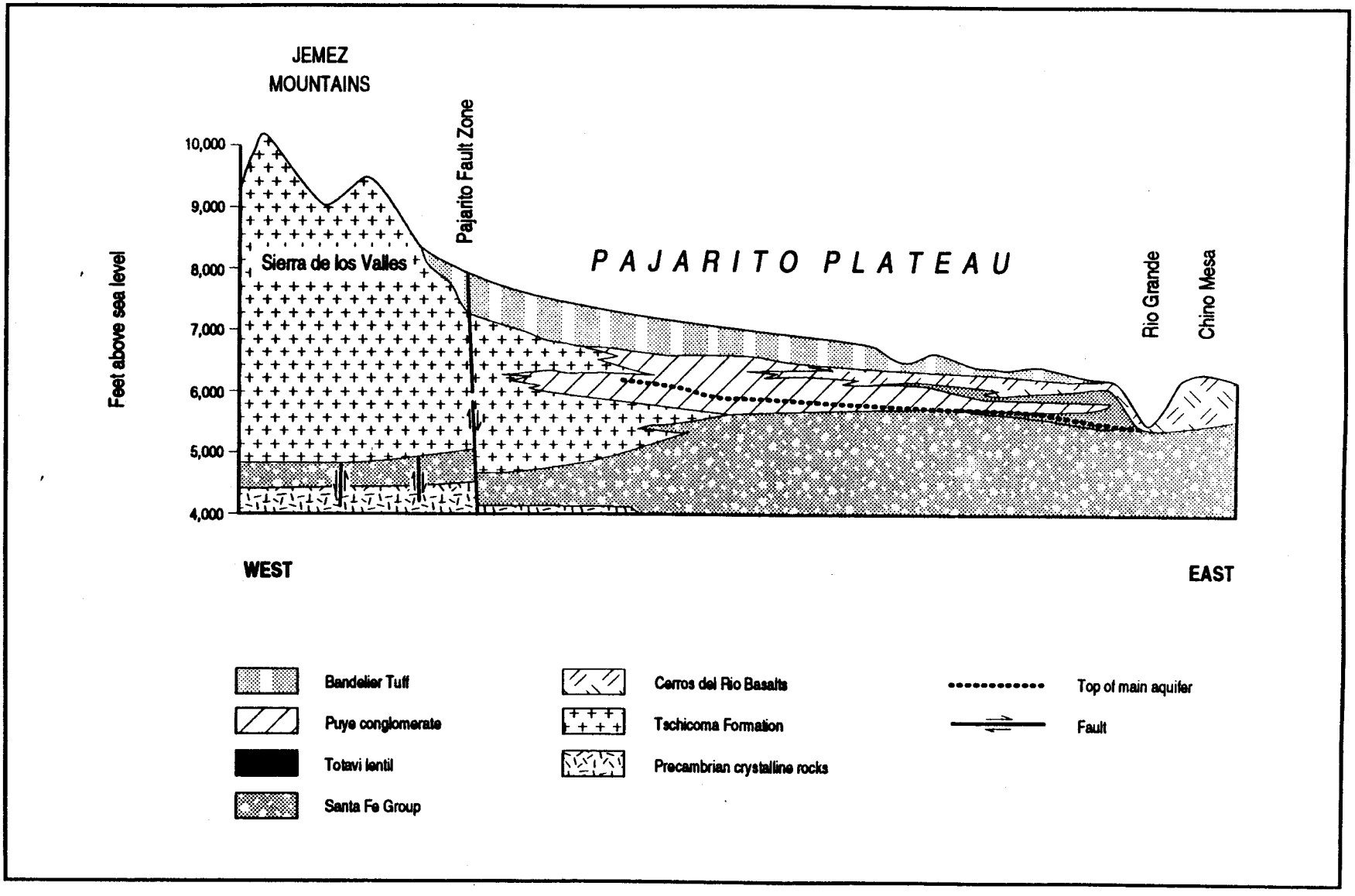


Figure 3. Generalized cross section of Pajarito Plateau.

Groundwater occurs in three modes:

- perched water in the shallow alluvium in the canyons
- perched water in volcanic sediments and basalts
- water in the main aquifer.

Alluvial Perched Groundwater

Perched groundwater occurs in the canyon alluvium and in volcanic sediments and basalts. Canyons of the plateau have alluvium deposits (ranging from 1 m [3 ft] to 30 m [100 ft] thick) composed of sands, gravel, pebbles, cobbles, and boulders in canyons that head on the flanks of the Jemez Mountains to clays, silts, sands, and gravel in canyons the head on the plateau. These alluvial layers are highly permeable, in contrast to the underlying volcanic tuff and sediments. As a result, storm runoff forms shallow alluvial groundwater zones that move down gradient within the alluvium. As perched alluvial groundwater moves down the canyons, it is depleted by evapotranspiration and infiltration into the underlying volcanics (Purtymun et. al. 1977).

The alluvial perched groundwaters in four canyons were sampled by means of shallow observation wells as part of the routine monitoring program (ESR 1993). In Acid Canyon, a small tributary of Pueblo Canyon, perched groundwater occurs seasonally in the alluvium, depending on the volume of surface flow from snowmelt, thunderstorm run-off, and sanitary effluents.

At Los Alamos Canyon water levels are highest in late spring from snowmelt run-off, and in late summer from thundershowers. Water levels decline during the winter and early summer when storm run-off is at a minimum. In Mortandad Canyon, there is considerable seasonable variation on the degree of saturation of the alluvium depending on the amount of run-off in a given year. Velocity of water movement in the perched alluvial groundwater ranges from 18 m/day in the upper reach to about 2 m/day in the lower reach of the canyon (Purtymun 1974, 1983). The top of the main aquifer is about 290 m (950 ft) below the perched alluvial groundwater.

In Pajarito Canyon water in the alluvium is recharged mainly through snowmelt and thunderstorm run-off. Three shallow observation wells were constructed in 1985 as part of a compliance agreement with the State of New Mexico to determine if technical areas in the canyon or solid waste disposal activities on the adjacent mesa were affecting the quality of shallow groundwater. No effects were observed.

A number of test bores in Cañada del Buey showed no presence of alluvial perched groundwater. Only one well, CDBO-6, had water present. It is thought that this water originates from PM-4 discharge.

Intermediate Perched Groundwater

Perched groundwater of limited extent occurs in the volcanic sediments and basalts beneath the alluvium in the middle and lower reaches of Pueblo and Los Alamos Canyons, and in the lower reaches of Sandia Canyon. Test Well 2A in a middle reach of Pueblo Canyon was drilled in 1949 to a depth of 40.5 m (133 ft). Depth to water was about 105 feet. Other wells encountered limited perched zones at 58 m (190 ft) in a lower reach of Pueblo Canyon, 61 m (200 ft) in Los Alamos Canyon, and 137 m (450 ft) in Sandia Canyon.

Some recharge to the perched groundwater in the basalt occurs near Hamilton Bend Spring. Recharge may also occur in Los Alamos Canyon (Abrahams 1966). Other studies suggest that a source of recharge to this intermediate depth is through infiltration of alluvial groundwater (Purtymun 1975; Abeele et. al. 1981).

Main Aquifer

The main aquifer beneath the Pajarito Plateau serves as the municipal water supply for Los Alamos and surrounding communities. Water for the Laboratory, the communities of Los Alamos and White Rock, and Bandelier National Monument is supplied from 11 deep wells in three well fields: Pajarito, Los Alamos, and Guaje.

The surface of the main aquifer rises westward from the Rio Grande within the Santa Fe Group into the lower part of the Puye Conglomerate beneath the central and western part of the plateau. The depths to water below the mesa tops range from 360 m (1,200 ft) along the western margin of the plateau to about 180 m (600 ft) at the eastern margin. The main aquifer is separated from the perched water in the alluvium and the perched water in the volcanics by 100 m (350 ft) to 190 m (620 ft) of tuff and volcanic sediments which impede the downward migration of surface and perched water. The main aquifer responds as an unconfined aquifer in the western part of the plateau, but exhibits semi-artesian to artesian conditions in the eastern part along the Rio Grande (Purtymun 1984). Although the water level in some places is dropping approximately two feet per year, after more than forty years of use, the main aquifer shows little observed depletion of resources: the piezometric surface has not declined significantly, and there are nearly complete water-level recoveries after the wells are shut down.

The exact source of recharge to the main aquifer is unknown. A large quantity of hydrologic, structural, and geochemical data have been accumulated as a result of studies that investigated several possibilities for recharge: under-flow from the Valles Caldera, run-off in canyons, and infiltration on mesas (Cushman 1965, Conover et al. 1963, Griggs and Hem 1964, Goff 1991). Natural recharge through undisturbed Bandelier Tuff on the mesa tops is believed to be insignificant (Purtymun and Kennedy 1971, Kearl et al. 1986). No data exist to support an evaluation of canyon run-off as a recharge source (IWP 1992).

Soil Moisture

Studies of soil moisture at the Laboratory have been conducted since the 1950s beginning with studies by the US Geological Survey (Purtymun 1990). Water as soil moisture generally occurs in the volcanic tuffs in the vadose zone at depths greater than a few meters at less than 10 percent by volume (ESR 1993) at least to the depth where the mesa walls meet the canyon floors. In the upper few meters the soil moisture undergoes significant fluctuation due to seasonal precipitation and evapotranspiration. The overall low moisture content of the vadose zone "...carries the implication that very little, if any, recharge from the mesas is able to reach the main aquifer, which is about 305 m (1000 ft) deep," (ESR 1993).

Due to the RCRA Facility Investigation various studies have been performed to investigate the potential for saturated conditions in canyons since the mid-1980s. These have included the installation of wells in Pajarito Canyon, Cañada del Buey, Sandia Canyon, Potrillo Canyon, Fence Canyon, Water Canyon, Canyon del Valle, and Mortandad Canyon (Purtymun 1990; ESR 1993). Most of these well installations were completed as observation wells for future monitoring of potential saturation conditions, but they are currently dry (Purtymun 1990; ESR 1993).

Of particular note is a study done in 1987 related to the inactive Waste Disposal Area P in TA-16. Nine observation wells were installed on the toe of the landfill above the channel alluvium. These wells revealed no saturation and showed no evidence of leachate or seepage from the landfill (ESR 1993).

Probably the most intensively studied area for soil moisture is Mesita del Buey because of the material disposal areas. These studies will be discussed later in this document in section 5.

3. Site Overview of TA-54

3.1 TA-54 History

Since the designation of the Mesita del Buey for military and scientific purposes in 1942, the primary function of TA-51 and -54 has been to serve as a waste disposal area for the Laboratory. TA-51 is topographically upgradient of TA-54.

Radioactive waste disposal began at TA-54 in 1957 when material disposal area (MDA) G, the largest disposal area at the Laboratory, was chosen for this purpose. TA-54 contains four MDAs: G, H, J, and L enclosed by security fences (RFI 1992).

An animal holding facility was constructed topographically upgradient of Area J in the western part of TA-54 in the mid 1960s. The facility was used by the Laboratory biomedical research program until the late 1980s. Structures in the inactive animal holding facility are presently being remodeled to analyze environmental samples (RFI 1992).

A radiation exposure facility located topographically upgradient of Area J in the western part of TA-54 was in operation from 1962 to the mid 1970s for biomedical research on the exposure of animals to radiation. The radiation sources were removed from the facility when research was terminated.

3.2 TA-54 Material Disposal Areas

3.2.1 TA-54 West

TA-54 West houses the nondestructive testing (NDT) facility in which transuranic wastes stored at MDA G, and destined for placement the Waste Isolation Pilot Plant in Carlsbad, New Mexico, will be remotely examined and certified. TA-54 West is located topographically upgradient from Area J (Figure 2). Construction of the NDT facility was completed in 1990. To date, the facility has performed only limited assay and limited x-ray tests on transuranic waste (RFI 1992).

3.2.2 MDA-H

The Laboratory used MDA H for the disposal of uncontaminated, classified wastes from 1960 to 1986. MDA H contains nine disposal shafts that are located within a fenced rectangular area. Eight of the disposal shafts are sealed. The one shaft that is not sealed last received waste in 1986. Although designated for uncontaminated wastes, tritium is known to have been disposed of in the shafts as well as materials contaminated with high explosives and radionuclides. MDA H is located west of and topographically at the same gradient of Area J (RFI 1992).

3.2.3 MDA-L

The disposal of nonradioactive chemical wastes at TA-54 commenced in the late 1950s with the excavation of Pit A at MDA L. MDA L is located east of Area J and topographically down gradient. MDA L is an inactive chemical waste disposal facility in which chemical waste was deposited in pits, impoundments, and shafts until 1985. It is now designated for chemical and low-level mixed waste treatment and storage, PCB-contaminated waste storage and nonhazardous chemical waste storage (RFI 1992).

A volatile organic contaminant (VOC) plume is present in the ground below and surrounding MDA L. A voluntary corrective action plan (VCA) is underway to remediate the VOC plume.

3.2.4 MDA-G

Radioactive waste disposal began at TA-54 in 1957 when MDA G, the largest disposal area at the Laboratory, was chosen for this purpose. MDA G has been the low-level radioactive waste landfill for the Laboratory since 1957, and will remain so indefinitely. MDA G is located to the East of Area J and is topographically downgradient.

Approximately 4500 m^3 (160,000 ft^3) per year of non regulated low-level waste are deposited in pits in MDA G currently. A compacting and baling operation provides volume reduction of compatible wastes prior to disposal. About 70% of the low-level wastes includes contaminated equipment and other debris that are placed directly into the pits. Certain nonreactive, nonhazardous chemical wastes that contain low levels of radioactivity, such as asbestos, empty pesticide containers, and PCB-containing solids, also are approved for pit disposal.

MDA G is also used for the storage of low-level and transuranic mixed waste, and will continue to store such wastes in support of the facility at TA-54 West for nondestructive testing of transuranic waste. Approximately 7400 m^3 (261,300 ft^3) of transuranic waste was stored before WIPP waste acceptance criteria were developed. Most of the previously generated uncertified transuranic waste is currently stored on three asphalt pads above ground and on earth-covered pads, while the WIPP-certified wastes are stored in an expandable tension-support structure of reinforced vinyl on aluminum I-beams. As of 1992, the generation rate of transuranic waste was 200 m^3 (7060 ft^3) per year.

A number of shafts up to 4 m (12 ft) in diameter and 18 m (65 ft) deep are used for the disposal of materials that may include tritium, mixed fission products, uranium, activation products, highly activated pieces of equipment, PCBs, and radioactively-contaminated animal tissues. (RFI 1992)

3.3 Area J

3.3.1 History

The Laboratory began disposing of administrative-controlled waste at MDA J in 1961, with the excavation of Pit 1 (Figure 4). Administratively controlled waste is defined by the Laboratory as "those wastes which are generated by various operating and experimental groups and, although nonhazardous, are restricted by the Laboratory from disposal in the Los Alamos County landfill or other locations" (Krueger 1991). The wastes themselves are largely innocuous: paper, degaussed magnetic computer tape, safe locks, objects with classified shapes, scrap equipment, and treated sand from the pads on which explosives are tested. These wastes are neither hazardous nor radioactive, but for security and/or safety reasons, the Laboratory desires to maintain long-term institutional control over them. About 1800 tons of solid waste is disposed of at Area J annually.

Historically, MDA J received wastes that were potentially contaminated with trace quantities of nonreactive high-explosive residues. Other wastes buried in early operations include discarded equipment, asbestos, and minimal, residual amounts of hazardous waste (3.7 % treated barium sands, 0.03 % inorganics, 0.03 % empty containers, and 0.04 % organics; the other 0.2% were miscellaneous disposed materials assumed to be hazardous waste constituents [RFI 1992]).

3.3.2 Design and Operation

MDA J covers 3.65 acres and contains six excavated pits, three of which are filled and three that are open (Figure 4). None of the pits are lined. Of the open pits, only pit 4 is receiving waste. In

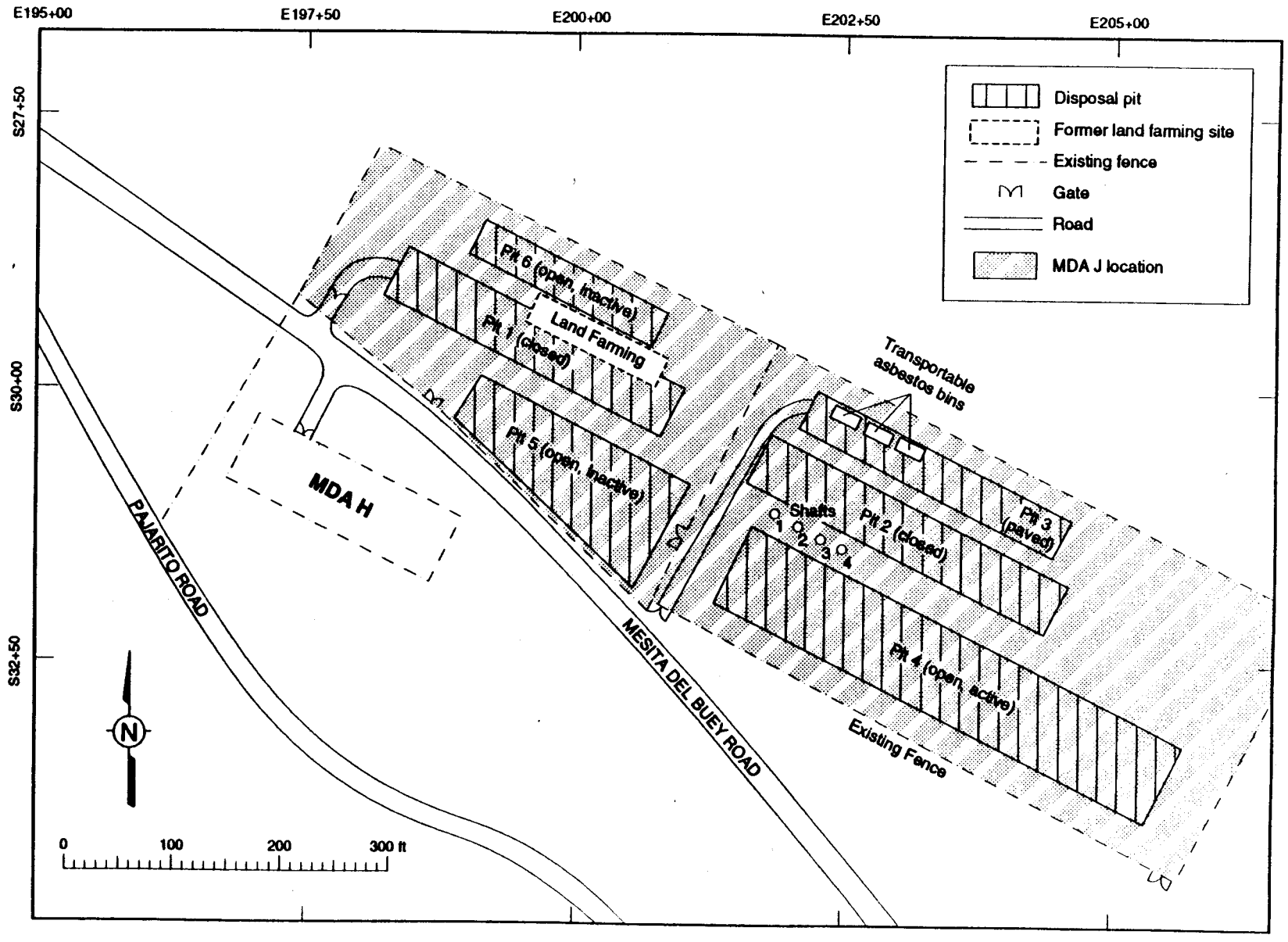


Figure 4. Detailed layout of Area J.

addition, there are four shafts: one shaft that is filled and capped, one active shaft for classified waste disposal, and two shafts that are ready to receive waste (verbal communication with Joe Gonzalez, 1994).

Pit 1 was excavated in 1961 and was used for waste disposal until 1966. It measures approximately 76 m (250 ft) long, 15.5 m (51 ft) wide, and 5 m (17 ft) deep. Waste disposal procedures associated with this pit required that wastes to be placed in layers and covered with crushed tuff approximately 30 cm (12 in) thick. To minimize void space, hollow items or open, empty containers and vessels were emplaced so that they would be filled with subsequent layers of waste or tuff. Liquids were prohibited from disposal. The pit is unlined and no special provisions were made to prevent storm runoff from entering the pit. The pit was filled and covered with soil to grade in July 1967. (Benchmark 1991)

Pit 2 was excavated in 1967 to allow for continued disposal after Pit 1 had reached its maximum capacity. The dimensions of Pit 2 are approximately 61 m (200 ft) long, 10 m (31 ft) wide, and 5 m (17 ft) deep. Pit 2 was closed and covered after April 1982. The cover over pit 2 is mounded to enhance surface runoff away from the covered pit (Benchmark 1991).

Pit 3 was excavated in or about 1984. The pit was filled and covered with an asphalt pad and is currently used as a storage pad. The approximate dimensions of the pit are 52 m (169 ft) long, 8 m (25 ft) wide, and 14 m (45 ft) deep.

Pit 4 is currently in operation at MDA J. Constructed in or about 1987, the pit measures 130 m (425 ft) long, 24 m (80 ft) wide, and 18 m (60 ft) deep and is used solely for the purpose of disposing of administratively-controlled waste. Appendix G contains the annual report forms for 1991, 1992, and 1993.

Pits 5 and 6 were recently excavated and have not yet received waste. (RFI 1992)

Shaft 1 was drilled in 1984 and was first used in January 1985. It is 2 m (6 ft) in diameter and 18 m (65 ft) deep (IT Corporation, 1987). The shaft was been filled and capped.

Shaft 2 was drilled in 1984 and is also 2 m (6 ft) in diameter and 18 m (65 ft) deep. Shaft 2 is currently use for disposal of classified waste.

Shafts 3 and 4 were excavated in 1993 to a depth of 16 m (60 ft) and are ready to receive waste.

Other activities include temporary storage of friable and nonfriable asbestos removed from facilities throughout the Laboratory. Friable asbestos is placed in sealed plastic bags, and then in dumpsters, before transport to MDA J. Nonfriable asbestos safes and ovens do not require plastic packaging. Both forms of asbestos are shipped off site for disposal.

Beginning January 1991, MDA J has served as the location for land farming of contaminated soil from underground storage tank releases. The soil was spread in thin layers (approximately 6 in lifts) near and on top of pit 1. The thin-spreading technique allowed for enhanced aeration that facilitated biodegradation of the remaining contaminants. No water or nutrients were added during the project which covered an area of 764 m^2 (225 ft^2). The project was suspended in June 1991 during excavation of pit 6, then restarted sometime in 1992. Landfarming at this location was discontinued as of early October 1994.

4. Geology of TA-54

Stratigraphic control for TA-54 and Mesita del Buey is obtained from three supply wells (PM-2, PM-4, and PM-5) as well as from several vadose zone boreholes (SHB-4, LLC-85-19, and several other borings on Mesita del Buey [IT Corp. 1987]).

The stratigraphy under TA-54 consists of about 150 m (500 ft) of Bandelier Tuff underlain by about 150 m (450 ft) of Cerros del Rio basalts. Puye Formation conglomerates underlie and are interbedded with the Cerros del Rio basalts. The Santa Fe Group of sediments exists beneath the Puye Formation. The top of the main aquifer beneath Mesita del Buey is either within the Puye Formation or the overlying basalts. It is at a depth of about 335 m (1100 ft) beneath Area J and 260 m (850 ft) below Area G (see Figure 5).

The Bandelier Tuff of Mesita del Buey is divided into two members: Tshirege and Otowi. The Tshirege Member is composed of multiple flow units of ash-flow tuff with varying degrees of welding and alteration. The Tshirege is about 65 m (200 ft) thick under Mesita del Buey and has been subdivided into a sequence of mappable units (1a, 1b, 2a, 2b, 3a, and 3b) based on erosional characteristics (Purtymun and Kennedy, 1971). Unit 2b is the surface unit at TA-54 and it is underlain by units 2a, 1b, and 1a as shown in Figure 6. These units dip to the southeast under Mesita del Buey.

Flow unit boundaries are locally separated by volcanic surge deposits consisting of well-sorted, fine-grained, cross-bedded crystal and pumice fragments. A volcanic surge deposit is known to exist between units 2b and 2a under Mesita del Buey at a depth of about 10 m (35 ft). This bed may have a higher lateral permeability than the overlying and underlying tuff (Rosenberg and Turin 1993). Individual flow units within the Tshirege contain vertical cooling joints that may or may not cross flow unit boundaries. Joint density tends to increase with the degree of welding (Crowe et al. 1978).

The contact between the Tshirege Member and the Otowi Member is marked by the Tsankawi Pumice Bed. The Tsankawi consists of up to 3 m (10 ft) of bedded, unconsolidated, pumice-rich ashfall tuff and may also be considered to have higher lateral permeability than the overlying and underlying tuff.

The Otowi Member underlies the Tshirege Member in the subsurface beneath Mesita del Buey. It is a non-welded vitric ashflow tuff composed of multiple flow units. It is highly porous and poorly indurated, and where it outcrops, joints are usually absent due to the lack of induration. The Otowi member is about 90 m (300 ft) thick under the west end of the mesa and thins to the southeast, eventually pinching out near White Rock. The base of the Otowi Member is made up of the Guaje Pumice Bed which consists of 3 to 18 m (10 to 65 ft) of unsorted pumice fragments 2 to 4 cm in size (Crowe et al. 1978).

Underlying the Otowi Member are the basaltic rocks of the Cerros del Rio volcanic field. These rocks outcrop beneath the Bandelier Tuff adjacent to the eastern end of Mesita del Buey in Pajarito Canyon and Cañada del Buey near White Rock. The volcanic field consists of many separate flows that are often separated by interflow breccias. To the west at PM-5, the basalts are interstratified with the underlying Puye Formation as shown in Figure 5. The basalts range from 80 to 150 m (260 to 500 ft) thick beneath Mesita del Buey.

The Puye Formation consists of stream flow deposits, debris flow deposits, volcanic ash and block flow deposits, and ash fall and pumice fall deposits (Waresback and Turbeville 1990). The Puye is 85 to 215 m (262 to 705 ft) thick under Mesita del Buey. The base of the Puye is made up of the Totavi Lentil. The Totavi Lentil is a poorly consolidated conglomerate that probably represents ancestral Rio Grande channel gravels (Rosenberg and Turin 1993). The Totavi Lentil is 12 to 24 m (40 to 80 ft) thick.

The Santa Fe Group of sediments underlies the Puye Formation and consists predominantly of fluvial sandstone, siltstone, and conglomerates with subordinate eolian deposits, ash beds, and lacustrine rocks. Beneath Mesita del Buey, the sedimentary rocks are interstratified with basaltic

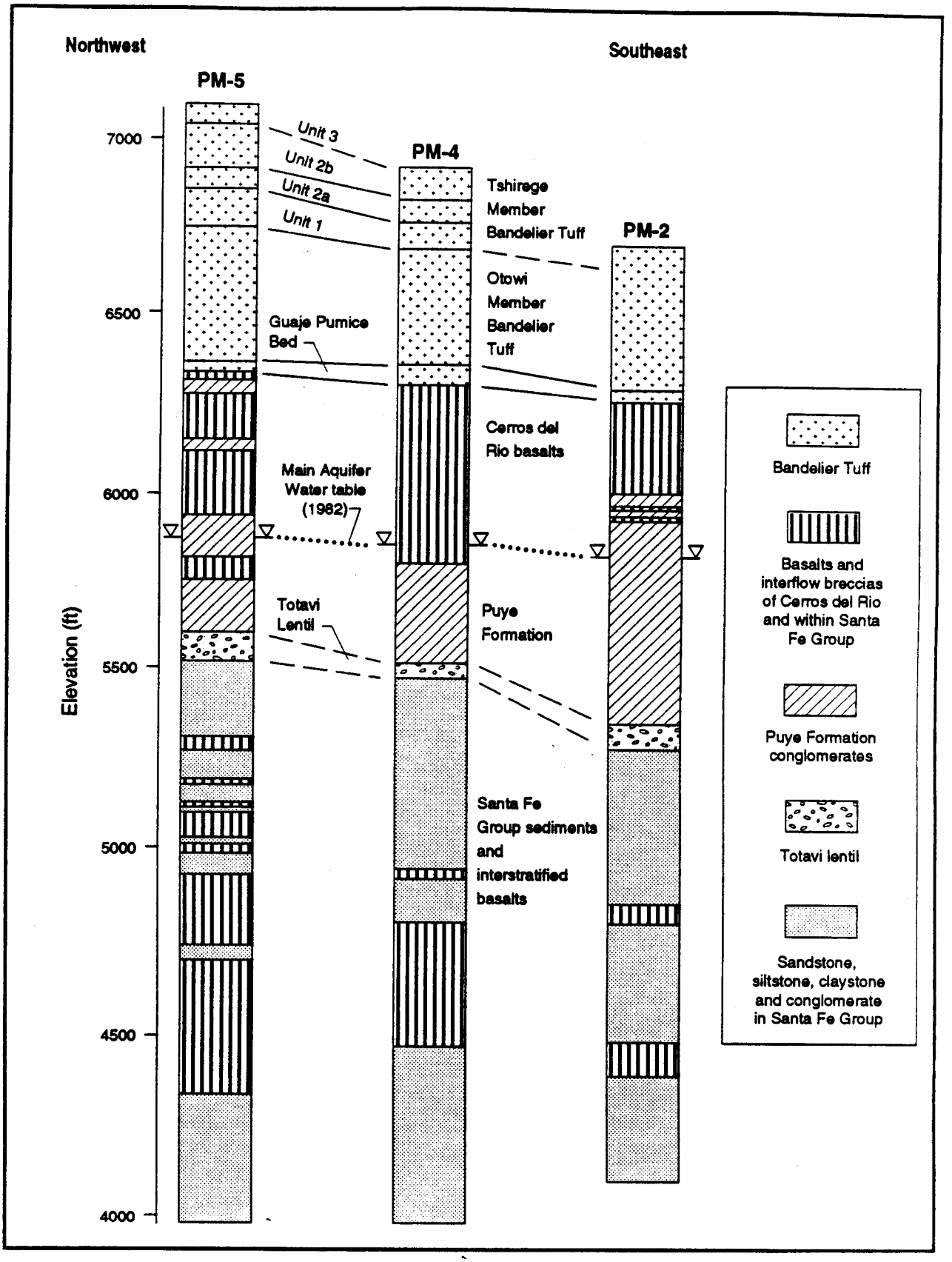


Figure 5. Lithologic logs for water-supply wells drilled near Mesita del Buey (Cooper et al. 1965).

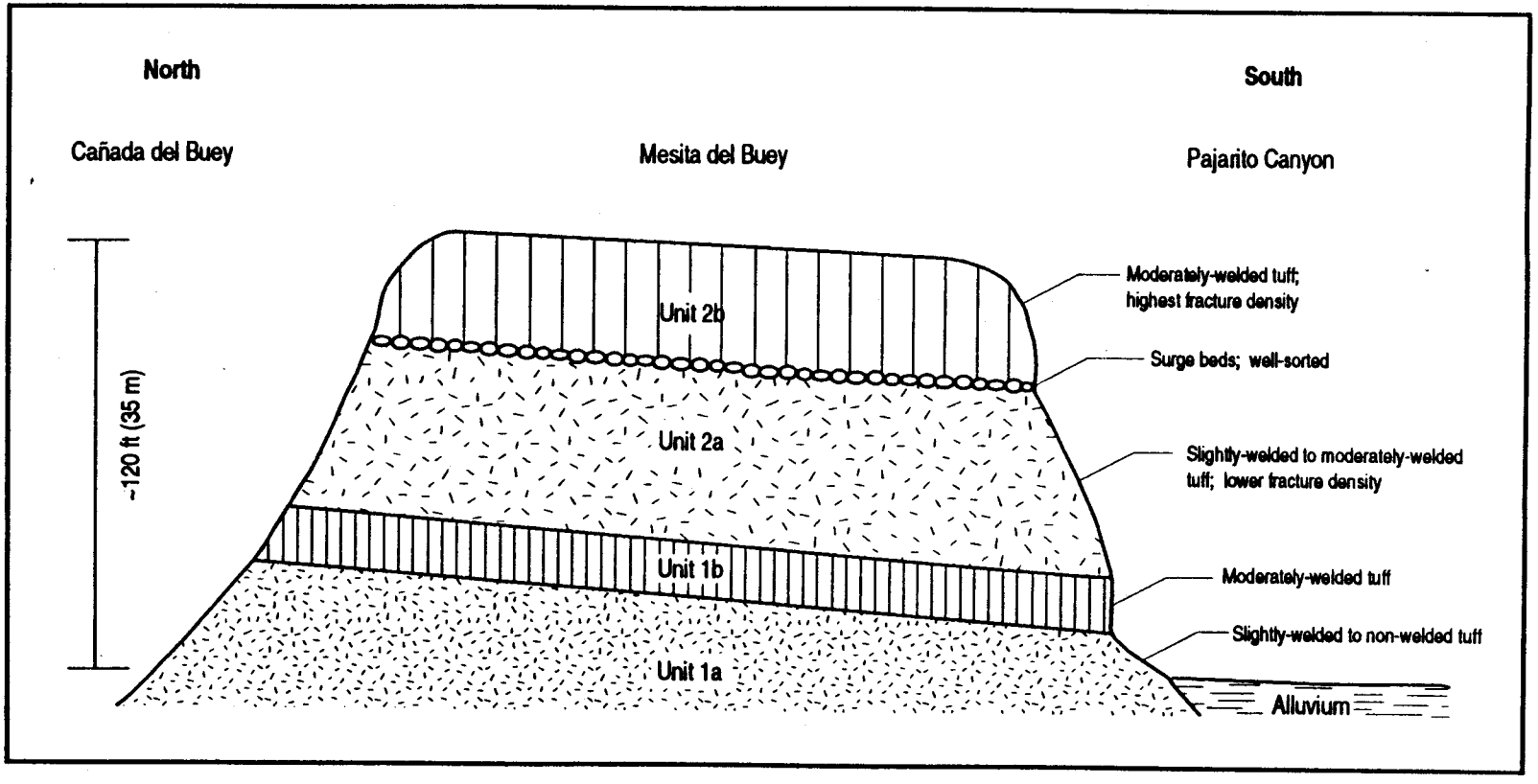


Figure 6. Cross section of Mesita del Buey

rocks. Water supply wells PM-2, PM-4, and PM-5 penetrate up to 500 m (1640 ft) of Santa Fe Group rocks.

5. Hydrology of TA-54

5.1 Main Aquifer

The top of the main aquifer under Mesita del Buey is at a depth of about 300 m (1000 ft) below Area J and about 260 m (850 ft) below Area G. It exists in either the Cerros del Rio basalts or the Puye Formation sediments below the mesa. Water level measurements show that water levels are declining in the area of Mesita del Buey and that depth to water is increasing. Nonpumping water levels in supply well PM-5 have declined about 3 m (10 ft) in ten years (ESR 1994).

The chemical quality of the main aquifer under Mesita del Buey is represented by samples from PM-4 and PM-2 which bound Area J to the north and south. The quality data for these wells for 1991 and 1992 is presented in Appendix F (ESR 1993, 1994). The data show no measurable contamination of the main aquifer upgradient or downgradient of Mesita del Buey, and that the water is well within federal drinking water standards.

5.2 Potential Perched or High Moisture Zones

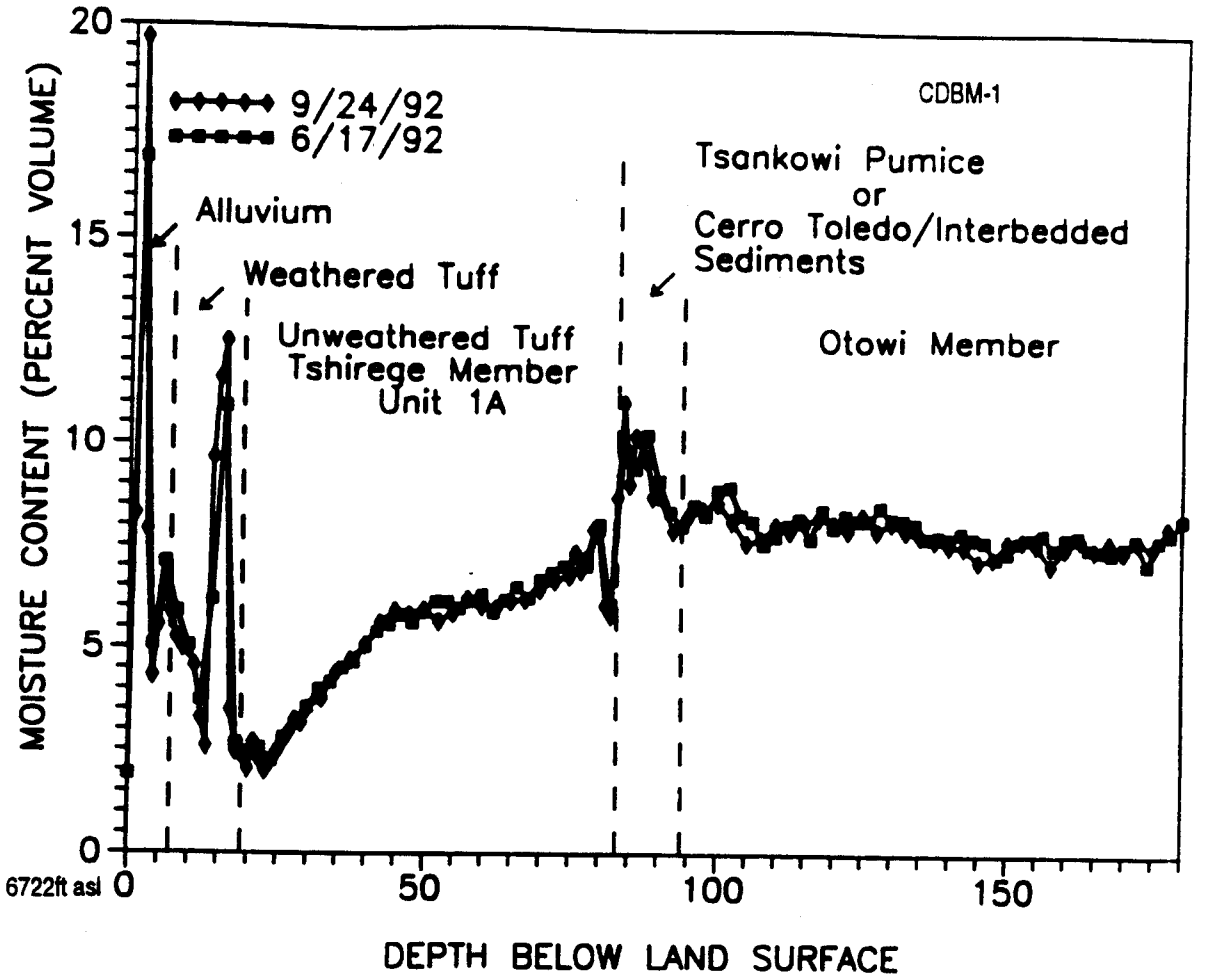
During a vadose zone study conducted by IT Corporation (1987) several borings were drilled into Mesita del Buey (Appendix D). No water was encountered in any of the borings, although an increase in moisture content was noted at some locations. Two locations, LLC-86-19 and LLM-85-01 are shown on Figure 2.

LLC-86-19 is located at an elevation of 2093 m (6860 ft) above sea level. Volumetric moisture content increased from less than 4 percent for the first 38 m (125 ft) of depth, to 26 percent at a depth of 150 ft. The moisture content then decreased to between 8 and 12 percent for the lower part of the borehole (UNC 1986; LANL 1993). Increased moisture content could be associated with a major change in lithology at this depth. The depth at which the increase occurs correlates with the elevation of the Pajarito Canyon bottom. It is possible that the increased moisture may be caused by wicking of moisture from the canyon as well as from the feeder canyon just south of TA-54 at Area J.

LLM-85-01 is located on the mesa top at an elevation of 2073 m (6800 ft) above sea level. The moisture profile for this boring shows a volumetric moisture content increase from 2 percent to about 10 percent at 38 m (125 ft) (LANL 1993). This increase may also be associated with a change in lithology or wicking of moisture from Pajarito Canyon. Another moisture access tube, CDBM-1 (2049 m [6722 ft]) was completed just north of LLM-85-01 in Cañada del Buey. The volumetric moisture content at CDBM-1 started on the surface at 20 percent and decreased with depth to about 10 percent. Moisture profiles for both LLC-85-01 and CDBM-1 are given in Figure 7.

Of the many borings and wells completed in the vicinity of TA-54, only two encountered water: CDBO-6 and SHB-4. CDBO-6 is at an elevation of 2078 m (6817 ft) and is completed in the alluvium of Cañada del Buey downgradient of PM-4. The water present in CDBO-6 is thought to be from blowdown associated with the startup of the pump at PM-4 (ESR 1994).

SHB-4 is located in a feeder canyon of Pajarito Canyon about 400 m (1280 ft) south of Area J at an elevation of 2060 m (6760 ft). Cuttings and core samples from 10 m (32 ft) to at least 38 m (125 ft) came out of SHB-4 damp and moist. The core tube and rock samples from about 38 m



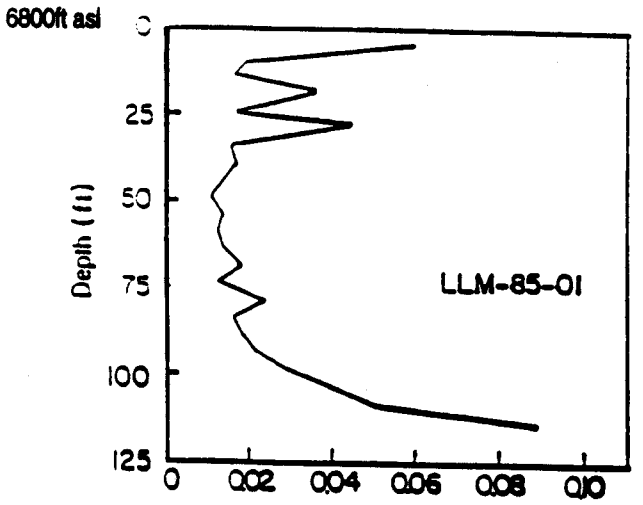


Figure 7. Moisture profiles for CDBM-1 and LLM-85-01.

(125 ft) and 44 m (145 ft) came out of the hole wet (Gardner et al. 1993). This data may indicate that the shallow alluvial perched groundwater in Pajarito Canyon has some vertical and lateral continuity into the tuffs beneath the mesas and canyons (Gardner et al. 1993).

5.3 Vadose Zone

As mentioned in the preceding main aquifer hydrology section, the main aquifer water table lies at a depth of 300 m (1000 ft) below land surface. The vadose zone comprises all the tuff and basalt between the mesa top and this water table. Of particular importance are the hydrologic properties and conditions of the Bandelier Tuff which form the upper 150 m (500 ft) of the vadose zone of Mesita del Buey. The overall characteristics of this tuff are described in the LANL IWP (Appendix , IWP 1993) along with some site-specific (i.e., TA-54) evaluations. Some relevant excerpts from the IWP are as follows:

> "Few definitive field measurement techniques exist by which to quantify natural recharge through mesa tops. One exception is the use of natural tracer profiles to infer recharge rates by comparison with analytical solute transport solutions. As an alternative, the flux of liquid water through the rock matrix that could eventually become recharged can be estimated as being approximately equal to the unsaturated hydraulic conductivity, implicitly assuming that flow is downward and at steady state.
>
> "In-situ hydraulic conductivities for tuff beneath the mesa top Material Disposal Area L at TA-54 were computed by Rogers and Gallaher (in preparation) from laboratory analyses of five undisturbed Bandelier Tuff cores obtained from three separate coreholes. Computed in-situ unsaturated hydraulic conductivities (i.e., fluxes) range from 3.0×10^{-12} to 1.5×10^{-8} cm/sec (3.7×10^{-5} to 1.9×10^{-1} ft/yr). For uniform flow through media with spatially varying hydraulic conductivity, the average hydraulic conductivity lies between the harmonic and arithmetic mean hydraulic conductivity (de Marsily 1986). The arithmetic and harmonic mean hydraulic conductivities for this set of cores are 4.7×10^{-9} to 8.7×10^{-12} cm/sec (5.8×10^{-2} to 1.1×10^{-4} ft/yr). At the moisture conditions and calculated unsaturated hydraulic conductivities at MDA L, the rates of water movement within the upper part of the mesa top are estimated to lie between 1.2 and 0.002 ft/yr, assuming that there are no "fast paths" of water movement such as fracture flow to significant depths.
>
> "These calculated rates are relatively low, implying very little water movement from the mesa tops to the main aquifer under natural conditions, which probably also applies to a one-time spill of contaminants at the land surface. Because of geochemical interaction between the rock and dissolved constituents, the rate of constituent movement, except for those that are highly soluble, should be lower than that of water."

As for the issue of "fast path" transport of contaminants, the IWP also provides some site-specific evaluation:

> "Although, fractures have a local effect upon infiltration in the upper portions of the mesas, it is less clear to what depth they play a role for three key reasons. First, water passing through a fracture system has a tendency to be "wicked" into the adjacent rock matrix by capillary suction forces in the tuff, provided the fracture/rock interface is not sealed with material of low permeability (Thomas et al. 1992). Analytical and numerical modeling of TA-54 indicate that transient infiltration pulses in fractures likely affect only the very near surface before being imbibed into the adjacent tuff (Rosenberg et al. 1993). Second, most of the open fractures occur in the moderately welded to welded Tshirege Member of the Bandelier Tuff, and the underlying nonwelded Otowi Member

is significantly less fractured (Baltz et al. 1963). Flow in the lower portions of the Bandelier Tuff, therefore, is far more likely to be dominated by the relatively slow process of capillarity."

Another important issue with regard to fractures is that vertical cooling joint density tends to be least for the nonwelded beds and greatest for the welded beds (Crowe et al. 1978). Two units are particularly important in this regard. First is the well-sorted, cross-bedded, and nonwelded volcanic surge deposits at the base of Unit 2b (the base of Cooling Unit 2, Crowe et al. 1978) in the Tshirege Member. Second, is the underlying nonwelded Otowi Member which is particularly at the top highly porous and poorly indurated. Where the Otowi outcrops, cooling joints are typically absent and it is believed to be due to the lack of induration (Rosenberg and Turin 1993). So while cooling cracks may be abundant in the mesa-capping material of Cooling Unit 2b, the cracks or fractures probably don't extend vertically down below the surge beds or the top of the Otowi. It is thought that this condition in conjunction with the hydrologic properties of these units provides a formidable barrier to downward migration (Gallaher, oral communication, 1994).

Rosenberg and Turin (1993) also noted that these units probably have a significantly higher lateral permeability than over- or underlying tuff. This was demonstrated at TA-54 by Purtymun (1973) who noted vapor phase migration of tritium from a storage shaft at Area G.

Additional site specific evaluations of the vadose zone characteristics are given in *Summary of Area G Geology, Hydrogeology and Seismicity for Radiological Performance Assessment* (Rosenberg and Turin 1993). This is included in its entirety as an appendix (Appendix I) since it reflects some of the most relevant information and calculations regarding the potential for contaminant transport at TA-54. Information and excerpts from this site-specific reference follows.

> "Vadose zone monitoring consisting of neutron moisture probe logging in boreholes in Areas G and L was conducted at TA-54 in 1985. Results of this logging showed low volumetric moisture content, about 2-5%, at depths greater than 3-5 m. One high moisture content interval or "kick" was identified in one boring (LGC-86-19) in Unit 1b. As mentioned in the previous section, this may be relate to moisture intrusion from the unnamed tributary canyon to Pajarito Canyon just north of TA-18.
>
> "At moisture contents of about 10 %, the unsaturated permeability of Bandelier Tuff is very low. Assuming the mesa is made up of homogeneous Bandelier Tuff with these hydrologic properties and assuming steady-state conditions and no fast paths, the calculated travel time from the top of the mesa to the water table is more than 10,000 years."

With regard to recharge from mesa tops Rosenberg and Turin (1993) state:

> "We are unaware of any definitive field measurements that quantify natural recharge through local mesa tops. We do know, however, that rainfall is moderate and evapotranspiration is very high. According to the meteorological information prepared by Radian Corporation for the Area G Performance Assessment [*unpublished material from Radian's Los Alamos office*], average annual precipitation at Area G is about 394 mm. Using micrometeorological data from TA-59, Radian has estimated that annually, evapotranspiration is about 85% of precipitation. If this calculation is applicable to Area G, average annual precipitation at Area G is about 335 mm. The remaining 59 mm must therefore contribute to either deep infiltration or runoff. Runoff is an easily observable and important hydrologic process on the Pajarito Plateau, so according to this simplified

analysis, the maximum amount of water available for deep infiltration must be significantly less than 59 mm/year. Assuming unit gradient conditions (i.e., steady-state system), recharge is approximately equal to the unsaturated hydraulic conductivity at the field moisture content. Using the hydrologic parameters given above gives a recharge estimate of less than 1 mm/yr. Note that this assumes that the Bandelier Tuff can be treated as an equivalent porous medium (i.e., no fast paths)."

6. Performance Testing by Modeling with HELP

A conservative computer code: *The Hydrologic Evaluation of Landfill Performance (HELP) 2 Model* developed by the US Army Engineer Waterways Experiment Station (WES), Vicksburg, MS for the US Environmental Protection Agency was used to simulate leachate percolation at the Area J Landfill (Brannon, written communication, 1994, Appendix H). The model was developed specifically to perform hazardous waste disposal landfill evaluations as required by RCRA. Model assumptions, input parameters, and model runs, are given in Appendix H. The average annual percolation from the bottom most layer (i.e., the pit bottom) is less than 0.8 in/yr over the 20-year modeling period (Brannon, written communication, 1994).

7. Potential for Contaminant Migration

For the active life of the landfill and the post-closure period there is essentially no potential for downward migration of hazardous contaminants to the uppermost aquifer (i.e., the main aquifer). This is based upon the following:

- The amount of hazardous or radioactive materials deposited at the site was exceedingly small (section 3.3.1)
- The depth to the water table for the uppermost aquifer (i.e., the main aquifer) is about 300 m (1000 ft) below land surface making the transport pathway exceedingly long especially when tortuosity is considered (section 5.1)
- The chemistry of supply wells in the main aquifer immediately adjacent to the site show no leachate contamination (section 5.1)
- No high moisture or perched zones exist at the site which cannot be explained by sources other than leachate (section 5.2)
- Rates of travel calculations (Rosenberg and Turin, 1993) estimate more than 10,000 yrs for fluid migration from the mesa top to the water table (section 5.3)
- The nonwelded surge beds of the lower Tshirege and upper Otowi Members provide a barrier for vertical fracture flow (section 5.3)
- The HELP model output suggests that only about 0.8 in/yr of percolation would be produced at the lower layer of the pit (section 6.0)

8. Vadose Zone Monitoring Plan

8.1 Vadose Zone Monitoring

In order to demonstrate no migration potential, LANL is proposing a limited-term vadose zone monitoring plan. This is to confirm low moisture profiles and low leachate migration as suggested by the previous text. Vadose zone monitoring will be done in a manner consistent with

that done at Area G; i.e., by using a combination of lysimeters and neutron access probes to sample and monitor moisture presence and migration. Lysimeters will be used to evaluate leachate migration at the oldest closed pit (i.e., number 1) and at the current active pit (i.e., number 4). Monitoring of pit 1 will permit evaluation of leachate migration at a pit with the longest time to develop a migration pathway. Monitoring of pit 4 will allow evaluation of a pit with the greatest potential to develop leachate (ie., since this pit is open).

Neutron logging of neutron probe access holes will be performed to monitor the development of soil moisture profiles. These profiles will reveal when excess moisture migrates to depths where landfill materials exist and where the lysimeters collection cups reside. This will provide information on storm events and the timing of sample collection from the lysimeters.

Locations for proposed installation of lysimeters and neutron probe access tubes are shown in Figure 8. Monitoring at these locations will continue for two years. If no leachate is detected during the initial two year period, LANL will reevaluate the monitoring/sampling schedule.

8.1.1 Lysimeters

Two lysimeters are proposed for installation under pits 1 and 4 for detection of possible vertical migration of leachate (see Figure 8). Pit 1 is assumed to be the oldest of the pits, therefore, if leachate exists, it would contain the highest concentrations of contaminants. Pit 4 is currently being filled.

The lysimeters will be installed adjacent to the pits and completed at least 1.5 m (5 ft) below the bottom of the adjacent pits. Placement of lysimeters adjacent to the pits will allow measurement of moisture content beside and below the pits as well as collection of samples if possible, i.e. if enough fluid fills the ceramic cup. Figure 9 is schematic diagram of a lysimeter.

8.1.2 Neutron Probe Access Tubes

Four neutron probe access tubes are proposed, three of which are near pits 1, 3, and 4 (see Figure 8). The fourth access tube shall be located in the north corner of the facility for the purpose of background measurements. This location will also allow correlation with previously obtained moisture data from the mesa. The access tube at pit 3 should, if possible, be set within the asphalt pad but still penetrate along the outside wall of the filled pit.

Neutron probe data will help in establishing moisture profiles adjacent to filled pits 1 and 3, partially filled pit 4, and the filled and plugged shaft 1. Detection of moisture in the access tubes will determine when sampling of lysimeters is necessary. The data obtained from the access tube near pit 3 may give some insight as to the affect of the asphalt covering on vertical migration of fluid within the pit due to capillarity.

8.1.3 Frequency

LANL will sample for presence of moisture using neutron probes at least twice monthly during the monsoon period (July to September). LANL will sample for moisture on a daily basis in the period from one to several days following significant precipitation. Should a neutron probe detect a significan moisture increase, an attempt will be made to extract samples from the lysimeters. If an adequate sample is found, LANL will analyze it for constituents (Appendix K, SWMR-4).

8.1.4 Constituents

SWMR-4 requires monitoring for the presence of Appendix K constituents when vadose zone monitoring is conducted. Sampling and analysis will be conducted in accordance with standard operating procedures established for the RFI, including quality assurance and quality control procedures (see *Quality Assurance Project Plans for RCRA Facility Investigations, May 1991*, and *Standard Operating Instructions, LANL Environmental Restoration Program, September 1994*).

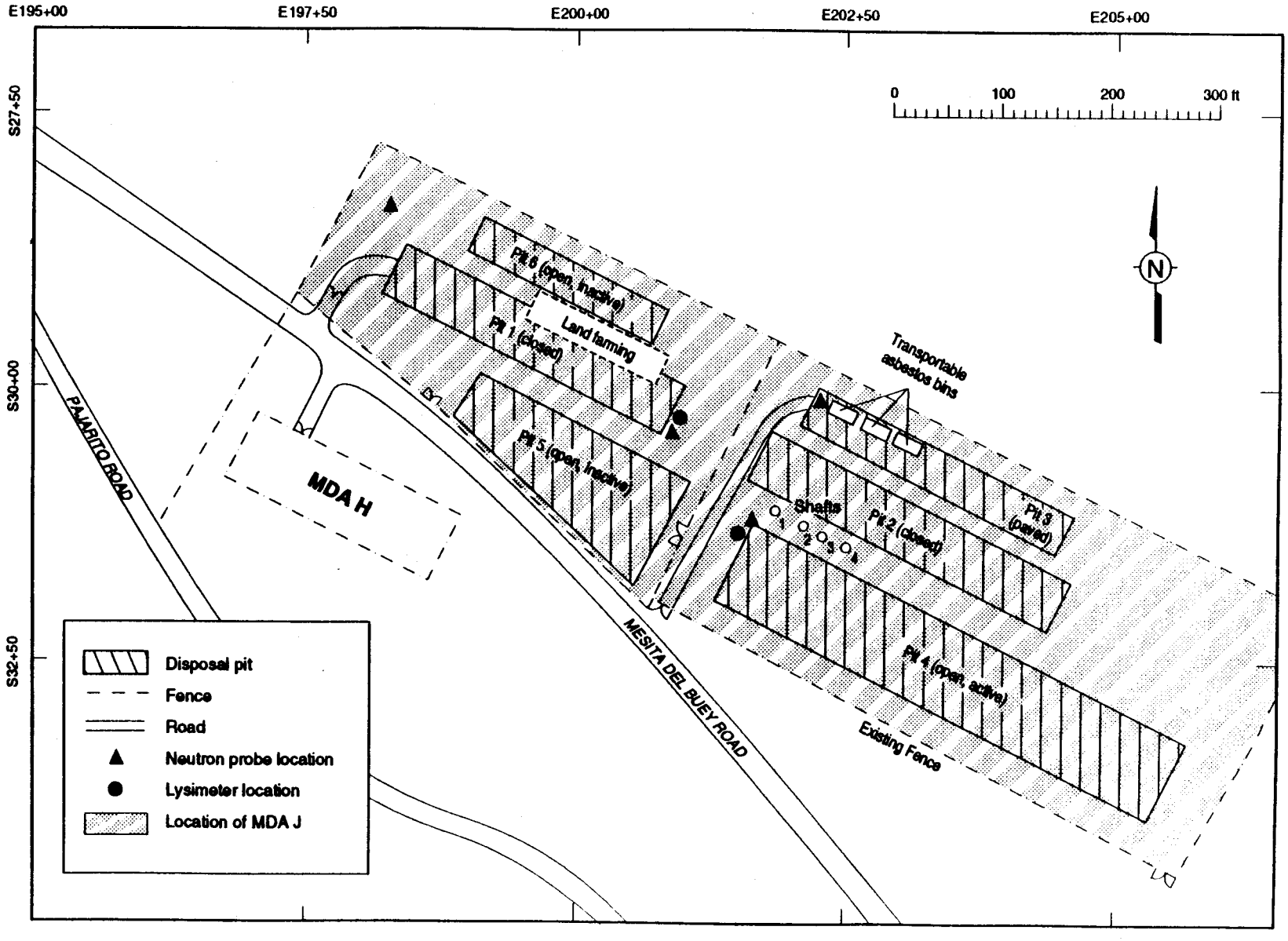


Figure 8. Proposed monitoring sites at Area J.

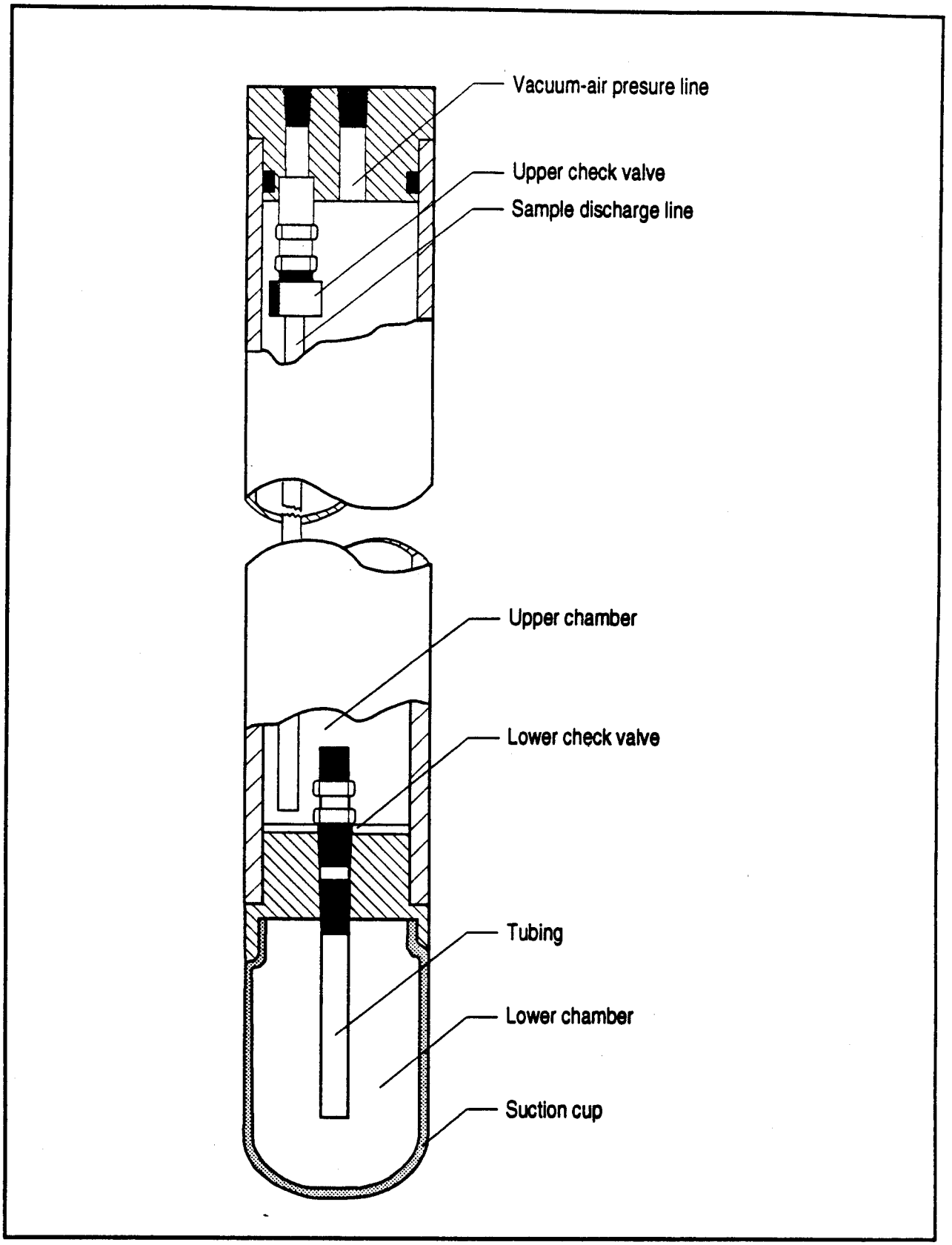


Figure 9. Engineering schematic of a lysimeter.

8.2 Schedule for Implementation

The Regulation requires that the Plan be entered into the operating record within 14 days of its approval by the Secretary. LANL will begin implementation of the plan beginning October 1, 1995 (FY96).

8.2.1 Placement of monitoring devices

Monitoring devices will be in place 90 days after beginning implementation.

8.2.2 Determine Background Levels

Background levels of constituents in the main aquifer have been established by testing of supply wells PM-2 and PM-4, both in the vicinity of Area J. (See section 5.1 and Appendix F.)

8.2.3 Sample collection and analysis

As discussed in section 7.1, if leachate is detected, and an adequate sample for testing can be collected, it will be analyzed for the presence of Appendix K constituents. Since LANL is not certain that leachate will even form, it is not possible to present a schedule for implementing sampling. Sampling will be conducted as stated in section 8.1.4.

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