Environmental Restoration
University of California
Environmental Restoration Project, MS M992
Los Alamos, New Mexico 87545
505-667-0808/FAX 505-665-4747

U. S. Department of Energy
Los Alamos Area Office, MS A316
Environmental Restoration Program
Los Alamos, New Mexico 87544
505-667-7203/FAX 505-665-4504

RECEIVED

Date: September 10, 1998
Refer to: EM/ER:98-337

LIBRARY COPY

Mr. Benito Garcia
NMED-HRMB
P.O. Box 26110
Santa Fe, NM 87501

SUBJECT: SAP FOR PRS 21-015 (FORMER OU 1106, FU 1)

Dear Mr. Garcia:

Enclosed please find the Sampling and Analysis Plan for Potential Release Site 21-015. We are submitting it to the New Mexico Environment Department as required in the Schedule of Compliance.

If you have any questions, please call Dave McInroy at (505) 667-0819 or Joe Mose at (505) 667-5808.

Sincerely,

Julie A. Canepa, Program Manager
LANL/ER Project

Sincerely,

Theodore J. Taylor, Program Manager
DOE/LAAO

JC/TT/JW/dm

Enclosure: SAP for PRS 21-015 (Former OU 1106, FU 1)

10349

Cy (w/ enc.):
D. Daymon, EM/ER, MS M992
D. McInroy, EM/ER, MS M992
J. Mose, LAAO, MS A316
D. Neleigh, EPA, R.6, 6PD-N
J. Newlin, CST-7, MS M992
C. Rodriguez, CIO/ER, MS M992
T. Taylor, LAAO, MS A316
T. Trujillo, DOE-AL, MS A906
J. White, ESH-19, MS K490
S. Dinwiddie, NMED-HRMB
M. Leavitt, NMED-GWQB
J. Parker, NMED-HRMB
G. Saums, NMED-SWQB
S. Yanicak, NMED-AIP, MS J993
RPF, MS M707

Information Only (w/o enc.):
T. Baca, EM, MS J591
D. Boak, TSA-10, MS M992
T. George, EM/ER, MS M992
T. Longo, DOE-HQ, EM-453
J. Plum, LAAO, MS A316
S. Rae, ESH-18, MS K497
G. Rael, AL-ERD, MS A906
J. Vozella, LAAO, MS A316
J. Walterscheid, EM/ER, MS M992
EM/ER File, MS M992

State of New Mexico
ENVIRONMENT DEPARTMENT
Hazardous & Radioactive Materials Bureau
2044 Galisteo Street
P.O. Box 26110
Santa Fe, New Mexico 87502
(505) 827-1557
Fax (505) 827-1544

GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

June 4, 1999

Mr. Theodore Taylor, Project Manager
Los Alamos Area Office
Department of Energy
528 35th Street, MS A316
Los Alamos, New Mexico 87544

Mr. John Browne, Director
Los Alamos National Laboratory
P. O. Box 1663, MS A100
Los Alamos, New Mexico 87545

RE: Approval of the Sampling and Analysis Plan for SWMU 21-015
Los Alamos National Laboratory
NM0890010515

Dear Mr. Taylor and Mr. Browne:

The Hazardous and Radioactive Materials Bureau (HRMB) of the New Mexico Environment Department has reviewed LANL's Response to Request for Supplemental Information and approves the Sampling and Analysis Plan for SWMU 21-015 dated September 10, 1998 and referenced by EM/ER:98-337, LA-UR-98-2901.

Should you have any questions regarding this letter, please contact me, John Kieling, at (505) 827-1558 x1012.

Sincerely,

John E Kieling

John Kieling, Supervisor
DOE Corrective Action Section,
Hazardous and Radioactive Materials Bureau

JEK:eaf

TL

cc: J. Bearzi, NMED HRMB
J. Canepa, LANL EM/ER, MS M992
J. Davis, NMED SWQB
E. Frank, NMED HRMB
M. Kirsch, LANL EM/ER, MS M992
H. LeDoux, DOE LAAO, MS A316
D. McInroy, LANL EM/ER, MS M992
D. Neleigh, EPA, 6PD-N
J. Parker, NMED DOE OB
J. Vozella, DOE LAAO, MS A316
S. Yanicak, NMED DOE OB, MS J993
File: Reading and HSWA LANL 1/1106/21
Track: LANL, Doc date, NA, DOE/LANL, NMED HRMB/Kieling, RE, File

LANL WF

LA-UR-98-2901
September 1998

Sampling and Analysis Plan for Potential Release Site 21-015

Environmental Restoration Project
A Department of Energy Environmental Cleanup Program

Los Alamos
NATIONAL LABORATORY
Los Alamos, NM 87545

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

CONTENTS

FIGURES ..... **V**

TABLES ..... **VI**

1.0 INTRODUCTION **1**

1.1 Objectives and Scope 3

1.2 Approach and Implementation 4

1.3 Background Issues 4
- 1.3.1 Regulatory Requirements 4
- 1.3.2 Other Issues 4

1.4 Data Quality Objectives Process 5

2.0 PRS 21-015, MDA B **6**

2.1 Characterization and Setting 6
- 2.1.1 Site Description 6
- 2.1.2 Operational History 12
- 2.1.3 Waste Characteristics 13

2.2 Investigatory Approach 13
- 2.2.1 Existing Data 13
  - 2.2.1.1 Nonsampling 13
  - 2.2.1.2 Sampling 14
- 2.2.2 Conceptual Model 19
  - 2.2.2.1 Nature and Extent of Contamination 19
  - 2.2.2.2 Fate and Transport 19
  - 2.2.2.3 Data Gaps 23
- 2.2.3 Sampling Activities 24
  - 2.2.3.1 Contaminant Source 25
  - 2.2.3.2 Media Characterization 26

3.0 DATA COLLECTION DESIGN AND PROCEDURES **26**

3.1 Data Quality Objectives 26

3.2 Quality Assurance/Quality Control 27

3.3 Field Activities 27

4.0 PROJECT MANAGEMENT **33**

4.1 Project Scheduling and Reporting Requirements 33

4.2 Health and Safety Plan 33

4.3 Investigation-Derived Waste Plan 33

4.4 Community Relations Plan 33

REFERENCES **35**

APPENDIX A ACRONYMS **A-1**

APPENDIX B TABLE 2.2-3 ..... **B-1**

APPENDIX C SOIL-GAS SAMPLING PROCEDURE FOR OPEN BOREHOLES **C-1**

FIGURES

1-1	Location map of TA-21 within Los Alamos National Laboratory, Los Alamos County, New Mexico	2
1-2	Location of TA-21 with respect to Laboratory TAs and surrounding land holdings.	3
1-3	Data-use decision logic diagram for final remedy selection	7
1-4	Data-use decision diagram for protectiveness required, type and extent of final cover	8
2.1-1	Location and topography of MDA B at TA-21	9
2.1-2	Generalized stratigraphy of TA-21	10
2.2-1	Aerial photograph of the MDA B area (approximately 1945 to 1948)	14
2.2-2	Map of MDA B showing location of test holes drilled in 1966	15
2.2-3	Surface soil sampling locations at MDA B during the 1994 investigation	18
2.2-4	Map of MDA B showing possible layout of disposal beds and proposed locations of angled boreholes	25
2.2-5	Proposed 1998 surface sampling locations at MDA B	26
3.3-1	Schematic diagram of angled borehole	29

TABLES

2.2-1	Physical properties of solvents	21
2.2-2	Physical properties of ethers	22
2.2-3	Summary of analyses to be performed in the MDA B investigation	B-1
3.3-1	Summary of sampling method requirements	28
3.3-2	Borehole core sampling methods requirements	28
3.3-3	Analyte suites and analytical methods for analysis of organic constituents in core samples	30
3.3-4	Analyte list, EDLs, and analytical methods for inorganic constituents (metals) in core samples	31
3.3-5	Analyte list, EQLs, and analytical methods for radionuclide constituents in soil, asphalt, vegetation, and core samples	32

1.0 INTRODUCTION

This sampling and analysis plan (SAP) describes the investigation planned for Material Disposal Area (MDA) B, Potential Release Site (PRS) 21-015, as part of Los Alamos National Laboratory's (the Laboratory's) Environmental Restoration (ER) Project. MDA B is a solid waste management unit (SWMU) under the Hazardous and Solid Waste Amendment (HSWA) and is listed in Module VIII of the Laboratory's Resource Conservation and Recovery Act (RCRA) hazardous waste facility permit. MDA B is located on the west end of DP Mesa in Technical Area (TA) 21 and consists of one or more liquid waste disposal trenches and one or more trenches containing radioactive waste. The exact number of trenches is unknown. The nature of the waste is highly heterogeneous, it is mostly contaminated debris, and the addition of liquids is generally thought to have been minimal. Portions of MDA B are covered with asphalt, and vegetation is growing through cracks in the asphalt. A Phase I RCRA facility investigation (RFI) of this area was completed in 1994 (Environmental Restoration Project 1996, 58213) primarily to identify areas of potential surface contamination from the southern fence at MDA B to the edge of BV Canyon. This Phase I subsurface investigation will take place during 1998 and will provide the additional data needed to define the nature of contamination beneath MDA B. These data will support a risk assessment and the development and screening of alternatives for closing the site. This SAP is consistent with the subsurface sampling approach outlined in Section 1.5.1, Chapter 16, of the TA-21 work plan (LANL 1991, 07529, p 16-6).

MDA B is one of approximately 25 MDAs or landfill-like PRSs at the Laboratory that can be described as engineered subsurface waste disposal. These sites offer unique challenges to the ER Project because of complexities associated with inventory, source terms, transport mechanisms, and risk. Having been used for the disposal of Manhattan Project era waste, the inventory, as well as the nature and extent of potential releases, are difficult to characterize by sampling and analysis. While present-day risk to human health and the environment is low, there is a potential future risk if contamination is made accessible by one or more transport pathways, including subsurface groundwater transport and biological perturbation. Recognizing that risk will remain low so long as contamination is inaccessible, alternative final remedies include inventory removal (and disposal elsewhere) and confirmatory sampling or stabilization in place and long-term monitoring.

The MDA core document is being developed, with direct involvement of the New Mexico Environment Department and DOE, to standardize and expedite the RFI/corrective measures study (CMS) process for MDAs and similar PRSs. The core document will prescribe streamlined site characterization and final remedy selection/evaluation. The RFI activities undertaken to characterize nature and extent of contamination at all MDAs and similar sites will be focused on information that is necessary and sufficient to support the CMS. This information includes data needed to perform fate and transport and risk assessment modeling to evaluate alternative remedies to ensure enduring protection of human health and environment.

In the interim, before the core document is implemented, RFI activities at MDAs, including those at MDA B, will proceed based on guidance from the MDA core document team to ensure consistency in approach. As a result of such guidance, the objective of this SAP is to collect field information that will assist understanding of the conceptual model of the site. This includes data related to both nature and extent of contamination (in a bounding sense) as well as environmental setting.

The Laboratory is a multidisciplinary research facility owned by the Department of Energy (DOE) and managed by the University of California. The Laboratory is located in north-central New Mexico approximately 60 miles northeast of Albuquerque and 20 miles northwest of Santa Fe (Figure 1-1). The Laboratory site covers 43 square miles of the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep canyons containing ephemeral and intermittent streams that run from west to east. Mesa tops range in elevation from approximately 6200 ft to 7800 ft. The eastern portion of the plateau stands 300–900 ft above the Rio Grande. TA-21 is located at the northern end of the Laboratory, south of State Road 502 and east of the main portion of the Los Alamos townsite (Figure 1-2).

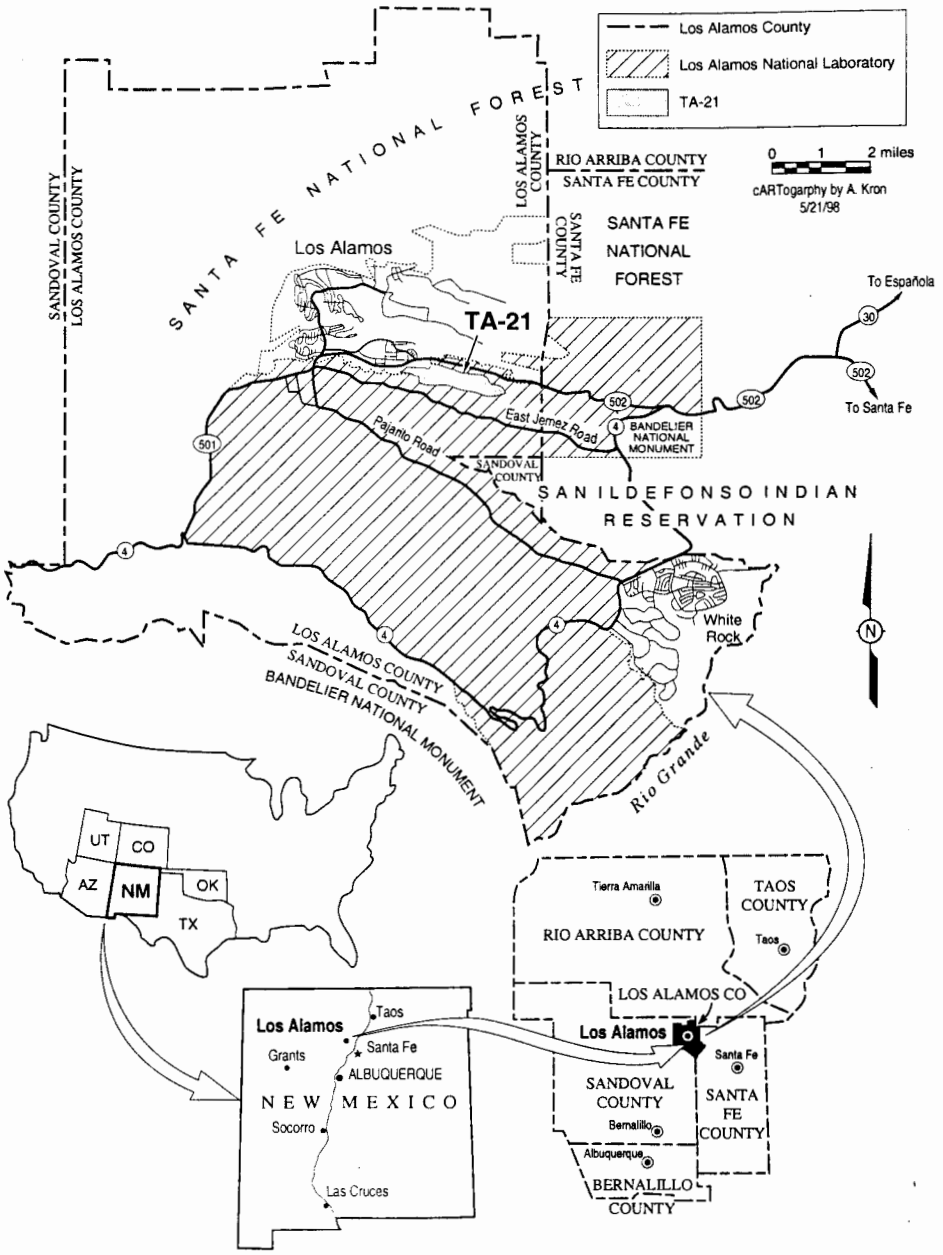

Figure 1-1. Location map of TA-21 within Los Alamos National Laboratory, Los Alamos County, New Mexico.

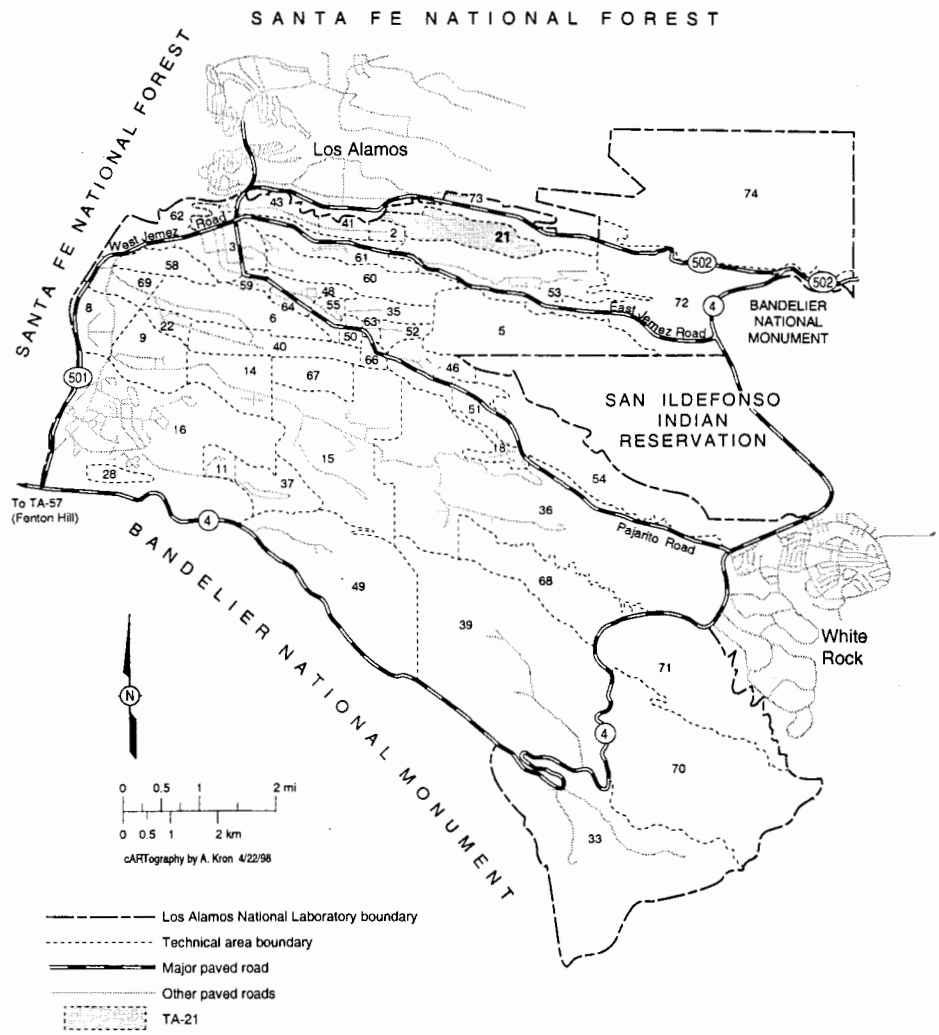

Figure 1-2. Location of TA-21 with respect to Laboratory TAs and surrounding land holdings.

This SAP is organized into four chapters. Chapter 1.0 contains the introduction; Chapter 2.0 contains detailed information about the site, including a description, operational history, conceptual model, and proposed sampling plan; Chapter 3.0 presents the data collection design and procedures; and Chapter 4.0 presents project management details. Appendix A lists the acronyms used in this document.

1.1 Objectives and Scope

The objective of this investigation is to obtain

- data to confirm the presence or absence of contaminants beneath the MDA B trenches and
- data necessary to evaluate whether there is contaminant migration from MDA B to surface soil and drainages.

1.2 Approach and Implementation

The proposed sampling will consist of collecting surface soil samples on the north and west sides of the paved area and subsurface soil cores under the asphalt pad and disposal trenches. The subsurface sampling collection is designed to ensure the maximum probability of detecting contaminant migration beneath MDA B.

Geophysical techniques will be used to determine the location and depths of the disposal trenches in MDA B. This information will subsequently be used to plan activities for angled borehole drilling to ensure that the disposal trenches are not penetrated and to determine the total length of the borehole required to collect core samples under the disposal trench area. This information will also be used in the future evaluation of alternatives for closing MDA B to determine the volume of material that would have to be excavated under an excavation alternative.

Core samples of the upper 2 feet of soil under the asphalt pad will be collected to determine water content of the soil. These data will be used in future analyses to determine if surface water entrapped under the asphalt is acting as a driving force for contaminant migration.

The field investigation of the area under the disposal trenches will include angled borehole drilling to determine if migration has occurred from MDA B and, if so, the nature of the subsurface contamination and the rate of migration. The core samples from the boreholes will be screened for radionuclides and organics, logged, and analyzed for metals, radionuclides, semivolatile organic compounds (SVOCs), and volatile organic compounds (VOCs).

Additional sampling of surface soils will be conducted on the west and north side of MDA B to determine if contaminants migrated into the MDA B drainage. Surface samples will be analyzed for radionuclides, SVOCs, and metals. These data would be used to finalize a determination of whether or not there was a release of contaminants to the surface from MDA B.

1.3 Background Issues

1.3.1 Regulatory Requirements

The investigation, including sampling and analysis, of SWMUs is conducted under requirements of Module VIII of the Laboratory's hazardous waste facility permit, which was issued on May 23, 1990, (EPA 1990, 1585) and modified on May 19, 1994.

An additional standard for radiological contaminants is DOE Order 5400.5, Radiation Protection of the Public and the Environment. In 1993, this DOE order was issued as a proposed rule [proposed Title 10 Code of Federal Regulations (CFR) Part 834] in the Federal Register. It covers, among other topics, establishment of dose limits to the public from radiation and radionuclides associated with DOE operations (58 Federal Register 16268). Although radionuclides are regulated by the DOE and are not regulated under RCRA, it is more efficient and cost effective to investigate all types of potential contamination during a single site characterization. Therefore, radiochemical concerns are addressed in this SAP.

1.3.2 Other Issues

MDA B is part of a proposed land transfer from DOE to others. It is expected that land transfer issues will include land-use projections that will affect risk evaluation scenarios, cleanup levels, and stabilization options.

1.4 Data Quality Objectives Process

Data quality objectives (DQOs) are specified in planning sample collection activities to ensure that the appropriate data are collected to support decisions about the alternatives being evaluated to close the site. Determining the DQOs depends upon the following inputs:

- a description of the problem,
- the desired decisions,
- information required to make decisions about the alternatives for closing the sites, and
- physical boundaries to which the decisions apply.

These inputs are described below.

MDA B contains principally radioactive waste in a solid form. Liquid waste disposal also occurred in at least one trench at the eastern end of MDA B (Section 2.1.2). No data exist on source concentrations. No subsurface sampling within the MDA B fence has been done. Data are required to confirm the presence or absence of contamination beneath MDA B, and if contamination is confirmed, calculate the rate of migration over the last 50 years. These data and existing geochemical and mineralogical data of the MDA B area will be used to screen alternatives for closing the site. These alternatives include no further action, placing a final engineered cover over MDA B, excavation and disposal of the material within MDA B, or a combination of the above.

No Further Action or Final Cover Alternative. To screen a no further action or final cover alternative, it will be necessary to calculate if migration has occurred (migration rate), how far it traveled over the last 50 years beneath MDA B, evaluate how contaminants could migrate from MDA B over time with or without a final cover, and estimate whether or not these alternatives would be protective of humans and ecological receptors. If a final cover is proposed for MDA B, it should be designed to limit percolation through MDA B, limit intrusion, limit the accumulation of moisture under the final cover, and therefore limit any existing contaminant migration from MDA B. Future migration rates with and without a final engineered cover will be simulated using data from this sampling program as input to computer models, such as the Finite Element Heat and Mass (FEHM) computer code used in the performance assessment for MDA G. The output of the model also will be used to assess future risks.

The data needed to support the computer model include mineralogical and geochemical properties of the subsurface under MDA B, whether there has been subsurface migration of contaminants beneath the MDA and if so to what extent, the rate of any migration, and a determination of whether or not fractures have acted as a pathway for contaminant migration.

No additional data on mineralogical and geochemical properties of the MDA B area will be collected during this subsurface investigation. Existing data on mineralogical and geochemical properties from Borehole 21-2523, near MDA V, will be used if modeling simulations for MDA B are conducted (Section 2.2.1.2). MDA V is adjacent to MDA B and representative of the geology of MDA B. This subsurface investigation is based on obtaining representative samples under each of the disposal trenches to determine if migration has occurred, characterize the nature of contamination in the subsurface, and determine the rate of migration over the last 50 years. This field investigation also includes drilling along fracture intersects to evaluate whether there is contaminant migration in fractures and in areas surrounding fractures.

Excavation Alternative. The data required to screen an excavation alternative are to determine the dimensions of each disposal trench. A geophysical survey of the trenches will be used to determine the dimensions. The disposal trenches will not be characterized during this investigation to avoid drilling into unknown materials disposed of in the trenches. If excavation is selected as the final remedy, characterization will occur as excavation progresses.

Boundary Investigation. The subsurface boundary of this investigation is the area directly beneath MDA B. This field investigation will examine the nature of contamination and spatial trends beneath MDA B, provide data to assess current human health and ecological receptor hazards, and assess pathways for contaminant migration, including fracture flow and water that may have accumulated under the asphalt pad. The rate of migration will be evaluated and estimated by studying decreasing trends in contaminant concentrations in boreholes. The surface boundaries of this investigation are areas to the north and west of MDA B where data gaps exist from the 1994 surface sampling program.

The information gathered from this field investigation and subsequent data analysis will be used to plan for any further field investigation to finalize data gaps required to answer the following questions:

1. Will the selected remedy be protective of human health and ecological receptors? Is the selected remedy cost-effective? What are the cost/benefit differences among alternatives?
2. What type and extent of final engineered cover is required if a cover is the selected remedy? What benefits is the final cover to achieve?
3. What is the volume of the contaminated material in disposal trenches?

To help establish data needs for the MDA B investigations, data-use decision logic diagrams were developed for final remedy selection (Figure 1-3) and for protectiveness required for a final cover alternative (Figure 1-4). The decision logic diagram for final remedy selection shows how the characterization will be used to evaluate data, determine the need for additional data, and prepare a risk assessment. A key component of the data assessment strategy is the use of a risk assessment to evaluate long-term risk to humans and ecological receptors after construction of the final cover over MDA B or excavation of the MDA. The first steps before a risk assessment are an evaluation of the key assumptions used to develop the sampling approach and updating the conceptual site model for MDA B.

Data from the surface soil investigation will be used to complete the 1994 evaluation of potential releases to MDA B surface soil and drainages.

2.0 PRS 21-015, MDA B

2.1 Characterization and Setting

2.1.1 Site Description

MDA B (PRS 21-015) is an inactive disposal site located on DP Mesa just west of the fenced area of TA-21 and south of commercial businesses on DP Road (Figure 2.1-1). The PRS is a SWMU listed in Module VIII of the permit. MDA B was operated from 1945 through 1948. The approximate area of the MDA is 6 acres (24,000 m^2); the TA-21 work plan states that buried waste pits occupy about 4650 m^2 with an estimated volume of 21,240 m^3 (LANL 1991, 07529, p. 16-24). MDA B consists of two areas, an unpaved fenced eastern area and a paved, fenced western area, neither of which have any surface structures. Vegetation has penetrated portions of

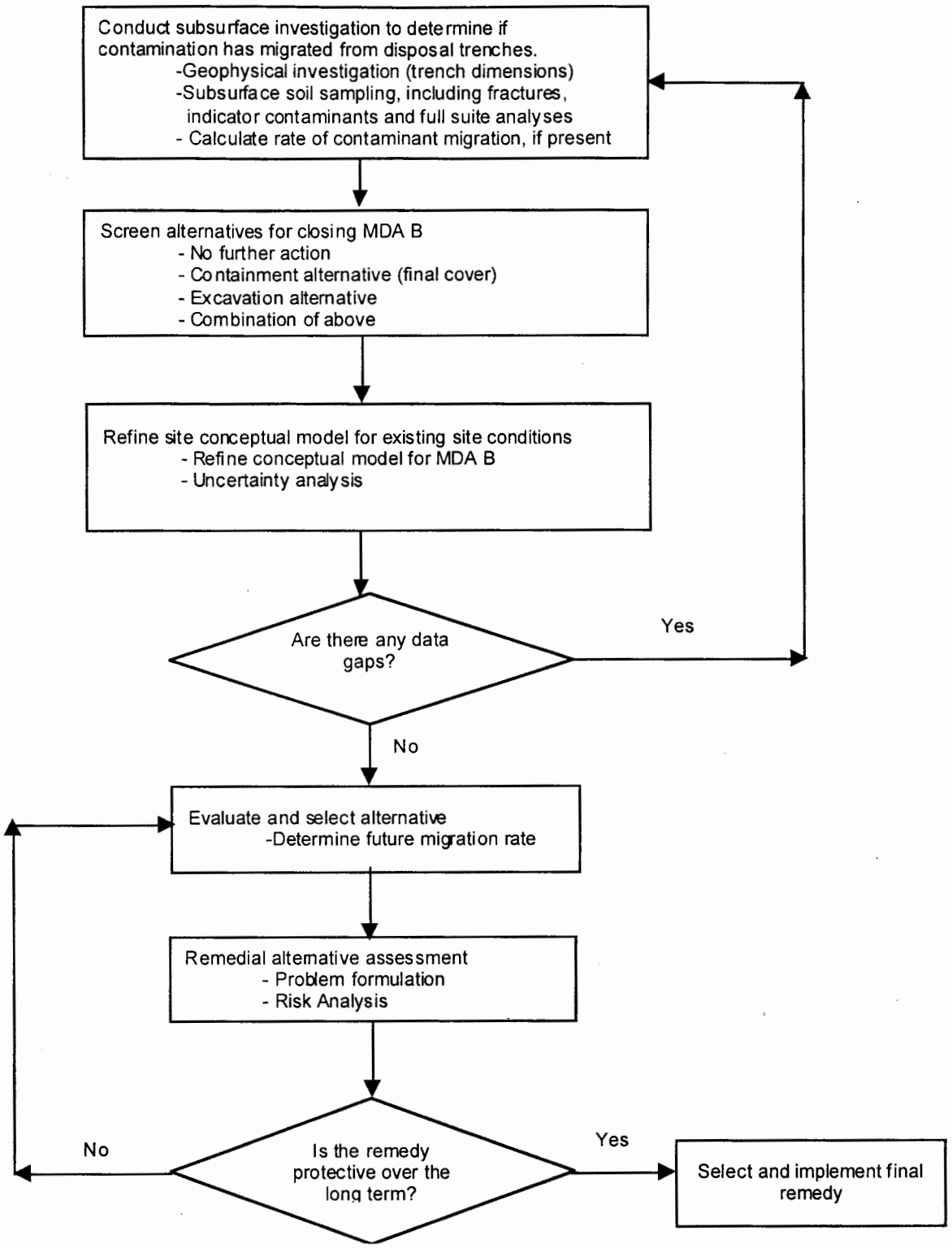

Figure 1-3. Data-use decision logic diagram for final remedy selection.

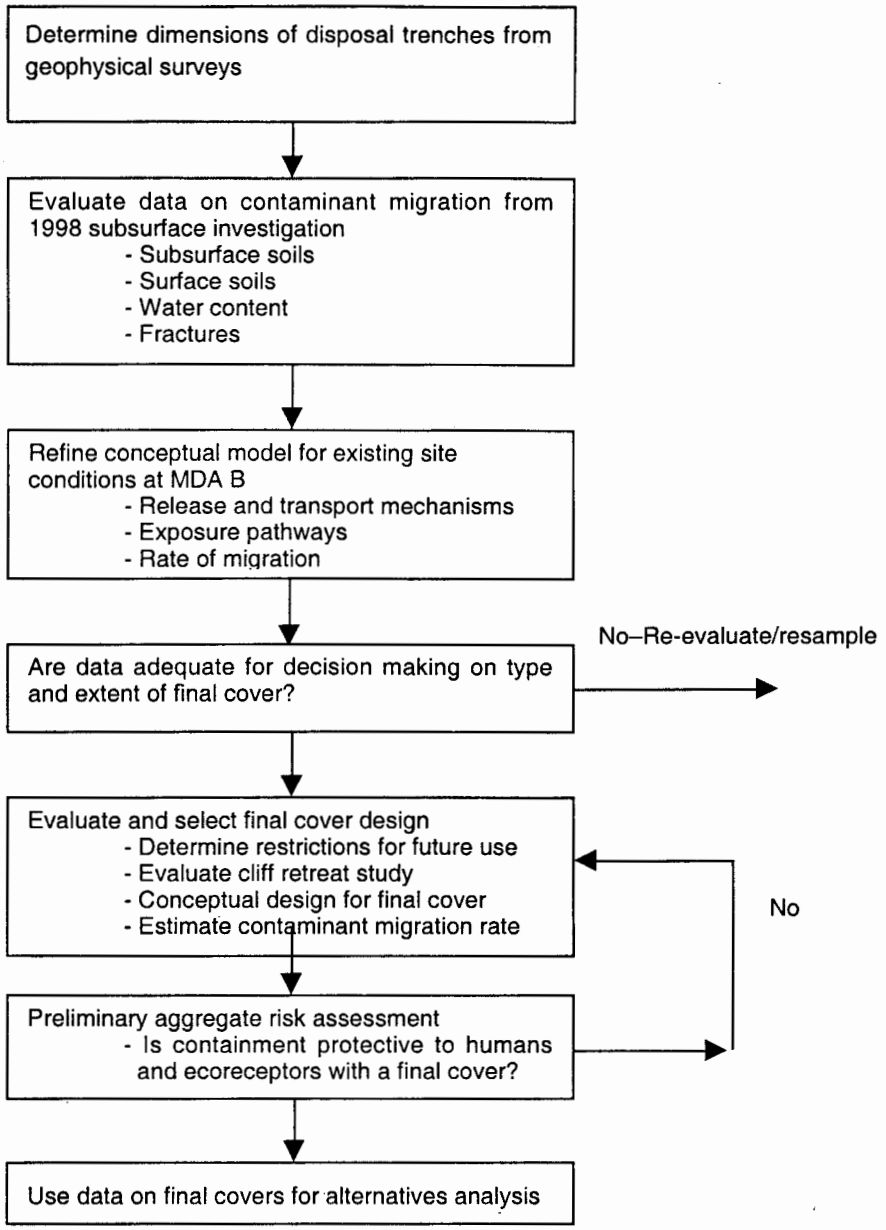

Figure 1-4. Data-use decision logic diagram for protectiveness required, type, and extent of final cover.

the asphalt pad, and trees line a portion of the northern boundary. The area on the north side of MDA B is covered with pavement and buildings from the commercial development along DP Road. The number of trenches in MDA B is unknown. The disposal trenches were reported to be approximately 15 ft wide by 300 ft long by 12 ft deep, and they were not lined (LANL 1991, 07529, p. 16-24). However, preliminary data from the SAGE 1997 geophysical survey indicate only one trench in the center section of MDA B at a width of 42 ft (Ferguson et al. in press, 58212).

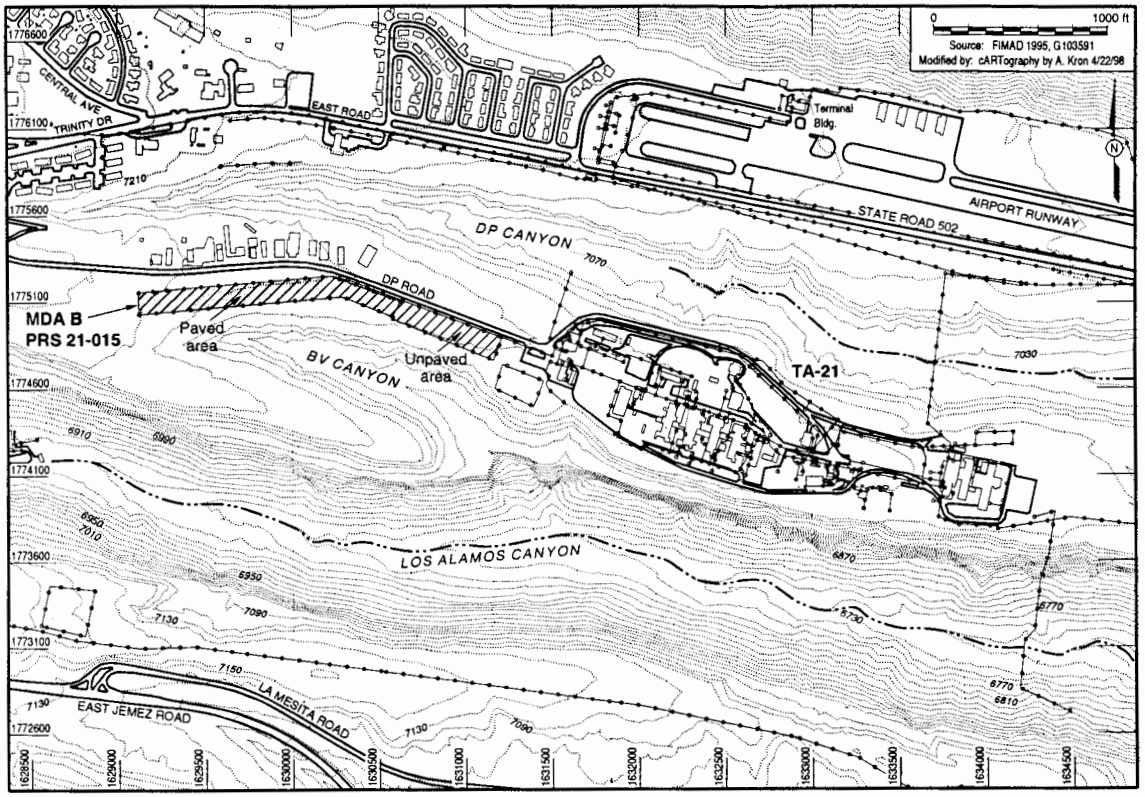

Figure 2.1-1. Location and topography of MDA B at TA-21.

Geologic Setting. Reports of geological studies at TA-21 are presented in Broxton and Eller (1995, 58207). A summary of that information, emphasizing conditions relevant to MDA B, is presented below.

TA-21 is located on DP Mesa at an elevation of 7120–7150 ft, approximately 1200 ft above the regional aquifer. The mesa is bounded on the north by DP Canyon and on the south by Los Alamos Canyon. The generalized stratigraphy of TA-21 is presented in Figure 2.1-2. MDA B is cut into Cooling Unit 3 of the Upper Member (Tshirege) of the Bandelier Tuff. Unit 3 is a cliff-forming, nonwelded to partially welded unit. At this location, the Bandelier Tuff is approximately 710 ft thick. Units exposed on the canyon walls on either side of TA-21 are poorly welded and rather easily eroded in areas near the mesa top and are strongly welded cliff-forming units in the lower areas. The strongly welded units exhibit well-developed fracturing.

Soils. At undisturbed areas at TA-21, moderately to well-developed soils overlie Bandelier Tuff and alluvium. Soils belong to either the Hackroy or Nyjack soil series (Nyhan et al. 1978, 5702). The Hackroy series consists of very shallow to shallow, well-drained soils that have an A-Bt-R profile. Soil textures range from sandy loam to clay. The Nyjack series consists of moderately deep, well-drained soils that have an A-Bt-C-R profile. Texture ranges from gravely sandy loam to clay loam. In the TA-21 area, the R horizon is highly fractured Bandelier Tuff that shows signs of incipient weathering and usually has a clay-rich soil matrix along bedrock fractures.

Most of TA-21 has been disturbed by construction and 50 years of site operations, with the result that natural soil profiles are, in general, not well preserved. For MDA B, the natural soil profiles have been disturbed by construction of waste pits, grading, and paving.

Hydrology. MDA B is located on the west and south end of DP Mesa. Surface drainage from MDA B flows south into BV Canyon, a tributary channel of Los Alamos Canyon (Figure 2.1-1). This tributary is a shallow, hanging valley incised within Tshirege Unit 3 and the underlying unwelded unit. Relatively little sediment is stored in this canyon. As flow from the canyon drops over a cliff into Los Alamos Canyon, it generally infiltrates an extensive, bouldery, colluvial deposit without reaching the main channel (Broxton and Eller 1995, 58207).

The regional aquifer beneath TA-21 is at an elevation of approximately 5900 ft (determined in Test Well 2 in Pueblo Canyon and in Otowi 4 in Los Alamos Canyon), chiefly within sediments of the Puye and Tesuque Formations (Purtymun 1995, 45344; Broxton and Eller 1995, 58207). Thus, for mesa-top sites at TA-21, such as MDA B, more than 1200 ft of tuff and volcaniclastic sediments separate the surface from the regional aquifer. In addition to the regional aquifer, a shallow alluvial aquifer exists in the sediments of Los Alamos Canyon and DP Canyon.

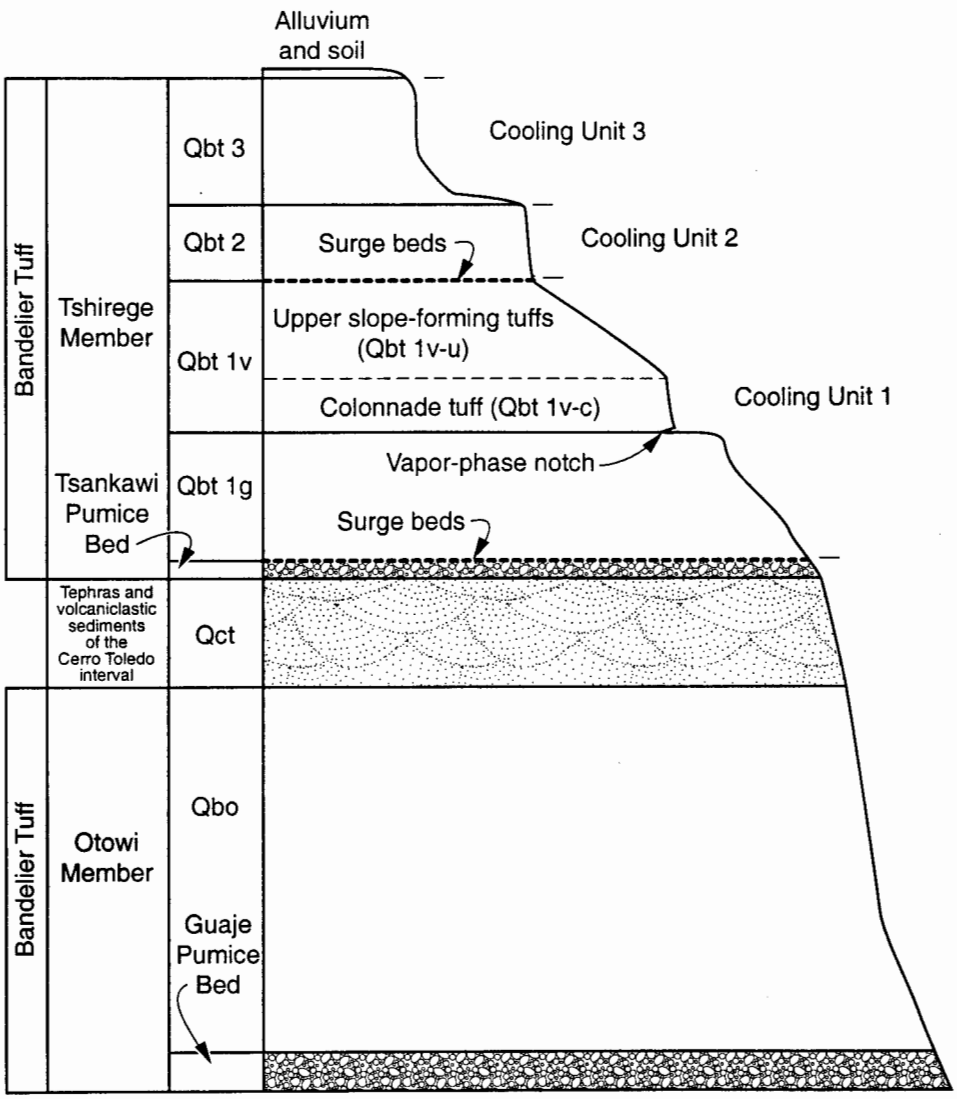

Figure 2.1-2. Generalized stratigraphy of TA-21.

Surface Water Assessment. At the Laboratory, surface water runoff and sediment transport are among the potential migration pathways by which contaminants might be transported to off-site receptors. Surface water may also access subsurface contaminants exposed by soil erosion. Soil erosion is dependent on several factors, including soil properties, the amount of vegetative cover, the slope of the contaminated area, exposure, the intensity and frequency of precipitation, and seismic activity.

The Laboratory's ER Project has assessed sediment transport and erosion concerns at specific PRSs. Surface water assessments (formerly known as 4.5 assessments) provide a basis for prioritizing and scheduling actions to control erosion of potentially contaminated soils at specific PRSs. The procedure is a two-part evaluation. Part A is a compilation of existing PRS analytical data, site maps, and knowledge-of-process information. Part B is an assessment of the erosion/sediment transport potential at the PRS. Erosion potential is numerically rated from 1 to 100 using a matrix system. PRSs that score below 40 have a low erosion potential; those that score from 40 to 60 have a medium erosion potential; and those that score above 60 have a high erosion potential.

A surface water assessment of PRS 21-015 was conducted on September 23, 1997. The assessment yielded a total score of 17.9. The calculated score included 8.8 for site setting, 8.1 for surface water runoff factors, and 0.0 for surface water run-on factors. This score indicates low erosion potential.

Biological Surveys. Comprehensive plant and animal inventories are required by the Federal Endangered Species Act of 1973; the New Mexico Wildlife Conservation Act; Executive Order 11 990, Protection of Wetlands; Executive Order 11 988, Floodplain Management; Title 10 CFR Part 1022, Compliance with Floodplain/Wetlands Environmental Review Requirements; and DOE Order 5400.1, General Environmental Protection Program. The MDA B area is addressed in a 1992 biological evaluation (Bennett 1996, 58236).

The preurban natural overstory for this portion of the mesa was a ponderosa pine forest and piñon-juniper woodland ecozone. The understory currently comprises grasses and forbs commonly found in disturbed soils (western wheat grass, Canada bluegrass, bottlebrush squirreltail, cheat grass, sand dropseed, summer cypress, prickly lettuce, and horseweed). There are no threatened or endangered species in the immediate vicinity of this site. Drainages flow south and east from MDA B into Los Alamos Canyon.

Cultural Surveys. In compliance with Section 106 of the National Historic Preservation Act of 1966 as implemented by Title 36 CFR Part 800, Protection of Historic Properties, the subsurface investigation at MDA B was reviewed for possible impacts to archaeological and other cultural resources. According to the information provided in ESH-ID Review 98-0062, the following determination was made on March 31, 1998.

- The area of potential impact is in a previously surveyed location. A cultural resource survey report covering this area has been sent to the State Historic Preservation Office and concurrence has been received. No known intact archaeological sites remain in the project area. The project can proceed without affecting any known cultural resources. If any buried archaeological artifacts or features are uncovered during sampling, work will stop, and ESH-20 archaeologists will be notified immediately.

2.1.2 Operational History

The following information was published in the TA-21 RFI work plan (LANL 1991, 07529, pp. 16-24 through 16-25).

"In 1945, pits at MDA A were being filled at such a rate that additional waste disposal pits were necessary. MDA B was a favorable location because sufficient space was available. Tyler (1945) suggested that a trench 15-ft wide by 300-ft long be dug at the eastern end of MDA B. Dow (1945) suggested that the excavation of this waste pit was to be continued until a depth of 12 ft was reached or until September 1, 1945, whichever came sooner. It is not known if the completed pit achieved the dimensions of 15 by 300 ft by 12-ft deep or precisely where it was located.

Other memos indicated there were additional pits. Meyer (1952) said that four pits were dug in MDA B by 1945 and that space was exhausted by 1948. The locations of these pits are not precisely known; however, their dimensions and orientations to fence lines are known. Personal testimony and reference to common Laboratory practice at the time suggested that four disposal pits 300-ft long, 15-ft wide, and 12-ft deep were located parallel to the fence line along DP road and that two pits of uncertain length were located in the north-south leg of MDA B at the western end of the site (Rodgers 1977).

Several sources indicated that additional trenches were located at the easternmost part of MDA B for chemical disposal. A 1964 memo (Safety Office 1964) stated that a covered shallow trench 2-ft wide by 40-ft long by 3-ft deep was located at the extreme eastern end of MDA B. Another source indicated several small slit trenches, 3-ft to 4-ft deep, 2-ft wide, and less than 40-ft long were reportedly dug in this area for chemical disposal (DOE 1987).

The exact number of pits cannot be ascertained with available information. However, one can assume that there were a minimum of four disposal pits parallel to the fence along DP road and at least one trench for chemical disposal at the easternmost end of MDA B.

A fire occurred at MDA B in 1948 (Buckland 1948). The fire was estimated to have lasted two hours, had great intensity, and covered a waste area of 2500 ft2 (McCurdy 1973). The probable cause was spontaneous combustion of mixed chemicals in waste probably containing plutonium, americium, and fission products. The location of this fire is not well known. Buckland and Enders had different recollections regarding where the fire occurred (Rogers 1978).

Because of the seriousness of the fire at MDA B and its close proximity to living and working areas, another disposal site location was selected near Ten Site (Rogers 1977). After the fire in 1949, MDA B was no longer used for waste disposal. Shortly after MDA B was closed, subsidence occurred. This was remedied by using the area for disposal of uncontaminated concrete and soil from construction sites (Rogers 1977).

MDA B was probably fenced as early as 1944 as indicated by the Meyer's memo (1952). In 1966, another request was made to replace the then-current fence with an 8-ft chain link fence (The Zia Company 1966).

The western two-thirds of MDA B was fenced and compacted in 1966 per instructions in Hilton (1966) and leased by DOE to Los Alamos County for trailer storage. The storage area is indicated by the paved area. Los Alamos County has been asked to vacate use of this site as a trailer storage area by September 30, 1990 (Bohannan 1990).

Surface stabilization of the east end of MDA B began on July 6, 1982 (Emelity 1982a) and was completed by October 15, 1982 (Emelity 1982b). The fence was moved outward by 10 ft, surfaces were decontaminated, vegetation was removed, and the area was covered with soil, compacted, and reseeded. Capping studies were initiated on the east end of Area B in 1987 to evaluate alternative cover designs."

2.1.3 Waste Characteristics

This section addresses the potential contaminants that may be present at this PRS, based on the information contained in Section 2.1.1, Site Description, and Section 2.1.2, Operational History. The following information on waste characteristics for MDA B was published in the TA-21 RFI work plan (LANL 1991, 07529).

"Nonradioactive Waste. There are some indications that hazardous chemicals may be present at MDA B: for example, Drager (1948), commenting on the 1948 fire, reported that there was some evidence that chemicals had been disposed of in the dump in an unauthorized manner, i.e., in cardboard containers used for the regular disposal of common laboratory waste. In the fire, several cartons of waste caused minor explosions, and on one occasion, a cloud of pink gas arose from the debris in the dump.

Documented employee interviews (DOE 1987) stated that chemical disposal occurred at the east end of MDA B. Chemicals disposed of included old bottles of organics, perchlorates, ethers, and solvents. A DOE (1987) document also stated that lecture bottles of mixtures, spent chemicals, old chemicals, and corrosive gases may be in the trench(es) at the east end of MDA B.

Radioactive Waste. MDA B contains solid wastes. The principal radioactive contaminants consist of the types of radioactive materials used at the time: plutonium, polonium, uranium, americium, curium, radioactive lanthanum (RaLa), actinium, and waste products from the water boiler reactor (Meyer 1952). However, approximately 90% of the waste consisted of radioactively contaminated paper, rags, rubber gloves, glassware, and small metal apparatus placed in cardboard boxes by the waste originator and sealed with masking tape. The remainder of the material consisted of metal, including air ducts and large metal apparatus. The latter type of material was placed in wood boxes or wrapped with paper (Meyer 1952).

At least one truck contaminated with fission products from the Trinity test is buried in MDA B (DOE 1987)."

2.2 Investigatory Approach

2.2.1 Existing Data

Existing data on geologic field investigations, geophysical investigations, and previous surface and subsurface sampling are summarized in the following sections.

2.2.1.1 Nonsampling

Geologic Field Investigations. In 1992 and 1993, geologic field investigations were conducted to support the RFI at TA-21. The investigations included studies of the site geology, fractures, stratigraphy, petrography, mineralogy, and geomorphology. These investigations are summarized in the report Broxton and Eller (1995, 58207). The results pertaining to fractures and cliff retreat are summarized below.

- A total of 1662 fractures was documented and measured along a 7312-ft section along Los Alamos Canyon on a line parallel to MDA B through MDA U. Northeast-striking fractures are approximately 30% more abundant than northwest-striking fractures. Furthermore, the northeast-striking fractures (those that dip north into the northwest quadrant) are over three times more abundant than south-dipping ones. Hence, as a first approximation, slant drilling in the direction S48E should optimize fracture intersections.
- Available data on the cliff-retreat process at TA-21 suggest that exposure of buried waste by the retreat of the slopes more than 50 ft from the cliffs is unlikely within a time frame of 10,000 years or more.

Geophysical Investigations. In June 1997, SAGE conducted geophysical investigations at MDA B to delineate the boundaries of the trench in the unpaved area. A complete total field magnetic map was made using a cesium vapor magnetometer. Four seismic refractions were shot transverse to the axis of the area, and 2 longitudinally and 13 ground-penetrating radar profiles were surveyed at the western end of the unpaved area (Ferguson et al. in press, 58212). Resistivity profiles were colocated with some of the radar profiles. The results of the investigation show that there appears to be only one trench about 13 m wide, rather than two at 4.6 m (15 ft) as described the TA-21 work plan (LANL 1991, 07529, p. 16-24). This conclusion is also supported by a historical aerial photograph in the SAGE report (Figure 2.2-1). There was not sufficient seismic data to determine the three-dimensional structure of the trench.

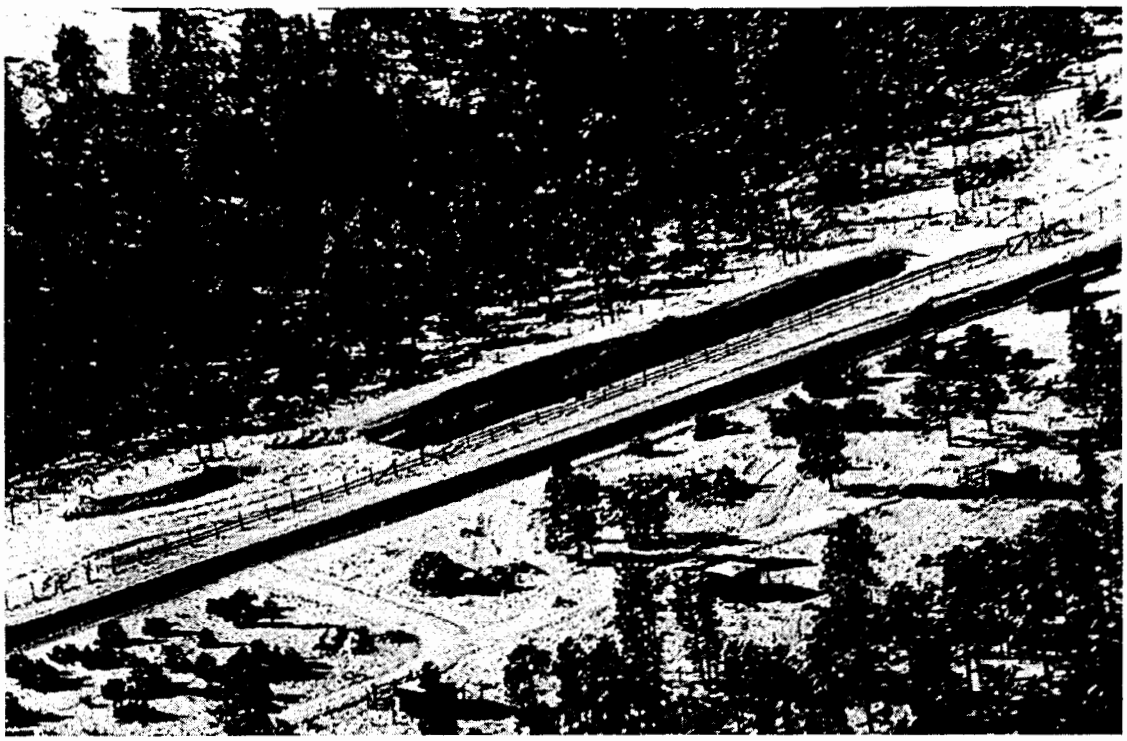

Figure 2.2-1. Aerial photograph of the MDA B area (approximately 1945 to 1948).

2.2.1.2 Sampling

Subsurface Soil Investigations. Data from previous subsurface investigations at MDA B are summarized below using information provided in the TA-21 work plan (LANL 1991, 07529, pp.

16-31 and 16-32). All of these investigations studied migration of contaminants from MDA B. These investigations focused on sampling around the periphery of the MDA and did not involve sampling of the contents of the disposal trenches or beneath them.

In 1966, the Laboratory and the USGS conducted a joint study and drilled 13 boreholes around the perimeter of MDA B [outside the disposal trenches to depths as great as 50 ft below ground surface (bgs)] (Figure 2.2-2). Data from these boreholes indicate no radioactivity greater than the background values determined for the study (7.2 pCi/g gross alpha radiation, 9 pCi/g gross beta radiation, and 3.4 µg/g total uranium). Plutonium values were less than the detection limit of 0.18 pCi/g.

In 1982, several subsurface soil samples were collected from beneath vegetation at depths to approximately 5 ft bgs for an intensive ecological study. It is not clear whether these samples were collected within the disposal trenches. Data from this study indicate that uranium and plutonium were present in soil samples at greater than background levels, and cesium was present at less than background levels. Scandium was also detected, but no background levels were provided. In addition, the results indicated a decrease in concentration with increasing depth for plutonium and cesium but no such decrease for uranium and scandium.

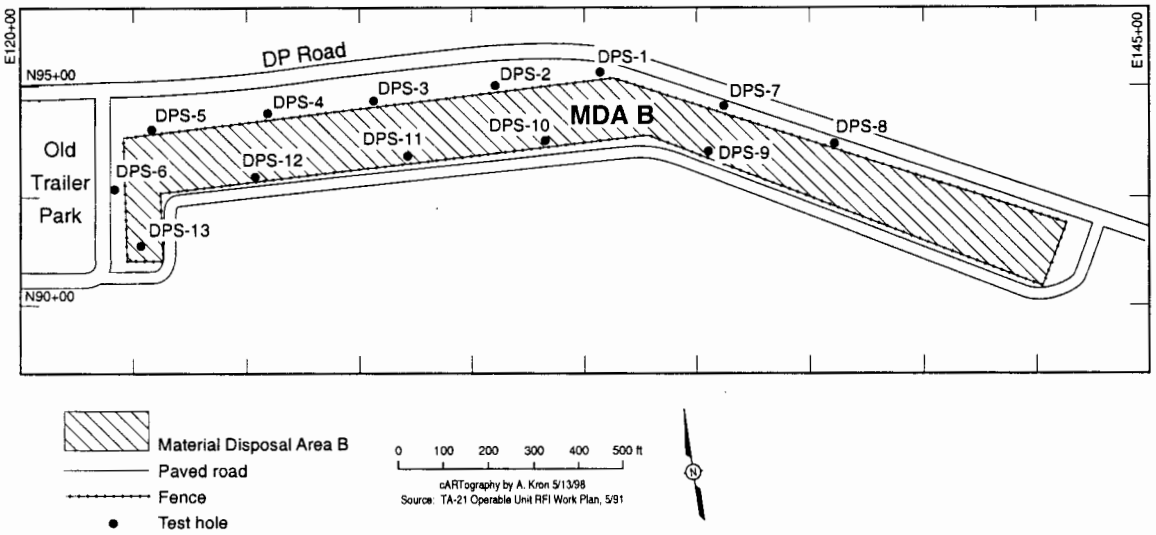

Figure 2.2-2. Map of MDA B showing location of test holes drilled in 1966.

In 1983, boreholes (two total) were drilled at the northeast and southeast edges of MDA B outside the disposal trenches to depths as great as 58 ft bgs. Samples were analyzed for tritium, uranium, plutonium-238, plutonium-239/240, and cesium-137. The report stated that cesium, plutonium-238, and most plutonium-239/240 concentrations were all within the background levels used for the study; two plutonium-239/240 levels in the 0-ft to 3-ft interval of hole B-1 (0.21 pCi/g) and the 3-ft to 8-ft interval for hole B-2 (0.25 pCi/g) were above background values used for the study. Uranium was slightly higher than the background range used for the study. However, those concentrations were within the range of surface contamination levels observed at TA-21 as a whole. Tritium concentrations, on the other hand, generally increased with depth. Tritium data are available only to a depth of 23 ft. The concentrations ranged from 7500 pCi/L to 36,000 pCi/L.

No historical data are available on the presence or subsurface migration of VOCs, SVOCs, or inorganics from MDA B.

Surface Soil Investigations. Data from surface soil investigations conducted at MDA B in the 1970s and early 1980s are summarized below using information provided in Wenzel et al. (1987, 58214).

"In 1970 a study was made of plutonium and strontium in soils at TA-21 near Area B (Kennedy and Purtymun 1971). The intent was to determine quantities of plutonium deposited from TA-21 stack emissions summarized by an earlier study by Jordan and Black in 1958. Plutonium contours were constructed at 0.005, 0.01, and 0.05 $\mu Ci/m^2$. The estimated amount Of ^{239}Pu within the 0.005 $\mu Ci/m^2$ and greater contours (the 0.01 contour included MDA B) was 0.26 Ci or 2% of the total release from the stacks through 1969.

During the late 1970s, a series of studies at MDA B was conducted as part of the environmental surveillance and radioecological programs at the Laboratory. Above background concentrations of ^{241}Am, ^{238}Pu, ^{239}Pu, ^{137}Cs, ^{233}U, total uranium, and ^{3}H were found in surface soils and vegetation of the site.

The radiological survey of the eastern unpaved portion of MDA B by Trocki in 1977 included a surface Phoswich gamma survey (energy levels 12-4 keV), surface soil sampling on a 10 x 15 m grid of the whole area, and surface soil samples where high Phoswich readings were obtained. Trocki found an 'apparent pit surface' with surface ^{233}U contamination along with high levels of surface ^{239}Pu (1370 pCi/g). Waste was exposed at the surface in this area and subsidence was evident. Line transect samples showed elevated tritium levels in the eastern portion of the site that tended to coincide with high gross alpha activity. The inventory of selected sites within MDA B showed the soil to have 0.0064 Ci of tritium. Alpha activity mainly from ^{239}Pu was 0.0047 Ci and gross beta due to ^{90}Sr and ^{60}Co was 0.0029. This study found little contamination along the northern fence of the eastern portion where fill from demolished buildings covered the area. It was Trocki's opinion that contamination in the middle and southern portion of the area was most likely due to late 1940s burial practices. Pieces of contaminated equipment were sometimes stored on the surface until a suitable pit location was available. Lack of adequate pit cover probably accounted for the above background gamma activity detected by the Phoswich over the 'apparent pit surface.'

During 1981 a decontamination crew removed most of the ^{233}U and ^{239}Pu in the surface soil near the apparent pit surface area. Soil was placed in drums and disposed at TA-54. After the surface contamination was removed, there remained large areas within MDA B with above-background levels of radionuclides along with areas of subsidence and exposed debris."

In response to a DOE milestone to complete surface stabilization of old burial sites, MDA B was covered in 1982, and all existing vegetation was removed before placement of the cover. Surface and near-surface contamination in an area near the location of the chemical disposal trench is summarized below using information provided in the report, Cesium-137, Plutonium-239/240, Total Uranium, and Scandium in Trees and Shrubs Growing in Transuranic Waste at Area B (Wenzel et al. 1987, 58214). Note that scandium was used as a trace element to mimic plutonium in this study. Scandium is not a COPC.

"Ponderosa pine 5 was found rooting in what may be a trench described by Rogers (1977) as being 90 cm wide and 2 m long. Soils in the area were deep and alpha contaminated debris was

exposed at the surface under the tree canopy. The tree was selected for excavation because of the presence of exposed 1.3-cm diameter metal pipe (electrical conduit) having measurable radioactivity (about 2000 alpha counts/minute/60 cm^2). The pipe continued downward beneath the roots. Beneath the roots some copper and electrical wires were uncovered, but had no detectable alpha radioactivity. At about 40 cm deep a mass of rubber gloves was excavated. Radioactivity on the surface of the gloves varied from 0 to 6000 alpha counts/minute. Other gloves in the area had no measurable alpha radioactivity. At 45 cm a large lateral root had come into contact with a rubber glove. The rubber glove and its contents (the glove contained a 6-cm ball of radioactive waste) provided resistance to root growth. Where the fingers of the glove had not provided resistance, the root had grown between the fingers until the resistance of the rubber had retarded growth. This gave the root the appearance of a hand. Soil and the glove measured 10,000 alpha counts/minute. Excavation was discontinued because of the high radiation levels. In the same layer there were brown Duroglass bottles still filled with liquid, rubber tubing, plaster, and metal tubing that had been painted. Roots and soils were collected and the hole backfilled. No cardboard or wood materials were found in the excavation site. This was probably due to decay of cardboard and wood and consumption by soil arthropods. There was also indication that some waste material was dumped in the trench without previous packaging."

In 1990, MDA B was surveyed and sampled intensively for surface radionuclide contamination; samples were analyzed for plutonium-238, plutonium-239/240, cesium-137, strontium-90, americium-241, tritium, and total uranium. The environmental surveillance data from the 1990 survey are summarized in Table 5.1.5-4 in the Phase I RFI report and indicate above background levels used for the study for americium-241, cesium-137, plutonium-238, plutonium-239, and uranium. All samples taken from the perimeter of MDA B had reported plutonium-239 values that were greater than the Laboratory-wide upper tolerance limit.

A Phase 1 RFI surface investigation of MDA B was conducted in 1994 to identify areas of surface contamination between the southern fence at MDA B and the edge of BV Canyon directly south of the disposal area and to determine if contaminants were migrating from the area through or into the drainage. The locations of samples taken during the 1994 surface soil investigation are shown on Figure 2.2-3. A radiological survey of MDA B was performed, and soil samples were collected from the 0- to 6-inch depth at MDA B and from the 0- to 12-inch depth in sediment at the MDA B drainage. Ninety-seven samples were analyzed for target analyte list (TAL) metals, 95 samples were analyzed for SVOCs, and 92 samples were analyzed for percent moisture, tritium, strontium, actinium-227, cesium-137, americium-241, isotopic plutonium, and total uranium. All samples were sent to a fixed-site laboratory for analysis. All TAL metals were below screening action levels (SALs). SALs were exceeded in 2 samples for cesium-137 and in 3 samples for plutomiun-239. Three polycyclic aromatic hydrocarbons were detected above SALs. The conclusions and recommendations from the RFI Report for Potential Release Site at TA-21 (Environmental Restoration Project 1996, 58213) are summarized below.

"Field survey and field screening (instruments and mobile radiological analytical laboratory) results suggest that radioactive contamination is not concentrated at any particular surface location at MDA B and has not migrated into the surface of the MDA B drainage. Environmental surveillance data collected in 1990 and data from the 1994 RFI indicate the presence of four radionuclides (cesium-137, plutonium-239, radium-226, and strontium-90) at concentrations above their respective SALs. To further investigate the potential for contact with radionuclide contamination on the north side of MDA B where potential for exposure is greater, a radiological

survey of the north side of MDA B was conducted in September 1995. No activity above the background levels used for the study was detected during this survey."

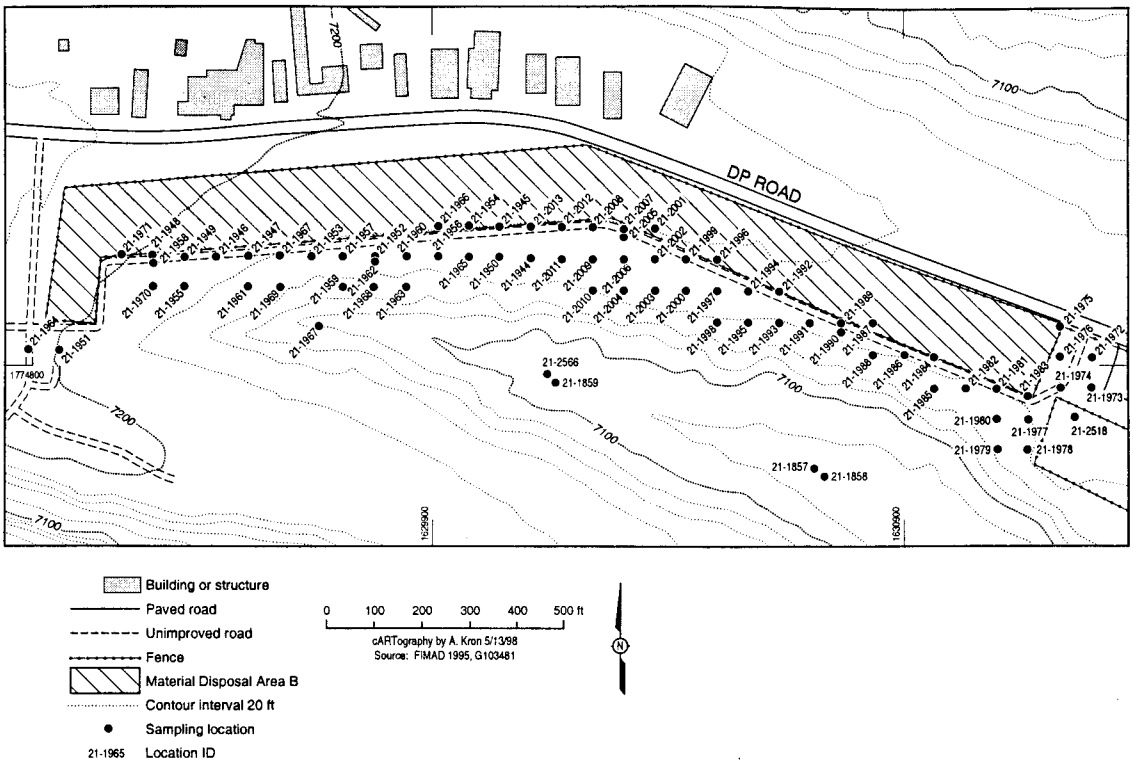

Figure 2.2-3. Surface soil sampling locations at MDA B during the 1994 investigation.

The report recommends, "Although these locations present no immediate threat to health and safety based on the results of this survey, it is recommended that additional sampling of surface soil on the north side of the paved area be done in conjunction with the Phase 1 subsurface sampling activities, and that soil samples be analyzed for radionuclides and inorganic chemicals to complete the evaluation of potential surface soil contamination."

During the 1994 RFI field investigation, budgetary constraints caused the cancellation of collection of samples on the west end of MDA B. The RFI Report for Potential Release Site at TA-21 (Environmental Restoration Project 1996, 58213) recommends the following: "Although fewer samples were collected at the west end of MDA B than elsewhere because of the change in the sampling grid, contaminants at these locations would migrate into the MDA B drainage, where they would be identified in samples taken at drainage locations. Further sampling on the west end of MDA B is recommended." The surface sampling to the north and west of MDA B was recommended to complete the 1994 evaluation of potential releases to MDA B surface soil and drainages.

Characterization of Mineralogy and Geochemical Parameters. A report on the geohydrology of TA-21, including borehole 21-2523 near MDA V (a 300-ft borehole referred to as V-DP in the work plan), is under preparation. Data on mineralogy and geochemistry from this report will be used to support any future modeling required for analyzing remedial alternatives for MDA B.

2.2.2 Conceptual Model

The conceptual model for the proposed surface and subsurface sampling is as follows. Water is perceived as the key component for contaminant migration at MDA B. Precipitation infiltration and runoff, the subsequent movement and fate of the water, and transported contaminants in the MDA B environs constitute the basic components for understanding contaminant migration at MDA B. Because of its low surface water assessment score, erosion is not considered a key component for contaminant migration at MDA B.

Water that infiltrates into the disposal trenches or surface water trapped beneath the asphalt pad can lead to enhanced percolation of water and associated waste solutes out of the burial environment. Migration of contaminants could be enhanced by the presence of fractures beneath the trenches; the fractures could be preferential routes of transport. The fractures have a high surface area for flow compared to the surface area within the rock mass surrounding the fractures. Vertical boreholes drilled by the USGS in 1966 on the periphery of the disposal trenches did not indicate migration of radionuclides. Angled boreholes will be drilled beneath the disposal trenches to determine if migration has occurred beneath the trenches and, if so, the rate of migration over the last 50 years.

If a storm or flooding event occurred, contaminants in surface soil could have been transported to the drainage and potentially carried further downgradient.

2.2.2.1 Nature and Extent of Contamination

The nature and extent of potential contaminants within and beneath MDA B is not known. The only records of the materials that were disposed of at MDA B are from employee interviews and reports from the operational history of facilities at TA-21. No sampling of the source term has been conducted. The only subsurface sampling was analysis of cores from vertical boreholes drilled outside the MDA B boundary in 1966 by the USGS, which showed radionuclides were within background values. A description of the radionuclides and organics that may be present in and beneath MDA B is included in Section 2.2.2.2.

2.2.2.2 Fate and Transport

Infiltration into surface soils depends on the rate of precipitation or snowmelt, antecedent soil water status, depth of soil, and soil hydraulic properties. Infiltration into the tuff depends on the unsaturated flow properties of the tuff. Joints and fractures in the tuff may provide additional pathways for moisture to enter the subsurface regime.

Movement of liquids in the Bandelier Tuff is dominated by unsaturated flow processes. Transient rather than steady-state conditions may describe the hydraulic character of the near-surface tuff. The influences include surface water infiltration and evapotranspiration. Liquid-water flow under ambient conditions can be represented by a porous media continuum model. A condition of nonflow may be present in the tuff below the influence of transient surface moisture effects. The movement of contaminants by liquids in the unsaturated zone may be in solution or as suspended solids. Retardation of contaminants will be primarily due to sorption on the tuff or organic material that is present on the tuff. Fractures may affect liquid transport. Their role is hypothesized to be dependent on the soil water content. Above a critical water content, fractures are expected to facilitate flow and transport. Below the critical water content, rock matrix properties will dominate the hydraulic response.

Vapor-phase processes are important as a transport process for certain contaminants. Matrix influences include porosity, permeability, moisture content, and other properties of the tuff. The exchange of pore gas with atmospheric air is a release mechanism for vapor-phase contaminants and is influenced by temperature gradients and atmospheric pressure changes. Fractures may be facilitators of gas exchange both within the rock and with the atmosphere.

Because plutonium and americium (actinides) under oxic conditions preferentially bind to fine soil or sediment particles or organic matter with high surface to volume ratios, it is likely that any actinides would tend to be concentrated in sediment catchment basins within the drainage.

Information on the fate of chemicals at MDA B, which were identified in the TA-21 work plan, is summarized below.

Radionuclides. Certain radionuclides behave similarly in the environment because of their chemical properties. Radionuclides suspected to be present at MDA B can be grouped as nonmetals, light metals, heavy metals, and actinides. The following information is summarized from Whicker and Schultz (1982, 58209, pp. 147–162).

Tritium, a nonmetal, has a half-life of about 12 years. In the form of tritiated water, tritium generally follows the hydrologic cycle. Tritium released in liquid form can be diluted by water and is subject to physical dispersion, percolation, and evaporation. Tritium readily enters plants by way of the roots.

Cesium-137, strontium-90, and radium-226 are light metals. Cesium-137 has a half-life of about 30 years. Soils and sediments of high clay content can effectively immobilize cesium by chemical binding, thus acting as a sink for cesium-137. Sandy soils with a low cation exchange capacity allow for the cycling of cesium through the system for long periods of time. The physiological and ecological behavior of cesium-137 is similar to that of potassium, an essential nutrient. A scarcity of potassium in the environment will usually lead to an increase in cesium-137 accumulation in the biota. Strontium-90 has a half-life of about 28 years. It has a tendency to form comparatively soluble compounds allowing it to be biologically mobile, transported by way of rainwater or snow melt. The physiological and ecological behavior of strontium-90 is similar to that of calcium, an essential nutrient. Plants make little distinction between the uptake of strontium-90 and calcium. Radium-226 has a half-life of about 1620 years. Radium-226 also has physiological and ecological behavior similar to that of calcium, an essential nutrient. It is reasonably mobile in the environment. Plants uptake radium by way of the roots, however, to a lesser degree than calcium.

Cobalt-60 and polonium are heavy metals. Cobalt-60 has a half-life of about 5.2 years. Cobalt is a trace element in the environment and plays a role in certain biochemical reactions of plants and animals. Cobalt-60 is readily accumulated from the environment by terrestrial organisms. Polonium is generated by the natural decay of thorium-232, uranium-238, and uranium-235. Most radioisotopes of polonium are very short-lived with the exception of polonium-210, which has a half-life of about 138 days.

Actinium, americium, plutonium, and uranium are all actinides. In general, the actinide nuclides form comparatively insoluble compounds in the environment and are not considered biologically mobile. The actinides are transported in ecosystems mainly by physical and sometimes chemical processes. Uptake of actinides by plants from soil is generally considered to be low. Plutonium in the environment undergoes hydrolysis and oxidation with PuO^2 as a common form. Under most environmental conditions, plutonium occurs in forms that are poorly transferred across biological

membranes; therefore, movement of plutonium from soil and sediments to plants and animals is greatly inhibited.

Organic Chemicals. Chemical properties, such as water solubility, adsorption coefficient, and vapor pressure, of organic chemicals help determine the fate and transport of such chemicals. Water solubility is perhaps the most important chemical characteristic used to assess chemical mobility, stability or breakdown, accumulation, bioaccumulation, and sorption. Soil sorption, chemical sorption, or bound chemicals in soil may be expressed as the extent to which an organic chemical partitions between a solid phase and a liquid phase. This value is known as the adsorption coefficient (Koc). Volatilization of a chemical into the air is an important migration pathway. The vapor pressure of a chemical provides an indication of whether a chemical will volatilize into the air. The following information is summarized from Ney (1995, 58210). Because the specific chemicals disposed of in MDA B are not known, solvents and ethers, which are discussed by Ney, are presented to give the reader an indication of the fate and transport tendencies of these kinds of chemicals.

The higher the water solubility of a chemical, the more likely it is to be mobile and less likely it is to be accumulative, bioaccumulative, volatile, and persistent. A highly soluble chemical (greater than 1000 ppm or mg/L) is prone to biodegradation and metabolism that may detoxify the parent chemical. The lower the water solubility of a chemical (less than 10 ppm or mg/L) the more likely it is that it will be immobilized by way of adsorption, and because it is less mobile, it is more accumulative or bioaccumulative, persistent in the environment, and slightly prone to biodegradation and may be metabolized in plants and animals. A chemical with a low vapor pressure (less than 0.000001 torr) is less likely to volatilize into the air. A chemical with high vapor pressure (greater than 0.01 torr) is more likely to volatilize into the air. Chemicals with a high Koc of greater than 10,000 will adsorb to soil organic carbon. Chemicals with a low Koc of 1000 will not adsorb to soil organic carbon.

Solvents, represented by dichloromethane, ethylene dichloride, 1,2,4,5-tetrachlorobenzene, trichloroethene, and toluene, have the water solubility, vapor pressure, and Koc, as shown in Table 2.2-1.

TABLE 2.2-1
PHYSICAL PROPERTIES OF SOLVENTS

Chemical	Water Solubility	Vapor Pressure	Koc
Dichloromethane	13,200 to 20,000	362.4 torr at 20°C	—
Ethylene dichloride	8690 ppm at 20°C	61 torr at 20°C	—
1,2,4,5-tetrachlorobenzene	2900 ppm	5 torr at 25°C	400
Trichloroethene	1100 ppm at 20°C	57.9 torr at 20°C	195
Toluene	534.8 ppm at 25°C	28.7 torr at 20°C	490

Dichloromethane, ethylenedichloride, and trichloroethene have a water solubility greater than 1000 ppm, indicating that the chemicals should leach, run off, and be biodegraded. They would

not adsorb to soil and should not bioaccumulate. The vapor pressures of each of these solvents are greater than 0.01 torr, indicating that these chemicals could volatilize into the air. The water solubility of toluene, supported by the Koc, indicates that toluene could leach, run off, and be biodegraded. It also should not adsorb in soil and should not be bioaccumulated. This chemical could also volatilize into the air. The water solubility supported by the Koc of 1,2,4,5-tetrachlorobenzene indicates that leaching, potential for biodegradation, and soil adsorptions should not occur.

This sampling of solvents suggests that similar solvents that may have been disposed of in MDA B have the physical properties conducive to migrating into the air by way of volatilization or migrating off site or deeper into the tuff by way of water. If any chlorinated solvents, such as 1,2,4,5-tetrachlorobenzene, were disposed of at MDA B, they may still be there.

Ethers, represented here by bis(2-chloroethyl)ether, bis(2-chloromethyl)ether, 4-bromophenyl phenyl ether, 4-chlorophenyl phenyl ether, and phenyl ether, have the water solubility, vapor pressure, and Koc, as shown in Table 2.2-2.

TABLE 2.2-2
PHYSICAL PROPERTIES OF ETHERS

Chemical	Water Solubility	Vapor Pressure	Koc*
Bis(2-chloroethyl)ether	10,200 ppm	0.71 torr at 20°C	—
Bis(2-chloromethyl)ether	22,000 ppm	30 torr	—
4-Bromophenyl phenyl ether	38 ppm at 20°C	0.0015 torr	—
4-Chlorophenyl phenyl ether	59 ppm	0.001 torr	—
Phenyl ether	21 ppm	—	—

* No data available in Ney (1995, 58210)

Bis(2-chloroethyl)ether and bis(2-chloromethyl)ether have water solubility greater than 1000 ppm, indicating that these ethers could leach, run off, and be biodegraded but should not adsorb to soil and should not be bioaccumulated. The vapor pressures are greater than 0.01 torr, indicating volatility. The water solubility parameters of 4-bromophenyl phenyl ether and 4-chlorophenyl phenyl indicate that these ethers could adsorb to soil, run off with soil, and be bioaccumulated but should not leach and should not be biodegraded. The vapor pressure indicates potential for volatility. The water solubility of phenyl ether indicates that this chemical could go either way in regard to leaching, runoff, adsorption, bioaccumulation, and biodegradation.

This sampling of ethers suggests that similar ethers that may have been disposed of in MDA B have the physical properties conducive to migrating into the air by way of volatilization or migrating by way of water off site or deeper into the tuff. Ethers are not generally as volatile as solvents.

Inorganic Chemicals. Information presented here on the fate and transport of inorganic chemicals in the soil is from Casarett et al. (1986, 58204, pp. 827–843), Brady (1974, 57672, pp. 563–566), and Budavari et al. (1996, 58033).

The fate and distribution of chemicals in the environment are determined by several variables that can interact in numerous ways, e.g., physicochemical properties of the individual chemical and the physical transport systems such as rainwater or snowmelt runoff. The physicochemical properties, such as water solubility, soils adsorption, and vaporization, are all important in determining the routes by which a metal may enter the environment and be distributed. In general, metallic cations are quite insoluble in soil, especially if the soil is not too acidic (Brady 1974, 57672, p. 565). Adsorption to particulate matter is a major mechanism by which chemicals are removed from solution and is dependent upon the type of soil. Vaporization from soil and water is a function of the vapor pressure of a chemical, as well as temperature, degree of adsorption, soil properties, and soil water content (Casarett et al. 1986, 58204, pp. 827–828). Metals, however, are not among the volatile or semivolatile chemicals. Information on a few inorganic chemicals that may have been disposed of in MDA B is presented below as representative examples of fate of inorganic chemicals in the environment.

The reaction of cadmium, copper, nickel, and zinc in soils is definitely affected by the pH, organic matter content, and the oxidation-reduction status of the soil. Ordinarily at pH values of 6.5 and above they tend to be only slowly available to plants, especially if the chemicals are present in their high-valent or oxidized forms. Consequently, most soils will tie up relatively large quantities of these elements if the soil pH is high and the drainage good (Brady 1974, 57672). Cadmium and nickel are insoluble in water; copper and zinc react slowly with ammonia water (Budavari et al. 1996, 58033). Cadmium will slowly oxidize in moist air, copper becomes dull when exposed to air, and nickel and zinc are stable in dry air (Budavari et al. 1996, 58033). Therefore, these inorganic chemicals would most likely be bound to the soil and move in the system by way of transport of soil particles by water as opposed to movement in the air because of volatilization or movement in the water as dissolved chemicals.

Inorganic mercury compounds added to soils react quickly with the organic matter and clay minerals to form insoluble compounds. In this form, the mercury is quite unavailable to growing plants (Brady 1974, 57672). Mercury is transported to aquatic ecosystems by way of surface runoff. It is tightly bound to both organic and inorganic particles. Sediments with high sulfur content will strongly bind mercury. The methylation of mercury by microorganisms is a detoxification response that allows the organism to dispose of heavy metal ions as small organometallic complexes. Conditions for methylation by sediment microorganisms are strict and occur only within a narrow pH range. The rate of synthesis of methyl mercury also depends on redox potential, composition of the microbial population, availability of Hg^{2+}, and temperature. The best conversion rate for inorganic mercury to methyl mercury under ideal conditions is less than 1.5 percent per month (Casarett et al. 1986, 58204, p. 842).

2.2.2.3 Data Gaps

The current understanding of the site remains incomplete because of the lack of data on whether subsurface migration beneath MDA B has occurred and the rate of migration beneath the trenches, if migration has occurred. This SAP fulfills the need to determine if contaminants have migrated beneath the disposal trenches, the nature of any such contamination, how far migration has occurred over the last 50 years, and whether contaminants would migrate from MDA B over time with or without a final cover. This information would then be used by risk assessors to estimate to what extent a final cover would be protective to humans and ecological receptors.

Additional data on potential surface soil contamination on the north and west side of MDA B would be used to complete the 1994 evaluation of potential releases to MDA B surface soil and drainages.

2.2.3 Sampling Activities

During 1998, a geophysical survey of the paved and unpaved areas will be conducted to locate the sides and bottoms of the disposal trenches, which will determine where the boreholes are to be placed.

In 1992, fractures were mapped along the north rim of Los Alamos Canyon, including the canyon wall south of MDA B (Broxton and Eller 1995, 58207). Generally, the mapping showed that fractures were oriented vertically and that the exposed fractures have a predominant northeast and northwest trend. Interpretation of the data suggests an additional east-west fracture set. Angled boreholes will be drilled to obtain the greatest number of potential fracture samples. This will be accomplished by intersecting at high angles as many fractures as possible near and beneath the disposal trenches. A direction of S48E was recommended in Broxton and Eller (1995, 58207) as having the best potential for intersecting fractures.

Seven angled boreholes will initially be drilled under the disposal trenches in the order shown in Figure 2.2-4. The final location of boreholes will be dependent on the geophysical survey. Boreholes 1 and 7 will be oriented and drilled to evaluate contaminant migration beneath disposal trenches in the paved area on the west side of MDA B. Boreholes 2 and 3 will be oriented and drilled to evaluate contaminant migration beneath north-south-oriented disposal trenches on the far west side of MDA B. Boreholes 4 and 5 will be oriented and drilled to evaluate contaminant migration beneath disposal trenches in the unpaved area on the east side of MDA B. Borehole 6 will be oriented and drilled to evaluate contaminant migration beneath the liquid waste disposal pit. All boreholes will be located to avoid site access restrictions, such as DP Road, or the canyon. Three additional boreholes (8, 9, and 10) may be drilled. The decision to drill and where to locate these boreholes will be based on the analysis of the results of field screening instruments used during the drilling of the first seven boreholes.

The actual angle of the boreholes, the starting point, and the borehole length will be calculated based on the capabilities of the available auger rig and the need to bore not closer than 5 ft from the outside corner of the disposal trench based on health and safety concerns of penetration of the disposal trenches. If the geophysical survey was not able to determine the dimensions of the trenches, a trench depth of 12 ft will be assumed (Section 2.1.1), and cores will be visually logged to ensure that the trench has not been penetrated.

A two- or three-dimensional figure of each borehole location will be produced to show the borehole angle, trench clearance, and total length of the borehole. Core samples from the boreholes will be logged, screened for radionuclides and organics, and sent for analysis to an analytical laboratory. Core samples will be measured for water content and analyzed for metals, radionuclides, SVOCs, and VOCs based on historical data on material that may have been disposed of at MDA B.

The amount of surface water trapped beneath the asphalt pad will be assessed. Soil samples collected from the fill under the asphalt pad during the 1998 geophysical survey will be analyzed for moisture content, as will the cores from the angled borehole drilling. These data will be used

to evaluate the potential contribution of subsurface water as a driving force to contaminant migration.

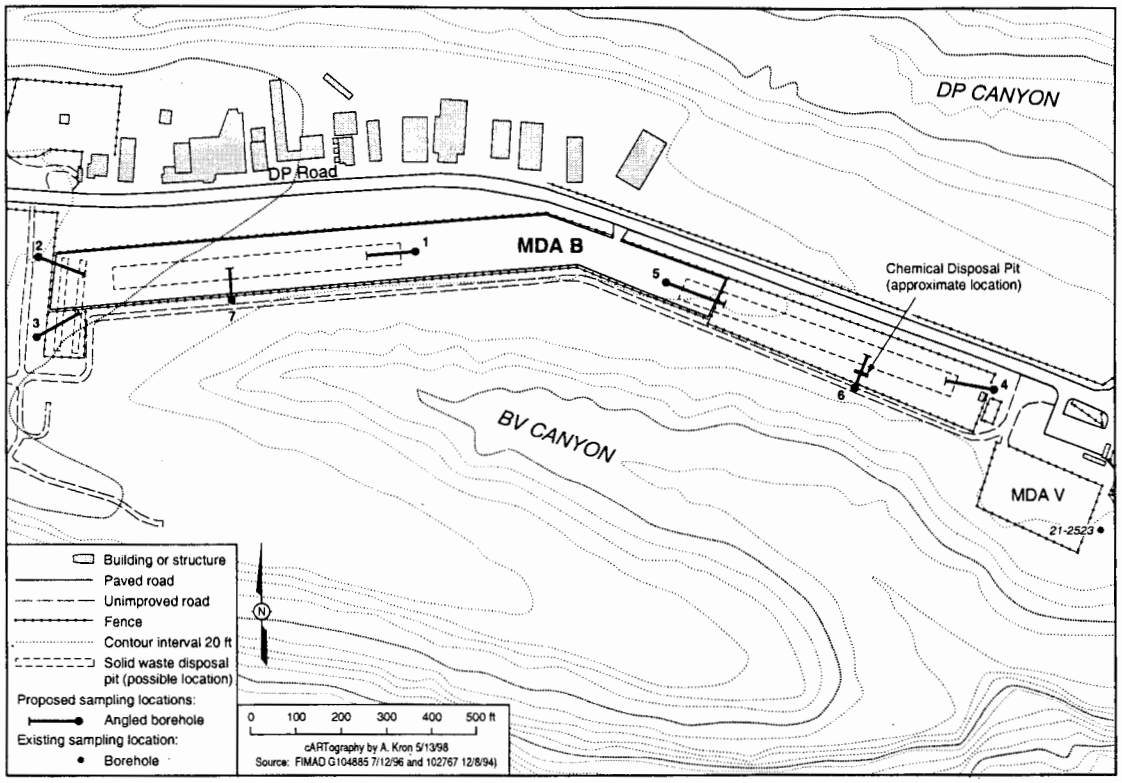

Figure 2.2-4. Map of MDA B showing possible layout of disposal beds and proposed locations of angled boreholes.

The MDA B report (Environmental Restoration Project 1996, 58213) recommended that additional sampling of surface soil be conducted on the west and north sides of MDA B to fill in surface soil data gaps. It also recommended that soil samples be analyzed for radionuclides and inorganic chemicals TAL metals to complete the evaluation of potential surface soil contamination. Eight discrete soil samples will be collected on the west end of MDA B, and twenty discrete soil samples will be collected north of the paved area. This sampling is representative of the grid spacing from the 1994 investigation (Figure 2.2-3).

Based on the sampling design discussion above and in Sections 2.2.3.1 and 2.2.3.2, the samples to be collected are presented in Table 2.2-3, Appendix B, and the sampling locations are shown on Figure 2.2-4 for subsurface sampling and Figure 2.2-5 for surface sampling.

2.2.3.1 Contaminant Source

Estimates of the contaminants in the disposal trenches (source term) will be based on historical data for radionuclides and identification of contaminants, if any, that have migrated from the disposal trenches. Direct characterization of the source term in MDA B is not practical because the material in the disposal trenches is heterogeneous; therefore, it would be difficult to obtain a representative sample. In addition, drilling into the trenches raises concerns for the health and safety of workers who could be exposed to the suspected high levels of radionuclides and hazardous chemicals buried in the disposal trenches.

2.2.3.2 Media Characterization

Media characterization will include sampling of subsurface soil below MDA B to determine if there has been migration, surface soil below the asphalt pad to determine water content, and surface soil north and west of the asphalt pad to fill in data gaps to determine risk from surface contamination.

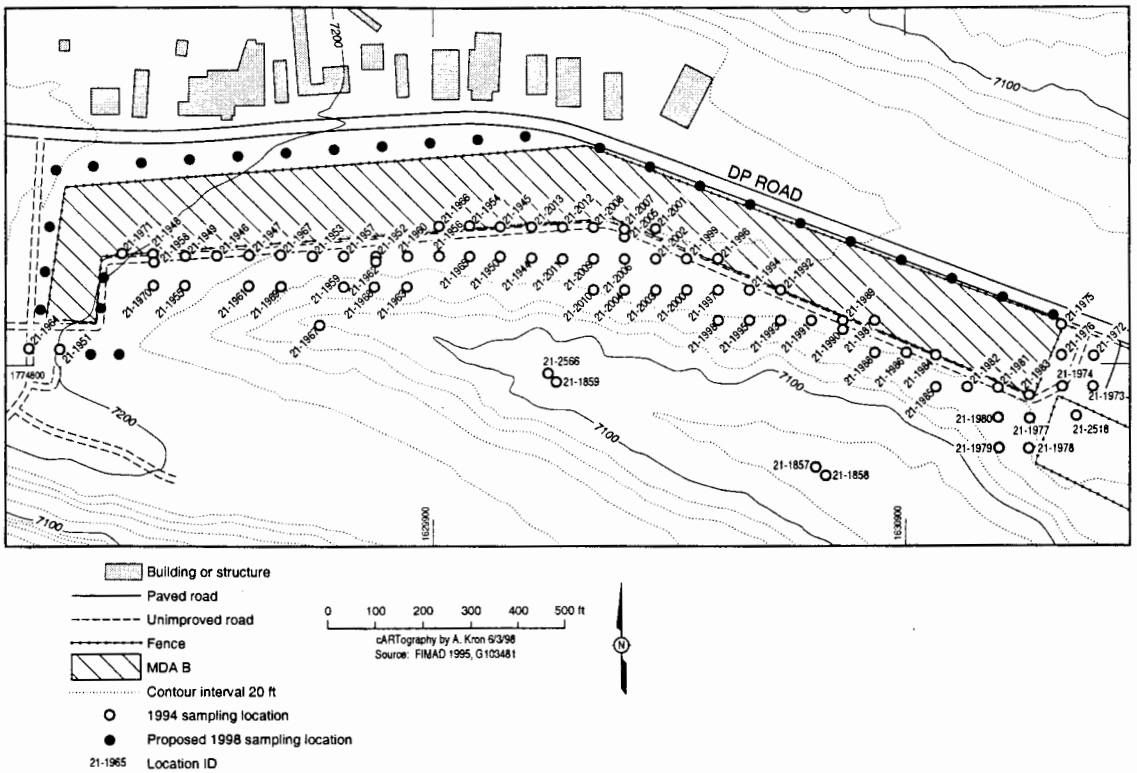

Figure 2.2-5. Proposed 1998 surface sampling locations at MDA B.

3.0 DATA COLLECTION DESIGN AND PROCEDURES

3.1 Data Quality Objectives

Analytical data for this PRS will be compared, as follows, to determine if contaminants are naturally occurring or related to MDA B activities. For inorganic chemicals and radionuclides, the data review will determine whether chemicals are present at levels exceeding background and/or fallout concentrations. For organic chemicals, the data review will identify which organic chemicals have been detected at the PRS.

Precision will be addressed by collecting one sample in triplicate from one borehole; accuracy will be assessed by laboratory spike and recovery of known concentrations of standards in one sample and the analysis of a blind sample.

When the fixed laboratory data are available, a chemist will determine the quality and usability of the data through a routine data validation process described in Section D1 of the ER Project quality assurance project plan (QAPP) (LANL 1996, 55574, Chapter 4.0). The data validation process includes data verification, which is a series of administrative checks to assure data users that the required results have been provided by the laboratories and that the data packages

supplied by the laboratories are complete. Data verification is followed by the actual validation process, which requires quality control (QC) data generated during analysis to be reviewed against numerical acceptance criteria. The data may then be subjected to a focused validation procedure, outlined in Section D2 of the Laboratory ER Project QAPP (LANL 1996, 55574, Chapter 4.0). The field data will be reviewed for accuracy and completeness by the field team at the time of collection as well as by the person responsible for entering the data into the field database.

When the data are deemed acceptable by a chemist, they may be subjected to a qualitative and quantitative analysis to assess their sufficiency to support the decisions outlined in Section 1.4. This data quality assessment is outlined in general terms in Section D of the Laboratory ER Project QAPP in the installation work plan (IWP) (LANL 1996, 55574, Chapter 4.0). Analyses may include statistical data preparation, exploratory data analysis (EDA), and qualitative and/or quantitative statistical analyses. Statistical data preparation may include the creation of subsets of the original data set that will be used for various statistical analyses. EDA involves graphical examination of the data to detect patterns, anomalies, or outliers in the data.

3.2 Quality Assurance/Quality Control

Quality assurance (QA) samples will be collected to assess the quality of sampling and measurement techniques and will assist in meeting the following objectives:

- provide information on false negatives needed to estimate negative bias,
- estimate sample collection and total measurement variance, and
- evaluate whether the data are complete, representative, and comparable.

One of every 20 core sections will be sampled in duplicate to determine the variance associated with all aspects of this effort (i.e., collection, location, handling, and analytical variances).

In addition to the field QA sample, the analytical laboratories will provide standard QC measurements, including method and calibration blanks, surrogates, spikes, and internal standards as specified by the statement of work with the analytical laboratory. Analytical data packages will contain all reported results, including all QA/QC information. The analytical data will be compared to standard detection limits to determine if the data are usable and whether there are any issues associated with the sample matrix and analysis.

Field QC samples, such as duplicates, rinsate blanks, and trip blanks, will be collected in accordance with current Laboratory ER Project guidance.

3.3 Field Activities

Surface and Subsurface Sample Collection. Surface and subsurface samples will be collected using the methods and ER Project standard operating procedures (SOPs) listed in Table 3.3-1. A scoop sampler or hand auger will be used to collect surface soil samples. A hand auger will be used to collect subsurface soil samples under the asphalt pad. All samples will be collected following the applicable ER Project SOPs for the collection, preservation, identification, storage, transport, and documentation of environmental samples, as described in Quality Assurance Project Plan Requirements for Sampling and Analysis (LANL 1996, 53450).

Boreholes will be drilled with a Failing F-10 (or equivalent) drill rig equipped with 8.25-inch-o.d. hollow-stem augers and a wire-line retrieval system. Continuous 3.125-inch-o.d. core samples will be retrieved using 2.5-ft or 5-ft stainless steel split-barrel samplers in conjunction with a wire-line

retrieval system. The drilling program will be completed in accordance with LANL-ER-SOP-04.01 (most recent version), Drilling and Drill Site Management. The drill rig and downhole drilling and sampling equipment will be decontaminated in accordance with LANL-ER-SOP-01.08 (most recent version), Field Decontamination of Drilling and Sampling Equipment. Other applicable SOPS for drilling operations and borehole sampling are listed in Table 3.3-2.

TABLE 3.3-1
SUMMARY OF SAMPLING METHOD REQUIREMENTS

Sampling Tools	Sample Types	LANL-ER-SOP*
Spade and scoop	Surface grab	06.09
Hand auger	Surface or subsurface grab	06.11

* Most recent versions

Decontamination of sampling equipment will be performed in accordance with LANL-ER-SOP-01.08 (most recent version), Field Decontamination of Drilling and Sampling Equipment. Wash water and other wastes generated during the sampling operation will be managed and disposed of in accordance with LANL-ER-AP-05.3 (most recent version), Management of ER Program Wastes, and a site-specific Waste Characterization Strategy form.

Each surface sample location will be marked, photographed, and assigned a unique ER sample location identification number. All samples will be field screened at the point of collection for gross radioactivity and organic vapors; hand-held instruments will be used. Before the samples are submitted to the field screening facility (FSF) for transport to a fixed-site analytical laboratory, gross alpha, beta, and gamma radiation and tritium measurements will be taken on each sample.

TABLE 3.3-2
BOREHOLE CORE SAMPLING METHODS REQUIREMENTS

Activity	LANL-ER-SOP*
Drilling methods and drill-site management	04.01
General borehole logging	04.04
Core-barrel sampling for subsurface earth materials	06.26
Field logging, handling, and documentation of borehole samples	12.01
General instructions for field investigations	01.01
Field decontamination of drilling and sampling equipment	01.08
Sample control and field documentation	01.04

* Most recent versions

Up to ten angled boreholes will be drilled using a hollow-stem auger rig. For each borehole, core from the 2.5-ft or 5-ft interval will be screened for VOCs and radioactivity using hand-held instruments. The core interval will be dependent on recovery and depth. If radionuclides or organics are identified, each subsequent interval will be logged, photographed, and inspected for fractures. Drilling will continue in each borehole to a total borehole length of approximately 100 ft (the total length will be determined after the geophysical survey). This distance will be verified based on the angle of drilling decided on after the geophysical survey, as represented in Figure 3.3-1. The 100-ft length will allow core samples to be taken under the entire width of the trench. For each 10-ft interval, a core sample will be collected for laboratory analysis; location of the sample would be preferentially based on the presence of fractures, elevated radionuclides, or VOCs. If a sample is taken from a fracture, a second sample will be taken for comparison purposes from an area in the core adjacent to the fracture. The reason for collecting the core will be recorded in the field notes. Core samples will first be screened at the TA-21 Radiological Screening Laboratory (RSL) for tritium and gross alpha, beta, and gamma radiation; their water content will also be determined. All samples will then be sent to an analytical laboratory for gamma spectroscopy analysis and analysis for isotopic plutonium, americium, isotopic uranium, tritium, SVOCs, and TAL metals.

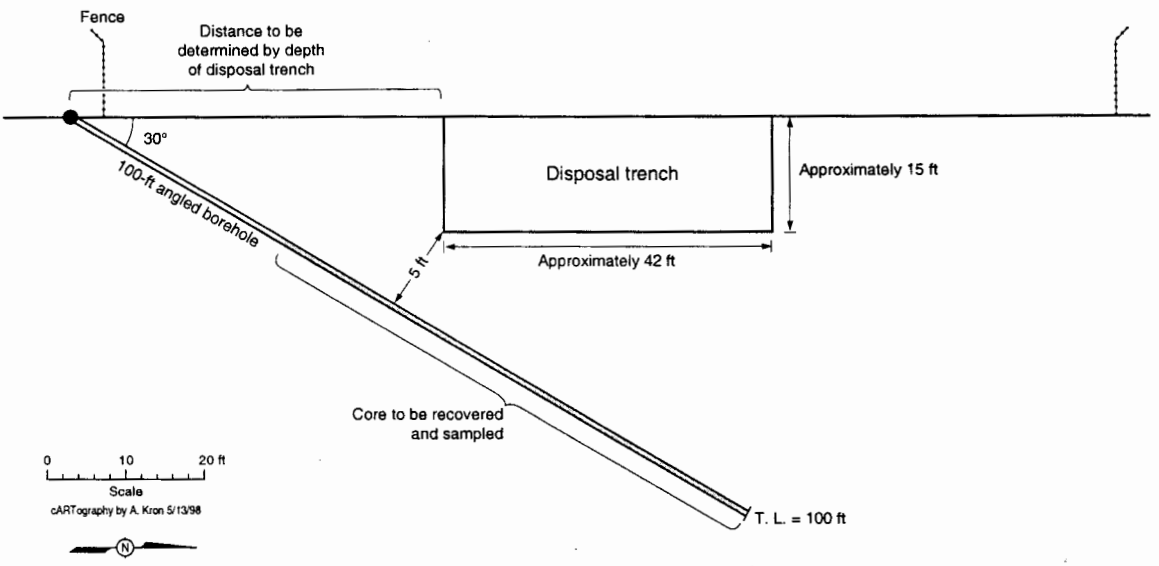

Figure 3.3-1. Schematic diagram of angled borehole.

Samples for VOC analysis will be collected at the end of the borehole and at two other locations along the borehole using the method described in Appendix C, Soil-Gas Sampling Procedure for Open Boreholes. Sample collection will be based on screening of VOCs using hand-held instruments. The reason for selecting the location for VOC sampling will be recorded in the field notes.

The boreholes will be located as follows (Figure 2.2-4):

- Borehole 1 will be drilled in an east-west direction and will pass beneath the east edge of and parallel to the center disposal trench(es).

- Boreholes 2 and 3 will be drilled in a west-east direction and pass beneath the west edge of the west disposal trench(es) at an angle that will cover as much of the subsurface beneath the trench(es) as possible.
- Borehole 4 will be drilled in an east-west direction and will pass beneath the east edge of and parallel to the east disposal trench(es).
- Borehole 5 will be drilled in a west-east direction and will pass beneath the west edge of and parallel to the east disposal trench(es).
- Boreholes 6 and 7 will pass perpendicular to and beneath the south edge of the east and center disposal trenches, respectively.
- Boreholes 8, 9, and 10 will be located based on the analysis of the results of field screening instruments used during the drilling of the first seven boreholes. These three are optional boreholes.

These locations may change based on the results of the 1998 geophysical survey.

Licensed surveyors will identify state planar coordinates for angled boreholes and surface soil locations and for the corners of the disposal trenches. All survey data will be submitted to the Facility for Information Management and Display (FIMAD). Surveys will be conducted in accordance with LANL-ER-SOP 03.01 (most recent version), Land Surveying Procedures.

A hand auger will be used to collect soil samples for water content from up to six soil samples collected under the asphalt pad.

Analytical Methods. All analyses will be performed at an ER Project-approved fixed-site laboratory. The analytical suites and methods for analysis of organic constituents are listed in Table 3.3-3. Analysis for VOCs will be performed on any sample for which a positive organic vapor measurement was obtained by field screening. All analyses for organic constituents will be performed according to EPA SW-846 protocols (EPA 1986, 31733). The detailed analyte lists, estimated quantitation limits (EQLs), required QC procedures, and the acceptance criteria are found in the ER Project analytical services statement of work (LANL 1995, 49738).

TABLE 3.3-3
ANALYTE SUITES AND ANALYTICAL METHODS FOR ANALYSIS OF ORGANIC CONSTITUENTS IN CORE SAMPLES

Analyte Suite	Analytical Method	Analytical Protocol
SVOCs[a]	GC/MS[b]	SW-8270
VOCs[a,c]	GC/MS	SW-8260

a. The laboratory will be requested to report all tentatively identified compounds.
b. GC/MS = gas chromatograph/mass spectrometer.
c. Samples will be analyzed for VOCs only if field screening indicated their presence.

The target analytes, estimated detection limits (EDLs), special required EDLs, and analytical methods for inorganic constituents in core samples are listed in Table 3.3-4. All analyses for inorganic constituents will be performed according to EPA SW-846 protocols (EPA 1986, 31733), using mineral acid sample extraction procedures for the inductively coupled plasma emission spectroscopy (ICPES) and graphite furnace atomic absorption (GFAA).

TABLE 3.3-4
ANALYTE LIST, EDLs, AND ANALYTICAL METHODS FOR INORGANIC CONSTITUENTS (METALS) IN CORE SAMPLES

Analyte	EDL (mg/kg)	Special Required EDL[a] (mg/kg)	Analytical Method	Analytical Protocol
Aluminum	40	–	ICPES	SW-6010B
Antimony	1.2	0.5	ICPES	SW-6010B or SW-6020
Arsenic	2	–	GFAA	SW-7060 or SW-6020
Barium	40	–	ICPES	SW-6010B
Beryllium	1	–	ICPES	SW-6010B
Cadmium	1	–	ICPES	SW-6010B
Calcium	500	–	ICPES	SW-6010B
Chromium	2	–	ICPES	SW-6010B
Cobalt	1.0	–	ICPES	SW-6010B
Copper	5	4.0	ICPES	SW-6010B
Iron	20	–	ICPES	SW-6010B
Lead	0.6	–	GFAA	SW-7421 or SW-6020
Magnesium	1000	–	ICPES	SW-6010B
Manganese	3	–	ICPES	SW-6010B
Mercury	0.1	–	CVAA[b]	SW-7471A
Nickel	8	6.0	ICPES	SW-6010B
Potassium	500	–	ICPES	SW-6010B
Selenium	1	0.3	GFAA	SW-7741 or SW-6020
Silver	2	1	ICPES	SW-6010B
Sodium	500	–	ICPES	SW-6010B
Thallium	2	0.5	GFAA	SW-7841 or SW-6020
Vanadium	10	–	ICPES	SW-6010B
Zinc	4	–	ICPES	SW-6010B

a. These lower detection limits for these chemicals, with the exception of thallium, are required to meet background values in tuff (Qbt 2 and 3). The lower detection limit for thallium is required to meet the 1/10 noncarcinogenic screening action level.
b. CVAA = cold vapor atomic absorption spectroscopy.

The target analytes and their half-lives, detected emissions, minimum detectable activity, and analytical methods for radionuclide constituents are listed in Table 3.3-5. Before chemical separation and counting for alpha or beta emissions, samples will undergo a complete digestion or fusion procedure. All samples submitted for tritium analysis will also be analyzed for moisture content. The analyte list for the gamma spectroscopy analysis includes long-lived activation and fission products as well as their shorter-lived daughter products. The shorter-lived daughter products are usually included in the analyte list to verify the presence of the longer-lived parents. Soil samples will be prepared for gamma spectroscopy measurements by homogenization and

drying; no sample extraction will be performed. The required QC procedures and acceptance criteria for both the inorganic and radiochemical analyses are found in the ER Project analytical services statement of work (LANL 1995, 49738).

TABLE 3.3-5
ANALYTE LIST, EQLs, AND ANALYTICAL METHODS FOR RADIONUCLIDE CONSTITUENTS IN SOIL, ASPHALT, VEGETATION, AND CORE SAMPLES

Analyte	Half-Life (yr.)	Detected Emission	MDA (pCi/g)	Analytical Method
Plutonium-238	87.7	α	0.1	α-Spectrometry
Plutonium-238/240[a]	$2.41\ 0 \times 10^4$	α	0.1	α-Spectrometry
Strontium-90	29.1	β	2.0	GPC[b]
Tritium-3	12.3	β	300 pCi/L	LCS[c]
Uranium-234	2.46×10^5	α	0.1	α-Spectrometry
Uranium-235	7.04×10^8	α	0.1	α-Spectrometry
Uranium-238	4.47×10^9	α	0.1	α-Spectrometry
Gamma spectroscopy analytes	—	γ	1[d]	γ-Spectrometry
Gross alpha	—	α	10.0	GPC or LCS
Gross beta	—	β	10.0	GPC or LCS
Gross gamma	—	γ	2.0	NaI(Tl) or HPGE[e] detection

a. The plutonium-239 and plutonium-240 isotopes cannot be distinguished by alpha spectrometry. The half-life of plutonium-239 is given.
b. GPC = gel permeation chromatography.
c. LCS = laboratory control sample.
d. The minimum detectable activity for americium-241 and cesium-137 is 1 pci/g; the value for other analytes will vary.
e. HPGE = high-purity germanium.

The gravimetric moisture content of all borehole core samples and subsurface samples collected under the asphalt pad will be determined using fast-turnaround analysis. The analytical method is ASTM D-4531-86 (ASTM 1997, 57501).

Sample Handling. All samples will be handled in accordance with LANL-ER-SOP-01.04 (most recent version), Sample Control and Field Documentation. Chain-of-custody requirements described in this SOP will be implemented; a member of the field team will maintain custody of the samples until they are delivered to the FSF. The FSF will be consulted regarding the appropriate sample containers and preservation. Samples will be packaged and shipped according to LANL-ER-SOP-01.03 (most recent version), Handling, Packaging, and Shipping of Samples. All samples will be shipped from the FSF to off-site laboratories.

Samples will have preassigned identification numbers from the Sample Data Management System. The sample and location identification numbers, sample depth, date and time of sample collection, and level of radioactivity and inorganic compounds (based on field screening) will be recorded on the sample collection log. When filled with sample material, sample bottles will be capped, labeled, sealed with custody tape, and temporarily stored in a sample cooler with blue ice to <4°C. Water samples from the core barrel and from under the asphalt pad may be stored in an insulated cooler without ice and out of direct sunlight or in a temperature-controlled room.

The data management scheme described in Sections A10 and B10 of the ER Project QAPP (LANL 1996, 53450) will be followed. Manually recorded data will be reviewed by the field team, as required by LANL-ER-SOP-1.01 (most recent version), General Instructions for Field Investigations; LANL-ER-SOP-01.04 (most recent version), Sample Control and Field Documentation; and LANL-ER-SOP-03.12 (most recent version), Field and Laboratory Notebook Documentation for Environmental Restoration Earth Sciences Studies. Data generated by the analytical laboratories will be submitted to the FSF following the requirements of the ER Project analytical services statement of work (LANL 1995, 49738). The reporting requirements include electronic and hard copy deliverables for routine analyses. The FSF is responsible for data verification, validation, and transmittal to FIMAD. The results of radiological screening conducted in the TA-21 RSL will be documented and sent to the FSF along with the samples.

Data generated by the analytical laboratories will undergo the verification and baseline validation procedures described in Sections D1 and D2 of the ER Project QAPP (LANL 1996, 53450). Field data will be reviewed for accuracy and completeness by the field team at the time of collection.

4.0 PROJECT MANAGEMENT

4.1 Project Scheduling and Reporting Requirements

The MDA Focus Area TA-21 team is responsible for performing the sampling and the preparation of reports for the field activities at MDA B. Field sampling activities are scheduled to be completed in FY98, and a report summarizing the results of the field activities is scheduled to be completed by June 1999.

4.2 Health and Safety Plan

A site-specific health and safety plan (Environmental Restoration Project 1998, 58704) is being developed in accordance with the ER Project health and safety plan (Environmental Restoration Project 1995, 56448).

4.3 Investigation-Derived Waste Plan

Investigation-derived waste, if any, will be handled in accordance with LANL-ER-SOP-1.06 (most recent version), Management of Environmental Restoration Project Wastes, and the site-specific Waste Characterization Strategy form.

4.4 Community Relations Plan

Community relations are governed by the Public Involvement Plan in the IWP (LANL 1996, 55574, Chapter 7).

REFERENCES

ASTM (American Society for Testing and Materials) 1997. Annual Book of ASTM Standards, Volume 0.408, Soil and Rock, Building Stones; Geotextiles. American Society for Testing and Materials, Philadelphia, Pennsylvania. (ASTM 1997, ER ID 57501)

Bennett, K., July 1996. "Biological and Floodplain/Wetlands Assessment for Environmental Restoration Program Operable Units 1106 & 1078, TA-1 and TA-21, Los Alamos and DP Canyons," Los Alamos National Laboratory report LA-UR-93-107, Los Alamos, New Mexico. (Bennett 1996, ER ID 58236)

Brady, N. C., 1974. *The Nature and Properties of Soils*, Eighth Edition, Macmillan Publishing Company, New York. (Brady 1974, ER ID 57672)

Broxton, D. E. and P. G. Eller (Eds), June 1995. "Earth Science Investigations for Environmental Restoration—Los Alamos National Laboratory Technical Area 21," Los Alamos National Laboratory report LA-12934-MS, Los Alamos, New Mexico. (Broxton and Eller 1995, ER ID 58207)

Budavari, S., M. O'Neil, A. Smith, P. Heckelman, and J. Kinneary, 1996. *The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals*, Twelfth Edition, Merck & Co., Whitehouse Station, NJ. (Budavari et al. 1996, ER ID 58033)

Casarett, L., J. Doull, C. Klaassen, and M. Amdur, 1986. *Casarett and Doull's Toxicology, The Basic Science of Poisons*, Third Edition, Macmillan Publishing Company, New York. (Casarett et al. 1986, ER ID 58204)

Environmental Restoration Project, April 13, 1995. "Environmental Restoration (ER) Project Health and Safety Plan (HASP) and Site-Specific Health and Safety Plan (SSHASP)," Los Alamos National Laboratory memorandum EM/ER:95-PCT-012, Los Alamos, New Mexico. (Environmental Restoration Project 1995, ER ID 56448)

Environmental Restoration Project, November 1996. "RFI Report for Potential Release Site at TA-21, 21-015, Material Disposal Area B," Los Alamos National Laboratory report LA-UR-96-4444, Los Alamos, New Mexico. (Environmental Restoration Project 1996, ER ID 58213)

Environmental Restoration Project, July 6, 1998. "LANL ER Project Site-Specific Health and Safety Plan (SSHASP), MDA B and U Site Characterization, TA-21 MDA B and U," SSHASP No. 209, Los Alamos National Laboratory, Los Alamos, New Mexico. (Environmental Restoration Project 1998, ER ID 58704)

Ferguson, J., W. S. Baldridge, G. Jiracek, V. Gonzalez, and P. Pope, "An Investigation of a Los Alamos National Laboratory, New Mexico, Environmental Restoration Site," Los Alamos National Laboratory report LA-UR-98-900 (to be published in *EOS, Trans. of Am. Geophys.*). (Ferguson et al. in press, ER ID 58212)

EPA (US Environmental Protection Agency), November 1986. "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," Volume 1B, SW-846, Third Edition, Final Update 1, Office of Solid Waste and Emergency Response, Washington, DC. (EPA 1986, ER ID 31733)

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, ER ID 1585)

LANL (Los Alamos National Laboratory), May 1991. "TA-21 Operable Unit RFI Work Plan for Environmental Restoration," Volume II, Los Alamos National Laboratory Report LA-UR-91-962, Los Alamos, New Mexico. (LANL 1991, ER ID 07529)

LANL (Los Alamos National Laboratory), July 1995. "Statement of Work–Analytical Support," Revision 2, RFP 9-XS1-Q4257, Los Alamos, New Mexico. (LANL 1995, ER ID 49738)

LANL (Los Alamos National Laboratory), March 1996. "Quality Assurance Project Plan Requirements for Sampling and Analysis," Los Alamos National Laboratory report LA-UR-96-441, Los Alamos, New Mexico. (LANL 1996, ER ID 53450)

LANL (Los Alamos National Laboratory), December 1996. "Installation Work Plan for Environmental Restoration Program," Revision 6, Los Alamos National Laboratory report LA-UR-96-4629, Los Alamos, New Mexico. (LANL 1996, 55574)

Ney, R., 1995. *Fate and Transport of Organic Chemicals in the Environment, A Practical Guide*, Second Edition, Government Institutes, Rockville, MD. (Ney 1995, ER ID 58210)

Nyhan, J. W., L. W. Hacker, T. E. Calhoun, and D. L. Young, June 1978. "Soil Survey of Los Alamos County, New Mexico," Los Alamos Scientific Laboratory report LA-6779-MS, Los Alamos, New Mexico. (Nyhan et al. 1978, ER ID 5702)

Purtymun, W. D., January 1995. "Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area," Los Alamos National Laboratory report LA-12883-MS, Los Alamos, New Mexico. (Purtymun 1995, ER ID 45344)

Wenzel, W. J., T. S. Foxx, A. F. Gallegos, G. Tierney, and J. C. Rodgers, November 1987. "Cesium-137, Plutonium-239/240, Total Uranium, and Scandium in Trees and Shrubs Growing in Transuranic Waste at Area B," Los Alamos National Laboratory report LA-11126-MS, Los Alamos, New Mexico. (Wenzel et al. 1987, ER ID 58214)

Whicker, F. and V. Schultz, 1982. *Radioecology: Nuclear Energy and the Environment*, Vol. I, CRC Press, Boca Raton, FL. (Whicker and Schultz 1982, ER ID 58209)

APPENDIX A
ACRONYMS

bgs	Below ground surface
CFR	Code of Federal Regulations
CMS	Corrective measures study
DOE	US Department of Energy
DQO	Data quality objective
EDA	Exploratory data analysis
EDL	Estimated detection limits
EPA	Environmental Protection Agency
EQL	Estimated quantitation limits
ER	Environmental restoration
FEHM	Finite Element Heat and Mass
FID	Flame ionization detector
FIMAD	Facility for Information Management, Analysis, and Display
FSF	Field screening facility
GFAA	Graphite furnace atomic absorption
HSWA	Hazardous and Solid Waste Amendments of 1984
ICPES	Inductively coupled plasma emission spectroscopy
IWP	Installation work plan
Laboratory	Los Alamos National Laboratory
LANL	Los Alamos National Laboratory
MDA	Material disposal area
PID	Photoionization detector
PRS	Potential release site
QA	Quality assurance
QC	Quality control
QAPP	Quality assurance project plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RSL	Radiological Screening Laboratory
SAL	Screening action level
SAP	Sampling and analysis plan
SOP	Standard operating procedure
SVOC	Semivolatile organic compound
SWMU	Solid waste management unit
TA	Technical area
TAL	Target analyte list (EPA)
USGS	United States Geological Survey
VOC	Volatile organic compound

TABLE 2.2-3

SUMMARY OF ANALYSES TO BE PERFORMED IN THE MDA B INVESTIGATION

		Field Survey			Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses								
Sample Number	Borehole length to sample or surface sample depth	Geodetic Survey	Geophysical Survey	Radiological Survey	Alpha Radiation	Beta/gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content and Tritium	Gamma Spectroscopy (CS 137)	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium and Gravimetric Water	Stontium-90	Volatile Organic Compounds (Summa)*	Semivolatile Organic Compounds*	Target Analyte List Metals
Borehole 1 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 2 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X

* The Laboratory will be requested to report tentatively identified compounds.

TABLE 2.2-3(continued)

		Field Survey			Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses								
Sample Number	Borehole length to sample or surface sample depth	Geodetic Survey	Geophysical Survey	Radiological Survey	Alpha Radiation	Beta/gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content and Tritium	Gamma Spectroscopy (CS 137)	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium and Gravimetric Water	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals
Borehole 2 (x° from horizontal, 100 ft long)																					
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 3 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 4 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

TABLE 2.2-3(continued)

		Field Survey			Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses								
Sample Number	Borehole length to sample or surface sample depth	Geodetic Survey	Geophysical Survey	Radiological Survey	Alpha Radiation	Beta/gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content and Tritium	Gamma Spectroscopy (CS 137)	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium and Gravimetric Water	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals
Borehole 4 (x° from horizontal, 100 ft long)																					
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 5 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 6 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X

TABLE 2.2-3(continued)

		Field Survey			Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses								
Sample Number	Borehole length to sample or surface sample depth	Geodetic Survey	Geophysical Survey	Radiological Survey	Alpha Radiation	Beta/gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content and Tritium	Gamma Spectroscopy (CS 137)	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium and Gravimetric Water	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals
Borehole 6 (x° from horizontal, 100 ft long)																					
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 7 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

TABLE 2.2-3(continued)

		Field Survey			Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses								
Sample Number	Borehole length to sample or surface sample depth	Geodetic Survey	Geophysical Survey	Radiological Survey	Alpha Radiation	Beta/gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content and Tritium	Gamma Spectroscopy (CS 137)	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium and Gravimetric Water	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals
Borehole 7 (x° from horizontal, 100 ft long)																					
9	Duplicate	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 8 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 9 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X

TABLE 2.2-3(continued)

		Field Survey			Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses								
Sample Number	Borehole length to sample or surface sample depth	Geodetic Survey	Geophysical Survey	Radiological Survey	Alpha Radiation	Beta/gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content and Tritium	Gamma Spectroscopy (CS 137)	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium and Gravimetric Water	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals
Borehole 9 (x° from horizontal, 100 ft long)																					
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Borehole 10 (x° from horizontal, 100 ft long)																					
1	30 ft	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
2	40 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
3	50 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
4	60 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	70 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
6	80 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	90 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X	X
8	100 ft	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hand auger cores under asphalt cover																					
1	—	X	—	—	—	—	—	—	X	X	X	X	—	—	—	—	X	—	—	—	—
2	—	X	—	—	—	—	—	—	X	X	X	X	—	—	—	—	X	—	—	—	—
3	—	X	—	—	—	—	—	—	X	X	X	X	—	—	—	—	X	—	—	—	—

TABLE 2.2-3(continued)

		Field Survey			Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses								
Sample Number	Borehole length to sample or surface sample depth	Geodetic Survey	Geophysical Survey	Radiological Survey	Alpha Radiation	Beta/gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content and Tritium	Gamma Spectroscopy (CS 137)	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium and Gravimetric Water	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals
Hand auger cores under asphalt cover																					
4	—	X	—	—	—	—	—	—	X	X	X	X	—	—	—	—	X	—	—	—	—
5	—	X	—	—	—	—	—	—	X	X	X	X	—	—	—	—	X	—	—	—	—
6	—	X	—	—	—	—	—	—	X	X	X	X	—	—	—	—	X	—	—	—	—
5	—	X	—	—	—	—	—	—	X	X	X	X	—	—	—	—	—	—	—	—	—
Surface Soil Samples																					
1	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
2	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
3	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
4	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
5	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
6	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
7	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
8	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
9	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
10	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
11	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X

TABLE 2.2-3(concluded)

		Field Survey			Field Screening				Screening Laboratory Analyses				Fixed Laboratory Analyses								
Sample Number	Borehole length to sample or surface sample depth	Geodetic Survey	Geophysical Survey	Radiological Survey	Alpha Radiation	Beta/gamma Radiation	Gamma Radiation	Organic Compounds	Gross Alpha Radiation	Gross Beta Radiation	Gross Gamma Radiation	Gravimetric Water Content and Tritium	Gamma Spectroscopy (CS 137)	Isotopic Plutonium	Isotopic Americium	Isotopic Uranium	Tritium and Gravimetric Water	Stontium-90	Volatile Organic Compounds (Summa)	Semivolatile Organic Compounds	Target Analyte List Metals
12	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
13	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
14	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
15	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
16	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
17	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
18	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
19	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
20	—	X	—	—	X	X	X	—	X	X	X	X	X	X	X	X	—	—	—	X	X
21	—	X	—	—	X	X	X	—	X	X	X	X	X	—	X	X	—	—	—	X	X
22	—	X	—	—	X	X	X	—	X	X	X	X	X	—	X	X	—	—	—	X	X
23	—	X	—	—	X	X	X	—	X	X	X	X	X	—	X	X	—	—	—	X	X
24	—	X	—	—	X	X	X	—	X	X	X	X	X	—	X	X	—	—	—	X	X
25	—	X	—	—	X	X	X	—	X	X	X	X	X	—	X	X	—	—	—	X	X
26	—	X	—	—	X	X	X	—	X	X	X	X	X	—	X	X	—	—	—	X	X
27	—	X	—	—	X	X	X	—	X	X	X	X	X	—	X	X	—	—	—	X	X
28	—	X	—	—	X	X	X	—	X	X	X	X	X	—	X	X	—	—	—	X	X

Note: If fractures are detected, then this table will be expanded to analyze samples from both the fractures and a sample adjacent to the fractures.

APPENDIX C
SOIL-GAS SAMPLING PROCEDURE FOR OPEN BOREHOLES

SUMMA canisters or resin tubes will be used to collect soil-gas samples from open boreholes. All SUMMA canisters or resin tubes and quality control samples will be filled with 3 L of gas. Samples will be collected using a packer assembly for collection of soil gas.

The gas-sampling procedure is as follows. Procedures 20 through 31 have been taken from LANL-ER-SOP-06.22 (most current version), Canister Sampling for Organics.

1. Remove all drilling tools from the borehole except for hollow-stem augers or casing.
2. Place the packer canister over the borehole.
3. Ensure that the packer membrane is clean and uncontaminated.
4. Attach a low-pressure, filtered air supply hose to the canister.
5. Evert the clean, uncontaminated packer membrane into the borehole to the desired depth.
6. Purge the isolated zone and sample lines.
7. Ensure that all gas-sampling equipment has been calibrated.
8. Assemble gas-sampling equipment on new plastic sheeting at the borehole.
9. Establish the sample line interval depth, and record on the Sample Collection Log.
10. Attach the purge pump to the sample line using new tubing internally lined with Teflon. Between the sample line and the new tubing to the pump there should be a 2-in piece of medical-grade silicone tubing that can be sealed with a clamp after the sample line has been purged. This short piece of tubing will be used to attach the TO-14 canister to the sample line.
11. Record the starting ambient temperature and flow rate on the Sample Collection Log.
12. While purging, the discharge line will be directed through a Brueland Kjaer gas monitor gas chromatograph instrument such as a flame ionization detector (FID) (Foxboro or equivalent) or photoionization detector (PID) (Photovac MicroTIP or equivalent). The screening instrument must be calibrated before its use in this sampling effort. The on-site calibration records must include the vendor of the calibration gas, calibration gas chemical constituent, concentration, vendor lot number, and instrument response concentration.
13. Gas monitor instrument results will be used to ensure proper purging identified by stabilization of screening results of natural soil gas tracers, such as CO_2 and O_2 concentrations.
14. Send the results of the field screens to the laboratory along with the Chain-of-Custody/Request of Analysis (see LANL-ER-SOP-01.04 (most current version), Sample Control and Field Documentation, for instructions on how to fill out the Chain-of-Custody/Request for Analysis form) in order to provide information for dilution before injection of analytical instrument and health and safety purposes for the staff cleaning the canisters.
15. At the completion of purging, turn off the purge pump and simultaneously clamp off the short section of medical-grade silicone tubing. Record volume purged on the Sample Collection Log.
16. Before sampling using air canisters, read the above standard operating procedure (SOP) and consult the analytical vendor providing the canisters. The referenced SOP is

consistent with the Environmental Protection Agency's (EPA's) 'The Determination of Volatile Organic Compounds (VOCS) in Ambient Air Using SUMMA Passivated Canister Sampling and Gas Chromatograph Analysis, EPA Compendium Method TO-14, May 1988.

17. The analytical contractor will clean and test the sample canister according to EPA's guidance before shipment to the Laboratory.
18. The canister should arrive with a vacuum up to 0.05 mm Hg. The canister will be used to sample in a grab mode. Collect 3 L from each sample interval.
19. The canister train consists of a short Teflon tube from the calibrated flow meter, short tubing to the vacuum gauge, and short tubing to the canister valve. The connection between the vacuum gauge and the canister valve should be a sealing quick-connect, such as Swagelock.
20. The canister train is attached to the well sample port after verification of the correct interval by the field team leader and canister sampling team member. If the sampling team member has not operated a canister, he/she should request from the laboratory a practice canister to practice opening and adjusting the flow rate and closing the canister valve before reaching ambient pressure inside the canister. [Caution: SUMMA canisters will be rejected at the receiving laboratory if they are at ambient pressure. The canister MUST have a slight negative pressure (subatmospheric)].
21. Record the initial canister vacuum reading on the Sample Collection Log.
22. Slowly open the valve and adjust the flow rate not to exceed 500 ml/min. The sample volume should not exceed 3 L.
23. Record the final vacuum reading of the gauge on the Sample Collection Log.
24. Record the ambient temperature.
25. Fill out the SUMMA canister tag with the unique sample number, time, date, final vacuum readings, printed name of sampler, and signature of sampler.
26. Record on the sample tag the field screen values. If over l000 mg/L, duct tape the readings to the two sides of the canister.
27. Complete the Chain-of Custody/Request for Analysis form as required by LANL-ER-SOP-01.04 (most current version), Sample Control and Field Documentation. Complete the rest of the forms required by LANL-ER-SOP-01.04.
28. Pack the canister back into the shipping container in which it was received.
29. Record the waybill number on the Chain-of-Custody/Request for Analysis form and seal the Department of Transportation-approved shipping container.
30. Complete the Sample Collection Log and make the appropriate notations on the Daily Activity Log.
31. Ship the canister to the Sample Management Office on the day of collection.

Types of Analyses to be Conducted in the Field

- Measurements of VOC concentrations will be made using calibrated B and K gas monitor or PID and FID instruments while purging the sample collection line.