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Date: January 25, 1995
Refer to: EM/ER:95-J024

Dear Mr. Honker:

SUBJECT: SUBMITTAL OF THE RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION (RFI) REPORT FOR POTENTIAL RELEASE SITES (PRSs) TECHNICAL AREAs (TA) 18 AND 27

Enclosed is Los Alamos National Laboratory's RFI Report concerning PRSs, 18-001(a,b,c), 18-007, 27-001, 27-003. This RFI Report is due to your office on January 30, 1995. This RFI report documents field work performed at TA-18 and 27 detailed in the approved RFI Work Plan for Operable Unit (OU) 1093.

Please ask your office to contact Gene Gould or Everett Trollinger of our staff at (505) 667-0402 or (505) 667-5801, respectively, if you have any questions.

Sincerely,

Jorg Jansen, Project Manager
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CERTIFICATION

I certify under penalty of law that these documents and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violation.

Document Title:

Submittal of the Resource Conservation and Recovery Act Facility Investigation (RFI) Report for Potential Release Sites (PRSs) in Technical Areas (TA) 18 and 27

Name: _____ Date: Jan 31, 95

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LIBRARY COPY

RFI Report for Potential Release Sites

18-001(a)
18-001(b)
18-001(c)
18-007
27-001
27-003

(located in former Operable Unit 1093)

Field Unit 2

Environmental Restoration Project

January 1995

A Department of Energy
Environmental Cleanup Program

Los Alamos
NATIONAL LABORATORY

LA-UR-95-295

RFI REPORT
FOR
OPERABLE UNIT 1093

POTENTIAL RELEASE SITES
18-001a,b,c; 18-007, 27-001, 27-003

Prepared for Los Alamos National Laboratory
by
ICF Kaiser Engineers, Inc.
Los Alamos NM

January 30, 1995

EXECUTIVE SUMMARY

This report addresses field investigations and subsequent data analysis for Operable Unit (OU) 1093, Technical Area (TA)-18 and TA-27, conducted as part of the Los Alamos National Laboratory's (Laboratory) Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) performed in compliance with RCRA corrective action. OU 1093 consists primarily of TA-18 and the portion of Pajarito Canyon that runs from east of TA-18 to State Road (SR) 4 at White Rock, New Mexico (Figure 1-1). Potential release sites (PRS), from which RCRA hazardous or radioactive constituents may have been released to the environment, are located in TA-18 and TA-27. During the 1940s, both technical areas were used for implosive tests as well as for nuclear criticality research. Since the end of the Manhattan Project in the mid-1940s, TA-18 has continued to be involved with nuclear criticality research. Operations at TA-27 were discontinued in the late 1940s.

PRSs at this site include various liquid waste management systems, such as septic systems and sanitary waste lines, that may have received hazardous or radioactive discharges; buried waste materials; storm sewer outfalls or other drains; areas of surface contamination from explosives testing; and bazooka impact areas used for target practice in the 1940s. This RFI Report addresses PRS 18-001 (a) and (b), a sanitary sewer line and related lagoons; PRS 18-001(c), a sump in one of the buildings in the central portion of TA-18; PRS-18-007, an armored vehicle allegedly buried in Pajarito Canyon; PRS 27-001, one or more naval guns also allegedly buried in the canyon; and PRS 27-003, a bazooka impact area. All of these PRSs except for 18-007 are currently listed in the Hazardous and Solid Waste Amendments (HSWA) module of the Laboratory's RCRA Part B permit.

OU 1093 is bounded on the north by the low but steep cliffs of Pajarito Canyon and to the south by Pajarito Mesa. The mesas on either side of Pajarito Canyon and the bedrock underlying most of the canyon are composed of Bandelier tuff. The canyon floor consists of alluvial material, varying up to 50 ft in thickness. A shallow groundwater body underlies most of the canyon floor, with the depth to water varying from 1 ft to 20 ft. Significant seasonal variation occurs in the thickness of this shallow saturated zone, primarily as a function of recharge from the ephemeral stream flowing in the canyon. Depth from the canyon floor to the main aquifer below is approximately 700 ft. There is no evidence of hydrologic connection between the shallow and deep aquifers, and no intervening perched aquifers are known to exist.

Field investigations, as described in this report, were carried out in the fall of 1993. Sediment and water samples were collected from the manholes associated with the sanitary sewer line. Sludge samples were taken from the lagoons, and water samples were collected from the sump. An explosive ordnance removal organization searched the bazooka impact area for unexploded ordnance (UXO). All located debris related to the bazooka firing was removed, and eight items of UXO were destroyed onsite. Soil samples were subsequently collected in the area most heavily affected by the bazooka shells.

All collected samples were analyzed for potential contaminants of concern (PCOC) related to the respective sites, and the resulting measurements were compared with health-based screening action levels (SAL). These SALs are calculated using methodologies similar to that in proposed Subpart S of 40 CFR 264. If concentrations of potential contaminants are below the SALs, it can generally be concluded that no health risk is posed by the unit. Quality assurance review of the analytical data disqualified a small percentage, but no additional sampling was performed as a result of this disqualification. The remaining data was judged to sufficiently support decision-making.

The objective of sampling in the manholes and lagoons was to support a decision on how best to decommission this system. The Laboratory wishes to decommission the sewer line and lagoons, which were taken out of service in December 1992. A review of the sampling data concluded that the measured contamination in the small quantity of sediment remaining in the manholes after sampling would not pose a significant health risk. Removal of the surface portions of the manholes and encapsulating the sediment in concrete will mitigate this low risk. No significant health risk is posed by the sludge in the lagoons; we

propose to remove the side-walls and above-grade portions of the lagoon — leaving the sludge in place — and backfill the excavation to grade. The Laboratory will submit a request for a Class III permit modification along with a plan for expedited clean-up (i.e., in-place stabilization) of the manhole and lagoons.

No contamination above SALs was detected in the sump. Potential sources of contamination to that sump have been rerouted, and a proposal for No Further Action will be submitted for PRS 18-001(c).

Geophysical surveys were performed in an attempt to locate the buried armored vehicle and naval guns; these investigations were unable to locate either. There is no substantial evidence that these items are present in Pajarito Canyon. We believe no additional action regarding that PRS is justified. As a result of this investigation, the Laboratory will propose No Further Action for both the buried naval guns (PRS 27-001) and the buried armored vehicle (PRS 18-007).

Sweep and removal of debris and UXO from the bazooka impact area successfully mitigated any hazard from the site. Soil sampling did not detect any potential contaminants significantly above background levels. The Laboratory will propose No Further Action for the bazooka site, PRS 27-003.

ACRONYMS AND ABBREVIATIONS

CEARP	Comprehensive Environmental Assessment and Response Program
CFR	Code of Federal Regulations
CRQL	contract-required quantitation limit
DOE	U.S. Department of Energy
DU	depleted uranium
EM	electromagnetic
EOD	explosive ordnance disposal
EPA	U.S. Environmental Protection Agency
HE	high explosives
HSWA	Hazardous and Solid Waste Amendments
IWP	Installation Work Plan
LANL, Laboratory	Los Alamos National Laboratory
MCL	maximum contaminant level
OU	Operable Unit
PCOC	potential contaminant of concern
PRS	potential release site
Pu	plutonium
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RCT	radiological control technician
RFI	RCRA Facility Investigation
SAL	screening action level
SR	State Road
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TA	Technical Area
TC	toxicity characteristic
TCLP	toxicity characteristic leaching procedure
Th	thorium
UTL	upper tolerance level
UXO	unexploded ordnance
VOC	volatile organic compound

TABLE OF CONTENTS

EXECUTIVE SUMMARY i

ACRONYMS AND ABBREVIATIONS iii

1.0 INTRODUCTION 1-1

1.1 Description and Background of OU 1093 1-1

1.2 RFI Phase I Work Plan Overview 1-1

2.0 ENVIRONMENTAL SETTING 2-1

2.1 Physical Description 2-1

2.2 Climate 2-1

2.3 Geology 2-1
2.3.1 Geologic Setting 2-1
2.3.2 Soils 2-3

2.4 Hydrology 2-3
2.4.1 Surface Water 2-3
2.4.2 Groundwater 2-4

3.0 INTRODUCTORY TOPICS 3-1

3.1 Summary of QA/QC Activities 3-1
3.1.1 Metals Analysis 3-1
3.1.2 Organic Analysis 3-2
3.1.2.1 Blanks 3-2
3.1.2.2 Holding Times 3-2
3.1.2.3 Method Accuracy 3-2
3.1.2.4 Percent Recovery 3-3
3.1.3 High Explosives 3-3
3.1.4 Radionuclides 3-3

3.2 Backgrounds 3-3
3.2.1 Statistical Methodology 3-4
3.2.2 Soils 3-4
3.2.2.1 Inorganics 3-4
3.2.2.2 Radionuclides 3-4
3.2.3 Groundwater 3-4
3.2.3.1 Inorganics 3-4
3.2.3.2 Radionuclides 3-5

3.3 RCRA Risk-Based Screening Levels....3-5
3.3.1 Water....3-5
3.3.2 Air....3-5
3.3.3 Soil....3-5

3.4 Risk-Based Screening Action Levels for Radioactive Constituents....3-5
3.4.1 Water....3-6
3.4.2 Air and Soil....3-6

3.5 Risk-Based Screening Action Levels for Multiple Constituents....3-6

3.6 Waste Criteria....3-6

3.7 Basis for Conclusions and Recommendations....3-6
3.7.1 Data Evaluation and Assessment....3-6
3.7.1.1 Blanks....3-6
3.7.1.2 Out-of-Control QC Samples....3-7
3.7.1.3 Matrix Interference, Triplicates....3-7
3.7.1.4 Comparison with Background, SALs, and Waste Criteria....3-7

4.0 INVESTIGATION RESULTS....4-1

4.1 PRS 27-003, Bazooka Impact Area....4-1
4.1.1 Site Description....4-1
4.1.2 Site Investigation and Analyses....4-1
4.1.3 Data Evaluation....4-7

4.2 PRS 18-001(a), (b) Sanitary Lagoons and Sanitary Sewer Line....4-7
4.2.1 Site Description....4-7
4.2.2 Site Investigation and Analyses....4-11
4.2.2.1 Sanitary Lagoon....4-11
4.2.2.2 Outfall....4-11
4.2.2.3 Sanitary Sewer Line....4-11
4.2.3 Evaluation of Results....4-11
4.2.3.1 Comparison with Background....4-22
4.2.3.2 Comparison with SALs....4-22
4.2.4 Conclusions....4-24

4.3 PRS 18-001(c), Sump....4-25
4.3.1 Site Description....4-25
4.3.2 Site Investigation and Analyses....4-25
4.3.3 Evaluation of Results....4-25
4.3.4 Conclusions....4-27

4.4 PRS 27-001, Buried Guns....4-27
4.4.1 Site Description....4-27
4.4.2 Site Investigation....4-27
4.4.3 Evaluation of Results....4-30
4.4.4 Conclusions....4-30

4.5 PRS 18-007, Buried Armored Vehicle....4-30
4.5.1 Description and Possible Locations....4-30
4.5.2 Site Investigation and Analyses....4-31
4.5.3 Evaluation of Results....4-31
4.5.4 Conclusions....4-31

5.0 REFERENCES....5-1

APPENDIX A Methodology and Results for Analysis of Background Concentrations....A-1
Table A-1....A-2
Table A-2....A-4
Table A-3....A-5

FIGURES

Figure 1-1 Location of Operable Unit 1093....1-2
Figure 1-2 Technical areas, land formations, and drainage at OU 1093....1-3
Figure 2-1 Three-dimensional hydrogeological model of OU 1093....2-2
Figure 2-2 Monitoring wells and shallow water table elevations near TA-18 in Pajarito Canyon....2-5
Figure 4-1 Location of PRS 27-003....4-2
Figure 4-2 Location of field investigations at Bazooka Impact Area....4-3
Figure 4-3 Ordinance debris removed from Bazooka Impact Area....4-5
Figure 4-4 Remediation of explosive hazards at Bazooka Impact Area....4-6
Figure 4-5 Location of sewage lagoons and inactive sanitary sewer line from TA-18....4-8
Figure 4-6 TA-18 present sewer system....4-9
Figure 4-7 Schematic representation of sewer system revisions, east-central TA-18....4-10
Figure 4-8 Sampling locations at SWMU 18-001(a), sewage lagoons, and outfall....4-12
Figure 4-9 Locations of site investigations for 18-001(c)....4-26
Figure 4-10 Area surveyed to locate PRS 27-001....4-28
Figure 4-11 Possible location of PRS 18-007....4-32

TABLES

Table 1-1 Potential Release Sites Included in RCRA Facility Investigation in OU 1093....1-4
Table 2-1 Well Inventory....2-6
Table 2-2 Monitoring and Temporary Water Wells in Pajarito Canyon (April 1993 - November 1994)....2-7
Table 4-1 Measured Concentrations of PCOCs in PRS 27-003....4-4
Table 4-2 Measured Concentrations of PCOCs in PRS 18-001(a) and (b)....4-13
Table 4-3 Measured Concentrations of PCOCs in PRS 18-001(c)....4-25

1.0 INTRODUCTION

1.1 Description and Background of OU 1093

Operable Unit (OU) 1093 consists primarily of Technical Area (TA)-18 and the portion of Pajarito Canyon that runs from east of TA-18 to State Road (SR) 4 at White Rock, New Mexico (Figure 1-1) The OU lies primarily within the confines of the canyon, from the low cliffs on the north to the top of the low mesa on the south; it also includes the eastern end of Threemile Canyon where it joins Pajarito Canyon within the boundaries of TA-18. Eastward-flowing ephemeral streams are present in both canyons, and a shallow groundwater body is present in the alluvium of Pajarito Canyon. Potential release sites (PRS) are located within TA-18 and east of TA-18 adjacent to Pajarito Road within the former TA-27 (Figure 1-2). These sites include liquid waste management systems (sanitary waste, storm drains, and outfalls), firing sites used during World War II, and possible material disposal areas. Before the start of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for this OU, there were no data indicating that any environmental release of contaminants had occurred.

TA-18 was first used during the Manhattan Project in the early 1940s. It contained two firing sites for implosive testing of high explosives (HE) used in the atomic bomb. Experimental facilities at the site investigated rates of spontaneous fission from samples of radioactive materials, including uranium (U), plutonium (Pu), and thorium (Th). The explosives testing operations frequently involved the use of depleted uranium (DU) as a surrogate for fissionable materials. The U.S. Army also used an impact area as a target range for bazookas. Two sewage lagoons, located a mile east of TA-18 on the south side of Pajarito Road, provided treatment for sanitary waste from the central portion of TA-18. Use of the lagoons was discontinued in 1992. Waste materials may have been buried at various locations within the OU, but there are no known locations for such disposals.

Since World War II, TA-18 site operations have been devoted primarily to the investigation of nuclear criticality. The experimental facilities used during the Manhattan Project in the central portion of TA-18 were replaced by remote facilities within Pajarito and Threemile canyons. No explosive tests have been conducted since 1947. Additional facilities associated with operations at TA-18 are located east of the site along Pajarito Road.

TA-27 was used during the Manhattan Project as a third firing area for implosive tests. Various firing pits and control buildings at the site were decommissioned after 1947.

1.2 RFI Phase I Work Plan Overview

The PRSs identified in the RFI Work Plan for OU 1093 (LANL 1993a) are presented in Table 1-1, along with their current status and whether they were listed in the Hazardous and Solid Waste Amendments (HSWA) module of the RCRA permit. Complete descriptions of these PRSs are presented in the RFI Work Plan.

This report addresses activities at six of those PRSs, all of which were originally listed in the HSWA permit:

- PRS 18-001(a), the sanitary sewage lagoons
- 18-001(b) the sanitary sewer line from TA-18 to the lagoons
- 18-001(c) a sump in the basement of Building TA-18-30
- 18-007, a buried military tank
- 27-001, a disposal site for naval guns
- 27-003, the bazooka impact area

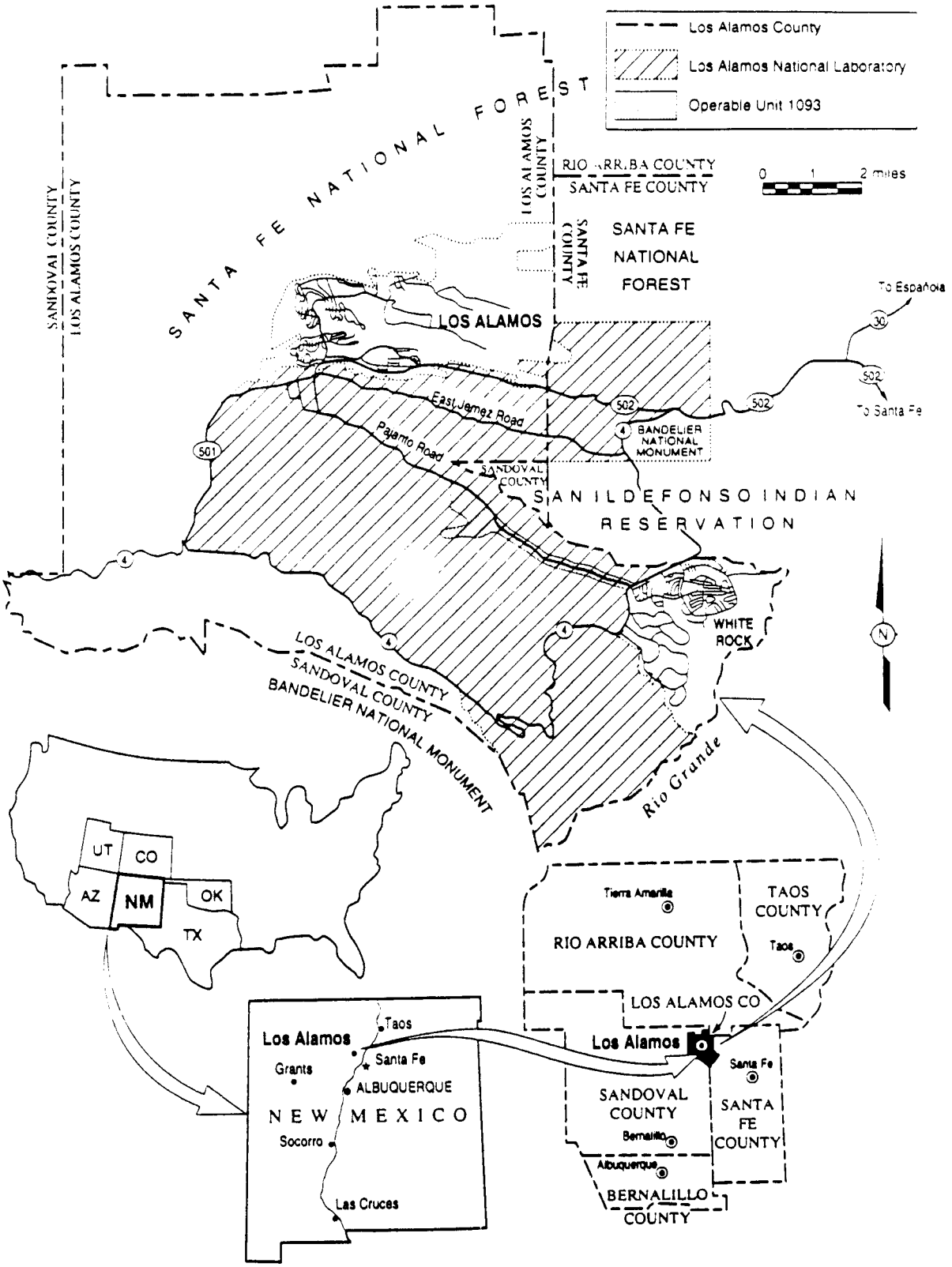

Figure 1-1. Location of Operable Unit 1093

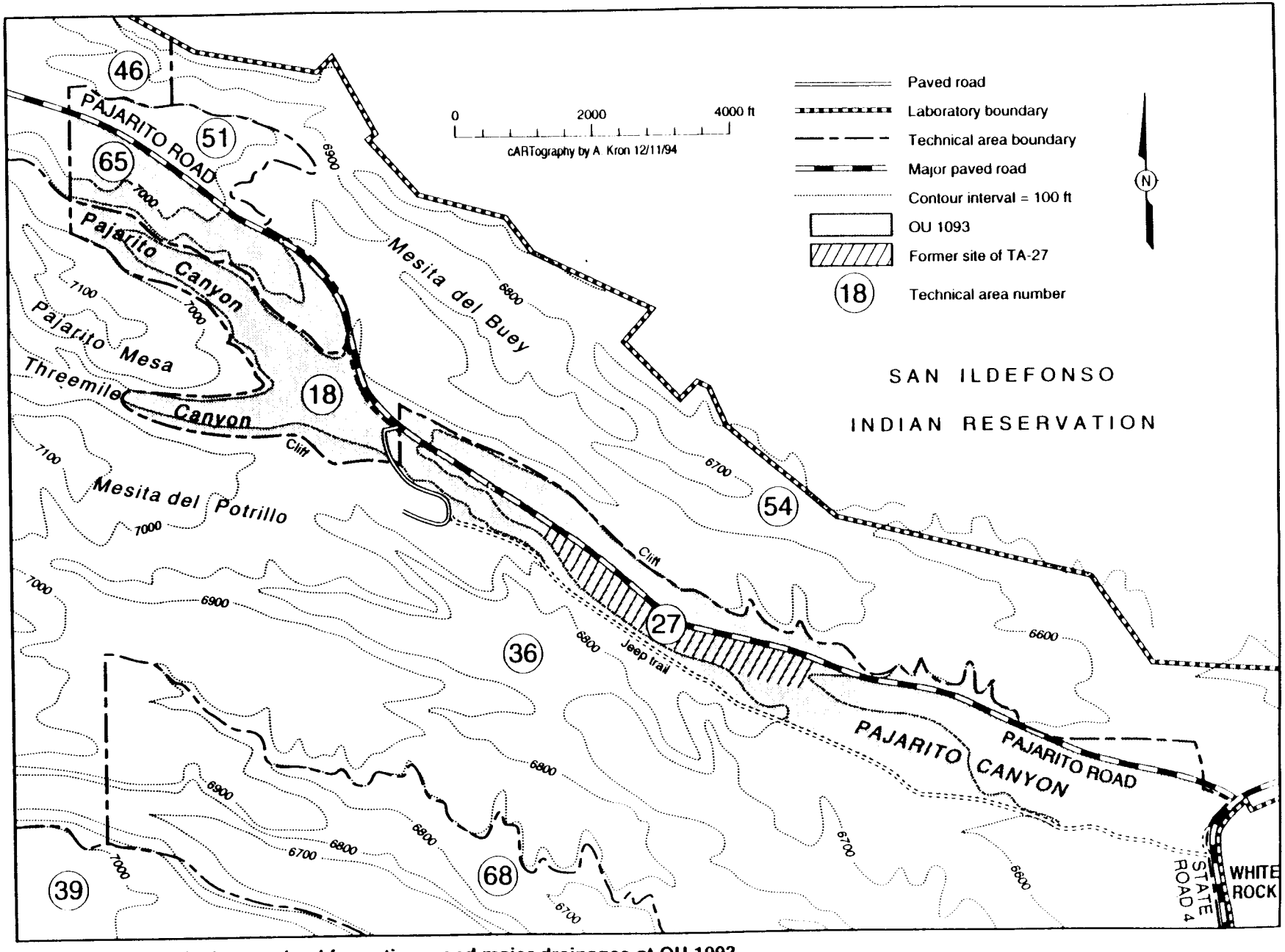

Figure 1-2. Technical areas, land formations, and major drainages at OU 1093.

TABLE 1-1
POTENTIAL RELEASE SITES INCLUDED IN RCRA FACILITIES INVESTIGATION IN OU 1093

PRS No.	Description/Location	SWMUs listed in Table A of HSWA Module	Location of Discussion: Section	Proposed Status
18-001	**LAGOONS AND DRAIN LINES**			
18-001(a)	Lagoons	X	4.2	NFA[c] after decommissioning
18-001(b)	Sanitary sewer lines	X	4.2	NFA after decommissioning
18-001(c)	Building 18-30 sump	X	4.3	NFA
18-002	**FIRING SITES**			
18-002(a)	Pajarito Canyon	X	NA[b]	
18-002(b)	Threemile Canyon	X	NA	
18-002(c)	Drop tower		NA	
18-003	**SEPTIC SYSTEMS/SETTLING PITS[a]**			
18-003(a)	Industrial waste; Kiva 1	X	NA	
18-003(b)	Sanitary waste; Kiva 1	X	NA	
18-003(c)	Kiva 2	X	NA	
18-003(d)	Kiva 3	X	NA	
18-003(e)	Buildings 18-31, 18-37, and 18-129	X	NA	
18-003(f)	Sanitary waste—Building 18-30	X	NA	
18-003(g)	Building 18-1	X	NA	
18-003(h)	Building 18-147	X	NA	
18-004	**RAD WASTE COLLECTION SYSTEM**			
18-004(a)	Waste line for Building 18-30		NA	
18-004(b)	Collection tanks	X	NA	
18-005	**MAGAZINE SITES**			
18-005(a)	Pajarito Canyon—Building 18-15	X	NA	
18-007	Buried military tank	X	4.5	NFA
18-008	Underground storage tank 18-104		NA	
18-010	**STORM SEWER OUTFALLS**			
18-010(b)	Drainage ditch west of Building 18-30		NA	
18-010(c)	Paved area drainage—Building 18-30		NA	
18-010(d)	Paved area NE of Building 18-37		NA	
18-010(e)	Paved area, Buildings 18-28, 18-147		NA	
18-010(f)	Roof and floor drains, Kiva 2		NA	
18-011	Soil near former Building 18-22		NA	
18-012	**SUMPS AND DRAINS**			
18-012(a)	Drain line and outfall—Kiva 3		NA	
18-012(b)	Outfall for Building 18-30, 18-31		NA	
18-012(c)	Sump and drains—Building 18-141		NA	
18-013	Special waste catch tank	X	NA	
27-001	Burial trench	X	4.4	NFA
27-002	Five firing sites at TA-27		NA	
27-003	Bazooka Impact Area	X	4.1	NFA

a. Assumed to be combined sanitary and industrial waste, except as noted.
b. NA—Not addressed in this report.
c. NFA—No Further Action.

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Sampling of sediments, sludge, or water associated with the first three PRSs was accomplished in September 1993. The objective of this sampling was to determine if RCRA-regulated or radioactive contaminants were present within these PRSs. For the sanitary sewer lines and lagoons, the sampling was also intended to determine appropriate decommissioning procedures. Geophysical surveys were conducted in an attempt to locate the buried tank and guns, and an explosive ordnance team surveyed the bazooka impact area and removed (or destroyed) all remnants of the residual bazooka shells. Soil samples were collected within the primary impact area to determine if any potential contaminants associated with the shell explosions were present above risk-based concentrations.

2.0 ENVIRONMENTAL SETTING

The environmental setting of the Laboratory is described in Section 2 of the Laboratory Installation Work Plan (IWP) for Environmental Restoration (LANL 1993a). A discussion of the environmental setting of TA-18 and adjacent areas is presented in the following sections and provides the detailed information required to evaluate potential migration pathways and conceptual exposure models at OU 1093.

2.1 Physical Description

OU 1093 lies entirely on U.S. Department of Energy (DOE)-owned land in the east-central portion of the Laboratory. In the foreseeable future, land in the area of OU 1093 is anticipated to be used exclusively for Laboratory operations. The residential community of White Rock lies a few miles east of TA-18 and borders the eastern end of the OU, but all other surrounding lands are DOE property. Pajarito Road (a public access road) traverses the length of the OU.

2.2 Climate

Los Alamos County has a semiarid, temperate mountain climate. Summers are generally sunny, with moderate, warm days and cool nights. 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 to the 50s (°F) after even the warmest day. Winter temperatures typically range from about 15°F to 25 °F during the night and from 30°F to 50°F during the day, with light winds.

Los Alamos receives an average of 18 in. of precipitation annually. Of this total, 40% occurs as brief, intense thunderstorms during July and August. Stream flow in Pajarito Canyon occurs as a result of these storms. Snowfall within the Los Alamos Townsite averages 51 in. annually, with the surrounding mountains receiving approximately three times that amount. Spring snowmelt runoff also commonly induces stream flow in Pajarito Canyon.

Because of the complex terrain, surface winds in Los Alamos vary greatly with the time of day and location. Within OU 1093, winds are predominantly either southwesterly or northeasterly.

2.3 Geology

2.3.1 Geologic Setting

Figure 2-1 graphically summarizes the general geology and hydrogeologic processes occurring within OU 1093. The dominant contaminant-transport process is surface erosion and sediment/solute transport. Some subsurface transport through the vadose zone or within the alluvial groundwater body could occur. The magnitude of groundwater flow in the unsaturated zone is uncertain, but it is expected to be small.

Specific detail of the geology of Pajarito Canyon in the vicinity of TA-18 has been determined from several studies of Mesita del Buey, directly north of Pajarito Canyon, as well as from a supply well and test holes in Pajarito Canyon east of TA-18 (Purtymun and Kennedy 1971, 0200; Devaurs 1985, 0046; LATA 1991, 16-0005).

OU 1093 is located midway along Pajarito Canyon near its intersection with Threemile Canyon (see Figure 1-2). Elevations at the site decline eastward from 6,900 to 6,780 ft. The site is bordered to the north by Mesita del Buey and to the south by Pajarito and Threemile mesas. Canyon walls in the area are nearly vertical.

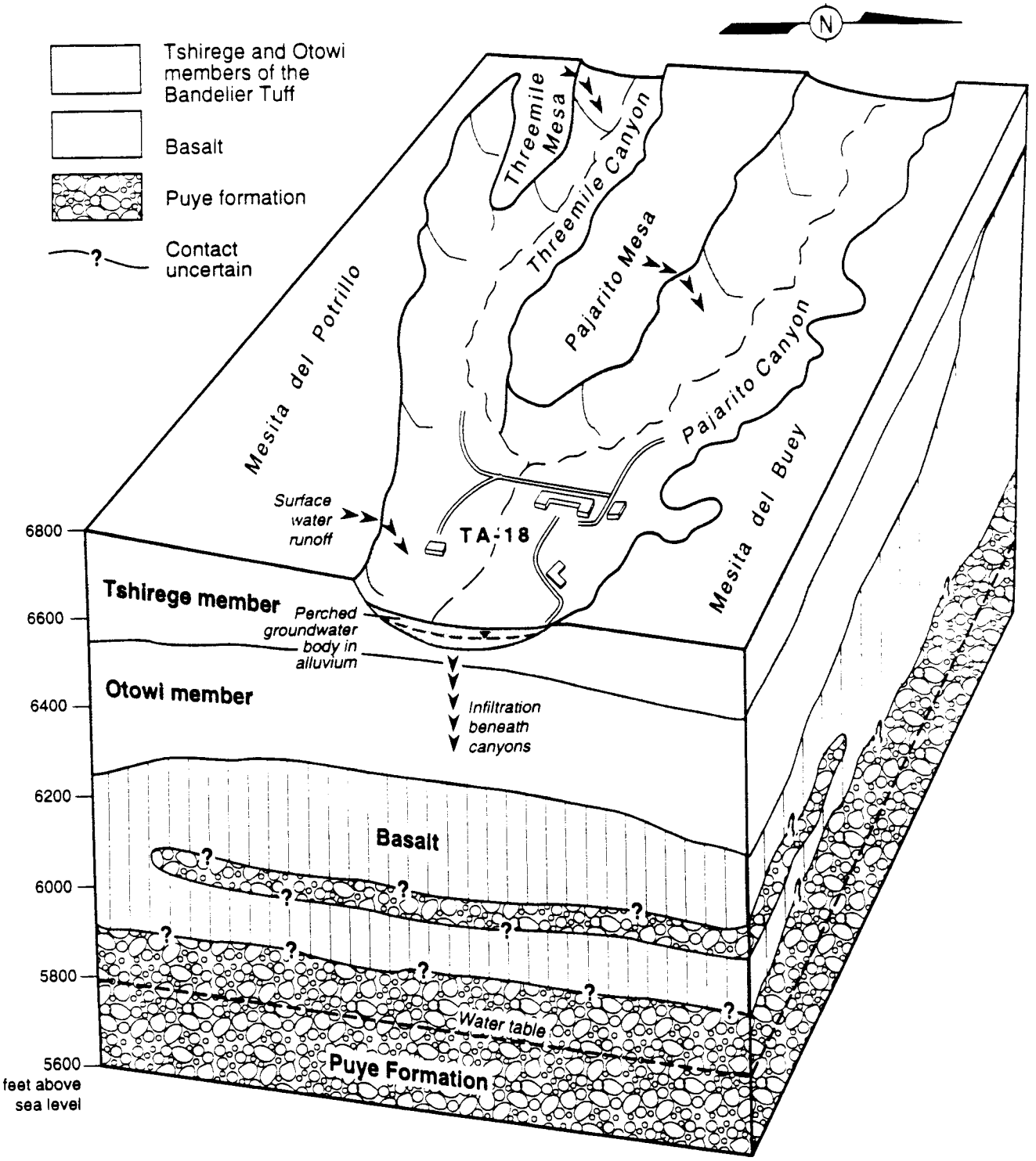


Figure 2-1. Three-dimensional hydrogeologic model of OU 1093.

Evidence of faulting can be seen in OU 1093. Faults lacking surface expression have been delineated approximately 0.5 mile east and 1 mile west of TA-18, and other minor faults exist near the area (Vaniman and Wohletz 1990, 0541). Numerous joints, formed because of contraction of the tuff during cooling, are common throughout the mesas surrounding OU 1093 and in borehole samples taken from within Pajarito Canyon. Joint blocks range in size from a few square feet to more than 500 ft^2 in surface exposures. Joint openings range from less than 0.25 in. to more than 2 in. and are typically filled with clay, weathering products, and precipitation minerals leached from the surrounding tuff (Purtymun and Kennedy 1971, 0200).

Pleistocene ash flows and ash falls of Bandelier tuff directly underlie the alluvial channel-fill deposits that form the floor of Pajarito and Threemile canyons. The subsurface thickness of the tuff, approximately 375 ft near TA-18, thins to approximately 150 ft 2 miles to the east, and tapers out entirely in the canyon bottom near SR 4. The Bandelier tuff is split into two distinct members, the Otowi and the Tshirege, each of which is comprised of a lower air-fall pumice bed and an upper sequence of ignimbrite flow sheets.

The Tshirege member comprises all of the surface rocks exposed at OU 1093. Its lower layer is a nonwelded to moderately welded light-orange to light-brown pumiceous tuff capped by a grayish brown tuff. The subsurface thickness of the unit is approximately 55 ft in the western end of the mesa, thinning to less than 35 ft to the east. That portion of the tuff exposed in OU 1093 is predominately a moderately welded ash-flow tuff that grades eastward into a nonwelded ash-fall pumice and tuff.

Alluvium in Pajarito Canyon is approximately 20 to 50 ft thick. In the upper reaches of the canyon, the alluvium is composed of sands and boulders, pebbles, and cobbles of dacite and rhyolite. In the area of OU 1093, the alluvium consists of sands, clayey sands, sandy clays, and clays, as well as pebbles and cobbles of Bandelier tuff. Significant deposits of volcanic gravels have also accumulated in the canyon east of TA-18. These tuff gravels and cobbles are typically subrounded to rounded, indicating streambed deposition. The sediment layers are poorly to well sorted. The sand and clay lenses are laterally discontinuous, highly variable, and range from a few inches to more than a foot in thickness.

2.3.2 Soils

Canyon-bottom soils of Pajarito Canyon are typically well-drained soils of the Totavi series (Nyhan et al. 1978, 0161). In general, the prevalent soil types have not been geochemically and hydrogeologically characterized to the extent necessary for effective contaminant-transport analysis.

At OU 1093, the primary erosional process is the movement of sediments through the canyon bottom during periods of stream flow. Rates of erosion, sediment transport, and sediment deposition in the canyon bottoms are not well-known. Minor amounts of wind erosion may also occur in the area.

2.4 Hydrology

2.4.1 Surface Water

Pajarito Canyon originates on the flanks of the Sierra de los Valles west of the Pajarito Plateau. The drainage basin area from the headwaters of the canyon to the Laboratory's eastern boundary is approximately 10.6 mi^2. Stream flow in short sections of the canyon is perennial on the mountain flanks and the western portion of the plateau and ephemeral across the eastern plateau, where the canyon passes through TA-18 to the Rio Grande. A significant volume of surface flow recharges the unconfined perched groundwater body in the channel-fill alluvium of the canyon, and the remainder is lost through evapotranspiration (Purtymun and Kennedy 1971, 0200; LATA 1991, 16-0005). Gravel pits east of TA-18 have been excavated into the top of the perched-water table and frequently contain ponded water. Semipermanent wetlands have developed in the abandoned pits. Storm-water runoff drains into the canyon from the flanks of the mountains and the surrounding mesas. During peak flow events, stream

flow in Pajarito Canyon may reach the Rio Grande. The streambed has been reinforced with earthen berms in some locations within TA-18 to protect facilities from flood damage (LATA 1991, 16-0005); however, site inspections suggest that the existing earthwork will have little effect on the potential for contaminant migration into the stream channel.

The elevation and location of the 100-year flood plain has been determined for all Laboratory drainages (McLin 1992, 0825). In Pajarito and Threemile canyons, the 100-year flood plain occupies an area more or less centered on the stream channel; PRSs near or adjacent to the stream channel are, therefore, within the 100-year flood plain. Nearly all of the TA-18 structures and their associated PRSs are above the 100-year flood plain. The sewage lagoons in Pajarito Canyon east of TA-18 are above the 100-year flood plain.

2.4.2 Groundwater

Vadose Zone. The properties of the tuff underlying OU 1093 are expected to be similar to the properties summarized in the IWP. In undisturbed areas, clay soils are often present that significantly inhibit the downward movement of liquids into the tuff (Purtymun and Kennedy 1971, 0200). Further, investigations conducted to date indicate that dry Bandelier tuff substantially impedes the movement of fluids through the subsurface (LANL 1992, 0768).

Previous investigations at TA-18 show that approximately the upper 15 ft of alluvium and soil is under unsaturated conditions (LATA 1991, 16-0005). The vadose-zone hydrogeology of these sediments has not been thoroughly characterized.

Saturated Alluvium. The channel-fill alluvium at OU 1093 contains a perennial shallow body of groundwater, as evidenced by shallow monitoring wells and wetland development. Directly beneath the main facilities at TA-18, the alluvium is saturated below a depth of about 15 ft to a depth of approximately 30 ft, where the alluvium comes in contact with the Bandelier tuff. Boreholes indicate that the shallow groundwater body is confined to the alluvium and does not extend underneath the mesas north and south of OU 1093. The alluvial system is recharged by infiltration along the entire length of the canyon. Water is believed to be lost from the shallow groundwater system only through evapotranspiration and discharge to wetland areas, but this has not been rigorously verified.

The hydraulic gradient in the saturated alluvium is shallow and spatially and seasonally variable. Measured hydraulic conductivity ranges from 0.012 to 0.035 ft/day (LATA 1991, 16-0005); however, these values are much lower than is typical of Pajarito Plateau alluvium, and higher values are likely in the canyon. The direction of groundwater flow is predominantly toward the Rio Grande. Currently, no water supply wells are pumping water from the alluvial groundwater body.

Perched groundwater occurs in the alluvium of Pajarito Canyon. The potentiometric surface of the regional groundwater system beneath the Pajarito Plateau lies between 5,900 and 5,870 ft. It is believed that the regional groundwater system is not hydraulically connected with the perched groundwater in Pajarito Canyon (Devaurs 1985, 0046; Purtymun and Kennedy 1971, 0200). No perched water is known to exist between the shallow alluvial groundwater body and the main aquifer below OU 1093 (Devaurs 1985, 0046).

Monitoring Wells. OU 1093 has 15 monitoring wells, six of which were installed during the summer of 1994. The depths of the permanent wells range from 10 to 50 feet. (See Figure 2-2 and Tables 2-1 and 2-2 for well locations, descriptions, and water levels.) One temporary well (18-1196) provides a data point for an area in which there is no permanent well. An additional six temporary wells were installed, sampled, and plugged during the summer of 1994. They allowed one-time sampling of subsurface sediment and groundwater for contaminants. The permanent monitoring wells are sampled on a quarterly basis.

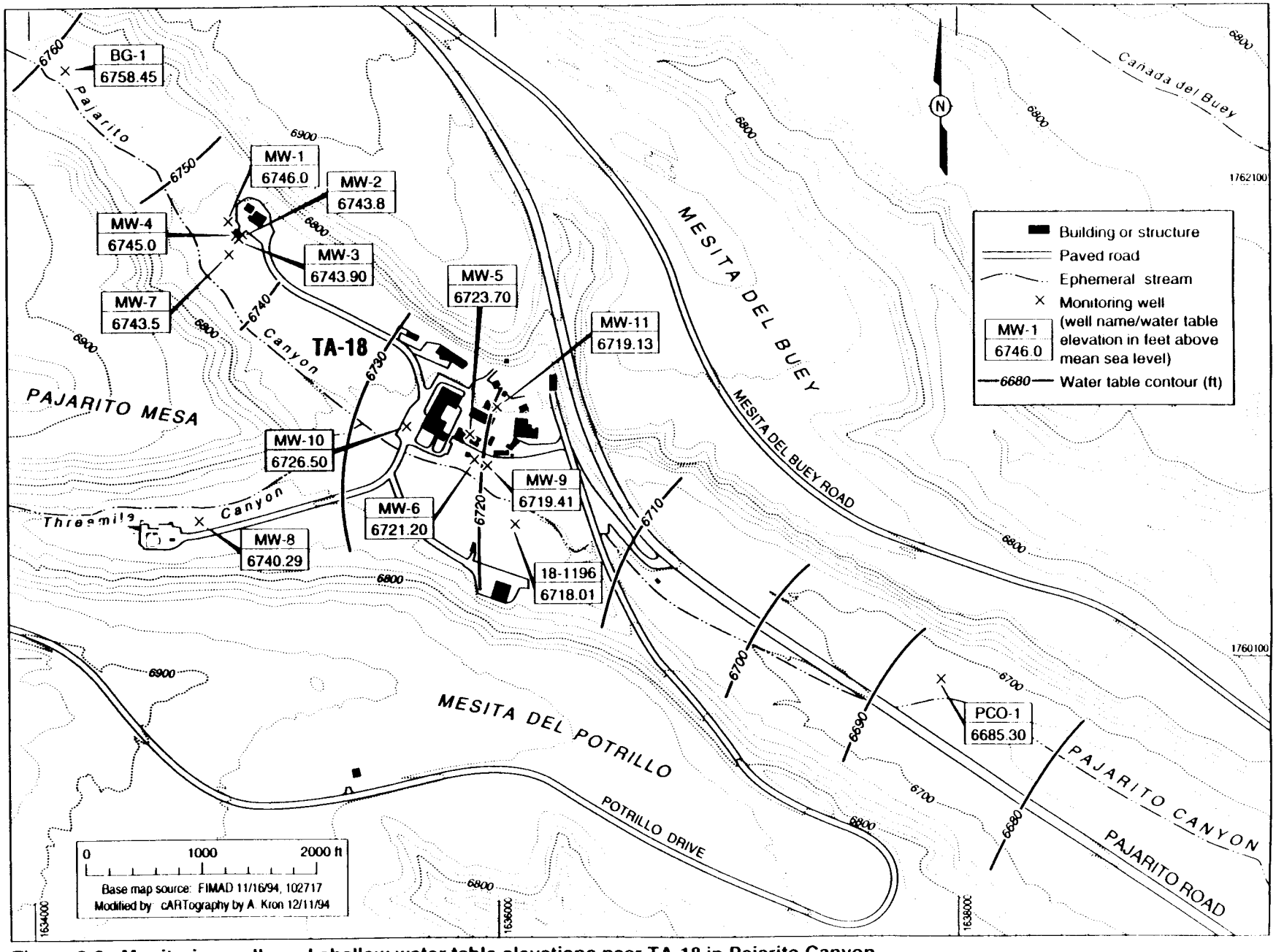


Figure 2-2. Monitoring wells and shallow water table elevations near TA-18 in Pajarito Canyon.

TABLE 2-1
WELL INVENTORY

Location ID	TA	Easting	Northing	Elevation	Well Type	Casing Size	Well Depth (ft)	Installation Date	Well Description
18-1060	18	1634152.9	1762575.36	6776.45	Monitoring Well	2 inch	37	8/1/94	BG-1
18-1063	18	1634119.84	1762585.9	6774.6	Temporary Well	2 inch	35	8/2/94	
18-1135	18	1634846.28	1761791.52	6755.5	Monitoring Well	2 inch	32	7/6/94	MW-7
18-1136	18	1634872.22	1761758.17	6754.01	Temporary Well	2 inch	24	7/7/94	
18-1165	18	1634723.53	1760674.42	6747.07	Temporary Well	2 inch	12.5	8/8/94	
18-1166	18	1634714.26	1760658.14	6747.79	Monitoring Well	2 inch	37.9	8/4/94	MW-8
18-1195	18	1636044.25	1760654.89	6724.11	Temporary Well	2 inch	10	7/5/94	
18-1196	18	1636069.88	1760642.6	6723.34	Temporary Well	2 inch	10	7/5/94	
18-1233	18	1635931.36	1760903.08	6730.01	Temporary Well	2 inch	20	7/20/94	
18-1234	18	1635949.81	1760893.56	6732.91	Monitoring Well	2 inch	23	7/21/94	MW-9
18-1254	18	1635576.1	1761043.68	6735.31	Temporary Well	2 inch	15	8/10/94	
18-1255	18	1635610.25	1761063.57	6735.9	Monitoring Well	2 inch	28.7	8/10/94	MW-10
18-1275	18	1636001.69	1761139.83	6740.13	Monitoring Well	2 inch	49	8/11/94	MW-11
18-2013	18	1634843.7	1761930.3	6758.8	Monitoring Well	2 inch	25.6	7/8/90	MW-1
18-2014	18	1634904.5	1761878.6	6758.3	Monitoring Well	2 inch	27.6	7/8/90	MW-2
18-2015	18	1634893.6	1761864.1	6758.3	Monitoring Well	2 inch	23.4	7/8/90	MW-3
18-2016	18	1634878.4	1761868.1	6758.5	Monitoring Well	2 inch	26.2	7/8/90	MW-4
18-2023	18	1635883.2	1761021	6736.7	Monitoring Well	2 inch	29.5	3/7/94	MW-5
18-2024	18	1635899.6	1760916.3	6730.1	Monitoring Well	2 inch	25	3/9/94	MW-6
36-2020	36	1637919.13	1759990.14	6687	Monitoring Well	4 inch	13	4/16/85	PCO-1
36-2021	36	1641699.75	1757441.3	6618.3	Monitoring Well	4 inch	10.1	4/17/85	PCO-2
36-2022	36	1646085.89	1755485.55	6546.3	Monitoring Well	4 inch	19.1	4/17/85	PCO-3

TABLE 2-2
WATER LEVEL ELEVATIONS IN MONITORING AND TEMPORARY WATER WELLS, PAJARITO CANYON
(APRIL 1993-NOVEMBER 1994)

Well No. TOC Elev.		April	May	June	July	August	September	November	February	March	June	July	August	September	October	November
PCO-1	Depth (ft)	1.12		1.15	1.30				2.70			1.70			1.00	
6687	Water Elev.	6685.88		6685.85	6685.70				6684.30			6685.30			6686.00	
PCO-2	Depth (ft)	5.00		5.35	7.45				Dry			9.00			6.90	
6618.3	Water Elev.	6613.30		6612.95	6610.85							6609.30			6611.40	
PCO-3	Depth (ft)	3.25		3.63					3.90			Dry			3.70	
6546.3	Water Elev.	6543.05		6542.67					6542.40			<6527.2			6542.60	
MW-1	Depth (ft)		7.33	9.75	13.00	10.91	11.95	16.78	17.40			12.80			12.40	
6758.8	Water Elev.		6751.47	6749.05	6745.80	6747.89	6746.85	6742.02	6741.40			6746.00			6746.40	
MW-2	Depth (ft)		8.27	9.85	14.56	11.91	12.83	17.10	17.50			14.50			14.00	
6758.3	Water Elev.		6750.03	6748.45	6743.74	6746.39	6745.47	6741.20	6740.80			6743.80			6744.30	
MW-3	Depth (ft)		8.26	9.82	14.46	11.84	12.74	16.93	17.40			14.40			14.00	
6758.3	Water Elev.		6750.04	6748.48	6743.84	6746.46	6745.56	6741.37	6740.90			6743.90			6744.30	
MW-4	Depth (ft)		8.46	9.11	13.59	11.50	12.44	16.60	17.60			13.50			13.20	
6758.5	Water Elev.		6750.04	6749.39	6744.91	6747.00	6746.06	6741.90	6740.90			6745.00			6745.30	
MW-5	Depth (ft)									17.50		13.00			14.70	
6736.7	Water Elev.									6719.20		6723.70			6722.00	
MW-6	Depth (ft)									18.00		8.90			8.50	
6730.1	Water Elev.									6712.10		6721.20			6721.60	
MW-7	Depth (ft)											12.00				13.90
6755.5	Water Elev.											6743.50				6741.60
MW-8	Depth (ft)													7.50		
6747.79	Water Elev.													6740.29		
MW-9	Depth (ft)											13.50				9.90
6732.91	Water Elev.											6719.41				6723.01
MW-10	Depth (ft)												9.40			8.90
6735.9	Water Elev.												6726.50			6727.00
MW-11	Depth (ft)												21.00			16.80
6740.13	Water Elev.												6719.13			6723.33
BG-1	Depth (ft)												18.00			
6776.45	Water Elev.												6758.45			
18-1063*	Depth (ft)												12.50			
6774.6	Water Elev.												6762.10			
18-1136*	Depth (ft)											17.90				
6754.01	Water Elev.											6736.11				
18-1165*	Depth (ft)												7.50			
6747.07	Water Elev.												6739.57			
18-1195*	Depth (ft)											6.40				
6724.11	Water Elev.											6717.71				
18-1196*	Depth (ft)										5.33					
6723.34	Water Elev.										6718.01					
18-1233*	Depth (ft)											12.00				
6730.01	Water Elev.											6718.01				
18-1254*	Depth (ft)												9.70			
6735.31	Water Elev.												6725.61			

Main Aquifer. At TA-18, the main aquifer lies at an elevation of 5,870 to 5,900 ft. Approximately 300 ft of Bandelier tuff lies between the alluvial groundwater body in Pajarito Canyon and the main aquifer. Although it is believed that no hydraulic connection exists between the alluvial aquifer and the main aquifer, no conclusive data supports this contention.

3.0 INTRODUCTORY TOPICS

3.1 Summary of QA/QC Activities

A summary of analytical results for quality assurance/quality control (QA/QC) samples and potential limitations in the use of the analytical data are presented in this subsection. Details of the Environmental Restoration QA/QC program are documented in the Site-Specific Quality Assurance Project Plan, Annex II of the RFI Work Plan for OU 1093 (LANL 1993).

QC data provide information for identifying and defining qualitative and quantitative limitations associated with measurement data. Data quality for this program was primarily based on the following QC parameters:

- Adherence to holding-time requirements
- Field and laboratory blank sample analyses
- Duplicate field-sample analyses
- Matrix spike and matrix spike duplicate analyses
- Surrogate spike recoveries
- Laboratory control sample analyses

QC data associated with this investigation indicate that, with some exceptions, sample analyte data are acceptable and defensible. The data show that QC mechanisms were generally effective in ensuring measurement data reliability within expected limits of sampling and analytical error. Measurement precision and accuracy estimates point to several potential limitations of the data. The following is a brief discussion of each potential limitation and how it may affect data usability.

3.1.1 Metals Analysis

DISCUSSION: Lead was detected at low concentrations in two field blanks. This suggests that measured lead concentrations in both soil and water lagoon samples may be biased slightly high. In addition, matrix interference resulted in a high uncertainty associated with the results of two soil lagoon samples.

DATA IMPACT: The amount of lead detected in the field blanks was approximately one order of magnitude less than the amount of lead detected in the samples. Thus, the presence of lead in the field blanks does not affect data usability. The amount of uncertainty associated with the two soil lagoon samples was approximately 60% to 90% of the sample results. Thus, the amount of lead in these samples may vary by up to 90%. Because the amount of lead detected in the samples is low, this variability does not impact data usability.

DISCUSSION: Two blind QC samples for mercury were low, with nominally 40% to 50% recovery. Other standard reference material analyzed for mercury exhibited excellent recoveries (EM-9 1994). One mercury triplicate for one soil sample demonstrated differences greater than 2 standard deviations from the analytical result. The other triplicate was within 2 standard deviations of the analytical result.

DATA IMPACT: The low recoveries in the blind QC samples are believed to have resulted from the interaction of mercury with the sample container walls when the soil aliquots were spiked. Since other standard reference material exhibited excellent recoveries, data are not considered to have been affected (EM-9 1994) and are considered usable. Since two out of three triplicates demonstrated standard deviations within acceptable criteria, these data are considered usable.

DISCUSSION: Two blind QC samples for silver were low relative to the nominal value for those QC samples. Both QC samples contained low concentrations of silver (i.e., < 1 mg/L) and were out-of-control low by approximately one order of magnitude. The analytical report (EM-9 1993) reported that silver at low concentrations is relatively unstable in solution, is light-sensitive, and tends to form insoluble chlorides.

DATA IMPACT: The out-of-control QC samples suggest that actual silver concentrations in the four samples associated with these QC samples may be approximately one order of magnitude more than the measured concentration. None of the four samples associated with these QC samples reported detected amounts of silver. Silver was not considered to be a PCOC for two of the samples associated with these QC samples. Thus, the data for these samples is unaffected. Although the amount of silver in the other two samples was reported as undetected, silver may be present at concentrations approximately one order of magnitude greater than the recorded limit of detection in these affected samples.

3.1.2 Organic Analysis

3.1.2.1 Blanks

DISCUSSION: Acetone, a common laboratory contaminant, was detected in one blank analytical QC sample.

DATA IMPACT: The concentration of acetone in the blank analytical QC sample was a factor of 2 less than the lowest measured concentration in any sample. Thus, data usability was not affected.

3.1.2.2 Holding Times

DISCUSSION: Holding times were exceeded on two occasions. Two semi-volatile samples were extracted one day outside of holding times. Two volatile samples exceeded holding times by an unrecorded number of days.

DATA IMPACT: Because the holding time was exceeded by only one day for the two semi-volatile samples, the impact is expected to be minimal and the data slightly biased low. The semi-volatile data for these two samples are considered usable. Since the holding times for the two volatile samples was unrecorded, these data are suspect. No volatiles were detected in the affected samples.

3.1.2.3 Method Accuracy

DISCUSSION: Several constituents were out-of-control low for the nominal value for a particular QC sample.

- Benzoic acid was below the limit of detection in two QC samples. The recorded detection limit was a factor of 2 and 5 less than the analyte concentration in the two QC samples.
- 4-Chloroaniline was undetected in the QC sample. The recorded detection limit was one order of magnitude less than the analyte concentration in the QC sample.
- 2,4-Dimethylphenol and fluoranthene were out-of-control low by a factor of approximately 3 relative to the nominal values for two QC samples.
- 2,4-Dinitrotoluene, 2-nitrophenol, 4-nitroaniline, phenanthrene, 1,2,3-trichlorofluoromethane, and 2,4,6-trichlorophenol were out-of-control low by a factor of approximately 2 relative to the nominal values for two QC samples.
- Acetone was above the calibration range for two manhole samples.
- The percent deviation for 2-butanone in the continuing calibration was 346% .

DATA IMPACT: The data associated with the aforementioned method accuracy discrepancies are considered usable.

The out-of-control QC samples suggest that the actual concentrations of benzoic acid, 4-chloroaniline, 2,4-dimethylphenol, 2,4-dinitrotoluene, fluoranthene, 4-nitroaniline, 2-nitrophenol, 4-nitroanaline, phenanthrene, 1,2,3-trichlorofluoromethane, and 2,4,6-trichlorophenol in the associated samples may be from a factor of 2 to one order of magnitude greater than the measured concentration. None of the aforementioned analytes were detected in any of the associated samples. Although the amount of these analytes in the samples was reported as undetected, the aforementioned analytes may be present at concentrations from a factor of 2 to one order of magnitude greater than the recorded limit of detection in these affected samples.

Acetone and 2-butanone are detected in two manhole samples associated with those QC samples that demonstrated calibration discrepancies. Their concentrations are considered estimates, with acetone biased low.

3.1.2.4 Percent Recovery

DISCUSSION: For one associated manhole sample (AAA5690), the surrogate recovery for 1,2-dichloroethane (1,2-DCA) was 148% relative to the EPA-established acceptable upper limit of 114% recovery for that constituent. For two associated manhole samples, the surrogate recovery of 66% for 4-bromo-fluoro-benzene was less than the EPA-established acceptable lower limit of 77% recovery for that constituent and the surrogate recovery of 74% for 1,2-DCA was less than the EPA-established acceptable lower limit of 76% for that constituent. For one wetland sample, the surrogate recovery of 19.47% for 2-fluorophenol was less than the EPA-established acceptable lower limit of 21% recovery. For another wetland sample, the surrogate recovery of 73.02% for 1,2-DCA was less than the EPA-established acceptable lower limit of 76% recovery.

DATA IMPACT: The value of 5.2 µg/L 1,2-DCA in the manhole sample AAA5690 is biased high by a factor of 1.3. Because this value is close to the screening action level of 5 µg/l, data usability is affected.

Volatiles were below the detection limit in the other associated samples. The low surrogate recoveries of 4-bromo-fluoro-benzene, 2-fluorophenol, and 1,2-DCA suggest that volatile concentrations in these samples may be slightly above the detection limits.

3.1.3 High Explosives

Overall, laboratory QC parameters were within expected limits of sampling and analytical error. Thus, HE data are usable.

3.1.4 Radionuclides

DISCUSSION: There were possible matrix interferences with iron, manganese, silver, lead, thallium, halides, and humic acid in the analysis of uranium in one soil manhole sample. The QC sample for uranium was out-of-control high by an factor of approximately 2 for the nominal value for one QC sample.

The QC for plutonium-238 (^{238}Pu) was out-of-control high by a factor of approximately 7 for the nominal value for one QC sample.

There were no QC data available for two thorium-228 (^{228}Th) samples. One thorium-230 (^{230}Th) duplicate differed from the original analysis by more than 2 standard deviations. One blind QC sample was out-of-control low for ^{228}Th, ^{230}Th, and thorium-232 (^{232}Th).

DATA IMPACT: The uranium concentration in the sample demonstrating possible matrix interferences is estimated. The uranium concentrations in the samples associated with the out-of-control QC samples are biased high by a factor of approximately 2. The plutonium concentrations in the samples associated with

the out-of-control QC sample are biased high by a factor of approximately 7. Concentrations of uranium and plutonium in these samples were sufficiently low that they did not affect data usability.

The out-of-control thorium QC sample suggest that the analytical results for thorium in the wetland samples associated with this QC sample may be less than the actual concentration. However, the concentrations in the associated samples are sufficiently high that data usability was not affected.

3.2 Background Data

One screening assessment decision point is a background comparison. Analytes that occur naturally in soils or groundwater (e.g., inorganics such as barium and beryllium) are compared with concentrations in comparable uncontaminated soils and groundwater.

3.2.1 Statistical Methodology

The statistical comparisons to background follow the general guidance provided in "Statistical Analysis of Ground-Water Monitoring Data" (EPA 1989, 1141). T the upper tolerance level (UTL) method was used to compare site data with Laboratory background concentrations in either soil or groundwater. The UTL method is designed to detect extreme values in the PRS data relative to background data. The UTL method is based on a 95% confidence level, as suggested in EPA (1989, 1141). Readers are referred to Appendix A for more details on the UTL calculations. An appropriate set of background data must be chosen for the statistical comparisons, and the source of the background data for soils and groundwater are presented below.

3.2.2 Soils

3.2.2.1 Inorganics

Data for surface soil samples presented in the Laboratory background database were used because many of the results presented in this report represent surface soil samples. The Laboratory background surface soil samples include samples from the A, B and C horizons from a variety of locations across Los Alamos County (Longmire et al., in preparation).

3.2.2.2 Radionuclides

Site radionuclide results are reported isotopically in units of activity (e.g., pCi/g). The Laboratory background soil database includes measurements of total concentrations of uranium, thorium, and plutonium. These data were converted to activity by assuming natural abundance of the radioisotopes for these metals. The Laboratory Environmental Surveillance reports (most recently LANL 1994) were used to estimate the activity of two additional radionuclides (^{238}Pu, $^{239/240}Pu$) in regional background soils.

3.2.3 Groundwater

3.2.3.1 Inorganics

The 1992 Laboratory environmental surveillance report (LANL 1994) presents metal concentrations in 10 water supply wells tapping the main aquifer. These data are not entirely appropriate for comparison with measured concentrations in the alluvial aquifer, but no background data exist for the alluvial aquifer in Pajarito Canyon. These data were used to estimate the UTLs for the following Inorganics in groundwater: aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, and zinc.

3.2.3.2 Radionuclides

The 1992 LANL environmental surveillance report (LANL 1994) presents radionuclide activities in 10 background wells. These data were used to estimate the UTLs for the following radionuclides in groundwater: ^{238}Pu, $^{239/240}Pu$.

3.3 RCRA Risk-Based Screening Action Levels

Screening action levels (SAL) are risk-based, media-specific action levels with which maximum concentrations of an analyte are compared with determine whether further evaluation of potential contamination is warranted (LANL 1993a). SALs are based on regulatory levels (e.g., maximum containment levels [MCL] for groundwater) or are calculated using a risk-based methodology described in the proposed RCRA Subpart S, Corrective Action for Solid Waste Management Units. An additional conservative modification of the Subpart S methodology was introduced to account for exposure to volatile organic compounds (VOC) volatilizing from water or soil. The soil/water-to-air volatilization factor was calculated based on an equation given by the U.S. Environmental Agency (EPA) and chemical-specific parameters (LANL 1993a).

SALs are calculated using the most current chemical-specific, route-specific toxicity values and default exposure parameters and are based on average daily exposures that will not result in exceeded target risks or hazard values (i.e., a cancer risk of 1 in a million for all Class A and B carcinogens, a cancer risk of 1 in 100,000 for all Class C carcinogens, and a hazard index of 1 for non-carcinogens).

3.3.1 Water

Proposed Subpart S specifies the use of the MCLs promulgated under the Safe Drinking Water Act as action levels for groundwater. Although not specifically stated, using the same SAL criteria for both groundwater and surface water constituents is consistent with Subpart S (LANL 1993a). This is considered to be a conservative approach, because New Mexico has not designated surface waters to be evaluated as drinking water sources. Where MCLs were not available for a particular carcinogenic constituent, the SAL was calculated using the assumption that a 70-kg adult ingests water at a rate of 2 L/day over a 70-year exposure duration. Noncarcinogenic SALs were calculated using the assumption that a 16-kg child ingests water at a rate of 2 L/day (LANL 1993a).

3.3.2 Air

SALs derived for constituents in air are based on the assumption that a 70-kg adult inhales air at a rate of 20 m^3/day over a 70-year exposure duration. Noncarcinogenic SALs were calculated using the assumption that a 16-kg child inhales air at a rate of 20 m^3/day (LANL 1993a).

3.3.3 Soil

A PCB action level of 1 ppm, based on Toxic Substances Control Act regulations, is recommended as a surrogate SAL value (ER Assessments Council 1994) and is under review by the EPA. SALs derived for constituents in soil are based on the assumption that a 70-kg adult ingests soil at a rate of 100 mg/day over a 70-year exposure duration. Noncarcinogenic SALs were calculated using the assumption that a 16-kg child ingests soil at a rate of 200 mg/day (LANL 1993a).

3.4 Risk-Based Screening Action Levels for Radioactive Constituents

Neither RCRA nor the proposed Subpart S regulations address radioactive constituents. To ensure that radioactive and nonradioactive compounds are addressed similarly and to simplify integrating RCRA, DOE, and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requirements for radioactive constituents, SALs for radioactive constituents were derived in a manner similar to that used for deriving action levels in proposed Subpart S (LANL 1993a).

3.4.1 Water

The SALs for radionuclides in water were based on regulations given in 40 CFR Part 141.16 and the proposed National Primary Drinking Water Regulations (LANL 1993a). For those constituents not specifically addressed in these documents, Federal Guidance Report No. 11 is currently used to derive the SALs for radionuclides in the water (LANL 1993a).

3.4.2 Air and Soil

For radionuclides for which media-specific concentration limits are not specified in other regulations (e.g., MCLs), the Laboratory has proposed SALs for radionuclides in soils based on an annual dose limit of 10 mrem/year (above background levels) from a single radioactive constituent via all pathways (e.g., inhalation, ingestion) (LANL 1993a).

3.5 Risk-Based Screening Action Levels for Multiple Constituents

If multiple constituents do not exceed but are near their SALs, then a SAL comparison ratio (i.e., concentration/SAL) is calculated for each constituent and added to SAL comparison ratios for other constituents with the same target organ or effect. For example, the SAL comparison ratios for all carcinogens are added together. Similarly, the SAL comparison ratios for all noncarcinogenic constituents that affect the liver are added together. Should the additive value of constituents with a similar target organ or effect exceed a target value of 1, further action may be considered (LANL 1993a).

3.6 Waste Criteria

Nonradiologic waste criteria are the possible presence of hazardous waste constituents, and RCRA toxicity characteristic (TC) screening levels. Hazardous constituents include spent halogenated and nonhalogenated solvents (EPA 1994). Historical knowledge of site operations suggest that some hazardous wastes may have been released to the sanitary waste line. TC screening levels are numerically equivalent to 20 times the Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels. The factor of 20 is based on the twenty-fold dilution that is incurred during the TCLP analyses (EPA 1994). Radioactive waste criteria are considered to be the presence of radioactive constituents at concentrations greater than background.

3.7 Basis for Conclusions and Recommendations

3.7.1 Data Evaluation and Assessment

This subsection describes the methodology used to evaluate data usability. It addresses the approach to data assessment (i.e., comparison with background, SALs, and waste criteria levels).

3.7.1.1 Blanks

When a laboratory or field blank contained detectable levels of common laboratory contaminants, then the sample results were considered as positive only if the concentrations in the samples exceeded 10 times the maximum amount detected in any blank. When a laboratory or field blank contained detectable levels of chemicals not considered by the EPA to be common laboratory contaminants, then the sample results were considered as positive only if the concentrations in the samples exceeded 5 times the maximum amount detected in any blank.

3.7.1.2 Out-of-Control QC Samples

When the QC sample was out-of-control high and the constituent was not detected in the analytical sample, the constituent was considered not to be present in the sample. When the QC sample was out-of-control low and the constituent was not detected in the analytical sample, the limit of detection for that constituent was multiplied by the ratio of the expected value/detected value, and this computed value was compared with background, SALs, and waste criteria. The rationale is that if the computed value is less than the SALs or waste criteria levels, then the constituent, if present in the sample, poses no problem. Similarly, if the constituent was present in the analytical sample, then this value was multiplied by the ratio of the expected value/detected value and this computed value was compared with background, SALs, and waste criteria. Although this approach may not be analytically correct (e.g., the assumption is that the analytical response is linear with respect to concentration over the entire sample range), it is considered to be conservative. None of the computed values were found to exceed SAL or waste criteria levels.

3.7.1.3 Matrix Interference, Duplicates

Where matrix interference was observed, the standard deviation error was added to the analytical value to estimate a high-end value, and this computed value was compared with background, SALs, and waste criteria. None of the computed values were found to exceed SAL or waste criteria levels.

When a duplicate had a difference of greater than 2 standard deviations from the analytical result, the sample with the highest concentration was compared with background, SALs, and waste criteria. None were found to exceed SAL or waste criteria levels.

3.7.1.4 Comparison with Background, Waste Criteria, and SALs

Constituents in soil and/or solid sludge samples were compared with the UTL for background concentrations as determined from data reported by Longmire et al. (1993). Constituents in water samples were compared with the UTL calculated from concentrations in groundwater in the main aquifer (LANL 1994).

Samples with radioactive constituents that exceeded background concentrations were considered to meet the criteria for radioactive waste. Those nonradioactive constituents whose concentrations exceeded background concentrations were compared with hazardous waste criteria. The presence of listed constituents may indicate that hazardous waste is present. If the sample value met or exceeded toxic waste criteria levels, it was considered as potentially meeting toxic waste criteria.

Sample analyte concentrations greater than background were compared with SALs. Multiple constituents were evaluated in the manner described in Section 3.4.

4.0 INVESTIGATION RESULTS

4.1 PRS 27-003, Bazooka Impact Area

4.1.1 Site Description

This PRS, the Bazooka Impact Area, is a target practice area used by the Army in 1947. Fenced and unused since 1962, the area is located north of Pajarito Road in Pajarito Canyon, 0.25 mi east of the inactive TA-18 sewer lagoons (TA-18-162) and 1.25 mi east of TA-18 (Figure 4-1). Most of the target area lies on the steep slope of the north wall of the canyon below the rim. However, the footprint of the impact area extends northward onto the top of Mesita del Buey within the TA-54 fence. The south side of the impact area extends downslope to the canyon floor, crosses the ephemeral stream there, and ends near Pajarito Road. The firing was done from a point located south of the curve in the current road. This road dates from 1962, when its relocation briefly allowed civilian access to UXO lying in the impact area. The accident that followed led to a countywide effort to locate such old impact areas.

Archival research retrieved numerous records that revealed the history of the site, including an accident investigation that included old photos of the ordnance impact area. Comparison of the photos with on-site inspections enabled the impact area to be located within the one-half-mile-long fenced region north of Pajarito Road. The location, visible as a distinct light-colored patch of highly fragmented rock on the cliff slope, was the center of investigation. The ordnance fired at the cliff face consisted of many hundreds of 2.36-inch rocket-propelled bazooka rounds, typically with armor-piercing, shaped-charge warheads. (The only other ordnance found were four fragments that appeared to have been from a former, one-time demolition shot). The nature of the hazard was possible unexploded warheads and fuzes buried in the soil or slope talus and traces of undetonated HE on warhead subassemblies.

Superimposed on the Bazooka Impact Area are two fragment impact areas for explosive testing conducted by the Laboratory. One is from abandoned Pajarito Canyon firing pits used from 1946 to 1947 (Figure 4-1). The second is from TA-36's "Lower Slobbovia" firing site, an operating test area beyond the mesa to the south of Pajarito Road. Occasional metal fragments from these tests were found in this PRS. Since these fragments were not related to UXO operations, they were not always retrieved from the outer edges of the Bazooka Impact Area. However, ferrous fragments were always removed so that they would not interfere with the magnetic surveys. Some aluminum fragments were found to be slightly radioactive, because of traces of DU explosively alloyed to them, and were handled separately.

4.1.2 Site Investigation and Analyses

The nature of the UXO hazard prompted a departure from the original intent of the site work plan, which was only to conduct a Phase I site investigation with remediation to follow in Phase II. The large quantity of ordnance debris present (based on initial visual survey) and its wide pattern of dispersion indicated the impracticality of marking and mapping each fragment rather than simply removing it when found. Discussions with explosive ordnance disposal (EOD) personnel from Environmental Hazards Specialists International, Inc. (EHSI), previously used by LANL to clear UXO in OU 1071, made clear the need to dispose of UXO immediately after its discovery to eliminate the hazard to survey personnel, a standard practice in ordnance-clearing operations. The EHSI personnel were contracted not only to search for but also to clear any unexploded bazooka rounds and to recover all ordnance debris from this PRS. Therefore, in this instance Phase I included site remediation.

Beginning October 5, 1993, the four-person team first determined the east-west boundaries of the impact zone (transverse to the line of flight), using visual inspection for surface debris. The extent of the search area is indicated in Figure 4-2. The site investigation involved visual search and the use of two types of metal detectors to locate surface and subsurface metallic objects to a depth of up to 18 in. within the search area. The team conducted sequential magnetic sweeps in 10-foot-wide adjoining lanes, oriented parallel to the cliff. Rocks and talus on the cliffs were moved, when possible, to check beneath for deeply

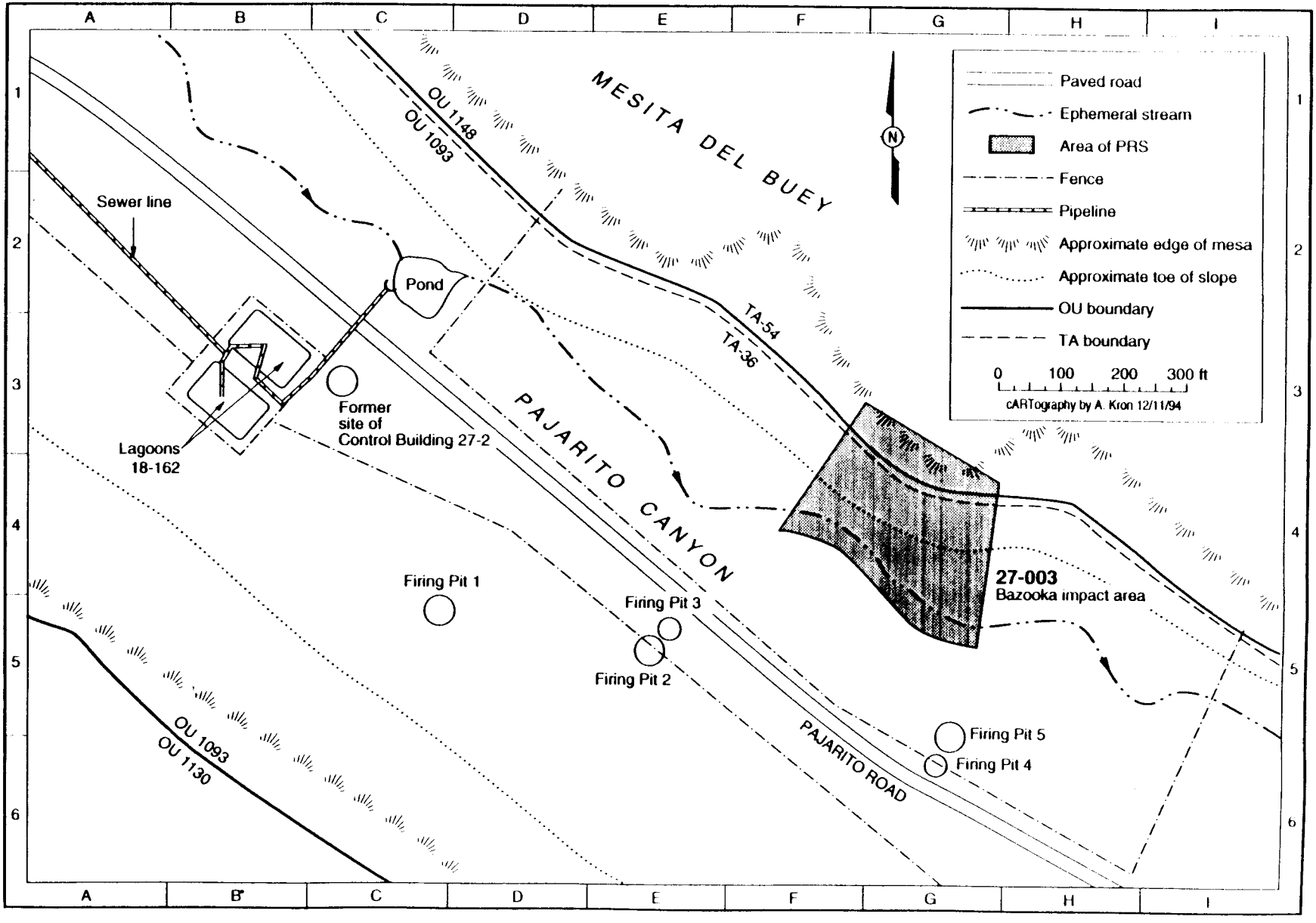


Figure 4-1. Location of PRS 27-003.

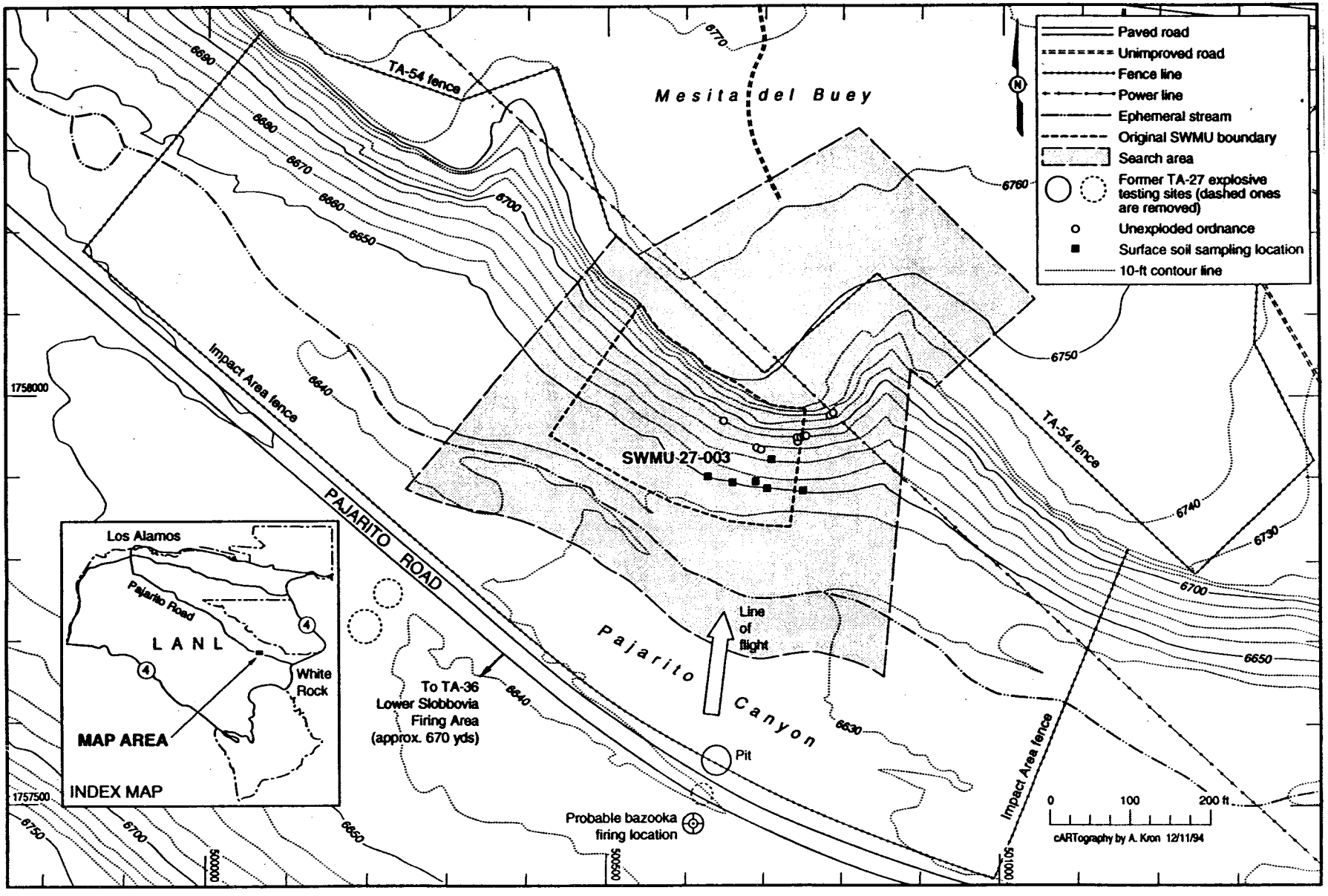


Figure 4-2. Location of field investigations at Bazooka Impact Area.

buried ordnance material. Vertical surfaces on the cliff were checked visually and magnetically by personnel rappelling from the mesa top. Cracks and ravines were also carefully checked. Sweeps were continued in the canyon bottom southward toward Pajarito Road until no further ordnance fragments were found, indicating the uprange limit of the fragment footprint. Sweep operations continued downrange from the impact area within the TA-54 fence on the mesa top. Only minor amounts of debris were recovered, indicating that the mesa top either had not been significantly affected or had been previously cleared by Army EOD teams from Ft. Bliss, Texas.

A total of 3,200 pieces of ordnance debris were removed between October 4 and November 2, 1993. This debris including 646 tail assemblies, an indication of the large number of rounds fired (considering that the area has been repeatedly swept by the U.S. Army). Photographs of typical material removed are presented in Figures 4-3 and 4-4. All ferrous metal detected was removed from the area. A total of 14 affected items of UXO — 8 live bazooka rounds and 6 unexploded booster assemblies (i.e., fuzes) — were located, each covered by loose sand and gravel on the upper slopes of the north canyon wall (Figure 4-2). The 14 pieces of UXO were detonated in place, using C-4 plastic explosive, in five separate firing operations (Figure 4-4). Each operation required Pajarito Road to be closed briefly. The Laboratory Emergency Management and Response Office coordinated the operations and provided explosives and communications. Protective Technology Los Alamos, Inc. was responsible for roadblocks and security.

The nine crates of ordnance debris (fragments, expended rocket motors, and some warhead subassemblies) were screened for radioactive material by radiological control technicians (RCT) from the Laboratory Health Physics Operations Group (ESH-1) and then sent to the TA-16 interim-status open-burning unit operated by the Fabrication Weapons Prototype Group to destroy any residual HE. A small number of slightly radioactive (30 dpm beta/gamma) aluminum fragments from nearby unrelated Laboratory explosive testing were found. These were disposed of separately at TA-54, Area G.

Surface soil sampling was conducted at this PRS in Summer 1994 to check for the presence of residual materials from the firing of such large quantities of ordnance. The sampling sites are shown in Figure 4-2. Samples were analyzed for metals and HE. Specific metals of concern are barium, which commonly occurs in explosives, and copper and lead, which are present as projectiles in the bazooka shell.

TABLE 4-1
MEASURED CONCENTRATIONS OF PCOCs IN PRS 27-003

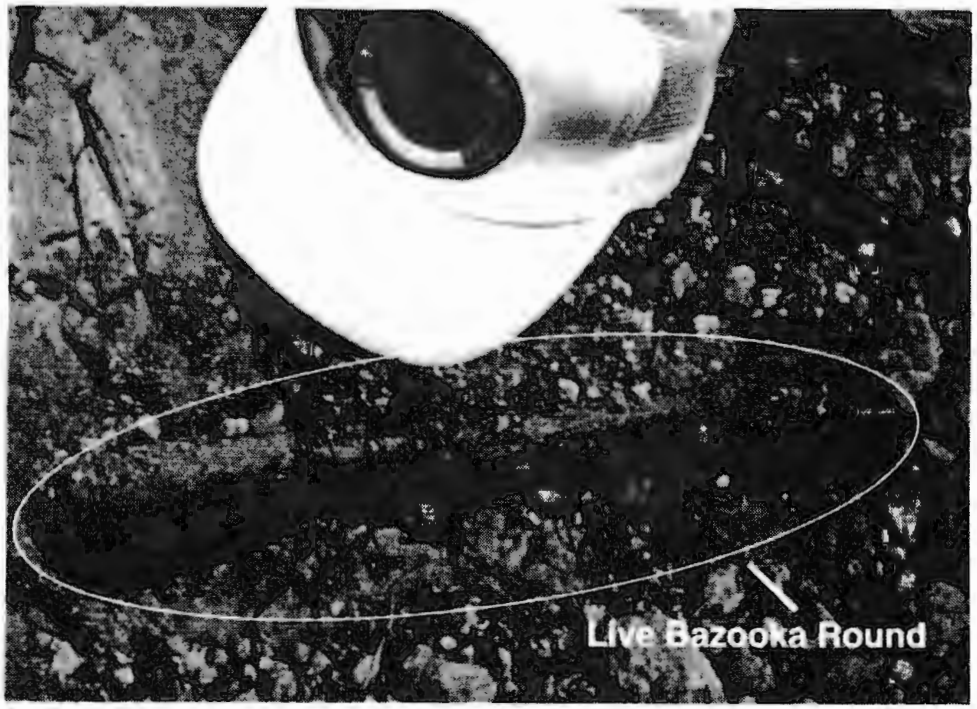
Sample Location	Sample Number	Sample Type	Units	Metals	High Explosives	SALs	CRQLs	Background
27-003 (5 Samples)	AAB4194	Sediment	mg/kg	30.7 Barium	None Detected	5600	40	1140
			mg/kg	4.1Copper		3000	5	15.7
			mg/kg	10.9 Lead		400	0.6	39
	AAB5195	Sediment	mg/kg	30.2 Barium	None Detected	5600	40	1140
			mg/kg	3.6 Copper		3000	5	15.7
			mg/kg	9.4 Lead		400	0.6	39
	AAB5196	Sediment	mg/kg	**37.0 Barium**	None Detected	5600	40	1140
			mg/kg	**17.5 Copper**		3000	5	15.7
			mg/kg	**11.8 Lead**		400	0.6	39
	AAB5198	Sediment	mg/kg	33.8 Barium	None Detected	5600	40	1140
			mg/kg	3.2 Copper		3000	5	15.7
			mg/kg	8.3 Lead		400	0.6	39
	AAB5199	Sediment	mg/kg	29.8 Barium	None Detected	5600	40	1140
			mg/kg	4.2 Copper		3000	5	15.7
			mg/kg	8.0 Lead		400	0.6	39

Maximum concentrations in **boldface.** Shaded values: measured values above background UTLs.

Bazooka subassemblies (top to bottom):
Rocket motor with fins
Nose cap
Copper slug from shaped charge
Nose cap
HE container from warhead
Rocket motor

(Right) Rocket motors and tailfins from PRS 27-003

Figure 4-3. Ordnance debris removed from Bazooka Impact Area.



Live bazooka round located by UXO team.

Explosive destruction of live bazooka rounds.

Figure 4-4. Remediation of explosive hazards at Bazooka Impact Area.

4.1.3 Data Evaluation

A geophysical team from ICF Kaiser Engineers, Inc. conducted a follow-up survey of the same area between October 26 and November 1, 1993, using sensitive magnetometer equipment as a QA check of the EHSI team's metal detector survey. However, the magnetic signature of the tuff bedrock and its fragments interfered with instrument readings and prevented collection of meaningful data. As a result, this survey was discontinued. The EHSI team also spent one day doing their own QA sweeps, and they were confident that no further significant ordnance debris remains in the search area.

PRS 27-003, the Bazooka Impact Area, is believed to be free of UXO. The geographic pattern of recovered material indicates that the impact area has been localized and its extent defined. All detectable ordnance material within it has been removed, although further extensive searching might eventually uncover a few metal fragments beyond the outer boundaries of the search area. Analytical results for HE analysis indicated no contaminants above background. The measured concentrations of all three target metals (barium, copper, and lead) were below background concentrations with one exception. The maximum measured copper concentration (17.5 mg/kg) was slightly above the background UTL (15.7 mg/kg), and substantially greater than the measured concentration for the other four samples. Whether this is the result of copper introduced by the bazooka firing or simply an aberrant natural concentration is conjectural. In any event, that maximum value is significantly less than the SAL for copper (3000 mg/kg).Therefore, no residual contamination related to use of the Bazooka Impact Area was detected. Limitation of access to the area based on former explosive hazards seems inappropriate, so the fences and explosive hazard signs surrounding the PRS are, in our opinion, no longer needed for safety reasons. The roadside fence along Pajarito Road should, however, be retained as a part of the DOE-mandated property fencing that was installed in 1993. The area remains Laboratory property and public access and therefore, remains constrained by trespass law.

In conclusion, we propose a finding of No Further Action for PRS 27-003.

4.2 PRS 18-001(a), (b) Sanitary Lagoons and Sanitary Sewer Line

4.2.1 Site Description

The sanitary lagoons are located on the south side of Pajarito Road, approximately 1 mile east of TA-18. The now-inactive portion of the sanitary sewer line (Manhole 160-161, and Manhole 169-177*) runs from TA-18 along the south side of Pajarito Road to the lagoons (Figure 4-5). Effluent from the lagoons discharged through an outfall into the stream in Pajarito Canyon. The sanitary line and lagoons were placed into service in 1969. Use of the lagoons and the sewer line east of TA-18 was discontinued in December 1992, when a new sewage treatment plant at TA-46 went into service.

The sanitary sewer line serves the central portion of TA-18 (Figure 4-6). However, as illustrated in Figure 4-7 , a portion of the sewer system employs plumbing that was originally connected to a now-inactive septic system, Septic Tank 18-40, PRS 18-003(e). Although operations in the buildings served by the sewer system do not currently involve radioactive or chemical contaminants, past operations did. Therefore, previously released contaminants could be present in the sewer line or lagoons. A review of past site operations led to development of a list of PCOCs, including plutonium, uranium, undifferentiated solvents, beryllium and other heavy metals, and undifferentiated semivolatile organics (SVOC).

* Note that the manhole numbers jump from 161 to 169.

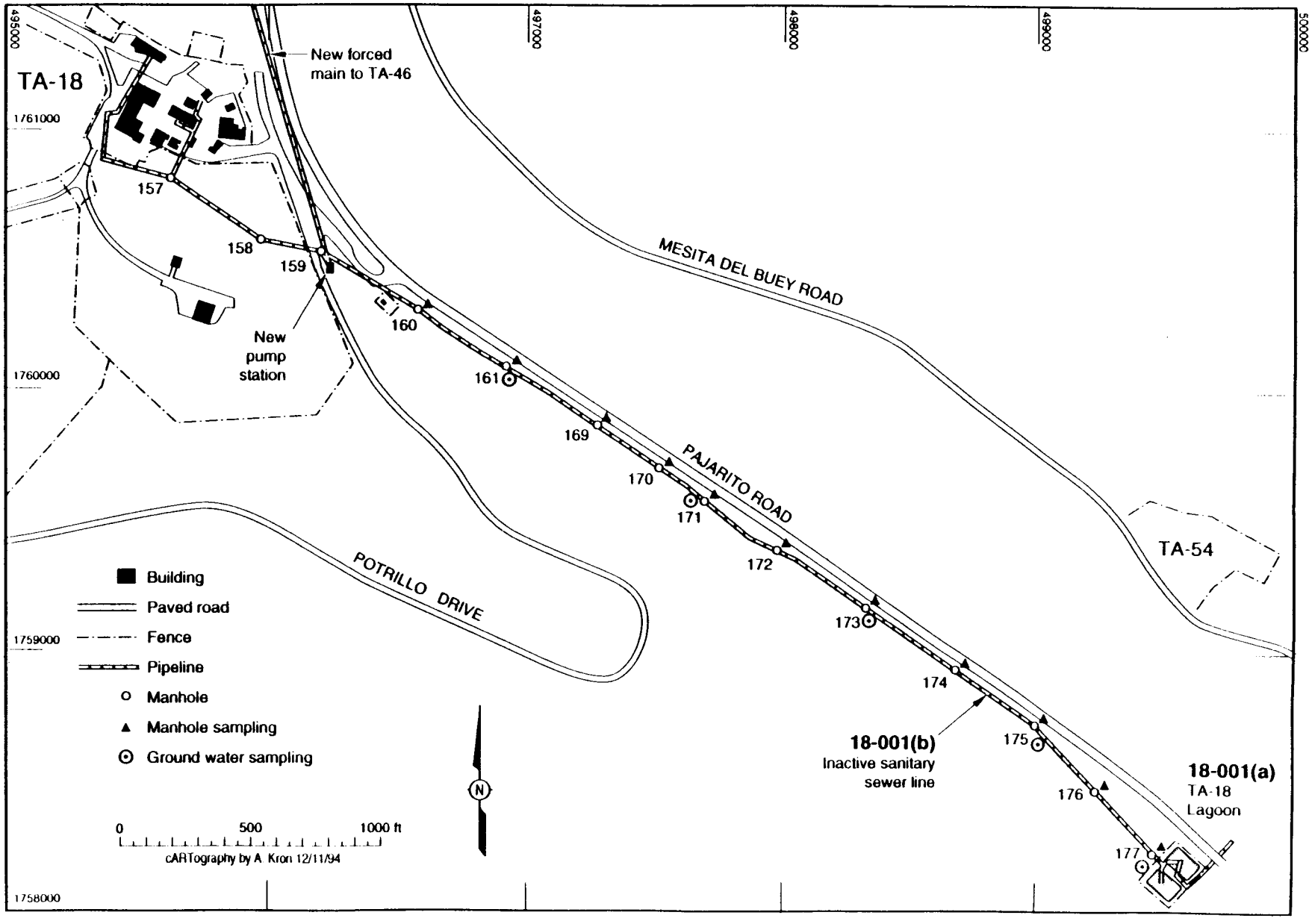


Figure 4-5. Locations of sewage lagoons and inactive sanitary sewer line from TA-18.

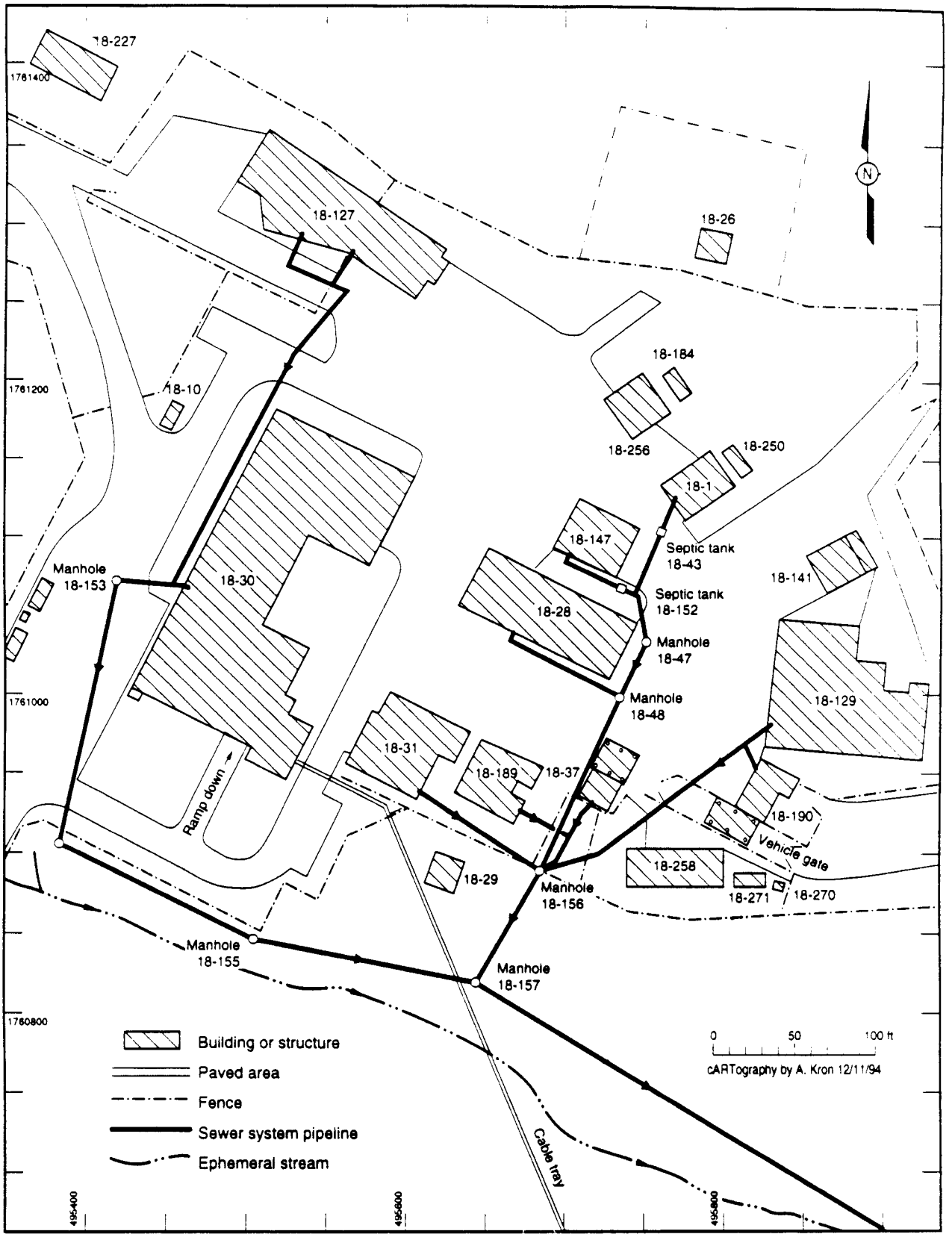


Figure 4-6. TA-18 present sewer system.

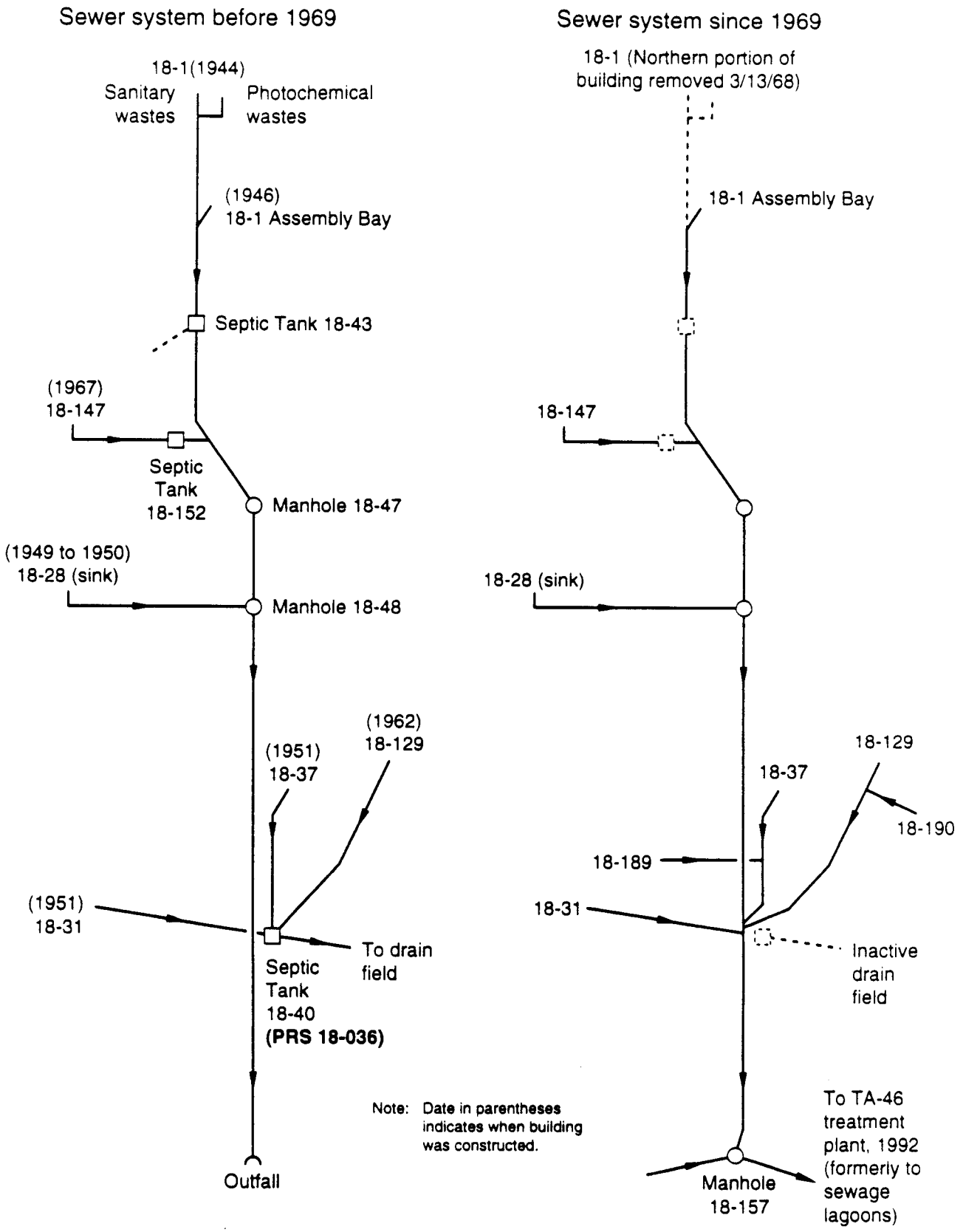


Figure 4-7. Schematic representation of sewer system revisions, east-central TA-18.

4.2.2 Site Investigation and Analyses

4.2.2.1 Sanitary Lagoon

Samples were collected at five locations in both the north and south lagoon (Figure 4-8). No water was present in either lagoon, so only sludge samples were collected. The sludge was approximately 1 foot thick in each lagoon, and samples were collected down to 1 foot. We originally planned to analyze the samples for the PCOCs identified in Section 4.2.1. However, because of the relatively shallow thickness of the sludge (1-1.5 ft), it seemed unlikely that VOCs would be present. Therefore, VOCs were excluded from the list of analytes. Industrial hygiene measurements were made at each sample location using a flame ionization detector. No readings above instrument background were observed. Sediments and water from the manholes were analyzed for VOCs, to provide a cross-check on the possible presence of VOCs in the lagoons. The detection of low concentrations of some VOCs in the manholes subsequently led to resampling the lagoons and analyzing the samples for VOCs.

4.2.2.2 Outfall

Water and sediment samples were collected from a wetland area within the shallow pond that received outflow from the sewage lagoons (Figure 4-8). No discharges have occurred from these lagoons since December 1992. Sediment samples were collected to a depth of 1 ft below the surface of the sediment. Water was flowing into and out of the pond, which is part of the ephemeral stream in Pajarito Canyon. Flow in the stream is supported, in part, by discharge of shallow groundwater upstream from the pond. The collected samples were analyzed for the PCOCs identified for the sanitary sewer line, as given in Section 4.2.1. Because the sample location also lies within the area possibly affected by former explosive testing at TA-27, analysis for HE was also performed.

4.2.2.3 Sanitary Sewer Line

Either sediment or water samples were collected from manholes 160, 169, 170, 173, 175, 176, and 177. In manholes 161, 171, 172, and 174 neither sediment nor water was present in sufficient quantities to allow sample collection. In those manholes, only swipes from the interior surface were collected. There was no manhole in which both water and sediment were present in sufficient quantities to allow sampling of both media. In fact, collection of sediment samples generally required removal of nearly all the sediment in a manhole. Water was flowing in small quantities in some manholes. This water is the result of infiltration of shallow groundwater into the manholes or connecting sewer line. The outflow from Manhole 177 was plugged when the line was taken out of service to prevent this water from entering the lagoons. Thus, Manhole 177, immediately upstream from the lagoon, had accumulated water to a depth of approximately 30 in. No sediment could be retrieved from the bottom of this manhole. Filter swipes were taken at four locations around the inside perimeter of each manhole and analyzed for gross alpha, beta, and gamma. This information will be used to assess disposal requirements when the sewer line is decommissioned.

4.2.3 Evaluation of Results

Table 4-2 presents a summary of the analytical data for all samples collected at the two PRSs discussed above including that from the outfall area. The table presents all detected, validated constituents for which SALs have been established. Analytical results that are in question because of factors such as missed holding times, failure of laboratory QC measures, or laboratory-introduced contaminants are not presented. A discussion of omitted data is presented in Section 3.1.

The contract-required quantitation limit, the established SAL, and the upper tolerance limit for background concentrations in soil and water are also presented in the table.

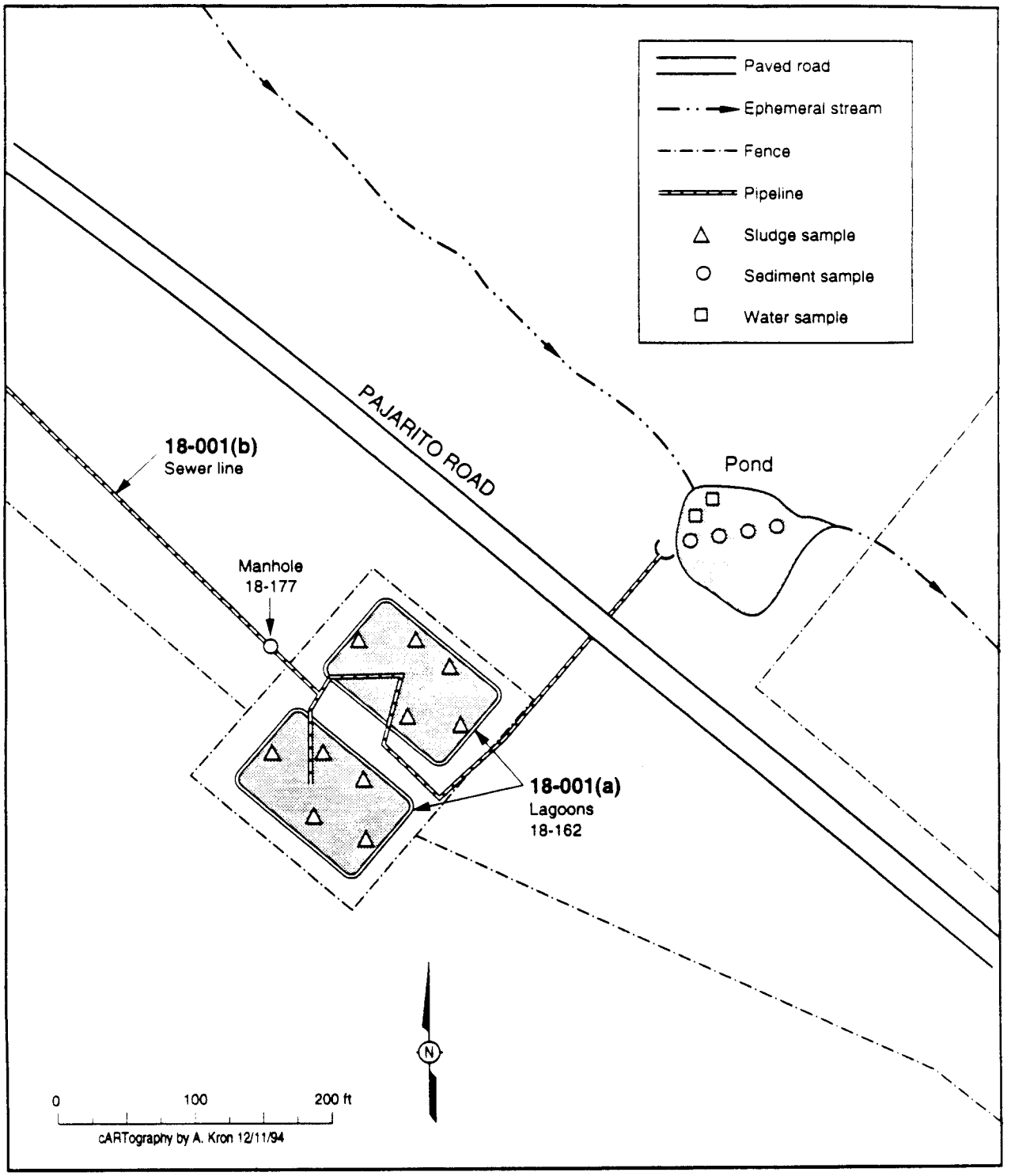


Figure 4-8. Sampling locations at SWMU 18-001(a), sewage lagoons and outfall.

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	SALs	CRQLs	Background
N Lagoon	AAA5790	Sediment	mg/kg	59 Barium		None Detected	None Detected	5600	40	1140
(6 Samples)	Duplicate		mg/kg	0.48 Beryllium				NC	1	3.31
	of		mg/kg	**0.64 Cadmium**				80	1	2.7
	AAA5792		mg/kg	6.5 Chromium				400	2	34.2
			mg/kg	12 Lead				400	0.6	39
			mg/kg	0.2 Mercury				24	0.04	0.1
			mg/kg	5.0 Nickel				1600	8	26.7
			mg/kg	90 Zinc				24,000	4	101
			mg/kg		1.42 U(total)			160	NA	2.09
	AAA5792	Sediment	mg/kg	93 Barium		None Detected	None Detected	5600	40	1140
	Duplicate		mg/kg	0.67 Beryllium				NC	1	3.31
	of		mg/kg	0.60 Cadmium				80	1	2.7
	AAA5790		mg/kg	8.9 Chromium				400	2	34.2
			mg/kg	18 Lead				400	0.6	39
			mg/kg	0.2 Mercury				24	0.04	0.1
			mg/kg	5.0 Nickel				1600	8	26.7
			mg/kg	**1.1 Silver**				400	2	NA
			mg/kg	**120 Zinc**				24,000	4	101
			mg/kg		1.21U(total)			160	NA	2.09
	AAA5793	Sediment	mg/kg	**110 Barium**		None Detected	None Detected	5600	40	1140
			mg/kg	**0.87 Beryllium**				NC	1	3.31
			mg/kg	**10.0 Chromium**				400	2	34.2
			mg/kg	16 Lead				400	0.6	39
			mg/kg	**0.3 Mercury**				24	0.04	0.1
			mg/kg	5.8 Nickel				1600	8	26.7
			mg/kg	78 Zinc				24,000	4	101
			mg/kg		1.38U(total)			160	NA	2.09
	AAA5794	Sediment	mg/kg	98 Barium		None Detected	None Detected	5600	40	1140
			mg/kg	0.75 Beryllium				NC	1	3.31
			mg/kg	9.0 Chromium				400	2	34.2
			mg/kg	18 Lead				400	0.6	39
			mg/kg	0.2 Mercury				24	0.04	0.1
			mg/kg	5.0 Nickel				1600	8	26.7
			mg/kg	110 Zinc				24,000	4	101
			mg/kg		1.13 U(total)			160	NA	2.09

Maximum concentration in **boldface**
Shaded values: measured values above background UTL
(J): Estimated Value NA: Not Available
NC: SALs for beryllium set at background

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	SALs	CRQLs	Background
N Lagoon (continued)	AAA5795	Sediment	mg/kg	50.0 Barium		None Detected	None Detected	5600	40	1140
			mg/kg	0.41 Beryllium				NC	1	3.31
			mg/kg	4.8 Chromium				400	2	34.2
			mg/kg	12 Lead				400	0.6	39
			mg/kg	0.1 Mercury				24	0.04	0.1
			mg/kg	4.0 Nickel				1600	8	26.7
			mg/kg	57.0 Zinc				24,000	4	101
			mg/kg		**1.65U(total)**			160	NA	2.09
	AAA5796	Sediment	mg/kg	110 Barium		None Detected	None Detected	5600	40	1140
			mg/kg	0.82 Beryllium				NC	1	3.31
			mg/kg	0.60 Cadmium				80	1	2.7
			mg/kg	9.6 Chromium			None Detected	400	2	34.2
			mg/kg	**19 Lead**				400	0.6	39
			mg/kg	0.1 Mercury				24	0.04	0.1
			mg/kg	**6.6 Nickel**				1600	8	26.7
			mg/kg	120 Zinc				24,000	4	101
			mg/kg		0.82U(total)			160	NA	2.09
S Lagoon (6 Samples)	AAA5797 Duplicate of AAA5798	Sediment	mg/kg	190 Barium			None Detected	5600	40	1140
			mg/kg	1.0 Beryllium				NC	1	3.31
			mg/kg	2.0 Cadmium				80	1	2.7
			mg/kg	18.0 Chromium				400	2	34.2
			mg/kg	38 Lead				400	0.6	39
			mg/kg	2.0 Mercury				24	0.04	0.1
			mg/kg	10 Nickel				1600	8	26.7
			mg/kg	12.0 Silver				400	2	NA
			mg/kg	340 Zinc				24,000	4	101
			pci/g		0.0607 Pu-238			20	NA	0.014
			pci/g		0.0055 Pu-239			18	NA	0.052
			mg/kg		2.21 U(total) (J)			160	NA	2.09
			mg/kg			0.68 Bis(2-ethylhexyl)phthalate		50	0.33	

Maximum concentration in **boldface**
Shaded values: measured values above background UTL
(J): Estimated Value NA: Not Available
NC: SALs for beryllium set at background

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	SALs	CRQLs	Background
S Lagoon (continued)	AAA5798 Duplicate of AAA5797	Sediment	mg/kg	170 Barium			None Detected	5600	40	1140
			mg/kg	1.0 Beryllium				NC	1	3.31
			mg/kg	17.0 Chromium				400	2	34.2
			mg/kg	28 Lead				400	0.6	39
			mg/kg	0.8 Mercury				24	0.04	0.1
			mg/kg	10 Nickel				1600	8	26.7
			mg/kg	250 Zinc				24,000	4	101
			pci/g		0.196 Pu-238			20	NA	0.014
			pci/g		0.0078 Pu-239			18	NA	0.052
			mg/kg		**4.69 U(total)**			160	NA	2.09
			mg/kg			0.39 Bis(2-ethylhexyl)phthalate		50	0.33	
	AAA5799	Sediment	mg/kg	180 Barium			None Detected	5600	40	1140
			mg/kg	0.98 Beryllium				NC	1	3.31
			mg/kg	19.0 Chromium				400	2	34.2
			mg/kg	35 Lead				400	0.6	39
			mg/kg	2.0 Mercury				24	0.04	0.1
			mg/kg	11 Nickel				1600	8	26.7
			mg/kg	7.6 Silver				400	2	NA
			mg/kg	290 Zinc				24,000	4	101
			pci/g		0.039 Pu-238 (J)			20	NA	0.014
			pci/g		0.0351 Pu-239			18	NA	0.052
			mg/kg		3.34 U(total)			160	NA	2.09
			mg/kg			**0.330 Benzo(a)anthracene (J)**		0.64	0.33	
			mg/kg			**0.300 Phenanthrene (J)**			0.33	

Maximum concentration in **boldface**
Shaded values: measured values above background UTL
(J): Estimated Value NA: Not Available
NC: SALs for beryllium set at background

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	SALs	CRQLs	Background
S Lagoon (continued)	AAA5800	Sediment	mg/kg	**300 Barium**			None Detected	5600	40	1140
			mg/kg	**1.1 Beryllium**				NC	1	3.31
			mg/kg	**3.9 Cadmium**				80	1	2.7
			mg/kg	**37.0 Chromium**				400	2	34.2
			mg/kg	**70 Lead**				400	0.6	39
			mg/kg	**4.0 Mercury**				24	0.04	0.1
			mg/kg	**16 Nickel**				1600	8	26.7
			mg/kg	**33.0 Silver**				400	2	NA
			mg/kg	**760 Zinc**				24,000	4	101
			pci/g		0.043 Pu-238			20	NA	0.014
			pci/g		0.222 Pu-239			18	NA	0.052
			mg/kg		4.06 U(total)			160	NA	2.09
						0.420 Fluoranthene		3200	0.33	
	AAA5801	Sediment	mg/kg	140 Barium		None Detected	None Detected	5600	40	1140
			mg/kg	1.0 Beryllium				NC	1	3.31
			mg/kg	13.0 Chromium				400	2	34.2
			mg/kg	21.0 Lead				400	0.6	39
			mg/kg	0.5 Mercury				24	0.04	0.1
			mg/kg	8.4 Nickel				1600	8	26.7
			mg/kg	120 Zinc				24,000	4	101
			pci/g		**2.36 Pu-238 (J)**			20	NA	0.014
			pci/g		**2.63 Pu-239**			18	NA	0.052
			mg/kg		2.32 U(total)			160	NA	2.09
	AAA5802	Sediment	mg/kg	78 Barium		None Detected	None Detected	5600	40	1140
			mg/kg	0.56 Beryllium				NC	1	3.31
			mg/kg	0.8 Cadmium				80	1	2.7
			mg/kg	8.3 Chromium				400	2	34.2
			mg/kg	16 Lead				400	0.6	39
			mg/kg	0.4 Mercury				24	0.04	0.1
			mg/kg	3 Nickel				1600	8	26.7
			mg/kg	10.0 Silver				400	2	NA
			mg/kg	140 Zinc				24,000	4	101
			pci/g		0.0477 Pu-238			20	NA	0.014
			pci/g		0.0804 Pu-239			18	NA	0.052
			mg/kg		2.64 U(total) (J)			160	NA	2.09

Maximum concentration in **boldface**
Shaded values: measured values above background UTL
(J): Estimated Value NA: Not Available
NC: SALs for beryllium set at background

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	SALs	CRQLs	Background
MH-177	AAA5690	Water	µg/l	**100 Barium**				2000	200	130
(2 Samples)			µg/l	**18.5 Lead**				50	3	1.1
			µg/l		**0.17 U(total)**			20 (MCL)	NA	0.0012
			pci/l		**0.01 Pu-238**			15	NA	0.051
			pci/l		0.01 Pu-239			15	NA	0.083
			µg/l				5.2 1,2 Dichloroethane	5	10	
	AAA5719	Water	µg/l	**100 Barium**				2000	200	130
			µg/l	6.0 Lead				50	3	1.1
			µg/l		0.167 U(total)			20 (MCL)	NA	0.0012
			pci/l		0.008 Pu-238			15	NA	0.051
			pci/l		**0.011 Pu-239**			15	NA	0.083
			µg/l			10 Di-n-butyl phthalate		3,500	10	
MH-176	AAA5699	Sediment	mg/kg	330 Barium				5600	40	1140
(1 Sample)			mg/kg	0.36 Beryllium				NC	1	3.31
			mg/kg	4.6 Cadmium				80	1	2.7
			mg/kg	64 Chromium				400	2	34.2
			mg/kg	480 Lead				400	0.6	39
			mg/kg	9.0 Mercury				24	0.04	0.1
			mg/kg	68 Nickel				1600	8	26.7
			mg/kg	93 Silver				400	2	NA
			mg/kg	620 Zinc				24,000	4	101
			pci/g		0.032 Pu-238			20	NA	0.014
			pci/g		0.676 Pu-239			18	NA	0.052
			mg/kg		4.387 U(total)			160	NA	2.09
			mg/kg			0.430 Benzo(a)pyrene		0.1	0.33	
			mg/kg			0.750 Benzo(b)fluoranthene		0.7	0.33	
			mg/kg			18.80 Bis(2-ethylhexyl)phthalate		50	0.33	
			mg/kg			0.450 Chrysene		22	0.33	
			mg/kg			0.550 Fluoranthene		3,200	0.33	
			mg/kg			0.800 Pyrene		2400	0.33	
			mg/kg				0.019 Chloroform	0.21	0.01	

Maximum concentration in **boldface**
Shaded values: measured values above background UTL
(J): Estimated Value NA: Not Available
NC: SALs for beryllium set at background

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	SALs	CRQLs	Background
MH-175	AAA5710	Water	µg/l	170 Barium		None Detected	None Detected	2000	200	130
(1 Sample)			µg/l	5 Chromium				50	10	24
			µg/l	19.0 Lead				50	3	1.1
			µg/l	79 Zinc				10,000	20	45
			pci/l		0.011 Pu-238			15	NA	0.051
			µg/l		0.065 U(total)			20 (MCL)	NA	0.0012
MH-174		None								
(No Samples)										
MH-173	AAA5730	Water	µg/l	130 Barium		None Detected	None Detected	2000	200	130
(1 Sample)			µg/l	1.5 Lead				50	3	1.1
			µg/l	77 Zinc				10,000	20	45
			µg/l		0.432 U(total)			20 (MCL)	NA	0.0012
MH-172		None								
(No Samples)										
MH-171		None								
(No Samples)										
MH-170	AAA5755	Sediment	mg/kg	21.0 Barium	None Detected			5600	40	1140
(1 Sample)			mg/kg	3.5 Chromium				400	2	34.2
			mg/kg	2.0 Silver				400	2	NA
			mg/kg	35.0 Zinc				24,000	4	101
			µg/l			34.0 Bis(2-ethylhexyl)phthalate		4	10	
			µg/l				27.0 Benzoic acid	140,000	0	
MH-169	AAA5764	Sediment	mg/kg	9400 Barium	None Detected	None Detected		5600	40	1140
(1 Sample)			mg/kg	1.2 Beryllium				NC	1	3.31
			mg/kg	3.2 Cadmium				80	1	2.7
			mg/kg	26 Lead				400	0.6	39
			mg/kg	94 Nickel				1600	8	26.7
			mg/kg	91 Zinc				24,000	4	101
			mg/kg				0.029 Chloroform	0.21	0.01	
MH-161		None								
(No Samples)										

Maximum concentration in **boldface**
Shaded values: measured values above background UTL
(J): Estimated Value NA: Not Available
NC: SALs for beryllium set at background

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	SALs	CRQLs	Background
MH-160	AAA5781	Sediment	mg/kg	36 Barium				5600	40	1140
(2 Samples)			mg/kg	0.12 Beryllium				NC	1	3.31
			mg/kg	1.2 Cadmium				80	1	2.7
			mg/kg	**22 Chromium**				400	2	34.2
			mg/kg	**43 Lead**				400	0.6	39
			mg/kg	**0.3 Mercury**				24	0.04	0.1
			mg/kg	5.0 Nickel				1600	8	26.7
			mg/kg	21 Silver				400	2	NA
			mg/kg	**620 Zinc**				24,000	4	101
			mg/kg		0.99 U(total)			160	NA	2.09
			mg/kg			**0.760 Bis(2-ethylhexyl)phthalate**		50	0.33	
			mg/kg			**0.47 Butyl benzyl phthalate**		16,000	0.33	
			mg/kg			0.480 Fluoranthene		3,200	0.33	
			mg/kg			0.460 2-Methylphenol		4,000	0.33	
			mg/kg			0.560 Pyrene		2,400	0.33	
			mg/kg			**0.30 Benzo(a)pyrene (J)**		0.1	0.33	
			mg/kg				**0.690 Acetone**	8000	0.01	
			mg/kg				**0.200 2-Butanone**	4000	0.01	
	AAA5791	Sediment	mg/kg	**40 Barium**				5600	40	1140
			mg/kg	**0.18 Beryllium**				NC	1	3.31
			mg/kg	**1.9 Cadmium**				80	1	2.7
			mg/kg	20 Chromium				400	2	34.2
			mg/kg	**85 Lead**				400	0.6	39
			mg/kg	**0.6 Mercury**				24	0.04	0.1
			mg/kg	**10.0 Nickel**				1600	8	26.7
			mg/kg	**40 Silver**				400	2	NA
			mg/kg	**950 Zinc**				24,000	4	101
			mg/kg		**3.51 U(total)**			160	NA	2.09
			mg/kg			**0.470 Benzo(b)fluoranthene**		0.7	0.33	
			mg/kg			0.740 Bis(2-ethylhexyl)phthalate		50	0.33	
			mg/kg			**0.350 Benzo(a)pyrene (J)**		0.1	0.33	
			mg/kg			**0.530 Fluoranthene**		3,200	0.33	
			mg/kg			**0.680 2-Methylphenol**		4,000	0.33	
			mg/kg			**0.470 Phenanthrene**			0.33	
			mg/kg			**0.650 Pyrene**		2,400	0.33	
			mg/kg				0.300 Acetone	8000	0.01	
			mg/kg				0.110 2-Butanone	4000	0.01	
			mg/kg				**0.012 Carbon disulfide**	7.4	0.01	

Maximum concentration in **boldface**
Shaded values: measured values above background UTL
(J): Estimated Value NA: Not Available
NC: SALs for beryllium set at background

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	High Explosives	SALs	CRQLs	Background
Wetland 6 (6 Samples)	AAA5915	Water	µg/l	66 Barium		No Analysis	None Detected		2000	200	130
			µg/l	**2.5 Lead**					50	3	1.1
			µg/l		0.222 U(total)				20 (MCL)		1.2
			pci/l		0.139 Th-230				15		NA
			pci/l		0.028 Th-232				15		NA
			pci/l		**0.01 Pu-238**				15	NA	0.051
			pci/l		**0.02 Pu-239**				15	NA	0.083
			µg/l					0.835 HMX	1,800		
			µg/l					0.242RDX	3.2		
			µg/l					**0.626 Tetryl(methyl-2,4,6-trinitrophenylnitramine)**			
	AAA5916	Water	µg/l	**74 Barium**		None Detected	None Detected		2000	200	130
			µg/l	2.0 Lead					50	3	1.1
			µg/l		**0.704 U(total)**				20 (MCL)		1.2
			pci/l		**0.179 Th-230**				15		NA
			pci/l		**0.089 Th-232**				15		5
			pci/l		0.01 Pu-238				15	NA	0.051
			µg/l					**0.954 HMX**	1,800		
			µg/l					**0.244 RDX**	3.2		
			µg/l					0.54 Tetryl(methyl-2,4,6-trinitrophenylnitramine)			
	AAA5917	Sediment	mg/kg	150 Barium		None Detected		None Detected	5600	40	1140
			mg/kg	**1.0 Beryllium**					0.16	1	3.31
			mg/kg	8.9 Chromium					400	2	34.2
			mg/kg	**27 Lead**					400	0.6	39
			mg/kg	**0.1 Mercury**					24	0.04	0.1
			mg/kg	12 Nickel					1600	8	26.7
			mg/kg	55 Zinc					24,000	4	101
			pci/g		**3.94 Th-230**				10		NA
			pci/g		1.01 Th-232				0.88		5
			µg/g		6.9 U(total)				160		1.2
			pci/g		**0.0161 Pu-238**				20	NA	0.014
			pci/g		0.0519 Pu-239				18	NA	0.052
			µg/g				**0.12 Acetone**		8000	0.01	

Maximum concentrations in **boldface**
NA: Not Available
Shaded values: values above background UTL

TABLE 4-2
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001 (a) AND (b)

Sample Location	Sample Number	Sample Type	Units	Metals	Radionuclides	SVOCs	VOCs	High Explosives	SALs	CRQLs	Background
Wetland 6 (continued)	AAA5918	Sediment	mg/kg	240 Barium		None Detected		None Detected	5600	40	1140
			mg/kg	1.0 Beryllium					0.16	1	3.31
			mg/kg	9.9 Chromium					400	2	34.2
			mg/kg	25 Lead					400	0.6	39
			mg/kg	13 Nickel					1600	8	26.7
			mg/kg	61 Zinc					24,000	4	101
			pci/g		1.45 Th-230				10		NA
			pci/g		1.4 Th-232				0.88		5
			µg/g		6.33 U(total)				160		1.2
			pci/g		**0.175 Pu-238**				20	NA	0.014
			pci/g		**0.0805 Pu-239**				18	NA	0.052
			µg/g				0.071 Acetone		8000	0.01	
	AAA5919	Sediment	mg/kg	140 Barium		None Detected		None Detected	5600	40	1140
			mg/kg	0.87 Beryllium					0.16	1	3.31
			mg/kg	8.1 Chromium					400	2	34.2
			mg/kg	**25 Lead**					400	0.6	39
			mg/kg	11 Nickel					1600	8	26.7
			mg/kg	50 Zinc					24,000	4	101
			pci/g		**1.44 Th-230**				10		NA
			pci/g		1.02 Th-232				0.88		5
			µg/g		6.18 U(total)				160		1.2
			pci/g		0.045 Pu-239				18	NA	0.052
			µg/g				0.043 Acetone		8000	0.01	
	AAA5920	Sediment	mg/kg	160 Barium		None Detected	None Detected	None Detected	5600	40	1140
			mg/kg	0.79 Beryllium					0.16	1	3.31
			mg/kg	7.6 Chromium					400	2	34.2
			mg/kg	18 Lead					400	0.6	39
			mg/kg	11 Nickel					1600	8	26.7
			mg/kg	46 Zinc					24,000	4	101
			pci/g		2.55 Th-230				10		NA
			pci/g		0.996 Th-232				0.88		5
			pci/g		0.061 Pu-238				20	NA	0.014
			pci/g		0.0311 Pu-239				18	NA	0.052

Maximum concentrations in **boldface**
NA: Not Available
Shaded values: values above background UTL

4.2.3.1 Comparison With Background

Comparison of the measured concentrations of metals in the manholes and lagoons with background is not entirely appropriate, because the sediment in the manholes and sludge in the lagoons is derived from sanitary wastes, which commonly have elevated levels of heavy metals. However, these concentrations do provide some measure of the risk, as compared with background, in the event a decision is made to decommission the manholes and lagoons in place rather than remove the sediment or sludge for disposal. Concentrations of metals and radionuclides above background are highlighted in Table 4-2.

Concentrations of all metals in sediments from the manholes are generally above the UTL for background concentrations in soil. This is not unexpected as heavy metal concentrations are generally elevated in sanitary waste. Mercury was generally elevated above the reported UTL in all sediment and sludge samples. Similarly, metal concentrations in water samples were elevated as compared with background concentrations in the main aquifer. This may in part be due to natural differences between the main and alluvial aquifer, as well as presence of contaminants from the waste stream. Reported concentrations of ^{238}Pu and ^{239}Pu were greater than background in several samples from both the manholes and lagoons. Former operations in the buildings served by the plumbing associated with the present sanitary line involved experimental operations using plutonium isotopes, so the presence of these constituents is not surprising.

Concentrations of metals in samples from the outfall area were generally below the background UTL, with the exception of lead (above the UTL for two water samples). This could easily be the result of natural differences between surface water in the wetlands and groundwater in the main aquifer, which was used as a basis for the UTL. Total uranium concentrations were above the UTL in three sediment samples. This could be the result of releases from the lagoons, from historical releases at a nearby abandoned firing site(which will be addressed in a subsequent report), or from natural differences between uranium concentrations in wetland samples and soil samples. Concentrations of plutonium isotopes were above the UTL in several sediment samples. Plutonium is not a potential contaminant for the nearby abandoned firing site. However, as with uranium, the concentrations above the UTL could have resulted from releases from the lagoons, or from naturally elevated values. Thorium -230 does not occur naturally, and its presence may be attributable to the former firing site mentioned above. Thorium was not a potential contaminant for this PRS.

SVOCs were detected in samples from several manholes and from the lagoons. Although many of these SVOCs may occur at uncontaminated sites, their presence in the sediment and sludge must be attributed to their occurrence within the wastestream, since no external sources can be identified (See Section 4.2.1 for a description of the waste collection system). No SVOCs were detected in any sample from the outfall area.

VOCs were reported in several water and sediment soil samples from the manholes and outfall area. Acetone, a common laboratory contaminant, was detected in one laboratory QC sample; however, it was present in some samples in the manholes at concentrations greater than to be expected solely as a laboratory contaminant. Concentrations of acetone in samples from the outfall area were low, consistent with laboratory contamination as a probable source. No VOCs were detected in samples from either lagoon.

4.2.3.2 Comparison with SALs

The sediments in the manholes and the sludge in the lagoon are waste materials rather than being environmental media (e.g., soil), and comparing sample concentrations with SALs is not entirely appropriate. However, the objective of the sampling was to develop recommendations on appropriate methods for decommissioning the lagoons and sewer line. One option is to remove only the structural components and leave the sludge and sediments in place. Although in the subsurface, these materials

would then be as available for contact as any environmental media. The water in the manholes, derived from infiltrating groundwater, could solubilize contaminants in the sediments in the manholes. Thus, sampling of the manhole water provides a conservative estimate of the concentration of PCOCs in groundwater immediately adjacent to the sewer line.

For the lagoons, reported concentrations of PCOCs in the sludge did not exceed the SALs for either radioactive or RCRA hazardous constituents. For SVOCs, metals, and radionuclides, the measured concentrations were consistently 10 to 100 times less than the SAL.

Reported concentrations of PCOCs in the outfall area were below established SALs with the exception of ^{232}Th. However, the SAL for ^{232}Th is within the range of background concentrations, and the measured concentration is below the background UTL.

SALs were exceeded in the sediments in all but one sampled manhole:

- In Manhole 176, lead was measured at a concentration of 480 mg/kg (SAL, 400 mg/kg). Benzo-a-pyrene was measured at 0.43 mg/kg (SAL, 0.1 mg/kg), and benzo(b)flouranthene at 0.75 mg/kg (SAL 0.7 mg/kg).
- In Manhole 170, bis(2-ethylhexyl)pthalate was measured at a concentration of 34.0 mg/kg (SAL 4 mg/kg)
- In Manhole 169, barium at 9400 mg/kg exceeded the SAL of 5600 mg/kg.
- In Manhole 160, benzo-a-pyrene was measured at 0.3 and 0.35 mg/kg in two samples (SAL 0.1 mg/kg). This chemical is commonly associated with petroleum products.

However, as indicated in Table 4-2, the values for Manhole 160 were J-flagged; that is, the chemical was detected, but the concentration was only estimated because of inaccuracies in the measurement. The reported concentrations of benzo-a-pyrene are in the range of the CRQL, which is a factor of 3 greater than the SAL.

SVOCs were detected in other manholes but were found to be consistently one or more orders of magnitude below the respective SAL in those locations. The reported concentrations of VOCs in sediment and water samples from the manholes were one or more orders of magnitude below the respective SAL except in Manhole 177, where the concentration of 1,2-DCA, at 5.2 mg/kg, slightly exceeded the SAL of 5 mg/kg. However, as noted in Section 3.1.2.2, VOC holding times were missed for two water samples, one from Manhole 175 and the other from Manhole 173. If necessary, additional water samples could be collected before decommissioning the manholes. However, we believe that the low concentrations of VOCs and other constituents detected in water in some manholes is indicative of the entire sewer line.

Analysis of the filter swipes collected in each of the 11 manholes identified removable beta contamination on only one swipe, from Manhole 176 (not reported in Table 4-2). The reported value was 35.4 pCi/100 cm^{-2}, compared with an analytical uncertainty of 23.8. The DOE release limit for removable beta contamination is 450 pCi/100 cm^{-2}.

As discussed above, metals, VOCs, or SVOCs were detected in nearly all the manholes at concentrations in excess of SALs. However, in all but one instance the SALs were exceeded by a factor of 4.3 or less. The SAL for bis(2-ethylhexyl)pthalate was exceeded by a factor of 9 in one manhole. The concentrations of all potential contaminants were well below the SALs in all samples from the lagoons.

The SAL values are calculated, assuming a conservative residential-based scenario, to be a concentration at which exposure would produce a risk of 10^{-6} (Section 3.4). Therefore, risk presented by the sludge in the lagoons is well below 10^{-6}, and is in the range of 10^{-5} to 10^{-6} for sediments in the manholes. However, we estimate that less than 0.5 liter of sediment was present in any one manhole after the samples were collected. We believe that this small volume will not pose a significant risk if appropriate decommissioning measures are taken. Decommissioning of the sewage lagoons and manholes is addressed in Section 4.2.4.

4.2.4 Conclusions

The data indicate that several potential contaminants were present in water samples from the manholes at concentrations above background values. This includes nearly all the metals, uranium, and some VOCs and SVOCs at one or more sampling locations. However, with one exception, the measured concentration were one or more orders of magnitude below SALs. The measured concentration of one VOC was equal to the SAL in one manhole. To the extent that water in the manholes is representative of groundwater infiltrating the sewer line, these values suggest that some historical releases occurred to groundwater but that no unacceptable groundwater contamination has occurred.

Review of the data in Table 4-2 indicates that radioactive or hazardous constituents were present in samples from both the lagoons and manholes. As discussed above, SALs were exceeded in four manholes and not at all in the lagoons. However, concentrations of radioactive or hazardous constituents are sufficiently low that leaving the material in place does not present an unacceptable risk.

For the sewer line, the above-grade and some of the below-grade portions of each manhole will be removed. Each manhole consists of a vertical concrete culvert, with a formed top holding the manhole cover. This covered culvert rests on the basin-like bottom of the manhole with ports for the inlet and outlet pipes that connect the manholes. All sediment is located in the bottom of the manhole, which is approximately 5 ft below grade.

After excavation around the manhole, the vertical portion of the manhole will be removed, and the basin-like bottom of the manhole will be filled with concrete to above the level of the inlet and outlet pipes. This concrete will plug the line, preventing further groundwater flow between the manhole locations, and will provide an encapsulation for any residual sediment in the manhole. The excavation will then be filled with clean soil. The removed manhole can be disposed of as uncontaminated waste.

The above-grade portions and sidewalls of the lagoons will be removed. The bottom of each lagoon is approximately 6 ft below grade. The sludge will be left in place, and the volume of the lagoons filled with clean soil.

There is no evidence of contamination within the outfall area that would pose an unacceptable risk. All measured concentrations of PCOCs were well below SALs (and in the range of background concentrations), except where SALs are within or below the range of background.

Decommissioning of the lagoons and manholes in this fashion will ensure that the low risk posed by sediments in the sewer line will be further reduced. The Laboratory will submit a request for a Class III permit modification along with a plan for expedited clean-up (i.e., in-place stabilization) of the manhole and lagoons.

4.3 PRS 18-001(c), Sump

4.3.1 Site Description

This sump, located in the basement of TA-18-30 (Figure 4-9) serves primarily to collect groundwater from drains outside the basement walls. However, some sinks and floor drains within TA-18-30 formerly drained to the sump. Those drains were diverted to the sanitary sewer line in the fall of 1992. The sump was erroneously grouped with the sanitary lagoons and sewer lines by the Laboratory Solid Waste Management Units (SWMU) Report (LANL 1990). The sump has never been connected to the sanitary system. Rather, it discharges to an outfall (PRS 18-012b) south of TA-18-30. (This latter PRS, not listed the HSWA permit, will be addressed in an RFI report scheduled for completion in October 1995). The PCOCs identified by a review of past operations at TA-18-30 are uranium, heavy metals, VOCs, and SVOCs.

4.3.2 Site Investigation and Analyses

Two water samples were collected from the sump and analyzed for the PCOCs identified in Section 4.3.1. No sediment was present in the bottom of the sump.

4.3.3 Evaluation of Results

The analytical data for the sump are presented in Table 4-3. Very low concentrations of barium, lead, and uranium were detected in one or both samples. These concentrations are significantly below SALs. Barium and uranium concentrations are below the calculated UTL for main-aquifer groundwater. (No background data are currently available for the shallow aquifer.) The lead concentration in one sample was slightly above background.

TABLE 4-3
MEASURED CONCENTRATIONS OF PCOCs IN PRS 18-001(c)

Sample Location	Sample Number	Sample Type	Units	Metal	Radionuclide	SVOC	VOC	SAL	CRQL	Background
Sump	AAA5839	Water	µg/l	**71 Barium**		None Detected		2000	200	130
			µg/l	**2.0 Lead**				50	3	1.1
			µg/l				2.0 Carbon disulfide	5	10	
			µg/l		**0.14 U(total)**			20 (MCL)	NA	1.2
	AAA5840	Water	µg/l	71 Barium		None Detected		2000	200	130
			µg/l	1.0 Lead				50	3	1.1
			µg/l		0.123 U (total)			20 (MCL)	NA	1.2

Maximum concentrations in **boldface.** Shaded values: measured values above background UTLs

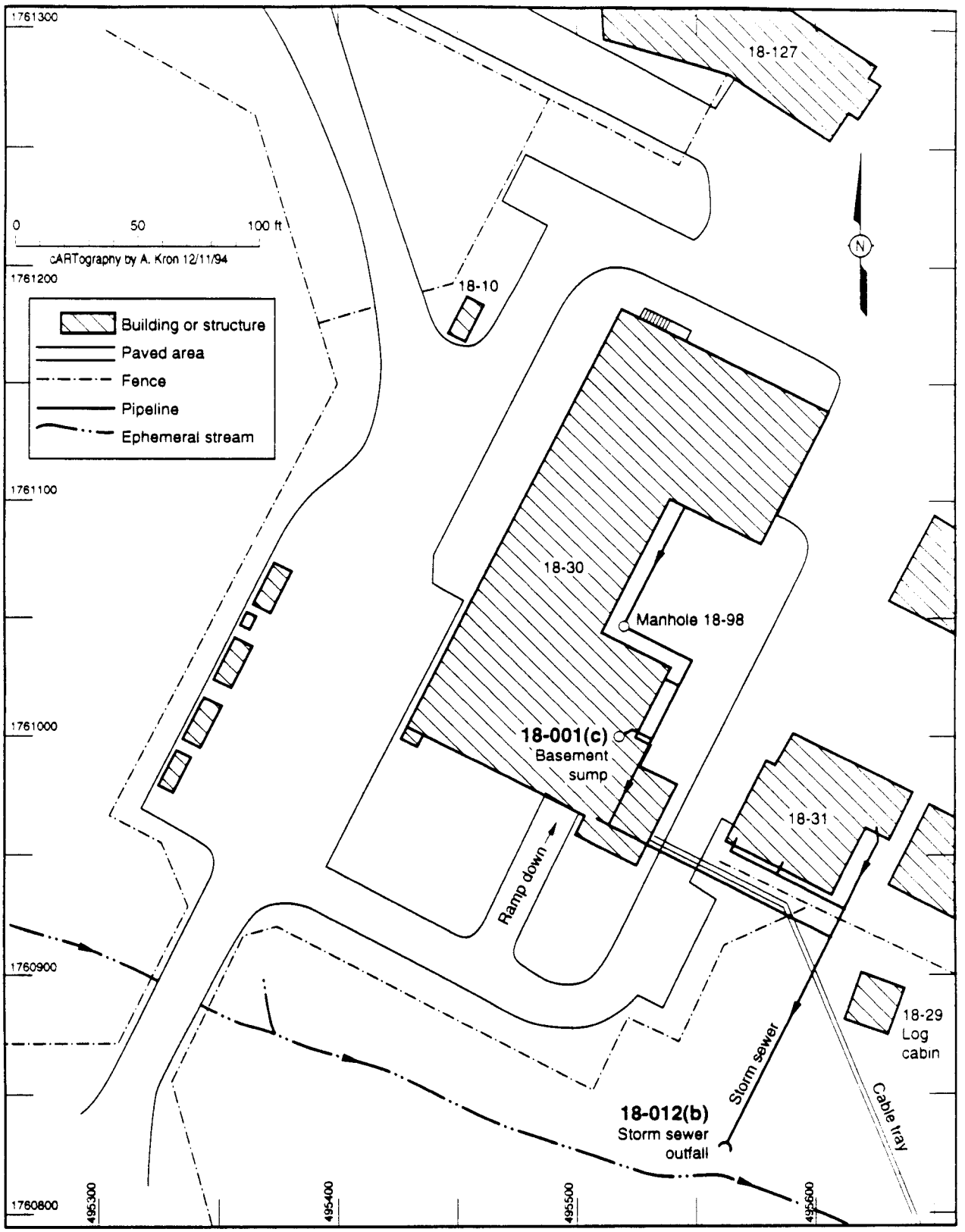


Figure 4-9. Location of site investigations for PRS 18-001(c)

4.3.4 Conclusions

No measured constituents were present above SALs. Three metals (including uranium) were present at concentrations within the range of background although the maximum uranium and lead concentrations were slightly above the UTL calculated for the main aquifer. This may in part be due to natural differences between the main and alluvial aquifers. The reported concentration of carbon disulfide was estimated, and at concentrations below the CRQL. This value is suspect, and the constituent may or may not have been present. No unacceptable risk is presented by this PRS.

A proposal for No Further Action for PRS 18-001(c) will be included in the next permit modification.

4.4 PRS 27-001, Buried Guns

4.4.1 Site Description

The 1990 SWMU Report (LANL 1990), based on the 1987 Comprehensive Environmental Assessment and Response Program (CEARP) (DOE 1987), described 8-inch naval gun barrels, possibly with inert projectiles, that reportedly were buried in Pajarito Canyon about 1946, when the Manhattan Project ended. This SWMU was included in the 1093 RFI Work Plan as PRS 27-001. Its location was indeterminate but was said in two accounts to be east of TA-18 on the north side of the canyon near the base of the cliffs. One document specified a 200-yd-long trench located north of where Pajarito Creek crosses Pajarito Road 1,400 ft east of TA-18. Another suspected location was the flat area adjacent to and east of the road fill where Pajarito Road descends into the canyon. Both of these possible locations, as well as the land between, were investigated (Figure 4-10).

4.4.2 Site Investigation

Research in the Laboratory archives located only two accounts about the rumored burial of naval guns in Pajarito Canyon. Each differed in reported location, though both indicated the area was near Indian caves. Other documents that were found discussed unsuccessful searches for the guns that have taken place in this canyon since 1964 and buried guns recovered elsewhere at the Laboratory.

Initial work began in March 1992 with low sun-angle photography of the flat area near TA-18, when winter snows, by then melted, had flattened the grass to reveal surface undulations. Neither photos taken from the cliff top nor those taken on the ground revealed linear features indicative of a burial trench. Old aerial photographs were studied for any such features; several, taken in 1958 and 1960, showed a linear patch of disturbed soil that would be located next to the modern road embankment (Pajarito Road was moved slightly east of the original road in 1962). However, low-altitude oblique aerial photos taken in 1949 and 1950, soon after the alleged time of burial, showed nothing unusual at this spot (these photos do, however, show major excavations for road gravel under way a few hundred yards to the east). If guns were buried in this flat area circa 1946, it is likely that the ground or vegetation disturbance would still show in 1949. Therefore, photo research does not establish clear evidence for a burial trench or its location.

Efforts to find evidence of a trench farther east concentrated on the narrow strip of canyon floor between the base of the cliffs and the wetland areas that lie along the center of the canyon (Figure 4-10). The wetlands themselves lie in elongated gravel pits where road materials were excavated between 1949 and 1962. Such excavations, which are about 8 to 10 ft deep, would have uncovered any burial trench located there. The excavated areas, which are covered with dense patches of cattails and with water, were investigated only visually. The shallow depth to bedrock makes a significantly deeper trench unlikely, so we believe any large gun barrels are probably not located there.

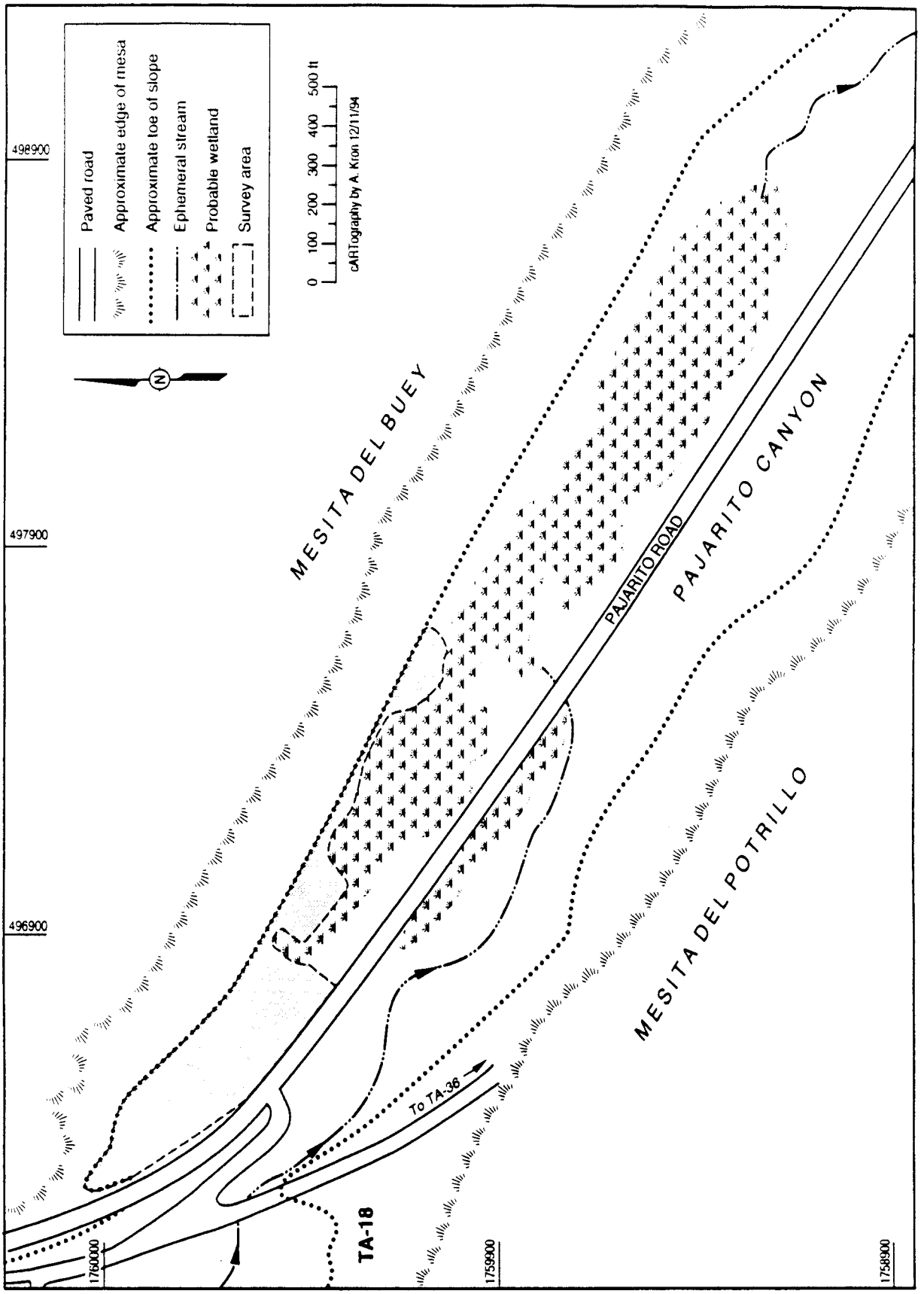


Figure 4-10. Location of site investigations for PRS 27-001.

Investigations in the strip along the base of the cliffs began with a botanist from the Laboratory Environmental Protection Group accompanying the field investigator to determine if vegetation patterns there hinted at disturbed soil. The pattern at the easternmost suspected location (the one north of where the creek crosses Pajarito Road) did indeed appear linear but might be related to ground disturbance caused by earthmoving equipment used in the adjacent excavations. Outwash of talus from the cliffs, the presence of large boulders and trees likely older than 50 years, and erosion tend to complicate the search area. Visual searching was inconclusive.

Geophysics were then used to determine if subsurface metallic objects could be located in the two search areas. An electromagnetic (EM) induction unit was carried along the strip of flat ground at the base of the cliffs from the eastern suspected location 1,650 ft westward to the highway embankment. All accessible flat areas were swept with the instrument.

The EM method used for this investigation consists of a system of two coils. One of these coils transmits a time-varying electromagnetic signal (primary magnetic field) that induces the flow of electrical current in subsurface materials. The amount of current flow is proportional to the electrical conductivity of the material it permeates.

The second, or receiver, coil detects a secondary magnetic field associated with the induced current flow. This complex secondary signal has both quadrature and in-phase components. The quadrature component has an amplitude proportional to the conductivity of subsurface materials. The measured conductivity is an apparent conductivity, referred to as "terrain conductivity", representing the resultant conductivity of the particular volume of material. Terrain conductivity values are affected by the presence of buried debris (especially metallic objects), differences in moisture content, and the lithologic character of subsurface materials. These measurements are commonly used in areas where rapid data acquisition is required. Terrain conductivity values can be used to delineate trench fill material, to determine the presence of buried objects (especially metallic), to map contaminant plumes, and for other applications. The in-phase component is sensitive to contrasts in subsurface conductivities. In-phase measurements are commonly used as a gross indicator of buried metal debris or large metallic objects.

The instrumentation consists of a Geonics EM31-DL ground conductivity meter. The system has a fixed-coil separation of 12 ft, which results in a depth of investigation of 15 to 18 ft under optimum conditions. The actual investigation depth is dependent upon local site parameters, in particular the conductivity of shallow subsurface materials. For example, the presence of a highly conductive clay layer can reduce the depth of investigation.

The EM method was selected for two reasons:

1. It is an excellent method of detecting buried objects (especially metal) within approximately 15 ft of the ground surface. In addition, a large amount of data can be obtained in a relatively short amount of time.

2. Magnetometry proved to be ineffective in Pajarito Canyon because of the high magnetite content of the Bandelier tuff at that location.

Magnetometry is slightly more sensitive for detecting buried metal than the EM method. However, before conducting the EM surveys, a magnetometer survey was conducted at PRS 27-003, the Bazooka Impact Area, in the southern section of Pajarito Canyon and at other randomly selected locations within the canyon. The results indicate anomalously high magnetometer readings (total field and vertical gradient) throughout the entire investigation site and at all other locations within the canyon. This effect overshadows any possible anomalies that would be caused by buried metal. However, the EM method measures a different property of subsurface materials than the magnetic method and is effectively insensitive to the high magnetite content of the tuff. It can therefore be used to assess the location of appreciable amounts of buried metal such as buried naval guns.

Throughout the surveyed area, EM data was reviewed in real time to avoid the cost of a grid survey and the time for downloading the data. The analog system continuously displayed data that was continuously observed as traverses were performed at approximately 5-ft intervals. Both east-west and north-south-trending traverses were performed. At each field investigation location, one person carried the EM meter and another person sited the traverse with a measuring tape and compass. The locations of any possible anomalies were directly marked in the field as they were observed.

4.4.3 Evaluation of Results

One EM anomaly, typical of an isolated buried object, was detected after all three field areas were surveyed. The anomaly, located within the northwesternmost area of PRS 27-001, was marked with a wooden stake and flags. The anomaly is typical of EM anomalies caused by buried metal; however, it is limited in lateral extent (a few feet in the north-south and east-west directions). Buried elongated objects (naval guns) would generate elongated anomalies. The naval guns might cause the observed anomaly if they were buried with their long axis perpendicular to the ground surface. However, this is impractical and highly unlikely; the alluvium is quite thin at that location (10-15 ft), and the guns were reported buried in a trench.

The only other observed anomalous conditions were caused by buried utilities in the field area closest to the road. These anomalies occurred where utility trenches were indicated in the field. In general, EM values not associated with the previously described anomalies ranged from 11 to 13 milliSiemens/meter (mS/m), showing little variation.

4.4.4 Conclusions

Since 1964, the matter of buried guns in Pajarito Canyon has been investigated by the Laboratory without success. Both areas mentioned in available accounts have been searched carefully. We believe large masses of steel such as naval gun barrels would have a markedly detectable EM signal, but none was found in any of the areas surveyed. In the absence of definitive information about guns' location, we are unable to productively pursue the investigation. For this reason we propose No Further Action for PRS 27-001.

4.5 PRS 18-007, Buried Armored Vehicle

4.5.1 Description and Possible Locations

An unnamed employee interviewed for the 1987 CEARP Report "remembered burying a tank 1.25 miles up the [Threemile] canyon from Kiva 2 [west of TA-18-32] in 1949". In addition, he mentioned an undated, unsigned memo in (an engineering file) indicates the possibility of material buried beyond [west of] the old kiva at TA-18" [TA-18-23]. The original interview notes and memo referenced by the CEARP Report could not be located.

The field investigator talked with six former employees who had worked at TA-18, some of whom had been there in 1946, and none could verify this story. Some even laughed or expressed indignation at its likelihood. However, another employee (since retired) who said he was here as a soldier during the Manhattan Project mentioned a similar story to the investigator. He claimed to have seen an M-3 tank without its gun next to a large excavation in Pajarito Canyon 0.75 mi west of TA-18 and, upon returning hours later, found both gone. He concluded the tank was buried in the hole. This individual may have been the one interviewed for the CEARP Report. In a later interview, the employee was no longer certain whether the tank was buried in Pajarito Canyon or in Threemile Canyon (see Figure 4-10) and how far west of TA-18 it had been buried. He said he would not be able to point it out. A second employee had heard (from an unstated source) that the tank was located 100 yd west of Kiva 2 in Threemile Canyon. No

documentation or discussion of this burial was found in archival research on TA-18; nonetheless, the investigation was pursued based on the CEARP Report and the first employee's alleged, but rather ambiguous, eyewitness account.

Since the U.S. Army did, in fact, use old M-3 "Stewart" light tanks for site defense during the Manhattan Project, we determined that the depth of burial to just cover this tank would have been 8 ft, requiring depth to bedrock of at least 10 ft. The hole would have had to be a minimum of 8 ft wide and 15 ft long, plus have an access ramp at least that long (resulting in about 45 to 50 yd^3 of soil displacement). Such a hole would have required significant room for access, excavation, and spoil disposal and would likely leave visible traces.

The space required for such a burial is not readily available in Threemile Canyon, which is deep, narrow, and covered with large trees older than 50 years. Its floor is occupied by an ephemeral creek. Access is restricted by a small, marshy pond just beyond the old abandoned firing area west of Kiva 2. The only flat areas in the narrow canyon bottom are small, tree-covered patches along the sides of the creek. Other than traces of an old footpath and the 1945 firing site, no road or man-caused soil disturbance was found in the canyon during several visits. A photo of the firing site taken during construction shows that even in 1945, dense forest covered the canyon bottom. Lack of a road would not, of course, preclude a tank having been carefully driven between the trees. Nevertheless, Threemile Canyon does not appear to be a likely location for burying a tank and thus was not geophysically surveyed as originally intended in the 1093 RFI Work Plan.

In contrast, Pajarito Canyon has a wide, flat bottom with large grassy meadows and traces of an old road that heads west, presenting both easy access and room for such a burial. Depth to bedrock, based on drilling conducted in 1994, is more than 25 ft. The search, therefore, was concentrated in this canyon.

4.5.2 Site Investigation and Analyses

An EM unit was used to survey the floor of Pajarito Canyon for a distance of 1,200 yd westward from Kiva 1 (Figure 4-11). To bury a tank, there would have been scant reason to bypass this area for a more remote, forested spot farther west.

EM data was reviewed in real time throughout the canyon as it was surveyed to avoid the cost of a grid survey and the time for downloading the data. The meter was continuously observed as all accessible areas were traversed at approximately 20-ft intervals. A buried military tank, if it existed, would easily have been detected with that spacing. The data was continuously displayed on an analog meter as each traverse was performed. One person carried the EM meter while another person sited each traverse.

4.5.3 Evaluation of Results

No EM anomalies typical of a buried tank were detected. Only one anomaly, approximately 1 mile northwest of Kiva 1, was detected; its source was determined to be a partially buried metal fence. The fence was excavated and the area was re-surveyed, resulting in no anomaly. Terrain conductivity values throughout the surveyed areas ranged from approximately 10 to 14 mS/m.

4.5.4 Conclusions

The report of a buried tank seems to rest on the interview of a single employee and has no other documentation to substantiate the claim. This in itself is not grounds for discounting the story. Discussions with the likely employee (at least one who claims personal knowledge of the event) failed to gain additional useful details such as a specific location, date, participants, nature of potential hazards, or any other facts that might narrow the range of possibilities. When pressed for details by other members of the field team, the employee unfortunately refused to cooperate further.

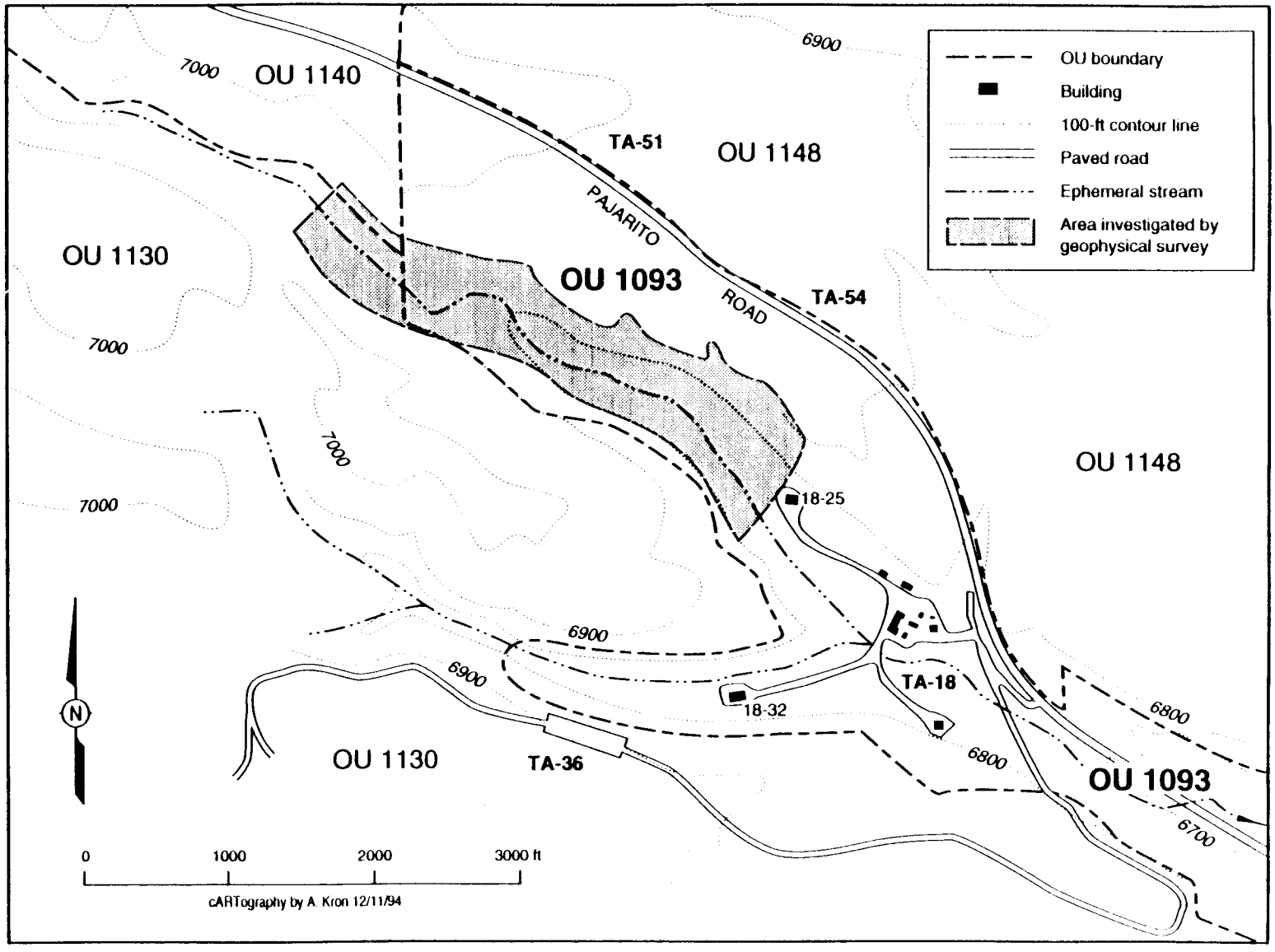


Figure 4-11. Location of site investigation for PRS 18-007.

Despite either the absence of corroborating evidence for the story of a buried tank or indications of what hazards might be associated with it, we felt it prudent to conduct the EM survey anyway. After inspecting Threemile Canyon and determining its unsuitability for such a burial, we chose to check Pajarito Canyon west of TA-18, the most reasonable location. Magnetometry revealed no contacts in the searched area that could be a large mass of metal. We have no information that would justify the expense of continuing the search in this extensive canyon.

The U.S. Environmental Protection Agency (EPA), after reviewing the RFI work plan for 1093 recommended that PRS 18-007 should be removed from the HSWA portion of the Laboratory's operating permit. This recommendation was made following an EPA determination that this PRS was not a SWMU and should not be in the permit. Based on our field investigations, we propose a status of No Further Action for this PRS.

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APPENDIX A

METHODOLOGY AND RESULTS FOR ANALYSIS OF BACKGROUND CONCENTRATIONS

APPENDIX A
METHODOLOGY AND RESULTS FOR ANALYSIS OF BACKGROUND CONCENTRATIONS

The primary purpose for conducting a statistical analysis of the RFI Phase I data is to compare site data with Los Alamos background data. This comparison is a part of the screening assessment data analysis described in Chapter 3. In concert with the statistical analysis, we also consider the human health risks, environmental consequences, and the geochemical basis of PRS data. These detailed evaluations are presented in Chapter 4 of this RFI Report.

The selection of appropriate background data is critical to the statistical comparisons discussed below. The ER Project has collected and analyzed Laboratory-wide background data for environmental decision-making. These data include soil and rock (Bandelier tuff), segregated according to significant geochemical characteristics (Longmire et al., in preparation, 1142).

The soil at all sites sampled in this report is disturbed and therefore represents a mixture of soil horizons and geochemical properties. We used all soil samples reported in Longmire et al. (in preparation) for the background data set. Another source of regional background concentrations are radionuclides associated with global fallout. The Laboratory Environmental Surveillance reports (most recently LANL 1994) summarize the regional background concentrations of ^{238}Pu and $^{239/240}$Pu. The reports were the source of the inorganic and radionuclide concentration data that represent Laboratory background groundwater conditions.

Hot Measurement Test (UTL Method)

The hot measurement test is based on a statistic that represents the upper range of the background concentrations. No matter what concentration is chosen to represent a hot measurement threshold, there is a probability that a background concentration measurement will exceed the hot measurement threshold. Thus, it is important to select a concentration for the hot measurement threshold that is statistically related to the highest background concentrations and thereby minimize the probability of a false-positive result. The tolerance limit is such a value and is one of the background comparison methods recommended in EPA (1989, 1141). A tolerance limit is a confidence limit on a percentile of the distribution. Given that the tolerance limit is a value that should be rarely exceeded, the 99th percentile is a reasonable value of the distribution to estimate. EPA recommends calculating an upper 95% confidence limit for the target percentile (EPA 1989, 1141). The upper tolerance limit (UTL) for the 99th percentile at 95% confidence is calculated by Equation (1).

$$UTL_{0.99,0.95} = \text{mean} + \text{standard deviation} * k_{0.99,0.95} \qquad (1)$$

The "k-factors" depend on the number of background samples. Complete tables of k-factors are published in EPA 1989 or Gilbert (1987, 0312). Table A-1 presents some selected k-factors that

TABLE A-1
Selected "k-factors" Used to Calculate UTLs

Number of background samples	$k_{0.99,0.95}$
10 *	3.981
45 *	2.897
46	2.8902
47	2.8834
48	2.8766
49	2.8698
50 *	2.863

represent the range of values used to compute the UTLs for Laboratory background soil samples. The background data must be either normal or transformed to normal (for example, by using log-transformation) to be able to apply Equation (1). Nonparametric methods are available for calculating tolerance limits, as described in Gilbert (1987, 0312), if data deviates sufficiently from normality to warrant use of nonparametric tolerance limits. In lieu of nonparametric tolerance limits, the analyst may trim outliers from the distribution when appropriate, and calculate the UTL based on the trimmed mean and standard deviation.

Laboratory soil background data were used to calculate the metal-analyte UTL values that are presented in Table A-2. Soil concentration distributions for which the median was not roughly equal to the mean were log-transformed. The UTLs calculated for the lognormal distribution were converted into the original units to simplify comparisons with site data. No values were trimmed from the distributions to calculate the mean and standard deviation. Values below the Laboratory detection limit, if four or fewer non-detects were reported for the analyte, were replaced by one-half the detection limit (per EPA guidance, EPA 1989, 1141). The UTL was not calculated for any analyte with more than four non-detect values (>10% non-detects). The maximum value is reported in lieu of the UTL for the analytes with more than 10% non-detects.

The background concentrations of radionuclides in soil are derived from two sources. The background activity of ^{232}Th, ^{234}U, ^{235}U, and ^{238}U were estimated from the total elemental concentrations of plutonium, thorium and uranium as measured by neutron activation methods. These total elemental concentration data are reported in the Laboratory background report, as were the metal data analyzed by the standard EPA methods (Longmire et al., in preparation, 1142). UTLs are calculated for these radionuclides. The other source of regional background soil concentrations of radionuclides is the Laboratory Environmental Surveillance reports. These reports present data from seven locations in Northern New Mexico for radionuclides associated with global fallout, which include: ^{238}Pu, ^{239}Pu, and ^{240}Pu. These data were collected from 1974 to 1990 at these locations. Given these data represent a time series at these locations, the maximum observed concentration is used in lieu of the UTL for these radionuclides.

The source of the UTLs for inorganic and radionuclide groundwater data was the 1992 Environmental Surveillance (LANL 1994). These UTLs are presented in Table A-3. The UTL was calculated for each analyte with at least 8 detected values out of 10 wells. As above, the less than detect values were replaced by one-half of the detection limit in order to calculate the UTL. The maximum value is reported in lieu of the UTL for the remaining analytes. None of these data were log-transformed before calculating the UTLs.

If the UTL is exceeded by sample values, this should not be taken as positive proof of a release. There is nominally a 1% chance that the UTL will be exceeded by each sample that is collected from the PRS (assuming the PRS is at background). In addition, a typical metals suite will require the comparison of 23 analytes to their background concentrations. Because we have not adjusted the probability values for these multiple comparisons, the results of the hot measurement test must be carefully evaluated. Concentrations that exceed the UTL must be considered in relation to human health or ecological screening levels. The possibility of an exceedance due to an unusual, but naturally occurring soil matrix must also be considered. These factors will help determine what kind of further background analysis is warranted.

TABLE A-2
UTL FOR LABORATORY SOIL BACKGROUND DATA.

Analyte	SAL (mg/kg)	Mean *	Standard deviation	UTL 99%,0.95	N	N > DL
Aluminum		19000	13800	58900	47	45
Antimony	32	2.45	0.36	2.5 (MAX)	46	0
Arsenic		4.4	2.5	11.6	46	45
Barium (LT)	5,600	161	129	1140	47	45
Beryllium		1.15	0.75	3.31	47	45
Cadmium	80	0.39	0.54	2.7 (MAX)	47	3
Calcium (LT)		5790	12500	54400	47	45
Chromium (Total) †		11.7	7.8	34.2	47	45
Cobalt (LT)		15.2	7.6	51.1	47	45
Copper		5.3	3.6	15.7	47	43
Iron		14500	7320	35600	47	45
Lead	400	15.0	8.3	39.0	47	42
Magnesium (LT)		2920	2150	16100	47	45
Manganese	11,000	343	238	1030	47	45
Mercury	24	0.05	0.01	0.1 (MAX)	48	1
Molybdenum	400	NA	NA	NA	NA	NA
Nickel	1,600	9.7	5.9	26.7	47	43
Potassium		2420	1304	6180	50	50
Selenium	400	0.43	0.41	1.7 (MAX)	46	22
Silver	400	NA	NA	NA	NA	NA
Sodium		577	453	1880	47	45
Strontium	48,000	NA	NA	NA	NA	NA
Thallium	6.4	0.27	0.24	0.9 (MAX)	45	20
Uranium	160	0.86	0.43	2.09	46	45
Vanadium	560	25	14	66	47	45
Zinc	24,000	41	21	101	47	45
Thorium-232 (1)	5	1.71	0.34	2.68	50	50
Uranium-234(1)	86	1.21	0.29	2.03	50	50
Uranium-235 (1)	18	0.052	0.012	0.088	50	50
Uranium-238 (1)	59	1.14	0.27	1.90	50	50
Plutonium-238 (2)	20	0.0013	0.0024	0.014 (MAX)	76	62
Plutonium-239/240 (2)	18	0.0083	0.0079	0.052 (MAX)	88	85

* Concentration values <DL (detection limit) were replaced by 1/2 of the DL; LT - UTL is based on log transformed data; NC - UTL was not calculated given the small frequency of detects; NA - data not available for LANL background; MAX - Maximum value is reported, rather than the UTL; (1) - Data, expressed in pCi/g, are converted from elemental concentrations reported in the Laboratory background report; (2) - Data, expressed in pCi/g, are from the Environmental Surveillance reports (1974 - 1990); † - SAL for Chromium-III is 80,000 mg/kg and for Chromium-VI is 400 mg/kg

Table A-3
UTL for LANL Groundwater Background Data**

Analyte	SAL (mg/L)	Mean *	Standard deviation	UTL 99%,0.95	N	N > DL
Aluminum		NC	NC	<0.03 (MAX)	10	0
Antimony		0.00093	0.00038	0.0025	10	10
Arsenic	0.05	0.0071	0.011	0.052	10	10
Barium	2	0.036	0.024	0.13	10	10
Beryllium	0.004	NC	NC	0.002 (MAX)	10	2
Boron		NC	NC	0.03 (MAX)	10	4
Cadmium	0.005	NC	NC	<0.0006 (MAX)	10	0
Chromium	0.1	0.0081	0.0037	0.024	10	8
Cobalt		NC	NC	<0.02 (MAX)	10	0
Copper	1.3	0.0085	0.00582	0.038	10	6
Iron		NC	NC	0.02 (MAX)	10	1
Lead	0.05	NC	NC	0.0011 (MAX)	10	1
Manganese	0.18	0.0033	0.0019	0.017	10	4
Mercury	0.002	NC	NC	0.0001 (MAX)	10	2
Molybdenum	0.17	0.0043	0.0023	0.014	10	8
Nickel	0.1	NC	NC	<0.03 (MAX)	10	0
Selenium	0.05	NC	NC	0.002 (MAX)	10	0
Silver	0.17	NC	NC	<0.0006 (MAX)	10	0
Strontium	21	0.096	0.036	0.24	10	10
Thallium	0.002	NC	NC	<0.0006 (MAX)	10	0
Tin	0.006	NA	NA	NA	0	0
Uranium	0.02	NC	NC	0.0012 (MAX)	10	2
Vanadium	0.24	0.03	0.024	0.13	10	10
Zinc	10	0.0095	0.0089	0.045	10	10
Plutonium-238 (1)	15	0.0027	0.012	0.051	10	10
Plutonium-239/240 (1)	15	0.020	0.016	0.083	10	10
Americium-241 (1)	15	0.028	0.011	0.070	10	10
Gross Alpha (1)	15	0.7	1.16	5.32	10	10
Gross Beta (1)		4.7	2.26	13.7	10	10
Gross Gamma (1)		-1	41.2	163	10	10

Source: 10 wells reported in LANL 1994

(1) - Units are pCi/L
NA - Not analyzed
NC - Not calculated
MAX - Maximum value, not UTL, is reported.

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