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Refer to: ER2006-0119

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FEB 2006

SUBJECT: SUBMITTAL OF THE REVISED APPENDIX C, MANAGEMENT PLAN FOR INVESTIGATION-DERIVED WASTE, INVESTIGATION WORK PLAN FOR GUAJE/BARRANCA/RENDIJA CANYONS AGGREGATE AREA AT TECHNICAL AREA 00

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the revised Appendix C, Management Plan for Investigation-Derived Waste, from the "Investigation Work Plan for Guaje/Barrancas/Rendija Canyons Aggregate Area at Technical Area 00." This revised Appendix is being submitted in response to the approval with modifications letter received from the New Mexico Environment Department (NMED) on January 9, 2006. Appendix C was revised in accordance with a conference call held on January 19, 2006, between John Young and Swarna Latha Vonteddu of the NMED and Kelly VanDerpoel and Becky Coel-Roback of Los Alamos National Laboratory. The revised Appendix C provides more detailed descriptions of the investigation-derived waste streams and their anticipated volumes as well as processes to ensure secure on-site waste storage and appropriate waste characterization.

If you have questions, please contact Becky Coel-Roback (505) 665-5011 (becky_cr@lanl.gov) or Robert Enz at (505) 667-7640 (renz@doeal.gov).

7767

Sincerely,

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Sincerely,

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Enclosures: Two hard copies with electronic files – revised Appendix C, Management Plan for Investigation-Derived Waste, from the "Investigation Work Plan for Guaje/Barrancas/Rendija Canyons Aggregate Area" (ER2006-0117, LA-UR-06-0923)

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ER2005-0303
July 2005

Investigation Work Plan for Guaje/Barrancas/Rendija Canyons Aggregate Area at Technical Area 00

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Prepared by
Environmental Stewardship–Environmental Remediation and Surveillance Program

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LA-UR-05-3869
ER2005-0303

Investigation Work Plan for Guaje/Barrancas/Rendija Canyons Aggregate Areas at Technical Area 00

July 2005

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EXECUTIVE SUMMARY

This investigation work plan identifies and describes the activities needed to complete the investigation of solid waste management units (SWMUs) and areas of concern (AOCs) located within the Guaje/Barrancas/Rendija Canyons aggregate area of Technical Area (TA) 00 at Los Alamos National Laboratory. TA-00 is located in the northern portion of the Laboratory, north of Rendija Road and generally north of the Los Alamos townsite. This investigation work plan is required by the March 1, 2005, Compliance Order on Consent (the Consent Order) signed by the New Mexico Environment Department, the Department of Energy, and the University of California.

The Guaje/Barrancas/Rendija Canyons aggregate area consists of the following SWMUs and AOCs:

- SWMU 00-011(a), a mortar impact area
- SWMU 00-011(c), a possible mortar impact area
- SWMU 00-011(d), a bazooka firing area
- SWMU 00-011(e), an ammunition impact area
- AOC 00-015, a firing range (Sportsmen's Club)
- SWMU 00-016, an inactive firing range
- AOC C-00-020, a possible mortar impact area
- AOC 00-024, a cistern
- AOC 00-025, a landfill
- AOC C-0-041, an asphalt and tar remnant site

Although previous investigations have addressed AOCs 00-024, 00-025, and 00-026 together because of their similarities, AOC 00-026 has been assigned to the Bayo Canyon aggregate area and will be addressed in the "Bayo Canyon Aggregate Area Investigation Work Plan" (due to the New Mexico Environment Department on July 30, 2005). SWMU 00-011(d), which is also located in Bayo Canyon, has been included in this plan because the nature of historical activities at this site is very similar to those activities conducted at the munitions impact sites in Rendija Canyon.

This work plan proposes both characterization and remediation activities. The objectives of these activities are to (1) characterize contamination associated with the SWMUs/AOCs that are part of the Guaje/Barrancas/Rendija Canyons aggregate, and (2) reduce or prevent the migration of contamination by removing environmental media with contaminant concentrations exceeding soil screening levels for inorganic and organic chemicals.

The sites have been placed into three categories:

- The first category contains those sites that are administratively complete (i.e., have a no further action determination and, if necessary, have been removed from Module VIII of the Laboratory's Hazardous Waste Facility Permit). This category includes SWMU 00-016, AOC 00-024, and AOC 00-025. This work plan describes their operational history and provides documentation of their completion and removal from the permit.

- The second category contains sites for which characterization is proposed to determine the nature and extent of contamination and the potential need for corrective action. This category includes SWMU 00-011(a), SWMU 00-011(c), SWMU 00-011(d), SWMU 00-011(e),

AOC C-00-020, and AOC C-00-041. This work plan describes the operational history of the sites, the results of previous sampling activities and currently available analytical data, and the proposed investigation activities. Munitions and explosives of concern surveys will be completed at these sites to verify similar surveys conducted in the early 1990s. Previous surveys at the two possible mortar impact areas [SWMU 00-011(c) and AOC C-00-020] did not find any evidence of former munitions firing (i.e., munitions debris). If no evidence of munitions and explosives of concern or munitions debris is found during the prescribed surveys, these two sites will not be characterized further. Soil samples will be collected at sites with past and current munitions and explosives of concern and munitions debris recovery to characterize the nature and extent of contamination. The sample results will be evaluated to determine whether nature and extent have been defined and whether any corrective action is warranted.

- The third category contains the one site that is still active, AOC 00-015, the Sportsmen's Club. This work plan describes the operational history of the site but does not present a plan for investigation. Instead, investigation of this site will be deferred until the site is no longer active because ongoing activities at the site affect the ability to perform a representative characterization. Deferring investigation of this site is consistent with the approach described in Section IV.A.5 of the Consent Order for deferring investigation of certain SWMUs and AOCs associated with active firing sites. When the site becomes inactive, an investigation work plan for AOC 00-015 will be submitted to NMED for review and approval. When it becomes inactive, the Department of Energy intends to transfer ownership of the land to the Los Alamos County. At that time, the County will determine the future land use for the site. One objective of the future investigation, therefore, will be to determine whether levels of contamination present at the site will be protective of the intended land use, as required by Section III.Y.1.b of the Consent Order.

Both munitions and explosives of concern and geophysical surveys will be used to identify and remove any remaining mortar, small arms ammunition, or munitions debris from sites that were former impact/firing areas [SWMUs 00-011(a), 00-011(d), and 00-011(e)]. Although previous surveys at SWMU 00-011(c) and AOC C-00-020 did not find any munitions and explosives of concern or munitions debris, new surveys will be conducted for verification.

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1.0 INTRODUCTION

Los Alamos National Laboratory (the Laboratory or LANL) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by the University of California (UC). The Laboratory (Figure 1.0-1) is located in north-central New Mexico, approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers 40 mi^2 of the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep canyons containing perennial and intermittent streams running from west to east. Mesa tops range in elevation from approximately 6200 to 7800 ft. The Guaje/Barrancas/Rendija Canyons aggregate area is shown in Figure 1.0-2.

The Laboratory's Environmental Stewardship–Environmental Remediation and Surveillance (ENV-ERS) Program, formerly the Environmental Restoration (ER) Project, is participating in a national effort by DOE to clean up sites and facilities formerly involved in weapons research and development. The goal of the ENV-ERS Program is to ensure that DOE's past operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve this goal, the ENV-ERS Program investigates sites potentially contaminated by past Laboratory operations.

The sites addressed in this work plan contain hazardous components. Depending on the type of contaminant(s) and the history of a site, the New Mexico Environment Department (NMED) or DOE has administrative authority over work performed by ENV-ERS at each site. The New Mexico Environment Department has authority under the New Mexico Hazardous Waste Act (NMHWA) over cleanup of sites with hazardous waste or certain hazardous constituents, including the hazardous waste portion of mixed waste (i.e., waste contaminated with both radioactive and hazardous constituents). The U.S. Department of Energy has authority over cleanup of sites with radioactive contamination. Radionuclides are regulated under DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management."

Corrective actions at the Laboratory are subject to the Compliance Order on Consent (hereafter, the Consent Order) signed on March 1, 2005, by NMED, DOE, the Regents of the UC, and the State of New Mexico Attorney General. The Consent Order was issued pursuant to the NMHWA, New Mexico Statutes Annotated 1978, § 74-4-10, and the New Mexico Solid Waste Act, New Mexico Statutes Annotated 1978, § 74-9-36(D).

This work plan describes proposed work activities to be completed in accordance with the Consent Order. Appendix A includes a list of acronyms and abbreviations, a glossary, and a metric conversion table. Appendix B provides data from past investigations. Appendix C describes the management of investigation-derived waste (IDW). Appendix D describes site conditions in each of the canyons and watersheds. Appendix E contains the guidance documents referred to in Section 4.

1.1 General Site Information

The Guaje/Barrancas/Rendija Canyons aggregate area consists of the following solid waste management units (SWMUs) and areas of concern (AOCs):

- SWMU 00-011(a), a mortar impact area
- SWMU 00-011(c), a possible mortar impact area
- SWMU 00-011(d), a bazooka firing area
- SWMU 00-011(e), an ammunition impact area
- AOC 00-015, a firing range (Sportsmen's Club)

- SWMU 00-016, an inactive firing range
- AOC C-00-020, a possible mortar impact area
- AOC 00-024, a cistern
- AOC 00-025, a landfill
- AOC C-0-041, an asphalt and tar remnant site

These sites were formerly part of Operable Unit (OU) 1071 within Technical Area (TA) 00. The Laboratory began operations at TA-00 in 1943 and had largely ceased using this area by 1986. Figure 1.0-1 shows the Guaje/Barrancas/Rendija watershed area with respect to Laboratory technical areas and surrounding land holdings. Although previous investigations have addressed AOCs 00-024, 00-025, and 00-026 together because of their similarities, AOC 00-026 has been assigned to the Bayo Canyon aggregate area and will be addressed in the corresponding "Bayo Canyon Aggregate Area Investigation Work Plan." Therefore, this AOC is not discussed further in this work plan. SWMU 00-011(d), which is also located in Bayo Canyon, has been included in this plan because the nature of historical activities at this site is very similar to those activities conducted at the munitions impact sites in Rendija Canyon (SWMUs 00-011 and AOC C-00-020). The SWMU and AOC locations within watershed aggregate areas are shown in Figure 1.0-2.

1.2 Investigation Objectives

The objective of this investigation work plan is to characterize the nature and extent of contamination, if any, associated with the sites. Characterization includes conducting sampling, if necessary, and analysis of sampling results to evaluate the potential need for corrective action.

In order to accomplish the objectives, this plan

- presents historical and background information on the sites;
- describes the rationale for proposed data collection activities; and
- identifies and proposes appropriate methods and protocols for collecting, analyzing, and evaluating data to finalize characterization efforts at these sites.

The sites fall into three categories:

- The first category contains those sites that are administratively complete (i.e., have a no further action [NFA] determination and, if necessary, have been removed from Module VIII of the Laboratory's Hazardous Waste Facility Permit). This category includes SWMUs 00-016, 00-024, and 00-025. This work plan describes their operational history and provides documentation of their completion and removal from the permit.
- The second category contains sites for which characterization is proposed to determine the nature and extent of contamination and the potential need for corrective action. This category includes SWMU 00-011(a), SWMU 00-011(c), SWMU 00-011(d), SWMU 00-011(e), AOC C-00-020, and AOC C-00-041. This work plan describes the operational history of the sites, the results of previous sampling activities and currently available analytical data, and the proposed investigation activities. Munitions and explosives of concern (MEC) surveys will be completed at these sites to verify results from similar surveys conducted in the early 1990s. Previous MEC surveys at the two possible mortar impact areas [SWMUs 00-011(c) and AOC C-00-020] did not result in finding any evidence of former munitions firing (i.e., munitions debris [MD]). If no evidence of MEC/MD is found during the prescribed surveys, these two sites

will not be characterized further. Soil samples will be collected at sites with past and current MEC/MD recovery to characterize the nature and extent of contamination. The sample results will be evaluated to determine whether the nature and extent have been defined and whether any corrective action is warranted.

- The third category contains the one site that is still active, AOC 00-015, the Sportsmen's Club. This work plan describes the operational history of the site but does not present a plan for investigation. Instead, investigation will be deferred until the site is no longer active because ongoing activities at the site affect the ability to perform a representative characterization. Deferring investigation of this site is consistent with the approach described in Section IV.A.5 of the Consent Order for deferring investigation of certain SWMUs and AOCs associated with active firing sites. When the site becomes inactive, an investigation work plan for AOC 00-015 will be submitted to NMED for review and approval. When the site becomes inactive, DOE intends to transfer ownership of the land to the County of Los Alamos. At that time, the County will determine the future land use for the site. One objective of the future investigation, therefore, will be to determine whether levels of contamination present at the site will be protective of the intended land use, as required by Section III.Y.1.b of the Consent Order.

The screening and characterization activities presented in this plan are based on the requirements outlined in the Consent Order as well as the data needs identified for the SWMUs and AOCs.

2.0 BACKGROUND

2.1 Site Description and Operational History

The following sections describe the sites and summarize their operational histories since 1943.

2.1.1 SWMU 00-011(a)

SWMU 00-011(a) is a 28.5-acre former mortar impact area located on General Services Administration (GSA) land about 0.4 mi. east of the Sportsmen's Club firing range (AOC 00-015) in Rendija Canyon (Figures 1.0-2, 2.1-1, and 2.1-2).

- Mid-1940s—Site was used as a mortar impact area. It was the target area for 60-mm and 81-mm rounds.
- Late-1940s—Operations ceased (LANL 1990, 07511).
- Current—This SWMU is not within the area burned by the Cerro Grande fire in 2000. The site is fenced and posted with DOE "no trespassing" signs. However, trails are present within the SWMU boundary on the south side of Rendija Road (Forest Service Road 57).

2.1.2 SWMU 00-011(c)

SWMU 00-011(c) is a possible mortar impact area located on GSA and public land managed by the U.S. Forest Service (USFS) in a tributary of Rendija Canyon north of the Sportsmen's Club (AOC 00-015) (Figures 1.0-2, 2.1-3, and 2.1-4). The area is approximately 10 acres in size.

- 1940s—The site was possibly used as a mortar impact area (LANL 1990, 07511). There is no documentation available providing information on the duration of operations.
- Current—This SWMU is within the area burned by the Cerro Grande fire in 2000. Current site conditions include numerous downed burned trees, very little other vegetation, and several

archaeological sites under investigation. Public hiking trails run through and around the perimeter of the site.

2.1.3 SWMU 00-011(d)

SWMU 00-011(d) is a bazooka firing area largely on Los Alamos County land except for a small section on private property. The area is in a small north-trending tributary of Bayo Canyon northeast of the intersection of San Ildefonso Road and Diamond Drive (Figures 1.0-2, 2.1-5, and 2.1-6). The area is approximately 5 acres in size.

- Mid-1940s—The site was used as a target area for 2.36-in. bazooka rounds.
- Late-1940s—Operations ceased (LANL 1990, 07511).
- Current—This SWMU is not within the area that was burned by the Cerro Grande fire in 2000. The site is open to the public.

2.1.4 SWMU 00-011(e)

SWMU 00-011(e) is a former ammunition impact area located on GSA and USFS land in a tributary of Rendija Canyon north-northeast of the Sportsmen's Club (AOC 00-015). The area extends north along the tributary to the top of the cliff face (Figures 1.0-2, 2.1-7, and 2.1-8). The area is roughly rectangular and is approximately 14 acres in size.

- Mid-1940s—Site was used as an impact area. It was the target area for 20-mm and 37-mm rounds.
- Late-1940s—Operations ceased (LANL 1990, 07511).
- Current—This SWMU is not within the area burned by the Cerro Grande fire in 2000. Access to the site is limited. Active rifle firing areas at the Sportsmen's Club are in direct alignment with the site.

2.1.5 AOC 00-015

AOC 00-015 is the Sportsmen's Club small-arms firing range (SAFR), an active range located on GSA land in Rendija Canyon (Figures 1.0-2, 2.1-9, and 2.1-10). The Club is leased to a nonprofit group from DOE. The area is approximately 30 acres in size.

- 1966 to present—Operations started in 1966 and consist of several SAFRs built and operated by the Sportsmen's Club. Several different firing ranges are currently in operation, including pistol ranges, a skeet range, two trap ranges, and a rifle range. Each range also contains one or more earthen primary impact berms and lateral or side berms. The rifle range contains primary impact berms at 100-, 200-, and 300-yd distances (Figure 2.1-10). There are shattered clay targets present on the skeet and trap ranges and lead within the earthen berms and on the range surfaces.
- Current—This SWMU is not within the area burned by the Cerro Grande fire in 2000. The site is used as an outdoor SAFR and includes skeet, trap, pistol, rifle, and indoor firing ranges used by members of the nonprofit Sportsmen's Club.

2.1.6 SWMU 00-016

SWMU 00-016 is a former SAFR located on public land managed by the USFS in Rendija Canyon (Figure 1.0-2). The area is approximately 4 acres in size.

- 1947 to early 1960s—Atomic Energy Commission (AEC) security personnel used the site as a SAFR.
- Early 1960s to 1992—Public used the site for recreational shooting.
- 1990s—The Laboratory implemented voluntary corrective action (VCA) activities at the site during the period 1993 through 1997 to remove lead and lead-contaminated soil.
- 1999—The VCA Report and NFA recommendation were approved by NMED (NMED 1999, 64564).
- 2001—The site was removed from Module VIII by NMED (NMED 2001, 71256). Therefore, this SWMU is not discussed further in this work plan.

2.1.7 AOC C-00-020

AOC C-00-020 is a 30-acre possible mortar impact area located along the north valley wall of Rendija Canyon on USFS land (Figures 1.0-2, 2.1-11, and 2.1-12). The site also includes a northern tributary of Rendija Canyon. Most of the site lies within the Santa Fe National Forest except for a small area on the southeastern edge that is private property. This site was suspected to be a former mortar impact area because of a “U.S. Property—No Trespassing” sign and nearly illegible, bilingual signs posted along the southern edge of the area. The “No Trespassing” signs are not currently posted and were only posted for a short time in the early 1940s (LANL 1992, 07667, p. 5-26).

- Early 1940s—The site was possibly used as a mortar impact area.
- Current—This AOC is within an area burned by the Cerro Grande fire in 2000. The stream channel that runs through the center of the site has been widened by flooding. There are burned and live trees on the steep slopes adjacent to the stream.

2.1.8 AOC 00-024

AOC 00-024 was a cistern located on private property on Barranca Mesa. It was an unlined hole in the Bandelier Tuff with a wood cover (Figure 1.0-2).

- Pre-1965—The cistern was used as a disposal site for expended munitions and gun components (LANL 1992, 07667, p. 6-3).
- 1965—The entire contents of the cistern were removed (LANL 1992, 07667, p. 6-3).
- 1992—AOC 00-024 was recommended for NFA in the OU 1071 Resource Conservation and Recovery Act (RCRA) field investigation (RFI) work plan (LANL 1992, 07667).
- 1993—The work plan and NFA recommendation were approved by the Environmental Protection Agency (EPA) (EPA 1993, 15110).
- 2005—The NFA determination was later confirmed by EPA in a letter to NMED (EPA 2005, 88464). Therefore, this AOC is not discussed further in this work plan.

2.1.9 AOC 00-025

AOC 00-025 was the Tank Mesa “landfill,” a possible waste disposal area. Tank Mesa, currently named Otowi Mesa, is located between Barrancas and Bayo Canyons at the east end of Barranca Mesa (Figure 1.0-2). The landfill was never located (LANL 1992, 07667, p. 6-4). Documentation providing the approximate years of operation is not available.

- 1992—AOC 00-025 was recommended for NFA in the OU 1071 RFI work plan (LANL 1992, 07667).
- 1993—The work plan and NFA recommendation were approved by EPA (EPA 1993, 15110).
- 2005—The NFA determination was confirmed by EPA in a letter to NMED (EPA 2005, 88464). Therefore, this AOC is not discussed further in this work plan.

2.1.10 AOC C-00-041

AOC C-00-041 was the site of a former asphalt batch plant in a 50- by 600-ft portion of a side slope and drainage channel that flows into Rendija Canyon on USFS land (Figures 1.0-2, 2.1-13, and 2.1-14).

- Late 1940s to 1958—Aerial photographs show evidence of asphalt plant operations (LANL 1996, 54925, p. 1).
- 1969—Land was transferred from the AEC to the USFS to manage as public land after the plant had been removed (LANL 1996, 54925, p.1).
- Current—The site is currently undeveloped public land.

2.2 Land Use

Current use of the sites is recreational. The only site being used consistently and almost daily is the Sportsmen's Club (AOC 00-015), a SAFR open to members of a nonprofit group. In the future, proposed land transfer may result in changes in land use, possibly to commercial or residential.

2.3 Conceptual Site Model

The sampling proposed in this plan uses a conceptual site model to predict areas of potential contamination and allow for adequate characterization of these areas. A conceptual site model describes potential contaminant sources, transport mechanisms, and receptors.

2.3.1 Potential Contaminant Sources

Releases at the sites occurred as a result of asphalt plant operations, mortar rounds, small arms rounds, and general ordnance (both exploded and unexploded) used at the impact sites and firing ranges. Those sites that have been sampled indicate high explosives (HE) are not present in surface samples collected from portions of drainage channels, but further sampling is necessary to determine inorganic chemical, HE, semivolatile organic compounds (SVOCs), and possible perchlorate extent.

2.3.2 Potential Contaminant Transport Mechanisms

Current potential transport mechanisms that may lead to exposure of potential receptors include

- dissolution and/or particulate transport of surface contaminants during precipitation and runoff events,
- airborne transport of contaminated surface soils,
- continued dissolution and advective/dispersive transport of chemical contaminants contained in subsurface soil and bedrock as a result of past asphalt plant operations or ordnance and ammunition use, and
- disturbance and uptake of contaminants in shallow soil by plants and animals.

2.3.3 Current and Future Potential Contaminant Receptors

Potential receptors of possible contaminants at all sites include

- residents,
- users of the Sportsmen's Club,
- trail users in the canyons and on the mesas, and
- plants and animals both on-site and in areas immediately surrounding the sites.

2.4 Previous Site Investigations

2.4.1 SWMU 00-011(a)

In 1993, RFI activities included identifying and removing unexploded ordnance (UXO) and MD, performing a geophysical survey to complete a quality assurance/quality control (QA/QC) check of the UXO/MD removal activities, mapping the geomorphology, and collecting surface soil and quaternary alluvium (QAL) samples. The SWMU boundary was determined by adding new areas (lanes) to search until no UXO/MD were found in the outermost lane, and no additional UXO/MD were found within 50 ft in all directions of the outermost MD fragments. If no UXO/MD were found, the innermost edge of the lane was considered the final boundary. If UXO/MD were found during the UXO sweep or geophysical survey, the entire lane would be reswept and the boundaries adjusted as necessary (LANL 1994, 59427, p. 8). Two live HE mortar rounds (60-mm and 81-mm) were found and destroyed without incident. After the detonations, the resulting MD was recovered (LANL 1994, 59427, p. 8). Other materials recovered during the ordnance sweep included almost 2400 pieces of ordnance fragments and three times as many pieces of scrap material (Figure 2.1-2). The locations of recovered fragments indicated that there was more than one firing point and that these firing points were located on the south side of the canyon floor (LANL 1994, 59427, p. 8). Two burial pits containing mostly tires and UXO/MD were excavated and cleaned out (EHSI 1994, 59057, p. 1).

Geomorphic mapping included mapping all drainage channels that drained the area enclosed within the boundaries of the site and the areas with high concentrations of ordnance fragments. Sampling locations were selected from sediment catchment areas within the drainage channels that drained the areas of high fragment concentration. Soil and QAL samples were collected from 18 locations (locations 00-01201 through 00-1218) and field screened for radioactivity (Figure 2.1-2). These samples were analyzed for inorganic chemicals on-site by the Chemical Sciences and Technology (CST) Division of the Laboratory. High explosives analyses were completed at an off-site fixed laboratory. Sampling results are presented in Section 2.5.1. The RFI report requested NFA and approval of the site for future residential use (LANL 1994, 59427, p. 8-10). The RFI report was approved by EPA in 1994 (EPA 1994, 62098). The Laboratory submitted a Class III permit modification request to NMED in June 2001 to remove SWMU 00-011(a) from Module VIII (LANL 2001, 71096).

2.4.2 SWMU 00-011(c)

In 1993, RFI activities included conducting an ordnance sweep followed by a geophysical QA/QC sweep. Ordnance surveys at the site found scrap metal such as bailing wire and tin cans. Because there was a complete absence of MD, it was assumed that the site was never used as an ordnance impact area. The RFI report requested NFA (LANL 1994, 59427, p. 13 and 14). The RFI report was approved by EPA in 1994 (EPA 1994, 62098).

2.4.3 SWMU 00-011(d)

In 1992 and 1993, RFI activities included identifying and removing UXO and MD, performing a geophysical survey to complete a QA/QC check of the UXO/MD removal activities, mapping the geomorphology, and collecting soil and sediment samples. The MD recovered was 2.36-in. bazooka round fragments, including fin assemblies, motors, bullets, and miscellaneous pieces as well as one partly intact round (LANL 1994, 59427, p. 15).

Geomorphic mapping of the impact area included mapping the surficial, unconsolidated sediment at the site and mapping the drainage channels that would likely be pathways for the surficial transport of contaminants. Sediment catchment areas along both the drainage channels on the hillslope below the cliff and along the axial drainage channels were selected for sampling because they were the areas with the highest probability of contaminant transport from the impact zone by surface water runoff (LANL 1994, 59427, p. 15). Soil and sediment samples were collected from seven locations (locations 00-01050 through 00-01056) and were field screened for radioactivity (Figure 2.1-6). These samples were analyzed for inorganic chemicals on-site by CST. The results of HE analyses were not usable because of exceedance of holding times. Therefore, 13 additional soil and sediment samples were collected later in 1993 from the same locations and from two additional locations, 00-01057 and 00-01058. These samples were analyzed for lead at CST on-site and for HE at an off-site fixed laboratory. Sampling results are presented in Section 2.5.2. The RFI report requested NFA and recommended that Los Alamos County remove the fence from the site boundary and open the area to the public (LANL 1994, 59427, pp. 15–18). The RFI Report was approved by EPA in 1994 (EPA 1994, 62098). The site remains open today.

2.4.4 SWMU 00-011(e)

In 1993, RFI activities included identifying and removing UXO and MD, performing a geophysical survey to complete a QA/QC check of the UXO/MD removal activities, mapping the geomorphology, and collecting shallow surface soil and sediment samples. The SWMU boundary was determined by adding new areas (lanes) to search until no UXO/MD were found in the outermost lane, and no additional UXO/MD were found within 50 ft in all directions of the outermost MD fragments. If no UXO/MD were found, the innermost edge of the lane was considered the final boundary. If UXO/MD were found during the UXO sweep or geophysical survey, the entire lane was reswept and boundaries adjusted as necessary (LANL 1994, 59427, p. 8). During the ordnance sweep, the materials recovered were primarily 37-mm rounds and fragments. The recovered MD included two 20-mm rounds, 102 armor piercing rounds, and fragments of an indeterminate number of 37-mm HE rounds (Figure 2.1-8). Recovered rounds were detonated within the main ordnance impact area of the site. After each of the detonations, the resulting MD was recovered (LANL 1994, 59427, p. 24).

Geomorphic mapping included mapping all of the drainage channels that drained the area within the boundaries of the site and areas that contained high concentrations of ordnance fragments. Sediment catchment areas along the drainage channels of the hillslope below the cliff and within and directly below the main impact zone were selected for sampling because they were areas with the highest probability of contaminant transport from the SWMU by surface water runoff (LANL 1994, 59427, p. 24). Samples were collected from eight locations from surface soils and selected sediment traps (locations 00-01219 through 00-01226) and field screened for radioactivity (Figure 2.1-8). These samples were analyzed for inorganic chemicals on-site by CST. High explosives analyses were completed at an off-site fixed laboratory. Sampling results are presented in Section 2.5.3. The RFI report requested NFA and approval for residential use (LANL 1994, 59427, pp. 22–27). The RFI report was approved by EPA in 1994 (EPA 1994, 62098). The Laboratory submitted a Class III permit modification request to NMED in June 2001 to remove SWMU 00-011(e) from Module VIII (LANL 2001, 71096).

2.4.5 AOC 00-015

In 1992, the OU 1071 RFI work plan recommended that no action be taken at this site until the firing range ceased operation and the land use changed (LANL 1992, 07667, p. 6-3). This work plan was subsequently approved by EPA (EPA 1993, 15110). No sample collection or remedial actions have been conducted at the site.

2.4.6 AOC-C-00-020

- 1991—An ordnance team from Fort Bliss, Texas, inspected the area and concluded that it was not a former impact area. However, because the arrangement of the "no trespassing" signs and the canyon geometry was similar to that found at SWMUs 00-011(c) and 00-011(d), the area was retained as an AOC (LANL 1992, 07667, p. 5-26).
- 1993—RFI activities included conducting an ordnance sweep followed by a geophysical QA/QC sweep. No ordnance, MD, or UXO were located. The geophysical survey found anomalies that turned out to be rocks and some pieces of tin. The RFI phase report recommended the site be designated for NFA and requested approval for residential land use (LANL 1994, 59427, pp. 28 and 29).

2.4.7 AOC C-00-041

- 1995—The USFS requested that DOE remediate the site per USFS regulations. Additionally, the NMED Surface Water Bureau considered the asphalt to be refuse in a watercourse and recommended its removal (LANL 1996, 54925, p.1). A VCA was conducted that included collecting samples to characterize the site before remediation activities were performed. Water, soil, and/or tar were sampled for site characterization at five locations (locations 00-03745 through 00-03749), and analyzed for RCRA metals, volatile organic compounds (VOCs), SVOCs, total petroleum hydrocarbons (TPH), polychlorinated biphenyls (PCBs), and pesticides (LANL 1996, 54925, p. 1). One tar sample was analyzed for RCRA metals and for waste characterization using the toxicity characteristic leaching procedure (TCLP). Asphalt was generally confined to the stream channel. A horizontal layer of asphalt, varying in thickness from 0.5 to 8 in., was found at a depth of 3 to 4 ft. Excavation removed most of this layer. However, excavation stopped when the remaining asphalt had thinned to a layer 1/16 to 1/4 in. thick by 3 ft wide at a depth of 4 ft beneath a cover of soil and vegetation and could not be excavated further with the backhoe (LANL 1996, 54925, p. 2). Approximately 300 yd^3 of material were excavated and taken to the Los Alamos County landfill for disposal. Robert Remillard of the USFS Los Alamos Area Office declared that the USFS was satisfied with the work at the site (LANL 1996, 54925, p. 2). Completion concurrence is currently pending with the DOE.
- 1999—After public users of the area complained about tar and asphalt remaining on-site, a field inspection was conducted in the area. As a result, a small amount of visible tar/asphalt was removed from the drainage channel, a standpipe drain was installed downstream of the Ponderosa Estates subdivision to control storm event runoff into the drainage channel, and rock-check dams were installed in the drainage channel. The standpipe drain was designed to use the natural drainage basin downstream of the subdivision as a storm water retention area and to dissipate flow from large runoff events into the drainage channel where this AOC was located (Veenis 1999, 69722).
- May 2005—The Laboratory constructed additional rock-check dams and other erosional control measures along the watercourse.

2.5 Data Evaluation

In 1993 and 1994, soil, sediment, and/or QAL samples were collected at SWMUs 00-011(a), 00-011(d), and 00-011(e) and analyzed for inorganic chemicals on-site by CST. The samples were analyzed for HE by an off-site laboratory. The QA/QC data for validation of the CST data are incomplete. Therefore, inorganic chemical data cannot be used to quantitatively determine the nature and extent of contamination at the SWMUs, but this extent can be qualitatively summarized. High explosives were analyzed at an off-site laboratory and have adequate QA/QC data. No HE was detected. Because HE was not detected and the inorganic chemical data cannot be used for decision making because of incomplete QA/QC data, these data are not presented in tables or figures in this report. High explosives data are included in Appendix B. At AOC C-00-041, three soil samples were collected from locations where soil and tar have been subsequently removed. Therefore, these soil sample analytical results are not indicative of current conditions and are not used to determine nature and extent. Sampling has not been conducted at SWMU 00-011(c), AOC 00-015, or AOC C-00-020; therefore, there are no sample results to discuss.

2.5.1 SWMU 00-011(a)

Site soil and QAL samples were collected at SWMU 00-011(a) and analyzed for HE and inorganic chemicals (Figure 2.1-2). High explosives were analyzed at an off-site fixed laboratory but were not detected in any sample. Screening-level evaluation of inorganic chemical data analyzed by CST indicates that the majority of the inorganic chemicals detected were collected in QAL samples (Figure 2.1-2, locations 00-01202 and 00-01203). However, no background data are available for comparison. Cobalt and lead were detected at concentrations greater than the soil background value (BV) (LANL 1998, 59730) in 2 out of 18 samples (Figure 2.1-2, locations 00-01208 and 00-01209). The cobalt concentration was within the range of background levels, while lead slightly exceeded the background level range (the site concentration was 29 mg/kg; the background level maximum is 28 mg/kg [LANL 1998, 59730]). Although sampling locations were selected from sediment storage locations within the drainage channels that drained the areas of high fragment concentration, samples were not collected from areas where ordnance fragments were previously removed (Figure 2.1-2). Additionally, the inorganic chemical analyses were performed on-site by CST and do not have adequate QA/QC information available for validation. Therefore, nature and extent have not been defined at this SWMU.

2.5.2 SWMU 00-011(d)

Site soil and sediment samples were collected at SWMU 00-011(d) and analyzed for HE and inorganic chemicals. High explosives were analyzed at an off-site fixed laboratory but were not detected in any sample. Evaluation of screening-level inorganic chemical data analyzed by CST indicates that 22 out of 26 inorganic chemicals analyzed were detected at concentrations greater than the soil and/or sediment BVs (LANL 1998, 59730). Twelve of the inorganic chemicals exceeded the maximum range of the soil and/or sediment background level data set (LANL 1998, 59730): aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, potassium, sodium, vanadium, and zinc. Some of these chemicals are found at the farthest downslope location (Figure 2.1-6, location 00-01056). Additionally, the inorganic chemical analyses were performed on-site by CST and do not have adequate QA/QC information available for validation. Therefore, nature and extent have not been defined for inorganic chemicals at this SWMU.

2.5.3 SWMU 00-011(e)

Site soil and sediment samples were collected at SWMU 00-011(e) and analyzed for HE and inorganic chemicals. High explosives were analyzed at an off-site fixed laboratory but were not detected in any sample. Screening-level evaluation of inorganic chemical data analyzed by CST indicates that only zinc

was detected at concentrations greater than the soil BV (LANL 1998, 59730) in one out of eight samples (Figure 2.1-8, location 00-01219). Although sampling locations were selected from sediment storage locations within the drainage channels that drained the areas of high fragment concentration, samples were not collected from areas where ordnance fragments were removed previously (Figure 2.1-8). Additionally, the inorganic chemical analyses were performed on-site by CST and do not have adequate QA/QC information available for validation. Therefore, nature and extent have not been defined at this SWMU.

3.0 SITE CONDITIONS

Site conditions for Guaje, Bayo, Barrancas, and Rendija Canyons (the North Canyons) are reported in the North Canyons work plan (LANL 2001, 72714) and are presented in detail in Appendix D. This appendix

- describes the environmental settings of Guaje, Bayo, Barrancas, and Rendija Canyons;
- summarizes existing information relevant to the characterization of the northern canyons systems;
- identifies additional information needed to expand the conceptual understanding of the environmental processes that occur within the systems and to assess the magnitude and importance of potential exposure pathways within the canyon systems; and
- provides the technical basis for the conceptual model, described in Chapter 4 of the North Canyons work plan.

The following sections summarize the current surface features and the existing subsurface geologic characteristics beneath the sites in Guaje, Bayo, Barrancas, and Rendija Canyons. Known surface and subsurface traits and their potential effects on the occurrence and concentration of contaminants include

- canyon-mesa terrain, which affects meteorological conditions and ecological habitats at the surface;
- a semiarid climate with low precipitation and a high evapotranspiration rate, which limits the extent of subsurface moisture percolation and limits the amount of moisture available to leach radionuclides or other hazardous waste constituents; and
- a thick, relatively dry unsaturated (vadose) zone, which greatly restricts or prevents downward migration of contaminants in the liquid phase through the vadose zone to the regional aquifer.

These, and other elements of the environmental setting, are useful in evaluating site investigation data with respect to the potential impacts of contamination from historical site activities.

3.1 Surface Conditions

3.1.1 Current Site Topography and Topographic Drainages

Guaje Canyon

Guaje Canyon is the northernmost canyon discussed in this work plan. The watershed drainage is approximately 16.9 mi^2. The watershed heads on the flanks of the Sierra de los Valles at an elevation of 10,497 ft. The Guaje Canyon channel extends east-southeast for approximately 16.4 mi to its confluence with Los Alamos Canyon at an elevation of approximately 5660 ft (LANL 1997, 62316, p. 3-2). The Guaje Canyon channel traverses predominately USFS land except for the lower 2.3 mi, which are within San Ildefonso Pueblo. The Guaje Canyon watershed primarily drains USFS land.

Three named tributaries are present in upper Guaje Canyon on the flanks of the Sierra de los Valles; each canyon trends northwest to southeast. Aqua Piedra Canyon is approximately 3.0 mi long and has a watershed area of 1.61 mi^2. Aqua Piedra Spring is located in the middle part of Aqua Piedra Canyon. Caballos Canyon is approximately 2.9 mi in length and contains another tributary canyon called Vallecitos Canyon, which is the westernmost tributary to Guaje Canyon, and extends for approximately 1.7 mi to the confluence with Caballos Canyon. Vallecitos and Caballos Canyons contain ephemeral streams, receiving snowmelt and storm water runoff from watershed areas of 1.2 and 1.5 mi^2, respectively.

In addition to the named tributaries, two unnamed tributaries of significance to Guaje Canyon are present in the middle and lower sections of its watershed. The “south fork” of Guaje Canyon extends for approximately 1.3 mi on the north side of Guaje Ridge and enters Guaje Canyon from the southwest. The “north fork” of Guaje Canyon extends for about 2.3 mi parallel to Guaje Canyon on the north and enters Guaje Canyon from the north-northeast. These tributaries contain ephemeral streams and occasionally contribute flow to Guaje Canyon. The lower reaches of Guaje Canyon also receive runoff from Rendija and Barrancas Canyons.

Barrancas Canyon

Barrancas Canyon has a relatively small drainage area of 4.9 mi^2 that heads on the northern Pajarito Plateau east of Barranca Mesa at an elevation of 7278 ft (LANL 1997, 62316, p. 3-2). The canyon extends east-southeast approximately 5.5 mi to its confluence with Guaje Canyon at an elevation of 5860 ft (LANL 1997, 62316, p. 3-2).

The main Barrancas Canyon channel crosses approximately 1.6 mi of Los Alamos County land, 0.4 mi of USFS land, 2.7 mi of Laboratory property, and 0.7 mi of San Ildefonso Pueblo land. The Barrancas Canyon watershed contains three unnamed tributaries. The southernmost tributary (the “south fork”) intersects the Barrancas Canyon channel about 0.66 mi west of the Guaje Canyon confluence and is about 1 mi long. The south fork is located predominately on Laboratory property within TA-74. Two longer tributaries north of the main Barrancas Canyon channel extend east from Deer Trap Mesa approximately 2.7 mi (middle fork) and 2.9 mi (north fork) before merging and continuing an additional 1.9 mi to the main Barrancas Canyon channel. These northern tributaries are mostly within USFS land but the headland areas are within Los Alamos County land.

Bayo Canyon

Bayo Canyon has a relatively small drainage area of 4.0 mi^2 and heads on the Pajarito Plateau in a residential area of Los Alamos at an elevation of approximately 7400 ft (LANL 1997, 62316, p. 3-2). The canyon extends east-southeast between North Mesa on the south and Barranca and Otowi Mesas on the north for a distance of approximately 8.2 mi to its confluence with Los Alamos Canyon. The elevation at the confluence is approximately 5790 ft (LANL 1997, 62316, p. 3-2).

Bayo Canyon contains an ephemeral stream. Most surface water flow occurs after heavy summer rains and is generally short in duration (less than 2 hr). There are currently no effluent discharges in Bayo Canyon (Purtymun 1995, 45344, p. 43). The channel traverses approximately 3.47 mi of Los Alamos County land, 3.12 mi of Laboratory property (TA-74), and 1.66 mi of San Ildefonso Pueblo land on its way to its confluence with Los Alamos Canyon (LANL 1997, 62316, p. 3-2). The watershed has an unnamed tributary (the “south fork of Bayo Canyon”) on Laboratory property approximately 1.9 mi from the confluence with Los Alamos Canyon. Another unnamed tributary in the western part of the watershed between Camino Encantada and Barranca Mesa is called the “north fork of Bayo Canyon.”

Rendija Canyon

Rendija Canyon is located immediately north of the Los Alamos townsite. The watershed has a drainage area of 9.5 mi^2. The canyon heads on the flanks of the Sierra de los Valle just west of the townsite at an elevation of 9826 ft. The canyon contains an ephemeral stream channel that extends approximately 9 mi east to its confluence with Guaje Canyon. The lowest elevation of the watershed is approximately 6300 ft (LANL, 1997, 62316, p. 3-2).

Rendija Canyon primarily crosses USFS land except for approximately 1.6 mi of the middle portion of the canyon that crosses GSA land. Parcels of private land and Los Alamos County land, such as the Guaje Pines Cemetery, are located in Rendija Canyon along the north side of the Los Alamos townsite. One named tributary, Cabra Canyon, enters the Rendija Canyon channel from the north in the central portion of the watershed. Cabra Canyon trends northwest-southeast, is approximately 2 mi long, has a watershed area of 1.2 mi^2, and is on USFS and GSA land. Three unnamed tributaries to Rendija Canyon are located west of Cabra Canyon and drain south-southeast into the main Rendija Canyon channel. These tributaries are approximately 1.5, 2.0, and 1.2 mi long.

3.1.2 Features and Structures

Man-Made Drainages

Man-made alterations to the Bayo, Rendija, and Guaje Canyon watersheds likely have changed the channel and drainage pathways in these canyons. Anthropogenic impact to the canyon floors and drainage has occurred from the installation of the roads serving these canyons, construction of sewers and water-supply pipelines for the Los Alamos townsite, and from Laboratory activities conducted within some of the watersheds. Within Guaje Canyon, additional changes have resulted from the installation of Guaje Reservoir and municipal water supply wells and pumping stations.

Vegetation

Vegetation generally includes a ponderosa pine-mixed conifer series in the higher, western portions of the watersheds and a piñon-juniper series in the lower, eastern portions of the watersheds (Biggs 1993, 48979).

Bayo Canyon is characteristic of the lower, eastern portions of the other three watersheds. The steep-sided and narrow upper part of Bayo Canyon is relatively moist and cool and supports a pine-fir forest. As the canyon widens, the pine-fir overstory thins and is restricted to the north-facing slope of Kwage Mesa. The canyon bottom supports many ponderosa pine trees, except in the vicinity of the old firing sites, where all vegetation was removed during the period of active site operation. Ponderosa pine woodland gives way to a piñon-juniper woodland on the drier south-facing slope of Otowi Mesa (Ferenbaugh et al. 1982, 06293).

Erosional Features and Sediment Transport

Recent sedimentation and degradation rates vary within each watershed and have not been fully identified. Localized aggradation and degradation processes may occur to raise or incise a specific interval of the streambed. In Bayo Canyon, sediments deposited since the 1950s range from 0.5 to 2 ft and include fragments of Laboratory debris. Sediments appear to cycle through Bayo Canyon every 100 to 1000 years. Tributary drainages exhibit additional cycles of erosion and deposition occurring on a time scale of tens to hundreds of years (Drake and Inoue 1993, 53456, pp. 1, 6, and 27).

The upper portions of the Guaje Canyon and Rendija Canyon watersheds burned extensively during the Cerro Grande fire in May 2000 (BAER 2000, 68662). Hydrologic changes caused by the fire have increased sediment load, peak flood discharges, and runoff volumes in these canyons. Postfire floods have already contributed to significant channel erosion in some places and sediment aggradation in others, and additional channel changes are likely in the next several years.

Barrancas Canyon and its tributaries have not been significantly impacted by Laboratory operations or other historic activities, with the exception of grazing and logging, and the canyon may be in a relatively natural state.

Basins

There are several structural basins located within the watersheds. These basins are discussed in detail in Appendix D, p. 3-45.

3.1.3 Current Site Usage and Operations

Current site usage and operations are described in Section 2.1 of this work plan.

3.1.4 Influential Features in Surrounding Sites

Sediment Transport and Surface Water Runoff

The water flowing through the North Canyons is used by plants, may be used by wildlife, and potentially may be used by humans; therefore, surface water constitutes a potential contaminant transport pathway to receptors. Surface water flow also provides one of the primary mechanisms for redistributing contaminants that may be present in the North Canyons. Normal precipitation and runoff in the watershed preclude a transport mechanism for contaminant migration to the top of the Puye Formation (Mayfield et al. 1979, 11717, pp. 50 and 58).

3.2 Subsurface Conditions

3.2.1 Subsurface Investigations

Subsurface investigations conducted to a limited extent in middle Bayo Canyon at former TA-10 site and in a small area in middle Guaje Canyon provide information on potential alluvial groundwater. The results of past investigations (see Appendix D, Section 3.4.4) provide the background of conditions needed to assess the importance of contaminant transport pathways. In 1961, four test holes were drilled in middle Bayo Canyon to determine if shallow groundwater was present at the former TA-10, Bayo site. Three test holes were drilled into the top of the Puye Formation to a maximum depth of 88.9 ft. Alluvium was reported to be 5 to 16 ft thick above the tuff in these holes. There was no indication of perched water or excessive moisture in the tuff above the Puye Formation. No contaminant analyses were performed on these samples. Subsurface investigations have not been conducted in Barrancas or Rendija Canyons.

3.2.2 Relevant Soil Horizons

Bayo Canyon is the smallest (in area) of the four northern canyons. The canyon heads in unit Qbt 3 of the Tshirege Member of the Bandelier Tuff, where the channel gradient is about 6.7%. As the canyon cuts through the Cerro Toledo interval and into the more erodible Otowi Member approximately 2 mi downstream, the gradient decreases to about 3%. Approximately 1.9 mi further downstream the channel incises the Puye Formation fanglomerates, and the gradient increases again to about 5%. Bayo Canyon

is incised into the upper Santa Fe Group for a short distance upstream of the confluence with Los Alamos Canyon.

Barrancas Canyon is the shortest of the four northern canyons discussed in this work plan. The total change in elevation from the head of Barrancas Canyon to its confluence with Guaje Canyon is about 1370 ft. The canyon heads in the Tshirege Member of the Bandelier Tuff. The relatively steep and narrow upper portion of the canyon cuts through Tshirege units Qbt 2 through Qbt 1v, and the gradient in the upper portion is about 5%. The channel then cuts through the Cerro Toledo interval and into the Otowi Member, where the gradient decreases slightly to about 4%. About 1.3 mi further downstream, the channel is incised into Tertiary sediments of the Puye Formation, and from that point to Guaje Canyon the gradient averages about 3.3%.

The upper reach (~0.6 mi) of Rendija Canyon is cut into lava flows and associated rocks of the Tschicoma Formation on the flanks of the Sierra de los Valles. Beginning about 13.5 km upstream from the confluence with Guaje Canyon, the channel cuts into the Bandelier Tuff, including tephras and volcaniclastic sediments of the Cerro Toledo interval. The channel is incised into the Puye Formation about 3 mi upstream from Guaje Canyon (Reneau and McDonald 1996, 55538, Figure 2-18). Exposures of the relatively erodible Otowi Member of the Bandelier Tuff and Cerro Toledo interval pumice deposits, for example, have led to extensive lateral stream erosion and development of relatively broad stream terraces. Where the Puye Formation is exposed, the gradient increases, the channel becomes more incised, and terraces are narrower (Reneau and McDonald 1996, 55538). The total change in elevation from the head of Rendija Canyon to its confluence with Guaje Canyon is 3530 ft, and the average gradient is 7.4%. The gradient varies significantly, largely in response to changes in lithology along the length of the canyon. In the upper reach where the Tschicoma Formation is exposed, the gradient is about 15%, and the canyon is narrow and steep-sided. Where the canyon floor consists of the Tshirege Member of the Bandelier Tuff, the gradient is more moderate, ranging from about 8% to 5%. In the Otowi Member and the Cerro Toledo interval, the gradient decreases to about 2%, and the canyon is broader. As the canyon cuts into the Puye Formation downstream of the Sportsmen's Club, the gradient increases again to about 4%.

Guaje Canyon is the longest of the four canyons addressed in this work plan. The total change in elevation from the head of Guaje Canyon to its confluence with Los Alamos Canyon is about 4840 ft (LANL 1997, 62316, p. 3-2), and the average gradient is about 5.6%. The gradient changes along the length of the canyon largely in response to changes in bedrock lithology. For about its first 3 mi, the canyon cuts into the Tschicoma Formation and is steep and narrow with a gradient of about 7%. The canyon is incised into the Puye Formation down to the basal axial facies west of the Guaje Mountain fault zone (GMFZ), at which point the Tschicoma Formation is again exposed for less than 1 mi. The gradient over the conglomerates of the Puye Formation west of the fault zone is about 4%. East of the GMFZ the canyon again is incised into Puye Formation rocks, including the axial facies but primarily the upper fanglomerate deposits, and is mantled with late Quaternary alluvial channel and terrace deposits. The gradient in the Puye Formation east of the fault zone averages about 3.5% but decreases gradually to about 1% or less in the lower reach immediately upstream of Los Alamos Canyon.

3.2.3 Anticipated Stratigraphic Units

The generalized stratigraphy of the Pajarito Plateau, where the sites in this work plan are located, is shown in Appendix D, Figure 3.3-1. The stratigraphy consists of Bandelier Tuff (Qbt) overlain by a thin layer of alluvium and soil. The alluvium is of Pleistocene and Holocene age and rests unconformably on the Bandelier Tuff and deeper units in some parts of all four canyons. The alluvium in the canyons generally consists of reworked Bandelier Tuff and older bedrock units. The alluvium may also contain a minor eolian component. The Bandelier Tuff unit is subdivided into two members, in ascending order: the

Otowi Member and the Tshirege Member. The sites described in this work plan are situated on top of the alluvium or within the Tshirege Member. The Otowi and Tshirege Members are separated at about 300 ft below ground surface (bgs) by the Cerro Toledo (Qct) interval, a 30-ft-thick sequence of volcaniclastic sediments deposited in braided stream systems. The Bandelier Tuff and deposits of the Cerro Toledo interval are derived primarily from explosive volcanic eruptions in the Valles Caldera approximately 1.2 million years ago (Broxton and Eller 1995, 58207, p. 7).

Sampling at the sites described in this work plan is not expected to exceed a depth of about 3 ft. Therefore, anticipated stratigraphic units include surficial soils and sediments, alluvium, and the uppermost portions of the Bandelier Tuff.

3.2.4 Presence of Groundwater

Observations of perched intermediate groundwater in Laboratory wells are rare on the Pajarito Plateau. Perched waters are thought to form mainly at horizons where medium properties change dramatically, such as at paleosol horizons with clay or caliche found in basalt and volcanic sediment sequences. The Cerro Toledo interval, Guaje Pumice Bed, and Puye Formation are local examples.

In 1961 four test holes were drilled at former TA-10 to determine if groundwater served as a migration pathway for contaminants from former firing sites in Bayo Canyon. The boreholes penetrated the alluvium into the underlying Puye Formation. Alluvial groundwater and significant moisture were not encountered (Mayfield et al. 1979, 11717, pp. 50 and 51). Additional information on the test holes is found in Appendix D, Section 3.4.2.

Several subsurface investigations designed to determine the nature and extent of contaminants at former TA-10 in Bayo Canyon have not encountered groundwater in the alluvium or the underlying formations. These investigations have included drilling approximately 14 boreholes in 1973 and 1974. Results of the investigations did not indicate the presence of groundwater or significant amounts of moisture in subsurface sediments. Borehole depths ranged from 8 ft to 40 ft. Most boreholes were located within 250 ft of the Bayo Canyon channel (Mayfield et al. 1979, 11717, pp. 47–59). Seven additional test holes were drilled in Bayo Canyon on November 12 and 13, 1980, to depths from 12 to 37 ft. The soil/tuff contact generally was encountered at depths of 6 to 27 ft. The bedrock beneath the streambed (Otowi Member of the Bandelier Tuff) was usually weathered, and some boreholes encountered pumice. No indications of moisture or groundwater were noted (Purtymun 1994, 58233, pp. 97-1 and 97-2).

A total of 93 boreholes were drilled and sampled during the RFI at former TA-10 in Bayo Canyon from May to November 1994. The investigation was conducted to characterize the nature and extent of potential subsurface contaminants. Each borehole was drilled to a minimum depth of 50 ft. The alluvium in middle Bayo Canyon was approximately 20 to 40 ft thick. Groundwater was not encountered in any of the boreholes. Damp alluvium and Bandelier Tuff were noted (LANL 1996, 54332, p. 9-13). These intermediate-depth boreholes are discussed in Appendix D, Section 3.4.2.

In fall 1966, two shallow test holes were drilled in Guaje Canyon between the Rendija Canyon fault and the Guaje Mountain fault. The boreholes were located approximately 3 mi downstream of the Guaje Reservoir. The test holes were drilled to depths of 17 and 23 ft. The screened intervals of the wells are not known. Saturation in the boreholes was reported from the approximate level of the Guaje Canyon stream channel to total depth (Purtymun 1995, 45344, p. 299). Groundwater samples were not collected, and the wells have not been routinely monitored.

In 1946, test wells were installed in lower Los Alamos and Guaje Canyons to determine if a water supply could be developed for Los Alamos. GT-4 was drilled in the lower reaches of Guaje Canyon at its

confluence with Los Alamos Canyon at an elevation of 5675 ft. The total depth of the well was 315 ft. Alluvium was encountered from the surface to a depth of 54 ft, and the Santa Fe Group was encountered from this depth to the total depth of the test hole. Specific references to saturation within the alluvium were not noted. However, it was determined that the alluvium was too thin to support a municipal water supply (Purtymun 1995, 45344, pp. 245 and 246).

Based on information from these investigations, shallow alluvial groundwater likely is present in the upper and middle reaches of Guaje Canyon, supported by infiltration from spring-fed surface water. Streamflow losses from evapotranspiration, infiltration, and possibly faults reduce the volume of surface water downstream. The saturated thickness of alluvial groundwater likely decreases downstream in the middle part of the canyon.

The regional aquifer in the Los Alamos area rises westward from the Rio Grande within the Santa Fe Group into the Puye Formation beneath the central and western portion of the Pajarito Plateau. Depth of the aquifer decreases from about 1200 ft bgs along the western margin of the plateau to about 600 ft bgs along the eastern margin. The water in the regional aquifer is separated from alluvial and perched water in the volcanics by 350 to 620 ft of tuff and volcanic sediments.

4.0 SCOPE OF ACTIVITIES

The scope of activities is dependent on the current knowledge of operational history and the degree of prior screening and characterization of each site. A phased approach will be used to determine the activities for each site, including site reconnaissance, screening, characterization, excavation, confirmation sampling, and evaluation of survey screening and sample data. This approach will allow for the acquisition of confirmation data and review of the results prior to demobilization. In turn, this information will ensure that the investigation objectives are met in an efficient and timely manner. The phased approach, and proposed screening, characterization, and remediation activities are discussed in the following sections. The characterization activities are based on the requirements outlined in the Consent Order, as well as the data needs identified for each site.

4.1 MEC Site Surveys

Although SWMUs 00-011(a), 00-011(c), 00-011(d), and 00-011(e) and AOC C-00-020 have been previously surveyed for MEC, additional surface MEC and/or MD may exist. The sites in Rendija Canyon have been subjected to recent floods as a result of the Cerro Grande fire, possibly leading to migration and unearthing of MEC and MD. Recent review of the floodplains/wetlands assessment for Rendija Canyon resulted in NMED comments requiring the DOE to investigate and remediate the mortar impact areas (i.e., remove any MEC) prior to any transfer or conveyance of land (NMED 2004, 87287). The New Mexico Environment Department indicated that the techniques and standards used when the sites were initially investigated are not adequate today (NMED 2004, 87287).

At these SMWUs and the AOC, surface surveys will be conducted to identify and remove surface metallic debris/MEC that could mask subsurface anomalies (defined as any identified subsurface mass that may be geologic in origin, MEC, or some other man-made material) and to aid in focusing the digital geophysical mapping (DGM) efforts to identify subsurface MEC. The surface survey will cover all areas within the SWMU/AOC boundaries.

SWMU 00-011(c) and AOC C-00-020 do not lend themselves to effective geophysical surveys and, therefore, will not be included in the DGM surveys. SWMU 00-011(c) has many burned and downed trees resulting from the Cerro Grande fire, and AOC C-00-020 has very irregular topography, both of which will hinder the survey attempts.

Digital geophysical mapping surveys, which will be completed at SWMUs 00-011(a), 00-011(d), and 00-011(e), apply magnetic and electromagnetic methods to identify the locations of subsurface MEC/MD. The priority for DGM surveys will be completed at the highest impact areas, as defined by the subdivisions where the highest amounts of MEC and MD were previously recovered. Applicable guidance is presented in Appendix E (USACE 2003, 88477; USACE 2003, 88478; ITRC 2004, 88479). The areas selected for DGM surveys will be mapped, and a list of anomalies will be generated. Applicable guidance is provided in Appendix E (USACE Data Item Description 005-05, “Geophysical Investigation Plan” [USACE 2003, 88477]).

The anomalies identified and reacquired in the field will be excavated and categorized as one of the following: MEC, MD, other identified scrap, false positive (e.g., no contact), or any other applicable designation. Anomaly identification logs will be maintained in accordance with applicable guidance provided in Attachment C of U.S. Army Corps of Engineers [USACE] Data Item Description 005-05, “Geophysical Investigation Plan” (USACE 2003, 88477) (see Appendix E). The locations of the removed MEC and MD will be recorded by a global positioning system (GPS) unit to serve as sampling locations for the grid samples described in Section 4.2 of this work plan.

All disposal operations will be conducted in accordance with Laboratory requirements and Bureau of Alcohol, Tobacco, and Firearms and USACE guidance (USACE 2003, 88711; USACE 2004, 88718). If possible, recovered MEC will be disposed of by detonation. After sympathetic detonation of the MEC (i.e., detonation of a charge by exploding another charge adjacent to it), a sweep of the demolition area will be conducted to ensure no MEC remains and all MD generated has been recovered. Only qualified UXO technicians will conduct demolition operations. All MD recovered from both the investigation and disposal operations will be certified as explosive-free by the UXO quality/safety officer and the senior UXO supervisor on the project.

4.2 Surface and Shallow Subsurface Sampling Activities

Characterization of potentially explosives-contaminated sites is difficult because of the very heterogeneous distribution of contamination in the environment and within samples (EPA 1996, 55840, p. 1). Approximately 70% to 90% of soil samples analyzed during an explosives site investigation do not contain detectable levels of explosives (EPA 1996, 55840, p. 1). Because sampling error (i.e., variability) is typically much greater than analytical error, especially for explosive residues, overall error is more effectively reduced by increasing the number of field-screening samples as opposed to the number of samples sent for off-site fixed laboratory analyses (EPA 1996 55840, p. 20).

For impact ranges such as SWMUs 00-011(a), 00-011(d), and 00-011(e), the most commonly found explosive constituents are 2,4,6-trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (EPA 2002, 88480, p. 3-13). Therefore, all locations (Figures 4.2-1, 4.2-4, and 4.2-5) will be sampled and field screened for TNT and RDX using, at a minimum, D TECH, an on-site analytical method for detecting explosives in soil. D TECH Immunoassay Test Kits (EPA SW846 Methods 4050 and 4051) employ immunoassay methods for detection of TNT and RDX with detection limits of 0.5 mg/kg. The results are presented as concentration ranges and correlate well with off-site fixed laboratory results of SW846 Method 8330 (EPA 2002, 88480, p. 7-39). The integrated use of both on-site field methods and laboratory analytical methods for explosive compounds detection will provide a comprehensive tool for determining the lateral and vertical extent of contamination (EPA 2002, 88480, p. 7-38).

The sampling activities have been tailored to each site as described in the following sections.

4.2.1 SWMU 00-011(a)

The proposed sample locations at SWMU 00-011(a) are shown in Figure 4.2-1 (explosive compounds field-screening locations) and Figure 4.2-2 (target analyte list [TAL] metal and perchlorate sampling locations). Table 4.2-1 provides a summary of the proposed sample locations, depths, and analytical suites.

To improve site characterization and reduce sampling error, a statistical approach has been used to determine the spacing and number of screening sampling locations required to obtain confidence in finding an area of contamination, if one exists. The statistical method summarized below involves sampling along a grid and is more fully explained in *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987, 56179, Section 10.1).

To determine the grid spacing, the statistical method requires the suspected size and shape of contamination (S), as well as an acceptable level of error (β) that meets project goals (Gilbert 1987, 56179, Section 10.1). If present, contamination would most likely be concentrated within those areas affected by the detonation of a round. Therefore, S is estimated from the lethal bursting diameters presented in the Army Field Manual Number 7-90, *Tactical Employment of Mortars* (Dept. of U.S. Army 1992, 88481, Figure B-5). At this site the majority of contamination resulting from detonation is assumed to be circular. In the calculation below, S is estimated from the average lethal bursting diameters for 60-mm and 81-mm mortar rounds recovered at this SWMU during previous remediation activities. According to Army Field Manual Number 7-90, lethal bursting diameters are 65.6 ft (20 m) and 111.5 ft (34 m) for the 60-mm and 81-mm mortar rounds, respectively. The average radius from both circles is 44.3 ft (13.5 m), calculated as (65.6 ft + 111.5 ft)/4.

The suspected size and shape of contamination (S) is calculated in the following manner:

$$S = \frac{\text{length of the short axis of the expected shape of contamination}}{\text{length of the long axis of the expected shape of contamination}}$$

For a circle, all axes are the same length and, as a result:

$$S = 1$$

To maximize the likelihood of detection of contamination, the acceptable risk of not finding elevated levels of contamination, or of committing a beta error (β), is set to 5% (Gilbert 1987, 56179, p. 121), resulting in a 95% confidence level of finding a localized area of contamination.

The following equation determines the spacing of sample locations required to obtain a 95% confidence level of placing a sample location within the average lethal bursting diameter for 60-mm and 81-mm mortar rounds:

$$L/G,$$

where

L= contamination radius or 44.3 ft (13.5 m), and
G= the spacing between sampling grid lines.

Figure 4.2-3 shows the statistical curves relating L/G to β for different circular target shapes when sampling on a square grid pattern (Gilbert 1987, 56179, Figure 10.3). Figure 4.2-3 shows that using the curve corresponding to the expected shape (S) of contamination, in this case 1, L/G can be found on the horizontal axis that corresponds to the predetermined acceptable probability of β, or 0.05 (shown on

vertical axis of Figure 4.2-3). As shown on Figure 4.2-3, for a 0.05 value of β, the ratio of L/G is approximately 0.60.

Solving for G:

L/G = 0.60

L= 44.3 ft (13.5 m)

0.60 = 44.3 ft (13.5 m)/G

G = 73.8 ft (22.5 m)

Therefore, in order to have a 95% confidence level that samples have been placed to coincide with the average lethal bursting diameter of the mortar rounds found at the site, a portion of samples will be collected on a grid with spacing of approximately 74 ft. For TAL metals and perchlorate, the area of potential contamination is assumed to be larger than for explosive compounds because the fragments of the mortar rounds expand beyond the lethal bursting diameter and likely overlap. Therefore, the grid sampling locations for TAL metals and perchlorate is set at 148 ft (2 x 74 ft), based conservatively upon twice the lethal bursting size, which is approximately equivalent to the explosion size needed to suppress or hit a target 90% of the time (Dept. of U.S. Army 1992, 88481, Figure B-10). Using the same 95% confidence level as for the explosive compounds field-screening sample locations, this grid spacing is calculated as two times the contamination radius (44.3 x 2) divided by the ratio of L/G (0.60), or (44.3 ft x 2)/0.60 = 148 ft.

To determine if contaminant migration has occurred, samples will also be collected approximately every 100 ft along active drainage areas in locations determined by a geomorphologist to be made up of post-1943 sediments (Figures 4.2-1 and 4.2-2, proposed biased samplinglocations). Any obvious active drainage/sediment catchment areas located within 10 ft of a grid location will replace those grid locations. Cliff areas will be sampled from one depth because of their nearly vertical surface topography.

SWMU 00-011(a) was previously subdivided during UXO/MD surveys/removal activities in 1993 and fragment recoveries were tallied for each subdivision (Figure 2.1-2). To focus sampling efforts within a site area of approximately 30 acres, these subdivisions were placed into “higher” or “lower” fragment recovery areas by calculating average fragment recoveries. Subdivisions with fragment recoveries greater than the average fragment recovery per subdivision at the site were designated as higher, and those equal to or less than the average were designated as lower. The average number of fragments recovered at the site per subdivision is 62 (Figure 2.1-2, recovery fractions, calculated as 2426 fragments/39 subdivisions = 62). Therefore, subdivisions with more than 62 fragments recovered were designated as the higher recovery areas. Contamination would more likely be present in the higher recovery areas compared to the lower recovery areas. Focusing sampling in the higher recovery areas increases the likelihood of finding contamination, if it exists.

Higher recovery areas will have grid spacing set approximately 74 ft apart (G, calculated above) with explosive compounds field screening, explosive compounds laboratory analyses, and TAL metal and perchlorate samples collected at varying grid intersections described below (Figures 4.2-1 and 4.2-2). Alternatively, lower recovery areas will be field screened for explosive compounds and sampled for TAL metals and perchlorate analyses less frequently, with samples collected approximately every 296 ft along the grid (every fourth sample location) (Figures 4.2-1 and 4.2-2). As indicated above, the 95% confidence level grid sampling interval of 74 ft will only apply to the higher recovery areas, where contamination, if it exists, is most likely to be present. However, if laboratory results indicate explosive compounds are present or if TAL metals or perchlorate concentrations are above background in more

than 20% of the samples, sampling in lower recovery areas will be changed to follow the same grid spacing as that for the higher recovery areas.

Explosive Compounds Sampling

In higher and lower recovery areas, samples will be collected from the 0- to 0.5-ft and 2.0- to 3.0-ft depth intervals and field screened for explosive compounds using D TECH (Figure 4.2-1). At each drainage sediment sample location, two depth intervals determined by the sediment depth will be field screened for explosive compounds (Figure 4.2-1). Cliff locations will have samples collected from one depth interval. If mortar rounds (fragments, parts, etc.) are found during the prescribed MEC and geophysical sweeps, these locations also will be field screened for explosive compounds. These sample locations will be labeled “biased locations” and will replace the closest grid location. If multiple fragments are found and removed from a localized area, one sample location will be established every 5 ft^2 of area in which the multiple fragments were found. The initial sample depth may change depending on the depth at which the ordnance is found. Samples collected from areas of removed ordnance will start at the depth just below the depth of the ordnance. That is, if a fragment is found 3 ft bgs, then the 0- to 0.5-ft interval will be 3.0 to 3.5 ft bgs.

Normally, at least 10% to 20% of field-screening samples with positive results are sent to an off-site fixed laboratory for explosive compounds analyses, and a smaller fraction of the nondetect samples also may be verified (EPA 1996, 55840, p. 20). In some cases, field-screening methods are used to identify samples containing explosive residues and these samples are sent for laboratory analyses (EPA 1996, 55840, p. 20). At SWMU 00-011(a), a minimum of 20% of the total locations field screened for explosive compounds, regardless of result, will be sent for off-site fixed laboratory explosive compounds analyses. If all field-screening results are negative, samples for off-site fixed laboratory explosive compounds analyses will be representative of the entire site (e.g., every fifth screening location will be sent to the laboratory). Any depth interval with a positive field-screening result will be sent for off-site fixed laboratory explosive compounds analyses. If explosive compounds are detected in the deepest interval at a sampling location, then deeper 1-ft intervals will be sampled until explosive compounds field-screening results are negative. The next depth interval with a negative field-screening result will be sent for off-site fixed laboratory explosive compounds analyses.

TAL Metals and Perchlorate Sampling

TAL metal and perchlorate sample locations overlap with all other explosive compounds field-screening locations; therefore, samples will be collected concurrently for these analyses. Screening locations with positive explosive compounds field-screening results not already identified as sampling locations for TAL metals and perchlorate will have soil or sediment collected concurrently for analyses of explosive compounds, TAL metals, and perchlorate at an off-site fixed laboratory.

In the higher recovery areas, locations approximately every 148 ft along the grid (every second grid point) will be sampled from the 0- to 0.5-ft and 2.0- to 3.0-ft intervals (Figure 4.2-2, locations 1 though 24). In the lower recovery areas, locations approximately every 296 ft along the grid will be sampled from the 0- to 0.5-ft and 2.0- to 3.0-ft intervals. Samples will be collected from two depth intervals as determined by the sediment depth approximately every 100 ft along active drainages (Figure 4.2-2, locations 25 through 56). All of these samples will be analyzed for TAL metals and perchlorate at an off-site fixed laboratory.

If mortar rounds (fragments, parts, etc.) are found during the prescribed MEC and geophysical sweeps, these locations also will be sampled for TAL metals and perchlorate. These sample locations will be labeled “biased locations” and will replace the closest grid location. If multiple fragments are found and removed from a localized area, one sample location will be established every 5 ft^2 of area in which the

multiple fragments were found. The initial sample depth may change depending on the depth at which the ordnance is found. Samples collected from areas of removed ordnance will start at the depth just below the depth of the ordnance. That is, if a fragment is found 3 ft bgs, then the 0- to 0.5-ft interval will be 3.0 to 3.5 ft bgs.

4.2.2 SWMU 00-011(c)

Previous removal efforts in the early 1990s did not find any MEC or MD at this site, indicating it was never used as a munitions impact area. Recent floods resulting from the Cerro Grande fire, may have led to migration and unearthing of MEC and MD. If MEC or MD are not found during the prescribed MEC survey, it will further support the conclusion that SWMU 00-011(c) was never used as an impact area. As a result of not finding any MEC or MD, characterization sampling will not be conducted. However, if MEC and/or MD are found, higher recovery areas (as determined by areas with more than the average number of recovered items found at this site) will be sampled using a grid system as described for SWMUs 00-011(a). The grid sizing and number of samples collected will depend on the type and locations of munitions recovered. If the type of munitions recovered is different from those discussed for SWMUs 00-011(a) and 00-011(e), the size of explosions will be estimated to determine grid sizing.

If warranted by the survey results, samples will be collected approximately every 100 ft along active drainages in locations determined by a geomorphologist to be post-1943 sediments. Any obvious active drainage/sediment catchment areas located within 10 ft of a grid location will replace those grid locations.

At each soil sample location, the 0- to 0.5-ft and 2.0- to 3.0-ft depth intervals will be field screened for explosive compounds using D TECH. At each drainage sediment sample location, two depth intervals determined by the sediment depth will be field screened for explosive compounds. A minimum of 20% of the total locations field screened for explosive compounds, regardless of result, will be sent for off-site fixed laboratory explosive compounds analyses. If all field-screening results are negative, samples for off-site fixed laboratory explosive compounds analyses will be representative of the entire site (e.g., every fifth screening location will be sent to the laboratory). Any depth interval with a positive field-screening result will be sent for off-site fixed laboratory explosive compounds analyses. If explosive compounds are detected in the deepest interval at a sampling location, then deeper 1-ft intervals will be sampled until explosive compounds field-screening results are negative. The next depth interval with a negative field-screening result will be sent for off-site fixed laboratory explosive compounds analyses. All TAL metal and perchlorate sample locations overlap with explosive compounds field-screening locations; therefore, samples will be collected concurrently for these analyses. Screening locations with positive explosive compounds field-screening results not already identified as sampling locations for TAL metals and perchlorate will have soil or sediment collected concurrently for analyses of explosive compounds, TAL metals, and perchlorate at an off-site fixed laboratory.

In higher and lower recovery areas, locations along the grid will be sampled from the 0- to 0.5-ft and 2.0- to 3.0-ft intervals and analyzed for TAL metals and perchlorate at an off-site fixed laboratory.

If rounds (fragments, parts, etc.) are found during the prescribed MEC sweeps, these locations will also be field screened for explosive compounds and samples will be collected for TAL metals and perchlorate off-site fixed laboratory analyses. These sample locations will be labeled “biased locations” and will replace the closest grid location. If multiple fragments are found and removed from a localized area, one sample location will be established every 5 ft^2 of area in which the multiple fragments were found. The initial sample depth may change depending on the depth at which the ordnance is found. Samples collected from areas of removed ordnance will start at the depth just below the depth of the ordnance. That is, if a fragment is found 3 ft bgs, then the 0- to 0.5-ft interval will be 3.0 to 3.5 ft bgs.

4.2.3 SWMU 00-011(d)

The proposed sample locations at SWMU 00-011(d) are shown in Figure 4.2-4. Table 4.2-2 provides a summary of the proposed sample locations, depths, and analytical suites.

According to the 1992 field investigation, the majority of bazooka rounds were fired into one main area along the southwest-facing side of the cliff (Figure 4.2-4, bazooka impact area). Therefore, samples will be collected in a biased manner from the impact area and along the downslope active drainages present at the site. If bazooka rounds (fragments, parts, etc.) are found during the prescribed MEC and geophysical sweeps, these locations will also be field screened for explosive compounds using D TECH and samples will be collected for TAL metal and perchlorate off-site fixed laboratory analyses. These sample locations will replace the closest prescribed location. If multiple fragments are found and removed from a localized area, one sample location will be established every 5 ft^2 of area in which the multiple fragments were found. The initial sample depth may change depending on the depth at which the ordnance is found. Samples collected from areas of removed ordnance will start at the depth just below the depth of the ordnance. That is, if a fragment is found 3 ft bgs, then the 0- to 0.5-ft interval will be 3.0 to 3.5 ft bgs.

Samples will be collected approximately every 100 ft along the drainage channel below the cliff from two depth intervals at locations determined by a geomorphologist to be post-1943 sediments (Figure 4.2-4, Locations 1 through 9). The former bazooka impact area will be sampled from three locations at one sample depth because of the nearly vertical surface topography (Figure 4.2-4, locations 10 through 12). The cliff area has multiple drainage channels along the face that will be sampled from two depth intervals at locations determined by a geomorphologist to be post-1943 sediments (Figure 4.2-4, locations 13 through 15). A total of six locations will be sampled west of the drainage channel at the bottom of the cliff to define lateral extent from the 0- to 0.5-ft and 2.0- to 3.0-ft depth intervals (Figure 4.2-4, locations 16 through 21). Samples will be screened for explosive compounds in the field and analyzed for TAL metals and perchlorate at an off-site fixed laboratory.

A minimum of 20% of the total locations field screened for explosive compounds, regardless of result, will be sent for off-site fixed laboratory explosive compound analyses. If all field-screening results are negative, samples for off-site fixed laboratory explosive compound analyses will be representative of the entire site (e.g., every fifth screening location will be sent to the laboratory). Any depth interval with a positive field-screening result will be sent for off-site fixed laboratory explosive compound analyses. If explosive compounds are detected in the deepest interval at a sampling location, then deeper 1-ft intervals will be sampled until explosive compounds field-screening results are negative. The next depth interval with a negative field-screening result will be sent for off-site fixed laboratory explosive compound analyses.

4.2.4 SWMU 00-011(e)

The proposed sample locations at SWMU 00-011(e) are shown in Figures 4.2-5 (explosive compounds field-screening locations) and 4.2-6 (TAL metal and perchlorate sampling locations). Table 4.2-3 provides a summary of the proposed sample locations, depths, and analytical suites.

This site will be sampled using the same statistical approach used for SWMU 00-011(a) to determine the spacing and number of sample locations required to obtain a 95% confidence level of finding a localized area of contamination if one exists. At this SWMU, L is assumed to be the average lethal bursting diameter for 20-mm and 37-mm rounds which were recovered at this SWMU. Although these specific rounds are not discussed in the Army Field Manual Number 7-90, *Tactical Employment of Mortars* (Dept. of U.S. Army 1992, 88481, Figure B-5), the lethal bursting diameters may be inferred to have a

similar relationship to the round size as those diameters calculated for the 60- and 81-mm mortar rounds. Because the majority of the rounds and MD recovered at this site were 37-mm in size, the average size round at this SWMU could conservatively be assumed to be 30-mm. Estimating from the 60-mm mortar round lethal bursting diameter, the value for a 30-mm round would be approximately half of 65.6 ft (20 m), or 32.8 ft (10 m). Assuming a circular shape, the average value of L (contamination radius based on the 30-mm round) is 16.4 ft (5 m).

Solving for G:

L/G = 0.60

L = 16.4 ft (5 m)

0.60 = 16.4 ft (5 m)/G

G = 27.3 ft (8.3 m)

Therefore, to have a 95% confidence level that samples have been placed to coincide with the average lethal bursting diameter of the rounds found at the site, a portion of samples will be collected on a grid with spacing of approximately 27 ft. For TAL metals and perchlorate, the area of potential contamination is assumed to be larger than that for explosive compounds because the fragments of the rounds expand beyond the lethal bursting diameter. Therefore, the grid sampling locations for TAL metals and perchlorate will be set at 54 ft (2 x 27 ft), based conservatively upon twice the lethal bursting size, which is approximately equivalent to the explosion size needed to suppress or hit a target 90% of the time (Dept. of U.S. Army 1992, 88481, Figure B-10). Using the same 95% confidence level as for the explosive compounds field-screening sample locations, this grid spacing is calculated as two times the contamination radius (16.4 x 2) divided by the ratio of L/G (0.60), or (16.4 ft x 2)/0.60 = 54 ft.

The site was previously subdivided during UXO/MD surveys and removal activities in 1993, and MD recoveries were tallied for each subdivision (Figure 2.1-8). Portions of the cliff with previous MD recovery at this SWMU are too steep to allow grid sampling or a large number of locations to be sampled (Figure 2.1-8, subdivisions with 1/6, 0/2, and 0/6 MD recoveries). Additionally, the majority of subdivisions previously surveyed did not result in finding any MD (Figure 2.1-8, 0/0 recoveries). Therefore, portions of these areas will be sampled from biased locations. To determine if contaminant migration has occurred, areas without fragment or round recovery will have samples collected every 100 ft along active drainage areas in locations determined by a geomorphologist to be post-1943 sediments (Figure 4.2-5, proposed biased screening locations). The steep cliff area with previous recovery will have three biased locations sampled from one depth in areas of suspected contamination (high-impact area, sediment-catchment area, etc.). Additionally, grid locations will be replaced by sampling any obvious active drainage/sediment catchment areas located within 10 ft of a grid location.

To focus sampling efforts within the remaining subdivisions with MD recovery, these areas were placed into higher or lower MD recovery areas by calculating average MD recoveries. Subdivisions with MD recoveries greater than the average fragment recovery per subdivision at the site were designated as higher, and those equal to or less than the average were designated as lower. The average number of rounds recovered per subdivision with recovery is 9 rounds (Figure 2.1-8, recovery fractions, calculated as 92 rounds/10 subdivisions = 9 rounds). The average number of fragments/bullets recovered per subdivision with recovery is 21 fragments/bullets (Figure 2.1-8, recovery fractions, calculated as 205 fragments and/or bullets/10 subdivisions = 21 fragments and/or bullets). Therefore, recovery areas with more than 9 rounds and 21 fragments/bullets recovered were designated as the higher recovery areas. Contamination would more likely be present in the higher recovery areas compared to the lower recovery areas. Focusing sampling in the higher recovery areas increases the likelihood of finding contamination, if it exists.

Higher recovery areas will have grid spacing set approximately 27 ft apart (G, as calculated above) with explosive compounds field screening, explosive compounds laboratory analyses, and TAL metal and perchlorate samples collected at the grid intersections (Figures 4.2-5 and 4.2-6). Alternatively, lower recovery areas will be field screened for explosive compounds and sampled for TAL metals and perchlorate analyses less frequently, with samples collected approximately every 108 ft along the grid (every fourth sample location) (Figures 4.2-5 and 4.2-6). As indicated, the 95% confidence level grid sampling interval of 27 ft will only apply to the higher recovery areas, where contamination, if it exists, is most likely to be present. However, if laboratory results indicate explosive compounds are present or if TAL metals or perchlorate concentrations are above background levels in more than 20% of the samples, sampling in lower recovery areas will be changed to follow the same grid spacing as for the higher recovery areas.

Explosive Compounds Sampling

In higher and lower recovery areas, samples will be collected from the 0- to 0.5-ft and 2.0- to 3.0-ft depth intervals and field screened for explosive compounds using D TECH (Figure 4.2-5). At each drainage sediment sample location, two depth intervals determined by the sediment depth will be field screened for explosive compounds (Figure 4.2-5). The steep cliff area with previous recovery will have three biased locations sampled from one depth interval in areas of suspected contamination (high impact area, sediment catchment area, etc., Figure 4.2-5). If rounds (fragments, parts, etc.) are found during the prescribed MEC and geophysical sweeps, these locations will also be field screened for explosive compounds. These sample locations will be labeled “biased locations” and will replace the closest grid location. If multiple fragments are found and removed from a localized area, one sample location will be established every 5 ft^2 of area in which the multiple fragments were found. The initial sample depth may change depending on the depth at which the ordnance is found. Samples collected from areas of removed ordnance will start at the depth just below the depth of the ordnance. That is, if a fragment is found 3 ft bgs, then the 0- to 0.5-ft interval will be 3.0 to 3.5 ft bgs.

A minimum of 20% of the total locations field screened for explosive compounds, regardless of result, will be sent for off-site fixed laboratory explosive compounds analyses. If all field-screening results are negative, samples for off-site fixed laboratory explosive compounds analyses will be representative of the entire site (e.g., every fifth screening location will be sent to the laboratory). Any depth interval with a positive field-screening result will be sent for off-site fixed laboratory explosive compounds analyses. If explosive compounds are detected in the deepest interval at a sampling location, then deeper 1-ft intervals will be sampled until explosive compounds field-screening results are negative. The next depth interval with a negative field-screening result will be sent for off-site fixed laboratory explosive compounds analyses.

TAL Metals and Perchlorate Sampling

TAL metal and perchlorate sample locations overlap with every other explosive compounds field-screening location; therefore, samples will be collected concurrently for these analyses. Screening locations with positive explosive compounds field-screening results not already identified as sampling locations for TAL metals and perchlorate will have soil or sediment collected concurrently for analyses of explosive compounds, TAL metals, and perchlorate at an off-site fixed laboratory.

In the higher recovery areas, locations approximately every 54 ft along the grid (every second grid point) will be sampled from the 0- to 0.5-ft and 2.0- to 3.0-ft intervals (Figure 4.2-6, locations 1 through 38). In the lower recovery areas, locations approximately every 108 ft along the grid will be sampled from the 0- to 0.5-ft and 2.0- to 3.0-ft intervals (locations 39 through 50). Areas without previous ordnance recovery will have only samples collected at two depth intervals approximately every 100 ft along active drainage

areas (locations 51 through 60). The cliff area with previously recovered ordnance will have samples collected from one depth interval in the same biased locations screened for explosive compounds (Figure 4.2-6, locations 61 through 63). All of these samples will be analyzed for TAL metals and perchlorate at an off-site fixed laboratory.

If rounds (fragments, parts, etc.) are found during the prescribed MEC and geophysical sweeps, these locations also will be sampled for TAL metals and perchlorate. These sample locations will be labeled "biased locations" and will replace the closest grid location. If multiple fragments are found and removed from a localized area, one sample location will be established every 5 ft^2 of area in which the multiple fragments were found. The initial sample depth may change depending on the depth at which the ordnance is found. Samples collected from areas of removed ordnance will start at the depth just below the depth of the ordnance. That is, if a fragment is found 3 ft bgs, then the 0- to 0.5-ft interval will be 3.0 to 3.5 ft bgs.

4.2.5 AOC C-00-020

Previous removal efforts in the early 1990s did not find any MEC or MD at this site, indicating that it may have never been used as a munitions impact area. Recent floods resulting from the Cerro Grande fire may have led to migration and unearthing of MEC and MD. If MEC or MD are not found during the prescribed MEC survey, this will further support the conclusion that AOC C-00-020 was never used as an impact area. As a result of not finding any MEC or MD, characterization sampling will not be conducted. However, if MEC and/or MD are found, higher recovery areas (as determined by areas with more than the average number of recovered items at this site) will be sampled using a grid system as described for SWMU 00-011(a). The grid sizing and number of samples collected will depend on the type and locations of munitions recovered. If the type of munitions recovered are different from those discussed for SWMUs 00-011(a) and 00-011(e), the size of explosions will be estimated to determine grid sizing.

If warranted by the survey results, samples will be collected approximately every 100 ft along active drainages in locations determined by a geomorphologist to be post-1943 sediments. Any obvious active drainage/sediment catchment areas located within 10 ft of a grid location will replace those grid locations.

At each soil sample location, the 0- to 0.5-ft and 2.0- to 3.0-ft depth intervals will be field screened for explosive compounds using D TECH. At each drainage sediment sample location, two depth intervals determined by the sediment depth will be field screened for explosive compounds. A minimum of 20% of the total locations field screened for explosive compounds, regardless of result, will be sent for off-site fixed laboratory explosive compounds analyses. If all field-screening results are negative, samples for off-site fixed laboratory explosive compounds analyses will be representative of the entire site (e.g., every fifth screening location will be sent to the laboratory). Any depth interval with a positive field-screening result will be sent for off-site fixed laboratory explosive compounds analyses. If explosive compounds are detected in the deepest interval at a sampling location, then deeper one foot intervals will be sampled until explosive compounds field-screening results are negative. The next depth interval with a negative field-screening result will be sent for off-site fixed laboratory explosive compounds analyses. All TAL metal and perchlorate sample locations overlap with explosive compounds field-screening locations; therefore, samples will be collected concurrently for these analyses. Screening locations with positive explosive compounds field-screening results not already identified as sampling locations for TAL metals and perchlorate will have soil or sediment collected concurrently for analyses of explosive compounds, TAL metals, and perchlorate at an off-site fixed laboratory.

In higher and lower recovery areas, locations along the grid will be sampled from the 0- to 0.5-ft and 2.0- to 3.0-ft intervals and analyzed for TAL metals and perchlorate at an off-site fixed laboratory.

If rounds (fragments, parts, etc.) are found during the prescribed MEC sweeps, these locations will also be field screened for explosive compounds and samples collected for TAL metals and perchlorate off-site fixed laboratory analyses. These sample locations will be labeled “biased locations” and will replace the closest grid location. If multiple fragments are found and removed from a localized area, one sample location will be established per every 5 ft^2 of area in which the multiple fragments were found. The initial sample depth may change depending on the depth at which the ordnance is found. Samples collected from areas of removed ordnance will start at the depth just below the depth of the ordnance. That is, if a fragment is found 3 ft bgs, then the 0- to 0.5-ft interval will be 3.0 to 3.5 ft bgs.

4.2.6 AOC-C-00-041

The proposed sample locations at AOC C-00-041 are shown in Figure 4.2-7. Table 4.2-4 provides a summary of the proposed sample locations, depths, and analytical suites.

Any remaining asphalt and tar are assumed to be restricted largely to the site itself, with the majority of tar residues to be found between the former location of the batch plant and the bottom of the watercourse. The potential contaminants at AOC C-00-041 are TAL metals, VOCs, SVOCs, and TPH. A walkover of the site will be conducted to look for remnants of tar and asphalt that may have been missed during the VCA or exposed subsequent to the VCA. If tar or asphalt is encountered, the coordinates will be identified by plotting a point on the site map using a GPS unit and the area will be marked by a pin flag and the material removed.

Biased samples will be collected at 100-ft intervals down the center of the AOC near the present watercourse (Figure 4.2-7, locations 1 through 12). Sample locations will be biased toward sediment pockets and former locations of asphalt and tar. Two biased sample locations will be established in the footprint of the former batch plant (Figure 4.2-7, locations 13 and 14). Three additional biased sample locations will be established downslope from the former batch plant location (Figure 4.2-7, locations 15 through 17). Samples will be collected at 0- to 0.5-ft and 2.0- to 3.0-ft depth intervals and analyzed for TAL metals, VOCs, SVOCs, and TPH.

4.3 Health and Safety Requirements

A site-specific health and safety plan and integrated work document will be written prior to conducting any field activities.

5.0 INVESTIGATION METHODS

All work will be performed in accordance with all applicable standard operating procedures (SOPs), quality procedures (QPs), and the ENV-ERS Quality Management Program. Applicable investigation methods are presented in Table 5.0-1.

5.1 Sample Point and Structure Location Surveying

Site attributes (i.e., soil sample locations, sediment sample locations, ordnance locations, as well as staked out sampling grids) will be located by using GPS. Horizontal locations will be measured to the nearest 0.5 ft. The survey results will be presented as part of the investigation report. Sample coordinates will be uploaded into the Environmental Restoration Database.

5.2 Collecting Soil and Rock Samples

The most common method for surface and shallow subsurface sampling is the spade-and-scoop method, described in Environmental Stewardship–Environmental Characterization and Remediation (ENV-ECR)

SOP-6.09. Stainless-steel shovels, spades, scoops, and bowls will be used because of their ease of decontamination. Disposable tools made of polystyrene or Teflon may also be used. In some cases, hand-augering tools may be used to collect shallow subsurface samples if geologic material conditions permit. The use of tools and their applicability is described in ENV-ECR SOP-6.10. If a surface sample location is in bedrock, an axe or hammer and chisel may be used to collect samples. Sites that may have explosive compounds will be sampled according to ENV-ECR SOP-01.07, Operational Guidelines for Taking Soil and Water Samples in Explosive Areas.

All samples (surface and subsurface) will be shipped through the Sample Management Office (SMO) to off-site fixed laboratories for analysis. Samples will be sent to laboratories on the ENV-ERS-approved suppliers list. All samples will be collected and handled according to ENV-ECR SOP-15.09, Chain of Custody for Analytical Data Record Packages. The analytical suites for each sample location are described in the sections pertaining to the individual site and listed in Tables 4.2-1 through 4.2-4.

Quality assurance/quality control samples will include field duplicate samples collected in accordance with ENV-ECR SOP-1.05. Field duplicate samples will be collected as directed by ENV-ECR SOP-01.05 at a frequency of at least 1 for every 10 regular samples per the Consent Order. Rinsate blanks will also be collected to confirm decontamination of sampling equipment.

5.3 Field Screening

Visual examination will be used at all of the sites to help aid in finding sampling locations. Explosive compounds field screening will be performed at all of the sites except AOC 00-041. Headspace vapor screening for VOCs will be performed only at AOC C-00-041. Explosive compounds field screening will be performed using D TECH Immunoassay Test Kits for TNT and RDX (EPA SW846 Methods 4050 and 4051). The results are presented as concentration ranges and correlate well with SW846 Method 8330 (EPA 2002, 88480, p. 7-39).

5.4 Equipment Decontamination

Following investigation activities, project personnel will decontaminate all equipment. Residual material adhering to equipment will be removed using dry decontamination methods (ENV-ECR SOP-01.08). If the equipment cannot be free-released following dry decontamination, a high-pressure sprayer, along with long-handled brushes and rods, will be used to remove contaminated material more effectively. Pressure-washing of equipment will be performed on a temporary wash pad with a high-density polyethylene liner. Cleaning solutions and wash water will be collected and contained for proper disposal. Decontamination solutions will be sampled to determine final disposition. All parts of the equipment will be thoroughly cleaned. Equipment air filters will be considered contaminated and will be removed and replaced before the equipment leaves the site.

5.5 Waste Management

Materials identified as waste will be segregated into specific waste types for appropriate disposal. Investigation activities will minimize the waste generated by following the ENV-ERS 2004 Pollution Prevention Roadmap (LANL 2004, 88465). Methods for managing investigation-derived waste, including soil, tuff, concrete and other structural material, protective personal equipment, and other miscellaneous materials, and the assumptions used to estimate waste volumes are described in Appendix C.

5.6 Excavation Backfilling and Cover Replacement

Excavations will be backfilled and compacted, and clean cover material will be placed over the affected area. The clean fill material will be procured from off-site. All affected surfaces will be restored to original

grade, reseeded with a native seed mix, and straw mulch will be applied to help stabilize the surface. To prevent future subsidence, the replaced material will be compacted to the extent practical and will be mounded slightly in anticipation of settling.

6.0 MONITORING AND SAMPLING PROGRAM

No monitoring is currently performed at any of the sites. It is anticipated that no further sampling or monitoring will be required at any of the sites after these work plan activities are completed.

7.0 SCHEDULE

Following approval of this work plan by NMED, readiness review and site preparation activities can begin. Preparation activities, implementation of the fieldwork, and demobilization are anticipated to require 4 to 6 months. Sample submittals to the SMO will be completed by this time. Receipt of analytical data is anticipated prior to demobilization so an evaluation can be made regarding the need for additional remediation. An investigation report will then be written and submitted to NMED, as required in the Consent Order.

8.0 REFERENCES

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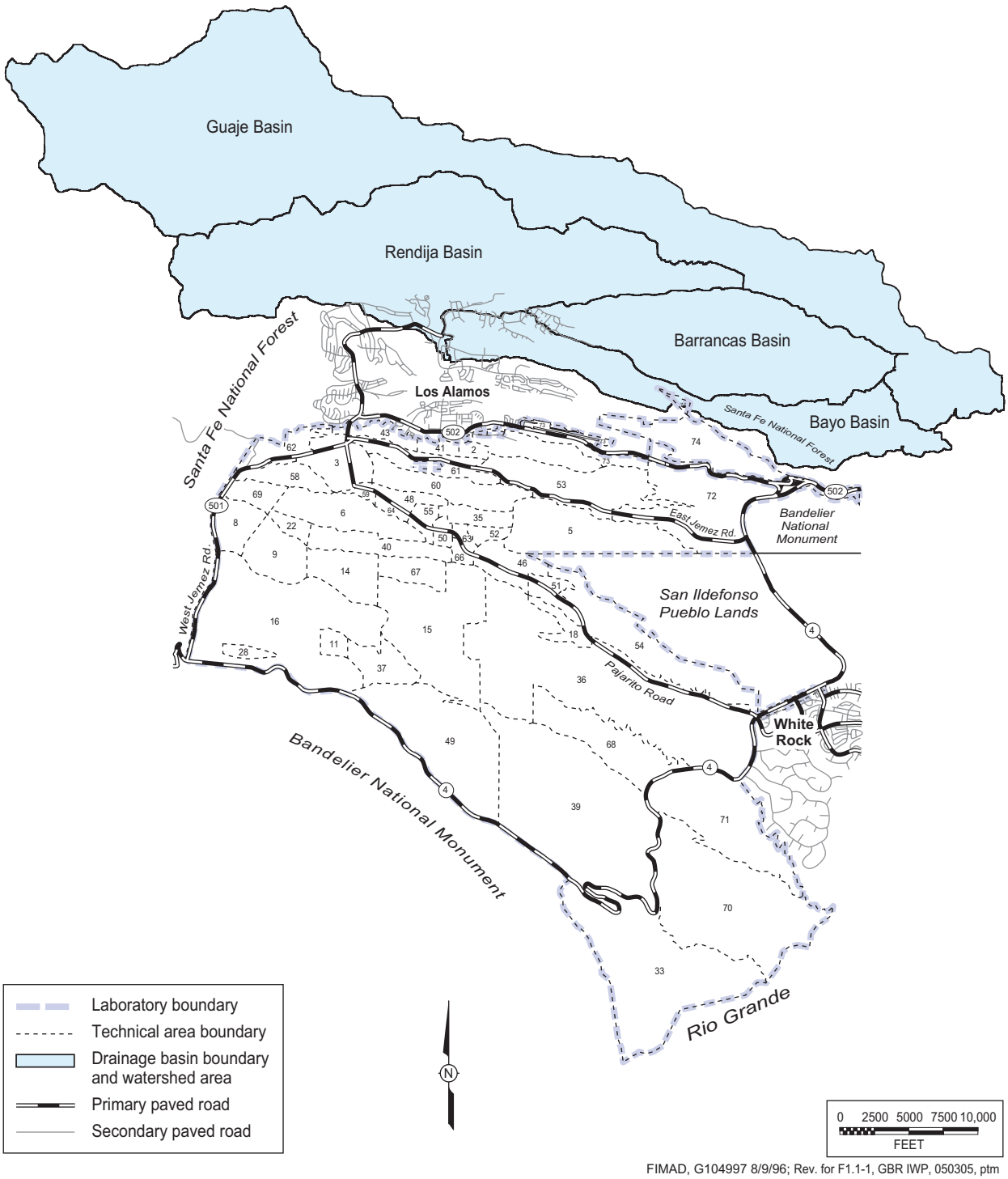


Figure 1.0-1. Location of Guaje, Barrancas, Rendija, and Bayo watersheds with respect to Laboratory technical areas and surrounding land holdings

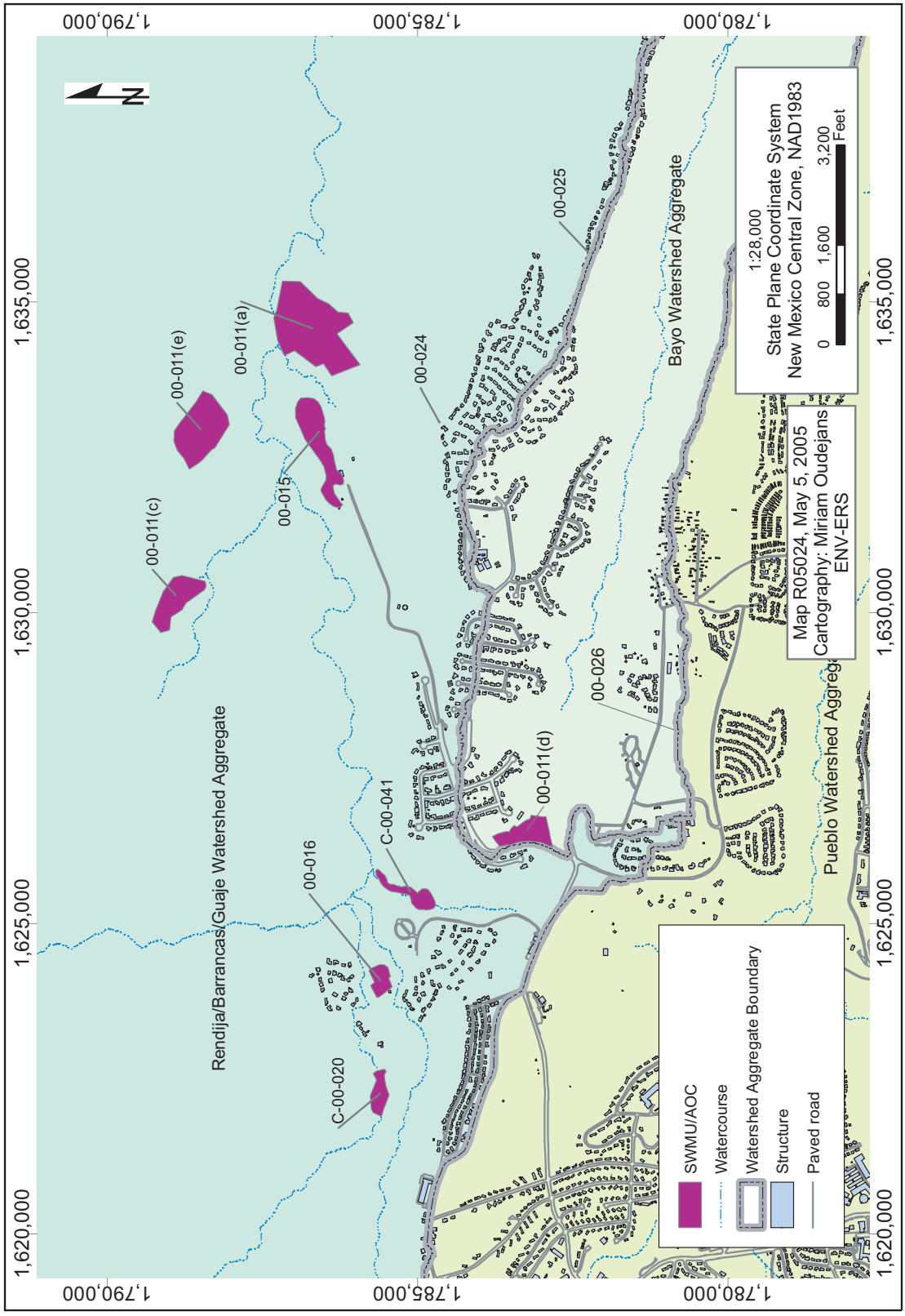


Figure 1.0-2. SWMU and AOC locations within the Bayo and Rendija/Barrancas/Guaje watershed aggregates

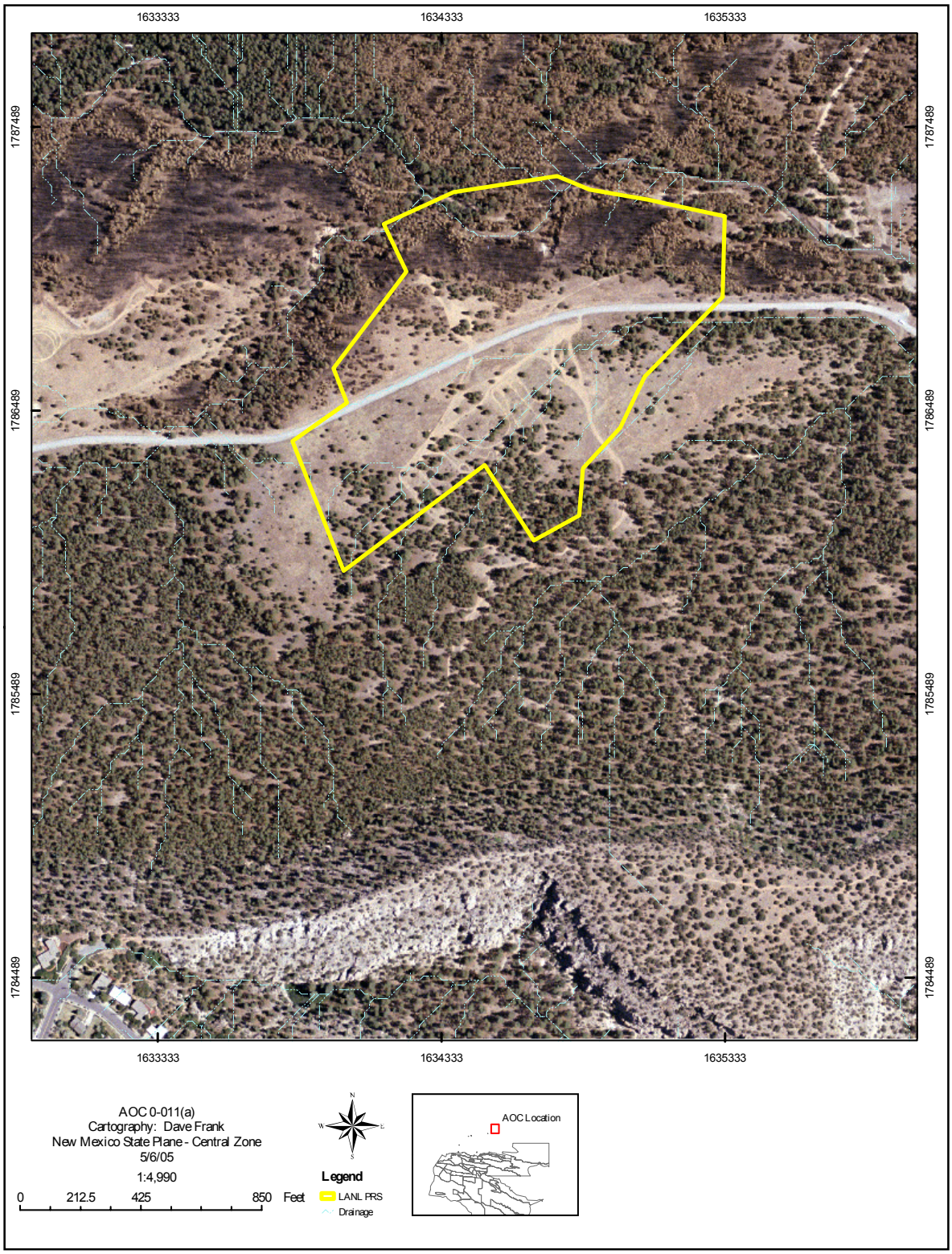
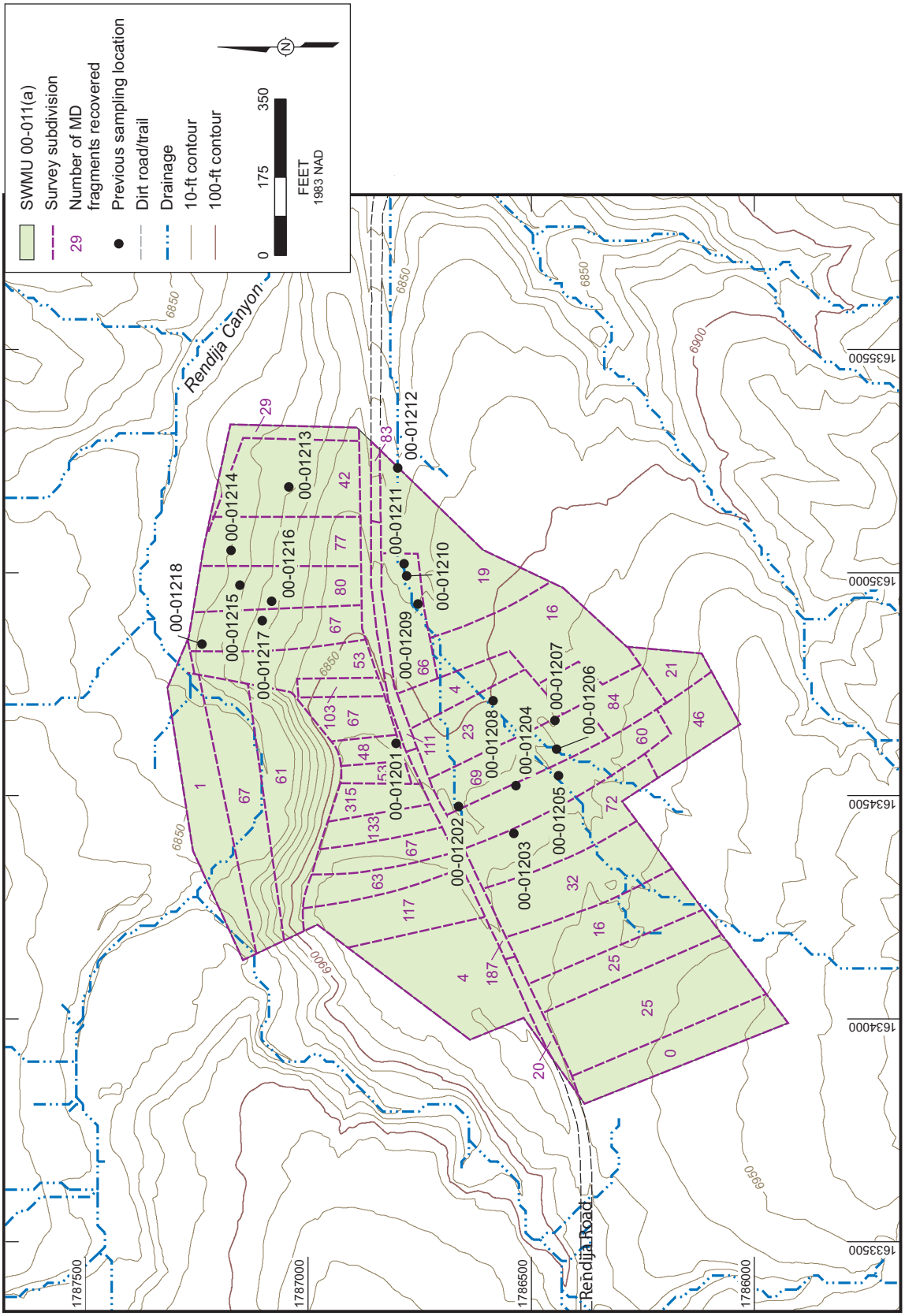


Figure 2.1-1. Aerial photograph of SWMU 00-011(a)



Source: D. Walther, GISLab m201434, 031005; modified for F2.4-1, GBR Cyns IWP, 050405, ptm

Figure 2.1-2. SWMU 00-011(a) areas of removed MD fragments, mortar rounds, and previous sampling locations

Figure 2.1-3. Aerial photograph of SWMU 00-011(c)

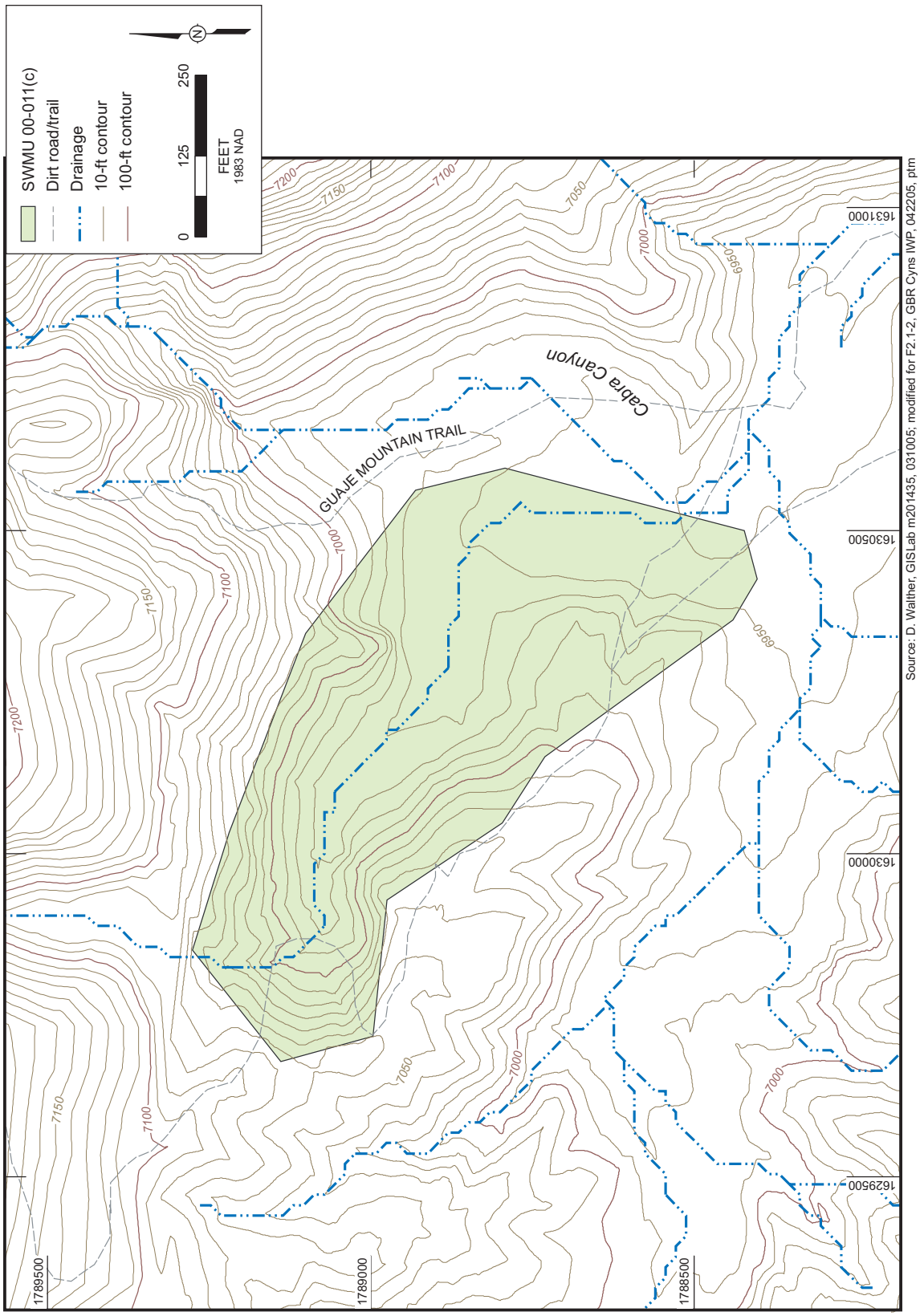


Figure 2.1-4. SWMU 00-011(c) site map

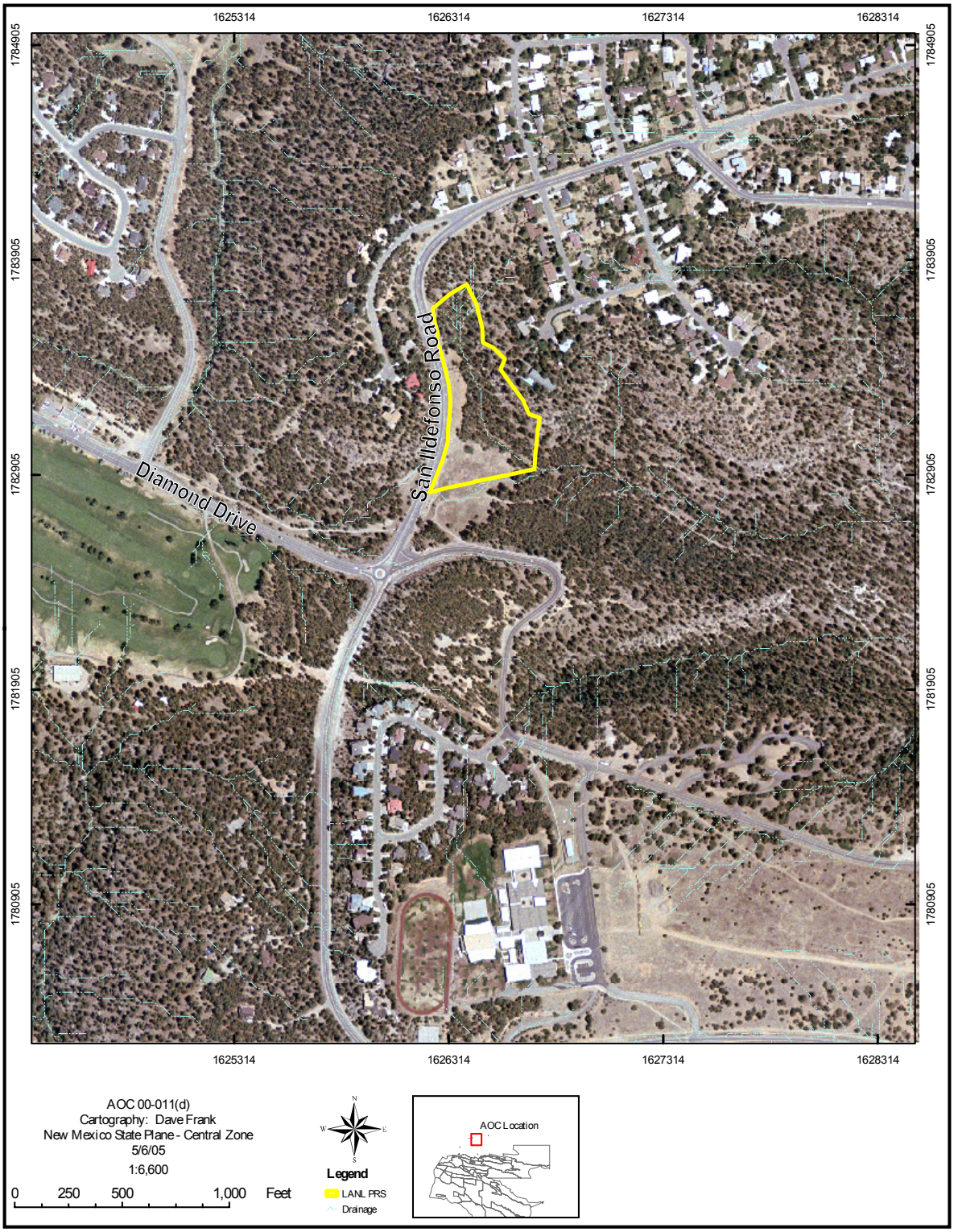


Figure 2.1-5. Aerial photograph of SWMU 00-011(d)

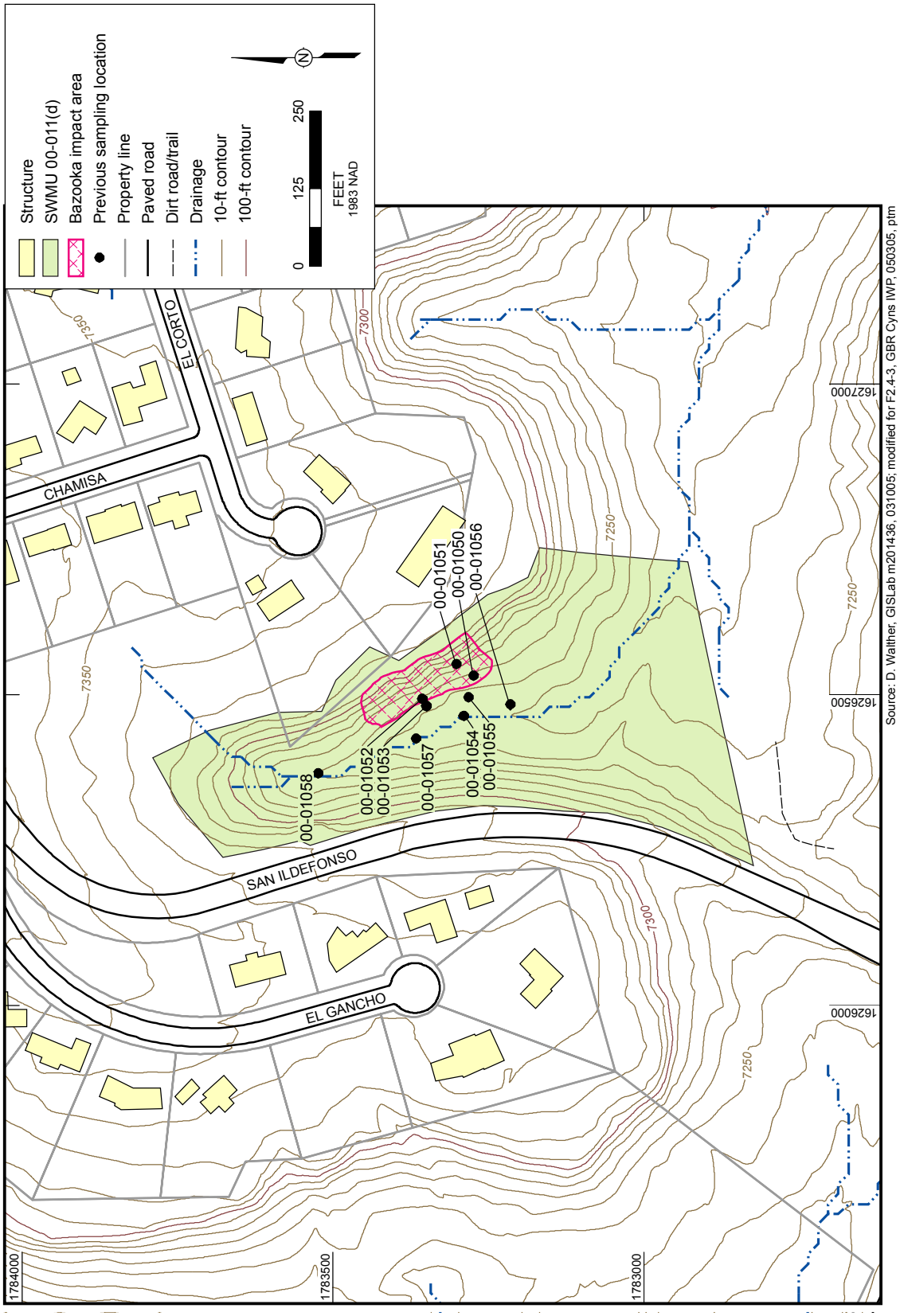


Figure 2.1-6. SWMU 00-011(d) bazooka impact area and previous sampling locations

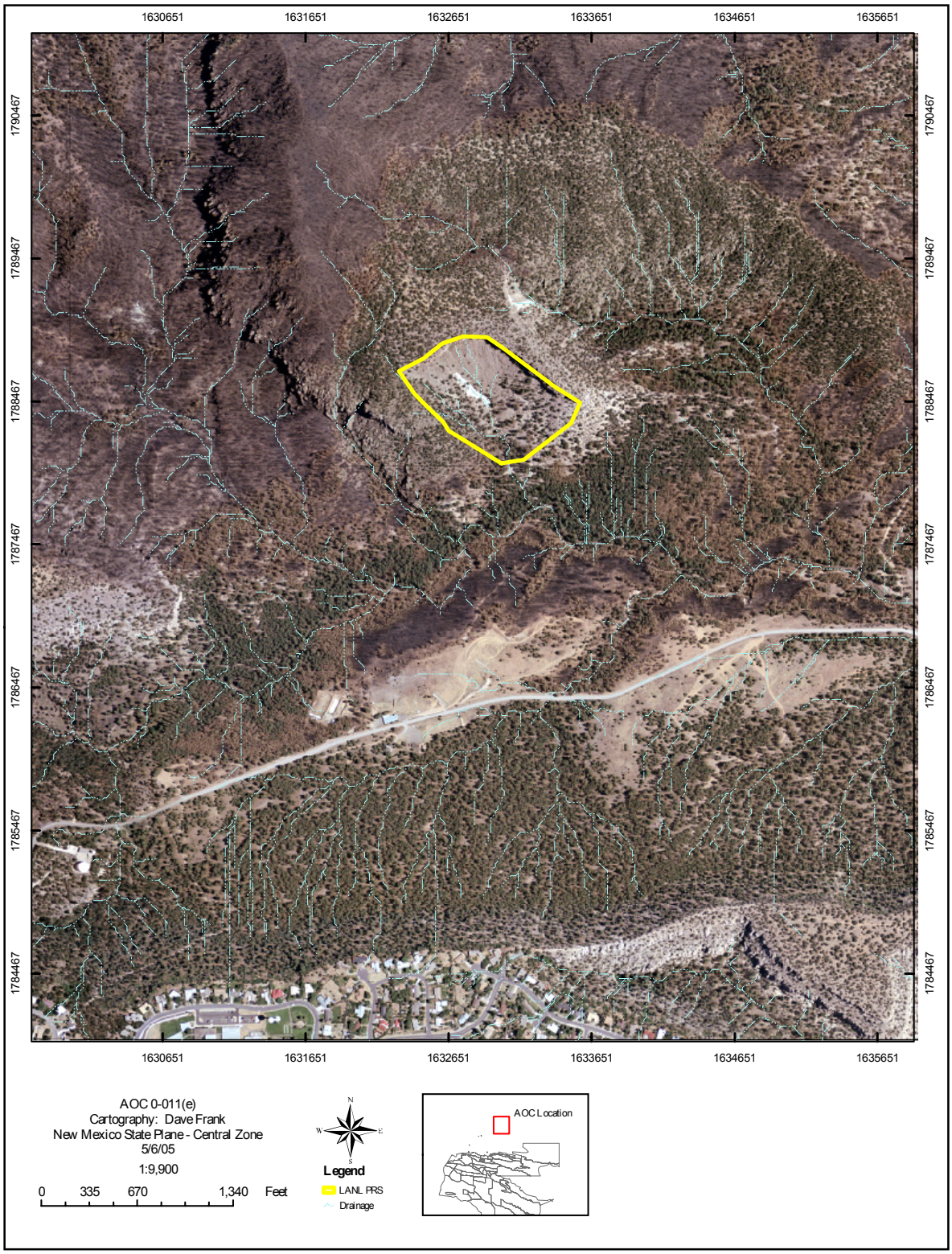
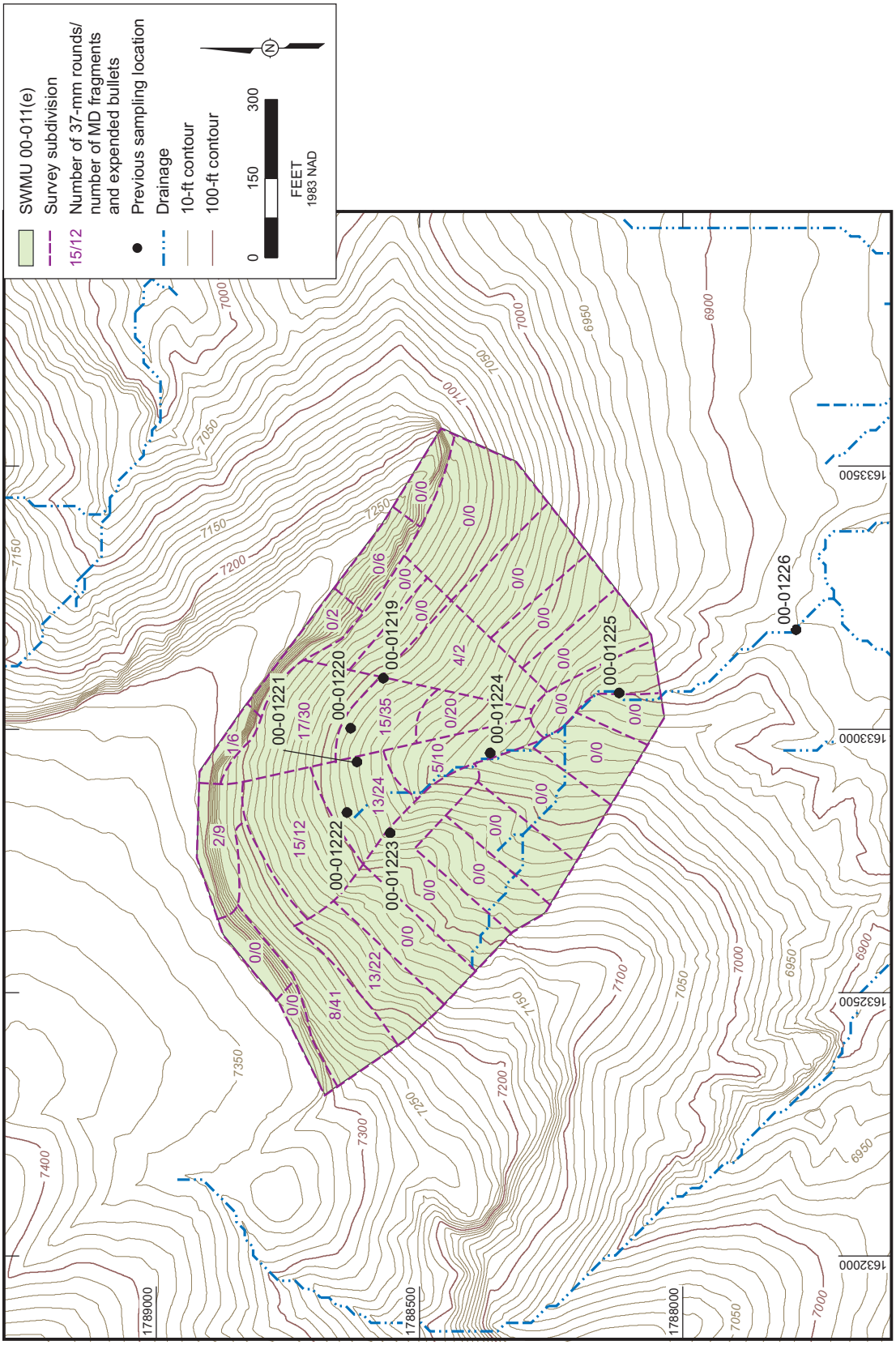


Figure 2.1-7. Aerial photograph of SWMU 00-011(e)



Source: D. Walther, GISLab m201437, 031005; modified for F2.4-4, GBR Cyns IWP, 050405, ptm

Figure 2.1-8. SWMU 00-011(e) areas of removed 37-mm rounds, MD fragments, expended bullets, and previous sampling locations

Figure 2.1-9. Aerial photograph of AOC 00-015

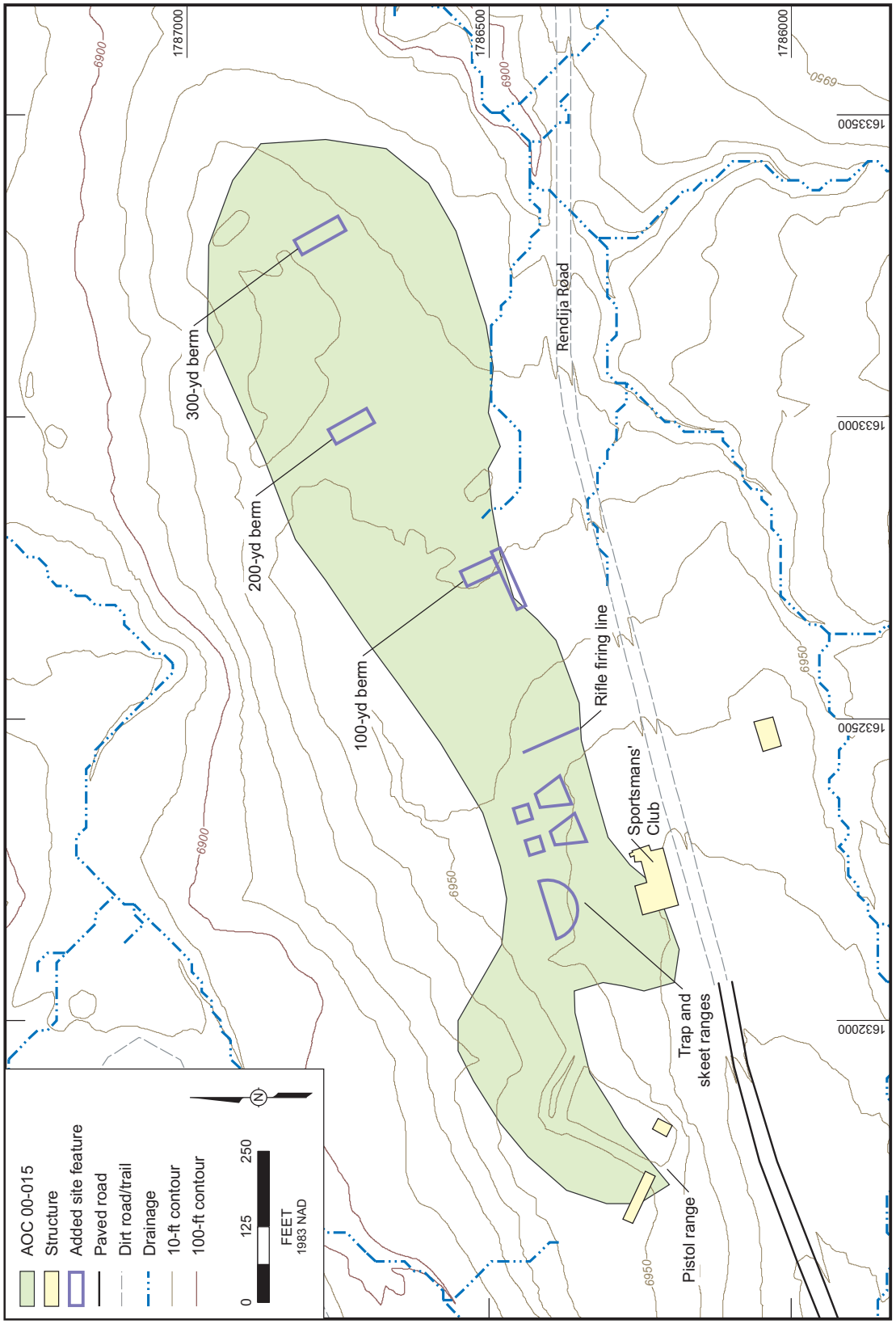


Figure 2.1-10. AOC 00-015 site map

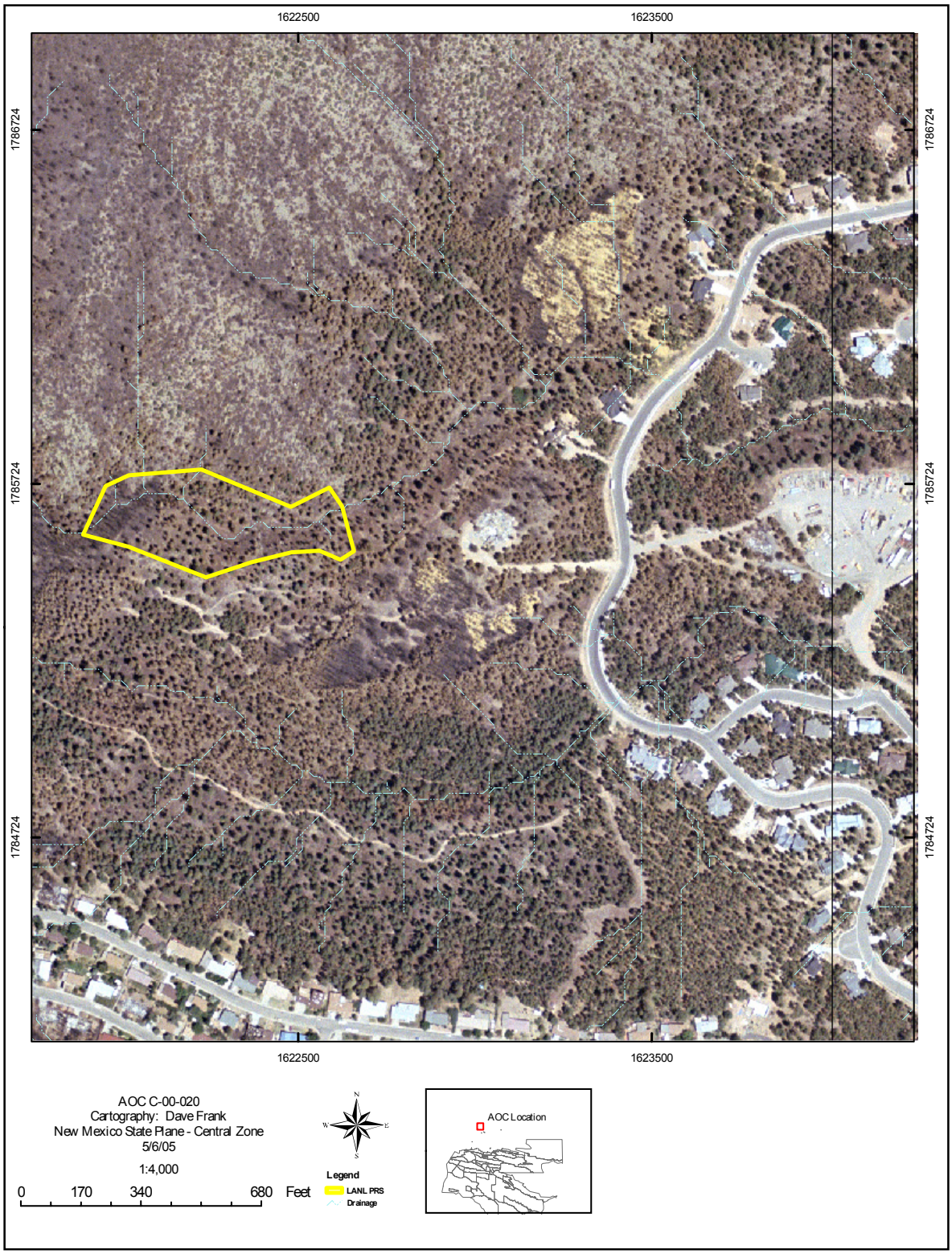
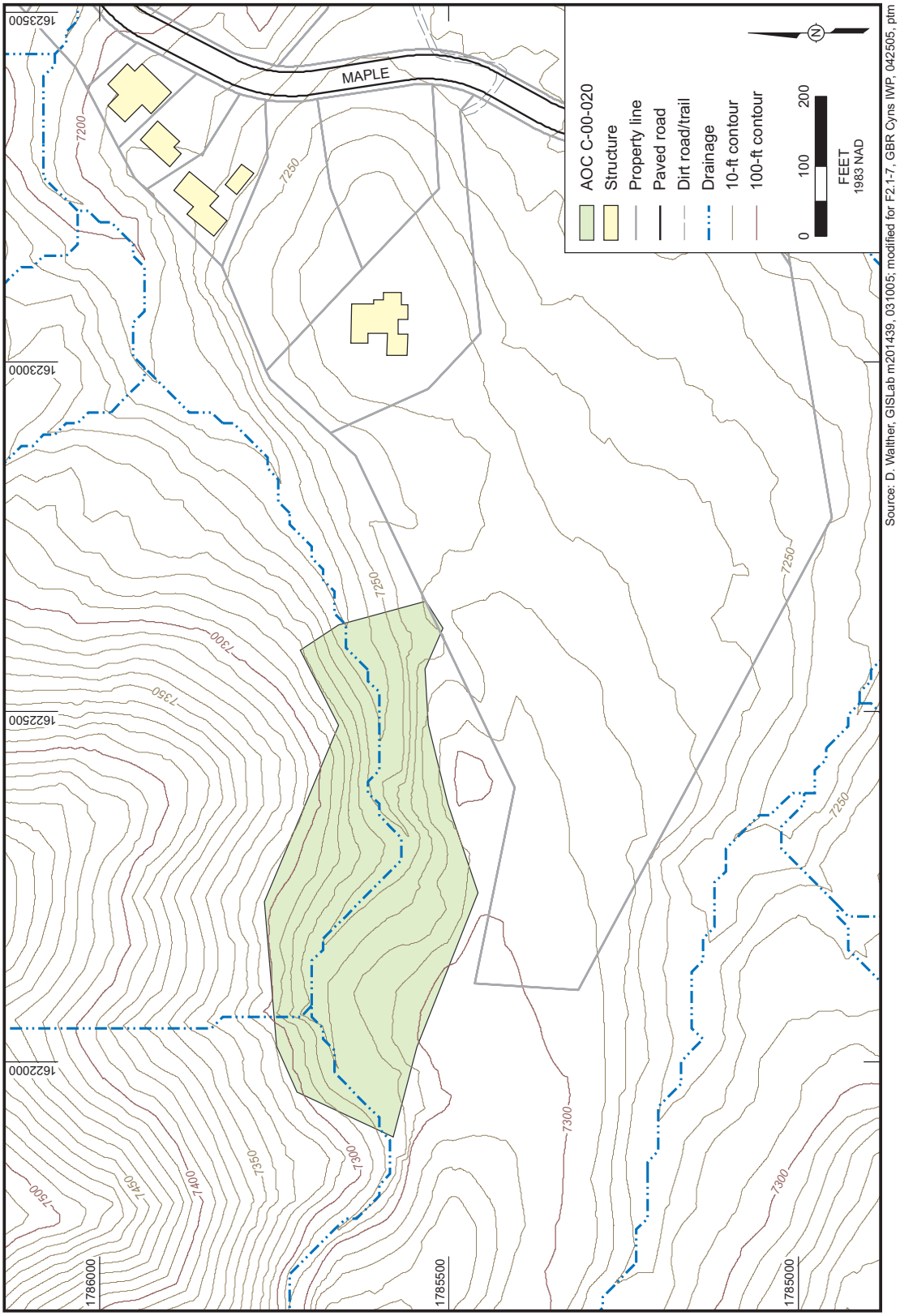


Figure 2.1-11. Aerial photograph of AOC C-00-020



Source: D. Walther, GISLab m201439, 031005; modified for F2.1-7, GBR Cyns IWP, 042505, ptm

Figure 2.1-12. AOC C-00-020 site map

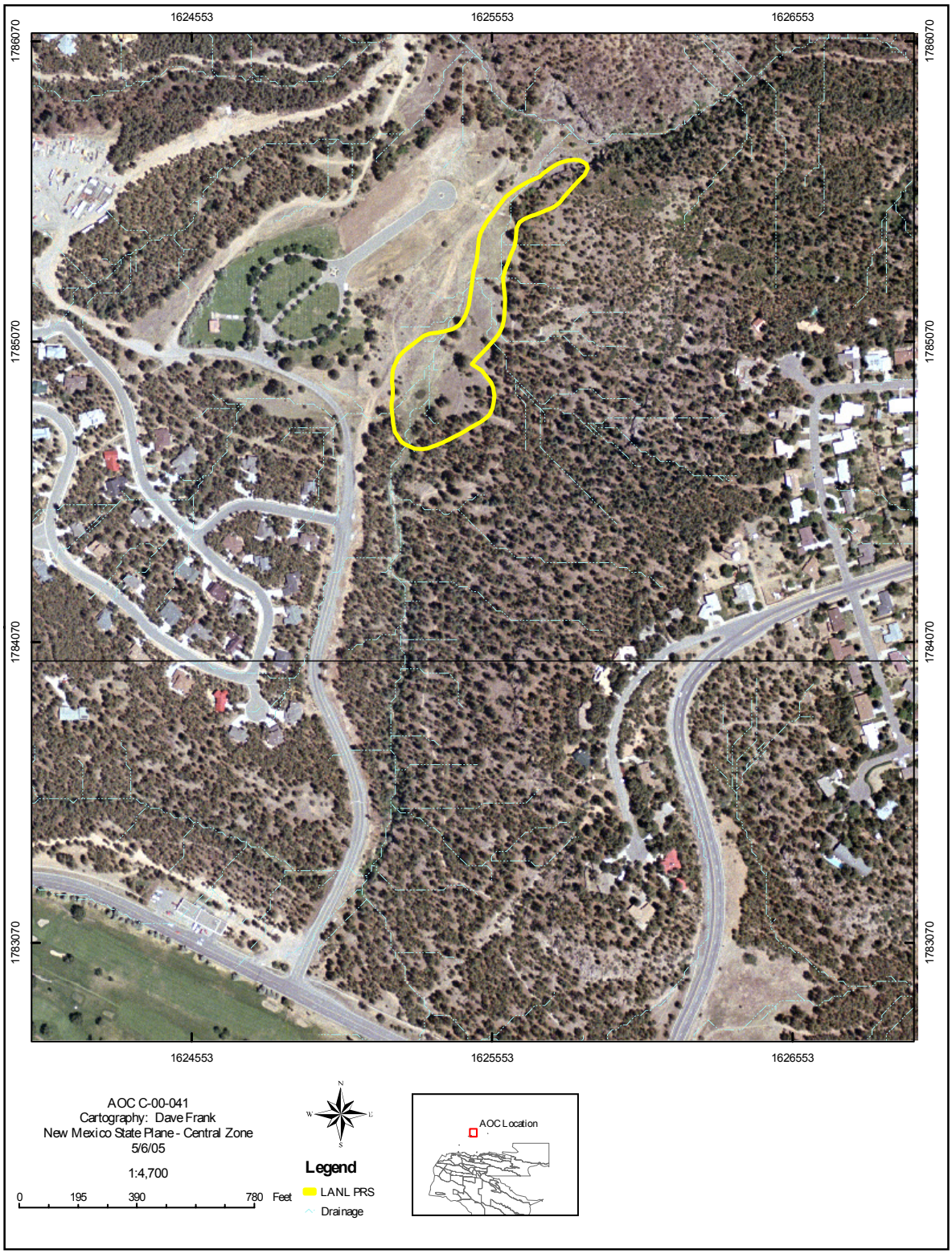


Figure 2.1-13. Aerial photograph of AOC C-00-041

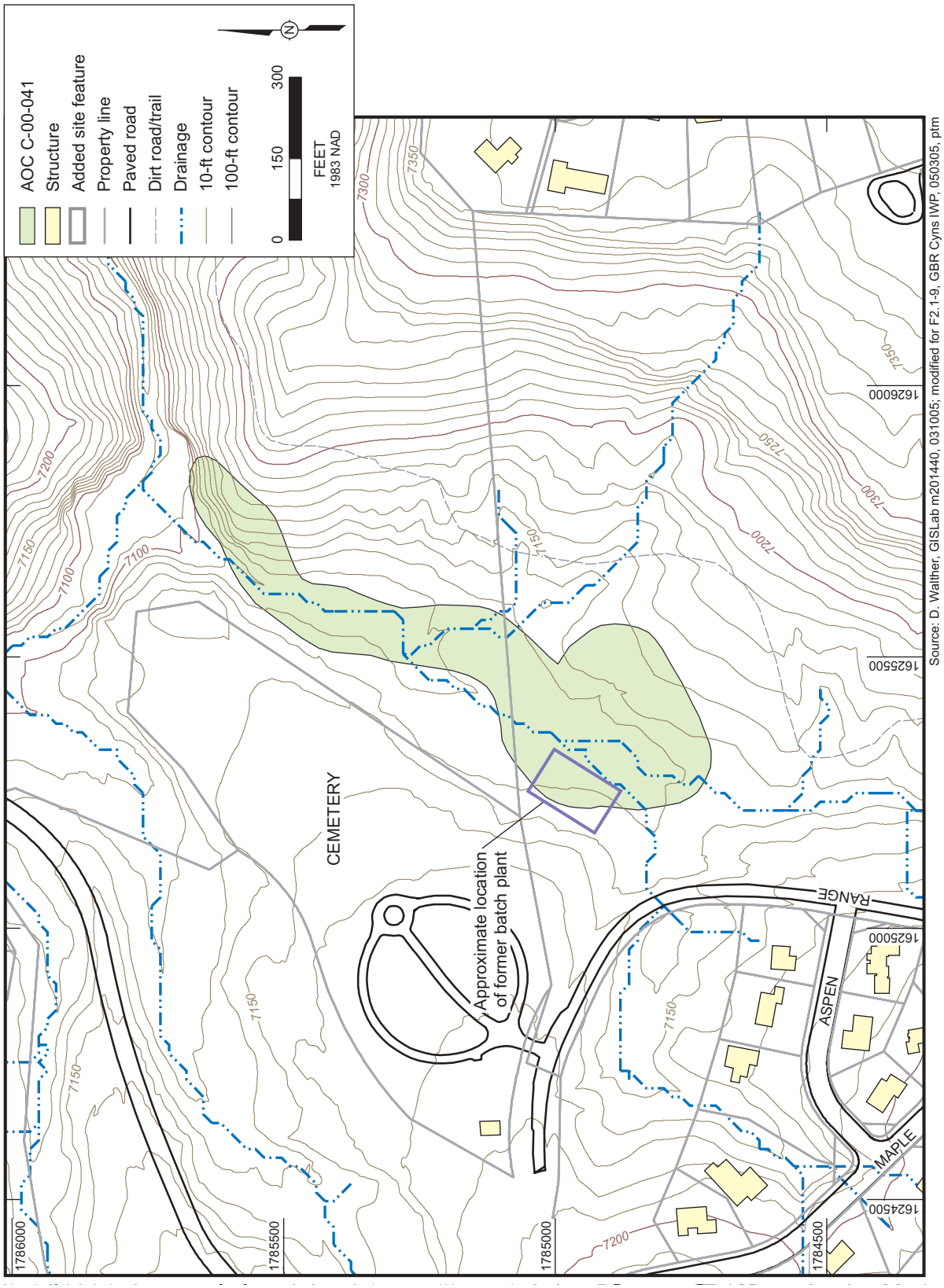
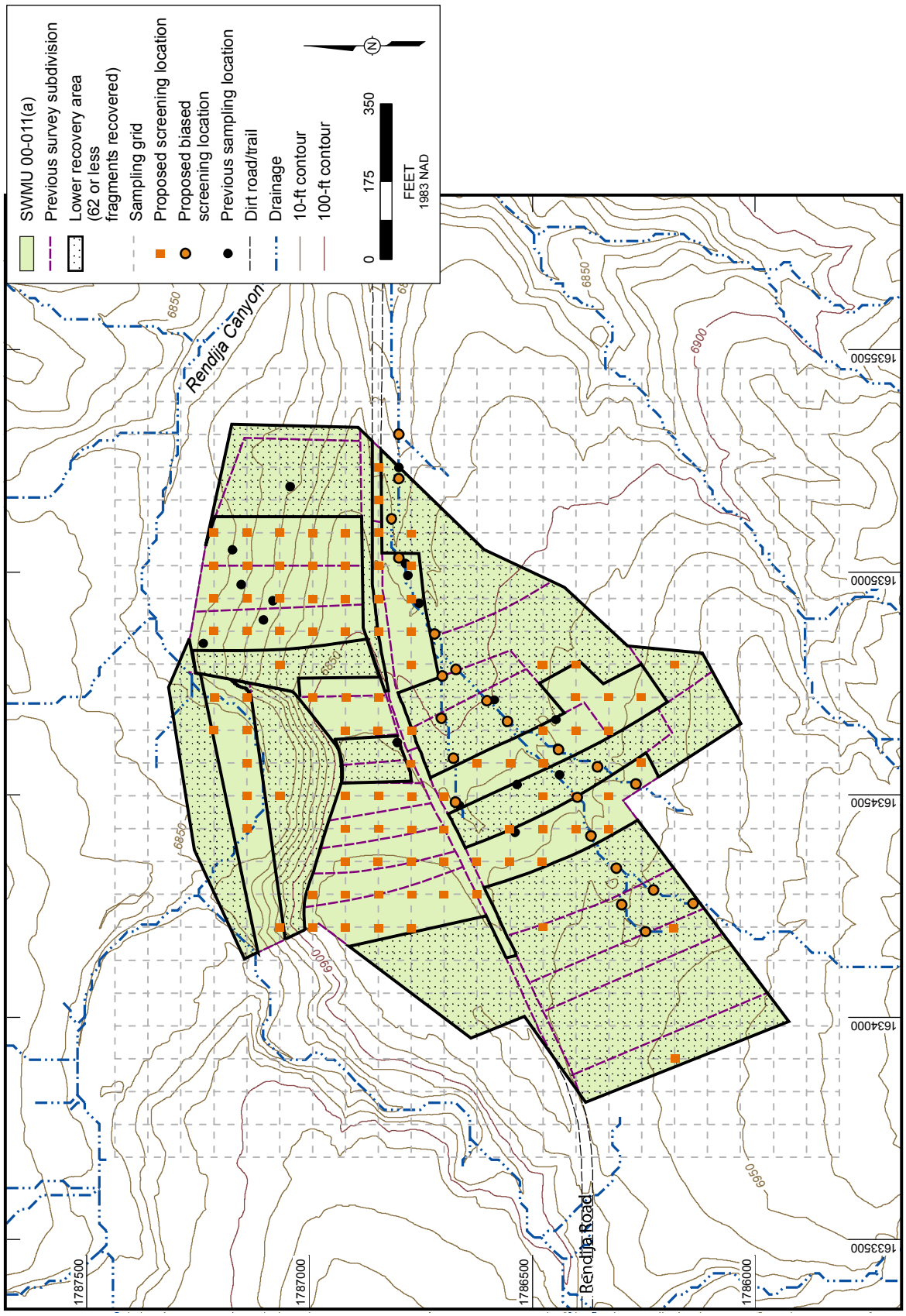
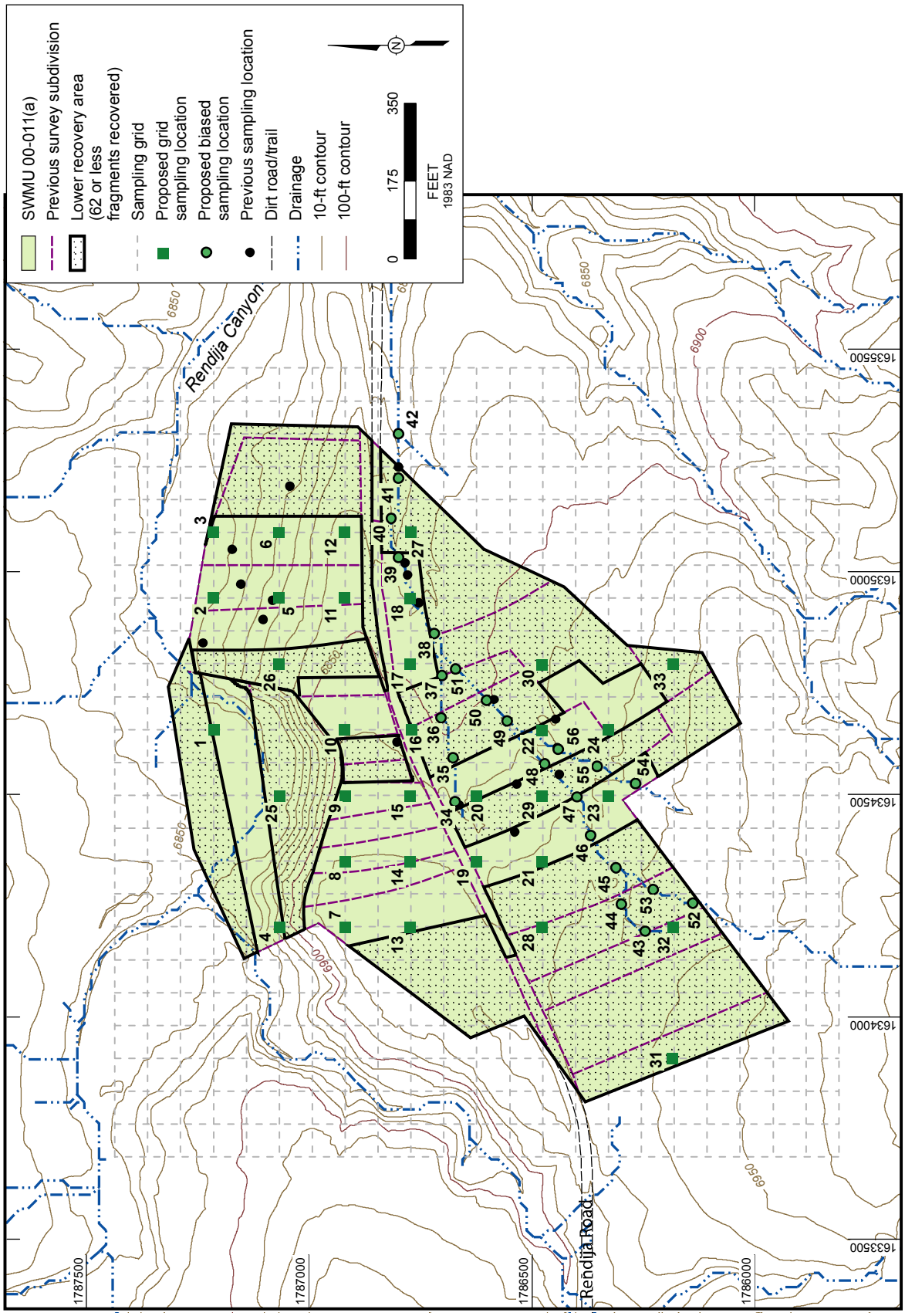


Figure 2.1-14. AOC C-00-041 site map



Source: D. Walther, GISLab m201434, 031005; modified for F2.4-1, GBR Cyns IWP, 050405, ptm

Figure 4.2-1. SWMU 00-011(a) proposed explosive compounds screening locations



Source: D. Walther, GISLab m201434, 031005; modified for F2.4-1, GBR Cyns IWP, 050405, ptm

Figure 4.2-2. SWMU 00-011(a) proposed sampling locations for TAL metal and perchlorate analyses

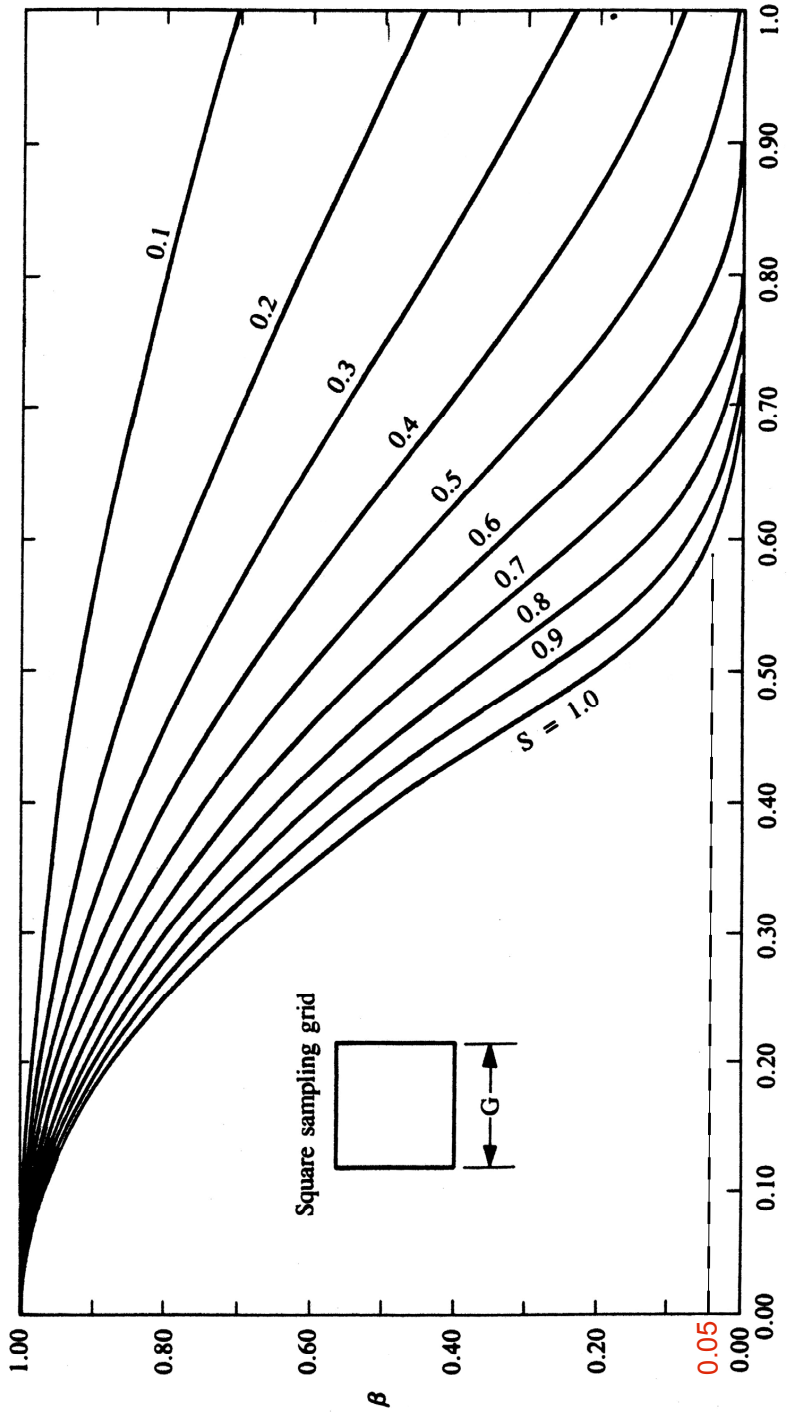
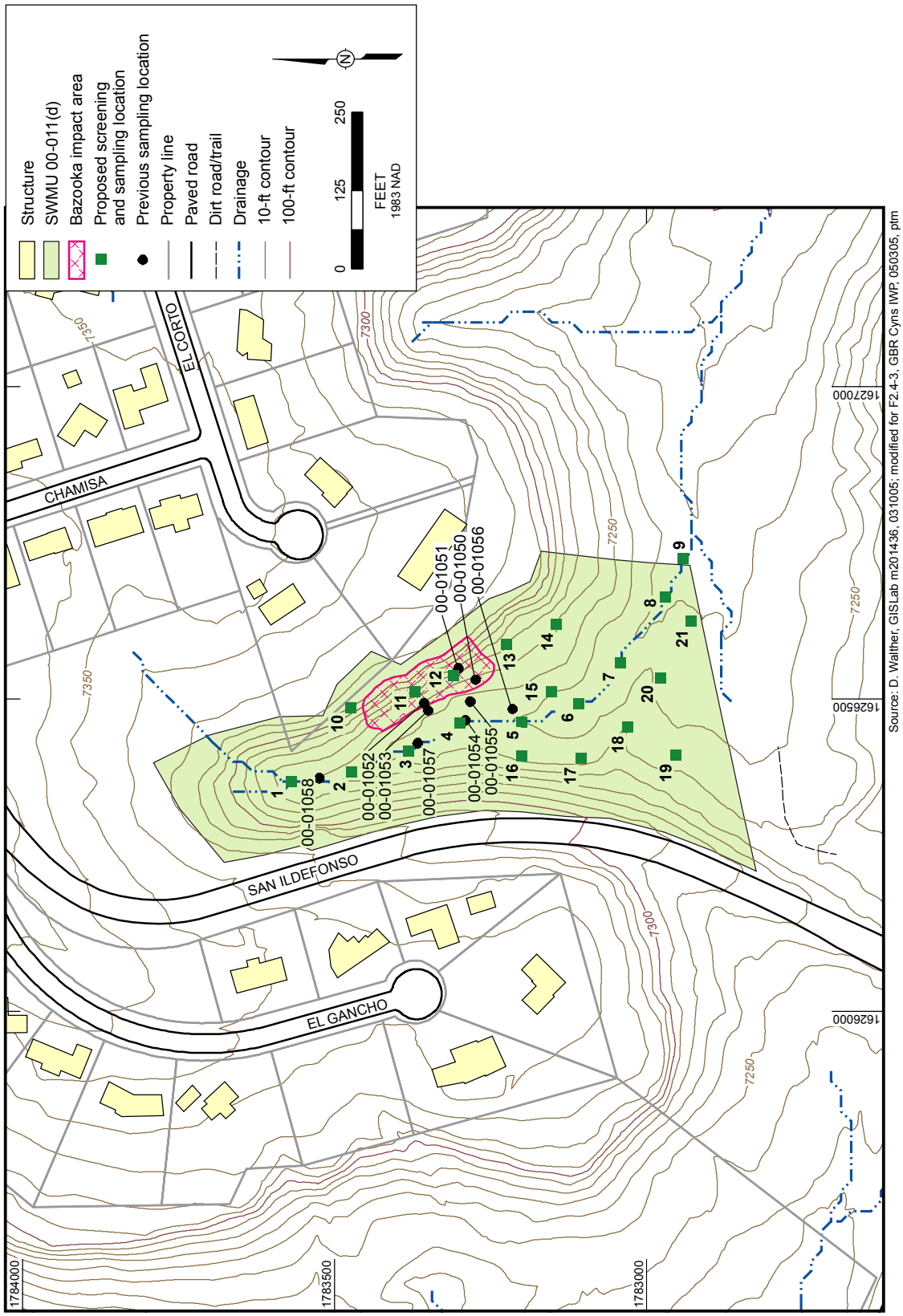


Figure 4.2-3. Curves relating L/G to β for different hotspot shapes when sampling is on a square grid pattern



Source: D. Walther, GISLab m201436, 031005; modified for F2.4-3, GBR Cyns IWP, 050305, ptm

Figure 4.2-4. SWMU 00-011(d) proposed sampling locations

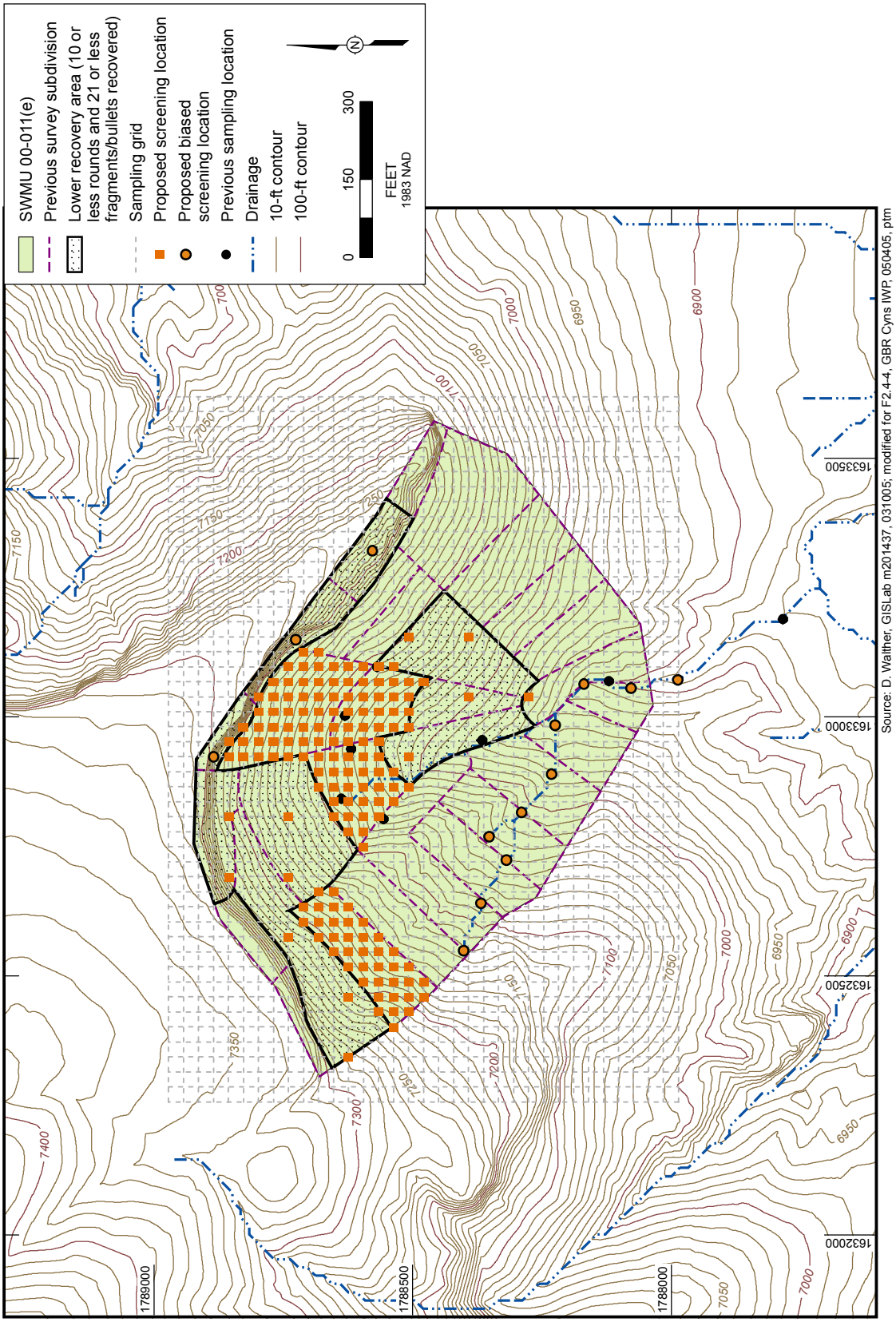


Figure 4.2-5. SWMU 00-011(e) proposed explosive compounds screening locations

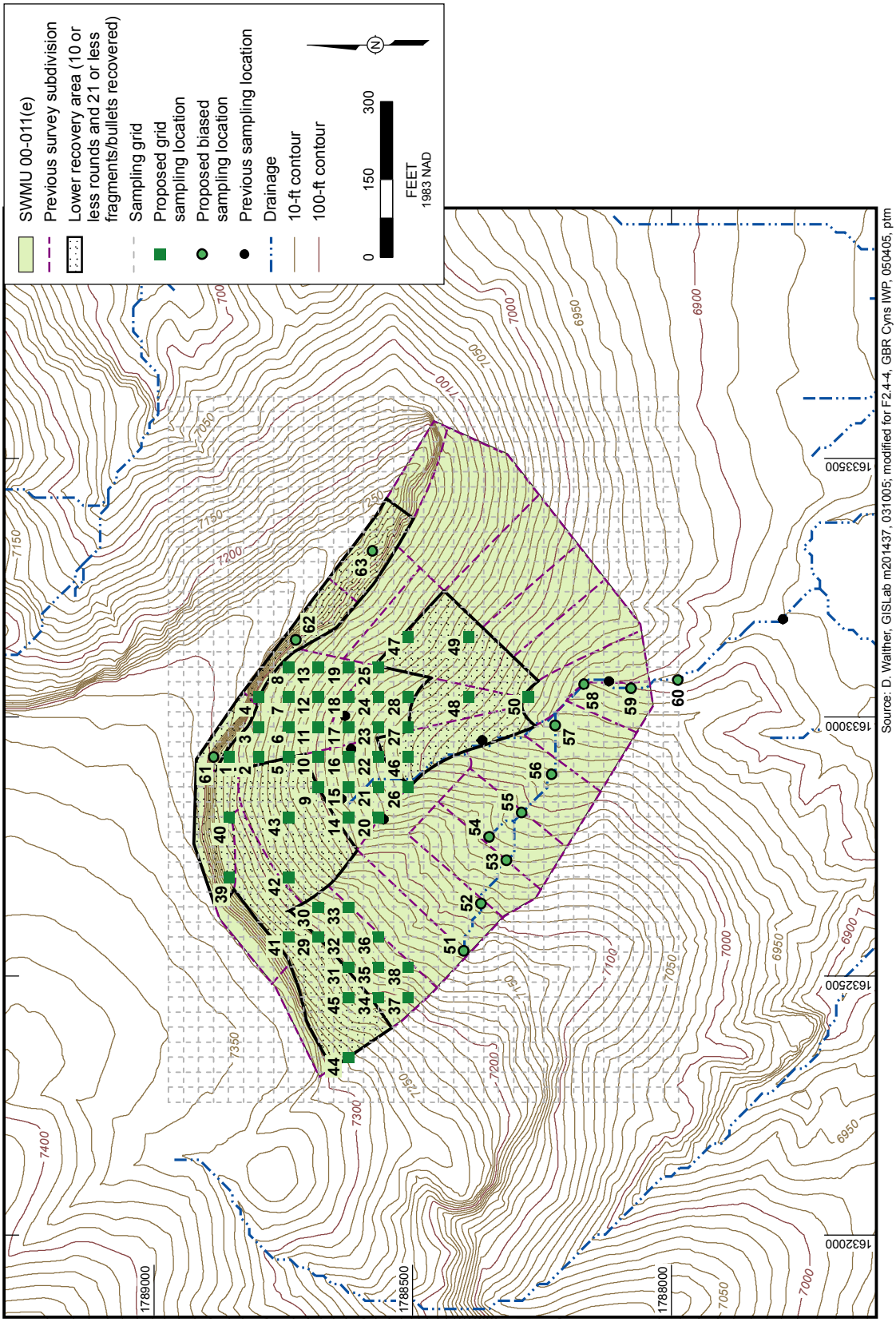
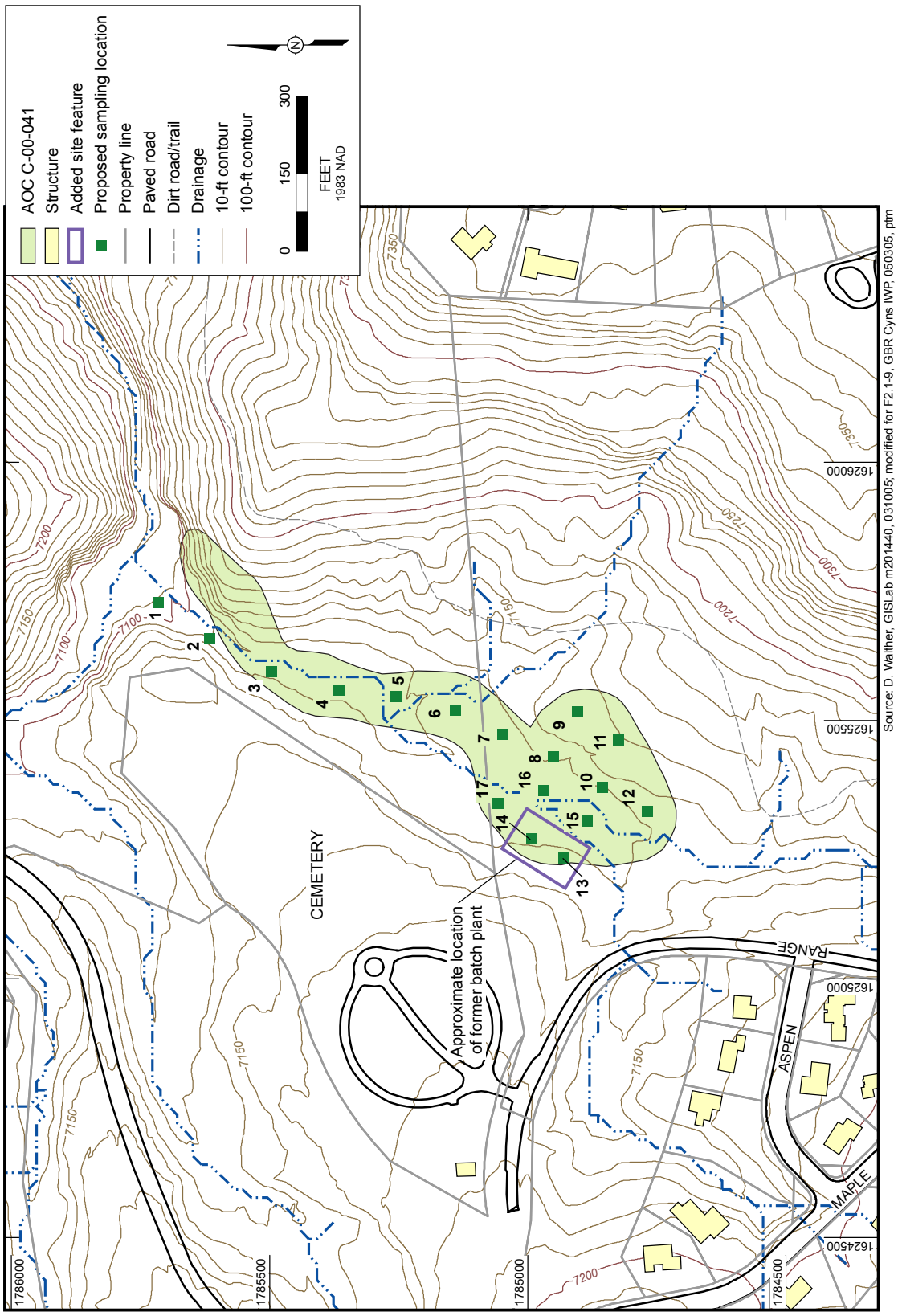


Figure 4.2-6. SWMU 00-011(e) proposed sampling locations for TAL metal and perchlorate analyses



Source: D. Walther, GISLab m201440, 031005; modified for F2.1-9, GBR Cyns IWP, 050305, ptm

Figure 4.2-7. AOC C-00-041 proposed sampling locations

Table 4.2-1
Summary of Proposed Soil Sampling at SWMU 00-011(a)

Location Number	Location	Sample Depth (ft)	TAL Metals	Perchlorate	Explosive Compounds Screening[1]
Grid Samples					
1–24	148-ft grid sample	0 to 0.5 2 to 3	X X	X X	X X
25–33	296-ft grid sample	0 to 0.5 2 to 3	X X	X X	X X
Active Drainages					
34–56	Biased sample	To be determined (TBD)[b]	X X	X X	X X
Entire Site					
~120 total	Biased samples and 74-ft and 296-ft grid samples	0 to 0.5 2 to 3 (TBD in drainages)			X X

[a] The two sample depths will be screened for explosive compounds in the field using D TECH. A minimum of 20% of the samples screened will be sent to an off-site fixed laboratory for confirmation.

b Locations and sampling depths will be determined in the field by a geomorphologist. The depth of sediment will determine sample depths collected.

Table 4.2-2
Summary of Proposed Soil Sampling at SWMU 00-011(d)

Location Number	Location	Sample Depth (ft)	TAL Metals	Perchlorate	Explosive Compounds Screening[a]
Drainage channel below cliff					
1	Northern end of drainage channel	To be determined (TBD)[b]	X X	X X	X X
2	100 ft south of location 1 in the drainage channel	TBD	X X	X X	X X
3	100 ft south of location 2 in the drainage channel	TBD	X X	X X	X X
4	100 ft south of location 3 in the drainage channel	TBD	X X	X X	X X
5	100 ft south of location 4 in the drainage channel	TBD	X X	X X	X X
6	100 ft south of location 5 in the drainage channel	TBD	X X	X X	X X
7	100 ft south of location 6 in the drainage channel	TBD	X X	X X	X X
8	100 ft south of location 7 in the drainage channel	TBD	X X	X X	X X
9	100 ft south of location 8 in the drainage channel	TBD	X X	X X	X X
Bazooka impact area					
10	North of bazooka impact area	TBD	X	X	
11	Within impact area, east of former location 00-01052	TBD	X	X	X
12	Within impact area near former location 00-01051	TBD	X	X	X
Cliff drainage area					
13	Start of drainage	TBD	X X	X X	X X
14	Middle of drainage	TBD	X X	X X	X X
15	South end of additional drainage area	TBD	X X	X X	X X
Area west of drainages					
16	West of location 5, along the hill base	0 to 0.5 2 to 3	X X	X X	X X
17	West of location 6, along the hill base	0 to 0.5 2 to 3	X X	X X	X X
18	100 ft west of drainage channel, west of location 7	0 to 0.5 2 to 3	X X	X X	X X
19	West of location 20, along the hill base	0 to 0.5 2 to 3	X X	X X	X X

Table 4.2-2
Summary of Proposed Soil Sampling at SWMU 00-011(d) (continued)

Location Number	Location	Sample Depth (ft)	TAL Metals	Perchlorate	Explosive Compounds Screening[a]
20	100 ft west of drainage channel, west of location 8	0 to 0.5 2 to 3	X X	X X	X X
21	100 ft west of location 9	0 to 0.5 2 to 3	X X	X X	X X

[a] The two sample depths will be screened for explosive compounds in the field using D TECH. A minimum of 20% of the samples screened will be sent to an off-site fixed laboratory for confirmation.

[b] Locations and sampling depths will be determined in the field by a geomorphologist. The depth of sediment will determine sample depths collected.

Table 4.2-3
Summary of Proposed Soil Sampling at SWMU 00-011(e)

Location Number	Location	Sample Depth (ft)	TAL Metals	Perchlorate	Explosive Compounds Screening[a]
Grid Samples					
1–38	54 ft grid sample	0 to 0.5 2 to 3	X X	X X	X X
39–50	108 ft grid sample	0 to 0.5 2 to 3	X X	X X	X X
Active Drainages					
51–60	Biased sample	To be determined (TBD)[b]	X X	X X	X X
Cliff Area					
61–63	Biased sample	TBD	X	X	X
Entire Site					
~160 total	Biased samples and 27 ft and 108 ft grid samples for field screening using D TECH	0 to 0.5 2 to 3 (TBD in drainages)			X X

[a] The two sample depths will be screened for explosive compounds in the field using D TECH. A minimum of 20% of the samples screened will be sent to an off-site fixed laboratory for confirmation.

[b] Locations and sampling depths will be determined in the field by a geomorphologist. The depth of sediment will determine sample depths collected.

Table 4.2-4
Summary of Proposed Soil Sampling at AOC C-00-041

Location Number	Location	Sample Depth (ft)	TAL Metals	VOCs	SVOCs	TPH
1	North end of drainage area along western edge of drainage	0 to 0.5 2 to 3	X X	X X	X X	X X
2	100 ft south of location 1 along western side of drainage	0 to 0.5 2 to 3	X X	X X	X X	X X
3	100 ft south of location 2 along western side of drainage	0 to 0.5 2 to 3	X X	X X	X X	X X
4	100 ft south of location 3 along center of SWMU area	0 to 0.5 2 to 3	X X	X X	X X	X X
5	100 ft south of location 4 along center of SWMU area	0 to 0.5 2 to 3	X X	X X	X X	X X
6	100 ft south of location 5 along center of SWMU area	0 to 0.5 2 to 3	X X	X X	X X	X X
7	100 ft south of location 6 along center of SWMU area	0 to 0.5 2 to 3	X X	X X	X X	X X
8	100 ft south of location 7 along center of SWMU area	0 to 0.5 2 to 3	X X	X X	X X	X X
9	100 ft southeast of location 8	0 to 0.5 2 to 3	X X	X X	X X	X X
10	100 ft southwest of location 8	0 to 0.5 2 to 3	X X	X X	X X	X X
11	100 ft southeast of location 10	0 to 0.5 2 to 3	X X	X X	X X	X X
12	100 ft southwest of location 10	0 to 0.5 2 to 3	X X	X X	X X	X X
13–14	Inside former batch plant boundary	0 to 0.5 2 to 3	X X	X X	X X	X X
15–17	Downslope of former batch plant boundary	0 to 0.5 2 to 3	X X	X X	X X	X X

Table 5.0-1
Summary of Investigation Methods

Method	Summary
Spade and Scoop Collection of Soil Samples	This method is typically used for collection of shallow (i.e., approximately 0–12 in.) soil or sediment samples. The “spade-and-scoop” method involves digging a hole to the desired depth, as prescribed in the sampling and analysis plan, and collecting a discrete grab sample. The sample is typically placed in a clean stainless steel bowl for transfer into various sample containers.
Hand Auger Sampling	This method is typically used for sampling soil or sediment at depths of less than 10–15 ft, but may in some cases be used for collecting samples of weathered or nonwelded tuff. The method involves hand-turning a stainless-steel bucket auger (typically with a 3–4 in. inner diameter), creating a vertical hole which can be advanced to the desired sample depth. When the desired depth is reached, the auger is decontaminated before advancing the hole through the sample depth. The sample material is transferred from the auger bucket to a stainless-steel sampling bowl before filling the various required sample containers.
Split-Spoon Core-Barrel Sampling	In this method, a stainless steel core barrel (typically with a 4-in. inner diameter and 2.5 ft long) is advanced using a powered drilling rig. The core barrel extracts a continuous length of soil and/or rock which can be examined as a unit. The split-spoon core barrel is a cylindrical barrel split length-wise so that the two halves can be separated to expose the core sample. Once extracted, the section of core is typically screened for radioactivity and organic vapors, photographed, and described in a geologic log. A portion of the core may then be collected as a discrete sample from the desired depth.
Headspace Vapor Screening	Individual soil, rock, or sediment samples may be field-screened for volatile organic compounds by placing a portion of the sample in a plastic sample bag or in a glass container with a foil-sealed cover. The container is sealed and gently shaken, and allowed to equilibrate for 5 min. The sample is then screened by inserting a photoionization detector probe into the container and measuring and recording any detected vapors.
Portable XRF Field Screening	A portable x-ray fluorescence analyzer may be used to measure metals content in soils while in the field to provide screening data and guide collection of samples for determination of extent of metals contamination. The instrument includes sealed radioactive sources and can identify and quantify 26 elements. The instrument must be properly warmed up and calibrated according to manufacturer’s directions before use. Soil samples should be homogenized and have large rocks, vegetation, and any foreign objects removed (samples may be sieved). The sample surface should be flattened or smoothed with a trowel or similar tool. For quantitative work, reference standard materials should be analyzed and the precision of the instrument determined at least once per day or once for every 20 samples. Precision may be determined by performing multiple analyses of certified reference standard materials.

Table 5.0-1 (continued)

Method	Summary
Handling, Packaging, and Shipping of Samples	Field team members seal and label samples before packing, and ensure that the sample containers and the containers used for transport are free of external contamination. Field team members package all samples so as to minimize the possibility of breakage during transportation. After all environmental samples are collected, packaged, and preserved, a field team member transports them to either the Sample Management Office (SMO) or an SMO-approved radiation screening laboratory under chain-of-custody. The SMO arranges for shipping of samples to analytical laboratories. The field team member must inform the SMO and/or the radiation screening laboratory coordinator when levels of radioactivity are in the action-level or limited-quantity ranges.
Sample Control and Field Documentation	The collection, screening, and transport of samples is documented on standard forms generated by the SMO. These include sample collection logs, chain-of-custody forms, and sample container labels. Collection logs are completed at the time of sample collection, and are signed by the sampler and a reviewer who verifies the logs for completeness and accuracy. Corresponding labels are initialed and applied to each sample container, and custody seals are placed around container lids or openings. Chain-of-custody forms are completed and assigned to verify that the samples are not left unattended.
Field Quality Control Samples	Field quality control samples are collected as directed in the March 1, 2005, Compliance Order on Consent as follows: Field Duplicate: At a frequency 10%; collected at the same time as a regular sample and submitted for the same analyses. Equipment Rinsate Blank: At a frequency of 10%; collected by rinsing sampling equipment with deionized water, which is collected in a sample container and submitted for laboratory analysis. Trip Blanks: Required for all field events that include the collection of samples for volatile organic compound analysis. Trip blank containers of certified clean sand that are opened and kept with the other sample containers during the sampling process.
Field Decontamination of Drilling and Sampling Equipment	Dry decontamination is the preferred method to minimize the generation of liquid waste. Dry decontamination may include the use of a wire brush or other tool for removal of soil or other material adhering to the sampling equipment, followed by use of a commercial cleaning agent (nonacidic, waxless cleaners) and paper wipes. Dry decontamination may be followed by wet decontamination if necessary. Wet decontamination may include washing with a non-phosphate detergent and water, followed by a water rinse and a second rinse with deionized water. Alternatively, steam cleaning may be used.
Containers and preservation of samples	Specific requirements/processes for sample containers, preservation techniques, and holding times are based on EPA guidance for environmental sampling, preservation, and quality assurance. Specific requirements for each sample are printed on the sample collection logs provided by the SMO (size and type of container, i.e. glass, amber glass, polyethylene, preservative, etc.). All samples are preserved by placing in insulated containers with ice to maintain a temperature of 4˚C. Other requirements such as nitric acid or other preservatives may apply to different media or analytical requests.

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Appendix A

Acronyms and Abbreviations, Glossary, and Metric Conversion Table

A-1.0 ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
AOC	area of concern
bgs	below ground surface
BV	background value
CST	Chemical Sciences and Technology
DGM	digital geophysical mapping
DOE	U.S. Department of Energy
DOT	Department of Transportation
ECR	Environmental Characterization and Remediation Group
ENV	Environmental Stewardship Division
EOD	explosive ordnance disposal
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration (as in *former ER Project*)
ERS	Environmental Remediation and Surveillance Program
GPS	global positioning system
GSA	General Services Administration
HE	high explosives
IDW	investigation-derived waste
LANL	Los Alamos National Laboratory
MD	munitions debris
MEC	munitions and explosives of concern
NFA	no further action
NMED	New Mexico Environment Department
NMHWA	New Mexico Hazardous Waste Act
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PPE	personal protective equipment
QA/QC	quality assurance/quality control
QAL	quaternary alluvium
S	suspected size and shape of contamination
SAFR	small-arms firing range
SMO	Sample Management Office
SOP	standard operating procedure

SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TA	technical area
TAL	target analyte list
TBD	to be determined
TCLP	toxicity characteristic leaching procedure
UC	University of California
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
UXO	unexploded ordnance
VCA	voluntary corrective action
VOC	volatile organic compound
WCSF	waste characterization strategy form
WPF	waste profile forms

A-2.0 GLOSSARY

administrative authority—For Los Alamos National Laboratory, one or more regulatory agencies, such as the New Mexico Environment Department, the U.S. Environmental Protection Agency, or the U.S. Department of Energy, as appropriate.

aggregate—At the Los Alamos National Laboratory, an area within a *watershed* containing solid waste management units (SWMUs) and/or areas of concern, and the media affected or potentially affected by releases from those SWMUs and/or areas of concern. Aggregates are designated to promote efficient and effective corrective action activities.

area of concern—(1) A release that may warrant investigation or remediation and is not a specific solid waste management unit (SWMU). (2) An area at Los Alamos National Laboratory[0] that may have had a release of a hazardous waste or a hazardous constituent but is not a SWMU.

background level—(1) The concentration of a substance in an environmental medium (air, water, or soil) that occurs naturally or is not the result of human activities. (2) In exposure assessment, the concentration of a substance in a defined control area over a fixed period of time before, during, or after a data-gathering operation.

barrier—Any material or structure that prevents, or substantially delays, the movement of solid-, liquid-, or gaseous-phase chemicals in environmental media.

chemical—Any naturally occurring or human-made substance characterized by a definite molecular composition.

cleanup—A series of actions taken to deal with the release, or threat of a release, of a hazardous substance that could affect humans and/or the environment. The term cleanup is sometimes used interchangeably with the terms remedial action, removal action, or corrective action.

cleanup levels—Media-specific contaminant concentration levels that must be met by a selected corrective action. Cleanup levels are established by using criteria such as the protection of human health and the environment; compliance with regulatory requirements; reduction of toxicity, mobility, or volume through treatment; long- and short-term effectiveness; implementability; and cost.

constituent — Any compound or element present in environmental media, including both naturally occurring and man-made elements.

contaminant—(1) Chemical and radionuclides present in environmental media or on debris above background levels. (2) According to the New Mexico Environment Department (NMED) Consent Order, any hazardous waste listed or identified as characteristic in 40 Code of Federal Regulations (CFR) 261 (incorporated by 20.4.1.200 New Mexico Administrative Code [NMAC]); any hazardous constituent listed in 40 CFR 261 Appendix VIII (incorporated by 20.4.1.200 NMAC) or 40 CFR 264 Appendix IX (incorporated by 20.4.1.500 NMAC); any groundwater contaminant listed in the Water Quality Control Commission (WQCC) Regulations at 20.6.3.3103 NMAC; any toxic pollutant listed in the WQCC Regulations at 20.6.2.7 NMAC; explosive compounds; nitrate; and perchlorate. (Note: Under the NMED Consent Order, the term “contaminant” does <u>not</u> include radionuclides or the radioactive portion of mixed waste.)

contamination — Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution).

corrective action—(1) In the Resource Conservation and Recovery Act, an action taken to rectify conditions potentially adverse to human health or the environment. (2) In the quality assurance field, the process of rectifying and preventing nonconformances.

corrective action process — One or more of a series of activities (initial site assessment, site characterization, interim actions, evaluation of remedial alternatives, and implementation of selected remedy); also refers to RCRA facility assessments, RFIs, corrective measures studies, and corrective measures implementations.

detection limit—The minimum concentration that can be determined by a single measurement of an instrument. A detection limit implies a specified statistical confidence that the analytical concentration is greater than zero.

discharge—The accidental or intentional spilling, leaking, pumping, pouring, emitting, emptying, or dumping of hazardous waste into, or on, any land or water. (Resource Conservation and Recovery Act, 40 Code of Federal Regulations [CFR] 260.10)

disposal—The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into, or on, any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwaters. (40 Code of Federal Regulations [CFR] 260.10)

effluent—Wastewater (treated or untreated) that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

environmental surveillance—The collection and analysis of samples from air, water, soil, foodstuffs, biota, and other media to determine the environmental quality of an industry or community. Environmental surveillance is performed commonly at sites that contain nuclear facilities.

exposure pathway—Any path from the sources of contaminants to humans and other species or settings through soil, water, or food.

groundwater—Interstitial water that occurs in saturated earth material and is capable of entering a well in sufficient amounts to be used as a water supply.

hazardous waste—(1) Solid waste (as defined in 40 Code of Federal Regulations [CFR] 261.2) that is a listed as hazardous waste (as provided in 40 CFR Subpart D), or as a waste that exhibits any of the characteristics of hazardous waste (i.e., ignitability, corrosivity, reactivity, or toxicity, as provided in 40 CFR, Subpart C). (2) According to the New Mexico Environment Department's Consent Order, any solid waste or combination of solid wastes that, because of its quantity, concentration, or physical, chemical, or infectious characteristics, meets the description set forth in New Mexico Statutes Annotated 1978, § 74-4-3(K) and is listed as a hazardous waste or exhibits a hazardous waste characteristic under 40 CFR 261 (incorporated by 20.4.1.200 New Mexico Administrative Code).

Hazardous and Solid Waste Amendments (HSWA)—Public Law No. 98-616, 98 Stat. 3221, enacted in 1984, which amended the Resource Conservation and Recovery Act of 1976 (42 United States Code § 6901 et seq).

Hazardous and Solid Waste Amendments (HSWA) Module — Module VIII of the Laboratory's RCRA Hazardous Waste Facility Permit. The permit allows the Laboratory to operate as a treatment, storage, and disposal facility. Module VIII regulates the cleanup of inactive sites and the activities of the ER Project for those PRSs listed on the permit.

high-explosives (HE) — The three most common high explosive substances found at the Laboratory are RDX (Royal Demolition eXplosive), TNT (2,4,6-initrotoluene), and HMX (High Melting eXplosive). These highly explosive materials do not occur naturally in the environment and are all used in making military shells, bombs, and grenades. Exposures to these materials are rare because they are generally used in controlled areas. People can be exposed to these chemicals by breathing dust contaminated with the materials, getting it on their skin, or drinking contaminated water.

- RDX can cause seizures, nausea, and vomiting. It may be a human carcinogen.
- TNT may cause anemia and abnormal liver function, spleen enlargement, and harmful effects on the immune system. It is a possible human carcinogen.
- HMX has no known harmful health effects. The EPA has not determined whether it is a human carcinogen.

inactive site — Waste disposal sites that are no longer being operated.

inorganic chemical — Compounds of elements other than carbon such as hexavalent chromium (the form of chromium in a valence state of +6).

interim measure—An action that can be implemented to minimize or prevent the migration of contaminants and to minimize or prevent actual or potential human or ecological exposure to contaminants, while long-term final corrective action remedies are evaluated and, if necessary, implemented.

in situ stabilization — A cleanup strategy that leaves the contaminants in place but unable to migrate or be released into the environment.

institutional controls—Controls that prohibit or limit access to contaminated media. Institutional controls may include use restrictions, permitting requirements, standard operating procedures, laboratory implementation requirements, laboratory implementation guidance, and laboratory performance requirements.

long-term surveillance and monitoring — Collecting periodic measurements over time to assess status and trends.

long-term maintenance — Maintaining the conditions and assumptions under which risk-based decisions were made.

medium (environmental)—Any material capable of absorbing or transporting constituents. Examples of media include tuffs, soils and sediments derived from these tuffs, surface water, soil water, groundwater, air, structural surfaces, and debris.

nature and extent of contamination — The "nature" of contamination is the chemicals (naturally occurring or man-made) present in or that have been released to the environment and are determined by detection of a chemical in one or more environmental samples. In the case of naturally occurring or widespread man-made chemicals, detection is determined by comparison to background levels. The "extent" of contamination means how much of a given chemical is present in the environment and is determined by comparison to site baseline values, if applicable, and/or analysis of trends in the data.

no further action—Under the Resource Conservation and Recovery Act, a corrective-action determination whereby, based on evidence or risk assessment, no further investigation or remediation is warranted.

notice of deficiency (NOD)—A written notification from the administrative authority to a facility owner/operator following the review of a permit application or other permit-related plan or report. The NOD requests additional information before a decision can be made regarding the original plan or report.

organic chemical — Compound of elements that contains carbon such as carbon dioxide.

permit modification—A change to a condition in a facility's Hazardous Waste Facility Permit, initiated by either a request from the permittee or by the administrative authority's action.

pollutant — Any substance, produced and released into the environment as a result of human activity, that has damaging effects on humans or ecological receptors.

polychlorinated biphenyls (PCBs)—Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees, or any combination that contains such substances. PCBs are colorless, odorless compounds that are chemically, electrically, and thermally stable and have proven to be toxic to both humans and other animals.

potential release site (PRS)—A potentially contaminated site at Los Alamos National Laboratory. PRSs include both solid waste management units and areas of contamination.

radiation—A stream of particles or electromagnetic waves emitted by atoms and molecules of a radioactive substance as a result of nuclear decay. The particles or waves emitted can consist of neutrons, positrons, alpha particles, beta particles, or gamma radiation.

receptor—A person, other animal, plant, or geographical location that is exposed to a chemical or physical agent released to the environment by human activities**.**

release—Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of hazardous waste or hazardous constituents into the environment.

remediation—(1) The process of reducing the concentration of a contaminant (or contaminants) in air, water, or soil media to a level that poses an acceptable risk to human health and the environment. (2) The act of restoring a contaminated area to a usable condition based on specified standards.

remedy or remedial action — Those actions consistent with permanent remedy instead of or in addition to removal actions in the event of a release or threatened release of a hazardous substance into the environment. Those actions used to prevent or minimize the release of hazardous substances so

that they do not migrate to cause substantial danger to present or future public health or welfare of the environment.

Resource Conservation and Recovery Act (RCRA)—The Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976. (Public Law [PL] 94-580, as amended by PL 95-609 and PL 96-482, United States Code 6901 et seq.)

RCRA Hazardous Waste Facility Permit — EPA or an authorized state issues RCRA permits to regulate the storage, treatment, and disposal of hazardous waste and the hazardous component of radioactive mixed waste. See also HSWA Module.

runoff—The portion of the precipitation on a drainage area that is discharged from the area either by sheet flow or adjacent stream channels.

run-on—Surface water that flows onto an area as a result of runoff occurring higher up on a slope.

sediment—(1) A mass of fragmented inorganic solid that comes from the weathering of rock and is carried or dropped by air, water, gravity, or ice. (2) A mass that is accumulated by any other natural agent and that forms in layers on the Earth's surface (e.g., sand, gravel, silt, mud, fill, or loess). (3) A solid material that is not in solution and is either distributed through the liquid or has settled out of the liquid.

site characterization—Defining the pathways and methods of migration of hazardous waste or constituents, including the media affected; the extent, direction and speed of the contaminants; complicating factors influencing movement; or concentration profiles. (U.S. Environmental Protection Agency, May 1994. Publication EPA-520/R-94/004)

site conceptual model—A qualitative or quantitative description of sources of contamination, environmental transport pathways for contamination, and receptors that may be impacted by contamination and whose relationships describe qualitatively or quantitatively the release of contamination from the sources, the movement of contamination along the pathways to the exposure points, and the uptake of contaminants by the receptors.

soil erosion — The removal and thinning of the soil layer due to climatic and physical process such as high rainfall that is greatly accelerated by certain activities such as deforestation as after a fire.

solid waste—Any garbage, refuse, or sludge from a waste treatment plant, water-supply treatment plant, or air-pollution control facility, and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. Solid waste does not include solid or dissolved materials in domestic sewage; solid or dissolved materials in irrigation return flows; industrial discharges that are point sources subject to permits under section 402 of the Federal Water Pollution Control Act, as amended; or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended.

solid waste management unit (SWMU)—(1) Any discernible site at which solid wastes have been placed at any time, whether or not the site use was intended to be the management of solid or hazardous waste. SWMUs include any site at a facility at which solid wastes have been routinely and systematically released. This definition includes regulated sites (i.e., landfills, surface

impoundments, waste piles, and land treatment sites), but does not include passive leakage or one-time spills from production areas and sites in which wastes have not been managed (e.g., product storage areas). (2) According to the New Mexico Environment Department (NMED) Consent Order, any discernible site at which solid waste has been placed at any time, and from which NMED determines there may be a risk of a release of hazardous waste or hazardous waste constituents (hazardous constituents), whether or not the site use was intended to be the management of solid or hazardous waste. Such sites include any area in Los Alamos National Laboratory at which solid wastes have been routinely and systematically released; they do not include one-time spills.

surface water — No perennial surface water flows extend completely across the Laboratory in any canyon. Periodic natural surface runoff occurs in two modes:

- Spring snowmelt runoff that occurs over days to weeks at a low discharge rate and sediment load, and
- Summer runoff from thunderstorms that occurs over hours at a high discharge rate and sediment load.

The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the waters.

technical area (TA)—At Los Alamos National Laboratory, an administrative unit of operational organization (e.g., TA-21).

topography—The physical or natural features of an object or entity and their structural relationships.

tuff—Consolidated volcanic ash, composed largely of fragments produced by volcanic eruptions.

watershed—A region or basin drained by, or contributing waters to, a river, stream, lake, or other body of water and separated from adjacent drainage areas by a divide, such as a mesa, ridge, or other geologic feature.

A-3.0 METRIC CONVERSION TABLE

Metric to US Customary Unit Conversions

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
kilometers (km)	0.622	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.281	feet (ft)
meters (m)	39.37	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.394	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (µm)	0.0000394	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.5	acres
square meters (m^2)	10.764	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (µg/g)	1	parts per million (ppm)
liters (L)	0.26	gallons (gal.)
milligrams per liter (mg/L)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

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Appendix B

Guaje/Barrancas/Rendija Canyons Aggregate Area
Analytical Data
(CD included with this report)

URI	REQUEST_NUM	SAMPLE_ID	EXCAV_FLAG	COMPOS_TYPE_CODE	SAMPLE_TECH_CODE	SAMPLE_USG_CODE	FIELD_PREP	PRS	LOCATION_ID	DEPTH	FLD_MATRIX_CODE	MEDIA_CODE	RFI_CLASS	ANALYTE_CODE	ANALYTE_NAME	PERCENT_MOISTURE	MDL	MDA	DILUTION_FACTOR	STD_SAMPLE_VALUE	STD_UNCERTAINTY	STD_REPORTING_UNITS	QUALIFIER	FIELD_QC_TYPE_CODE	SAMPLE_TYPE_CODE	ANALYTICAL_SUITE	ANYL_METH_CODE	LAB_NAME	ANALYSIS_DATE	COLLECTION_DATE
9076552	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-01-4	Vinyl Chloride					10	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076562	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-00-3	Chloroethane					10	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076572	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	74-97-5	Bromochloromethane					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076582	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	74-95-3	Dibromomethane					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076592	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	74-88-4	Iodomethane					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076602	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	74-87-3	Chloromethane					10	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076612	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	124-48-1	Chlorodibromomethane					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076622	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	120-82-1	Trichlorobenzene[1,2,4-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076632	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	108-90-7	Chlorobenzene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076642	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	108-88-3	Toluene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076652	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	108-86-1	Bromobenzene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076152	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	100-41-4	Ethylbenzene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076182	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	95-49-8	Chlorotoluene[2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076192	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	91-20-3	Naphthalene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076202	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	87-68-3	Hexachlorobutadiene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076212	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	87-61-6	Trichlorobenzene[1,2,3-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076222	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	79-01-6	Trichloroethene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076232	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	79-00-5	Trichloroethane[1,1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076242	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	99-87-6	Isopropyltoluene[4-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076252	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	98-82-8	Isopropylbenzene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076262	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	98-06-6	Butylbenzene[tert-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076272	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	96-18-4	Trichloropropane[1,2,3-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076282	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	96-12-8	Dibromo-3-Chloropropane[1,2-]					10	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076292	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	78-93-3	Butanone[2-]					20	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076302	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	78-87-5	Dichloropropane[1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076312	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	76-13-1	Trichloro-1,2,2-trifluoroethane[1,1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076322	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-71-8	Dichlorodifluoromethane					10	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076332	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-35-4	Dichloroethene[1,1-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076342	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-34-3	Dichloroethane[1,1-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076352	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-27-4	Bromodichloromethane					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076362	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-25-2	Bromoform					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076372	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	563-58-6	Dichloropropene[1,1-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076382	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	56-23-5	Carbon Tetrachloride					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076392	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	156-60-5	Dichloroethene[trans-1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076402	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	156-59-2	Dichloroethene[cis-1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076412	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	142-28-9	Dichloropropane[1,3-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076422	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	135-98-8	Butylbenzene[sec-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076432	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	1330-20-7	Xylene (Total)					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076442	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	127-18-4	Tetrachloroethene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076452	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	74-83-9	Bromomethane					10	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076462	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	71-55-6	Trichloroethane[1,1,1-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076472	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	71-43-2	Benzene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076482	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	67-66-3	Chloroform					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076492	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	67-64-1	Acetone					20	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076502	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	630-20-6	Tetrachloroethane[1,1,1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076512	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	594-20-7	Dichloropropane[2,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076522	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	591-78-6	Hexanone[2-]					20	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076532	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-15-0	Carbon Disulfide					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076542	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-09-2	Methylene Chloride					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076662	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	108-10-1	Methyl-2-pentanone[4-]					20	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076672	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	107-06-2	Dichloroethane[1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076682	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	106-93-4	Dibromoethane[1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076692	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	10061-02-6	Dichloropropene[trans-1,3-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076702	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	103-65-1	Propylbenzene[1-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076712	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	104-51-8	Butylbenzene[n-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076722	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	106-46-7	Dichlorobenzene[1,4-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076732	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	106-43-4	Chlorotoluene[4-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076742	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	10061-01-5	Dichloropropene[cis-1,3-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076752	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	100-42-5	Styrene					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076762	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	541-73-1	Dichlorobenzene[1,3-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076772	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	79-34-5	Tetrachloroethane[1,1,2,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076782	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	108-67-8	Trimethylbenzene[1,3,5-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076792	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	75-69-4	Trichlorofluoromethane					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076162	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	95-63-6	Trimethylbenzene[1,2,4-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995
9076172	21582	AAC4123	N	NA	DC	QC	Unfiltered	C-00-041	NA	0-0 FT	W	NA	ORGANIC	95-50-1	Dichlorobenzene[1,2-]					5	0	UG/L	U	FTB	CS	VOC	SW-846:8260	Roy F. Weston, West Chester, PA	5/5/1995	3/16/1995

URI	REQUEST_NUM	SAMPLE_ID	EXCAV_FLAG	COMPOS_TYPE_CODE	SAMPLE_TECH_CODE	SAMPLE_USG_CODE	FIELD_PREP	PRS	LOCATION_ID	DEPTH	FLD_MATRIX_CODE	MEDIA_CODE	RFI_CLASS	ANALYTE_CODE	ANALYTE_NAME	PERCENT_MOISTURE	MDL	MDA	DILUTION_FACTOR	STD_SAMPLE_VALUE	STD_UNCERTAINTY	STD_REPORTING_UNITS	QUALIFIER	FIELD_QC_TYPE_CODE	SAMPLE_TYPE_CODE	ANALYTICAL_SUITE	ANYL_METH_CODE	LAB_NAME	ANALYSIS_DATE	COLLECTION_DATE
25827092	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	118-96-7	Trinitrotoluene[2,4,6-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827102	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	606-20-2	Dinitrotoluene[2,6-]					0.00027		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827112	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	479-45-8	Tetryl					0.00068		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827122	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	99-99-0	Nitrotoluene[4-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827152	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	99-08-1	Nitrotoluene[3-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827162	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	98-95-3	Nitrobenzene					0.00027		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827172	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	88-72-2	Nitrotoluene[2-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827182	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	121-14-2	Dinitrotoluene[2,4-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827192	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	121-82-4	RDX					0.001		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827202	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	2691-41-0	HMX					0.0023		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827142	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	99-35-4	Trinitrobenzene[1,3,5-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827132	15782	AAA6112	N	NA	SS	INV	Not Applicable	00-011(a)	00-01218	0.17-0.33 FT	S	ALLH	ORGANIC	99-65-0	Dinitrobenzene[1,3-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827412	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	99-35-4	Trinitrobenzene[1,3,5-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827422	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	99-99-0	Nitrotoluene[4-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827432	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	98-95-3	Nitrobenzene					0.00028		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827442	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	606-20-2	Dinitrotoluene[2,6-]					0.00028		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827392	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	99-08-1	Nitrotoluene[3-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827402	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	99-65-0	Dinitrobenzene[1,3-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827332	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	2691-41-0	HMX					0.0023		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827342	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	118-96-7	Trinitrotoluene[2,4,6-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827352	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	121-82-4	RDX					0.001		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827362	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	121-14-2	Dinitrotoluene[2,4-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827372	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	479-45-8	Tetryl					0.00069		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25827382	15782	AAA6115	N	NA	SS	INV	Not Applicable	00-011(a)	00-01214	0.17-0.33 FT	S	ALLH	ORGANIC	88-72-2	Nitrotoluene[2-]					0.00026		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/11/1993	9/23/1993
25829732	15794	AAA6121	N	NA	SS	INV	Not Applicable	00-011(e)	00-01219	0-0.33 FT	S	ALLH	ORGANIC	121-14-2	Dinitrotoluene[2,4-]					0.00027		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/15/1993	9/24/1993
25829742	15794	AAA6121	N	NA	SS	INV	Not Applicable	00-011(e)	00-01219	0-0.33 FT	S	ALLH	ORGANIC	2691-41-0	HMX					0.0024		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/15/1993	9/24/1993
25829752	15794	AAA6121	N	NA	SS	INV	Not Applicable	00-011(e)	00-01219	0-0.33 FT	S	ALLH	ORGANIC	118-96-7	Trinitrotoluene[2,4,6-]					0.00027		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/15/1993	9/24/1993
25829822	15794	AAA6121	N	NA	SS	INV	Not Applicable	00-011(e)	00-01219	0-0.33 FT	S	ALLH	ORGANIC	99-99-0	Nitrotoluene[4-]					0.00027		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/15/1993	9/24/1993
25829832	15794	AAA6121	N	NA	SS	INV	Not Applicable	00-011(e)	00-01219	0-0.33 FT	S	ALLH	ORGANIC	98-95-3	Nitrobenzene					0.00028		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/15/1993	9/24/1993
25829842	15794	AAA6121	N	NA	SS	INV	Not Applicable	00-011(e)	00-01219	0-0.33 FT	S	ALLH	ORGANIC	121-82-4	RDX					0.0011		MG/KG	UJ	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	11/15/1993	9/24/1993

UNI	REQUEST_NUM	SAMPLE_ID	EXCAV_FLAG	COMPOS_TYPE_CODE	SAMPLE_TECH_CODE	SAMPLE_UNIT_CODE	FIELD_PREP	PRE	LOCATION_ID	DEPTH	FLD_MATRIX_CODE	MEDIA_CODE	RPI_CLASS	ANALYTE_CODE	ANALYTE_NAME	PERCENT_MOISTURE	MDL	MDA	DILUTION_FACTOR	STD_SAMPLE_VALUE	STD_UNCERTAINTY	STD_REPORTING_UNITS	QUALIFIER	FIELD_QC_TYPE_CODE	SAMPLE_TYPE_CODE	ANALYTICAL_SUITE	ANYL_MRTN_CODE	LAB_NAME	ANALYSIS_DATE	COLLECTION_DATE
1497532	13784	AAA1732	N	NA	SS	INV	Not Applicable	00-01110	00-01058	0-0.17	FT S		ALLH	ORGANIC	100-12-9	Ethyl-4-nitrobenzene(1-)				40	0	PCT	R	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	5/19/1993	10/22/1992
1497422	13784	AAA1732	N	NA	SS	INV	Not Applicable	00-01110	00-01058	0-0.33	FT S		ALLH	ORGANIC	100-12-9	Ethyl-4-nitrobenzene(1-)				137	0	PCT	R	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	5/19/1993	10/22/1992
1497132	13784	AAA1732	N	NA	SS	INV	Not Applicable	00-01110	00-01053	0-0.33	FT S		ALLH	ORGANIC	100-12-9	Ethyl-4-nitrobenzene(1-)				60	0	PCT	R	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	5/19/1993	10/22/1992
1497232	13784	AAA1732	N	NA	SS	INV	Not Applicable	00-01110	00-01054	0-0.33	FT S		ALLH	ORGANIC	100-12-9	Ethyl-4-nitrobenzene(1-)				62	0	PCT	R	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	5/19/1993	10/22/1992
1497532	13784	AAA1728	N	NA	SS	INV	Not Applicable	00-01110	00-01052	0-0.5	FT S		ALLH	ORGANIC	100-12-9	Ethyl-4-nitrobenzene(1-)				58	0	PCT	R	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	5/19/1993	10/22/1992
1497352	13784	AAA1731	N	NA	SS	INV	Not Applicable	00-01110	00-01054	0-0.33	FT S		ALLH	ORGANIC	100-12-9	Ethyl-4-nitrobenzene(1-)				57	0	PCT	R	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	5/19/1993	10/22/1992
1496892	13784	AAA1728	N	NA	SS	INV	Not Applicable	00-01110	00-01051	0-0.5	FT S		ALLH	ORGANIC	100-12-9	Ethyl-4-nitrobenzene(1-)				59	0	PCT	R	NA	CS	HEXP	SW-846:8330	Quanterra Environmental Services, St. Louis, MO	5/19/1993	10/22/1992

Appendix C

Management Plan for Investigation-Derived Waste

C-1.0 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

This appendix to the work plan describes how investigation-derived waste (IDW) generated during the investigation of the Guaje/Barrancas/Rendija Canyons aggregate area sites at Los Alamos National Laboratory (LANL or the Laboratory) will be managed. IDW is waste generated as a result of field investigation activities and may include, but is not limited to, contaminated personal protective equipment (PPE), sampling supplies, plastics, and all other wastes potentially contacting contaminants. IDW generated during the investigation of Guaje/Barrancas/Rendija Canyons aggregate area sites will be managed to protect human health and the environment, comply with applicable regulatory requirements, and adhere to the Laboratory waste minimization goals.

All IDW generated during field investigation activities will be managed in accordance with applicable Environmental Stewardship–Environmental Characterization and Remediation (ENV-ECR) Group standard operating procedures (SOPs). These SOPs incorporate the requirements of all applicable U.S. Environmental Protection Agency (EPA) and New Mexico Environment Department (NMED) regulations, U.S. Department of Energy (DOE) orders, and Laboratory Implementation Requirements (LIRs). ENV-ECR SOPs applicable to the characterization and management of IDW are

- SOP-1.06, Management of Environmental Restoration Project Waste and
- SOP-1.10, Waste Characterization.

These SOPs are among the SOPs applicable to the investigation at Guaje/Barrancas/Rendija Canyons aggregate area sites and are available at the following URL: http://erproject.lanl.gov/documents/procedures.html.

Before the start of field investigation activities, a Waste Characterization Strategy Form (WCSF) will be prepared and approved per requirements of SOP-1.10. The WCSF will provide detailed information on the IDW characterization and management described in this plan. IDW characterization will be completed by using existing data and/or documentation, site characterization data from samples of the media being investigated (i.e., surface soil, subsurface soil, etc.), and/or by direct sampling of the IDW, if needed. If direct waste characterization sampling is necessary, it will be described in the WCSF

The selection of waste containers will be based on the appropriate U.S. Department of Transportation requirements, waste types, and estimated volumes of IDW to be generated. Each waste container will be individually labeled as to the waste classification, item identification number, and date of generation. Waste containers will be managed in clearly marked and appropriately constructed waste accumulation areas. Waste accumulation area postings, labeling, storage duration, and inspection requirements will be based on IDW type and classification, and regulatory and LANL requirements. Container and storage requirements are described in this plan and will be detailed in the WCSF and approved before the waste is generated.

The Laboratory's 2004 Pollution Prevention Roadmap (LANL 2004, 88465) will be implemented during field investigations of the Guaje/Barrancas/Rendija Canyons aggregate area to minimize waste generation. This plan is updated annually as a requirement of Module VIII of the Laboratory's Hazardous Waste Facility Permit.

The IDW waste streams associated with the investigation of Guaje/Barrancas/Rendija Canyons aggregate area sites are identified and described in the following paragraphs. Table C-1 also summarizes the waste type, characterization method, estimated volume, method of on-site management, and expected disposition for each of these waste streams.

Spent PPE. The spent PPE waste stream will consist of PPE that has potentially come into contact with contaminated environmental media and cannot be decontaminated. The bulk of this waste stream will consist of protective clothing such as coveralls, gloves, and shoe covers. Spent PPE will be collected in containers, such as drums, and stored within a locked field trailer. Characterization of this waste stream will be performed through acceptable knowledge (AK) of the waste PPE materials, the methods of generation, and the analytical results from the environmental media samples with which the PPE materials were in contact. Based on historical knowledge of the site, no radiological sampling will take place as part of the investigation and therefore, no PPE will be managed as radioactive waste. The Laboratory expects these wastes to be designated as nonhazardous, nonradioactive solid waste that will be disposed of at a Laboratory-approved off-site industrial waste facility.

Disposable sampling supplies and dry decontamination waste. The disposable sampling supplies waste stream will consist of all equipment and materials necessary for collecting samples that come into direct contact with contaminated environmental media and that cannot be decontaminated. This waste stream also includes wastes associated with dry decontamination activities resulting from decontamination of sampling equipment, when possible. The dry decontamination wastes will consist primarily of paper and plastic items collected in bags at the sampling location and transferred to accumulation drums. The drums will be stored within a locked field trailer. Characterization of this waste stream will be performed through AK of the sampling and decontamination waste materials, the methods of generation, and the analytical results from environmental media samples with which the materials were in contact. Based on historical knowledge of the site, no radiological sampling will take place as part of the investigation, and, therefore, no disposable sampling supplies will be managed as radioactive waste. The Laboratory expects these wastes to be designated as nonhazardous, nonradioactive solid waste that will be disposed of at a Laboratory-approved off-site industrial waste facility.

Spent acetone with soil from high explosives (HE) test kits. This waste stream consists of spent solvent mixed with soil. HE soil screening with DTECH test kits uses acetone as a solvent to extract the HE compounds from soil. Approximately 20 mL of waste is generated per test. This waste will be characterized using AK of the process generating the waste and the material used in this process (based on information from material safety data sheets [MSDSs] and product-ingredient lists). This waste will be managed as hazardous waste. Acetone, as a spent solvent, is a listed hazardous waste (EPA Hazardous Waste Number F003) and exhibits the characteristic of ignitability (D001). This waste will be packaged in a sealed inner container and stored inside a hazardous waste drum within a registered Satellite Accumulation Area (SAA), in accordance with all regulatory and Laboratory requirements. The SAA will be located within a locked field trailer. The waste will be disposed of at a Laboratory-approved off-site treatment, storage, and disposal facility (TSDF).

Residual sodium azide buffer solution. This waste stream consists of unused residual buffer solution from HE screening kits. The DTECH test kits used for HE screening have buffer solutions bottles containing sodium azide. Approximately 1 mL of residual sodium azide buffer solution may be left over per sample analysis and will be transferred into a 1 L polyethylene bottle. This waste will be characterized using AK of the process generating the waste and the material used in this process (based on information from MSDSs and product ingredient lists). The residual buffer solution is a residue to be managed in accordance with 40 CFR Part 261.33(c), whereby the residue in the container carries the hazardous waste listing unless the container is deemed “RCRA empty” per 40 CFR 261.7. The residual sodium azide buffer solution is listed as acutely hazardous waste, EPA Hazardous Waste Number P105, and will be segregated and stored in a sealed container within a registered SAA. The SAA will be located within a locked field trailer. The waste will be disposed of at a Laboratory-approved off-site TSDF.

Empty containers from HE test kits. This waste stream consists of plastic containers, glass tubes, and/or eye droppers formerly containing sodium azide buffer solution or acetone solutions from HE test kits. The DTECH test kits use acetone as a solvent and a separate buffer solution containing sodium azide. All test kit component containers will be fully emptied of their contents as part of the process and will meet the definition of RCRA-empty, per 40 CFR 261.7, before being declared as waste. Less than 4 L of this waste stream will be generated for the entire investigation. The empty containers will be stored in a sealed 5-gal. container within a locked field trailer. The empty containers will be managed as empty product containers and disposed of as nonhazardous, nonradioactive solid waste. As a best management practice, the containers that held acetone will be kept separate from those that held sodium azide buffer solution, and all containers will be disposed of at a Laboratory-approved industrial waste facility.

Metal shrapnel debris. The metal shrapnel debris will consist of varying sizes of metal collected during the initial inspection of the sites during the investigation activities. Based on the known lead content of the material, this waste stream will be characterized as hazardous waste and stored in an approved SAA. The SAA will consist of a container, such as a drum, located in a locked securable structure or device, such as a “clamshell,” within a locked fence at the Guaje/Barrancas/Rendija Canyons aggregate area sites. The debris will be managed as hazardous waste (EPA Hazardous Waste Number D008) and disposed of at a Laboratory-approved off-site TSDF.

Returned soil samples. Soil samples returned from the analytical laboratory will be containerized in a 15-gal. container and stored in a locked field trailer, pending transportation and disposal. Returned soil samples will be managed in a manner consistent with analytical results, and it is anticipated that the returned soil samples will be classified as nonhazardous, nonradioactive solid waste. The returned soil samples will be disposed of at a Laboratory-approved off-site industrial waste facility.

REFERENCES

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the ENV-ERS Program Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the ENV-ERS Program master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; and the ENV-ERS Program. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

EPA (U.S. Environmental Protection Agency), April 1990. U.S. Environmental Protection Agency, Region 6 Hazardous Waste Permit (Hazardous and Solid Waste Amendments). (EPA 1990, 01585)

EPA (U.S. Environmental Protection Agency), April 1994. “Module VIII, Special Conditions Pursuant to the 1984 Hazardous and Solid Waste Amendments to RCRA for Los Alamos National Laboratory, EPA ID NM0890010515 38817,” module of EPA Hazardous Waste Facility Permit issued to Los Alamos National Laboratory, Dallas, Texas. (EPA 1994, 44146)

LANL (Los Alamos National Laboratory), November 2004. “2004 Pollution Prevention Roadmap,” Los Alamos National Laboratory document LA-UR-04-8973, Los Alamos, New Mexico. (LANL 2004, 88465)

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Table C-1
Summary of Estimated IDW Generation and Management

Waste Stream	Characterization Method	Expected Waste Type	Estimated Volume	On-Site Management	Expected Disposition
Spent PPE	AK from site characterization date and method of generation	Nonhazardous, nonradioactive solid waste	55 gal.	Accumulation in 55-gal. drums, stored in locked field trailer	LANL-approved off-site industrial waste facility
Disposable sampling supplies	AK from site characterization data and method of generation	Nonhazardous, nonradioactive solid waste	55 gal.	Accumulation in 55-gal. drums, stored in locked field trailer	LANL-approved off-site industrial waste facility
Spent acetone with soil	AK from method of generation and product content (MSDSs and ingredient list)	Hazardous waste (F003)	20 mL per test	SAA in locked field trailer	LANL-approved off-site TSDF.
Residual sodium azide buffer solution	AK from method of generation and product content (MSDSs and ingredient list)	Hazardous waste (P105)	1 mL per test	SAA in locked field trailer	LANL-approved off-site TSDF
Empty containers from HE spot test	AK, knowledge of process	Nonhazardous solid waste	4 L	Accumulation in 5-gal. container, stored in locked field trailer	LANL-approved off-site industrial waste facility
Metal shrapnel debris	AK from historical knowledge	Hazardous waste (D008)	Less than 55 gal.	SAA*	LANL-approved off-site TSDF
Returned soil samples	AK from sample analytical data and method of generation	Nonhazardous, nonradioactive solid waste	15 gal.	SAA*	LANL-approved off-site industrial waste facility

*The SAA will consist of a container located in a locked clamshell or other securable device within a locked fence at the Guaje/Barrancas/Rendija Canyons aggregate area sites.

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Appendix D

Site Conditions:
Chapter 3 of North Canyons Work Plan

3.0 ENVIRONMENTAL SETTING

This chapter has four major functions: it

- describes the environmental settings of Bayo, Barrancas, Rendija, and Guaje Canyons (the "north canyons systems");
- summarizes existing information relevant to the characterization of the northern canyons systems;
- identifies additional information needed to expand the conceptual understanding of the environmental processes that occur within the systems and to assess the magnitude and importance of potential exposure pathways within the canyon systems; and
- provides the technical basis for the conceptual model, which is described in Chapter 4 of this work plan.

The regional environmental setting of Los Alamos National Laboratory (the "Laboratory") is presented in Chapter 3 of "Core Document for Canyons Investigations" (the "core document") (LANL 1997, 62316) and in Chapter 2 of the "Installation Work Plan for Environmental Restoration Project" (IWP) (LANL 2000, 66802).

Nomenclature used in this Document

Since circa 1961, boreholes drilled in the north canyons have been advanced for their intended purpose, completed, left open and uncompleted, or plugged and abandoned. These boreholes and completions are designated by letters and numbers. Generally, the first two or three letters or numbers designate the canyon or technical area (TA). For example, BC = Bayo Canyon, GC = Guaje Canyon, 10- = boreholes at TA-10. The last letter or letters designate borehole function. Historic drilling efforts have often used additional notations. Municipal water well locations often are designated by a single letter to identify the canyon.

BCO-	observation well in Bayo Canyon; completed with screen or perforated casing to monitor groundwater
BCM-	moisture access hole in Bayo Canyon; borehole cased with 2-in. (5.08-cm)-diameter aluminum pipe, plugged at the bottom to keep water out of the pipe; intended for logging in situ moisture measurements with a neutron moisture/density probe
Well G-	Guaje Canyon municipal water supply well
GR-	Guaje Canyon municipal water supply replacement wells; completed to replace aging municipal wells in Guaje Canyon
GT-	Guaje test wells
LA-	Los Alamos Canyon municipal water supply wells
TH-	test hole

Each letter typically is followed by a number, which normally indicates the sequence of well installation. In some canyons the number designation increased down-canyon. However, due to the paucity of wells in

the north canyons, no numbering system has been implemented. The Guaje Canyon municipal supply wells generally are numbered in the order of installation, which was from the lower canyon upward.

Some boreholes, originally designated “TH” for test hole, were drilled as exploration test holes in various canyons on the Pajarito Plateau. For clarification in this work plan, a two-letter abbreviation that designates the specific canyon has been added to “TH” (such as GCTH, for Guaje Canyon test hole) to provide a specific symbol relating to each borehole’s location.

Within this work plan, “well” refers to a completed borehole with the capability to contain water, specifically the water supply, test, observation, and water-balance wells. Uncompleted core holes are referred to as “boreholes,” whereas the “moisture access holes” are referred to as such. A comprehensive compilation and description of boreholes and completions installed by the Laboratory before circa 1993 are provided by Purtymun (1995, 45344).

Environmental surveillance sediment sampling locations are designated as “Bayo at SR 502,” and “Guaje at SR 502,” which indicate a location near a major highway.

The New Mexico Environment Department (NMED) Oversight Bureau describes collection sites by various nomenclatures. Springs are identified by local name as “Indian Springs” or by the canyon abbreviation preceding the spring number (e.g., “Guaje Canyon Spring 1”). Surface water locations are identified by the canyon name abbreviation and the distance in miles as measured upstream from the Rio Grande. For example, surface water has been collected at station Guaje Canyon Spring 5.7, which is located in Guaje Canyon 5.7 mi (9.17 km) from the confluence with the Rio Grande. It should be noted that the abbreviation “GC” also has been used to designate samples collected in Garcia Canyon. Groundwater sampling locations are identified by the Laboratory well nomenclature.

3.1 Location, Topography, and Surface Drainage

3.1.1 Bayo Canyon

Bayo Canyon has a relatively small drainage area of 4.0 mi^2 (10.4 km^2) that heads on the Pajarito Plateau in a residential area of Los Alamos at an elevation of approximately 7400 ft (2256 m) (LANL 1997, 62316, p. 3-2). The location of the canyon and watershed area is shown in Appendix A, Figure A-1 *(this figure is now attached to the end of this text [Appendix D]).* The canyon extends east/southeast between North Mesa on the south and Barranca and Otowi Mesas on the north, for a distance of approximately 8.2 mi (13.2 km) to the confluence with Los Alamos Canyon. The elevation at the confluence is approximately 5790 ft (1765 m) (LANL 1997, 62316, p. 3-2).

Bayo Canyon contains an ephemeral stream. Most surface water flow occurs after heavy summer rains and is generally short in duration (less than 2 hr). There are currently no effluent discharges in Bayo Canyon (Purtymun, 1995, 45344, p. 43). The channel length is approximately 3.47 mi (5.58 km) on Los Alamos County property, 3.12 mi (5.0 km) on Laboratory property (TA-74), and approximately 1.66 mi (2.66 km) on San Ildefonso Pueblo land to the confluence with Los Alamos Canyon (LANL 1997, 62316, p. 3-2). The watershed has an unnamed tributary (the “south fork of Bayo Canyon”) on Laboratory property approximately 1.9 mi (3.1 km) from the confluence with Los Alamos Canyon.” Another unnamed tributary in the western part of the watershed between Camino Encantada and Barranca Mesa is called the “north fork of Bayo Canyon” (Figure A-1).

Bayo Canyon transects the northern section of the Laboratory and encompasses former TA–10 and portions of TA-74. The canyon drains a portion of the Barranca Mesa residential area, some potential release sites (PRSs) within TA-0, former TA-10, and the central portion of TA-74 (Figure A-1).

3.1.2 Barrancas Canyon

Barrancas Canyon has a relatively small drainage area of 4.9 mi^2 (12.7 km^2) that heads on the northern Pajarito Plateau east of Barranca Mesa at an elevation of 7278 ft (2219 m) (LANL 1997, 62316, p. 3-2). The canyon extends east-southeast approximately 5.5 mi (8.9 km) to its confluence with Guaje Canyon at an elevation of 5860 ft (1786 m) (LANL 1997, 62316, p. 3-2) (Figure A-1).

The main Barrancas Canyon channel crosses approximately 1.6 mi (2.6 km) of Los Alamos County land, approximately 0.4 mi (0.6 km) on US Forest Service (USFS) land, 2.7 mi (4.3 km) on Laboratory property, and 0.7 mi (1.1 km) on San Ildefonso Pueblo land. The Barrancas Canyon watershed contains three unnamed tributaries. The southernmost tributary (south fork) intersects the Barrancas Canyon channel about 0.66 mi (1 km) west of the Guaje Canyon confluence and is about 1 m (1.6 km) long. The south fork is located predominately on Laboratory property within TA-74. Two longer tributaries north of the main Barrancas Canyon channel extend east from Deer Trap Mesa approximately 2.7 mi (4.3 km) (middle fork) and 2.9 mi (4.6 km) (north fork) before merging and continuing an additional 1.9 mi (3.1 km) to the main Barrancas Canyon channel. These northern tributaries are mostly within USFS land but the headland areas are within Los Alamos County land (Figure A-1).

Barrancas Canyon and tributaries contain ephemeral streams that receive intermittent flow from snowmelt and storm water runoff. The Barrancas Canyon watershed drains a portion of the Los Alamos town site, Laboratory property at TA-74, and USFS land. There are no effluent discharges in the watershed (Figure A-1).

3.1.3 Rendija Canyon

Rendija Canyon is located immediately north of the Los Alamos town site. The watershed has a drainage area of 9.5 mi^2 (24.6 km^2). The canyon heads on the flanks of the Sierra de los Valle just west of the town site at an elevation of 9826 ft (2311 m). The canyon contains an ephemeral stream channel that extends approximately 9 mi (14.5 km) east to the confluence with Guaje Canyon. The minimum elevation of the watershed is approximately 6300 ft (1920 m) (LANL, 1997, 62316, p. 3-2).

Rendija Canyon primarily crosses USFS land except for approximately 1.6 mi (2.6 km) of the middle portion of the canyon that crosses General Services Administration (GSA) land. Parcels of private land and Los Alamos County land, such as the Guaje Pines Cemetery, are located in Rendija Canyon along the north side of Los Alamos. One named tributary, Cabra Canyon, enters the Rendija Canyon channel from the north in the central portion of the watershed. Cabra Canyon trends northwest to southeast, is approximately 2 mi (3.2 km) long, and has a watershed area of 1.2 mi^2 (3.1 km^2) on USFS and GSA land (Figure A-1). Three unnamed tributaries to Rendija Canyon are located west of Cabra Canyon and drain south-southeast into the main Rendija Canyon channel. These tributaries are approximately 1.5, 2, and 1.2 mi (2.4, 3.2, and 1.9 km) long.

Rendija Canyon and its tributaries contain ephemeral streams. There are no effluent discharges in the Canyon. The watershed drains portions of Los Alamos town site, GSA land, and USFS land (Figure A-1).

3.1.4 Guaje Canyon

Guaje Canyon is the northernmost canyon discussed in this work plan. The watershed drainage is approximately 16.9 mi^2 (43.8 km^2). The watershed heads on the flanks of the Sierra de los Valles at an elevation of 10,497 ft (3199 m). The Guaje Canyon channel extends east-southeast for approximately 16.4 mi (26.4 km) to the confluence with Los Alamos Canyon at an elevation of approximately 5660 ft (1725 m) (LANL, 1997, 62316, p. 3-2). The Guaje Canyon channel transverses predominately USFS land

except for the lower 2.3 mi (3.7 km), which are within San Ildefonso Pueblo land. The Guaje Canyon watershed primarily drains USFS land.

Three named tributaries are present in upper Guaje Canyon on the flanks of the Sierra de los Valles; each canyon trends northwest to southeast. Aqua Piedra Canyon is approximately 3.0 mi (4.8 km) long and has a watershed area of 1.61 mi^2 (4.1 km^2). Aqua Piedra Spring is located in the middle part of Aqua Piedra Canyon. Caballos Canyon is approximately 2.9 mi (4.6 km) in length and contains another tributary canyon called Vallecitos Canyon, which is the westernmost tributary to Guaje Canyon, and extends for approximately 1.7 mi (2.7 km) to the confluence with Caballos Canyon. Vallecitos Canyon and Caballos Canyon contain ephemeral streams, receiving snowmelt and storm water runoff from watershed areas of 1.2 and 1.5 mi^2 (3.1 and 3.9 km^2), respectively.

In addition to the named tributaries, two unnamed tributaries of significance to Guaje Canyon are present in the middle and lower sections of the Guaje Canyon watershed. The south fork of Guaje Canyon extends for approximately 1.3 mi (2.1 km) on the north side of Guaje Ridge and enters Guaje Canyon from the southwest. The north fork of Guaje Canyon extends for about 2.3 mi (3.7 km) parallel to Guaje Canyon on the north and enters Guaje Canyon from the north-northeast. These tributaries contain ephemeral streams and occasionally contribute flow to Guaje Canyon. The lower reaches of Guaje Canyon also receive runoff from Rendija Canyon and Barrancas Canyon (Figure A-1).

Guaje Canyon is informally divided into three sections for discussion purposes. The upper part of Guaje Canyon refers to the portion upstream and up-channel of the confluence with the south fork of Guaje Canyon. The middle part of Guaje Canyon extends from the confluence with the south fork to the confluence with Rendija Canyon. The lower part of Guaje Canyon extends from the confluence with Rendija Canyon to Los Alamos Canyon.

Two springs at an elevation of approximately 8850 ft (2700 m) support a perennial reach in upper Guaje Canyon. Guaje Reservoir, a small concrete structure, is located in upper Guaje Canyon at an elevation of 8020 ft (2445 m), approximately 3 mi (4.8 km) upstream from the confluence with the south fork. The reservoir is about 25 ft long and 11 ft high with a capacity of 250,000 gal.; it receives flow from the springs and from the watershed area of 6 mi^2 (15.4 km^2) above the reservoir. The reservoir was constructed and equipped with a pipeline system to divert water to Los Alamos (Purtymun 1975, 11787, pp. 276–282). The reservoir served as a municipal water supply from 1947 to 1959 with annual production ranging from approximately 24 x 10^6 to 213 x 10^6 gal. From 1972 to 1992, water diverted from the reservoir was used for irrigation purposes by Los Alamos County. During this period, annual production ranged from 2.2 x 10^6 to 9.7 x 10^6 gal. (McLin et al. 1998, 63506, p. 13).

The Guaje well field is located in the lower and middle parts of the canyon. The Guaje well field provides a significant portion of the municipal water supply for the Los Alamos area (Figure A-1).

3.2 Climate

Los Alamos County has a semiarid, temperate, mountain climate, which is summarized in the core document (LANL 1997, 62316, p. 3-1) and Chapter 2 of the IWP (LANL 2000, 66802). Detailed data compilations and extensive statistical summaries, including projected probabilities of meteorological occurrences, are provided by Bowen (1990, 6899).

Historical site-specific meteorological data for the north canyons are not available. The monitoring locations closest to the canyons are tower stations at TA-53 (mesa top) and TA-41 (canyon site) and precipitation gages at TA-74 and the North Community of Los Alamos (see Figure A-1). Annual climate summaries are presented in the annual environmental surveillance reports (ESP 2000, 68661).

In 2000 after the Cerro Grande fire, several remote automated weather stations (RAWS) were installed north of Los Alamos. The Guaje Canyon and the Garcia Canyon RAWS are located in or near the north canyons watersheds. Two RAWS are located within the north canyons watershed area. One, the "Garcia Canyon" station, is located at the northern boundary of Aqua Piedra Canyon, which is a tributary to Guaje Canyon, and another, the "Guaje Canyon" station, is located on Guaje Ridge between Rendija Canyon and Guaje Canyon (BAER, 2000, 68662, p. 199; Figure A-1 of this document). These stations monitor meteorological parameters including precipitation and are used to provide a flash flood warning in areas of risk. A flash flood warning is issued when a RAWS records a sustained rainfall at a rate of 1 in./hr. RAWS data are available at the Desert Research Institute web site at http://www.wrcc.dri.edu/losalamos/.

3.3 Geology

Discussions of the regional geologic setting of the Pajarito Plateau are presented in Griggs (1964, 65649), the IWP (LANL 2000, 66802), the hydrogeologic work plan (LANL 1998, 59599), and most recently in the core document (LANL 1997, 62316, p. 3-6). The following discussion uses the core document as the technical basis for the geologic setting and provides detail that is specific to Guaje, Rendija, Bayo, and Barrancas Canyons. Unless otherwise noted, locations of wells and boreholes discussed in this document are shown on Figure A-1. Some locations are beyond the extent of Figure A-1; these wells and boreholes can be found on maps and figures in the core document (LANL 1997, 62316) and/or the hydrogeologic work plan (LANL 1998, 59599).

The surface distribution of bedrock geologic units is shown on geologic maps prepared by Griggs (1964, 65649), Smith et al. (1970, 9752), and Rogers (1995, 54419). Structure is discussed in Wachs et al. (1988, 6690).

3.3.1 Stratigraphy

The principal bedrock units in the Guaje-Rendija-Bayo-Barrancas Canyons area consist of the following, in ascending order:

- Santa Fe Group: 4 to 21 Ma (Manley 1979, 11714);
- Puye Formation: 1.7 to 4 Ma (Turbeville et al. 1989, 21587; Spell et al. 1990, 21586) and interstratified volcanic rocks including the Tschicoma Formation on the west (2.53 to 6.7 Ma) and basalts of the Cerros del Rio volcanic field on the east (2 to 3 Ma) (Gardner and Goff 1984, 44021; WoldeGabriel et al. 1996, 54427);
- Otowi Member of the Bandelier Tuff: ca 1.61 Ma (Izett and Obradovich 1994, 48817);
- tephras and volcaniclastic sediments of the Cerro Toledo interval (Broxton and Reneau 1995, 49726, p. 11); and
- Tshirege Member of the Bandelier Tuff: ca 1.22 Ma (Izett and Obradovich 1994, 48817; Spell et al. 1990, 21586).

The bedrock stratigraphy in the Pajarito Plateau area is illustrated in Figure 3.3-1. The stratigraphy is based on the sitewide three-dimensional stratigraphic model, which contains detailed stratigraphic mapping for the sedimentary deposits and has been supplemented by additional detail on the volcanic units (Carey et al., 66782). Stratigraphic information for pertinent wells in the Guaje Canyon and Bayo Canyon areas is discussed in Section 3.4.2.

Bandelier Tuff	Tshirege Member	Qbt 4	Ash-flow units
		Qbt 3	
		Qbt 2	
		Qbt 1v	
		Qbt 1g	
		Tsankawi Pumice Bed	
Cerro Toledo interval		Volcaniclastic sediments and ash-falls	
Bandelier Tuff	Otowi Member	Ash-flow units	
		Guaje Pumice Bed	
Puye Formation and intercalated volcanic rocks	Fanglomerate	Fanglomerate facies includes sand, gravel, conglomerate, and tuffaceous sediments	
	Volcanic rocks	Cerros del Rio basalts intercalated within the Puye Formation, includes up to four interlayered basaltic flows. Andesites of the Tschicoma Formation present in western part of plateau	
	Fanglomerate	Fanglomerate facies includes sand, gravel, conglomerate, and tuffaceous sediments; includes "old alluvium"	
	Axial facies deposits of the ancestral Rio Grande	Totavi Lentil	
Santa Fe Group	Coarse sediments	Coarse-grained upper facies (called the "Chaquehui Formation" by Purtymun 1995, 45344)	
	Basalt		
	Coarse sediments		
	Basalt		
	Coarse sediments		
	Basalt		
	Coarse sediments		
	Basalt		
	Coarse sediments		
	Arkosic clastic sedimentary deposits	Undivided Santa Fe Group (includes Chamita[?] and Tesuque Formations)	

Source: Baltz et al. 1963, 8402; Purtymun 1995, 45344; LANL 1998, 59599; Broxton and Reneau 1995, 49726.

Figure 3.3-1. Generalized stratigraphy of bedrock geologic units of the Pajarito Plateau

Alluvium of Pleistocene and Holocene age rests unconformably on the Bandelier Tuff and deeper units in some parts of all four canyons. The alluvium in the canyons generally consists of reworked Bandelier Tuff and older bedrock units. The alluvium may also contain a minor eolian component.

3.3.2 Geomorphology

3.3.2.1 Bayo Canyon

Bayo Canyon is the smallest (in area) of the four northern canyons. The total change in elevation is 1610 ft (491 m); and the average gradient over its entire length is 0.037 m/m (3.7%, 2.1 degrees) (LANL 1997, 62316, p. 3-2). The channel gradient changes in response to bedrock lithologic changes over the length of the canyon.

The canyon heads in unit Qbt 3 of the Tshirege Member of the Bandelier Tuff, where the channel gradient is about 0.067 m/m (6.7%, 3.8 degrees). As the canyon cuts through the Cerro Toledo interval and into the more erodible Otowi Member approximately 2 mi (3.2 km) downstream, the gradient decreases to about 0.03 m/m (3%, 1.9 degrees). Approximately 1.9 mi (3.1 km) further downstream the channel incises the Puye Formation fanglomerates, and the gradient increases again to about 0.05 m/m (5%, 2.9 degrees). Bayo Canyon is incised into the upper Santa Fe Group for a short distance upstream of the confluence with Los Alamos Canyon.

A veneer of late Quaternary alluvium forms the floor of much of Bayo Canyon, ranging in thickness from 0 to 26 ft (0 to 7.9 m) as measured in several test holes drilled in the canyon. The alluvium near the axis of the canyon is typically greater than 13 ft (4 m) thick (Cogbill 1994, 46146, p. 2). Bayo Canyon at former TA-10 is asymmetric, with the active channel shifted to the north side of the canyon and flanked by one or more stepped terraces (Drake and Inoue 1993, 53456, p. 18).

A series of Quaternary terraces has been identified in Bayo Canyon at former TA-10. Quaternary alluvial deposits have been subdivided into three units, the youngest of which (Qal 3) contains historic artifacts from TA-10 and probably dates from the period 1944 to 1963 (Drake and Inoue 1993, 53456, p. 6). These units are 0.5 to 3.5 ft (0.15 to 1.1 m) thick at former TA-10 and downstream. The alluvial deposits consist of terraces along the main channel and tributary channels, fan deposits associated with side drainages, and colluvial deposits at the base of steep valley side slopes. The Q3 surface of Drake and Inoue is defined as the top of the Qal 3 sediment deposits. The Q3 terrace surfaces have a maximum width of about 250 ft (76 m), but generally occur as laterally restricted terraces 30 to 80 ft (9 to 24 m) across. They are 0.5 to 2 ft (0.15 to 0.6 m) above local base level along the main channel, but can be up to 3.7 ft (1.1 m) above local base level along tributary channels.

The Qal 1 and Qal 2 sediments as characterized by Drake and Inoue lie beneath the Q1 and Q2 surfaces, do not contain historic artifacts, and are considered older than 50 yr. The older Qal 1 sediments consist primarily of fan deposits near the valley floor and colluvium underlying valley side slopes, and are typically about 6 ft (1.8 m) thick. The younger Qal 2 sediments consist of terrace and fan deposits at or near the canyon floor, and are typically greater than 2.5 ft (0.76 m) thick. Q1 surfaces comprise most of the canyon floor on the south side of the active channel, and Q2 surfaces comprise most of the remainder of the narrow inner canyon (Drake and Inoue 1993, 53456, pp. 17–18).

The late Quaternary terraces and soils in Bayo Canyon appear to reflect at least two cycles of incision and aggradation, followed by a third period of incision during the late Holocene. Preliminary interpretations suggest that sediment is cycled through some parts of the canyon on a time scale of 10^2 to 10^3 yr. Up to 3.5 ft (1.1 m) of historic sediment has been deposited along the main channel on the south side of the canyon below the former TA-10 since about 1944 (Drake and Inoue 1993, 53456, pp. 1–26).

3.3.2.2 Barrancas Canyon

Barrancas Canyon is the shortest of the four northern canyons discussed in this work plan. Barrancas Canyon contains an ephemeral stream with no perennial reaches, springs, or wetlands. Stream loss caused by infiltration and evaporation generally prevents runoff from reaching Guaje Canyon (LANL 1998, 59599, p. 4-86).

The total change in elevation from the head of Barrancas Canyon to its confluence with Guaje Canyon is about 1370 ft (417 m). The canyon heads in the Tshirege Member of the Bandelier Tuff. The relatively steep and narrow upper portion of the canyon cuts through Tshirege units Qbt 2 through Qbt 1v and the gradient in the upper portion is about 0.05 m/m (5%, 2.9 degrees). The channel then cuts through the Cerro Toledo interval and into the Otowi Member, where the gradient decreases slightly to about 0.04 m/m (4%, 2.3 degrees). About 1.3 mi (2.1 km) further downstream, the channel is incised into Tertiary sediments of the Puye Formation, and from that point to Guaje Canyon the gradient averages about 0.033 m/m (3.3%, 1.9 degrees).

3.3.2.3 Rendija Canyon

Rendija Canyon contains an ephemeral stream with no springs, perennial reaches, or wetlands (LANL 1998, 59599, p. 4-85). The upper reach (~1 km, 0.6 mi) of Rendija Canyon is cut into the lava flows and associated rocks of the Tschicoma Formation on the flanks of the Sierra de los Valles. Beginning about 13.5 km (8.4 mi) upstream from the confluence with Guaje Canyon, the channel is cut into the Bandelier Tuff, including tephras and volcaniclastic sediments of the Cerro Toledo interval. The channel is incised into the Puye Formation at about 5 km (3 mi) upstream from Guaje Canyon (Reneau and McDonald 1996, 55538, Figure 2-18). Changes in bedrock lithology along the length of the canyon result in some changes in the morphology of the channel and associated deposits. Exposures of the relatively erodible Otowi Member of the Bandelier Tuff and Cerro Toledo interval pumice deposits, for example, have led to extensive lateral stream erosion and development of relatively broad stream terraces. Where the Puye Formation is exposed, the gradient increases, the channel becomes more incised, and terraces are narrower (Reneau and McDonald 1996, 55538).

The total change in elevation from the head of Rendija Canyon to its confluence with Guaje Canyon is 3530 ft (1076 m), and the average gradient is 7.4%. The gradient varies significantly, largely in response to changes in lithology along the length of the canyon. In the upper reach where the Tschicoma Formation is exposed, the gradient is about 0.15 m/m (15%, 8.5 degrees), and the canyon is narrow and steep-sided. Where the canyon floor consists of the Tshirege Member of the Bandelier Tuff, the gradient is more moderate, ranging from about 0.08 m/m (8%, 4.6 degrees) to 0.05 m/m (5%, 2.9 degrees). In the Otowi Member and the Cerro Toledo interval, the gradient decreases to about 0.02 m/m (2%, 1.1 degree), and the canyon is broader. As the canyon cuts into the Puye Formation downstream of the Sportsman's Club, the gradient increases again to about 0.04 m/m (4%, 2.3 degrees).

Rendija Canyon contains at least five Pleistocene and four Holocene stream terraces that are perhaps the best-preserved flight of terraces on the Pajarito Plateau. They range in age from about 0.5 to greater than 160 ka, as determined by carbon-14 dating and soil chronofunctions (Reneau and McDonald 1996, 55538). In the reaches downstream of the Sportsman's Club, the Rendija Canyon channel is incised into fanglomerates of the Puye Formation, with a significant increase in stream gradient and narrowing of the Holocene terraces.

3.3.2.4 Guaje Canyon

Guaje Canyon is the longest of the four canyons addressed in this work plan, and it contains an interrupted stream. A perennial reach extends from a series of springs located upstream of Guaje Reservoir to some distance downstream of the reservoir. The stream is ephemeral downstream from that point to its confluence with Los Alamos Canyon (LANL 1997, 62316, p. 3-26).

The total change in elevation from the head of Guaje Canyon to its confluence with Los Alamos Canyon is about 4840 ft (1476 m) (LANL 1997, 62316, p. 3-2), and the average gradient is about 0.056 m/m (5.6%, 3.2 degrees). The gradient changes along the length of the canyon largely in response to changes in bedrock lithology. For about the first 3 mi (4.8 km), the canyon is cut into Tschicoma Formation, and is steep and narrow, with a gradient of about 0.07 m/m (7%, 4 degrees). The canyon is incised into the Puye Formation down to the basal axial facies west of the Guaje Mountain fault zone (GMFZ), at which point the Tschicoma Formation is again exposed for less than 1 mi (1.6 km). The gradient over the conglomerates of the Puye Formation west of the fault zone is about 0.04 m/m (4%, 2.3 degrees). East of the GMFZ the canyon again is incised into Puye Formation rocks, including the axial facies but primarily the upper fanglomerate deposits, and is mantled with late Quaternary alluvial channel and terrace deposits. The gradient in the Puye Formation east of the fault zone averages about 0.035 m/m (3.5%, 2 degrees), but decreases gradually to about 1% or less in the lower reach immediately upstream of Los Alamos Canyon.

3.4 Environmental Setting

3.4.1 Surface Sediments

3.4.1.1 Background Conditions

Background data on concentrations of inorganic chemicals and radionuclides in sediments are available from several areas on the Pajarito Plateau that are unaffected by Laboratory operations (Ryti et al. 1998, 59730). These data include samples from Guaje Canyon and from other canyons that are geologically similar to the north canyons. The term "background value" (BV) indicates an estimate of the upper range of the background concentrations, and is either the 95% upper tolerance limit (UTL) value for an analyte or detection limits for infrequently detected analytes (Ryti et al. 1998, 59730).

Portions of the north canyons receive runoff from urban areas at Los Alamos. Therefore, sediments may contain concentrations of metals and other constituents that may be more representative of urban “baseline” conditions rather than developed BV conditions (e.g., Reneau et al. 1998, 59160, p. 1-7).

In May 2000, the Cerro Grande fire burned large parts of upper Rendija Canyon and Guaje Canyon. Thus, fire-related chemicals and combustion products are present in these watersheds. Postfire sampling has shown that concentrations of metals and radionuclides in ash and muck (sediment that is dominated by reworked ash) are greater than previously determined sediment BVs (LANL 2000, 69054). Changes in sediment chemistry as a result of the Cerro Grande fire will be considered in the assessment of media sampled in Rendija and Guaje Canyons.

3.4.1.2 Historic Channel Changes

Changes are known to have occurred in the north canyons’ channels since the beginning of Laboratory operations. An understanding of recent sedimentation and erosion patterns may identify potential contaminant transport mechanisms and horizontal and vertical distribution of possible contaminants in the alluvium. Sedimentation and erosion patterns have not been well defined in the north canyons.

Man-made alterations to the Bayo, Rendija, and Guaje Canyon watersheds likely have altered the channel and drainage pathways in these canyons. Anthropogenic impact to the canyon floors and drainage has occurred from the installation of the roads serving these canyons, construction of sewers and water-supply pipelines for Los Alamos town site, and from Laboratory activities conducted within some of the watersheds. Within Guaje Canyon, additional changes have resulted from the installation of Guaje Reservoir and municipal water supply wells and pump stations.

Recent sedimentation and degradation rates vary within each watershed and have not been fully identified. Localized aggradation and degradation processes may occur to raise or incise a specific interval of the streambed. In Bayo Canyon, sediments deposited since the 1950s near former TA-10 range from 0.5 to 2 ft (0.15 to 0.6 m) and include fragments of laboratory debris. Sediment deposits associated with activities at former TA-10 are up to 3.5 ft (1 m) (Drake and Inoue 1993, 53456, pp. 1, 26, 27). Sediments appear to cycle through Bayo Canyon every 100 to 1000 yr. Tributary drainages exhibit additional cycles of erosion and deposition occurring on a time scale of tens to hundreds of years (Drake and Inoue 1993, 53456, pp. 1, 6, 27).

The upper portions of the Guaje Canyon and Rendija Canyon watersheds burned extensively during the Cerro Grande fire in May 2000 (BAER 2000, 68662). Hydrologic changes caused by the fire have increased sediment load, peak flood discharges, and runoff volumes in these canyons. Postfire floods have already contributed to significant channel erosion in some places and sediment aggradation in others, and additional channel changes are likely in the next several years.

Barrancas Canyon and its tributaries have not been significantly impacted by Laboratory operations or other historic activities, with the exception of grazing and logging, and may be in a relatively natural state.

3.4.1.3 Historic Sediment Investigations

3.4.1.3.1 Plutonium Investigations in North Canyons

In 1965 and 1970, investigations were conducted across the Los Alamos area to assess the concentration and movement of soil-bound plutonium and radioactivity in stream channels. As part of the investigation, sediments were collected from each of the north canyons. Sediments from Bayo and Barrancas Canyons were sampled and analyzed for gross activity in 1965, and, in 1970, for gross activity and plutonium. Sampling locations in Bayo Canyon were approximately 1 mi downstream of former TA-10 and above the confluence with Los Alamos Canyon. Barrancas Canyon was sampled above the confluence with Guaje Canyon. Three sediment stations were established in Rendija Canyon and sampled for plutonium-238 and plutonium-239 in 1970. These stations were located near Guaje Pines Cemetery, downstream of the Sportsman's Club, and above the confluence with Guaje Canyon (Mayfield et al. 1979, 11717, pp. 50, 56; Purtymun 1970, 4795; Purtymun 1975, 11787, pp. 23–30).

In 1970, sediment stations were also established in Guaje Canyon and samples were collected for the analyses of plutonium isotopes. The three Guaje Canyon sediment stations were located above the confluence with Rendija Canyon, Barrancas Canyon, and Los Alamos Canyon. Sediments were collected from active channels (less than 1-in. [2.5-cm] depth) in each of the north canyons. Particle-sized distribution of the sediments was determined on material less than 4 mm to assess the percentage of clay- and silt-sized particles. Generally, the sediments were composed of 3% to 7.5% (by weight) of silt- and clay-sized material. Analyses for plutonium-238 and plutonium-239 were conducted by concentration and purification using ion exchange chemistry followed by an alpha spectrometer assay. Results of the analyses indicated activity within the range attributed to worldwide fallout (Mayfield et al. 1979, 11717, pp. 50, 56; Purtymun 1970, 4795; Purtymun 1975, 11787, pp. 23–30).

3.4.1.3.2 Former TA-10 Site in Bayo Canyon

Historic activities at former TA-10, Bayo site, are the primary Laboratory activities that affect Bayo Canyon. Bayo site was active from 1949 to 1963. An estimated 1.4 Ci of "natural uranium," 1.2 Ci of depleted uranium, and from 30 to 40 Ci of strontium-90 were dispersed to the surface environment in Bayo Canyon and beyond by the explosives testing. An additional 85 to 120 Ci of strontium-90 were deposited in the waste handling facilities (Mayfield et al. 1979, 11717, p. 4). In 1964 buildings and structures were decommissioned and decontaminated and in 1967 the property was transferred to Los Alamos County (see Section 2.3.2.2 of this document).

In 1973, four sediment sampling stations were established along Bayo Canyon including

- Station A - approximately 6500 ft (2000 m) upstream from Bayo site;
- Station B - within Bayo site;
- Station C - approximately 6500 ft (2000 m) downstream of Bayo site; and
- Station D – approximately 15,000 ft (4600 m) downstream of Bayo site.

Each station included five sampling locations, a center location, and locations 65 ft (20 m) and 650 ft (200 m) east and west of the center. Samples were collected from the bed sediments or stream bank. Stations A and B (upstream and within Bayo site) were analyzed for gross alpha and beta activity, and plutonium-238 and plutonium-239. Stations C and D (downstream of Bayo site) were analyzed only for plutonium-238 and plutonium-239. Analytical results from Stations A and B (upstream of Bayo site and within Bayo site) showed that gross alpha activity and plutonium concentrations were approximately background levels while gross beta concentrations were approximately twice background levels. Soil samples were collected from Stations A and B at points 20 and 200 m (65 ft and 650 ft) north and south of the center sediment sampling location. Analytical results showed that gross alpha and plutonium isotope concentrations were within background levels for the area. Gross beta activity was about 2 to 3 times background levels. The investigation concluded that elevated gross beta activity seen at Stations A and B appears attributable to the presence of strontium-90 (Mayfield et al. 1979, 11717, p. 50).

The Formerly Utilized Sites Remedial Action Program (FUSRAP) investigation included the collection of samples from approximately 27 random and nonrandom sampling locations in natural drainage pathways and the active stream channel at the former TA-10 site. The purpose of the sampling was to assess the redistribution or deposition of residual contaminants by surface water runoff (Mayfield et al. 1979, 11717, pp. 25, 26, 30). The sample depths were approximately 0 to 30 cm (0 to 12 in.) and included core samples (composite) and profile samples (discrete intervals). Results of the analyses showed that total uranium concentrations in sediment samples ranged from 1.6 to 7.6 μg/g, with highest concentrations from shallow depths (0 to 5 cm [0 to 2 in.]) at the former TA-10 site (Mayfield et al. 1979, 11717, p. 35). Concentrations of strontium-90 ranged from 0 to 8.2 pCi/g with the highest concentrations from the 0- to 5-cm (0- to 2-in.) interval. (Mayfield et al. 1979, 11717, p. 34). The background concentration of strontium-90 attributable to worldwide fallout at the time was estimated to be 0.4 pCi/g (Mayfield et al., 1979, 11717, p. 32).

3.4.1.3.3 Routine Environmental Surveillance of Active Channel Sediments

Since 1973, the Laboratory Environmental Surveillance Program has collected active channel sediment samples from locations in Bayo Canyon and Guaje Canyon. Table 3.4-1 summarizes the sediment sampling locations and dates. The sampling locations are shown on Figure A-1.

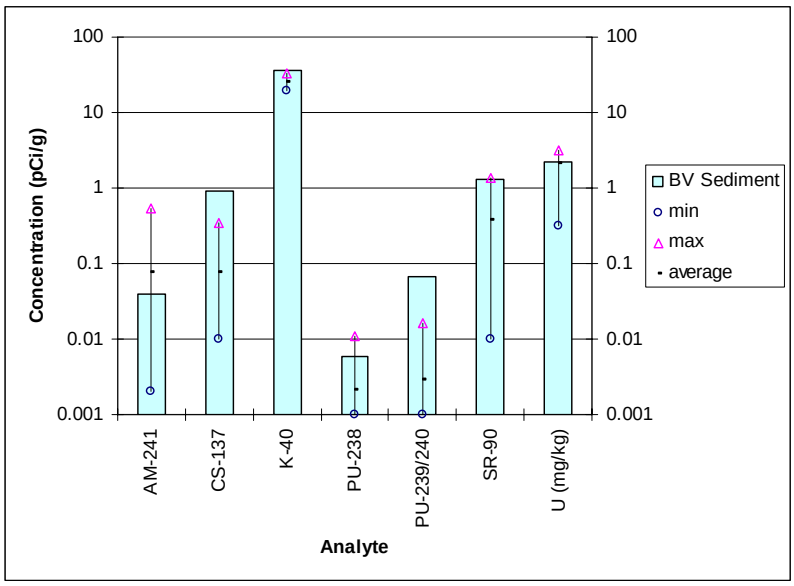
Table 3.4-1
Environmental Surveillance Sediment Sampling Locations

Location	Comment
Bayo Canyon at SR 502	Active channel sediment site at SR* 502, 1978 to 1999
Guaje Canyon at SR 502	Active channel sediment site at SR 502, 1977 to 1999
Guaje Canyon near G-4	Active sediment site near municipal well G-4, 1973 to 1980
Guaje Reservoir	Sediment collected from Guaje Reservoir, 1999

Source: Environmental Surveillance Reports, 1973–1999.
*SR = state road.

Bayo Canyon

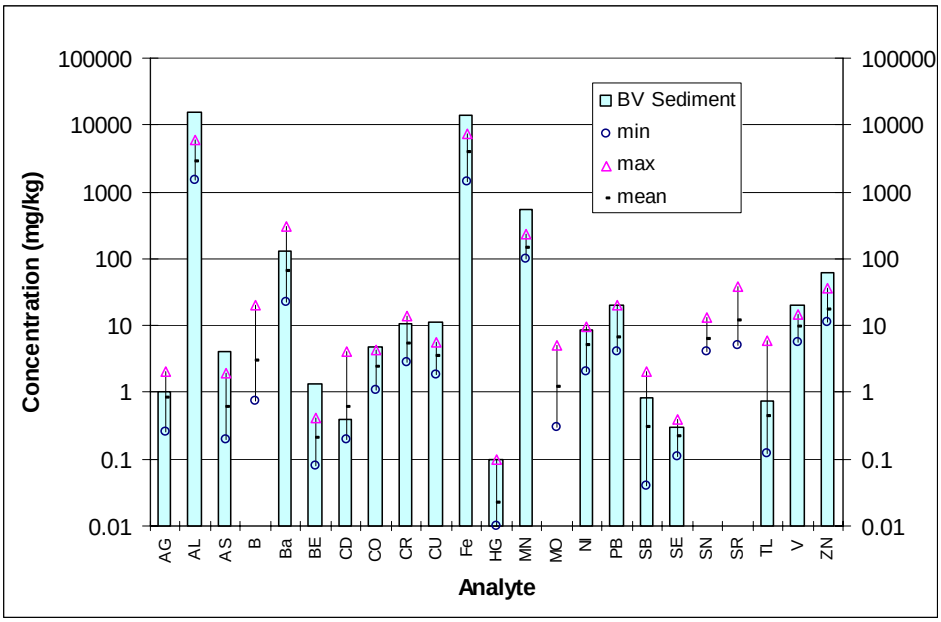
Active channel sediment samples have been collected in Bayo Canyon above the confluence with Los Alamos Canyon at State Road (SR) 502 annually since 1978. The samples are routinely analyzed for radionuclides. In some years since 1990 the samples were analyzed for metals. A summary of the results for radionuclides is shown in Figure 3.4-1. The radionuclide concentrations have generally been found to be within sediment BVs. However, americium-241 has been measured in concentrations above the sediment BV in 1992, 1998, and 1999, at concentrations of 0.106, 0.17, and 0.55 pCi/g, respectively (Environmental Surveillance Reports, 1978–1999). All americium-241 concentrations observed above BV were analyzed by gamma spectroscopy; results of alpha spectrometry for americium-241 have all been below BV.



Source: Environmental Surveillance Reports, 1978—1999.

Figure 3.4-1. Summary of radionuclides in Bayo Canyon sediments at SR 502

The summary of the results of analyses of sediments for metals is shown in Figure 3.4-2. Most metals have been observed in concentrations below the BV for sediments. Metals found in concentrations above the sediment BV include barium, cadmium, and thallium. In 1996 the sediment samples from Bayo Canyon were also analyzed for high explosive (HE) compounds, which were found to be below detection limits for HE compounds.

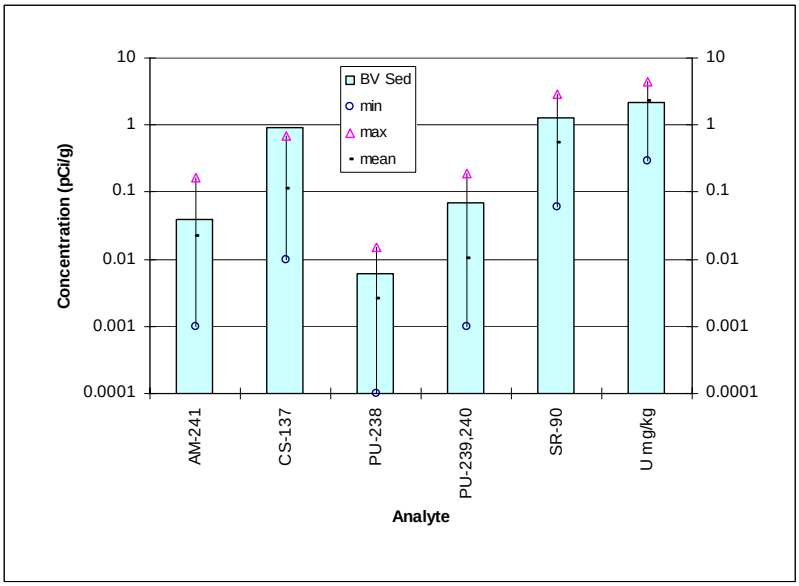


Source: Environmental Surveillance reports, 1990–1999.

Figure 3.4-2. Summary of metals in Bayo Canyon sediments at SR 502

Guaje Canyon

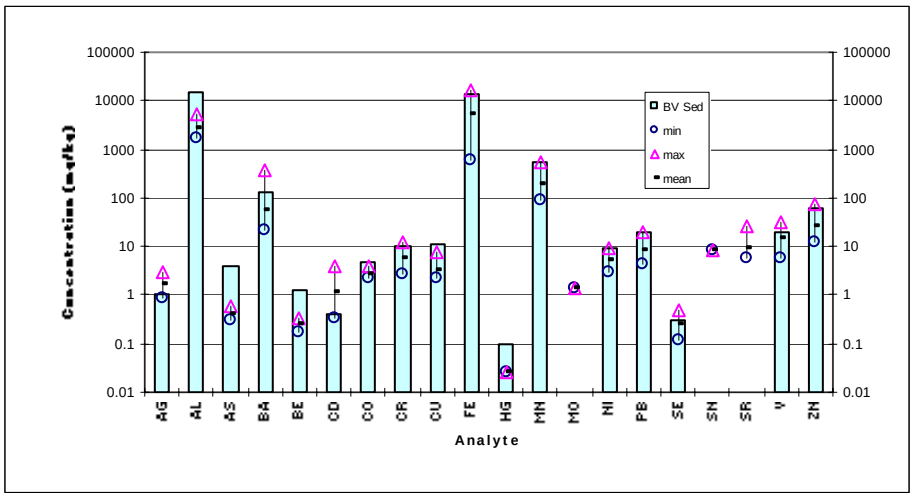
Active channel sediment samples have been collected annually in lower Guaje Canyon at SR 502 above the confluence with Los Alamos Canyon since 1977. The samples are routinely analyzed for radionuclides; since 1990, the samples also have been analyzed for metals. A summary of radionuclide analyses is shown in Figure 3.4-3. Maximum values for americium-241, plutonium-238, plutonium-239,240, strontium-90, and uranium have been above the BV for sediments. All results of americium-241 that have been observed above the BV have been from gamma spectroscopy measurements; all measurements of americium-241 using alpha spectrometry have been below the BV.



Source: Environmental Surveillance Reports, 1977–1999.

Figure 3.4-3. Summary of radionuclides in Guaje Canyon sediments at SR 502

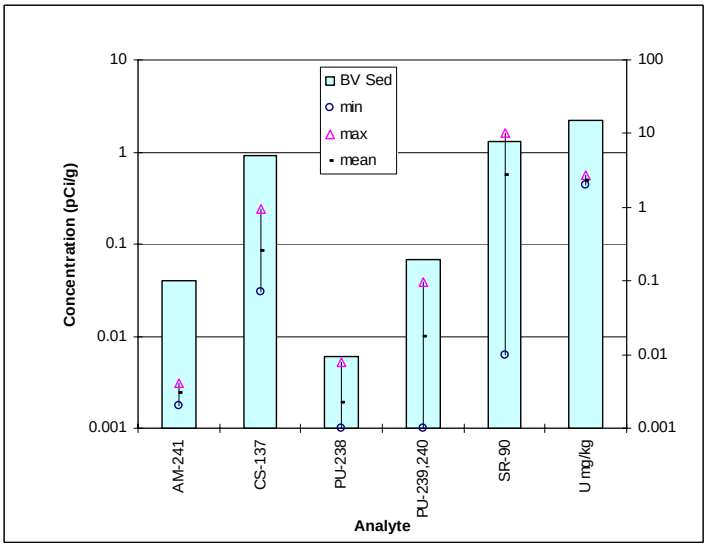
A summary of metals analyses obtained since 1990 for sediment samples collected in Guaje Canyon at SR 502 is shown in Figure 3.4-4. Most metals showed concentrations below the BV for sediments; however, maximum values of silver, barium, and cadmium have been above the BV.



Source: Environmental Surveillance Reports, 1990–1999.

Figure 3.4-4. Summary of metals in sediments collected at Guaje Canyon at SR 502

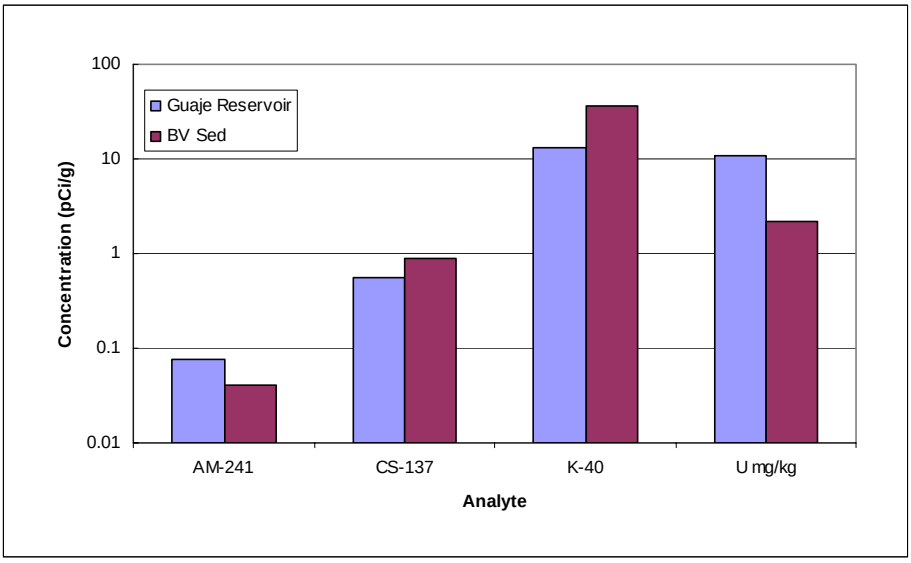
From 1973 through 1980, six sediment samples were collected in Guaje Canyon near well G-4 and the samples were analyzed for radionuclides. A summary of the results is shown in Figure 3.4-5. Gross gamma and strontium-90 were measured in concentrations above the BV for sediments. Three of four samples collected in Guaje Canyon contained strontium-90 in concentrations above the BV. The maximum concentration of strontium-90 was 10.4 pCi/g, which was collected in October 1976 (Environmental Surveillance Reports, 1973–1980).



Source: Environmental Surveillance Reports, 1973–1980.

Figure 3.4-5. Summary of radionuclides in Guaje Canyon sediment near well G-4, 1973 through 1980

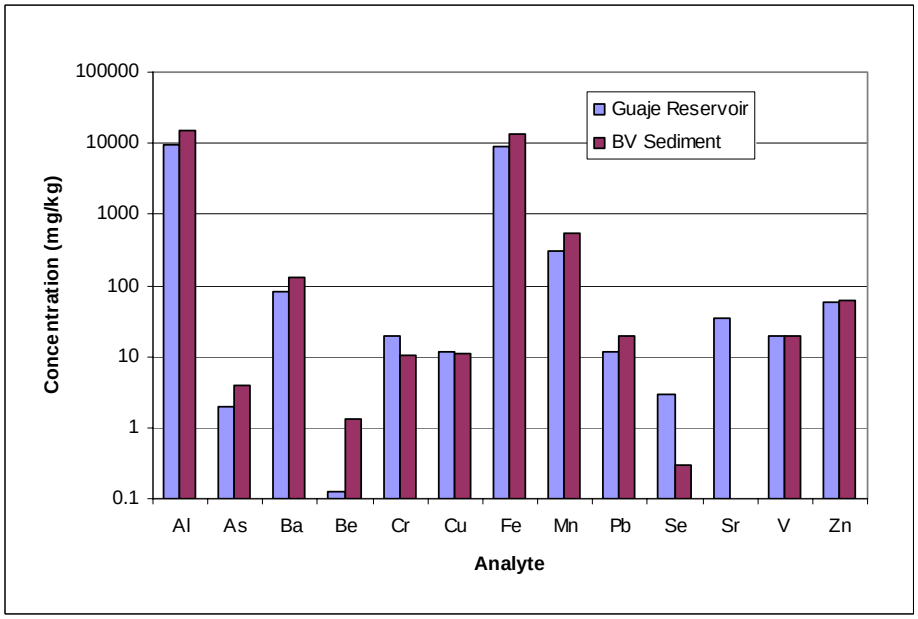
In 1999 a sediment sample was collected from Guaje Reservoir in Guaje Canyon and analyzed for metals and radionuclides (ESP 2000, 68661, p. 170). A summary of the radionuclide analyses is shown in Figure 3.4-6. Americium-241 (gamma spectroscopy), gross alpha, gross beta, and uranium were measured in concentrations above the BV for sediments (ESP 2000, 68661, pp. 225 et seq.).



Source: ESP 2000, 68661, pp. 170, 225.

Figure 3.4-6. Summary of radionuclides in Guaje Reservoir sediment, 1999

A summary of the metals analyses from samples collected from Guaje Reservoir in 1999 is shown in Figure 3.4-7. Metals measured in concentrations above the BV for sediments included copper and selenium (ESP 2000, 68661, pp. 245 et seq.).



Source: ESP 2000, 68661, pp. 170, 245, 251.

Figure 3.4-7. Summary of metals in Guaje Reservoir sediment, 1999

3.4.1.3.4 Recent Environmental Surveillance Sediment and Soil Sampling

In 1999, the US Environmental Protection Agency (EPA) collected four sediment samples from Bayo Canyon approximately 1 mi (1.6 km) east of former TA-10. Sediment collection depths were as follows: Bayo-1, 0-14 cm; Bayo-2, 14 to 27 cm; Bayo-3, 10 to 22 cm; and Bayo-4, 4 to 11 cm. Split samples were collected by the Laboratory Water Quality and Hydrology Group (ESH-18). The samples collected by ESH-18 were analyzed for radionuclides and metals.

Figure 3.4-8 summarizes the radionuclide analyses and Figure 3.4-9 summarizes the metals analyses obtained by ESH-18. All radionuclides were found in concentrations below the BV for sediment except for one sample that contained americium-241 in a concentration of 0.129 pCi/g using gamma spectroscopy; however, the same sample analyzed using alpha spectrometry contained 0.0037 pCi/g americium-241, below the sediment BV. All metals were found in concentrations below the BV for sediments (ESP 2000, 68661, pp. 170, 223, 297).

From June 1 to 19, 2000, after the Cerro Grande fire in May, surface soil samples were collected from locations on Laboratory property, at perimeter stations, and at background stations to assess potential contaminants from fallout ash, smoke and Laboratory air stack emissions, and fugitive dust (e.g., the resuspended dust from contaminated areas at Laboratory facilities). One perimeter station was located in Rendija Canyon near the Sportsman's Club. Analysis of samples from that location indicated the average concentrations of radionuclides and trace elements were similar to results obtained from soils collected in 1999 (Fresquez 2000, 68663, pp. 3, 5, 8).

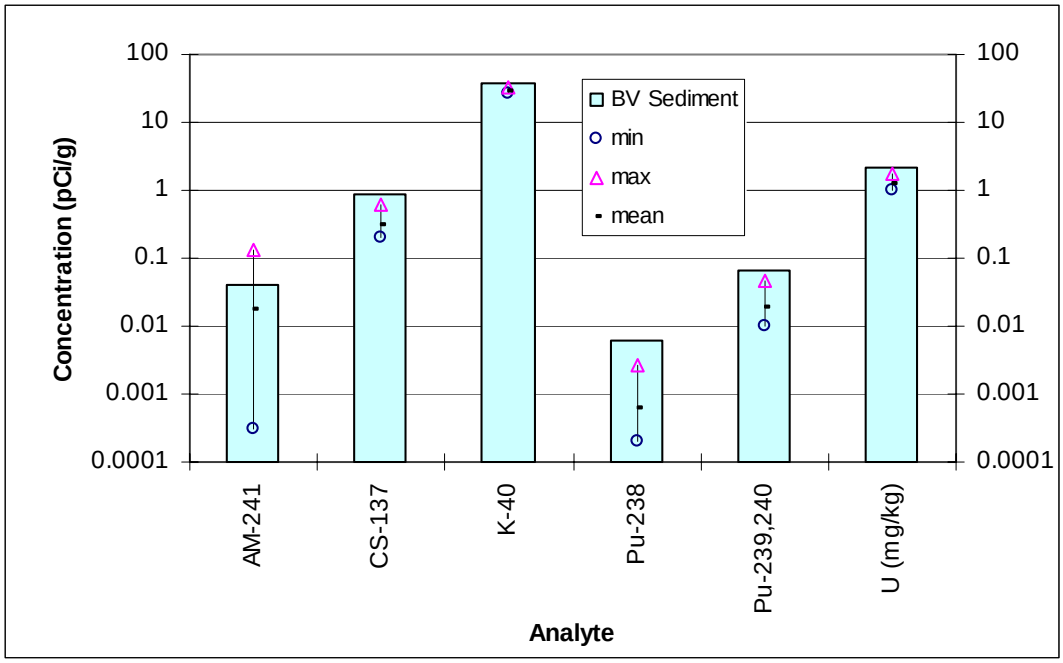
3.4.1.3.5 RFI Sediment and Soil Sampling

The Laboratory ER Project has conducted field investigations and sampling activities at PRSs within TA-0 in Rendija Canyon and upper Bayo Canyon, and at PRSs at former TA-10 in Bayo Canyon and Barrancas Canyon. Resource Conservation Recovery Act facility investigation (RFI) soil sampling has been conducted at the Guaje well field G-1 site in Guaje Canyon. The results of the investigation were reported in the RFI reports for former TA-10 in Operable Unit (OU) 1079 (LANL 1995, 49974; LANL 1996, 54332), the supplemental RFI report (LANL 1996, 54617), and RFI reports for PRSs at TA-0 in OU 1071 (LANL 1994, 59427; LANL 1996, 54837; LANL 1998, 59996). Results of the investigations are summarized below.

3.4.1.3.5.1 Summary of Soil and Sediment Sampling at TA-0

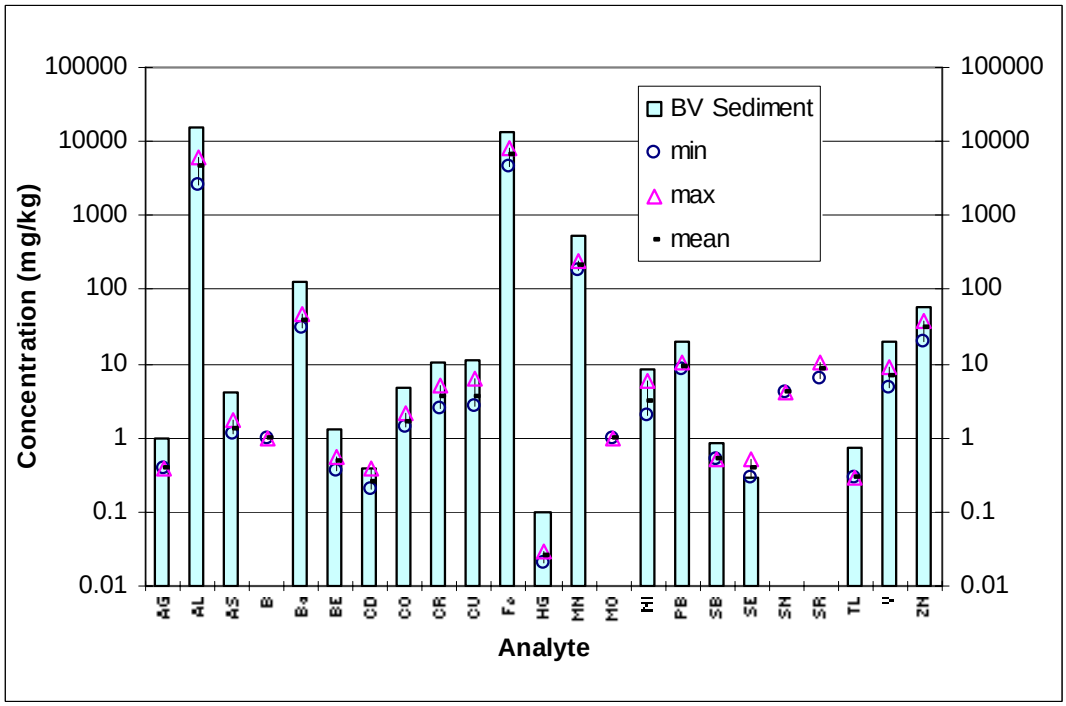
Rendija Canyon

In 1993, 1994, 1996, and 1997 sediment samples were collected from 78 locations in side drainages in Rendija Canyon as part of the RFI for PRSs 0-011(a), 0-011(e), and 0-016 in the canyon. Most were surface samples (less than 1-ft [0.3-m] depth), with a few samples collected from depths up to 1.17 ft (0.36 m). The samples were analyzed for inorganic constituents and HE compounds (LANL 1998, 59996; LANL 1994, 59427). Figure 3.4-10 shows the aggregated results of the sample analyses. Metals measured in concentrations above BVs include cobalt, lead, and selenium, of which lead was measured most often above BV. A total of 70 samples were analyzed for lead and 24 (34%) contained concentrations above the BV. Of 26 samples analyzed for cobalt and selenium, 14 samples (54%) contained cobalt above the BV and 13 samples (50%) contained selenium above the BV.



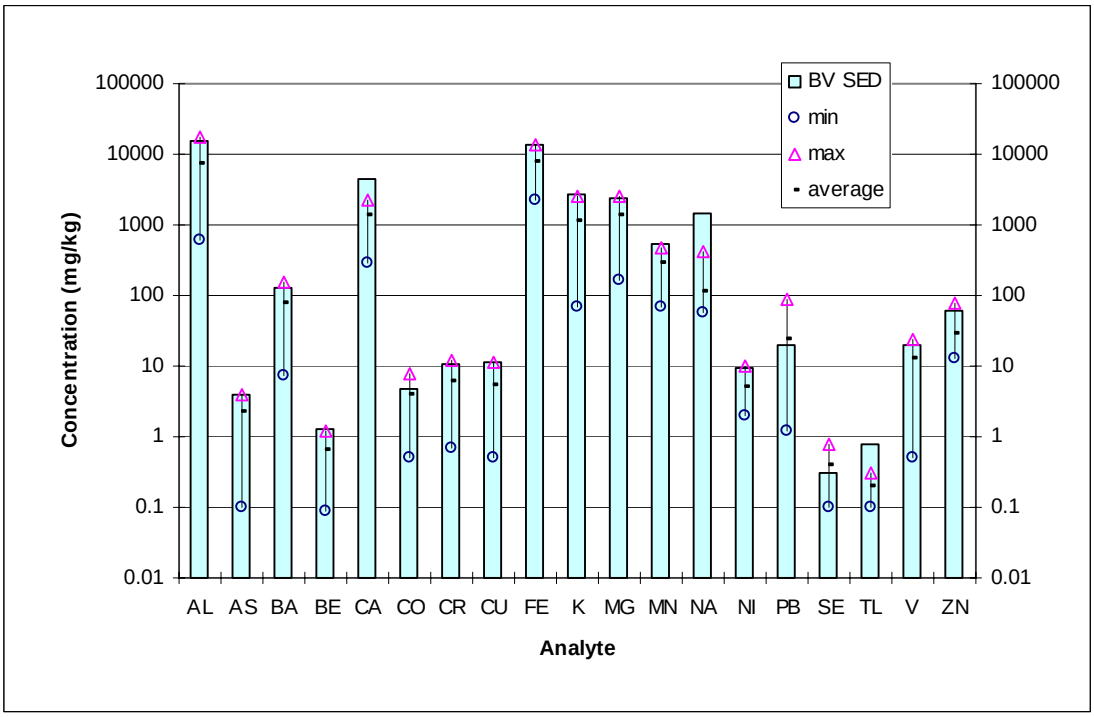
Source: Environmental Surveillance Report, 1999.

Figure 3.4-8. Summary of radionuclides in Bayo Canyon sediment, December 1999



Source: Environmental Surveillance Report, 1999.

Figure 3.4-9. Summary of metals in Bayo Canyon sediments, December 1999



Source: LANL 1998,59996; LANL 1994, 59427.

Figure 3.4-10. Summary of detects of inorganic constituents in Rendija Canyon surface sediment samples

At PRS 00-016, the maximum lead concentration remaining after the voluntary corrective action (VCA) was performed was 85.6 mg/kg in the main cleanup area. The maximum concentration remaining in the side drainage channel area north of the main cleanup site was 70.6 mg/kg. Of 41 samples in the main cleanup areas, 15 were above the soil BV of 22.3 mg/kg, and 3 of 3 first-order-drainage samples were above the BV (LANL 1998, 59996, pp. 48–53; LANL 2000, 67472, p. 2-6).

At PRS 00-011(a), 1 sample of 17 was above the BV for lead; the maximum lead concentration in drainages was 29 mg/kg. Selenium was above the BV (0.3 mg/kg) in 13 of 17 samples collected at PRS 00-011(a) and the highest selenium concentration was 0.8 mg/kg (LANL 1994, 59427, pp. 11, 12).

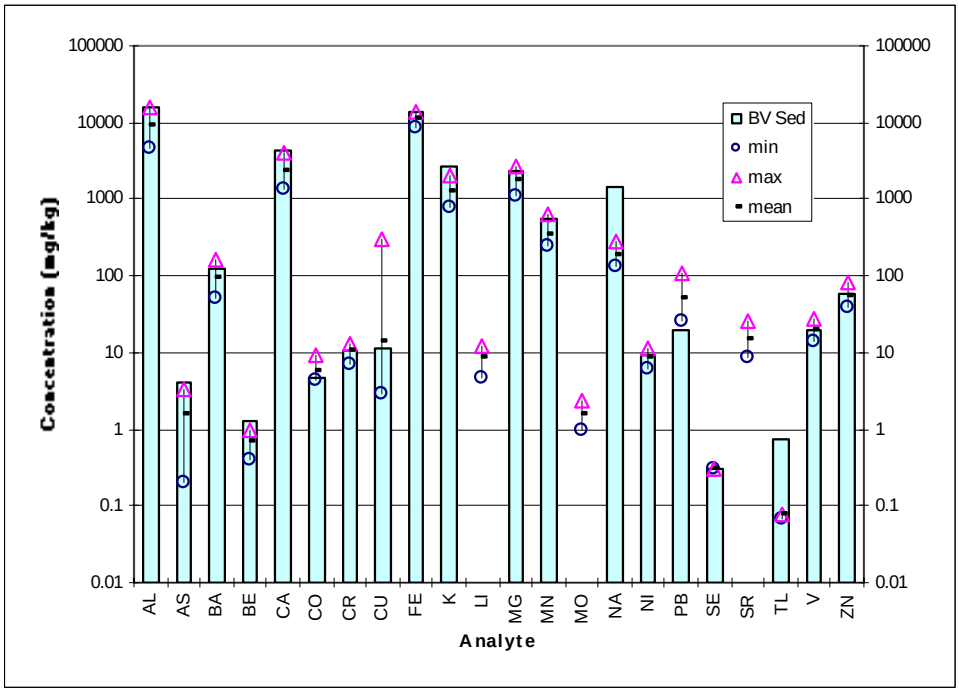
At PRS 0-011(e), no samples were above the BV for lead or other inorganic constituents (LANL 1994, 59427, p. 26).

Organic HE compounds were not detected in samples from the mortar impact sites.

Upper Bayo Canyon

In October 1992 surface sediment samples were collected from seven side-drainage locations at PRS 00-011(d), a bazooka impact area in upper Bayo Canyon. The samples were analyzed for metals (using hydrofluoric acid-leach procedure) and HE compounds (LANL 1994, 59427, p. 16). The results showed that three samples contained lead above the BV but below the screening action level (SAL) value. Additionally, the surface samples contained detectable amounts of the HE compound ethyl-4-nitrobenzene. However, the holding time for HE analysis had been exceeded, so in June 1993 nine additional samples were collected and analyzed for HE compounds and some samples were analyzed for

metals using the nitric-acid leach procedure. The summary of the results of the metals analyses is shown in Figure 3.4-11. Metals measured in concentrations above sediment BVs included copper (one sample contained 300 mg/kg copper) and lead, which was measured above the sediment BV in all samples. Lead concentrations ranged from 31 to 156 mg/kg. HE compounds were not detected in concentrations above the method detection limits in any of the samples (LANL 1994, 59427, p. 18).



Source: LANL 1994, 59427.

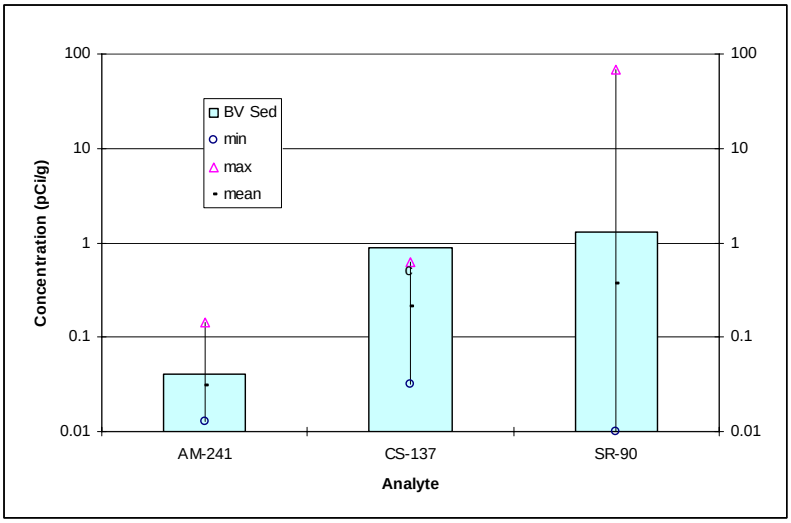
Figure 3.4-11. Summary of metals analyses at PRS 00-011(d) in upper Bayo Canyon

3.4.1.3.5.2 Summary of RFI Sampling at Former TA-10

Middle Bayo Canyon

The RFI for PRSs at former TA-10 in Bayo Canyon was performed from 1994 through 1996. Surface samples were analyzed for semivolatile organic compounds (SVOCs), metals, total uranium, and strontium-90; about 50% of the samples were analyzed for HE compounds. The results of the investigation were reported in the RFI reports for former TA-10 in OU 1071 (LANL 1995, 49974; LANL 1996, 54332) and the supplemental RFI report (LANL 1996, 54617). These samples were collected in a grid that covered much of the canyon floor in the area within and surrounding former TA-10. Some sampling locations were within post-1942 sediment along the channel in Bayo Canyon, but most were located throughout the rest of the valley floor to characterize contamination associated with shot dispersal from the former firing sites.

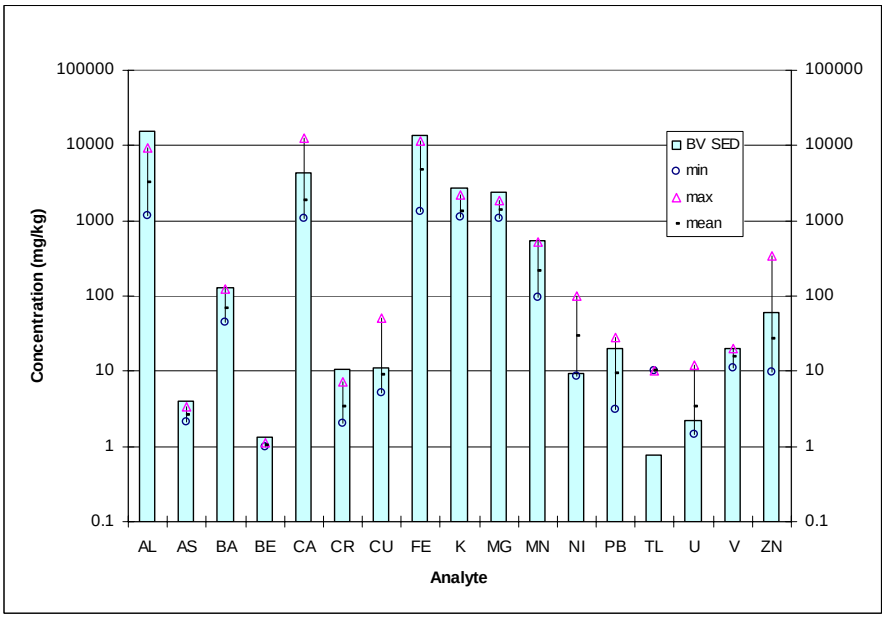
Figure 3.4-12 shows the results of radionuclide analyses of 103 surface samples (less than 1 ft [0.3 m] deep). The radionuclide detected most often was strontium-90; 7 samples contained strontium-90 above the sediment BV. The highest concentration of strontium-90 observed in the surface samples was 67 pCi/g. Americium-241 was detected in 2 samples above the BV, with a maximum concentration of 0.144 pCi/g using gamma spectroscopy (LANL 1996, 54617).



Source: LANL 1996, 54617.

Figure 3.4-12. Summary of radionuclides in surface samples in middle Bayo Canyon

The summary of inorganic constituents in surface sediments from Bayo Canyon is shown in Figure 3.4-13. Inorganic constituents measured in concentrations greater than sediment BVs include calcium, copper, nickel, lead, uranium, and zinc (LANL 1995, 49974; LANL 1996, 54332). Metals found in concentrations greater than the sediment BV include copper (3 of 98 samples above the BV), nickel (1 of 98 samples above the BV), and uranium, which was measured in 78 of 98 (80%) samples at concentrations greater than the sediment BV. The sediment BV for uranium is 2.22 mg/kg whereas the Qbt 1v BV is 6.22 mg/kg. Many of the samples may have been collected from material associated with units of the Tshirege Member of the Bandelier Tuff, which outcrops in the area where the samples were collected, and for which sediment BVs are not an appropriate comparison.



Source: LANL 1996, 54332.

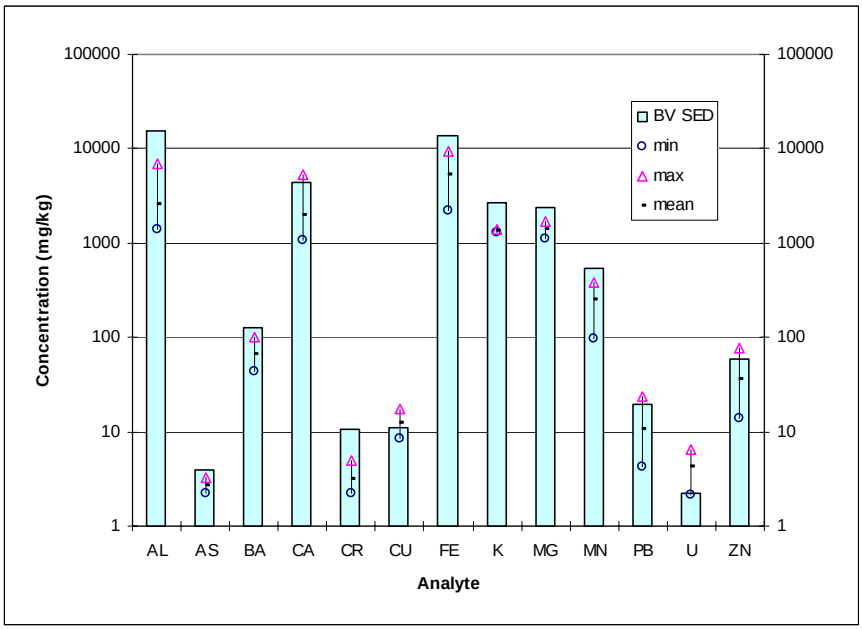
Figure 3.4-13. Summary of inorganic constituents in surface sediments at former TA-10 in Bayo Canyon

HE compounds detected in Bayo Canyon surface samples include nitrobenzene, nitrotoluene, and dinitrotoluene (LANL 1995, 49974; LANL 1996, 54332).

In 1996, surface samples were collected from an area about 200 ft (61 m) long and 160 ft (49 m) wide at former TA-10 in Bayo Canyon (LANL 1996, 55698). The samples were collected from beneath vegetation and from a grid spaced at 20-ft (6-m) centers. Field screening measurements for beta/gamma activity were obtained for sediment samples that were used to estimate the strontium-90 concentration. Strontium-90 concentrations in surface and near-surface soil samples ranged from 2 to 146 pCi/g with a mean of 21.9 pCi/g and a median value of 13 pCi/g (LANL 1997, 56358, Table 1, pp. 6–9). Of 98 surface sample sites collected in the grid pattern for analyses at off-site laboratories, 25 sites (25%) contained strontium-90 in concentrations above the sediment BV of 1.3 pCi/g (LANL 1997, 56358, p. 5).

Barrancas Canyon

Sediment samples were collected in the Barrancas Canyon watershed in 1994 and 1995 during the RFI investigation of former TA-10 in Bayo Canyon. Surface sediment samples were collected from 12 locations in small drainages on mesa-tops and side-canyons and analyzed for inorganic constituents, HE, and strontium-90. The results of analyses for inorganic constituents that were detected in the samples are shown in Figure 3.4-14. Copper was detected in two samples, one of which contained 17.7 mg/kg, above the BV of 11.2 mg/kg. Uranium was detected in all 12 samples analyzed and 11 samples contained uranium above the sediment BV of 2.22 mg/kg. The highest uranium concentration measured was 6.4 mg/kg (LANL 1995, 49974, pp. 24–27, Table A-4). The samples collected in Barrancas Canyon may have been collected from material derived from unit Qbt 1v, which outcrops in the area where the samples were collected. Qbt 1v has a uranium BV of 6.22 mg/kg, about 3 times the BV of other units in the Tshirege Member of the Bandelier Tuff and of stream sediment BVs at the Laboratory (Ryti et al. 1998, 59730, Table 6-1). Other inorganic constituents generally were measured in concentrations below sediment BVs.



Source: LANL 1995, 49974.

Figure 3.4-14. Summary of inorganic constituents detected in surface sediment samples from Barrancas Canyon

Two samples collected from small drainages on the side of a mesa within the Barrancas Canyon watershed detected strontium-90 but in concentrations below the sediment BV. One sample contained high melting explosive (HMX) in a concentration of 1.56 mg/kg and nitrobenzene in a concentration of 0.154 mg/kg (LANL 1995, 49974, p. 25, Table A-6, p. A-33). The presence of these HE compounds in the Barrancas Canyon watershed probably resulted from the experimental detonations conducted in Bayo Canyon during the 1940s and 1950s (see Section 2.3.2).

3.4.1.4 Summary of Surface Sediment Data

Significant information about surface sediments provided in Section 3.4.1.3 is summarized below.

- Surface sediments in upper Bayo Canyon near PRS 00-011(d) contained lead in concentrations of 31 to 156 mg/kg (above the sediment BV) and one sample contained 300 mg/kg copper.
- Surface sediments in middle Bayo Canyon near former TA-10 contained calcium, copper, nickel, uranium, and zinc in concentrations above sediment BV; copper, nickel, and uranium were above the sediment BV. Strontium-90 was present in surface sediments in concentrations up to 67 pCi/g. HE compounds detected in Bayo Canyon surface sediment samples included nitrobenzene, nitrotoluene, and dinitrotoluene.
- Surface sediments from small side drainages to Barrancas Canyon were found to contain copper and uranium above BVs. The HE compounds HMX and nitrobenzene were also detected in the surface sediments.
- Routine environmental surveillance sampling for stream sediments in the active channel was conducted at Bayo Canyon at SR 502 and Guaje Canyon at SR 502, but no sampling of floodplain sediments has occurred.
- Active channel samples collected in lower Bayo Canyon at SR 502 generally contained radionuclide concentrations within sediment BVs. Barium, cadmium, and thallium also were found in concentrations above the sediment BV.
- In Rendija Canyon, metals measured in concentrations above BVs include cobalt, lead, and selenium; lead was measured most often (in 34% of samples) above BV. The maximum lead concentration at PRS 00-016 after the VCA was performed was 85.6 mg/kg. The maximum lead concentration at PRS 0-011(a) was 29 mg/kg and selenium was above the BV in 13 samples. Lead concentrations at PRS 0-011(e) were below the BV. Organic HE compounds were not detected in samples from the mortar impact sites in Rendija Canyon.
- Sediment samples collected from Guaje reservoir in 1999 contained americium-241, gross alpha, gross beta, and uranium in concentrations above the sediment BV.
- Sediment samples collected in Guaje Canyon near well G-4 contained gross gamma and strontium-90 in concentrations above BVs.
- Active channel sediment samples collected in lower Guaje Canyon at SR 502 showed average values for all radionuclides within the BVs for sediments, although maximum values for plutonium-238, plutonium-239,240, strontium-90, and uranium were above the sediment BVs. Silver, barium, and cadmium concentrations have been measured above the sediment BVs.

3.4.2 Previous Subsurface Investigations

Subsurface investigations conducted to a limited extent in middle Bayo Canyon at former TA-10 and in a small area in middle Guaje Canyon provide information on potential alluvial groundwater. Subsurface investigations have not been conducted in Barrancas Canyon or Rendija Canyon.

3.4.2.1 Bayo Canyon

In 1961 four test holes, TH-1 through TH -4, were drilled at TA-10 in middle Bayo Canyon. Borehole locations are shown in Figure A-1. For clarification in nomenclature, the boreholes currently are identified as BCTH-1 through BCTH-4. The test holes were drilled to determine if shallow groundwater was present at the former TA-10, Bayo site. Three test holes were drilled into the top of the Puye Formation to maximum depth of 88.9 ft (27.1 m). Alluvium was reported to be 5 to 16 ft (1.5 to 4.9 m) thick above the tuff in these holes. There was no indication of perched water or excessive moisture in the tuff above the Puye Formation. The small volumes of water hauled in and used for previous site operations and normal precipitation and runoff in the watershed precluded a transport mechanism for contaminant migration to the top of the Puye Formation (Mayfield et al. 1979, 11717, pp. 50, 58). No contaminant analyses were performed on these samples.

In 1973 and 1974, additional test holes (the M-series) were drilled in the vicinity of the former liquid waste disposal area at TA-10 to collect samples for contaminant analysis. These holes were drilled from 8 to 39 ft (2.4 to 11.9 m) deep. No groundwater was encountered in the test holes. Cuttings from some holes contained strontium-90 in concentrations greater than the BV. The area was further investigated by drilling 10 additional boreholes. These test holes (the E and W series) were advanced from 6 to 35 ft (1.8 to 10.7 m). No groundwater was reported. The results of sample analyses showed that gross alpha activity was near background levels with the exception of one borehole where 4 to 10 times the background levels was detected. Gross beta activity generally was detected above background levels at all locations. The maximum gross beta value was 24,000 pCi/g (Mayfield et al. 1979, 11717, pp. 47–59).

During the 1974 FUSRAP investigation, subsurface samples were collected from the firing sites, former structures, and the canyon floor in middle Bayo Canyon. About 380 subsurface soil samples were collected and analyzed for gross alpha and beta activity. Laboratory analyses for selected radionuclides were performed on selected and random samples, and strontium-90 analyses were conducted on 68 of the subsurface samples. Twelve of the subsurface samples contained strontium-90 in concentrations greater than 20 pCi/g and eight samples exceeded 100 pCi/g; the maximum strontium-90 concentration was 4310 pCi/g. No groundwater or excessive moisture was reported from the sampling effort (Mayfield et al. 1979, 11717, pp. 4, 25, 26, 30, 51, 88).

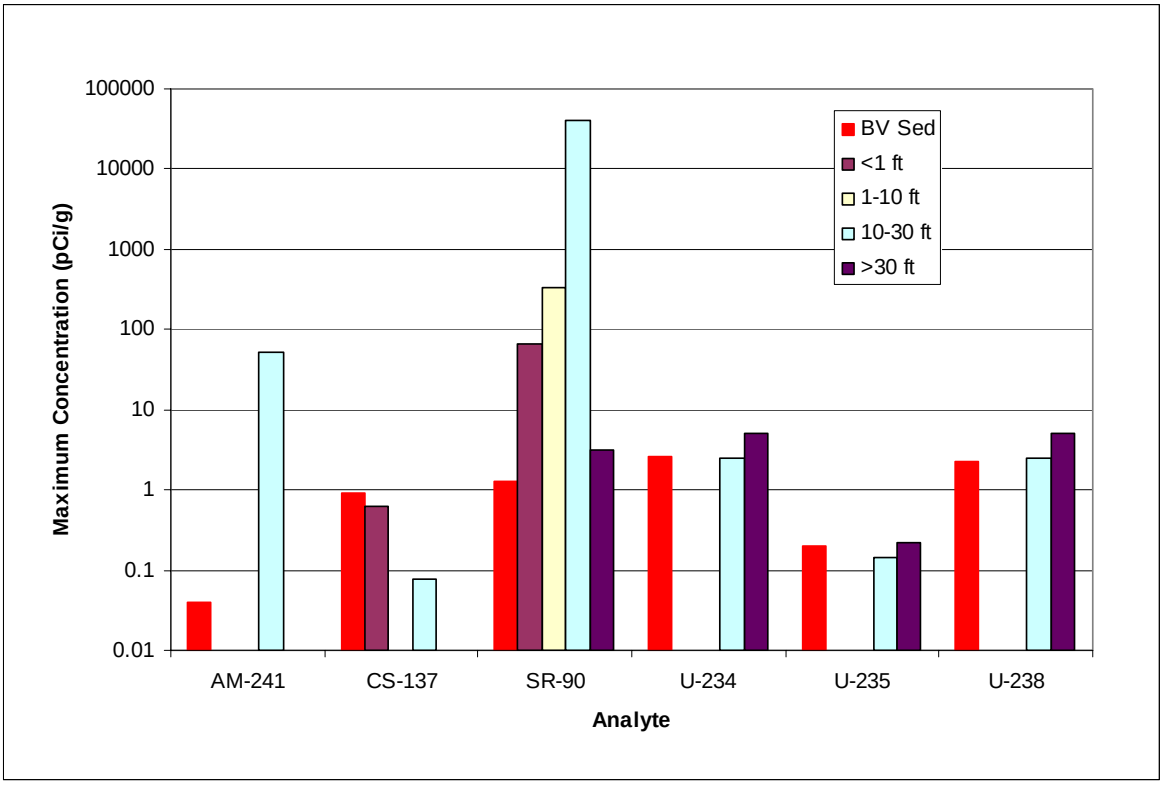
Seven additional test holes were drilled in Bayo Canyon in 1980 to further define the extent of potential contaminants identified in previous investigations. The boreholes were drilled to depths of 12 to 37 ft (3.6 to 11.2 m). The soil/tuff contact generally was encountered at depths from 6 ft to 27 ft (1.8 to 8.2 m). Groundwater was not detected (Purtymun 1994, 58233, p. 97-1). Samples collected within 10 ft (3 m) of the surface were within background levels for gross alpha and gross beta activity at all locations. At greater depths, strontium-90 concentrations were found to be above 100 pCi/g (FBD Inc. 1981, 8032, p.1-4).

In 1996, three samples were collected from a borehole drilled to 4.5 ft (1.4 m) during the RFI at PRS 00-028(b), located on North Mesa within the Bayo Canyon watershed. Samples were collected at depths of 0 to 0.5 ft, 2.5 to 3 ft, and 4 to 4.5 ft (0 to 0.2 m, 0.8 to 0.9 m, and 1.2 to 1.4 m). The samples were analyzed for radionuclides, metals, volatile organic compounds (VOCs), SVOCs, and PCB compounds

(LANL 1996, 54837, p. 19). Metals generally were found in concentrations below the sediment BV; however, metals measured in concentrations slightly above sediment BVs included silver, uranium, and vanadium (LANL 1996, 54837).

The RFI for PRSs at former TA-10 in Bayo Canyon was performed from 1994 through 1996. Surface and subsurface sediment samples were collected from 93 boreholes. At least 4 subsurface samples were collected from each borehole and analyzed for SVOCs, metals, total uranium, and strontium-90; about 50% of the samples were analyzed for HE compounds. The results of the investigation were reported in the RFI reports for former TA-10 in OU 1071 (LANL 1995, 49073; LANL 1995, 49974; LANL 1996, 54332) and the supplemental RFI report (LANL 1996, 54617). Two of the boreholes were completed as observation wells. BCM-1, a moisture monitoring tube and BCO-1, a shallow observation well, were installed in middle Bayo Canyon in 1994. The moisture access tube and the observation well were dry at the time of installation and since 1995 have not been monitored.

Figure 3.4-15 shows the maximum radionuclide concentrations measured in samples from different depths in the RFI boreholes. The radionuclide detected most often was strontium-90. Of 349 samples collected from the subsurface (deeper than 1 ft [0.3 m]) in middle Bayo Canyon, 44 samples (13%) contained strontium-90 in concentrations greater than the sediment BV. The highest concentrations of strontium-90 were observed at depths from 10 to 30 ft (3 to 9 m), where numerous locations contained strontium-90 in concentrations of several hundred picocuries per gram up to a maximum observed concentration of 40,325 pCi/g (LANL 1996, 54617).

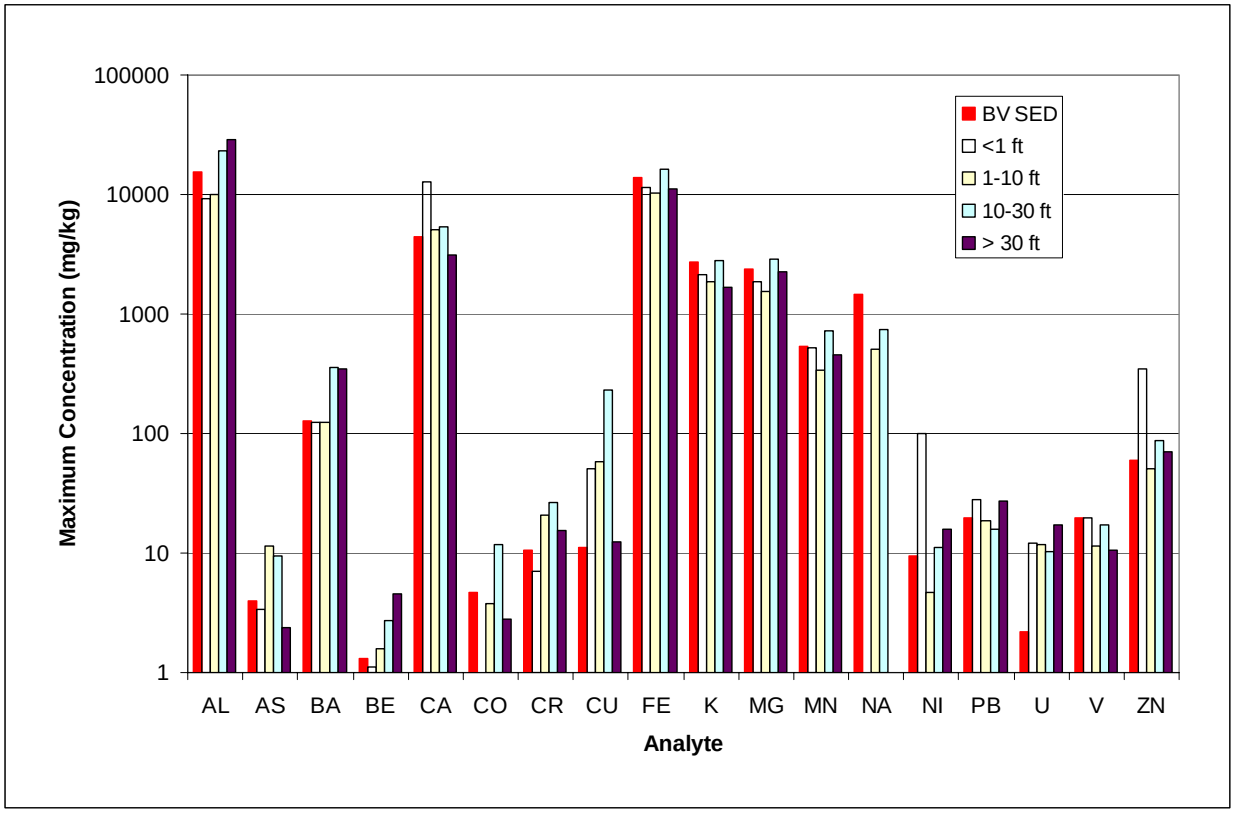


Source: LANL 1996, 54617.

Figure 3.4-15. Summary of radionuclides in RFI subsurface samples from middle Bayo Canyon

Other radionuclides measured in concentrations above sediment BVs in Bayo Canyon included americium-241, uranium-234, and uranium-238, which were detected in samples collected deeper than 10 ft (3 m). Americium-241 (using gamma spectroscopy) was detected in two of 21 samples with a maximum value of 51 pCi/g. Uranium-234 was detected above the sediment BV in 1 of 17 samples (maximum value 5.15 pCi/g) and uranium-238 (maximum value 5.11 pCi/g) was detected above the sediment BV in 2 of 17 samples. These samples were collected from deeper geologic formations present beneath the canyon floor that may not be representative of sediment background conditions (LANL 1996, 54617).

The summary of inorganic analyses (maximum concentrations) for surface and subsurface sediments collected in Bayo Canyon is shown on Figure 3.4-16. Inorganic constituents in subsurface samples measured in concentrations higher than the sediment BV include arsenic, barium, beryllium, cobalt, chromium, copper, and uranium (LANL 1995, 49974; LANL 1996, 54332). The units present in the subsurface in middle Bayo Canyon may not be comparable with sediment BVs.



Source: LANL 1996, 54332.

Figure 3.4-16. Summary of inorganic constituents in subsurface sediments in Bayo Canyon

HE compounds were not detected in subsurface samples in concentrations above the method detection limit (LANL 1995, 49974; LANL 1996, 54332).

3.4.2.2 Guaje Canyon

In 1946, test wells were installed in lower Los Alamos and Guaje Canyons to determine if a groundwater supply could be developed for Los Alamos. Test well GT-4 (also known as LA-3A) was installed in lower

Guaje Canyon at the confluence with Los Alamos Canyon to a total depth of 315 ft (96 m). Artesian conditions were encountered, and the well was screened with 2-in., perforated, galvanized steel from 60 to 315 ft (18 to 96 m). The borehole log indicates 54 ft (16.5 m) of alluvium was penetrated. No alluvial groundwater was noted, and no core samples were collected (Purtymun 1995, 45344, pp. 245, 246).

In 1950, the Layne Western company installed a well to supply water to drill and construct the municipal supply wells in the Guaje field. The well, referred to as the “Layne Western well,” is located in lower Guaje Canyon and was installed to a depth of 157 ft (48 m). Approximately 12 ft (3.8 m) of alluvium was encountered. No alluvial groundwater was reported, and no samples were collected for analyses (Purtymun 1995, 45344, pp. 211, 219, 226).

From 1950 to 1954, six municipal water supply wells were completed in Guaje Canyon. A seventh well was completed in 1964 (Purtymun 1995, 45344, p. 247). The wells are identified as G-1, G-1A, G-2, G-3, G-4, G-5, and G-6. Alluvium ranged from 8 ft (2.5 m) at G-5 to 40 ft (12.2 m) at G-6. Alluvial groundwater was not reported in any water supply wells (Purtymun 1995, 45344, pp. 253–259). Four replacement wells (GR-1 through GR-4) were installed near the original wells in 1997 and 1998 (LANL 1999, 63516, p. 77).

Two test holes, TH-1 and TH-2, were drilled in Guaje Canyon between the Rendija Canyon and Guaje Mountain faults in fall 1966 to investigate geologic structures and their relationship to the presence of groundwater. For clarification in nomenclature, the boreholes are identified as GCTH-1 and GCTH-2. The boreholes are located approximately 3 mi (4.8 km) downstream of Guaje Reservoir. GCTH-1 was drilled in alluvium to a depth of 23 ft (7 m). The alluvium was saturated from the base of the borehole to approximately stream level. GCTH-2 was drilled to a depth of 103 ft (31.4 m), encountering 17 ft (5.1 m) of alluvium overlying the Puye Formation. Both units were reported as saturated to near-stream level (Purtymun 1995, 45344, p. 299). GCTH-1 and GCTH-2 were completed as 2-in. (5.0-cm)-diameter monitoring wells. Specific screen intervals were not reported (Purtymun 1995, 45344, p. 299).

3.4.2.3 Summary of Subsurface Investigations

Significant information about subsurface sediments provided in Section 3.4.2 is summarized below.

- Subsurface sediments in middle Bayo Canyon at former TA-10 contain arsenic, barium, beryllium, cobalt, chromium, copper, and uranium in concentrations higher than the sediment BV.
- Subsurface sediments in middle Bayo Canyon at former TA-10 contain strontium-90 in concentrations up to a maximum observed concentration of 40,325 pCi/g.
- The alluvium in middle Bayo Canyon was reported to be 5 to 16 ft thick overlying the Guaje Pumice Bed and the Puye Formation.
- Subsurface investigations have not been conducted in Barrancas or Rendija Canyon.
- Two test wells were drilled in middle Guaje Canyon west of the GMFZ in 1966. Saturated alluvium was observed in both wells and saturation was observed to a depth of 103 ft (31 m) in the Puye Formation.
- The alluvium in lower Guaje Canyon in the Guaje well field ranged from 8 ft (2.5 m) to 40 ft (12 m) in thickness.
- No alluvial groundwater has been reported downstream of any north canyons PRSs.

3.4.3 Surface Water

The water that flows through the north canyons is used by plants, may be used by wildlife, and potentially may be used by humans; therefore, surface water constitutes a potential contaminant transport pathway to receptors. Surface water flow also provides one of the primary mechanisms for redistributing contaminants that may be present in the north canyons system. The results of past investigations (see Section 3.4.4) provide the background of conditions needed to assess the importance of these contaminant transport pathways. This section elaborates on surface water as a potential contaminant transport pathway in the north canyons systems.

The general hydrology of the canyon systems is discussed in Section 2.2.2.2 of the IWP (LANL 2000, 66802) and Section 3.5 of the core document (LANL 1997, 62316).

3.4.3.1 Stream Channel System and Streamflow

The stream channel characteristics and geomorphology of the north canyons and their tributaries are described in Sections 3.1 and 3.3.2. The watershed areas of each canyon are shown in Appendix A, Figure A-1. Streamflow in Bayo Canyon, Barrancas Canyon, and Rendija Canyon is entirely ephemeral. Perennial streamflow in upper Guaje Canyon is maintained by two springs in the upper watershed. Streamflow characteristics of each canyon are described in the following sections.

3.4.3.1.1 Bayo Canyon

Currently, there are no outfalls or National Pollutant Discharge Elimination System (NPDES)-permitted discharges in or into the Bayo Canyon watershed. Streamflow in the canyon is entirely ephemeral, arising from storm water runoff and snowmelt. Runoff is augmented by storm water discharges from a portion of Los Alamos town site on North Mesa and Barranca Mesa. Other runoff comes from San Ildefonso Pueblo land and Laboratory property in TA-74. During periods of heavy thunderstorms, streamflow from runoff in Bayo Canyon may extend beyond the Laboratory boundary to Los Alamos Canyon. However, there are no stream gaging stations in Bayo Canyon so no data for runoff events are available.

3.4.3.1.2 Barrancas Canyon

Barrancas Canyon and its three tributaries contain entirely ephemeral streams. The canyon receives storm water runoff and snowmelt from a small portion of Los Alamos town site on Barranca Mesa and Otowi Mesa, from USFS land, and from a small part of Laboratory property at TA-74. There are no outfalls or NPDES-permitted discharges into the Barrancas Canyon watershed. During periods of heavy thunderstorms streamflow from Barrancas Canyon runoff may discharge into Guaje Canyon. However, no data for runoff events are available because there are no stream gaging stations in Barrancas Canyon.

3.4.3.1.3 Rendija Canyon

Rendija Canyon and its tributaries contain ephemeral streams. The watershed receives storm water runoff and snowmelt from portions of Los Alamos town site, GSA land containing former firing sites and mortar impact areas, and USFS land (Figure A-1). No data for runoff events is available because no gaging stations are located in Rendija Canyon. The installation of a new gaging station in lower Rendija Canyon above the confluence with Guaje Canyon is planned for 2001.

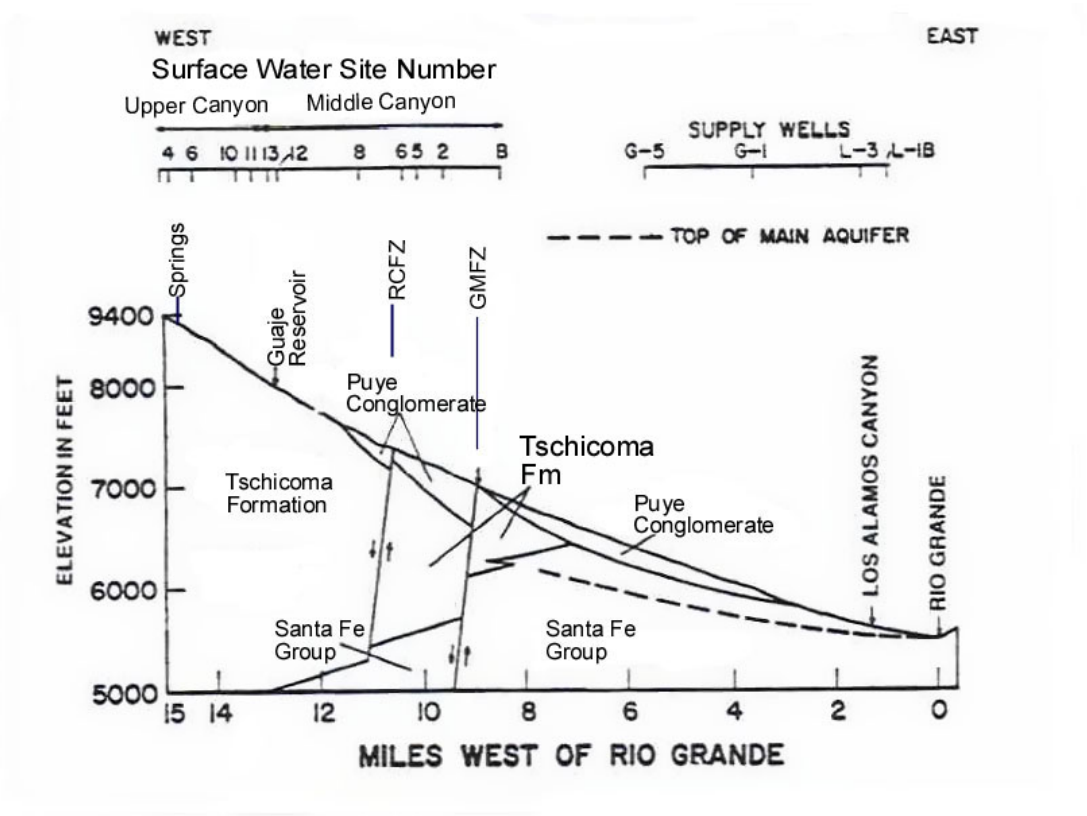
Two NPDES-permitted outfalls associated with wells G-6 (04A-176) and GR-4 (04A-177) in the Guaje well field were located in lower Rendija Canyon. These NPDES-permitted outfalls were transferred from

the Laboratory to Los Alamos County with the transfer of the water supply system. Discharges from these outfalls are intermittent and are associated with start-up of the pumps after the pumps were shut down for maintenance. Discharge rates and volumes are not known.

3.4.3.1.4 Guaje Canyon

Two springs in upper Guaje Canyon supply perennial streamflow to the upper part of the canyon. Agua Piedra Spring in Agua Piedra Canyon supplies base flow for a short distance downstream. Guaje Canyon receives storm water runoff and snowmelt primarily from USFS land in the upper and middle part of the canyon and occasional runoff from Rendija and Barrancas Canyons in the lower part of the canyon. Five NPDES-permitted outfalls associated with wells in the Guaje well field were located in middle and lower Guaje Canyon. These NPDES-permitted outfalls were transferred from the Laboratory to Los Alamos County with the transfer of the water supply system. Discharges from these outfalls are intermittent and are associated with start-up of the pumps after the pumps were shut down for maintenance. Discharge rates and volumes are not known.

Figure A-1 shows locations of the springs and the approximate perennial reach. Figure 3.4-17 shows the stream channel profile of Guaje Canyon and the locations of streamflow monitoring stations that were monitored periodically from 1958 to 1967.



Source: Purtymun 1995, 45344, p. 317; Purtymun 1975, 11787, p. 279.
GMFZ = Guaje Mountain fault zone.
RCFZ = Rendija Canyon fault zone.

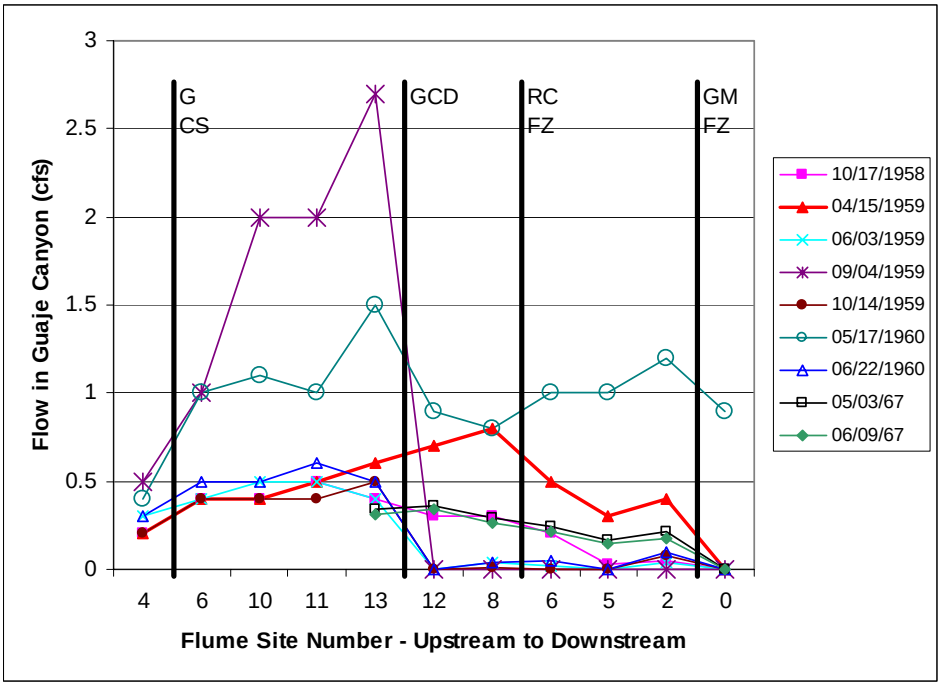
Figure 3.4-17. Channel profile of Guaje Canyon showing locations of historical surface water monitoring stations

Flow investigations were conducted in Guaje Canyon periodically from 1958 through 1960 to relate geologic structure to loss or gain in streamflow. Flow measurements were collected at 11 sites located from approximately 2 mi (3.2 km) upstream to about 4 mi (6.4 km) downstream of the reservoir. During this period (1958–1960), flows obtained in the months of September were 0.5 to 2.7 cfs and in the months of May, 0.4 to 1.5 cfs, which likely reflected the effect of seasonal precipitation events and snowmelt. Flows obtained downstream of Guaje Reservoir typically ranged from 0.0 to 0.3 cfs; however, at the time of the investigation, surface water was being diverted from the reservoir to Los Alamos town site. On one occasion, when water was not diverted, downstream flows were slightly higher than those upstream (Purtymun 1995, 45344, pp. 315–321).

The installation of two new gaging stations in Guaje Canyon is planned for 2001. One gaging station is planned for Guaje Canyon upstream of the confluence with Rendija Canyon and another gaging station is planned for lower Guaje Canyon upstream of the confluence with Los Alamos Canyon.

The springs in upper Guaje Canyon provide perennial base flow in Guaje Canyon as far as the Guaje Reservoir, and when water is not diverted at the reservoir, for a distance of approximately 6 mi (9.7 km) downstream (Purtymun, 1975, 11787, pp. 276–279). Water from the reservoir has not been diverted to Los Alamos since 1992 (McLin et al. 1998, 63506, p.13).

Figure 3.4-18 shows the results of monitoring low streamflow in Guaje Canyon at nine discrete times from October 1958 to June 1967. Flow was measured using Parshall flumes at 11 sites in the upper part of the canyon. The flume monitoring sites were numbered in descending integers (from 13) away from the intake to the reservoir both upstream and downstream; however the numbers attached to the flume sites do not represent a unit of distance away from the reservoir. Figure 3.4-17 shows the locations of the flume sites in upper Guaje Canyon (Purtymun 1975, 11787, p. 180; Purtymun 1995, 45344, p. 317).



Source: Purtymun 1975, 11787, p. 280.
GCS = Guaje Canyon springs.
GCD = Guaje Canyon Dam.
RCFZ = Rendija Canyon fault zone.
GMFZ = Guaje Mountain fault zone.

Figure 3.4-18. Streamflow in upper Guaje Canyon measured at 11 Parshall flume sites

The uppermost flume measurement site was upstream of Guaje Canyon Spring 1, where streamflow ranged from 0.2 to 0.5 cfs (90 to 220 gal./min). Flow measured downstream of Guaje Canyon Spring 1 increased to 0.4 to 1.0 cfs (180 to 450 gal./min), indicating that flow from the spring contributed from 0.1 to 0.6 cfs (45 to 270 gal./min). At most measurement times, flow from Guaje Canyon Spring 1 to the reservoir was relatively steady at about 0.4 to 0.6 cfs (180 to 270 gal./min). Measurements obtained on September 4, 1959, and May 17, 1960, however, showed increased flow downstream from Guaje Canyon Spring 1 to the reservoir, up to 2.7 cfs (1200 gal./min), possibly from storm water runoff and snowmelt runoff, respectively, and possibly from tributaries above the reservoir (Purtymun 1975, 11787, p. 180; Purtymun 1995, 45344, p. 317).

Water was being diverted from the reservoir when measurements were obtained, except on April 15, 1959. When water was diverted form the reservoir, flow in the channel downstream of the reservoir was always less than the flow entering the reservoir. All six measurements obtained in 1959 and 1960 showed no streamflow downstream of the reservoir. In 1959 and 1967 when flow measurements above the reservoir were about 0.5 cfs (220 gal./min), streamflow downstream of the reservoir was 0.3 cfs (135 gal./min), indicating a diverted volume of flow of about 0.2 cfs (90 gal./min). The streamflow measurements obtained on April 15, 1959, when water was not diverted from the reservoir, increased in the reach below the reservoir from 0.6 cfs (above the reservoir) to 0.8 cfs (270 to 360 gal./min), a gain of 0.2 cfs (90 gal./min) (Purtymun 1975, 11787, p. 180; Purtymun 1995, 45344, p. 317).

During four of the eight measurement periods when water was being diverted from the reservoir, streamflow downstream of the reservoir was 0.3 to 0.9 cfs (135 to 405 gal./min). At these times streamflow usually decreased downstream by about 0.1 cfs (45 gal./min) between each flume station, probably due to evapotranspiration (ET) and infiltration into the alluvium. During four measurement periods when there was no discharge from the reservoir at station #12, streamflow was observed downstream at station 8; this streamflow continued downstream to station #6 during two measurement periods (Purtymun 1975, 11787, p. 180; Purtymun 1995, 45344, p. 317). Flow in the channel downstream of the reservoir was likely from baseflow emerging from the alluvium downstream from the reservoir.

The Rendija Canyon fault zone (RCFZ) is located downstream of the reservoir between flume stations 8 and 6. The GMFZ is located downstream of the RCFZ between stations 2 and 0. Of 11 measurement periods, 10 showed that flow in the channel decreased across the RCFZ. One measurement period obtained on May 17, 1960, showed an increase in flow across the RCFZ from 0.8 to 1 cfs (360 to 450 gal./min), possibly due to snowmelt runoff contributions from tributaries.

3.4.3.2 Springs

There are no known springs or seeps in Bayo, Barrancas, or Rendija Canyons or their tributaries. Springs on the eastern flank of the Sierra de los Valles supply base flow in the upper reaches of Guaje Canyon. Guaje Canyon Spring 1 and Guaje Canyon Spring 2 are present in upper Guaje Canyon at an elevation of 8850 ft (2698 m) and 8840 ft (2695 m), respectively. Guaje Canyon Spring 1 is located in the main Guaje channel and Guaje Canyon Spring 2 is located in a small southern tributary near the head of Guaje Canyon (Figure A-1). Both springs are located on canyon floors in Bandelier Tuff. The estimated spring flow is 25 and 40 gal./min (Purtymun 1995, 45344, pp. 26, 282, 284; Griggs 1964, 65649, p. 137).

Aqua Piedra Spring is located at an elevation of 8100 ft (2470 m) in Aqua Piedra Canyon, a tributary to Guaje Canyon. The flow volume from Agua Piedra Spring has not been documented. Streamflow from Agua Piedra Spring extends downstream for an unknown distance.

3.4.3.3 Storm Water and Snowmelt Runoff Investigations

Personnel from ESH-18 have sampled storm water runoff periodically at several sites in the north canyons area. Runoff samples have been collected from Rendija Canyon near the confluence with Guaje Canyon at municipal well G-6, and from Guaje Canyon near SR 502. The results are reported in the annual environmental surveillance reports. Results of the analyses of runoff samples are discussed in Section 3.4.3.7. Because no gaging stations are present in the north canyons area, flow volumes of runoff were not obtained at sampling times. Three new gaging stations in lower Rendija and Guaje Canyons are planned for installation in 2001.

3.4.3.4 Flooding Potential

Flow and floodplain estimates for the Los Alamos region were developed using computer-based models (HEC 1 and HEC 2) developed by the US Army Corps of Engineers Hydrologic Engineering Center (McLin 1992, 12014, p. 4). The models project the effects of severe thunderstorms on all watersheds in the Los Alamos area and the effects of storm runoff on flood elevations within the canyons and on different Laboratory areas and structures. Precipitation totals and floodplain elevations were projected for 2-, 5-, 10-, 25-, 50-, and 100-yr storms.

A theoretically estimated 24-hr runoff resulting from a 2-yr recurrent, 6-hr thunderstorm event and an estimated 24-hr runoff, 50-yr recurrent, 6-hr thunderstorm event were modeled for Bayo, Barrancas, and Guaje Canyons. The model assessed the runoff for the events at specific locations for each watershed. Table 3.4-2 shows the estimates for the 24-hr runoff volumes, the associated 50-yr peak flow at the eastern Laboratory boundary, and the calculated precipitation for the 50-yr event for Bayo, Barrancas, and Guaje Canyons.

Table 3.4-2
Estimates of 24-hr Runoff in the North Canyons Area

Canyon	Locations for Runoff Estimates	2-yr/6-hr Runoff (ac-ft)	50-yr/6-hr Runoff (ac-ft)	50-yr/6-hr Peak Flow (cfs)	50-yr/6-hr Subbasin Precipitation (in.) and Average Elevation (ft)
Bayo	Tributary confluence upstream of east Laboratory boundary	<1	44	111	2.32 in. at town site (7220 ft) 1.75 in. at the main channel (6500 ft) 1.43 in. at the southern tributary at Totavi (6100 ft)
Barrancas	Tributary confluence below east Laboratory boundary	<1	24	67	1.81 in. at town site tributary (6580 ft) 1.51 in. at southern tributary (6200 ft) 1.83 in. at northern 2 tributaries (6600 ft) 1.46 in. above elevation of 5897 ft
Guaje	Above Barrancas Canyon confluence	8	333	666	3.03 in. above 7172 ft 1.91 in. above 6253 ft 2.23 in. near Rendija Canyon at 6253 ft 1.67 in. at Barrancas Canyon above 5897 ft 1.29 in. above the Los Alamos Canyon confluence (5920 ft)

Source: McLin 1992, 12014, pp. 13, 19, 20.

In most canyons on the Pajarito Plateau, and likely for the north canyons, the 100-yr floodplain occupies an area along the canyon floor that is more or less centered on the stream channel (McLin 1992, 12014, p. 4). PRSs at former TA-10 in Bayo Canyon are located near the channel and are thus in the potential flood areas.

In May 2000, the Cerro Grande fire severely burned portions of numerous watersheds in the Los Alamos area. Figure 3.4-19 shows the areas in the north canyons that were affected by the fire. The upper portions of both Guaje and Rendija Canyon watersheds were damaged.

The fire burned approximately 56% of the Guaje Canyon watershed and about 78% of the Rendija Canyon watershed. About 30% of the burned acreage in the Guaje Canyon watershed and about 51% in the Rendija Canyon watershed were classified as high-burn severity (BAER 2000, 68662, p. 280). The areas with high-burn severity generate more runoff than unburned areas and increase the volume of storm water runoff from a storm event. The anticipated time needed to return to prefire hydrologic conditions is approximately 5 yr.

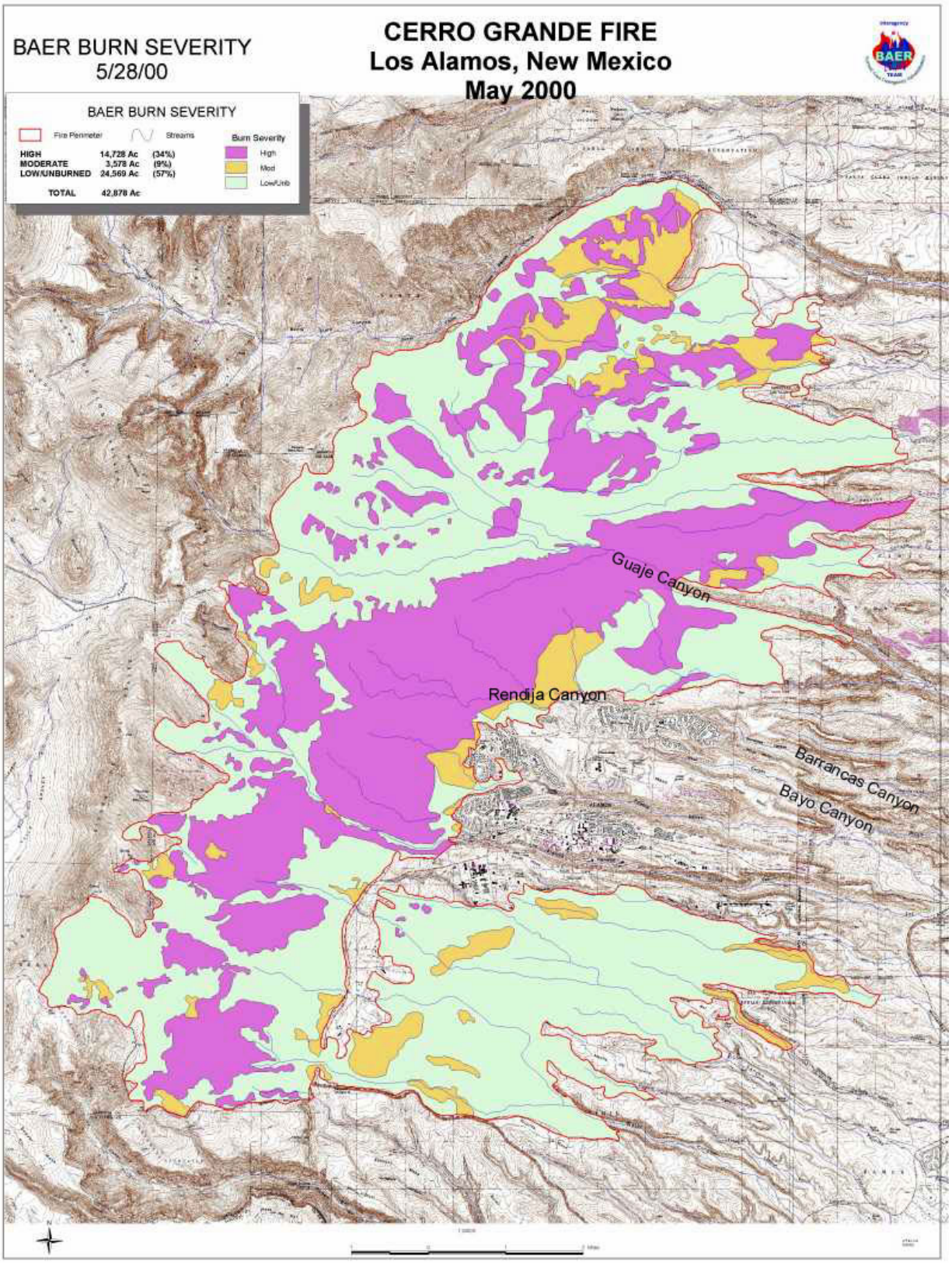
Storm water runoff projections were modeled after the Cerro Grande fire using pre- and postfire parameters. Results of modeling for the Guaje Canyon watershed under prefire conditions for a 25-yr, 1-hr event (1.9 in.) predicted a peak flow of 30 cfs at the Rendija Canyon confluence. Flow projections calculated for after the fire for the same 25-yr, 1-hr event are a maximum of 437 cfs at the Guaje Reservoir. Total runoff for the watershed at the Rendija Canyon confluence was predicted to be 179 ac-ft (BAER 2000, 68662, p. 287).

Storm water runoff flow modeling in Rendija Canyon using prefire parameters for a 25-yr, 1-hr event (1.9 in.) predicted a peak flow of 4 cfs. Flow modeling for after the fire for the same 25 yr, 1-hr event predicted a peak flow of 2398 cfs at the Guaje Pines Cemetery and 686 cfs at the confluence with Guaje Canyon. Total postfire runoff for the watershed was projected to be 283 ac-ft (BAER 2000, 68662, pp. 280, 286, 287).

3.4.3.5 Infiltration Below Stream Bed

Surface water enters the north canyons channels from storm water runoff and snowmelt. As the surface water flows downstream, the water infiltrates into the alluvium, into underlying formations, or is lost to ET. Site-specific infiltration data for the north canyons are not available, although infiltration beneath canyon floors is higher than beneath mesa-tops and has been calculated to be approximately 0.18 in. (4.4 mm)/yr beneath Cañada del Buey and between 0.8 and 4 in. (20 and 100 mm)/yr beneath Pajarito Canyon (LANL 1998, 57576, p. 54).

Geologic investigations in Guaje Canyon have provided data that can be used to infer general rates of infiltration in the canyon. In the upper part of the canyon to about the confluence with the south fork of Guaje Canyon (Figure A-1), the channel is underlain by thin deposits of alluvium overlying the Tschicoma Formation. The upper surface of the Tschicoma Formation may form a barrier to the infiltration of water from the streambed. Streamflow measurements obtained above and below Guaje Reservoir indicate no significant loss by infiltration into the underlying rocks (Tschicoma Formation) at the reservoir. Downstream, in middle Guaje Canyon, the channel is underlain by thicker deposits of alluvium that overlie the Puye Formation. In this reach surface water is lost by ET and infiltration. When water is not diverted at Guaje Reservoir, continuous surface water flow is maintained for approximately 3 mi (4.8 km) below the reservoir before ET and infiltration into the alluvium and underlying Puye Formation depletes the surface water flow (Purtymun 1975, 11787, pp. 276–282).



Source: BAER 2000, 68662.

Figure 3.4-19. Burn severity of the Cerro Grande fire in the north canyons area

Two shallow test holes were drilled west of the Guaje Mountain fault in 1966. The holes contained saturation to depth and indicated that infiltration of surface water into the shallow alluvium and underlying formation may be occurring. The test holes, GCTH-1 and GCTH-2, were drilled to 23 ft (7 m) and 103 ft (31.4 m), respectively. GCTH-1 was completed in the alluvium and was saturated to near-stream level. GCTH-2 encountered 17 ft (5.2 m) of alluvium and 86 ft (26.2 m) of Puye Formation gravel. GCTH-2 was also saturated to near-stream level (Purtymun 1995, 45344, p. 299). The results of the investigation suggested that surface water was being lost to the alluvium and underlying bedrock in middle Guaje Canyon. The surface water may be providing direct recharge to the regional aquifer (Purtymun 1975, 11787, p. 281).

In the lower reaches of Guaje Canyon, NPDES-permitted outfalls are associated with the Guaje water supply wells. The rate and frequency of discharge are not known; however, portions of the discharges likely infiltrate into the shallow alluvium.

When BCO-1 and BCM-1 were installed in middle Bayo Canyon in 1994, dampness was noted in the cuttings at the base of the alluvium at about 30-ft (9.1-m) depth, indicating that some infiltration to depth below the base of the alluvium likely occurred.

3.4.3.6 Surface Water and Runoff Quality and Contaminant Data

3.4.3.6.1 Environmental Surveillance Sampling of Perennial Surface Water

Surface water samples have been collected from Guaje Canyon since 1968. Most stream channels within the north canyons have ephemeral flow and therefore are not subject to surface water monitoring. Guaje Canyon is the only canyon within the north canyons that has a reach of perennial flow. Historic surface water sampling locations include the Guaje Canyon Reservoir and “Guaje Canyon,” a sampling location in Guaje Canyon below the confluence with Aqua Piedra Canyon (e.g., ESP 2000, 68661, p. 291). Figure A-1 shows the locations of surface water sample-collection sites. Laboratory personnel have not collected surface water samples from Bayo Canyon, Rendija Canyon, or Barrancas Canyon. Surface water samples identified as Bayo-1, Bayo-2, and Bayo Sewage Treatment Plant (STP) are located in Pueblo Canyon downstream of the Bayo STP.

Guaje Canyon

Guaje Reservoir

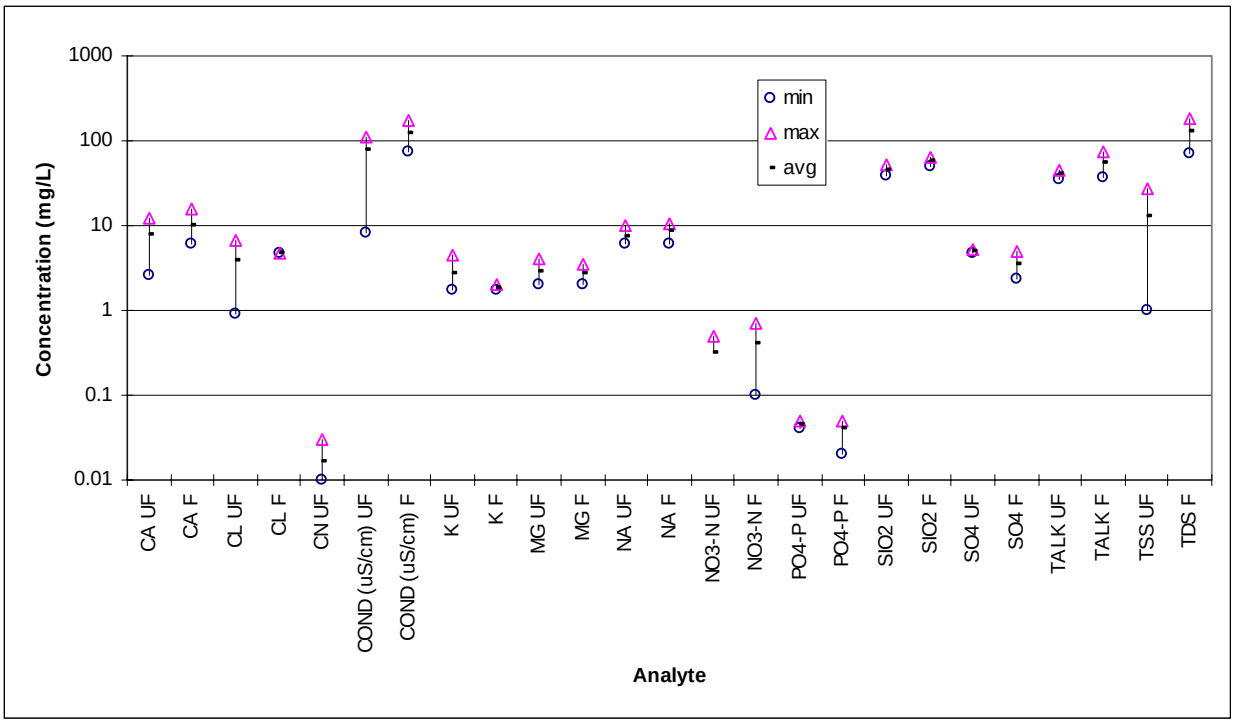
In 1968, 1986, 1988, and 1989 unfiltered surface water samples were collected from Guaje Reservoir and analyzed for radionuclides. Table 3.4-3 shows the radionuclide concentrations obtained from the analyses. The maximum concentration for cesium-137 was 6 pCi/L and for tritium was 2400 pCi/L.

Table 3.4-3
Radionuclides in Unfiltered Surface Water from Guaje Reservoir, 1968-1989

Sample Date	Cs-137 (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)	H-3 (pCi/L)	Pu-238 (pCi/L)	Pu-239,240 (pCi/L)	U (µg/L)
24-Apr-68		2					0.5
02-Sep-86	-14		-840	2400	0.014	0.019	1
01-Jan-88	6		48	-800	0	-0.009	1
15-Mar-89	-46		-624	200	-0.005	-0.011	2.4

Source: Environmental Surveillance Reports, 1968, 1986, 1988, 1989.

In 1989 the surface water samples from Guaje Reservoir were also analyzed for general inorganic constituents. The total dissolved solids (TDS) values were 97 mg/L and the hardness was 23 mg/L. The summary of the results of the analyses including surface water from the Guaje Canyon site is shown in Figure 3.4-20.



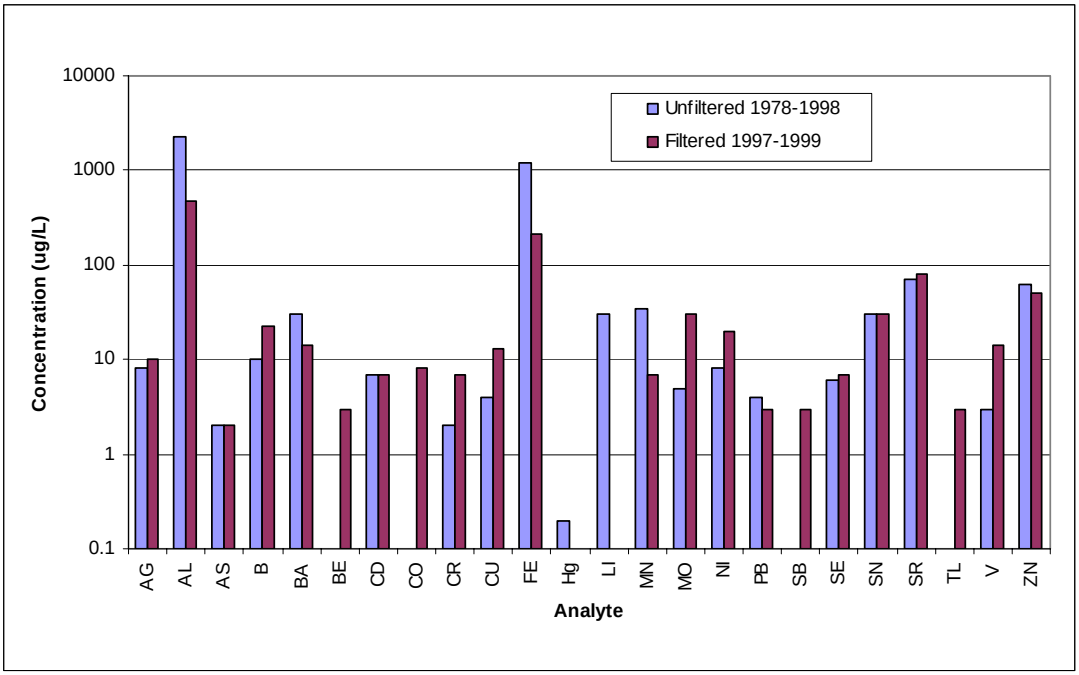
Source: Environmental Surveillance Reports, 1978, 1981–1999.
F = filtered, UF = unfiltered.

Figure 3.4-20. Summary of general inorganic constituents in filtered and unfiltered surface water from Guaje Canyon site, 1978, 1981–1999

Guaje Canyon Site

Surface water samples were collected from Guaje Canyon below the confluence with Agua Piedra Canyon in 1978 and annually since 1981. From 1978 through 1996, analyses were performed on unfiltered samples for general inorganic constituents and radionuclides. Since 1997, the samples were filtered for the analyses of general inorganic constituents and the samples remained unfiltered for radionuclide analyses. The summary of the results of the analyses for general inorganic constituents (filtered and unfiltered samples) is shown in Figure 3.4-20.

Surface water samples from the Guaje Canyon site were analyzed for metals in 1978 and from 1991 through 1999. Early analyses were performed on unfiltered samples but since 1997 analyses have been performed on filtered samples. Figure 3.4-21 shows the maximum values obtained for metals in both filtered and unfiltered samples. In 1998 selenium was observed in a concentration of 3 μg/L, above the New Mexico Water Quality Control Commission (NMWQCC) wildlife habitat standard of 2 μg/L (ESG 1999, 64034, pp. 140, 172).



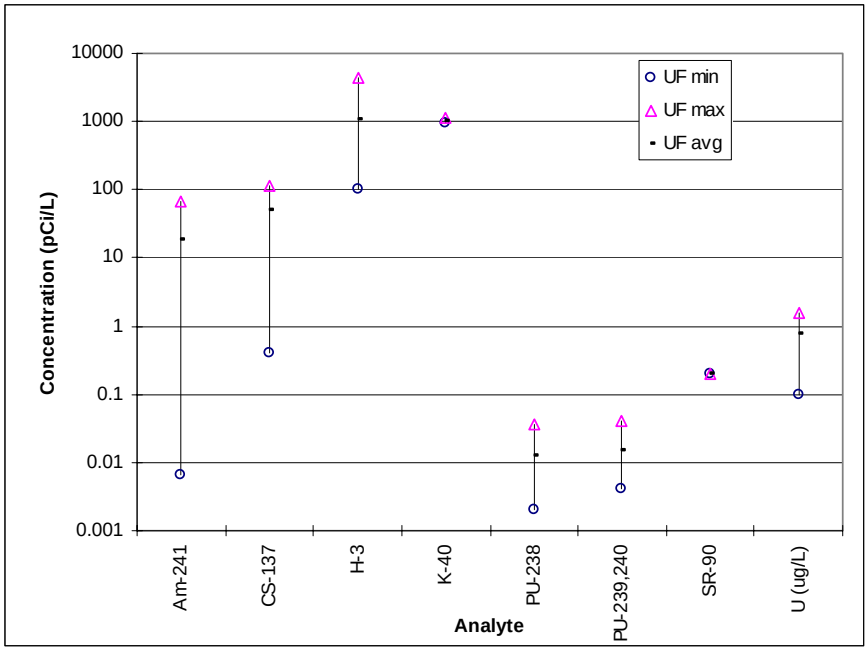
Source: Environmental Surveillance Reports, 1978, 1991–1999.

Figure 3.4-21. Maximum metals values in filtered and unfiltered surface water from Guaje Canyon site, 1978, 1991–1999

Surface water samples from the Guaje Canyon site were analyzed for radionuclides in 1974 and annually since 1978. Most analyses were performed on unfiltered samples. Figure 3.4-22 summarizes the analyses for radionuclides on the unfiltered samples. During the early 1980s tritium concentrations ranged from 1000 to 2000 pCi/L with the highest concentration, 4500 pCi/L, observed in 1983. Since 1985 tritium has been measured at near-detection limits. The sample collected in November 1998 contained 68 pCi/L americium-241, the highest recorded; the concentration measured in November 1999 was 4.29 pCi/L. The highest cesium-137 concentration was 115 pCi/L in 1984, but since 1995 the cesium-137 concentration has been near or below detection limits. The highest plutonium isotope concentrations were observed in the 1980s, when detection limits were higher than in recent years. In the late 1990s, the plutonium isotope concentrations were below detection limits.

3.4.3.6.2 Other Surface Water Sampling

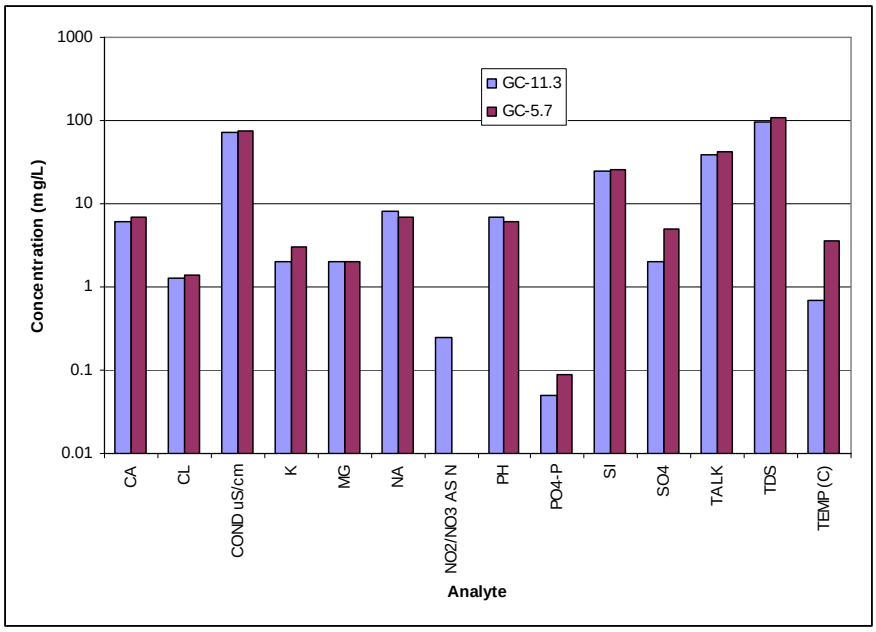
Personnel of the NMED Oversight Bureau conducted surface water sampling on February 26, 1997, at two locations in Guaje Canyon, Guaje Canyon Spring 5.7, and Guaje Canyon Spring 11.3 (Figure A-1). Guaje Canyon Spring 5.7 was located in middle Guaje Canyon and Guaje Canyon Spring 11.3 was located in upper Guaje Canyon downstream of Guaje Reservoir. Filtered surface water samples were collected and analyzed for general inorganic constituents, metals, and gross-alpha and –beta radioactivity. These data did not undergo validation review by the ER Project. Figure 3.4-23 shows the results of the analyses for general inorganic constituents. The TDSs of the samples were 96 and 110 mg/L and sodium was less than 10 mg/L. Gross alpha activity was less than 1 pCi/g; gross beta activity was 6.1 pCi/L at Guaje Canyon Spring 11.3 and 2.6 pCi/L at Guaje Canyon Spring 5.7. Metals detected in Guaje Canyon Spring 5.7 were aluminum (300 μg/L), iron (200 μg/L), and strontium (40 μg/L). Metals detected in Guaje Canyon Spring 11.3 were lithium (10 μg/L) and strontium (30 μg/L) (Yanicak 1998, 57583).



Source: Environmental Surveillance Reports, 1974, 1978–1999.

UF = unfiltered.

Figure 3.4-22. Summary of radionuclides in unfiltered surface water at the Guaje Canyon collection site, 1974, 1978–1999

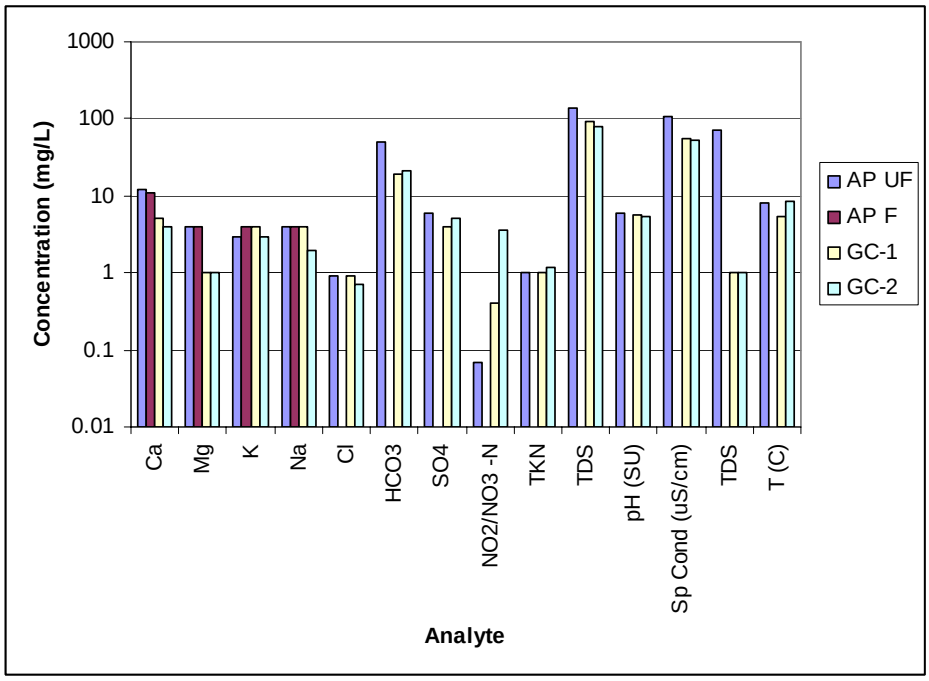


Source: Yanicak 1998, 57583.

Figure 3.4-23. Results of NMED surface water sampling in Guaje Canyon, 1997

The NMED Oversight Bureau personnel collected samples from the two springs in Guaje Canyon and from Agua Piedra Spring in Agua Piedra Canyon in August 1997. The samples were analyzed for general

inorganic constituents, metals, and selected radionuclides. Both filtered and unfiltered samples were collected from Agua Piedra Spring and unfiltered samples were collected from Guaje Canyon Spring 1 and Guaje Canyon Spring 2 (Yanicak 1998, 57583). These data did not undergo validation review by the ER Project. Figure 3.4-24 shows the results of the analyses for selected general inorganic constituents. Total suspended solids (TSS) in the samples were less than the detection limit of 20 mg/L. As a result, the filtered and unfiltered samples collected from Agua Piedra Spring were very similar in chemical composition. TDSs in Guaje Canyon Spring 1 and Guaje Canyon Spring 2 were less than 100 mg/L but the TDSs in Agua Piedra Spring were 140 mg/L. The concentration of bicarbonate (HCO_3) in Agua Piedra Spring was 50 mg/L, significantly higher than in Guaje Canyon Spring 1 and Guaje Canyon Spring 2, which contained 19 and 21 mg/L bicarbonate, respectively (Yanicak 1998, 57583).



Source: Yanicak 1998, 57583.

AP = Agua Piedra Spring, GC = Guaje Canyon spring.

Figure 3.4-24. Summary of general inorganic constituents in springs in Guaje Canyon, 1997

Agua Piedra Spring contained 0.12 μg/L uranium and gross alpha; gross beta activities were below detection limits. Guaje Canyon Spring 1 contained 0.074 pCi/L uranium-234, 0.013 pCi/L uranium-235, and 0.046 pCi/L uranium-238. Other radionuclides were not analyzed. Most trace metals were not observed in concentrations above the method detection limit (Yanicak 1998, 57583).

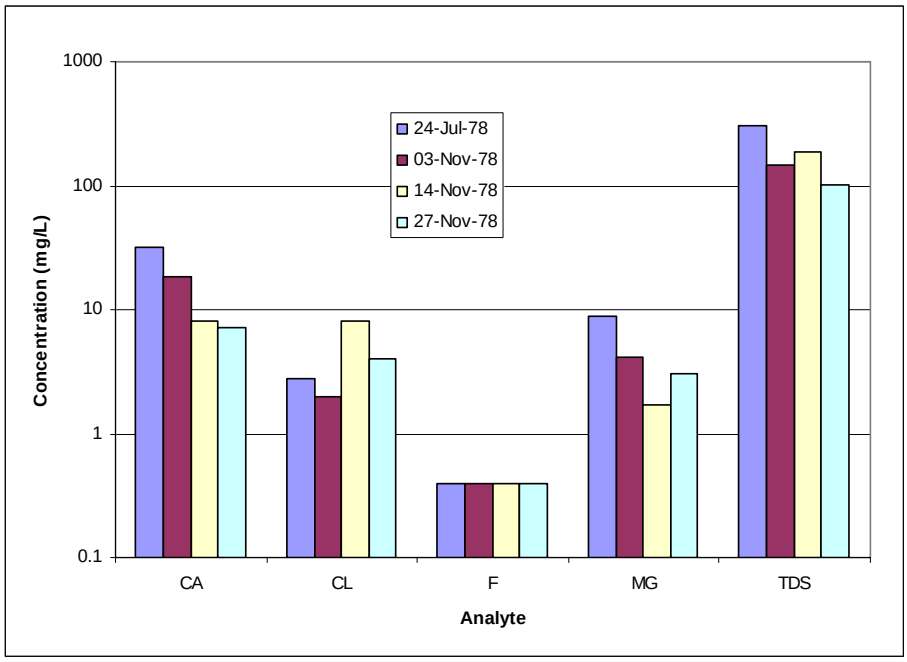
3.4.3.6.3 Environmental Surveillance Runoff Sampling

ESH-18 and its predecessors periodically have collected storm water runoff samples from Rendija Canyon, near the confluence with Guaje Canyon at municipal well G-6 and from Guaje Canyon near SR 502.

Rendija Canyon

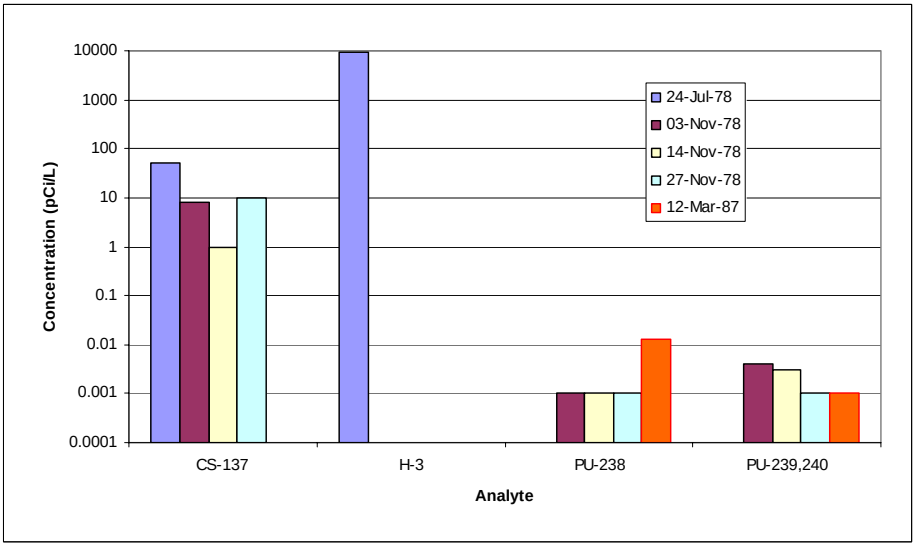
Storm water runoff samples were collected from Rendija Canyon near well G-6 during four runoff events in July and November 1978. The samples were filtered; aliquots were analyzed for general inorganic

constituents and radionuclides. Additionally, runoff samples were collected from Rendija Canyon in March 1987 and analyzed for plutonium-238 and plutonium-239/240. The summary of the results of the analyses of these samples is shown in Figures 3.4-25, 3.4-26, and 3.4-27. The highest TDS observed in the filtered samples was 300 mg/L. Tritium was measured in the July runoff event at 9300 pCi/L; tritium analyses were not performed on subsequent samples (ESG 1979, 05819).



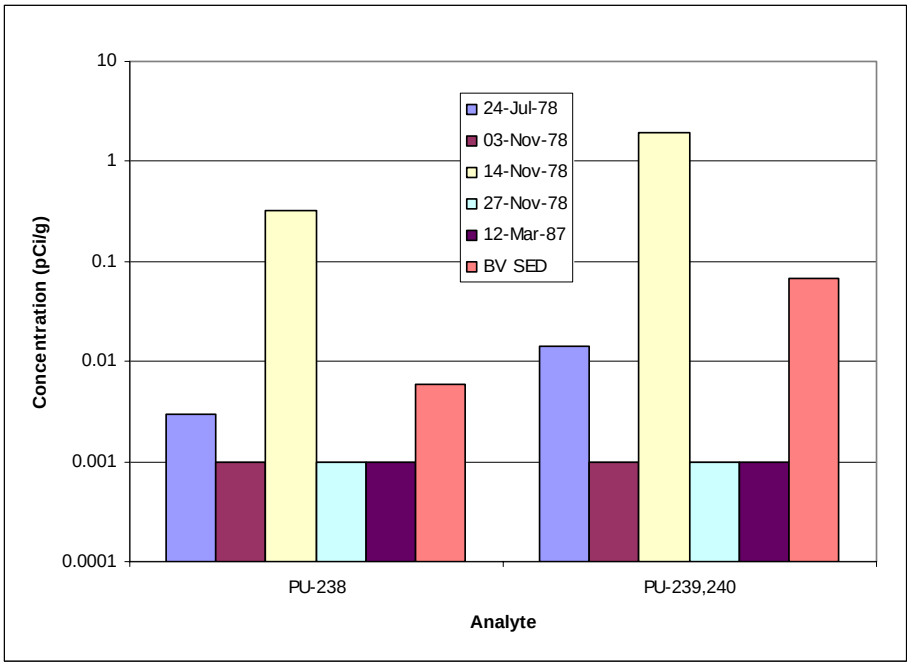
Source: ESG 1979, 05819.

Figure 3.4-25. Summary of general inorganic constituents in filtered storm water runoff in Rendija Canyon, 1978



Source: ESG 1979, 05819; ESG 1988, 6894.

Figure 3.4-26. Summary of radionuclides in filtered storm water collected in Rendija Canyon, 1978 and 1987



Source: ESG 1979, 05819; ESG 1988, 6894.

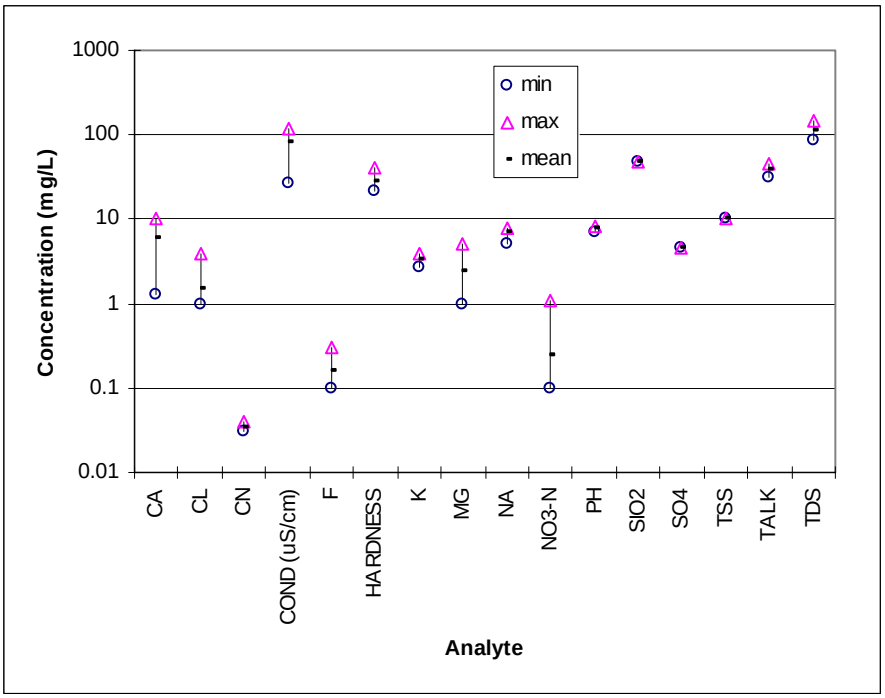
Figure 3.4-27. Summary of radionuclides in suspended sediment fraction of storm water runoff from Rendija Canyon, 1978 and 1987

The suspended sediment fraction of the samples was analyzed for plutonium-238 and plutonium-239/240 (Figure 3.4-27). The plutonium isotopes were measured in concentrations generally below the BVs for sediments, except for one runoff event in November 1978 when the suspended sediments yielded results of 0.32 pCi/g plutonium-238 and 1.93 pCi/g plutonium-239/240 (ESG 1979, 05819). No known Laboratory activities in the watershed involved radionuclides; the suspended sediment results may reflect regional fallout levels.

Guaje Canyon

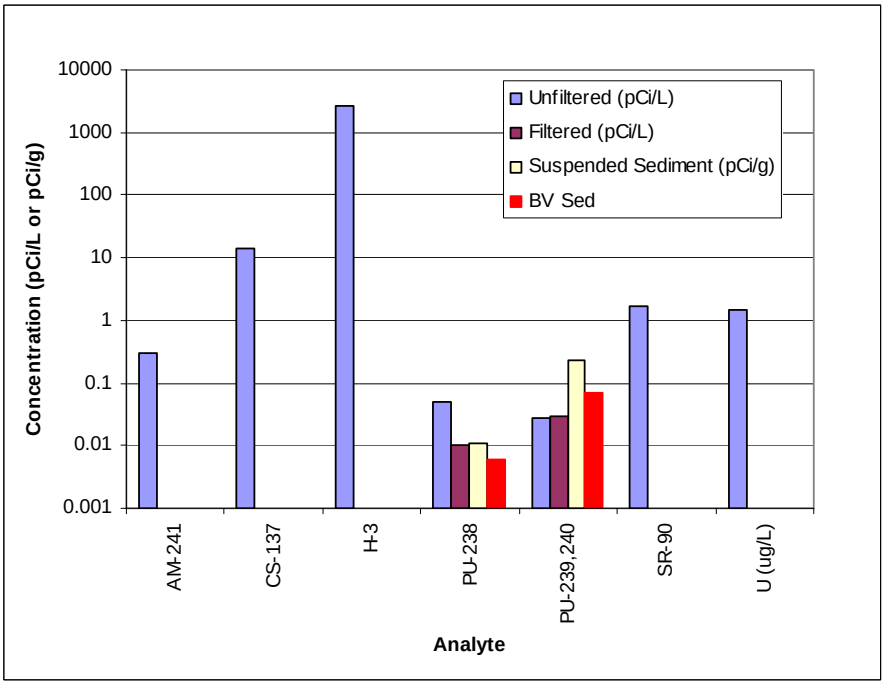
From 1973 to 1977 and in 1980 and 1987 storm water runoff samples were collected in Guaje Canyon at SR 502, above the confluence with Los Alamos Canyon. The samples were analyzed for radionuclides; from 1974 to 1980 they also were analyzed for general inorganic constituents. Figure 3.4-28 shows results of the analyses for general inorganic constituents in unfiltered samples. The TDS and hardness values were obtained from filtered samples. The TDS values ranged from 86 to 148 mg/L (Environmental Surveillance Reports, 1973–1977, 1980–1987).

From 1973 through 1980, unfiltered runoff samples collected in Guaje Canyon at SR 502 were analyzed for radionuclides. In 1987 runoff samples were collected during three separate runoff events; filtered samples were analyzed for radionuclides and the suspended sediment fractions of the samples were analyzed for plutonium isotopes. Figure 3.4-29 shows maximum concentrations of radionuclides measured in the runoff and the suspended sediment. Tritium values as high as 2600 pCi/L were measured in 1976. Maximum concentrations of plutonium-238 (0.011 pCi/g) and plutonium-239,240 (0.233 pCi/g) in the suspended sediment were above sediment BVs in 1987, although no known Laboratory activities involve these radionuclides in the watershed. No runoff samples were collected in Guaje Canyon at SR 502 from 1988 through 1999 (Environmental Surveillance Reports, 1973–1987).



Source: Environmental Surveillance Reports, 1973–1977, 1980–1987.

Figure 3.4-28. Summary of general inorganic constituents in unfiltered runoff from Guaje Canyon at SR 502



Source: Environmental Surveillance Reports, 1973–1987.

Figure 3.4-29. Maximum concentrations of radionuclides in runoff and suspended sediment collected in Guaje Canyon at SR 502, 1973–1987

3.4.3.7 Summary of Surface Water

The surface water hydrology of the north canyons is summarized below.

- Natural streamflow in Bayo, Barrancas, and Rendija Canyons is ephemeral. A reach of upper Guaje Canyon has perennial flow from springs located in the upper reaches of the Canyon. The continuous flow combined with storm water runoff usually does not extend beyond the middle part of the canyon.
- NPDES outfalls in lower Rendija Canyon and lower Guaje Canyon discharge an unknown volume of water. Flow from the discharges infiltrates the alluvium.
- Storm water runoff samples collected in Rendija Canyon near well G-6 in 1978 contained tritium in a concentration of 9300 pCi/L. The suspended sediment fraction of a runoff sample contained 0.32 pCi/g plutonium-238 and 1.93 pCi/g plutonium-239/240, which is above sediment BVs.
- Surface water samples from Guaje Reservoir have contained cesium-137 at 6 pCi/L and tritium at 2400 pCi/L.
- Surface water samples from the Guaje Canyon site contained selenium in a concentration of 3 μg/L, above the NMWQCC wildlife habitat standard for 2 μg/L. During the early 1980s tritium concentrations ranged from 1000 to 2000 pCi/L, with the highest concentration 4500 pCi/L; however, since 1985 tritium has been measured at near-detection limits.
- Runoff samples collected from lower Guaje Canyon have contained tritium in concentrations as high as 2600 pCi/L in 1976. Maximum concentrations of plutonium-238 and plutonium-239,240 in suspended sediment were above sediment BVs in 1987, although the cause of these results is unknown.

3.4.4 Alluvial Groundwater

3.4.4.1 Alluvial Groundwater Investigations

Few investigations of alluvium and shallow groundwater have been conducted in the north canyons. Information regarding the alluvial zones is largely inferred from boreholes drilled in middle Bayo Canyon and middle and lower Guaje Canyon and from conceptual models describing the relation of surface water recharge to the presence of alluvial groundwater. No monitoring or groundwater investigations have been conducted in Barrancas or Rendija Canyons.

During periods of precipitation and increased runoff and streamflow, the surface waterfront advances downstream. As the surface water infiltrates the alluvial sediments, the alluvium may become locally saturated for short periods following these runoff events, but this saturation is not likely to persist.

Bayo Canyon

In 1956, a geologic survey was conducted in Bayo Canyon to assess the potential for contaminant migration pathways. The survey suggested that a possible hydraulic connection existed between Bayo Canyon and Pueblo Canyon in the vicinity of Hamilton Bend Spring and Otowi Seep. Water samples from Hamilton Bend Spring in Pueblo Canyon were often high in nitrates, and wastes from TA-10 in Bayo Canyon were treated with nitric acid (Abrahams 1956, 5319). However, investigations conducted in 1961, 1973, and 1974 (described below) determined that the migration of contaminants from TA-10 in Bayo

Canyon to Pueblo Canyon was unlikely, due to the limited quantity of surface water, and alluvial groundwater in Bayo Canyon was insufficient to move contaminants from the liquid waste disposal pit through the subsurface (Mayfield et al. 1979, 11717, pp. 13, 48, 49).

In 1961 four test holes, BCTH-1 through BCTH-4, were drilled at former TA-10 to determine if groundwater served as a migration pathway for contaminants from former firing sites in Bayo Canyon. The boreholes penetrated the alluvium into the underlying Puye Formation. Alluvial groundwater and significant moisture were not encountered (Mayfield et al. 1979, 11717, pp. 50, 51). Additional information on the test holes is found in Section 3.4.2.

Several subsurface investigations designed to determine nature and extent of contaminants at former TA-10 in Bayo Canyon have not encountered groundwater in the alluvium or the underlying formations. These investigations have included drilling approximately 14 boreholes in 1973 and 1974. Results of the investigations did not indicate the presence of groundwater or significant amounts of moisture in subsurface sediments. Borehole depths ranged from 8 ft (2.4 m) to 40 ft (12.2 m). Most boreholes were located within 250 ft (76 m) of the Bayo Canyon channel (Mayfield et al. 1979, 11717, pp. 47–59). Seven additional test holes were drilled in Bayo Canyon on November 12 and 13, 1980, to depths from 12 to 37 ft (3.6 to 11.2 m). The soil/tuff contact generally was encountered at depths of 6 to 27 ft (1.8 to 8.2 m). The bedrock beneath the streambed (Otowi Member of the Bandelier Tuff) usually was found to be weathered and some boreholes encountered pumice (Guaje Pumice Bed). No indications of moisture or groundwater were noted (Purtymun 1994, 58233, pp. 97-1, 97-2).

A total of 93 boreholes were drilled and sampled during the RFI at former TA-10 in Bayo Canyon from May to November 1994. The investigation was conducted to characterize the nature and extent of PRSs where potential subsurface contaminants may be a concern. Each borehole was drilled to a minimum depth of 50 ft (15.2 m). The alluvium in middle Bayo Canyon was approximately 20 to 40 ft (6 to 12 m) thick. Groundwater was not encountered in any of the boreholes. Damp alluvium and Bandelier Tuff were noted (LANL 1996, 54332, p. 9-13). These intermediate-depth boreholes are discussed in Section 3.4.2.

Guaje Canyon

In fall 1966, two shallow test holes were drilled in Guaje Canyon between the Rendija Canyon fault and the Guaje Mountain fault. The boreholes GCTH-1 and GCTH-2 were located approximately 3 mi (4.8 km) downstream of the Guaje Reservoir. GCTH-1, drilled near the intersection of the Guaje Pines Cemetery Road and Guaje Canyon road, encountered alluvium to the total depth of 23 ft (7 m). GCTH-2, drilled west of the Guaje Mountain fault to a total depth of 103 ft (31.4 m) encountered alluvium from 0 to 17 ft (5.2 m) and Puye Formation to total depth. Both boreholes were completed as 2-in.-diameter monitoring wells. The screened intervals of the wells are not known. Saturation in the boreholes was reported from the approximate level of the Guaje Canyon stream channel to total depth (Purtymun 1995, 45344, p. 299). Groundwater samples were not collected and the wells have not been monitored routinely.

In 1946 test wells were installed in lower Los Alamos and Guaje Canyons to determine if a water supply could be developed for Los Alamos. GT-4 was drilled in the lower reaches of Guaje Canyon at the confluence with Los Alamos Canyon at an elevation of 5675 ft (1730 m). The total depth of the well was 315 ft (96 m). Alluvium was encountered from surface to a depth of 54 ft (16.5 m) and the Santa Fe Group was encountered to the total depth of the test hole. Specific references to saturation within the alluvium were not noted. However, it was determined that the alluvium was too thin to support a municipal water supply (Purtymun 1995, 45344, pp. 245, 246).

Based on information from these investigations, shallow alluvial groundwater likely is present in the upper and middle reaches of Guaje Canyon, supported by infiltration from spring-fed surface water. Streamflow

losses due to ET and infiltration and possible losses to geologic structures (faults) reduce the volume of surface water downstream. The saturated thickness of alluvial groundwater likely decreases downstream in the middle part of the canyon.

3.4.4.2 Relationship Between Alluvium and Bedrock Stratigraphic Units

Little information on the relationship of the alluvium to underlying formations, groundwater, or presence of potential contaminants is available for most parts of the north canyons and their tributaries. Subsurface investigations have been conducted in small sections of Bayo Canyon and Guaje Canyon.

Bayo Canyon

The alluvium in the Bayo Canyon floor ranges from a thin veneer to approximately 40 ft (12.2 m) deep near of the stream channel. Figure 3.4-30 is a cross section across Bayo Canyon at former TA-10 that shows the general relationship of the bedrock stratigraphic units identified from subsurface investigations. Because Bayo Canyon heads on the Pajarito Plateau, alluvium at TA-10 is derived entirely from the Tshirege and Otowi Members of the Bandelier Tuff. The alluvium thickens downstream and in the center of the modern drainage, indicating that a deeper inner canyon was cut in the Bandelier Tuff prior to the deposition of the alluvium. The poorly sorted, clay-rich sand and gravel alluvium overlies the Otowi Member of the Bandelier Tuff in the vicinity of the former TA-10. The Guaje Pumice Bed at the base of the Otowi Member was encountered in the RFI boreholes drilled at former TA-10. Generally, the Guaje pumice was in contact with the overlying alluvium. However, in some locations away from the center of the canyon, particularly in the southeast section of former TA-10, the Otowi Member was encountered beneath alluvium (see Figure 3.4-30). In the lower reaches of Bayo Canyon, the alluvium is underlain by the Puye Formation (Mayfield et al. 1979, 11717, p. 47).

The Puye Formation underlies the Guaje Pumice Bed in middle Bayo Canyon. The Puye Formation consists of fine- to coarse-grained sediments interbedded locally with thin tephras, axial river gravels, and lacustrine siltstone and clays. Several low-permeability paleosols have been observed in the upper portion of the Puye Formation that, if present, may serve locally as a layer that is impermeable to the infiltration of groundwater (LANL 1996, 54332, pp. 9–13; Broxton and Eller 1995, 1162).

The bedrock units in Bayo Canyon at the former TA-10 site dip southeast. If shallow alluvial groundwater were present and could come into contact with subsurface contaminants, the water may infiltrate bedrock units such as the Guaje Pumice Bed and continue down-dip in the bedrock units, potentially on a path not parallel to the canyon.

Guaje Canyon

The alluvium in upper and middle Guaje Canyon is derived from the Tschicoma Formation and the Bandelier Tuff, producing angular to sub-rounded clasts of Tschicoma Formation rocks with minerals derived from the Puye Formation. These minerals include feldspar, biotite, and other ferromagnesium minerals and quartz of the Tschicoma Formation. Quartz, sanidine, and silts and clays from the Bandelier Tuff are also present in the alluvium in Guaje Canyon.

In 1966 two shallow test holes were drilled in middle Guaje Canyon to evaluate subsurface conditions. GCTH-1 was drilled to 23 ft (7 m) into alluvium. GCTH-2 was drilled to 103 ft (31.4 m) in 17 ft (5.2 m) of alluvium underlain by the Puye conglomerate to the total depth of the borehole. Both units were saturated from the base of the borehole to near-stream level, indicating hydrologic communication between the alluvium and underlying Puye Formation at this location (Purtymun 1995, 45344, p. 299).

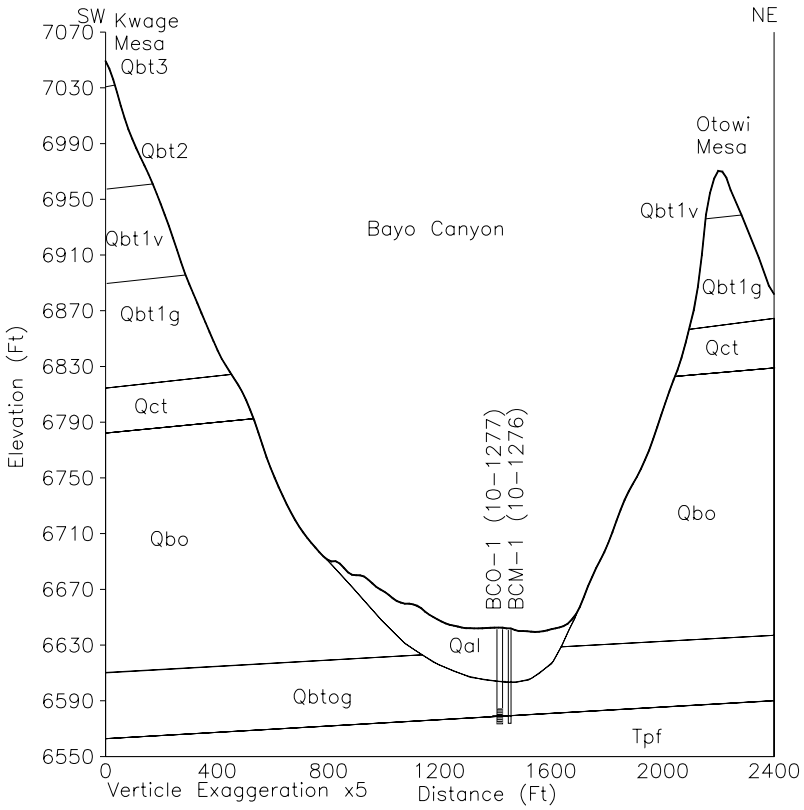


Figure 3.4-30. Cross section of Bayo Canyon at former TA-10 showing monitoring well locations

GCTH-2 was drilled in a structural basin located upstream from the GMFZ. The fault is down-thrown on the west and juxtaposes Puye Formation fanglomerate on the west against Tschicoma Formation dacite on the east. GCTH-2 encountered saturation throughout the alluvium and Puye Formation to total depth. At the time of the investigation, a small amount of water was observed emerging from the GMFZ and flowing for a short distance downstream before infiltrating the alluvium. Purtymun postulated that the Puye Formation in the small structural basin formed by the normal fault was saturated with water from the stream (see Figure 3.4-17). Relatively impermeable rocks of the Tschicoma Formation underlie the Puye Formation and are adjacent to the Puye Formation across the fault. Recharge from the stream infiltrates into the Puye Formation in the structural basin ("ponding") and then overflows at the fault into the stream channel, which is cut into the downstream Tschicoma Formation. The "pond" of groundwater in the structural basin adjacent to the fault also may provide recharge to the regional aquifer via the GMFZ (Purtymun 1975, 11787, p. 281).

Another small structural basin is formed where the Rendija Canyon fault crosses Guaje Canyon. A similar situation develops where a small structural basin of Puye Formation fanglomerates overlies less-permeable Tschicoma Formation dacite and is adjacent to the Tschicoma Formation across the fault (see Figure 3.4-17). No detailed information about saturation in this structural basin is available.

GT-4, drilled in 1946 in the lower reaches of Guaje Canyon near the confluence with Los Alamos Canyon, encountered alluvium from surface to a depth of 54 ft (16.5 m). The alluvium was underlain by the Santa

Fe Group to the total depth of the test hole (315 ft [96 m]). Alluvial groundwater was not noted (Purtymun 1995, 45344, pp. 245, 246).

Municipal water supply wells have been installed in the middle and lower reaches of Guaje Canyon. The alluvium is typically 12 to 17 ft (3.6 to 5.2 m) thick. The minimum thickness of 8 ft (2.4 m) was recorded at G-5, the furthest upstream well. The maximum thickness of alluvium (40 ft [12.2 m]) was reported at well G-6, located in Rendija Canyon approximately 0.8 mi (1.3 km) from the confluence with Guaje Canyon. Alluvial groundwater was not noted at well G-6. The alluvium in all wells is underlain by Puye Formation fanglomerate (Purtymun 1995, 45344, pp. 253, 259).

The Guaje Canyon water supply wells were installed at the edge of the canyon floor and may not have been located sufficiently near the center of the canyon to intersect alluvial groundwater, if present in the lower part of the canyon.

3.4.4.3 Summary of Alluvial Groundwater

Information about the alluvial groundwater in the north canyons is summarized below.

- Available data indicate no persistent alluvial groundwater in the north canyons downstream from PRSs.
- In upper Guaje Canyon surface water is likely a source of recharge to the alluvium and possibly to deeper units.
- There are no known alluvial groundwater discharge points in Bayo Canyon, Rendija Canyon, and Barrancas Canyon. Losses from ET and infiltration into deeper units are the likely sources of moisture loss in the alluvium and of any loss of alluvial groundwater. An unknown volume of infiltrated water may seep downward into subsurface units at locations upstream of PRSs.
- In Guaje Canyon, alluvial groundwater may discharge into deeper formations located in structural basins upstream from the Rendija Canyon fault and the Guaje Mountain fault.
- One intermediate-depth groundwater monitoring well and one subsurface moisture-monitoring well were installed in unsaturated material in Bayo Canyon in 1995. These wells initially were dry, and have not been monitored regularly since 1996. No monitoring wells have been installed in the lower reaches of Bayo Canyon.

3.4.5 Air Monitoring Investigations

3.4.5.1 Historical Monitoring

During 1950, an aerial study of air emissions from TA-10 in Bayo Canyon was conducted by the Air Force Research Laboratory. A Boeing B-17 was equipped with an ion-conductivity measuring device designed to correlate values in an attempt to measure the path of dust clouds containing active particulate and fall-out pattern following test shots from Bayo Canyon. Approximately seven flights were conducted with at least two flights tracking radioactive lanthanum (RaLa) shots from Bayo site. A later review of these investigations concluded that difficulties relating the Air Force Research Laboratory measurements with ionizing radiation were caused by variations from altitude and weather (Dummer 1996, 55951, p. 9).

The 1974 FUSRAP investigation included air sampling around former TA-10 in Bayo Canyon to ascertain if residual radionuclides from the former firing activities were a potential health concern. Airborne

concentrations of strontium-90 and uranium were compared to that of other Northern New Mexico locations. The results did not reveal a statistically significant difference in concentrations (Mayfield et al. 1979, 11717, pp. 4, 11).

3.4.5.2 AIRNET Monitoring

The Laboratory operates a network of more than 50 environmental air monitoring stations ("AIRNET") to sample radionuclides in ambient air. The network is designed to measure environmental levels of airborne radionuclides that may be released from Laboratory operations. Annual Laboratory emissions include microcurie (μCi) quantities of plutonium and americium, millicurie (mCi) quantities of uranium, and curie (Ci) quantities of tritium and activation products. In addition to Laboratory emissions, natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by the air surveillance program. Each station collects both a total particulate matter sample and a water vapor sample for analysis (ESP 2000, 68661, p. 88). Particulate matter in the atmosphere primarily is caused by resuspension of soil, which is dependent on meteorological conditions. Windy, dry days can increase the soil resuspension, but precipitation can wash particulate matter out of the air. Consequently, there are often large daily and seasonal fluctuations in airborne radioactivity concentrations caused by changing meteorological conditions. The measured airborne concentrations generally are several orders of magnitude less than the EPA concentration limit for the general public. The EPA limit represents a concentration that would result in an annual dose of 10 mrem (ESP 2000, 68661, pp. 88, 108).

AIRNET sampling locations are categorized as regional, pueblo, perimeter, quality assurance, technical area, or other on-site locations (ESP 2000, 68661, p. 88). The environmental surveillance program monitors one station within the Bayo Canyon watershed annually. The station is a perimeter sampling location at Barranca School (see Figure A-1) located at the head of the Bayo Canyon watershed. Air samples are analyzed for tritium; americium-241; plutonium-238; plutonium-239, 240; uranium-234; uranium-235; uranium-238; gamma spectroscopy; and gross alpha and beta radioactivity (ESP 2000, 68661, pp. 89-93, 140).

Routine publication of AIRNET data on the World Wide Web began during 1997, and data are now available on the World Wide Web within two to three months following the sampling period. The web site is located at http://www.esh.lanl.gov/~AirQuality/. The web site also includes follow-up information on investigations of higher-than-normal values.

3.4.5.3 TLDNET Monitoring

The Laboratory Air Quality Group (ESH-17) monitors for cosmic, gamma, and neutron radiation. These types of radioactivity are both naturally occurring and man-made. As the natural background radiation doses from terrestrial and cosmic sources are much larger than those from man-made sources, the man-made sources are difficult to distinguish from natural sources. As of 1999, the Laboratory's monitoring program included 97 thermoluminescent dosimeter (TLD) stations located on the Laboratory and at off-site regional stations to detect any impact from Laboratory operations. Monitoring locations have changed over the duration of the program. In 1999, the Laboratory monitored three locations in the Bayo Canyon watershed, all classified as perimeter locations. These stations are located at Barranca School (station #5), Cumbres (Middle) School (station #7), and at the end of Los Pueblos Street on Otowi Mesa (station #46). Two TLD monitoring stations are located in Pueblo Canyon; they are identified as "Bayo Canyon Well" and "Bayo Canyon."

In 1999, the annual dose recorded at Barranca School (#5) was 134 +/- 17 mrem, the dose at Cumbres School (#7) was 132 +/- 17 mrem, and the dose at the end of Los Pueblos Street (#46) was 153 +/- 20

mrem. The annual dose equivalents at the perimeter and regional stations ranged from 100 to 180 mrem. These dose rates are consistent with natural background measurements (ESP 2000 68661, pp. 100, 101, 130, 150).

3.4.5.4 NEWNET

Neighborhood Environmental Watch Network (NEWNET) is a Laboratory Nonproliferation and International Security Division program for radiological monitoring in local communities. The program establishes meteorological and external penetrating radiation monitoring stations in the local community and around radiological sources. The data include the current date, time, gross gamma radiation, wind direction, wind speed, barometric pressure, temperature, and humidity. Figure A-1 shows the locations of nearby NEWNET meteorological stations. The data are posted with at most a 24-hr delay on the World Wide Web at the NEWNET site at http://newnet.lanl.gov/ (ESG 2000, 68661, p. 107). NEWNET stations located nearest the north canyons are located at Los Alamos High School and at Eastgate near the Los Alamos Airport.

3.5 Biological Setting of the Northern Canyons

The general biological setting for the Los Alamos region and the canyons is discussed in Section 3.8 of the core document (LANL 1997, 62316). The unique aspects of the biological setting of the northern canyon systems are described here.

The biological assessments discussed below include fauna evaluations conducted in many TAs within the north canyons watershed areas (Dunham 1992, 31276; Banar 1996, 58192; Biggs and Cross 1995, 52028). This discussion also summarizes the threatened, endangered, and sensitive species that potentially are present, based on the habitats identified by these assessments.

Potentially threatened and endangered species in the canyon systems are listed in Table 3-6 of the core document (LANL 1997, 62316). Surveys conducted during the biological assessments discussed in Section 3.5.6.1.1 of this work plan did not confirm the presence of threatened, endangered, and sensitive species in the study areas. Preliminary risk assessments for the threatened Mexican spotted owl, the southwestern willow flycatcher, and the bald eagle have been completed. The results of the risk assessments determined that no unacceptable risks were present (Gallegos et al. 1997, 57915; Gallegos et al. 1997, 59790; Gonzales et al. 1998, 62349; Gonzales et al. 1998, 62350).

This section discusses the threatened, endangered, and sensitive species that potentially are present within the north canyons watersheds. The information is based on the habitats identified in the biological assessments conducted by the Laboratory Ecology Group (ESH-20) for the ER Project.

3.5.1 Bayo Canyon Biotic Environment

During 1991, field surveys were conducted in OU 1079 for compliance with the Federal Endangered Species Act of 1973; New Mexico's Wildlife Conservation Act; New Mexico Endangered Plant Species Act; US Department of Energy (DOE) Executive Order 11990, "Protection of Wetlands," and DOE Executive Order 11988, "Floodplain Management"; 10 CFR 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements"; and DOE Order 5400.1, "General Environmental Protection Program."

3.5.1.1 Flora

During August 1991, the Biological Resource Evaluation Team (BRET) of the Laboratory's Environmental Protection Group (EM-8) conducted field surveys for OU 1079, TAs-10, -31, -32, and -45. Vegetation ranged from a ponderosa pine-mixed conifer series in the western portions of the OU to a piñon-juniper series in the lower east portion of the OUs (Biggs 1993, 48979).

The steep-sided and narrow upper part of Bayo Canon is relatively moist and cool and supports a pine-fir (*Pinus ponderosa, Pseudotsuga menziesii, Abies concolor*) forest (Table 3.5-1). As the canyon widens into the section where the old TA-10 site was located, the pine-fir overstory thins and is restricted to the north-facing slope of Kwage Mesa. The canyon bottom supports many ponderosa pine trees (*Pinus ponderosa*) scattered throughout the old TA-10 site, except in the vicinity of the old firing sites, where all vegetation was removed during the period of active site operation. Ponderosa pine gives way to a piñon-juniper woodland (*Pinus edulis, Juniperus monosperma*) on the drier south-facing slope of Otowi Mesa (Ferenbaugh et al. 1982, 6293).

Table 3.5-1
Common Vegetative Species in Bayo Canyon

Scientific Name	Common Name
Grasses and Forbs	
Andropogon scoparius	Little bluestem
Bouteloua gracilis	Blue grama
Bromus tectorum	Cheatgrass
Koelaria cristata	Junegrass
Taraxicum officinale	Dandelion
Verascum thapsis	Woolly mullein
Shrubs and Subshrubs	
Artemesia tridentata	Big sagebrush
Atriplex canescens	Saltbush
Chrysothamnus nauseosus	Chamisa or rabbitbrush
Fallugia paradoxa	Apache plume
Forestiera neomexicana	New Mexico olive
Gutierrezia microcephala	Snakeweed
Prunus virginiana, var. *melancarpa*	Chokecherry
Quercus gambelii	Gambel oak
Quercus undulata	Scrub oak
Rhus trilobata	Squawbush
Robinia neomexicana	New Mexico locust
Disturbed-Habitat Plants	
Artemisia frigida	Wormwood
Chenopodium fremontii	Lambsquarters
Chrysopsis villosa	Goldenweed
Croton texensis	Doveweed
Cryptantha jamesii	James cryptantha

Table 3.5-1 (continued)
Common Vegetative Species in Bayo Canyon

Scientific Name	Common Name
Erodium cirdutarium	Filaree
Heliathus petiolaris	Prairie sunflower
Lupinus caudatus	Lupine
Mirabilis mulriflora	Wild four o'clock
Salsola iberica	Russian thistle or tumbleweed
Viguiera multiflora	Crownbeard

Source: Ferenbaugh et al. 1982, 6293, p. 31.

3.5.1.2 Fauna

The plant community type found west of the town site and extending into Bayo Canyon supports characteristic fauna such as mule deer, Abert's squirrel, Steller's jay, montane vole, deer mouse, and pipistrelle bat. Characteristic fauna in the north-facing slopes in upper Bayo Canyon include mule deer, red squirrel, and mountain cottontail.

Threatened and endangered animals that regionally nest or forage in the ponderosa pine forest habitats include the meadow jumping mouse, northern goshawk, and spotted bat (LANL 1995, 49974, pp. 7, 8).

3.5.1.3 Threatened and Endangered Species

Biological surveys did not find any threatened and endangered plant or animal species in Bayo Canyon (Biggs 1993, 48979). The spotted bat (*Euderma maculatum)*, a candidate for federal protection and a New Mexico-protected endangered species, may use the rocky cliffs as a roosting area. The northern goshawk *(Accipter gentillis)*, a candidate for federal protection, prefers ponderosa pine/oak and mixed conifer habitats, which occur on the north-facing slopes in the upper portion of the canyon. However, the goshawk tends to avoid humans, and its presence is unlikely because of the suburban areas on the mesa tops above the upper canyon. The Mexican spotted owl (*Strix occidentalis lucida)* nests in lower Pueblo Canyon and is expected to forage into middle Pueblo Canyon and possibly adjacent Bayo Canyon.

The Laboratory's BRET conducted Level 2 (habitat-evaluation) and Level 3 (species-specific) surveys during 1991 to provide information for a site characterization plan. The purpose of the field surveys was three-fold: to determine if species protected by the state or federal government were present before soil sampling took place; to determine if sensitive habitats were present; and to gather baseline data for future studies on plant and wildlife species in OU 1079. Information gathered from the field surveys was compared with habitat requirements of potentially occurring protected species (both threatened and endangered) (Biggs 1993, 48979).

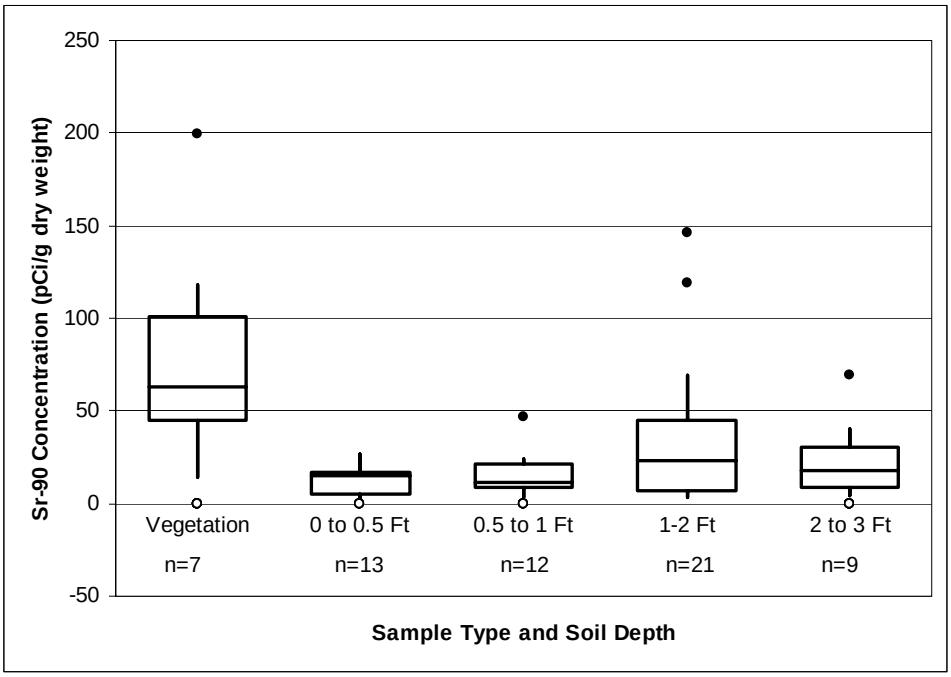
After a search of the BRET threatened, endangered, and sensitive species database, and after consulting with state and federal agencies, several plant and wildlife species were listed as potentially occurring in the area. No protected species currently are known to use the areas of TA-10.

3.5.1.4 Radionuclide Concentrations in Biota

Chamisa (*Chrysothamnus nauseosus*) growing in a former liquid waste disposal site (PRS 10-007) in Bayo Canyon were collected and analyzed for strontium-90 and total uranium. The vegetation samples

were ashed and the ash was analyzed. Surface soil samples also were collected from below (understory) and between (interspace) shrub canopies. Both chamisa plants growing at PRS 10-007 contained significantly higher concentrations of strontium-90 than a control plant. Top growth material from one plant contained 90,500 pCi/g strontium-90 in ash. Similarly, surface soil samples collected beneath and between plants contained strontium-90 concentrations above background levels and screening action levels. This may have occurred as a result of the chamisa plant's bringing strontium-90 from the subsurface and incorporating the radionuclide in the leaf material; leaf fall and plant litter may have contaminated the soil understory area followed by water and/or winds moving strontium-90 to the soil interspace area. Although some migration of strontium-90 in the surface soil has occurred at PRS 10-007, the concentration of strontium-90 in stream channel sediments collected downstream of former TA-10 at the Bayo Canyon-SR 502 intersection has been within regional background concentrations (Fresquez et al. 1995, 68471, p. 1).

Another investigation was conducted in 1996 and 1997 to address strontium-90 in vegetation at the former site of the central portion of TA-10 in Bayo Canyon. An interim action was planned to remediate chamisa plants containing elevated activity (LANL 1996, 55698, p. 1). However, the results of a radiation survey that was conducted to determine which chamisa plants should be removed indicated that several plant species in addition to chamisa contained elevated radioactivity. Other vegetation samples that contained elevated radioactivity included ponderosa pine, annuals, and grasses. Figure 3.5-1 shows the results of vegetation and soil sampling obtained during the investigation at former TA-10. Vegetation samples were dried and the dried material was submitted to a fixed laboratory for analyses. Soil samples were measured using a beta-gamma meter and the results were converted to concentration values using a conversion factor. Strontium-90 in seven vegetation samples ranged from 14 to 199 pCi/g dry weight, and strontium-90 in surface soil samples (0 to 0.5 ft [0 to 15 cm] depth) ranged from 2 to 27 pCi/g. Higher concentrations of strontium-90 were observed at depths of 1 to 2 ft (0.3 to 0.6 m) (LANL 1997, 56358, Table 1).



Source: LANL 1997, 56358, pp. 6–9.

Figure 3.5-1. Box plots showing strontium-90 concentrations in vegetation and soil samples at former TA-10

A risk assessment was developed from the characterization data obtained during the investigation. Pathways used in the assessment included (1) inhalation of resuspended dust and soil, (2) ingestion of soil, (3) ingestion of plant material, (4) ingestion of meat from animals that had foraged in the area, and (5) inhalation of wood smoke from firewood gathered at the site. Plant ingestion was the primary contributor (93%) to annual dose and ingestion of game meat was the second highest contributor (5%). The annual dose calculated from the plant ingestion scenario was less than 10 mrem/yr (LANL 1997, 56358, p. 11).

3.5.2 Rendija Canyon Biotic Environment

In 1991, the BRET conducted Level 2 (habitat evaluation) and Level 3 (species-specific) surveys to provide information for a site characterization plan. One purpose of the field surveys was to gather baseline data for future studies on plant and wildlife species in OU 1071 (Biggs 1996, 62928, p. 3). Surveys were conducted in Rendija Canyon as part of this assessment. The surveys were conducted for compliance with the Federal Endangered Species Act; the New Mexico Wildlife Conservation Act; the New Mexico Endangered Plant Species Act; DOE Executive Orders 11990, “Protection of Wetlands,” and 11988, “Floodplain Management”; 10 CFR 1022; “Compliance with Floodplain/Wetlands Environmental Review Requirements”; and DOE Order 5400.1, “General Environmental Protection Program.”

3.5.2.1 Flora

Several vegetation analyses and surveys have been conducted in portions of the canyons and mesa tops of OU 1071. These studies include a vegetation survey of Cabra Canyon, a tributary of Rendija Canyon; a winter plant survey of Cabra Canyon; a vegetation and ecological survey of the Pueblo Canyon-Los Alamos Canyon confluence; a vegetation survey of an old farm field in Rendija Canyon; and several smaller surveys in various scattered locations. These studies and surveys were conducted between 1980 and 1991 (Biggs 1996, 62928, p. 16).

The vegetation survey of Cabra Canyon was conducted to determine if any threatened, endangered, and sensitive plant species were present in an area proposed for disturbance and none was found (Biggs 1996, 62928, p. 18). Habitat at the Cabra Canyon site was not suitable for any federally proposed endangered or threatened plant species. It was noted that the site could be potential habitat for state-protected species if the site were not so disturbed (Biggs 1996, 62928, p. 19).

The old farm fields in Rendija Canyon were dominated by wormwood and brome grass and an open area near the canyon road was dominated by blue juniper, ponderosa pine, and cottonwood (Biggs 1996, 62928, p. 4). Vegetation transects in Rendija Canyon were established on the north- and east-facing slopes and along the canyon bottom where the terrain is relatively open (near the access road to the firing range and archery range) (Biggs 1996, 62928, p. 37). Ponderosa pine was the dominant overstory species in the canyon bottom, along the north-facing slope, and at the old field. Piñon pine was the dominant species along the east-facing slope. The diameter at breast height (DBH) of ponderosa pine along the north-facing slope was more than twice that of ponderosa pine in the canyon bottom (8.38 and 20.91 in., respectively). The old field consisted of a young ponderosa pine stand (DBH of 5 in.). Douglas fir was found only along the canyon bottom but is expected to also occur on the north-facing slope. Juniper was found in all areas but occurred most often along the north-facing slopes (Biggs 1996, 62928, pp. 37–38). A complete checklist of plant species identified during these surveys and of species identified in the most recent field surveys is given in Appendix A of the “Biological and Floodplain/Wetlands Assessment for Environmental Restoration Program, Operable Unit 1071, TAs-0, -19, -26, -73, and -74” (Biggs 1996, 62928).

3.5.2.2 Fauna

The biological assessments discussed above in Section 3.5.3.1 include fauna investigations for the technical areas located within the Rendija Canyon watershed for OU 1071 (Biggs 1996, 62928). The investigation conducted habitat evaluation surveys (Level 2) after searching a BRET database containing the habitat requirements for all state- and federally listed threatened, endangered, and sensitive plant and animal species known to occur within the boundaries of the Laboratory and the surrounding areas. The habitat information gathered during the field surveys was compared with the habitat requirements for each species of concern that was identified in the database search. If habitat requirements were not met for any species of concern, no further surveys were conducted. If habitat requirements were met, specific surveys for the species of concern were conducted.

Based on the results of the Level 2 survey, a Level 3 survey was conducted for the meadow jumping mouse in August 1991 along a portion of the stream channel in Rendija Canyon. The meadow jumping mouse inhabits meadows along streams or other similar water sources. No meadow jumping mice were found during the survey (Biggs 1996, 62928, p. 29). Although water was flowing through the canyon at the time of the survey, it was due to recent, heavy rainfall. This species is not expected to occur in the Rendija Canyon area, based on the results of this survey and the lack of a perennial flowing stream and associated suitable habitat (Biggs 1996, 62928, p. 4-5).

In summer 1992, an investigation was conducted to compare nocturnal, small-mammal communities at wet area created by wastewater outfalls with communities in naturally created wet and dry areas. Of the 13 locations chosen for sampling, 1 was in Rendija Canyon. Data were collected on-site type (dry, outfall, or natural), location, and species trapped, and the tag number of each individual captured was recorded. The site in Rendija Canyon was considered a dry area. One species of small mammal, the deer mouse, was captured in Rendija Canyon (Biggs and Raymer 1994, 56038, p. 8). The data were used to determine the mean number of species, percent capture rate, and species diversity. When data from each type of site were pooled, no significant differences were observed in these variables between dry, outfall, and natural location types (Biggs and Raymer 1994, 56038, p. 1).

3.5.2.3 Threatened and Endangered Species

A search of the database and consultation with state and federal agencies found that potential species of concern for the Rendija Canyon area (OU 1071) (based on habitat and known occurrences) are the northern goshawk, Mexican spotted owl, black hawk, bald eagle, Mississippi kite, broad-billed hummingbird, willow flycatcher, spotted bat, meadow jumping mouse, Say's pond snail, Wright's fishhook cactus, Santa Fe cholla, grama grass cactus, sessile-flowered false carrot, threadleaf horsebrush, Plank's catchfly, Santa Fe milk vetch, cyanic milk vetch, Taos milk vetch, tufted sand verbena, wood lily, checker lily, sandia alumroot, and Pagosa phlox (Biggs 1996, 62928, p. 4). Table 3.5-2 lists the occurrence potential of species likely to be found in Rendija Canyon. A habitat evaluation for OU 1071 and the middle part of Rendija Canyon found that two species appear to have at least a moderate potential for occurrence in the area: the spotted bat and the meadow jumping mouse.

3.5.3 Barrancas Canyon Biotic Environment

No specific biological studies have been conducted in Barrancas Canyon. A portion of Barrancas Canyon is located in TA-74 and can be partially grouped with OUs 1071 and 1079. See Section 3.5.1 for Bayo Canyon biotic environmental factors.

Table 3.5-2
Threatened, Endangered, and Sensitive Species
Potentially Occurring in the Rendija Canyon Watershed

Scientific Name	Common Name	Legal Status	Potential for Occurrence
Wildlife			
Buteogallus anthracinus	Common black hawk	State protected	Low to none
Cyantyhs latirostris	Broad-billed hummingbird	State endangered	Low to none
Empidonax traillii	Willow flycatcher	Federal candidate	Low to none
Euderma maculatum	Spotted bat	Federal candidate/state threatened	Moderate to high
Haliaeetus leucocephalus	Bald eagle	Federally endangered	Low to none
Accipiter gentilis	Northern goshawk	Federal candidate	Low
Ictinia mississippiensis	Mississippi kite	State endangered	Low to none
Abronia bigelovii	Tufted sand verbena	Federal candidate/state sensitive	Low to none
Aletes sessiliflorus	Sessile-flowered false carrot	State sensitive	Low to none
Strix occidentalis lucida	Mexican spotted owl	Federal candidate	Low to none
Zapus hudsonius	Meadow jumping mouse	Federal candidate/state endangered	Moderate to high
Lymnaea captera	Say's pond snail	State endangered	Low to none
Astragalus cyaneus	Cyanic milk vetch	State sensitive	Low to none
Plants			
Astragalus feensis	Santa Fe milk vetch	State sensitive	Low to none
Astragalus Mathewsii	Mathew's woolly milk vetch	State sensitive	Low to none
Astragalus puniceus var. gertudis	Taos milk vetch	State sensitive	Low to none
Mammillaria wrightii	Wright fishhook cactus	State sensitive	Low to none
Opunita viridiflora	Santa Fe cholla	Federal candidate	Low to none
Phlox caryophylla	Pagosa phlox	State sensitive	Low to none
Silene plankii	Plank's catchfly	State sensitive	Low to none
Lilium philadelphicum var. *andium*	Wood lily	State endangered	Low to none
Fritillaria atropurpurea	Checker lily	State sensitive	Low to none
Heuchera pulchella	Sandia alumroot	State endangered	Low to none
Tetradymia filifolia	Threadleaf horsebrush	State sensitive	Low to none
Toumeya papyracantha	Gramma grass cactus	Federal candidate/state endangered	Low to none

Source: Biggs 1996, 62928, pp. 31, 32, Appendix C.

3.5.4 Guaje Canyon Biotic Environment

During the summers of 1993 and 1994, the BRET conducted baseline studies within two canyon systems, Los Alamos Canyon and Guaje Canyon. Biological data were collected within each canyon to provide background and baseline information for ecological risk models (Foxx 1995, 50039, p. vii).

3.5.4.1 Flora

Table 3.5-3 lists the dominant trees and shrubs in Guaje Canyon. Vegetation in upper Guaje Canyon is characterized by mixed conifer with aspen, and ponderosa pine. The National Wetlands Inventory (NWI) classifies this area as riverine, upper perennial, unconsolidated bottom, and permanently flooded (Foxx 1995, 50039, p. xiii).

The terrain in the mid-portion of Guaje Canyon is much like that in the upper portion. Although the canyon sides are not as steep as those in upper Guaje Canyon, the canyon bottom is narrow and is characterized by dense vegetation (mixed conifer with aspen). Water flow in the stream channel in middle Guaje Canyon is ephemeral. The NWI classifies this area similar to upper Guaje Canyon.

The lower section of Guaje Canyon is broader than the upper and middle sections. Where surveys were conducted in lower Guaje, the stream is ephemeral. The NWI classifies this area as riverine, intermittent, streambed, and seasonally flooded. Vegetation in lower Guaje Canyon is characterized by mixed conifer, ponderosa pine, and piñon-juniper (Foxx 1995, 50039, p. xiii).

For the canyon bottom and riparian vegetation, vegetation surveys along the stream channel and within the canyon bottom showed 126 species in Guaje Canyon. Understory species with the highest importance values were as follows: cutleaf coneflower, goosegrass, Richardson's geranium, and meadow horsetail (Foxx 1995, 50039, p. xvi).

Table 3.5-3
Dominant Trees and Shrubs of Guaje Canyon

Area of Canyon	Dominant Trees	Dominant Shrubs
Upper	Alder	Cliff bush
	New Mexico maple	Serviceberry
	Engelmann spruce	
	Ponderosa pine	
Middle	Alder	Serviceberry
	Water birch	Rose
	Aspen	
	Douglas fir	
Lower	New Mexico maple	Gooseberry
	Alder	Fendler
	Narrowleaf cottonwood	Barberry
	Ponderosa pine	

Source: Foxx 1995, 50039, p. xv.

3.5.4.2 Fauna

The Ecological Studies Team (EST) of the Laboratory's Ecology Group (ESH-20) collected aquatic samples from the streams within Guaje Canyon during two six-month sampling seasons in 1993 and 1994. The EST measured water quality parameters and collected aquatic macroinvertebrates from permanent sampling stations (Foxx 1995, 50039, p. 91). Over 35,000 individual aquatic invertebrates within 81 taxa in Guaje Canyon were collected, identified, and analyzed (Foxx 1995, 50039, p. xvii).

In 1993 and 1994, 6 plant litter samples were collected from below deciduous trees or shrubs in Guaje Canyon. Using standardized sorting and identification techniques, a total of 997 individual snails representing 8 families and 13 species were sorted and identified. Species richness and numbers of individuals varied greatly between samples (Foxx 1995, 50039, p. 195).

For two consecutive years (1993 and 1994), terrestrial arthropod studies were conducted in Guaje Canyon. More than 22,500 arthropods were captured and identified. All arthropods were identified down to the family level (Foxx 1995, 50039, p. 225). The EST also conducted surveys of the birds in Guaje Canyon in 1993 and 1994. In 1993, they found 48 species and 669 birds and in 1994 the census revealed 42 species and 568 birds in Guaje Canyon.

In July and August 1993 and 1994, the BRET conducted field surveys in Guaje Canyon. Biological data were collected, including live-capture and release studies on rodent populations. The primary purpose of collecting small mammal data was to obtain sufficient information to estimate population size, density, and species diversity. The trapping sites were located in two habitat types: mixed conifer and ponderosa pine, and a transition zone of these two types. Deer mice were captured in all trapping locations. Shrews and voles were captured in the upper locations of the canyon and deer mice and a small number of harvest mice were captured in the ponderosa pine habitat of the lower portion of the canyon (Foxx 1995, 50039, p. 255).

Eleven small mammals were captured from Los Alamos and Guaje Canyons. Eight percent (8%) of the deer mice and four percent (4%) of the voles captured in Guaje and Los Alamos Canyons were positive for hantavirus. Three other species were questionably positive.

3.5.4.3 Threatened and Endangered Species

The BRET maintains a threatened, endangered, and sensitive database of all species that potentially occur in Los Alamos and surrounding counties. The threatened, endangered, and sensitive database search identified 23 species that might be present in Guaje Canyon. Four species (Mexican spotted owl, spotted bat, meadow jumping mouse, and Jemez Mountain salamander) have a high or high-to-moderate potential for actually occurring within Guaje Canyon. In addition, eight species were identified but more data were required to determine their presence in the canyon (Foxx 1995, 50039, p. 277). Threatened, endangered, and sensitive species that potentially occur in the Guaje Canyon watershed are listed in Table 3.5-4.

Table 3.5-4
Threatened, Endangered, and Sensitive Species
Potentially Occurring in the Guaje Canyon Watershed

Common Name	Scientific Name	Legal Status	Potential for Occurrence
Western toad	*Bufo boreas*	State endangered	Low
Jemez Mountain salamander	*Plethodon neomxicanus*	State-endangered candidate for federal listing	Moderate to high
Mexican spotted owl	*Strix occidentalis lucida*	Federally threatened	Low
Northern goshawk	*Accipiter gentilis*	Federal candidate	Low
Common black hawk	*Buteogallus anthracinus*	State protected	Low to none
Bald eagle	*Haliaeetus leucocephalus*	Federally endangered	Low to none
Mississippi kite	*Ictinia mississippiensis*	State endangered	Low to none
Whooping crane	*Grus americana*	Federally endangered	Low
Least tern	*Sterna antillarum*	Federally endangered and state-endangered	Low
White-faced Ibis	*Plegadis chihi*	Candidate for federal listing	Low
Broad-billed hummingbird	*Cyantyhs latirostris*	State endangered	Low to none
Willow flycatcher	*Empidonax traillii*	Federal candidate	Low to none
Rio Grande silvery minnow	*Hybognathus amarus*	Federally proposed and state endangered	Low
Bluntnose shiner	*Notropis simus*	State endangered	Low
Pine marten	*Martes americana*	State endangered	Moderate
Spotted bat	*Euderma maculatum*	Federal candidate/state threatened	Moderate to high
Meadow jumping mouse	*Zapus hudsonius luteus*	Candidate for federal listing/state endangered	Moderate to high
Occult little brown bat	*Myotis lucfugus occultus*	Candidate for federal listing/state endangered	Moderate
Wood lily	*Lilium philadelphicum*	Candidate for federal listing/state endangered	Moderate
Helleborine orchid	*Epipactis gigantea*	State endangered	Moderate
Lilljeborg's pea-clam	*Pisidium lilljeborgi*	State endangered	Low to moderate
Say's pond snail	*Lymnaea caperata*	State endangered	Low

Source: Foxx 1995, 50039, p. 280; LANL 1997, 62316, p. 3-49.

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These numbers are assigned by the Laboratory's ER Project to track records associated with the project. These numbers can be used to locate copies of the documents at the ER Project's Records Processing Facility and, where applicable, within the ER Project reference library titled "Reference Set for Canyons."

Copies of the reference library are maintained at the New Mexico Environment Department Hazardous Waste Bureau; the US Department of Energy-Los Alamos Area Office; US Environmental Protection Agency, Region 6; and the ER Project Canyons Focus Area. This library is a living document that was developed to ensure that the administrative authority has all the necessary material to review the decisions and actions proposed in this document. However, documents previously submitted to the administrative authority are not included in the reference library.

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Appendix E

Geophysical Investigation