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Investigation Work Plan for Sites at Technical Area 49 Inside the Nuclear Environmental Site Boundary

Prepared by the Environmental Programs Directorate

Los Alamos National Laboratory, operated by Los Alamos National Security, LLC, for the U.S. Department of Energy under Contract No. DE-AC52-06NA25396, has prepared this document pursuant to the Compliance Order on Consent, signed March 1, 2005. The Compliance Order on Consent contains requirements for the investigation and cleanup, including corrective action, of contamination at Los Alamos National Laboratory. The U.S. government has rights to use, reproduce, and distribute this document. The public may copy and use this document without charge, provided that this notice and any statement of authorship are reproduced on all copies.

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EXECUTIVE SUMMARY

This investigation work plan presents the investigation activities at solid waste management units (SWMUs) and areas of concern (AOCs) located at Technical Area (TA) 49 within the nuclear environmental site (NES) boundary. The purpose of this work plan is to (1) complete the Resource Conservation and Recovery Act facility investigation by defining the nature and extent of potential contamination at the sites included in this work plan, (2) obtain general site characterization data for the evaluation of remedial alternatives, and (3) establish a long-term site-specific monitoring network. This work plan addresses only those sites at TA-49 that are within the boundaries of a Hazard Category-2 NES. This NES contains an underground radionuclide inventory exceeding U.S. Department of Energy STD-1027 thresholds.

TA-49 sites will be investigated under two separate work plans in accordance with the March 1, 2005, Compliance Order on Consent (the Consent Order): the TA-49 sites within the NES boundary (this document) and the TA-49 sites outside the NES boundary. TA-49 sites within the NES boundary include 11 SWMUs and AOCs, several of which comprise Material Disposal Area (MDA) AB. The U.S. Environmental Protection Agency approved Area 11, AOC 49-009, for no further action; therefore, the site is not included in this work plan.

Ten SWMUs and AOCs are included in this work plan. However, (surface) soil contamination at AOC 49-008(c) is deferred per Table IV-2 of the Consent Order. Therefore, no surface investigation will be conducted at AOC 49-008(c). Subsurface investigations will be conducted at all sites, including AOC 49-008(c). This work plan also includes one site (SWMU 49-003) that is not deferred. SWMU 49-003 is contained within the boundaries of AOC 49-008(c), which is deferred per Table IV-2 of the Consent Order. SWMU 49-003 is a subsurface leach field with no surface expression. Although this work plan does include subsurface sampling for the SWMU 49-003, it does not propose sampling for the encompassing deferred site, AOC 49-008(c).

To facilitate the discussion of these sites and the corresponding proposed activities, the SWMUs and AOCs included in this work plan are subdivided according to their locations and operational histories into the following six areas.

- Area 1: SWMU 49-001(a), experimental shafts
- MDA AB:
    - ❖ Area 2: SWMU 49-001(b), experimental shafts; and SWMU 49-001(g), contaminated surface soil
    - ❖ Area 2A: 49-001(c), experimental shafts
    - ❖ Area 2B: 49-001(d), experimental shafts
- Area 3: SWMU 49-001(e), experimental shafts
- Area 4: SWMU 49-001(f), experimental shafts
- Area 11: SWMU 49-003 and AOC 49-008(c), leach field, associated drainlines, and an area of potential soil contamination
- Area 12: AOC 49-008(d), Bottle House, and Cable Pull Test Facility

The main activities associated with the investigations are (1) conducting geodetic and geophysical surveys to locate SWMUs and AOCs and associated subsurface structures, historical sampling locations, and proposed sampling locations; (2) conducting radiological surveys of surface radiation; (3) sampling surface and subsurface soil; and (4) drilling boreholes and performing subsurface sampling.

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1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by Los Alamos National Security, LLC. The Laboratory is located in north-central New Mexico approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory covers 40 mi^2 of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons containing perennial and intermittent streams running from west to east. Mesa tops range in elevation between 6200 and 7800 ft above mean sea level (amsl).

The Laboratory's Environmental Programs (EP) Directorate, formerly the Environmental Restoration 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 EP Directorate is to ensure that past operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve this goal, the EP Directorate is currently investigating sites potentially contaminated by past Laboratory operations. The sites under investigation are designated as either solid waste management units (SWMUs) or areas of concern (AOCs).

The SWMUs and AOCs addressed in this investigation work plan are potentially contaminated with both hazardous and radioactive components. The New Mexico Environment Department (NMED), pursuant to the New Mexico Hazardous Waste Act (HWA), regulates cleanup of hazardous wastes and hazardous constituents. DOE regulates cleanup of radioactive contamination, pursuant to DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management." Information on radioactive materials and radionuclides, including the results of sampling and analyses of radioactive constituents, is voluntarily provided to NMED in accordance with DOE policy.

Corrective actions at the Laboratory are subject to the March 1, 2005, Compliance Order on Consent (the Consent Order) issued pursuant to the New Mexico HWA, New Mexico Statutes Annotated (NMSA) 1978, § 74-4-10, and the New Mexico Solid Waste Act, NMSA 1978, § 74-9-36(D). This work plan describes work activities that will be executed and completed in accordance with the Consent Order as well as those activities needed to meet DOE requirements for radiological contamination.

Technical Area (TA) 49 sites within the nuclear environmental site (NES) boundary include 11 SWMUs and AOCs, several of which comprise Material Disposal Area (MDA) AB (Table 1.1-1). The U.S. Environmental Protection Agency (EPA) approved one site, AOC 49-009, for no further action (NFA); therefore, the site does not require additional action under the Consent Order and is not included in this work plan. The remaining SWMUs and AOCs are included in this work plan and include SWMUs 49-001(b), 49-001(c),49-001(d), 49-001(g), 49-001(a), 49-001(e), 49-001(f), 49-003, and AOCs 49-008(c) and 49-008(d). In this work plan, SWMUs 49-001(b), 49-001(c), 49-001(d), and 49-001(g) are referred to as MDA AB; however, historically, MDA AB also included SWMUs 49-001(a), 49-001(e), and 49-001(f).

Soil contamination at AOC 49-008(c) is deferred per Table IV-2 of the Consent Order. Therefore, no surface investigation is proposed at AOC 49-008(c). Subsurface investigations will be conducted at all sites, including AOC 49-008(c). This work plan also includes one site (SWMU 49-003) that is not deferred. SWMU 49-003 is contained within the boundaries of AOC 49-008(c), which is deferred per Table IV-2 of the Consent Order. SWMU 49-003 is a subsurface leach field with no surface expression. Although this work plan does include subsurface sampling for the SWMU 49-003, it does not propose sampling for the encompassing deferred site, AOC 49-008(c).

To facilitate the discussion of these sites and their corresponding proposed activities, the SWMUs and AOCs included in this work plan are subdivided according to their locations and operational histories into six areas.

- Area 1: SWMU 49-001(a), experimental shafts
- MDA AB:
    - ❖ Area 2: SWMU 49-001(b), experimental shafts; and SWMU 49-001(g), contaminated surface soil
    - ❖ Area 2A: 49-001(c), experimental shafts
    - ❖ Area 2B: 49-001(d), experimental shafts
- Area 3: SWMU 49-001(e), experimental shafts
- Area 4: SWMU 49-001(f), experimental shafts
- Area 11: SWMU 49-003 and AOC 49-008(c), leach field, associated drainlines, and an area of potential soil contamination
- Area 12: AOC 49-008(d), Bottle House, and Cable Pull Test Facility (CPTF)

The site descriptions and operations as well as historical investigations are summarized for each SWMU and AOC in the following sections and are included in detail in a separate historical investigation report (HIR) (LANL 2007, 098492).

1.1 General Site Information

Technical Area 49, also known as the Frijoles Mesa site, occupies approximately 1280 acres along the south-central boundary of the Laboratory. The mesa is centrally located on the Pajarito Plateau at an average elevation of approximately 7140 ft amsl. The plateau is roughly midway between the Jemez Mountains to the west and the White Rock Canyon of the Rio Grande to the east. TA-49 is located within the Ancho, North Ancho, and Water Canyon Watersheds. The northern boundary of TA-49 is defined by the edge of the Frijoles Mesa, which overlooks Water Canyon and forms the southern boundaries of TA-15 and TA-37. State Highway 4 forms the southwest boundary of TA-49 as well as the Laboratory's boundary with Bandelier National Monument. The southeast boundary of TA-49 is formed by TA-39. Table 1.1-1 lists the SWMUs and AOCs inside the TA-49 NES boundary.

A period of intense experimental activity at TA-49 took place from late 1959 to mid-1961, during which hydronuclear and related experiments deposited significant amounts of plutonium, uranium, lead, and beryllium in underground shafts. Thirty-five hydronuclear experiments and nine related calibration, equation-of-state, and criticality experiments, all involving some fissile material, were conducted in 3-ft- or 6-ft-diameter shafts at depths ranging from 31 ft to 108 ft (Purtymun and Stoker 1987, 006688, p. 2).

Areas 1, 2, 2A, 2B, 3, and 4 each contain subsurface test shafts used from 1959 to 1961 for underground hydronuclear safety, tracer, and containment experiments. Area 11 is the site of a former radiochemistry laboratory, associated leach field, and subsurface test-shot area. Area 12 includes the former Bottle House and CPTF. Sporadic and noncontinuous areas of surface soil contaminated with hazardous and radioactive materials have historically been associated with each area.

Figure 1.1-1 presents the location of TA-49 in relation to the Laboratory. Figure 1.1-2 illustrates the location of each TA-49 SWMU and AOC.

1.2 Investigation Scope and Objectives

This investigation work plan describes the sampling supplemental to the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plan for Operable Unit (OU) 1144 (LANL 1992, 007670) for and Areas 1, 2, 2A, 2B, 3, 4, 11, and 12. This investigation work plan complies with requirements specified in the Consent Order for the completion of TA-49 investigations as well as the format requirements for investigation work plans. This investigation work plan presents the rationale for the remaining surface and subsurface sampling and analyses for Areas 1, 2, 2A, 2B, 3, 4, 11, and 12. This work plan will achieve the following objectives: (1) determine the nature and extent of contamination in soil, sediment, surface water, and groundwater at TA-49; (2) obtain general site characterization data for the evaluation of remedial alternatives; and (3) establish a long-term site-specific monitoring network.

2.0 BACKGROUND

2.1 Site Operational History

Before 1959, the Laboratory recognized there were potential safety problems with nuclear weapons in the nation's stockpile. These problems were related to the possibility of a significant nuclear yield because of accidental detonation of the device's high explosive (HE) component. The possibility of detonation during the assembly stage or while the device was stored in the arsenal required further investigation. Underground experiments were designed and conducted to assess this potential problem. Historical aspects of the decision to conduct the experiments are described in a Laboratory report (Thorn and Westervelt 1987, 006672, p. 1-3). The favorable environmental setting of Frijoles Mesa, combined with its relatively remote location and the flat terrain that afforded desirable operational characteristics, led to selection of the Frijoles Mesa site for the experiments. In fall 1959, TA-49 was created on Frijoles Mesa and underground experiments were conducted through August 1961. The central portion of TA-49 was devoted to the site of the underground experiments conducted in Areas 1, 2, 3, and 4 (Figure 1.1-2).

An unusual aspect of the hydronuclear safety experiments was that the use of special nuclear materials (SNM) required extremely close accounting of the quantities of uranium, plutonium, lead, and beryllium. The quantities and locations of these materials are known with an unusually high degree of precision. Explosives used in the experiments consisted largely of TNT (2,4,6-trinitrotoluene); RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine); and HMX (1,3,5,7-tetranitro-1,3,5,7-tetrazocine). It is likely that the explosives, except for a barium component used as an inert in explosives, were completely consumed by the detonations. Based on the detailed historical information available, it is evident that other chemicals were used in limited quantities at TA-49 (LANL 1992, 007670, p. 3-8).

The majority of TA-49 contaminants consist of buried radionuclides, lead, and beryllium. In 1986, MDA AB was estimated to contain over 80% of the Laboratory's inventory of buried transuranic material by radioactivity content (LANL 1992, 007670, p. 7-17).

The primary historical use of TA-49 as a buffer zone for activities at adjacent firing sites (TA-15 and TA-39) is expected to continue indefinitely according to the Laboratory's Ten-Year Comprehensive Site Plan (LANL 2001, 070210).

Currently, there are only a few small-scale on-site uses of TA-49. The Laboratory's High-Power Microwave Group occasionally uses the Day Room building (building 49-115) and its immediate vicinity for equipment development and the roadway between Areas 10 and 12 as a microwave test range. The Laboratory's Hazardous Devices Team uses the Hazardous Devices Team Training Facility

(building 49-113) and the associated HE magazine (structure 49-114) for small-scale explosives training exercises.

Building 49-113 also houses the Laboratory's Alternate Emergency Operations Center. This facility is equipped with extensive communications systems and computers. In addition, the building is used for routine classroom training and the Laboratory conducts electrical grounding measurements in a small area immediately west of the Hazardous Device Team Training Facility.

The Laboratory also maintains the Bandelier Meteorological Station in the southeast portion of TA-49 as part of its network of meteorological stations (LANL 1992, 007670, p. 3-12).

Past soil moisture-monitoring activities occurred in Area 2 of TA-49 on a quarterly basis, but moisture data are no longer collected (LANL 2005, 092389). The Ancho Canyon Watershed is also monitored as part of the Laboratory's "2007 Interim Facility-Wide Groundwater Monitoring Plan" (IFGMP) (LANL 2007, 096665) and includes continuous monitoring of regional wells DT-5A, DT-9, and DT-10, which are located within TA-49 (LANL 2007, 096665, p. 24).

2.2 Important Historical Events

Hydronuclear safety experiments (shots) were conducted in subsurface shafts between January 1960 and June 1961 (Thorn and Westervelt 1987, 006672, p. 5-6). Shot locations, type of shots executed, and shot depths are illustrated in Figures 2.2-1 through 2.2-4 (Area 1; Areas 2, 2A, and 2B; Area 3; and Area 4; respectively).

An unexpected contamination incident occurred during the hydronuclear safety experiments at MDA AB in 1960 during the drilling and subsequent drifting of shaft 2-M (LANL 1992, 007670, p. 3-11). In November 1960, the horizontal drift for shaft 2-M (Figure 2.2-2) was drilled toward the southwest and intercepted contamination from the southeast-trending horizontal drift from shaft 2-L (completed for shot 2-L). In December, contamination from shot 2-L was discovered around Area 2, found in Area 6, and traced to shops at TA-3. During cleanup, contaminated equipment and soil were placed into shaft 2-M (no shot was fired in 2-M, but the shaft is filled with contaminated materials). In January 1961, the surface of Area 2 was capped with compacted clay and gravel after all the open shafts were filled with sand and crushed tuff. In September 1961, the cap was extended 12.5 ft beyond the outermost shafts and paved with 4 to 6 in. of asphalt to retard infiltration. The shaft 2-M contamination incident left near-surface radionuclide contamination beneath the Area 2 asphalt pad. It is believed that this is the source of most or all of the above-background levels of radionuclides historically observed in surface soil and drainage areas around Area 2 (LANL 1992, 007670, pp. 7-26–7-27).

Other releases of radionuclides occurred in January 1960 at shaft 2-H, in March 1960 at shaft 2-S, and in March 1961 at shaft 2B-H (Weir and Purtymun 1962, 011890). In all three cases, contamination was controlled by covering contaminated soil with concrete pads (LANL 1998, 059166, pp. 6–7).

In 1970 and 1971, Area 11 radiochemistry structures were decontaminated, demolished, and removed (LANL 1992, 007670, p. 6.2-6).

The second significant event at shaft 2-M occurred in March 1975 when it was discovered that the asphalt pad over the backfilled shaft had collapsed, leaving an opening approximately 6 ft × 3 ft wide and 3 ft × 4 ft deep in the asphalt and underlying fill. An inspection of core hole CH-2 indicated that the water level had risen to approximately 50 ft of standing water (approximately 450 ft below ground surface [bgs]) since the previous inspection (LANL 1992, 007670, p. 7-28). The hole in the asphalt may have formed in late 1974 and collected snowmelt throughout the winter.

In September 1976, the opening over shaft 2-M was filled with crushed rock and clay, and the entire pad was repaved with another 4 to 6 in. of asphalt (Purtymun and Ahlquist 1986, 014722). Unfiltered samples of the water bailed from core hole CH-2 in October 1977 and August 1978 yielded concentrations of 1.7 to 3.1 pCi/L of plutonium-239. It was concluded that the opening in the asphalt pad allowed water to collect, penetrate the pad, and contact subsurface contamination (possibly contaminated backfill in shaft 2-M) (Purtymun and Stoker 1987, 006688, p. 14). The contaminated water presumably moved through fractures to core hole CH-2 and traveled down the annular spacing between the casing and the borehole (LANL 1992, 007670, p. 7-28). Another possibility is the enhanced infiltration caused by the collapsed hole created saturated soil conditions that extended laterally to core hole CH-2 and traveled down the annular spacing between the casing and the core hole. In this case, the source of the contamination would be the soil rather than shaft 2-M. Core hole CH-2 was originally drilled to a diameter of 4 in. and reamed to a diameter of 6.5 in. to facilitate logging (Zia Company 1960–1962, 098490); the casing installed was 2-in. galvanized pipe (Weir and Purtymun 1962, 011890, p. 29). Because of the annular spacing between the casing and core hole, downward flow may have been likely given saturated soil conditions and the open space or loose backfill in the annular spacing.

In 1977, the La Mesa fire burned over much of TA-49, destroying essentially all remaining combustible structures (LANL 1992, 007670, p. 3-10).

Several times from April to May 1979 and from April to June 1980, approximately 150 ft of standing water was measured in core hole CH-2. During this period, water was bailed from core hole CH-2, and the filtered water and suspended sediment were analyzed for isotopic plutonium. Concentrations ranged from 0.1 to 5.5 pCi/L for filtered water and from 0.54 to 0.72 pCi/g for suspended sediment (LANL 1992, 007670, p. 7-30).

In 1980, a study was performed in order to understand the observed accumulation of water in core hole CH-2. This study involved drilling five test holes (TH-1, TH-2, TH-3, TH-4, and TH-5) at locations adjacent to Areas 2, 2A, and 2B (Figure 2.2-5). The boreholes were drilled to depths that would provide moisture monitoring of the tuff below the bottom of the shafts in Areas 2, 2A, and 2B. Cuttings from the holes were logged and moisture content was determined at 5-ft drilling intervals. Three additional test holes (2A-O, 2A-Y, and 2B-Y) were drilled in unused, backfilled shot shafts. The boreholes were drilled through the sand fill and into the underlying tuff. The boreholes were logged, and moisture content was determined for the sand and tuff. The test holes were cased with 2-in. polyvinyl chloride (PVC) pipe to facilitate neutron logging. Casing depths vary, depending on how much sloughing occurred when the auger was pulled from the test hole (Purtymun and Ahlquist 1986, 014722, p. 16). Details for these boreholes are summarized in Table 2.2-1.

From 1980 to 1987, core holes CH-1, CH-2, CH-3, and CH-4 were monitored for standing water on an annual basis. No standing water was detected during this period in any TA-49 core hole, including CH-2, which had been bailed dry in June 1980 (LANL 1992, 007670, p. 7-30).

In 1981, the upper 2 ft of sand in the sand-filled shafts in Areas 2A and 2B was replaced with concrete (LANL 1992, 007670, p. 7-30).

In May 1991, cracks were observed in the Area 2 asphalt pad. Inspection of core hole CH-2 indicated the presence of approximately 100 ft of standing water. The cracks in the asphalt pad were resealed in November 1991. Through the summer and fall of 1991 and spring of 1992, water-level measurements collected on a monthly basis indicated that the water level remained stable. In December 1991, a transducer was installed in core hole CH-2 for continuous monitoring of the water level. Data from December 1991 to April 1992 indicated the water level in core hole CH-2 remained stable. The stability of the water level is significant because it indicates that the response was very sluggish to both the intense

rainfall that occurred throughout the summer of 1991 and the snowmelt in the spring of 1992. Water analyses for a bailed sample from core hole CH-2 in May 1991 indicated measurable, but low concentrations of plutonium-239/240 (LANL 1992, 007670, p. 7-34).

In 1994, a surface and subsurface RFI was conducted at MDA AB and Areas 1, 3, 4, 11, and 12. For the subsurface RFI at Area 2, seven boreholes (four shallow and three deep) were drilled for hydrogeologic characterization and for determining the nature and extent of contamination (LANL 1999, 070349). The locations of the seven boreholes are presented in Figure 2.2-5. The four 10-ft-deep boreholes (locations 49-02902, 49-02903, 49-02904, and 49-02905) were backfilled immediately after drilling and sample collection had been completed. The two 150-ft-deep boreholes (locations 49-02906 and 49-02907) and one 700-ft-deep borehole (49-02901) were cased and left open for monitoring purposes. The 700-ft-deep borehole (49-02901) was drilled approximately 100 ft to the southeast of the boundary of Area 2, while the other six boreholes were drilled through the asphalt cover on Area 2. Results of the 1994 surface and subsurface RFIs are summarized in sections 2.4 through 2.10 and in detail in section 3.0 of the HIR associated with this work plan (LANL 2007, 098492).

The Area 2 asphalt pad was removed during an interim measure (IM) implemented in 1998 in cooperation with NMED (LANL 1999, 063919, p. 6). The area was covered with soil and gravel as part of stabilization activities. The IM was conducted to address concerns arising from moisture accumulation beneath the asphalt pad. The asphalt cap was replaced with an evapotranspiration (ET) cover that is 2.1 m thick in the center tapering to 0 at the edges to control moisture migration. The cover is instrumented to monitor moisture quarterly (LANL 2005, 092389).

In May 2000, the Cerro Grande fire burned the western and northern edges of TA-49, but did not burn vegetation or remaining structures near MDA AB.

2.3 Conceptual Site Model

Releases at the TA-49 NES can be organized into three general categories: (1) deep inventory remaining in place within the hydronuclear testing shaft areas (Areas 1, 2, 2A, 2B, 3, and 4); (2) highly localized surface and near-surface contamination; and (3) minor inventories associated with supporting experimental areas (Areas 11 and 12).

The presence of surface contamination is primarily attributed to the tracking of contaminated material brought to the surface during the release event associated with the shaft 2-M incident (section 2.2) and, to a lesser extent, is associated with localized operations at the testing and support areas. Surface contamination observed during previous investigations indicates a sporadic heterogeneous distribution of contaminants with a generally low correlation of radionuclide and inorganic chemical collocation. Primary transport pathways focus on the potential for surface-water runoff and erosion by water and air. The mesa setting at TA-49 provides a predominately flat topography, with the exception of SWMU 49-001(g), which is located north of Area 2 on a slope toward Water Canyon. Historically, excavation and dispersion of contaminated soil by burrowing animals has occurred at Area 2 but has been minimized since the installation of the biobarrier as part of the IM activities performed at the site (section 2.5.1.4).

Permeability and dominant transport potential are variable for the stratigraphic units beneath TA-49 (Figure 2.3-1). Generalized characteristics for each are described below:

- The Tshirege Member of the Bandelier Tuff (Qbt) is characterized by low matrix permeability and high fracture permeability where fractures are present. Fracturing is more abundant in the upper cliff forming unit of Qbt 3 and characteristic of Qbt 2 (Broxton and Reneau 1995, 049726, pp. 15–17). In borehole location 49-02901, it was noted that only a few irregular fractures are

present in the first 35 ft and four subvertical fractures with mineral coatings from 243 to 255 ft bgs within Qbt 2 (Stimac et al. 2002, 073391, p. 8).

- Pumiceous units such as the Tsankawi Pumice Bed (Qbt t), the Cerro Toledo interval (Qct), and the surge bed at the base of Qbt 4 are characterized by low fracture permeability and high matrix permeability.
- The Otowi Member of the Bandelier Tuff (Qbo) is a relatively homogenous ash-flow tuff unit and is characterized by low fracture permeability and low matrix permeability.

The subsurface conceptual site model (CSM) at TA-49 includes the following key elements (LANL 1992, 007670, pp. 4-54–4-55).

- The transport of contaminants through the unsaturated zone to the regional aquifer is not a pathway of immediate concern because of the very thick unsaturated zone and low percolation rate at the site.
- The movement of contaminants by percolating water in the unsaturated zone is expected to occur primarily as suspended solids.
- Although fractures may facilitate contaminant transport, this should occur only above critical water content; therefore, matrix flow is expected to be the dominant transport mechanism.
- Unit contacts and characteristics (e.g., the surge bed at the base of Qbt 4, the vapor-phase notch at the base of Qbt 1v-c, the Tsankawi Pumice Bed [Qbt t] and the Cerro Toledo interval [Qct]) can strongly affect lateral flow.
- Significant saturated flow is unlikely, but transient, rather than steady conditions may describe the near-surface conditions.

The hydronuclear shaft areas contain a low to moderate inventory of mobile contaminants and a large inventory of strongly adsorbing contaminants. The necessary drivers for contaminant mobility in the vadose zone include saturated or near-saturated conditions or a significant vapor phase. Neither of these drivers are anticipated because of low present-day infiltration conditions across the site.

Moisture-monitoring data at TA-49 support the CSM under native conditions. Since 1959, the water content of tuff in native areas has been measured in the unsaturated zone. Moisture content tends to be very low, ranging from 5% and 10% by volume to depths of approximately 100 ft (Weir and Purtymun 1962, 011890; LANL 2005, 092389, pp. A-1–A-3). Near-surface water content measured from locations within the boundary of the ET cover and former asphalt pad at MDA AB tend to be slightly higher, ranging from 5% to 20% by volume to depths of approximately 30 ft (LANL 2005, 092389, pp. A-3–A-6). Continuous moisture monitoring of the near-surface cover material at Area 2 shows that seasonal impulses of water are readily removed in the spring and summer when ET is maximized.

Area 2, part of MDA AB, presents a unique situation where native conditions have been altered because of the installation of an asphalt pad. The asphalt pad increased moisture accumulation at the site as discussed in section 2.2. Therefore, the CSM for Area 2 includes a period of enhanced infiltration from 1961 to 1998 followed by a return to near-background conditions. However, the impact of increased infiltration in shaft 2-M and standing water in the Area 2 core hole, CH-2, introduces uncertainty in the moisture profile and potential for contaminant migration to depths of 500 ft or greater immediately beneath shaft 2-M and core hole CH-2.

No substantial direct human exposure routes (other than those created by deliberate excavation of the materials during remediation) have been identified for contaminants in deeply buried waste units at

TA-49. The likelihood is high that future land use at TA-49 will not change significantly over the 100-yr period assumed for institutional control, and it will remain industrial. Table 2.3-1 provides the industrial soil screening levels for TA-49. Over longer time frames, surface-water infiltration to groundwater may be relevant because of the magnitude of the source term in MDA AB and Areas 1, 3, and 4 (LANL 1992, 007670, p. 4-50).

2.3.1 Potential Receptors

A detailed discussion of potential receptors can be found in the "RFI Work Plan for OU 1144" (LANL 1992, 007670, pp. 4-47–4-50). At present, the relevant human receptor of TA-49 contaminants is an on-site worker. Contaminated surface soil, inhalation, dermal contact, external irradiation, and incidental ingestion are identified as the most likely exposure pathways in this case.

Excavation and dispersal of contaminated soil by burrowing animals have occurred at MDA AB; thus, burrowing animals are known biological receptors. Uptake and dispersion of soil contamination by plants also may occur. In addition, such biological activity can lead to enhanced human exposure through direct contact, inhalation, or ingestion. Dispersion of soil contamination into the atmosphere by wildfire is also a potential pathway for human exposure.

2.4 Area 1: SWMU 49-001(a), Experimental Shafts

2.4.1 Site Description

SWMU 49-001(a), known as Area 1, is an area of experimental shafts within MDA AB. Area 1 is approximately 100 ft × 100 ft in area. Twenty-two shafts were drilled at Area 1 to depths ranging from 31 ft to 80 ft bgs. Ten of the 22 shafts were used for shot testing using radioactive materials, 5 of the shafts were used for containment testing using HE only, 6 of the shafts were not used and were backfilled, and 1 shaft was used as a gas expansion hole. Substantial amounts of lead generally were present in the experimental packages, and small amounts of beryllium may have been used in some experiments. Figure 2.2-1 presents the shaft locations, shaft depths, and shot types in Area 1 (LANL 2007, 098492).

2.4.2 1995 RFI

In 1995, a surface RFI was performed at Area 1, SWMU 49-001(a). Twenty surface-soil samples were collected. All samples were submitted for laboratory analyses of gamma-emitting radionuclides. Ten of the samples were submitted for laboratory analyses of inorganic chemicals, including total uranium and isotopic plutonium (LANL 2007, 098492).

Decision-level data indicate uranium and zinc detected above background values (BVs) in Area 1. Total uranium and zinc concentrations were detected above BVs and concentrations of plutonium-239/240 were detected above fallout values (FVs) (LANL 1998, 059730).

Concentrations and sampling locations of inorganic chemicals and radionuclides above BVs or FVs are presented in Figures 2.4-1 and 2.4-2 and Tables 2.4-1 and 2.4-2.

The "Work Plan for OU 1144" proposed one 150-ft borehole, one 700-ft borehole, and one lateral borehole beneath Area 1 (LANL 1992, 007670, pp. 7-66–7-69); however, the boreholes were not drilled (LANL 2007, 098492).

2.5 Areas 2, 2A, and 2B: SWMUs 49-001(b), 49-001(c), 49-001(d), and 49-001(g), MDA AB

In this work plan, SWMUs 49-001(b), 49-001(c), 49-001(d), and 49-001(g) are referred to as MDA AB. However, historically, MDA AB also included SWMUs 49-001(a), 49-001(e), and 49-001(f). With the exception of SWMU 49-001(g), all SWMUs are associated with hydronuclear and related experiments conducted at TA-49 from late 1959 to mid-1961. These experiments were conducted in underground shafts (typically 6 ft in diameter) drilled into the tuff at Areas 1, 2, 2A, 2B, 3, and 4 and involved the use of HE and radioactive materials such as SNM (plutonium-239 and uranium-235). SWMU 49-001(g) is a site of contaminated surface soil associated with Area 2 activities (LANL 2007, 098492).

Before being used for hydronuclear experiments, some of the shafts were used to conduct containment shots using HE without radioactive materials (LANL 1992, 007670, pp. 7-18–7-19). The containment shots were designed to characterize tuff fracturing that resulted from the underground explosions and to provide data needed to asses whether releases of radioactivity would occur because of experiments. This included determining the required spacing between the experimental shafts so that contamination would not be encountered when a new shaft was drilled adjacent to an existing used shaft. In one incident at SWMU 49-001(b) (Area 2), contamination was encountered during drilling of a new shaft (LANL 2007, 098492).

Experimental packages that contained HE and radioactive materials were placed in the bottom of the shafts, which were backfilled with sand or crushed tuff to provide containment and prevent release of radioactivity (LANL 1992, 007670, pp. 7-19–7-20). Some experiments were configured to collect samples of radioactive particulates entrained in the explosion-generated gases. For these experiments, short, horizontal side drifts were installed at the bottom of the shafts, and pipes routed gases from the drifts to sealed, steel sampling boxes near the surface. After exiting the sampling boxes, the gases were routed back underground through shafts known as gas expansion holes. After an experiment, subsidence caused by the explosion was backfilled with sand or crushed tuff. Shafts used in SNM experiments were generally capped with concrete. If gas-sampling boxes were used, they generally were filled with concrete and left in place. Sample pipes were disposed of in smaller (3-ft-diameter) boreholes known as pipe dump holes (LANL 2007, 098492).

In 1987, the A411 survey was performed to investigate soil contamination at MDA AB and Areas 1, 3, and 4 (Soholt 1990, 007510). Activities included collecting surface soil and vegetation samples from MDA AB and Areas 1, 3, and 4. Samples collected in Area 1 indicated negligible surface contamination. Results from samples collected in Areas 2, 2A, and 2B showed elevated levels of plutonium and americium near the northeast corner of the asphalt pad at Area 2. Based on the contamination detected at Area 2 during the A411 survey, additional soil and vegetation samples and radiological surveys were conducted in September 1987 near the northeast corner of the asphalt pad. Results indicated contamination in a drainage channel flowing from Area 2. Samples were collected from Area 3 from the shaft area and from the area believed to have been used for burning contaminated structures; no significant contamination was detected. At Area 4, samples were collected from the experimental shaft grid and from a leveled area immediately southeast of the shaft area. Several discrete areas had elevated levels of americium-241, plutonium-239/240 (LANL 2007, 098492).

The following sections present descriptions of the individual SWMUs within MDA AB and details regarding the previous investigation activities at each of them.

2.5.1 Area 2: SWMU 49-001(b), Experimental Shafts

2.5.1.1 Site Description

SWMU 49-001(b), known as Area 2, is an area of experimental shafts within MDA AB. Area 2 is approximately 100 ft × 100 ft. This area was designed to contain a maximum of 25 shafts on a uniform 25-ft × 25-ft grid (25-ft shaft spacing). Twenty-two experimental shafts were drilled at Area 2. Four of these, ranging from 52 to 68 ft deep, were used for containment shots or shots with small amounts of uranium tracer. Sixteen shafts were used for other experiments involving radioactive materials. Twelve of the 16 experiments involving radioactive materials used plutonium, 1 used uranium-235, and 3 used uranium-238 as the principal radioactive materials. The experiments using plutonium also used uranium-238 and, in some cases, uranium-235. Similarly, the experiment using uranium-235 also used uranium-238. Most of the shafts used for shots with radioactive materials were 57 ft deep; one shaft was 78 ft deep. One 58-ft-deep shaft was backfilled without being used, and one 35-ft-deep shaft was used as a gas expansion hole. Area 2 also contained five 3-ft-diameter × 30-ft-deep pipe dump holes. Some experiments used downhole neutron sources that expended a total of a few curies of tritium. Some experiments at Area 2 may have used liquid scintillation detectors containing organic chemicals, including p-terphenylene, toluene, polystyrene, and zinc stearate. These organic chemicals should have been consumed during the explosions. Substantial amounts of lead were typically present in the experimental packages, and small amounts of beryllium may have been used in some experiments. Some experiments used portable pulse neutron sources. Large portable concrete radiation shields provided shielding during these experiments. Figure 2.2.2 presents the shaft locations and shot types in Area 2 (LANL 2007, 098492).

In 1961, an asphalt pad was placed over Area 2 in response to the release of radioactive contamination during the drilling of shaft 2-M (previously described in section 2.2). In March 1975, the asphalt pad was discovered to have collapsed over shaft 2-M, creating a hole approximately 6 ft long × 3 ft wide × 3 ft to 4 ft deep in the asphalt and underlying fill. This hole apparently allowed snowmelt to enter core hole CH-2, which is located approximately 10 ft from shaft 2-M. This infiltrating water apparently carried contamination from shaft 2-M into core hole CH-2, and samples of water that accumulated in core hole CH-2 contained plutonium-239. In September 1976, the opening over shaft 2-M was filled with crushed rock and clay, and the entire pad covering Area 2 was repaved with another 4 to 6 in. of asphalt. Monitoring from 1980 to 1987 showed no standing water in core hole CH-2 (LANL 2007, 098492).

In May 1991, cracks were noted in the asphalt pad with vegetation growing through some of these cracks, and standing water was detected again in core hole CH-2 (LANL 1992, 007670, p. 7-34). In November 1991, these cracks were sealed with asphalt. Standing water continued to be detected in core hole CH-2 after the asphalt pad was repaired. The source of water in corehole CH-2 is believed to have originated from the following scenario: during RFI activities in 1994, the soil layer beneath the asphalt pad was observed to be saturated. The water was contaminated with plutonium-239 from shaft 2-M. Water flowed down the annular spacing between the core hole CH-2 casing and the borehole (the casing was 2 in. in diameter). The core hole was reamed to a diameter of 6.5 in. Downward flow in the annular spacing between the casing and core hole may have occurred given saturated soil conditions and the open space or loose backfill in the large annular spacing. Water entered the core hole CH-2 casing through the 20-ft slotted section at the bottom of the casing. The core hole CH-2 casing was removed and the core hole was grouted in 1998 (LANL 2007, 098492).

2.5.1.2 Surface RFI

In April 1993, 34 soil samples (0 to 6 in.) were collected around the asphalt pad and in the northeast drainage of Area 2, SWMU 49-001(b). To establish background concentrations for the area, another nine samples were collected from areas with known or possible contamination. Samples were submitted for laboratory analyses of inorganic chemicals and radionuclides (LANL 1999, 070349, p. 9).

In 1994, a radiological field screening of surface soil in Area 2, SWMU 49-001(b), was performed using a Violinist III field instrument for detection of low-energy radiation. Soil was screened for plutonium-238, americium-241, and cesium-137. Results of the field screening were compared against site background concentrations (LANL 1999, 070349, p. 14).

In 1998, a low-energy gamma detection probe was used to conduct a radiological field screening survey of Area 2, SWMU 49-001(b); Area 12, AOC 49-008(d); and the drainage following the road to the south and stretching into the entrance of Water Canyon to the north. This survey was performed to determine potential release and/or redistribution of radionuclides within and around Area 2, SWMU 49-001(b) (LANL 2007, 098492).

2.5.1.3 Subsurface RFI

In 1994, seven RFI boreholes (four 10-ft boreholes, two 150-ft boreholes, and one 700-ft borehole) were drilled at locations within and near the asphalt pad at Area 2 (LANL 1999, 070349). Borehole location 49-02901 was drilled to a depth of 700 ft with a recovery to 692 ft. The primary objective of borehole location 49-02901 was to evaluate the potential contaminant pathways for the near-surface and the vadose zone to a depth of at least 700 ft (across the potential water-perching Tshirege Otowi contact) (LANL 2007, 098492).

Two 150-ft-deep boreholes (locations 49-02906 and 49-02907) were drilled at or near locations 2-G and 2-R (Figure 2.2-5) to evaluate the subsurface conditions below the depths of the shafts and to augment the existing moisture-monitoring holes, TH-1 through TH-5, around Area 2. Locations 2-G and 2-R were proposed shot shaft locations that were not drilled. Locations 2-G and 2-R were selected because no shots were conducted at these locations and the closest shots were approximately 25 ft away. Therefore, detection of contaminants from nearby shots was unlikely, and these boreholes would confirm that the lateral spread of contamination is limited to less than 25 ft (LANL 2007, 098492).

The 10-ft boreholes (locations 49-02902 through 49-02905) were drilled through the asphalt pad to provide information on the distribution of contaminants in the soil/fill material, to confirm the thickness and composition of the soil/fill, and to quantify the distribution of moisture underneath the pad at the soil/tuff interface. Fourteen samples at location 49-02902 were collected: four for gamma spectroscopy analyses; seven for gross alpha, gross beta, and gross gamma analyses; one for tritium analysis; two for isotopic plutonium analyses; four for metals analyses; nine for percent moisture determination; and two for total uranium analyses. Nine samples at location 49-02903 were collected: four for gamma spectroscopy analyses, gross alpha, gross beta, and gross gamma analyses; one for tritium analysis; two for isotopic plutonium, and metals analyses (including total uranium); and nine for percent moisture determination. Seven samples at location 49-02904 were collected: two for gamma spectroscopy, isotopic plutonium, and metals analyses (including total uranium); three for gross alpha and gross beta analyses; two for gross gamma analyses; one for tritium analysis, and six for percent moisture determination. Nine samples at location 49-02905 were collected: two for gamma spectroscopy, isotopic plutonium and metals analyses (including total uranium); four for gross alpha, gross beta, and gross gamma analyses; one for tritium analysis; one for amerecium-241 analysis; and eight for percent moisture determination. Much of the original 1994 sampling data for isotopic plutonium, uranium, and americium were rejected because of

various laboratory analytical and reporting problems. During 1998, the decision was made to recollect samples from the original core as close as possible to each of the original sampling locations and intervals (LANL 2007, 098492).

In March 1998, a shallow subsurface screening investigation was conducted beneath the asphalt pad at MDA AB (LANL 1999, 070349, p. 14). The investigation was undertaken in preparation for possible earth-moving activities associated with the removal of the asphalt. Twenty-nine shallow borings were advanced beneath the asphalt pad. Based on radiological field-screening results, 20 soil samples were collected and analyzed from the 29 shallow borings. During the field investigation, the locations of the concrete caps (if present) covering the shot shafts were located beneath the asphalt pad to create a reference grid of the area (LANL 2007, 098492).

In May 1998, soil samples were collected beneath the Area 2 asphalt pad for a tritium screening analyses. Twenty-eight samples were collected from locations above each shaft and at shallow borehole locations on the pad. In June 1998, three locations were sampled and field screened for HE around shaft 2B-H directly beneath the cement cap. The samples were collected from 2 to 4 in. bgs depending on the thickness of the cement at the surface (LANL 2007, 098492).

Samples were collected and submitted for laboratory analyses for gamma-emitting radionuclides, tritium, isotopic plutonium, isotopic uranium, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals. No organic chemicals were detected in the samples submitted for VOC and SVOC analyses. One cadmium concentration was detected above BVs and several radionuclide concentrations were detected above BVs or FVs (LANL 2007, 098492).

Sampling locations and sample analytes detected above BVs are presented in Figures 2.5-1 through 2.5-3. Tables 2.5-1 and 2.5-2 provide the concentrations of radionuclides above BVs and inorganic screening-level results. Results indicate that americium-241, plutonium-238, plutonium-239/240 concentrations were detected above BVs at SWMU 49-001(b) (LANL 2007, 098492).

2.5.1.4 Interim Measures

A stabilization plan was prepared for implementing IMs at SWMUs 49-001(b), 49-001(c), 49-001(d), and 49-001(g) (LANL 1998, 059166). These activities were primarily designed to stabilize contamination beneath the asphalt cap and prevent further releases associated with moisture infiltration or biological intrusion. From August 1998 to February 1999, the following activities took place.

- Core hole CH-2 and the two 150-ft RFI boreholes (locations 49-02906 and 49-02907) were plugged and abandoned.
- The existing asphalt cap was removed.
- The site was regraded with crushed tuff.
- A topsoil ET cover was placed over the site, and the ET cover was seeded with shallow-rooting grasses.
- Erosion controls and biological intrusion barriers were installed, and the security fence around the site was replaced (LANL 1999, 063919, p. 1).

During the IM activities performed in 1998, 13 shallow boreholes were drilled into tuff along the western and southern perimeter of MDA AB to provide information on the subsurface stratigraphy. Forty-eight samples were collected from these 13 boreholes and submitted for laboratory analyses of inorganic chemicals, radionuclides, and percent moisture. The IM involved the removal of the asphalt pad overlying

MDA AB. Upon removal, composite samples of asphalt were collected from each of the four corners and from the center of the pad location and were submitted for laboratory analyses of inorganic chemicals and radionuclides. Surface-soil samples were collected from the soil immediately below the asphalt pad at each shaft location and from 6 additional locations for a total of 28 samples. These samples were analyzed for tritium and soil moisture (LANL 1999, 063918; LANL 1999, 063919; LANL 1999, 063920).

2.5.1.5 Best Management Practices

In 1998 and 1999, best management practice activities were conducted at Area 2 including

- installation of a run-on diversion channel to the west of Area 2,
- removal of the asphalt cover over Area 2,
- surface regrading of Area 2 to eliminate ponding,
- grouting and abandonment of core hole CH-2 and the two 150-ft-deep RFI boreholes,
- installation of an ET cover (as part of the IM) composed of crushed tuff monofill and covered with a steel mesh biobarrier,
- installation of a silt fence surrounding the ET cover to control both erosion and contaminant transport, and
- seeding the ET cover with shallow-rooting grasses (LANL 1999, 063920).

2.5.1.6 Moisture Monitoring

Following the 1998 removal of the asphalt pad and installation of the ET cover at Area 2, a moisture-monitoring system was installed to evaluate moisture content and relative changes within and beneath the new cover material. During February 2000, three shallow neutron-logging access tubes were installed through the ET cover, each to a depth of 15 ft bgs. Four time-domain reflectometry (TDR) probes were also installed in the ET cover at two depths within two locations (0.5 and 6 ft bgs at one location and 0.5 and 10 ft bgs at the second location) (LANL 2005, 092389). The TDR probes collected measurements every 12 hours to an automated data logger. The four neutron-logging access tubes were monitored monthly until 2003 when NMED approved bimonthly monitoring (LANL 2005, 092389). Additionally, eight neutron access holes surrounding Area 2 were monitored bimonthly (monthly until the first quarter of fiscal year [FY] 2002) for moisture content. Six additional access holes located across the TA-49 site, where bimonthly monitoring began in the fourth quarter of 2003, provided a more comprehensive data set describing moisture trends across TA-49 (LANL 2005, 092389). Figure 2.5-4 shows the locations of neutron access holes, TDR probes, the cover, and the gopher barrier boundary. Table 2.5-3 provides the corresponding depths of the TDR probes within the array. Moisture monitoring at TA-49 was suspended after the last monitoring event in November 2005 to address NES operational requirements and has not resumed (LANL 2007, 098492).

Neutron access hole 2A-Y has had a small quantity of standing water in the bottom since neutron logging began in 2000. Because of the wet winter from 2004 to 2005, the water column in this neutron access hole rose to a depth of nearly 3 ft. The water was bailed and a sample was submitted on June 27, 2005, to the Sample Management Office (SMO) for radionuclide analyses (gross alpha, gross beta, gamma spectroscopy). The gross beta measured 37.01 pCi/L and no other radioactivity was detected (LANL 2005, 092389, p. 9). The gross beta result most likely represents the presence of naturally occurring radionuclides because there is a lack of corresponding radionuclides detected in the water sample. The detected gross beta activity in the water is below the EPA maximum contaminant level (MCL) of 50 pCi/L

gross beta. When 2A-Y was neutron logged on September 28, 2005, 1 ft of water column was present in the borehole (LANL 2005, 092389, p. 9; LANL 2007, 098492).

2.5.2 Area 2A: SWMU 49-001(c), Experimental Shafts

2.5.2.1 Site Description

SWMU 49-001(c), known as Area 2A, is an area of experimental shafts within MDA AB (Figure 2.2-2). Area 2A is adjacent to the west side of Area 2 [SWMU 49-001(b)] and is approximately 100 ft × 30 ft. Six experimental shafts were installed in this area in a single row and spaced 25 ft apart. These shafts were installed after Area 2 was closed in response to the contamination release at shaft 2-M. Four shafts in Area 2A were used for experiments involving radioactive materials. Plutonium was used in three of these shafts and uranium-235 was used in one. The shafts used for shots with radioactive materials were 57 ft and 58 ft deep. Two shafts, both 58 ft deep, were backfilled without being used for shots. Lead typically was present in the experimental packages, and small amounts of beryllium may have been used in some experiments (LANL 2007, 098492).

2.5.2.2 1994 RFI

In 1994, six surface-soil samples were collected from SWMU 49-001(c) as part of the surface RFI. Screening-level data were obtained from the results of laboratory analyses for gamma-emitting radionuclides, gross alpha, gross beta, isotopic plutonium, and inorganic metals analyses (Figures 2.5-1 through 2.5-3). Several total uranium concentrations were detected above BVs (LANL 2007, 098492). Results are presented in Tables 2.5-4 and 2.5-5.

2.5.3 Area 2B: SWMU 49-001(d), Experimental Shafts

2.5.3.1 Site Description

SWMU 49-001(d), known as Area 2B, is an area of experimental shafts within MDA AB. Area 2B is south of Area 2 and is approximately 200 ft ×100 ft. Shafts at Area 2B were aligned on a staggered grid with 11 shafts installed and another 15 proposed but not drilled. Six shafts were used for experiments with radioactive materials. Plutonium was used as the principal material in five of these shafts, which ranged from 57 ft to 58 ft deep, and uranium-235 was used in the other shaft, which was 78 ft deep. One 60-ft-deep shaft was used as a gas expansion hole, and four other shafts (three 58 ft deep and one 78 ft deep) were backfilled without being used. Two pipe dump holes were installed approximately 100 ft south of the shaft area. Substantial amounts of lead were typically present in the experimental packages, and small amounts of beryllium may have been used in some experiments. Figure 2.2-2 presents the shaft locations and shot types in Area 2B.

2.5.3.2 1994 RFI

In 1994, six surface-soil samples were collected from four locations in SWMU 49-001(d) as part of the surface RFI. Screening-level data were obtained from the results of laboratory analyses for gamma-emitting radionuclides, isotopic plutonium, and metals. Mercury was the only inorganic chemical detected above BV. Several radionuclides were also detected above BVs or FVs (LANL 2007, 098492). Results are presented in Tables 2.5-6 and 2.5-7.

2.5.4 Area 2: SWMU 49-001(g), Contaminated Surface Soil

2.5.4.1 Site Description

SWMU 49-001(g) is an area of soil contamination located to the north of SWMUs 49-001(b) and 49-001(c), resulting from the transport of surface and near-surface radionuclide contamination associated with the shaft 2-M incident at Area 2 (discussed in section 2.2). SWMU 49-001(g) is the area of highest runoff and erosion potential, located on a slope that runs from the mesa top to the bottom of Water Canyon (LANL 2007, 098492).

2.5.4.2 1994 RFI

During the 1994 RFI activities, 10 surface-soil samples were collected from SWMU 49-001(g) at depths of 0 to 0.5 ft and submitted for laboratory analyses for gamma-emitting radionuclides, isotopic plutonium, and metals. Screening-level analyses detected cadmium, mercury, and total uranium concentrations above BVs. Plutonium-239/240, cesium-137, plutonium-238, potassium-40, radium-226, and thorium-232 concentrations were detected above BVs or FVs (LANL 2007, 098492). Tables 2.5-8 through 2.5-9 show the results and Figure 2.5-5 shows sampling locations.

2.6 Area 3: SWMU 49-001(e), Experimental Shafts

2.6.1 Site Operational History

SWMU 49-001(e), known as Area 3, contains experimental shafts occupying approximately 100 ft × 100 ft. Area 3 was used exclusively to develop confinement and sample-recovery techniques that were used in the other experimental areas. Thirteen shafts were drilled in a grid-like pattern in Area 3. Seven of the 13 shafts were shot with a tracer, 4 of the shafts were used for containment shots, and the remaining 2 shafts were backfilled without being used (LANL 2007, 098492). Figure 2.2-3 presents the shaft locations and shot types in Area 3.

2.6.2 1995 RFI

During the 1995 RFI activities, 20 surface-soil samples were collected from 0 to 0.5 ft at SWMU 49-001(e). All samples were submitted for laboratory analyses for gamma-emitting radionuclides. Ten samples were submitted for laboratory analyses for metals and isotopic plutonium (LANL 2007, 098492). Inorganic chemical results are presented in Table 2.6-1, and sampling locations and concentrations of sample analytes detected above BVs are presented in Figures 2.6-1 and 2.6-2.

Decision-level results indicate that copper, lead, total uranium, and zinc concentrations were detected above BVs. All radionuclide concentrations were below BVs or FVs (LANL 2007, 098492).

The “RFI Work Plan for OU 1144” proposed one 150-ft borehole at Area 3; however, the borehole was not drilled (LANL 1992, 007670, p. 7-66; LANL 2007, 098492).

2.7 Area 4: SWMU 49-001(f), Experimental Shafts

2.7.1 Site Operational History

SWMU 49-001(f), known as Area 4, is the site of experimental shafts within MDA AB (Figure 2.2-4). Area 4 occupies approximately 100 ft × 125 ft. Area 4 was designed to contain 25 shafts on a uniform grid. Twenty-one shafts were drilled in Area 4. Thirteen shafts were shot with radioactive material, one

shaft was used for containment testing, one shaft was used as a gas expansion hole, three shafts were used as pipe dump holes, and the remaining three shafts were not used and were backfilled (LANL 2007, 098492).

2.7.2 1995 RFI

During the 1995 RFI activities, 20 surface-soil samples were collected from 0 to 0.5 ft within Area 4. All samples were analyzed for gamma-emitting radionuclides. Ten samples were submitted for analyses of metals (including total uranium), and isotopic plutonium (LANL 2007, 098492).

In one sample from location 49-04019, the highest concentrations of antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, magnesium, nickel, potassium, selenium, silver, thallium, and vanadium recorded at TA-49 were detected. In all other samples, cadmium, lead, nickel, total uranium, and zinc concentrations were detected above BVs in one sample each. Copper was detected in four samples (LANL 2007, 098492).

Americium-241, plutonium-238, and plutonium-239/240 concentrations were detected above FVs in samples collected at SWMU 49-001(f) (LANL 2007, 098492). Tables 2.7-1 and 2.7-2 show the results and Figures 2.7-1 and 2.7-2 show the sampling locations and concentrations above BVs.

The RFI proposed one 150-ft borehole at Area 4; however, the borehole was not drilled (LANL 1992, 007670, p. 7-66; LANL 2007, 098492).

2.8 Area 11: SWMU 49-003, Leach Field and Associated Drainlines

2.8.1 Site Operational History

SWMU 49-003 is an inactive leach field and associated drainlines in Area 11 (Figure 2.8-1). The leach field was associated with radiochemistry operations conducted in a laboratory and change house (building 49-15). The radiochemistry operations were associated with hydronuclear experiments conducted at TA-49 from 1960 to 1961. SWMU 49-003, a leach field, was located approximately 20 ft to 25 ft east of former building 49-15. SWMU 49-003 connected to the building by a drainline. The leach field was reportedly constructed of vitrified clay pipe installed in gravel bedding. The building 49-15 laboratory was used to analyze samples collected during the experiments conducted in the shafts at Areas 2, 2A, 2B, and 4. The estimated total volume of materials discharged to the leach field was less than 50 gal. of organic chemicals and less than several hundred gallons of water. The radiochemistry structures in Area 11 were decontaminated, demolished, and removed in 1970 and 1971 (LANL 1992, 007670, pp. 6-2–6-6; LANL 2007, 098492).

2.8.2 1995 RFI

In 1995, a Phase I RFI was conducted in Area 11 that included the collection of 25 surface-soil samples from SWMU 49-003. Twelve shallow (less than 4.3 ft deep) subsurface samples were collected from 12 locations in the leach field. All samples were submitted for laboratory analyses for gamma-emitting radionuclides. Thirteen surface soil and six subsurface samples were submitted for laboratory analyses for metals (including total uranium) and isotopic plutonium (LANL 2007, 098492).

Inorganic chemical results from surface soil indicate cadmium and uranium concentrations above BVs. Inorganic chemical results from subsurface soil and rock indicate aluminum, antimony, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, selenium, uranium, and vanadium concentrations were detected above BVs. Radionuclides detected above FVs in

surface soil include americium-241, plutonium-238, and plutonium-239/240. Radionuclides detected or detected above BVs or FVs in subsurface soil and rock include cesium-137, europium-152, plutonium-238, and plutonium-239/240 (LANL 2007, 098492).

Sampling locations and concentrations detected or detected above BVs or FVs are presented in Figures 2.8-2 through 2.8-4. Results are presented in Tables 2.8-1 and 2.8-2.

2.9 Area 11: AOC 49-008(c), Area of Potential Soil Contamination

2.9.1 Site Operational History

AOC 49-008(c) consists of contaminated soil within Area 11 (Figure 2.8-1) (LANL 1992, 007670, p. 6-2). Small-scale containment experiments were conducted in 13 underground shafts located on the west side of Area 11. The shafts were drilled to a depth of 12 ft and lined with 10-in.-diameter steel casing. HE was placed in the shafts, which were backfilled to contain the explosions. Small amounts of irradiated uranium-238 tracer were used in some experiments. The structures in Area 11 were decontaminated, demolished, and removed in 1970 and 1971. Some contamination was detected in sinks, ducts, and blowers in building 49-15. Contaminated debris was removed and disposed at TA-54, and uncontaminated debris (approximately 2160 ft^3) was taken to the open burning/landfill area at Area 6, SWMU 49-004 (LANL 2007, 098492).

2.9.2 1995 RFI

Eight surface-soil samples and three subsurface soil and rock samples were collected from eight locations within Area 11. The subsurface samples were collected from boreholes advanced to a depth of 12 ft, which corresponded to the depth of the small-scale shot test shafts. Samples were collected from depths 7 to 12 ft bgs within the boreholes and were field screened for radioactivity. The samples were submitted to a laboratory for gamma-emitting radionuclide analyses. Three surface soil and three subsurface soil and rock samples were submitted for metals analyses. Two surface soil and three subsurface soil and rock samples were submitted for isotopic plutonium. Three subsurface soil and rock samples were submitted for total uranium and SVOCs analyses. Two subsurface rock samples were submitted for explosive residues analysis (LANL 2007, 098492).

Inorganic chemical results from surface-soil samples indicate cobalt, manganese, and uranium concentrations were detected above BVs. Inorganic chemical results from subsurface soil and rock samples indicate antimony, calcium, and uranium concentrations were detected above BVs. Two subsurface samples collected from depths of 0 to 3 ft bgs and from 7 to 12 ft bgs yielded detections of bis(2-ethylhexyl)phthalate and di-n-octylphthalate. Radionuclide results from surface-soil samples indicate the concentration of plutonium-239/240 was detected above FVs. Radionuclide results from subsurface soil and rock samples indicate plutonium-238 and plutonium-239/240 concentrations were detected (LANL 2007, 098492).

Sampling locations and concentrations of sample analytes detected above BVs are presented in Figures 2.8-2 through 2.8-4 and results are presented in Tables 2.9-1 through 2.9-3.

2.9.4 AOC 49-009: Area 11, Suspected Underground Fuel Tank

The EPA has approved AOC 49-009 for NFA (EPA 2005, 088464). AOC 49-009 was thought at one time to be an underground storage tank, but Laboratory records show that it was actually an aboveground tank

holding butane. The tank was taken to a salvage yard in September 1971 and found to contain no significant levels of chemical or toxic contamination (Eller 1991, 055331).

2.10 Area 12: AOC 49-008(d), Bottle House and CPTF

2.10.1 Site Operational History

AOC 49-008(d) is an area of contaminated soil located within Area 12 (Figure 2.10-1), which is located immediately east of MDA AB. Area 12 was used in 1960 and 1961 to conduct confinement experiments related to the hydronuclear experiments conducted at MDA AB. These experiments involved HE detonations in sealed metal bottles. The bottles measured up to 5 ft in. diameter × 16 ft long and were placed in a 10-ft-diameter × 30-ft-deep underground shaft during the experiments. Building 49-23 constructed over the shaft was known as the Bottle House. Approximately 26 confinement experiments were conducted at Area 12 (LANL 1992, 007670, p. 6.6-3).

After the confinement experiments at Area 12 ceased, Area 12 was used to conduct tests to determine the strength of cables used in other experiments. The CPTF, building 49-121, was constructed approximately 60 ft south of building 49-23 in the early or mid-1960s to perform these tests (LANL 1992, 007670, p. 3-9). The shaft in building 49-23 was backfilled with crushed tuff, and a hydraulic system was installed in the building. Underground hydraulic lines were run to building 49-121. The total fluid capacity of the hydraulic system is estimated to have been less than 10 gal. (LANL 2007, 098492).

All structures at Area 12 have been removed. The site is used occasionally to support microwave experiments that involve portable equipment (LANL 2007, 098492).

2.10.2 1995 RFI

The Phase I RFI was conducted for AOC 49-008(d) in 1995 at three specific areas: the soil inside and around the former Bottle House (building 49-23), the soil around the former CPTF (building 49-121), and a small area of stained soil approximately 80 ft south of the CPTF. Radiation surveys were conducted at each of these areas, and radiation was not detected above screening values around the CPTF or at the stained-soil site. However, four radiation survey points around the Bottle House showed radiation levels above screening values. Soil samples were collected from the three areas of investigation (LANL 2007, 098492).

Near building 49-23, surface-soil samples were collected from 16 locations and 3 shallow surface samples (0.5 to 1 ft bgs) were collected from 3 of these locations. All samples were field screened for radioactivity and submitted for analyses of gamma-emitting radionuclides. Samples from six of the surface locations and three of the subsurface locations were submitted for analyses of metals and isotopic plutonium. One surface sample, collected near the location of the hydraulic system in the Bottle House, was submitted for analyses of SVOCs and polychlorinated biphenyls (PCBs) (LANL 2007, 098492).

Near the CPTF, eight surface-soil samples were collected from four locations. All samples were field screened for radioactivity. One sample from each location, plus a field duplicate, was submitted for analyses of gamma-emitting radionuclides and SVOCs. In addition, one sample from each location was submitted for analysis of PCBs (LANL 2007, 098492).

At the stained-soil site, two surface samples were collected from one location. Both samples were field screened for radioactivity. One sample was submitted for analyses of gamma-emitting radionuclides and SVOCs. The other sample was submitted for analysis of PCBs (LANL 2007, 098492).

Inorganic chemical results from surface-soil samples indicate cadmium, copper, lead, sodium, six uranium, and zinc concentrations were detected above BVs. Inorganic chemical results from subsurface samples indicate cadmium and uranium concentrations were detected above BVs. A surface-soil sample collected from 0 to 0.5 ft bgs had detected concentrations of alpha-BHC, alpha-chlordane, and gamma chlordane. Radionuclide results from surface-soil samples indicated the concentration of plutonium-239/240 was detected above FVs. Radionuclide results from subsurface samples indicate americium-241, plutonium-238, and plutonium-239/240 concentrations were detected. Uranium-234, uranium-235, and uranium-238 concentrations were detected above BVs in surface-soil samples (LANL 2007, 098492).

Screening-level data were obtained for americium-241, gamma-emitting radionuclides gross alpha and gross beta, isotopic plutonium, metals (including total uranium), and PCBs. Several metals, including barium, cadmium, lead, mercury, nickel, and uranium concentrations were detected above their respective BVs. PCBs were not detected and no radionuclide concentrations were detected above BVs or FVs (LANL 2007, 098492).

Sampling locations and concentrations are presented in Figures 2.10-2 through 2.10-4 and summarized in Tables 2.10-1 through 2.10-6.

2.10.3 Voluntary Corrective Actions

In 1997 and 1998, three voluntary corrective actions (VCAs) were conducted at AOC 49-008(d). These VCAs consisted of radiological field screening in conjunction with soil sampling to remove isolated contamination (LANL 1997, 056923, p. 17).

The initial VCA at AOC 49-008(d) was conducted to remove soil contaminated with uranium-234, uranium-235, and/or uranium-238 above cleanup levels (LANL 1997, 056923, p. 17). Confirmatory samples revealed contamination still present in the soil above cleanup levels (LANL 2007, 098492).

A supplemental low-level gamma radiation survey of surface soil around the Bottle House was conducted in April 1998 (LANL 1998, 062405). Of 2000 measurements taken, 8 measurements were above 9000 counts per min (cpm) (9140 to 32,200 cpm), which was considered above background. All of these detections were near areas where soil was removed during the 1997 VCA (LANL 2007, 098492).

In November 1998, a remedial action was conducted during which all brushy vegetation was removed and a preexcavation radiological survey was conducted on a 3-ft × 3-ft grid that repeated some of the locations covered in the April 1998 survey. Radiological screening results were used to identify areas for additional soil removal, and soil was removed to a depth of 12 in. A postexcavation radiological survey was conducted in which three more locations were found that exceeded screening-action levels. Additional small amounts of soil were removed at these locations (LANL 1998, 062405).

Additional confirmatory sampling was conducted from the areas of the highest radiological survey measurements and from randomly selected locations. Analyses were performed on these samples for isotopic uranium. One of these confirmatory samples exceeded cleanup level for uranium-238 (270 pCi/g). Following the confirmatory sampling, soil-removal areas were backfilled with clean crushed tuff, covered with a thin layer of topsoil, and seeded (Wilson 1999, 066470.426).

Cleanup of site construction materials was completed on January 19, 1999. Two fenced-off exclusionary radiological areas remain, one around the primary site of soil removal and one near the historical latrine, which may have been used for material disposal (LANL 1999, 063920).

2.11 Materials Testing Results and Additional Investigations

2.11.1 Materials Testing Results

Approximately 150 soil samples were collected from the cores of various wells, core holes, and testing shafts drilled at TA-49 from 1959 to 1961. Tests performed measured strength assessments, thermal conductivity, specific heat, particle-size distribution, density, specific gravity, moisture content, porosity, and permeability (Weir and Purtymun 1962, 011890). Table 2.11-1 provides the results of these tests.

2.11.2 Investigations at Borehole Location 49-02901

In November 1997, the casing in borehole location 49-02901 was removed, and permeability, anemometry, and caliper measurements were made throughout the open borehole. The anemometry and permeability measurements were intended to provide a better understanding of the airflow characteristics of the tuffs at depths projecting well below the adjacent canyon floors. Borehole location 49-02901 was instrumented with both a straddle packer measurement system, which provided air permeability measurements along the length of the borehole, and an open borehole anemometry measurement system, which measured the air production zones in the borehole under vacuum extraction conditions. Results of the study indicated high borehole production of air in areas of high permeability. Measurements near the bottom of the borehole are suspect because the borehole was enlarged beyond the sealing range of the packers (Wykoff et al. 1998, 098069; LANL 2007, 098492). Figure 2.11-1 presents the results of the study.

In December 1997, a sensor bundle with thermocouple psychrometers, gypsum blocks, and platinum resistance temperature detectors was installed in the borehole to measure matric potential and temperature at 11 depths. The sensors were pushed against the borehole walls using an inverting membrane liner (SEAMIST). Average matric potential and temperature measurements from this test (Mason and Lowry 1998, 098323) are presented in Figure 2.11-2.

Core data were collected from borehole location 49-02901 and from boreholes in other MDAs at the Laboratory to provide total head gradients with depth. These data indicate that water flow is generally downward, but with gradient reversals that may be caused by atmospheric venting through boreholes or exposure to canyon walls. Gradient reversals present barriers to downward aqueous transport of contaminants. Figure 2.11-3 shows water content profiles from the 700-ft-deep borehole location 49-02901 and from the 150-ft-deep borehole locations 49-02906 and 49-02907 (Neeper and Gilkeson 1996, 070104, pp. 427–432).

2.11.3 Geophysical Investigations

In 1993, a high-performance ground-penetrating radar survey was conducted at Area 2 (Hoeberling and Rangel 1994, 098277). The ground-penetrating radar survey was conducted to verify that the six planned Area 2 borehole locations were clear of subsurface structures that might indicate undocumented contaminated areas. The survey was also conducted to verify the locations of the hydronuclear test shafts. The ground-penetrating radar survey found that the location for one of the planned 150-ft RFI boreholes generated a strong ground-penetrating radar reflection, indicating either buried objects or a zone of high water content and high clay content. The location for borehole 49-02907 was moved approximately 3 ft to the west and 8 ft to the south of the initially proposed borehole location (Hoeberling and Rangel 1994, 098277).

In March 1998, an additional geophysical survey was conducted using field magnetics and electromagnetics to identify unreinforced concrete and metal structures and debris in the subsurface of

Area 2 to a depth of 8 to 10 ft. The survey indicated that there were 21 geophysical anomalies in the subsurface of Areas 2, 2A, and 2B (Sirles 1998, 066497). The survey results will be used to avoid buried objects during subsequent subsurface activities.

2.11.4 Chloride and Stable Isotope Investigations

Water fluxes have been estimated based on chloride and stable isotope analyses from core collected from the 700-ft-deep borehole (location 49-02901) and from a 139-ft-deep borehole located near groundwater well DT-10, known as TDBM-1. Chloride-based flux estimates range from 0.01 to 0.2 yr/m^3 for the zone above the Qbt 1v-Qbt 1g contact (also known as the vapor-phase notch) for both boreholes. These low flux rates are likely the result of evaporative removal of water in the mesa. Heavy stable isotope values from borehole location 49-02901 support this interpretation. Flux estimates range from 0.24 to 1 yr/m^3 for the zone below the Qbt 1v-Qbt 1g contact in borehole location 49-02901. These deeper rates may represent past conditions during the late Pleistocene and early Holocene epochs (Newman et al. 1997, 059371).

Chloride profiles for the two boreholes showed similar behavior in the top 30 ft. Below the 30 ft depth, TDBM-1 shows a greater accumulation of chloride in unit 3 than borehole location 49-02901, which indicates that water moved more slowly near TDBM-1. The difference in chloride concentrations and flux rates is probably caused by higher evaporation rates at TDBM-1 because of its location close to the side of Frijoles Mesa. The chloride bulges in both profiles are consistent with deep, as opposed to surface, evaporation effects, and water is being removed from the mesa through vertical or horizontal fractures or through high-permeability zones that are exposed on the mesa sides. In addition, isotopically heavy water occurs in borehole location 49-02901 below a depth of 50 ft, which is indicative of deep evaporation (Newman et al. 1997, 059371; LANL 2007, 098492).

2.11.5 Area 2 Modeling Investigation

The flow and transport of dissolved uranium, dissolved cesium, and colloidal particles under various infiltration conditions were simulated at Area 2. Simulation times were 39 yr (1960 to 1999) for conditions that represent increased subsurface fluxes resulting from the presence of the cracked asphalt cover. Under infiltration conditions of 6 yr/m^3 (assumed for most of Area 2 because of the cracked asphalt pad), virtually no migration of either dissolved or colloidal uranium or dissolved cesium is predicted. Under infiltration conditions of 39 yr/m^3 (assumed for shaft 2-M and core hole CH-2 because of the collapsed asphalt pad), migration of uranium does occur. The dissolved uranium plume spread from its original diameter of 15 ft to about 40 ft. However, the total mass of dissolved uranium available for transport is limited by its low solubility. Uranium may also be transported as colloidal-sized particles that were formed during the hydronuclear safety experiments. It is expected that such particles are quite large compared with the water-filled pores in the subsurface and (approximately 99%) would not migrate (Birdsell et al. 1999, 098068; LANL 2007, 098492).

2.11.6 Non-RFI Surface Activities

Twelve sediment-sampling locations were established at MDA AB as part of the Environmental Surveillance Program (LANL 1996, 054769). The sediment-sampling program at Area 2 was initiated by the Environmental Studies and Assessment Group in 1979. Two of the sediment locations, AB-2 and AB-3, are located in drainage areas to the northeast and northwest of Area 2 (Figure 2.11-4). Radionuclide analyses conducted annually at these stations since 1979 have included tritium, cesium-137, plutonium-238, plutonium-239, gross alpha, gross beta, gross gamma, and total uranium. Two additional isotopes, americium-241 and stronium-90, were added in 1992 (LANL 2007, 098492).

The data indicate that AB-3 had levels of plutonium-238 and plutonium-239 greater than the other 11 stations; the majority of the analyses were above Laboratory sediment BVs (LANL 1998, 059730). All other radionuclides show a decreasing trend over time (LANL 1996, 054769). No other significant trends were observed with respect to the data. The data are summarized for sediment collection stations AB-2 and AB-3 in Table 3.8-3 of the HIR associated with this work plan (LANL 2007, 098492).

2.11.6.1 Environmental Surveillance Surface Soil and Vegetation Sampling, 1987 and 1991

The initial surface-soil investigation at Area 2 was conducted by the Environmental Surveillance Group in 1987 (Soholt 1990, 007510). This investigation was also referred to as the A411 survey. Forty-five samples were collected. The study indicated that contaminant concentrations to the south and west of the pad were at or slightly above BVs. Several sampling locations immediately adjacent to the asphalt pad showed plutonium-238, plutonium-239, and americium-241 concentrations above BVs. Later sampling at Area 2, including the additional 1987 study and the 1991 sampling effort described below, confirmed the levels reported (LANL 2007, 098492).

An additional 20 soil samples were collected from the area northeast of the pad in September 1987. Radionuclides detected above background included gross alpha and plutonium-239. Beryllium was also detected above BV in one sample.

In March 1991, 12 samples of pocket gopher soil diggings from the northeast corner of the pad were collected and analyzed for radionuclides (LANL 1992, 007670, p. 7-37). Results indicated that contamination had washed a short distance along the northeast drainage area toward Water Canyon; plutonium-238, plutonium-239, and americium-241 concentrations were detected in the drainage area and northeast corner (24, 43, and 38 pCi/g, respectively). Gopher diggings at the same location were resampled in April 1991(LANL 1992, 007670, p. 7-37). Elevated gross alpha activity (1200 pCi/g) was noted; however, isotopic analyses did not correlate with the earlier sampling event (LANL 1992, 007670). Additional analyses indicated no detected VOC, SVOC, or PCB concentrations (LANL 2007, 098492).

Forty-nine vegetation samples were collected from the 20 locations. Four types of vegetation were sampled including chamisa, goldenweed, mullein, and false tarragon. Results detected americium-241, plutonium-238, plutonium-239, cesium-137, uranium, lead, and beryllium. The mean concentration of plutonium-239 and americium-241 in the ash samples from all 49 samples including the 4 types of vegetation were 0.50 and 0.23 pCi/g of ash, respectively. In summary, the 1987 and 1991 studies indicated that the most elevated radionuclide levels with respect to background in surface soil were concentrated in the northeast corner of Area 2. The available information also indicated that these contaminants appeared to be associated with the excavation of contaminated soil beneath and adjacent to the asphalt pad because of gopher activity (LANL 2007, 098492).

3.0 SITE CONDITIONS

3.1 Topography

The sites within the NES boundary are located in the center of TA-49 where the topography is quite flat; therefore, surface-water runoff and erosion are minimal. No perennial sources of water at or near the site exist. No established runoff channels exist and surface water is expected to occur as sheet flow during strong rainfall events or rapid snowmelt. Run-on control is provided by drainage ditches along the roads within TA-49 (LANL 2007, 098492).

Soil at MDA AB, Area 11, and Area 12 has been disturbed. The soils were originally composed of Hackroy Series and Eutroboralf soil. The soil is intermixed with patches of bedrock, which occurs predominantly near the edges of the mesa east of developed TA-49 areas. Hackroy soil is classified as Alfisols, in part reflecting the clayey subsurface horizon, and is described in "Soil Survey of Los Alamos County, New Mexico" as follows: "The surface layer of the Hackroy soil is a brown sandy loam, or loam, about 10 cm thick. The subsoil is a reddish brown clay, gravelly clay, or clay loam about 20 cm thick. The depth to tuff bedrock and effective rooting depth is 20 to 50 cm. (Nyhan et al. 1978, 005702)" Typic Eutroboralf soil is a fine loamy soil that consists of deep, well-drained soil formed in material weathered from tuff (LANL 2007, 098492).

3.2 Subsurface Conditions

The subsurface hydrology at TA-49 is dominated by unsaturated conditions. The top of the regional saturated zone occurs approximately 1170 ft bgs at deep test well DT-5A near the center of MDA AB. The upper 800 ft of the unsaturated zone is within the Bandelier Tuff (LANL 1992, 007670, p. 4-18).

Relatively small volumes of water move beneath mesa tops on the Pajarito Plateau under natural conditions because of low rainfall, high evaporation, and efficient water use by vegetation. During wetter years, vegetal growth is enhanced and is capable of removing larger volumes of available moisture. Atmospheric evaporation may extend within mesas, further inhibiting downward flow (Rogers and Gallaher 1995, 049824, p. 27). Water content in the unsaturated zone within the tuff has been measured monthly or bimonthly since 2000. The water content in the unsaturated zone tends to range from 5% to 10% by volume under natural conditions (LANL 2005, 092389, pp. A-1–A-3). Water content measured at locations within the boundary of the ET cover and the former asphalt pad at MDA AB is slightly higher, ranging from 5% to 20% by volume (LANL 2005, 092389, pp. A-3–A-6). Continuous moisture monitoring of the near-surface cover material at Area 2 shows that seasonal impulses of water are readily removed in the spring and summer when ET is maximized (LANL 2007, 098492).

3.2.1 Geology

A detailed description of the geology and regional setting of TA-49 can be found in Chapter 4 of the "RFI Work Plan for OU 1144" (LANL 1992, 007670, pp. 4-32–4-41).

Technical Area-49 lies on the east side of the Jemez Mountains volcanic field and on the west perimeter of the Española Basin of the Rio Grande rift. Factors that may affect the actual geometry and distribution of subsurface units beneath TA-49 include abrupt lateral and vertical facies variations in rock units, significant relief on paleotopographic surfaces on which rock units were deposited, and fault offsets in the older units that are masked by younger rocks. Exposed rock near TA-49 is comprised entirely of the Tshirege Member of the Bandelier Tuff (LANL 1992, 007670 p. 4-33; LANL 2007, 098492).

In 1959, the stratigraphy of TA-49 was mapped using three deep test wells: DT-5A, DT-9, and DT-10 (Weir and Purtymun 1962, 011890, pp. 21–39). Later that year, four core holes (CH-1, CH-2, CH-3, and CH-4) provided additional information for mapping the stratigraphy of MDA AB. Early studies used the 1960s nomenclature (Weir and Purtymun 1962, 011890, pp. 91–153). The rock column (from youngest to oldest) beneath TA-49 consists of the following:

- Approximately 640 to 670 ft of the Tshirege Member of the Bandelier Tuff, which was divided into six units, based mainly on physical and mineralogical characteristics imparted by cooling. The units include multiple rhyolitic ignimbrite flow units, a widespread pyroclastic surge bed up to several feet thick, and numerous thin discontinuous surge deposits.

- Approximately 200 ft of the Otowi Member of the Bandelier Tuff (the Otowi Member also includes up to 91 ft of the Guaje Pumice Bed).
- Approximately 500 to 600 ft of deposits consisting of interbedded Puye Formation conglomerates, Tschicoma Formation latites, and quartz latites.
- Approximately 50 to 90 ft of the Totavi Lentil conglomerate (of the Puye Formation) with characteristic quartzite cobbles and other typical Precambrian lithologies.
- An undetermined thickness (at least 290 ft) of undivided siltstones and sandstones of the Santa Fe Group (LANL 2007, 098492).

A hydrogeologic report on TA-49 describes what now appears to be unusual stratigraphic relationships based upon the current understanding of the stratigraphy. Some of the disputed layers and issues include the Guaje Pumice Bed and the Tschicoma Formation quartz latites. Many of the discrepancies are caused by variations in nomenclature for different units, but few of the discrepancies have been traced to misidentification of the lavas source (Paliza Canyon Formation, Tschicoma Formation, and/or Cerros del Rio basalts) (Weir and Purtymun 1962, 011890).

In 1995, a revised stratigraphic nomenclature for the Bandelier Tuff was proposed to provide guidance for the consistent use of rock names to support a common stratigraphic framework for discussing the influence of geology on contaminant transport (Broxton and Reneau 1995, 049726).

In 1994, a 700-ft-deep borehole (location 49-02901) was drilled southeast of Area 2 to provide supplementary information to the geologic map of TA-49. A report was published that detailed the petrologic log of borehole location 49-02901 using both geologic field observations of adjacent canyons and geologic logs from location 49-02901 (Stimac et al. 2002, 073391, p. 1). The report concluded the following.

- The exposed bedrock stratigraphic sequence in Water Canyon is restricted to units of the Tshirege Member of the Bandelier Tuff. The Tshirege Member is a multiple-flow ash-flow sheet that forms a series of step-like vertical cliffs and sloping ledges along canyon walls. Canyon exposures immediately north of the borehole consist of, in ascending order, Qbt 1g, Qbt 1v, Qbt 2, Qbt 3, and Qbt 4 of the Tshirege Member of the Bandelier Tuff.
- The borehole extended beneath the level of adjacent canyon floors; therefore, several unexposed units were discovered. These unexposed units included, in descending order, the Tsankawi Pumice Bed, tephras and volcaniclastic sediment of the Cerro Toledo interval, and the Otowi Member of the Bandelier Tuff. The bottom of the borehole coincided with the Otowi Member.
- Examination of moisture content indicates some lithologic control. The most prominent features of the moisture data indicate an abrupt increase in moisture content at the transition of the glassy (Qbt 1g) to devitrified (Qbt 1v) Tshirege Member and at the Tsankawi Pumice Bed. The difference in moisture content between the Qbt 1g layer and the Qbt 1v layer may represent a preferential path for groundwater movement at the layer interface.

The stratigraphy encountered in borehole 49-02901 is presented in Figure 3.2-1.

In 1995, geologic logs, construction records, and locations of wells drilled in Los Alamos were compiled in “Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface-Water Stations in the Los Alamos Area” (Purtymun 1995, 045344). In this report, the geologic logs of wells were updated to reflect the most current geologic nomenclature (Broxton and Reneau 1995, 049726).

3.3 Summary of Excavations

3.3.1 Shafts

The test shafts drilled for hydronuclear safety experiments at MDA AB were 6 ft and 3 ft in diameter and from 31 ft to 142 ft in depth. The shafts in Areas 1, 2, 3, and 4 are located in a grid pattern with 25-ft spacing on center. The design of the experimental layout was based on preliminary tests that indicated that the explosive tests would not disperse radioactive material beyond a 15- to 20-ft radius centered on the shaft in the subsurface (LANL 2007, 098492).

The shot itself was encased in lead, which accounts for the largest weight of all the contaminants. Iron and steel cable, aluminum materials, and piping associated with the test shots are also in the shafts. Radioactive materials used in the downhole testing included plutonium, uranium-235, and uranium-238. Since 1961, the shafts have been inactive except for monitoring and maintenance activities associated with the concrete pads located over the shots (LANL 2007, 098492).

3.3.1.1 Area 1

Twenty-two shafts were drilled at Area 1 (Figure 2.2-1). Ten of the 22 shafts were used for shot testing using radioactive materials; 5 of the shafts were used for containment testing with explosives only; 6 of the shafts were never used and backfilled; and 1 shaft was used as a gas expansion hole. The shafts at Area 1 are between 31 and 80 ft deep (LANL 2007, 098492).

3.3.1.2 Areas 2, 2A, and 2B

Forty-six shafts were drilled in Areas 2, 2A, and 2B (Figure 2.2-2). Twenty-nine of the shafts were used for shot testing using radiological materials; these shafts are between 35 and 78 ft deep. Seven smaller shafts were used for disposal of potential contaminated debris and other materials; these shafts were 3 ft wide × 30 ft deep. Two of the shafts were drilled for purposes of trapping gases expelled from the test shots. One shaft used for containment testing had dimensions of 6 ft × 53 ft. Seven shafts were not used and were backfilled (LANL 2007, 098492).

3.3.1.3 Area 3

Thirteen shafts were drilled in a grid-like pattern in Area 3 (Figure 2.2-3). Seven of the shafts were shot with a tracer, four of the shafts were used for containment shots, and the remaining two shafts were not used and backfilled (LANL 2007, 098492).

3.3.1.4 Area 4

Twenty-one shafts were drilled in Area 4 (Figure 2.2-4). Thirteen of the shafts were shot with radioactive material, one was used for containment testing, one was used as a gas expansion hole, three were used for disposal of debris, and the remaining three shafts were not used and backfilled (LANL 2007, 098492).

3.3.1.5 Area 11

At Area 11, 13 10-in.-diameter × 12-ft-deep vertical steel-cased boreholes were used for small-scale containment experiments (Figure 2.8-1). In some of these shots, irradiated uranium-238 tracer was used. Neptunium-239 has a half-life of 2.3 d and has decayed to negligible levels of plutonium-239. Some of the

shot shafts also may have contained small quantities of lead. Some shafts probably were backfilled partially with concrete at the conclusion of the experiments (LANL 1992, 007670, p. 6.2-3).

3.3.1.6 Area 12

At Area 12, a large shaft, 30 ft deep × 10 ft diameter, was located beneath the Bottle House and used in 1961 for small-scale containment experiments (Figure 2.10-1). When the containment experiments were concluded, the Bottle House shaft was backfilled with crushed tuff (LANL 1992, 007670, p. 6.6-3).

3.3.2 Drainlines

Radiochemistry operations were performed in Area 11 in building 49-15. A drainline was installed from the southwest portion of the radiochemistry building to a leach field located a few feet to the east. The drainage system from the radiochemistry building was most likely constructed of vitrified clay pipe laid in a gravel matrix (Eller 1991, 055331).

3.4 Exploratory Borings and Monitoring Wells

This section provides a history of each borehole or well drilled at TA-49 that have not been previously described in section 2. Table 2.2-1 lists the completion details and current status of each borehole and well at TA-49 drilled to a depth greater than 15 ft. Figure 3.4-1 shows the locations of these boreholes and wells within TA-49.

In 1959 and 1960, five deep test wells (DT-5, DT-5A, DT-5P, DT-9, and DT-10) were drilled through Frijoles Mesa. Three deep test wells (DT-5A, DT-9, and DT-10) were drilled into the regional aquifer and are currently used as groundwater monitoring wells. The boreholes were drilled to determine the thickness of the tuff and volcanic sediment, to determine the hydrologic characteristics of the regional aquifer, and to test for the presence of perched water (none was found) (LANL 2007, 098492). The construction of the three groundwater monitoring wells is presented in Figure 3.4-2.

During the initial site characterization in 1959 and 1960, four core holes (CH-1, CH-2, CH-3, and CH-4) were drilled beneath MDA AB and cased with 2-in. galvanized pipe. These core holes, which range in depth from about 300 ft (CH-3 and CH-4) to 500 ft (CH-1 and CH-2), were drilled in the centers of the four main experimental areas to detail the geologic and hydrologic characteristics of the underlying tuff. The surface geology of the area was mapped and correlated with subsurface geology as determined from logs of the test wells and other holes (LANL 2007, 098492).

In 1960, three additional boreholes (Alpha, Beta, and Gamma) were drilled for geologic information. Alpha was drilled just east of MDA AB, Beta was drilled into the floor of Water Canyon, and Gamma was drilled into the floor of Ancho Canyon (LANL 2007, 098492).

In 1980, a study was conducted to understand the observed accumulation of water in core hole CH-2. The study involved drilling five test holes (TH-1, TH-2, TH-3, TH-4, and TH-5) at locations adjacent to Areas 2, 2A, and 2B. The boreholes were drilled to depths that would provide moisture monitoring of the tuff below the bottom of the shafts in Areas 2, 2A, and 2B. Cuttings from the test holes were logged, and moisture content was determined over 5-ft drilling intervals. Three additional test holes (2A-O, 2A-Y, and 2B-Y) were drilled in unused, backfilled shot shafts. The boreholes were drilled through the sand fill and into the underlying tuff. The boreholes were logged, and moisture content was determined in the sand and tuff. The test holes were cased with 2-in. PVC pipe to facilitate neutron logging. The casing depths

vary, depending on how much cave-in occurred when the auger was pulled from the test hole (Purtymun and Ahlquist 1986, 014722, p. 16).

3.5 Exploratory and Monitoring Well Boring Geophysical Logging

Stratigraphic diagrams have been derived from borehole logs of deep test wells DT-5A, DT-5P, DT-9, and DT-10; core holes CH-1, CH-2, CH-3, and CH-4; and boreholes Alpha, Beta, and Gamma and are presented in Figures 3.5-1 through 3.5-11. These diagrams display the stratigraphy using both the old 1960s nomenclature and the more recent nomenclature (Broxton and Reneau 1995, 049726).

3.6 Groundwater Conditions

3.6.1 Alluvial Groundwater

In 1990, three shallow monitoring wells were installed in Water Canyon downgradient of TA-49. No perched water zones were encountered during drilling activities. Springs and seeps are known to occur in the lower reaches of Water and Ancho Canyons, far downgradient of TA-49 (near the Rio Grande), but none have been identified within the boundaries of TA-49 (LANL 2007, 098492).

Lateral groundwater flow occurs between stratigraphic permeability barriers within the Bandelier Tuff. Lateral discharges from canyon walls or canyon bottoms provide a possible route for contaminant transport. However, this is not plausible given the average annual rainfall and infiltration quantities seen at TA-49 (LANL 1992, 007670, p. 4-21).

3.6.2 Perched Intermediate Groundwater

The three test wells (DT-5A, DT-9, DT-10) and other boreholes drilled within TA-49 have not indicated the presence of perched water in tuff or volcanics above the regional aquifer in spite of the presence of potential perching beds (Purtymun and Stoker 1987, 006688, p. 8). Perched groundwater beneath TA-49 has also not been indicated during subsurface moisture monitoring conducted at TA-49 from 2000 to 2005. The absence of perched water indicates that no recharge to the regional aquifer occurs through the Pajarito Plateau near TA-49 (Purtymun and Stoker 1987, 006688, p. 8).

3.6.3 Regional Groundwater

Deep groundwater beneath TA-49 is part of the regional aquifer that serves all of the municipal and industrial water use in Los Alamos County (Purtymun 1984, 006513). Little to no recharge occurs through the mesa tops of the Pajarito Plateau to the regional aquifer (LANL 2007, 098492).

The annual general facility information report provides updates to the topographic, geologic, and hydrologic data as it becomes available. Figure 3.6-1 shows the elevation of the top of the regional aquifer and groundwater flow direction at the Laboratory (LANL 2007, 095364).

Beneath TA-49, the potentiometric surface of the regional aquifer lies completely within the Puye sediment and the Cerros del Rio basalt. The groundwater moves eastward discharging into the Rio Grande through seeps and springs (Purtymun et al. 1980, 006048). Aquifer tests performed in the three deep test wells at TA-49 found the average groundwater velocity to be 345 ft/yr in the upper 490 ft of the aquifer. The gradient on the upper surface of the aquifer is about 40 to 60 ft/mi beneath the western and central part of the plateau. It steepens to 80 to 120 ft/mi as groundwater moves into less permeable sediment of the Tesuque Formation (Purtymun and Ahlquist 1986, 014722).

Well DT-5A has presented an approximate 4-ft water-level decline from 1960 to 1964. This decline was attributed to pumping of supply wells located to the north. Well DT-9 recorded a 3-ft water-level drop over a 21-yr period from 1960 to 1982. At well DT-10, water levels dropped 0.5 ft/yr from 1960 to 1967. These drops in water level reflect the normal deep groundwater level trend for the region (Purtymun and Ahlquist 1986, 014722).

3.7 Surface-Water Conditions

Runoff and infiltration are the critical components that influence the surface hydrology at TA-49. These mechanisms are the predominant pathways by which contaminants could be mobilized and transported from the site. There is no current evidence of a hydraulic connection between the surface water and groundwater at TA-49. The surface hydrology features relevant to TA-49 (LANL 1992, 007670) include

- areas and pathways of surface-water runoff and sediment deposition;
- rates of soil erosion, transport, and sedimentation;
- locations and sizes of areas of disturbed and undisturbed surface soil in drainages;
- infiltration versus runoff ratios;
- presence and effectiveness of sorptive media and/or hydraulic properties in retarding infiltration of water-borne contaminants; and
- fate of infiltrating water on mesa tops (Purtymun and Ahlquist 1986, 014722; and Weir and Purtymun 1962, 011890).

3.7.1 Surface-Water Runoff

Surface-water runoff potentially carries contaminants into surface water that drains off-site. The direction of surface-water runoff from Frijoles Mesa flows either northward into Water Canyon, eastward into a tributary canyon to Ancho Canyon, or southward into Ancho Canyon (LANL 2007, 098492).

Runoff from summer storms on the Pajarito Plateau typically reaches a maximum discharge in less than 2 h and has a duration of less than 24 h (Purtymun et al. 1990, 006992). When the discharge rate is high, the runoff can carry large masses of suspended and bed-load sediment as far as the Rio Grande. Spring snowmelt occurs at a less intense rate (e.g., over a period of several weeks to months compared with a 24-h period). This lower flow rate also results in the movement of sediment but with less surface erosion than during the summer storms. Both Ancho Canyon and Water Canyon, downgradient of TA-49, experience ephemeral flow caused by runoff during the intense summer storms and snowmelt events.

3.7.2 Surface-Water Quality

Surface-water quality data have been collected for approximately 30 yr at the Beta borehole surface-water station in Water Canyon (about 2000 ft north of MDA AB), in Water and Ancho Canyons at State Highway 4, and sporadically in drainages leading from MDA AB following intense rainfall events. No contamination of surface water at these locations by TA-49 contaminants has been identified in the 30 yr of monitoring (LANL 1992, 007670, p. 4-45; LANL 2006, 093925).

3.7.3 Surface-Water Infiltration

Surface-water infiltration provides a potential mechanism by which contaminants may move into the subsurface (LANL 1992, 007670, p. 4-13). Surface-water infiltration studies conducted at Pajarito Canyon have indicated that infiltration through mesa-top soil into the tuff is not significant (LANL 2007, 098492). Surface-water infiltration pathways at TA-49 include

- native or disturbed soil,
- intact tuff,
- backfilled shafts, and
- fracture systems and boreholes.

Evapotranspiration processes limit the transfer of water to the Bandelier Tuff. The characteristics of the tuff (naturally low moisture content and high porosity) provide a large storage capacity for infiltrating fluids and likely prevent infiltrating liquids from penetrating the thick unsaturated zone at TA-49 (LANL 1992, 007670, p. 4-14).

3.8 Institutional Controls

The current institutional controls include a fence with a locked gate and security patrols of the area. Access to MDA AB requires sign-in at a manned station within TA-49. These controls are expected to remain in effect throughout the institutional control period.

4.0 PROPOSED ACTIVITIES

Investigation activities outlined in the following subsections will provide additional data needed to define the lateral and vertical extent of contamination at Areas 1, 2, 2A, 2B, 3, 4, 11, and 12. The investigation activities will provide data specified in Section IV.C.4.c.i of the Consent Order to characterize the sites within the TA-49 NES boundary.

4.1 Investigation Objectives

Upon review of the “RFI Work Plan for OU 1144” (LANL 1992, 007670) and documentation of RFI activities to date, it was determined that insufficient data exist to determine the nature and extent of contamination at MDA AB and Areas 1, 3, 4, 11, and 12. The data gaps identified include the following:

- no data for subsurface characterization of Areas 1, 3, and 4;
- insufficient determination of potential contaminant migration caused by standing water in core hole CH-2;
- insufficient data to determine the vertical extent of subsurface contamination at Areas 11 and 12;
- insufficient data to determine the lateral extent of surface contamination at MDA AB, and Areas 1, 3, 4, 11, and 12; and
- overland corridors used for the transport of equipment and personnel between Area 5 and the testing and support areas have not been previously investigated and are included in this plan for surface investigation. (Area 5 is the central control area and is included in the work plan for TA-49 sites outside the NES boundary [LANL 2007, 098522] and is not included in this work plan.)

Additionally, insufficient data exist to characterize the hydrogeology at MDA AB. Specific hydrogeologic data needs, which define the potential of contaminant migration, include

- evaluation of fractures as potential transport pathways,
- determination of the presence of perched water beneath MDA AB, and
- characterization of the lateral extent of the pyroclastic surge bed (base of unit Qbt 4).

These data needs must be addressed to characterize the potential for surface and subsurface migration of contaminants.

The sampling proposed in this investigation work plan will define the nature and extent of surface and subsurface contamination at MDA AB and Areas 1, 3, 4, 11, and 12 and the potential for migration of those contaminants. This approach has been developed to refine the surface and subsurface investigations prescribed in the "RFI Work Plan for OU 1144" (LANL 1992, 007670) while satisfying the requirements of Section IV.C.4.c of the Consent Order. The data collected will allow the completion of the MDA AB investigation report in which recommendations for MDA AB and Areas 1, 3, 4, 11, and 12 will be made.

4.2 Site Surveys

Before the initiation of investigation activities, the locations of all subsurface shafts and structures will be verified. Existing documentation (engineering drawings, surveys, site and aerial photos) and site inspections will be evaluated against current coordinates in the Laboratory's geographic information system database. Geodetic surveys will be conducted using existing surface expressions to correlate and verify the locations of disposal units, current and former monitoring locations, structures, and fence lines. Additional surveys such as ground-penetrating radar or electromagnetic surveys may be used to refine and augment locations and dimensions of structures and utilities.

4.3 Surface Investigations

Previous surface investigations have identified sporadic low-level contamination in surface soil of radionuclides and inorganic chemicals (summarized in section 2.4 of this document and in detail in section 3.0 of the TA-49 NES HIR [LANL 2007, 098492]). The surface investigation strategy presented in this work plan will focus on defining the lateral and vertical extent of surface contamination at MDA AB and Areas 1, 3, 4, 11, and 12, while providing additional data to define the nature of contaminants present. Although surface sampling is specified by section IV.C.4.c.iii.8 of the Consent Order over the small shot area and radiochemistry building footprint in Area 11, AOC 49-008(c) is deferred per Table IV-2 of the Consent Order. Therefore, no surface sampling for AOC 49-008(c) is proposed in this work plan.

4.3.1 Surface Sampling

The strategy for characterizing the nature and extent of surface contamination will combine systematic screening sampling with systematic and criteria-based biased analytical sampling. The results of previous sampling campaigns are used to establish a systematic sampling array in surrounding areas of previously detected inorganic chemicals or radionuclides (LANL 1999, 070349). Discrete samples will be collected from 0 to 6 in. and 6 to 18 in. on a 25-ft × 25-ft systematic grid that extends a minimum of 100 ft from the outermost concentrations above BVs or FVs. Each array consists of three categories of samples based on the proximity to previous concentrations in excess of BVs or FVs. The categories are described below.

Soil samples will be collected using methods described in section 5.3.1. Dry decontamination methods will be used between sampling locations to avoid generation of liquid waste and to minimize the investigation-derived waste (IDW).

In order to characterize the nature and extent of contamination, two types of data will be collected from each grid array: (1) field-screening analyses will be conducted to determine gross alpha and gross beta levels and (2) laboratory analyses to obtain decision-level data will be conducted to determine the nature and confirm the extent of contamination in surface soil. Two grab samples, one each from 0 to 6 in. and 6 to 18 in., will be collected from each sample location.

- Screening samples will be collected for gross alpha and gross beta analyses. These samples will be used to delineate locations with potential radiological contamination. To ensure quick turnaround of data, gross alpha and gross beta samples will be screened at an on-site mobile radiological trailer or a local radiological laboratory. Sufficient sample material will be collected from each interval during sampling for subsequent submission of samples for laboratory analyses.
- Laboratory samples will be collected for gamma spectroscopy, isotopic americium, isotopic plutonium, isotopic uranium, and target analyte list (TAL) metals. Analytical suites and methods are presented in Table 4.3-1. Results will be obtained based on two criteria: (1) previously defined contamination and (2) threshold values based on gross alpha and gross beta screening analyses. The threshold for conducting laboratory analyses is 25 pCi/g gross alpha radiation and 50 pCi/g gross beta radiation. Appendix C provides the basis for gross alpha and gross beta thresholds.

Three categories of sampling locations are proposed within each sampling array:

- Category 1: All sampling locations near historical detects of metals or radionuclides above BVs or FVs. For Category 1 sampling locations, the following samples will be collected:
    - ❖ Screening samples. Discrete samples from 0 to 6 in. and 6 to 18 in. from all Category 1 sampling locations will be submitted for gross alpha and gross beta analyses.
    - ❖ Biased laboratory samples. All Category 1 samples will be submitted for analyses of gamma spectroscopy, isotopic americium, isotopic plutonium, isotopic uranium, and TAL metals. Samples from Area 12 will also be submitted for analyses of VOCs, SVOCs, and PCBs. Samples from Area 11, SWMU 49-003, will be submitted for analyses of iodine-129, strontium-90, and technetium-99.
    - ❖ Criteria-based biased samples. Discrete samples from 0 to 6 in. and 6 to 18 in. from all Category 1 sampling locations for which gross beta exceeds 50 pCi/g will be submitted for analyses of iodine-129, stronium-90, and technetium-99.
- Category 2: Sampling locations within 50 ft of Category 1 locations. For Category 2 locations, the following samples will be collected:
    - ❖ Screening samples. Discrete samples from 0 to 6 in. and 6 to 18 in. from all Category 2 sampling locations will be submitted for gross alpha and gross beta analyses. Sufficient material will be collected from each interval for subsequent laboratory analyses based on criteria-based or systematic location selection.
    - ❖ Systematic samples. Discrete samples from 0 to 6 in. and 6 to 18 in. from approximately 20% of Category 2 sampling locations will be submitted for laboratory analyses for gamma spectroscopy, isotopic americium, isotopic plutonium, isotopic uranium, and TAL

metals. Samples from Area 12 will also be submitted for analyses of VOCs, SVOCs, and PCBs. Samples from Area 11, SWMU 49-003, will be submitted for analyses of iodine-129, strontium-90, and technetium-99. Category 2 systematic sampling locations have been preselected to provide spatial coverage around historical detections above BVs and FVs.

- ❖ Criteria-based biased analytical samples. Discrete samples from 0 to 6 in. and 6 to 18 in. from all Category 2 sampling locations for which gross alpha exceeds 25 pCi/g will be submitted for analyses of gamma spectroscopy, isotopic americium, isotopic plutonium, isotopic uranium, and TAL metals. Sampling locations for which gross beta exceeds 50 pCi/g, will be submitted for analyses of iodine-129, strontium-90, and technetium-99. Samples from Area 12 will also be submitted for analyses of VOCs, SVOCs, and PCBs.

- Category 3: Sampling locations approximately 50 ft to 100 ft from Category 1 locations. Initial Category 3 sampling locations are spaced 50 ft apart across rows with locations staggered between rows to provide for spatial coverage. For Category 3 locations, the following samples will be collected:
  - ❖ Screening samples. Discrete samples from 0 to 6 in. and 6 to 18 in. from all Category 3 sampling locations will be submitted for gross alpha and gross beta analyses. Sufficient material will be collected from each interval for subsequent laboratory analyses based on systematic or criteria-based selection.
  - ❖ Systematic samples. Discrete samples from 0 to 6 in. and 6 to 18 in. from approximately 10% of Category 3 sampling locations will be submitted for analyses of gamma spectroscopy, isotopic americium, isotopic plutonium, isotopic uranium, and TAL metals. Samples from Area 12 will also be submitted for analyses of VOCs, SVOCs, and PCBs. Samples from Area 11, SWMU 49-003, will be submitted for analyses of iodine-129, strontium-90, and technetium-99. Category 3 systematic sampling locations have been preselected to provide spatial coverage around historical detections above BVs and FVs.
  - ❖ Criteria-based biased analytical samples. Discrete samples from 0 to 6 in. and 6 to 18 in. from all Category 3 sampling locations for which gross alpha exceeds 25 pCi/g will be submitted for analyses of gamma spectroscopy, isotopic americium, isotopic plutonium, isotopic uranium, and TAL metals. Sampling locations for which gross beta exceeds 50 pCi/g will be submitted for analyses of iodine-129, strontium-90, and technetium-99. Samples from Area 12 will also be submitted for analyses of VOCs, SVOCs, and PCBs.
  - ❖ If a Category 3 sample exceeds either of the criteria-based threshold values, all adjacent unsampled 25 ft grid locations will be submitted for gross alpha or gross beta analyses. The grid will be expanded at 25 ft increments to allow for complete characterization of extent of contamination. Any additional sampling locations exceeding gross alpha or gross beta thresholds will be submitted for appropriate laboratory analyses.

4.3.2 Area 1

Figure 4.3-1 illustrates the surface-sampling grid pattern to be used for Area 1. Sixteen Category 1 samples will be collected from grid locations near historical detections above BVs or FVs in the shaft area. One hundred twenty Category 2 samples will be collected for gross alpha and gross beta analyses, and a minimum of 24 samples will be submitted for laboratory analyses (additional samples may be submitted for analyses based on the gross alpha and gross beta results). Eighty-four Category 3 samples will be collected for gross alpha and gross beta analyses, and a minimum of 18 samples will be submitted

for laboratory analyses (additional samples may be submitted for analyses based on the gross alpha and gross beta results).

4.3.3 Areas 2, 2A, and 2B (MDA AB), and Area 12

Figure 4.3-2 illustrates the surface-sampling grid pattern to be used for Areas 2, 2A and 2B (MDA AB) and Area 12. These areas are combined because of their proximity to one another. Additional Category 3 sampling locations are added west of Area 2 to determine whether contamination occurs because of surface runoff toward the drainage (section 4.3.5). Ten Category 1 samples will be collected for gross alpha and gross beta analyses from grid locations near historical detections above BVs or FVs in Area 12; all samples will be submitted for laboratory analyses. Contaminated surface soil in MDA AB has already been removed and replaced with an ET cover and no samples will be collected within that area. One hundred eighty-four Category 2 samples will be collected for gross alpha and gross beta analyses, and a minimum of 38 samples will be submitted for laboratory analyses (additional samples may be submitted for analyses based on the threshold value results). Two hundred twenty-eight Category 3 samples will be collected for gross alpha and gross beta analyses, and a minimum of 44 samples will be submitted for laboratory analyses. Additional samples may be submitted for laboratory analyses based on the gross alpha and gross beta threshold values.

4.3.4 Area 3

Figure 4.3-3 illustrates the surface-sampling grid pattern to be used for Area 3. Twenty Category 1 samples will be collected for gross alpha and gross beta from grid locations near historical detections above BVs or FVs in the shaft area; all samples will be submitted for laboratory analyses. One hundred sixteen Category 2 samples will collected for gross alpha and gross beta analyses, and a minimum of 24 samples will be submitted for laboratory analyses (additional samples may be submitted for analyses based on the threshold value results). Eighty-four Category 3 samples will be collected for gross alpha and gross beta analyses with a minimum of 18 samples submitted for analyses. Additional samples may be submitted for laboratory analyses based on the gross alpha and gross beta threshold values.

4.3.5 Area 4

Figure 4.3-4 illustrates the surface-sampling grid pattern to be used for Area 4. Sixteen Category 1 samples will be collected for gross alpha and gross beta analyses near historical detections above BVs and FVs; all samples will be submitted for laboratory analyses. One hundred twenty-two Category 2 samples will collected for gross alpha and gross beta analyses, and a minimum of 24 samples will be submitted for laboratory analyses (additional samples may be submitted for analyses based on the threshold value results). Eighty-four Category 3 samples will be collected for gross alpha and gross beta analyses, and a minimum of 18 samples will be submitted for laboratory analyses. Additional samples may be submitted for analyses based on the gross alpha and gross beta threshold values.

4.3.6 Sediment in Drainage Channels

Sediment in drainages will be sampled to determine the nature and extent of contamination potentially transported from TA-49 SWMUs and AOCs into drainages and canyons downgradient of the sites within the NES boundary. Each drainage has been divided into reaches based on runoff and drainage features (major streams and ephemeral drainages) and potential contributing sources of contamination. Within each reach, sampling locations have been selected to evaluate upper-, middle-, and lower-reach conditions. Figure 4.3-5 shows the drainages and the approximate locations of the 49 sediment samples.

In order to provide a snapshot of contaminant distribution within each drainage feature at TA-49, samples will be collected along a transect perpendicular to the channel at each location including one location in the center of the channel, two locations perpendicular to the direction of flow, and one location on each side of the active channel along the transect. A survey of each drainage channel will be conducted before sampling to identify zones of sediment accumulation near each sampling location. If a sediment accumulation zone is less than 6 ft in width (perpendicular to flow), the outer samples will be collected from the outer edge of the accumulation zone. Discrete samples will be collected from each transect location from 0 to 6 in. and 6 to 18 in. to obtain gross alpha and gross beta results and to obtain laboratory analyses for gamma spectroscopy, isotopic americium, isotopic plutonium, isotopic uranium, TAL metals, and PCBs.

The South Canyons Investigation Work Plan (LANL 2006, 093713) addresses the potential to transport contamination from TA-49 SWMUs and AOCs by surface water into Water and Ancho Canyons. The canyon alluvial sediment at TA-49 will be investigated as part of this work plan.

4.3.7 Overland Corridors

Review of aerial photographs have revealed linear features that indicate potential overland corridors extending radially from the central control area (Area 5) to MDA AB and Areas 1, 3, and 4 (Purtymun and Stoker 1987, 006688). These corridors likely served as direct transportation routes for equipment and cabling during the testing period. Surface-soil investigations along these corridors will be performed to evaluate the nature and extent of contamination resulting from the use of these corridors during historical operations. Figure 4.3-6 shows the approximate location of the corridors as determined by a review of historical aerial photos and approximate locations of the 45 samples to be collected. Before sampling, a field survey will be conducted to map each corridor and select sampling locations. At each sampling location, grab samples spaced 10 ft apart will be collected along a transect with the middle sample being located at the approximate center of the corridor. Discrete samples will be collected from 0 to 6 in. and 6 to 18 in. for gross alpha and gross beta screening and for submittal to a laboratory for gamma spectroscopy, isotopic americium, isotopic plutonium, isotopic uranium, and TAL metals analyses. If a gross alpha or beta result exceeds the threshold value, all adjacent unsampled 10-ft grid locations will be sampled. The grid will continue to be expanded based on screening results to ensure the complete characterization of the extent of contamination. Additional samples may be submitted for laboratory analyses based on the gross alpha and gross beta threshold values.

4.4 Subsurface Investigations

4.4.1 Areas 2, 2A, and 2B (MDA AB): SWMUs 49-001(b), 49-001(c), and 49-001(d)

The subsurface investigation at MDA AB will address two objectives: (1) vadose-zone characterization and (2) design and installation of a monitoring system based upon the results. The drilling activities will be conducted in the following order to allow the design optimization of each subsequent drilling phase.

4.4.1.1 Deep Borehole

One vertical core hole will be advanced within Area 2 to the base of the Guaje Pumice Bed (approximately from 900 to 950 ft depth). The core hole will be located near shaft 2-R north of the abandoned 150-ft borehole location 49-02906. Borehole location 49-02906 was chosen because Shaft 2-R was planned but not drilled, and borehole location 49-02906 was successfully drilled (i.e., did not encounter contamination).

Shaft 2-R presents an optimal location for a deep core hole because it is adjacent to shaft 2-M and core hole CH-2 and will allow characterization within the region of highest historically observed infiltration in Area 2 while avoiding potential contamination in the blast radius of adjacent plutonium shot shafts.

Objectives of the deep borehole include

- characterization of contamination in the vadose zone beneath Area 2;
- characterization of the surge bed at the base of Qbt 4 (at anticipated depths of 60 to 80 ft) as a potential contaminant pathway that may coincide with the base elevation of the surrounding shafts;
- characterization of moisture and potential contaminant distributions at unit contacts and within higher permeability units (e.g. the vapor-phase notch at the base of Qbt 1v-c, Qbt t, and Qct);
- determination of the moisture profile adjacent to and below shaft 2-M and core hole CH-2 with particular emphasis on geologic contacts and higher permeability zones (e.g. surge deposits and welding breaks)
- determination of the presence of perched intermediate groundwater beneath Area 2;
- determination of the geophysical and hydrogeologic properties of the subsurface beneath Area 2;
- characterization of the high permeability zones observed at depths of 285 to 300 ft bgs during the previous drilling of core hole CH-2 and well DT-5A;
- determination of the potential contact between the Tshirege and Otowi Members of the Bandelier Tuff to act as a hydraulic barrier (encountered at approximately 600 ft bgs in nearby borehole location 49-02901); and
- completion of the borehole as a moisture-monitoring or vapor-monitoring well based on monitoring results.

The borehole will be advanced to the base of the Guaje Pumice Bed (approximately 900 to 950 ft bgs) using drilling methods appropriate for achieving the 900 ft depth. Based on the stratigraphy encountered in nearby well DT-5A, stratigraphic units potentially present at this depth include the Otowi Member, the Guaje Pumice Bed, and the upper Puye Formation.

If intermediate perched water is encountered, drilling will immediately cease to avoid penetrating the perched unit. The depth to water will be sounded and a groundwater sample will be collected if sufficient water is present. A temporary well will be installed and NMED will be notified of the presence of perched water. A perched groundwater well installation and monitoring plan will be submitted to NMED for review and approval before permanent well installation.

If perched water is not encountered, the borehole will be advanced as planned to 900 ft. Upon completion, an appropriate moisture-monitoring or vapor-monitoring well installation and sampling plans will be submitted to NMED for review and approval before permanent well installation.

If radiological contamination is encountered, drilling will immediately cease and NMED will be notified. The drilling of the borehole in the area will be reevaluated and a collaborative decision will be made to relocate the borehole.

4.4.1.2 Perimeter Boreholes

Following completion of the deep borehole and review of all data, four additional vertical boreholes will be drilled along the perimeter of Areas 2, 2A, and 2B. Boreholes will be no closer than 20 ft from any shot point; the reported maximum fracture zone is a 10- to 15-ft radius from a shot point (LANL 1992, 007670, p. 7-16). Preliminary locations are presented in Figures 4.4-1; however, the final locations of these boreholes may be revised pending the results of field verification surveys and/or to achieve optimal lateral bounding of subsurface contamination at MDA AB. Each borehole will be advanced to a minimum depth of 130 ft bgs, which is 50 ft below the deepest shaft at Areas 2, 2A, and 2B, or 25 ft below the deepest detected contamination based on field screening, if beyond the minimum depth.

Objectives of the perimeter boreholes include

- characterization of lateral and vertical contamination beneath MDA AB and definition of the MDA AB lateral subsurface footprint;
- characterization of the surge bed (base of Qbt 4) at anticipated depths of 60 to 80 ft, which may coincide with the base elevation of the surrounding shafts;
- determination of the moisture profile along the perimeter of MDA AB at depth; and
- completion as a moisture-monitoring or vapor-monitoring well based on subsurface sampling results.

Pore-gas samples will be collected from each borehole using a single straddle packer in advance of the drill bit during borehole advancement to isolate discrete depths (minimum 10-ft intervals) within the borehole as determined by field screening. These samples will be submitted for analyses of VOCs and tritium.

Upon completion and sampling of each borehole, a moisture-monitoring well will be installed. If vapor-phase contamination is confirmed by laboratory analyses, a temporary well will be installed and a vapor-monitoring well installation and sampling plan will be submitted to NMED for review and approval before well installation is completed.

4.4.1.3 Directional Borehole

The drilling of a directional (horizontal) borehole beneath MDA AB is contingent upon conditions observed during drilling of the deep borehole (section 4.4.1.1). If radiological contamination is identified below the depth of the deepest experimental shaft, moisture content is observably elevated, or intermediate perched water is encountered in the deep borehole, NMED will be notified. The horizontal borehole may be drilled based on a collaborative decision made between the Laboratory and NMED.

If drilled, this borehole will provide additional fracture characterization, characterization of lateral extent of contamination and/or elevated moisture levels within the vadose zone beneath MDA AB and long-term monitoring capability in support of a final remedy.

This borehole is sited as entering the side of the canyon northeast of Area 2 in a tributary of Water Canyon. The borehole would enter the side of the canyon from the east to northeast and trend south to southwest. The borehole is designed to travel horizontally below Area 2 at a depth based on the results from the drilling of the deep borehole. The anticipated location of this horizontal borehole is presented in Figure 4.4-2.

4.4.2 Areas 1, 3, and 4 (Experimental Shafts): SWMUs 49-001(a), 49-001(e), and 49-001(f)

No data exist for the subsurface characterization of potential contamination at Areas 1, 3, and 4. No type of site cover or other surface modification has been implemented at Areas 1, 3, and 4; therefore, no adverse moisture impacts are anticipated.

The subsurface investigation activities at Areas 1, 3, and 4 share a common approach. Four vertical boreholes will be drilled along the perimeter of each area. Boreholes will be no closer than 20 ft from any shot point; the reported maximum fracture zone is a 10- to 15-ft radius from a shot point (LANL 1992, 007670, p. 7-16). Locations are presented in Figures 4.4-2 through 4.4-4; however, the final locations of these boreholes may be revised pending the results of field verification surveys. Each borehole will be advanced to a minimum depth of 50 ft bgs below the deepest shaft at each area or 25 ft below the deepest detected contamination based on field screening if beyond the borehole minimum depth.

Objectives of the perimeter boreholes are

- characterization of potential vertical and lateral contamination beneath Areas 1, 3, and 4 and definition of the lateral subsurface footprint for each area;
- characterization of the surge bed (base of Qbt 4) at anticipated depths of 60 to 80 ft;
- determination of the moisture profile along the perimeter of Areas 1, 3, and 4 at depth; and
- completion as a moisture-monitoring or vapor-monitoring well as indicated by results.

The maximum shaft depth and minimum borehole depth at each area are as follows:

- at Area 1, the maximum shaft depth is 85 ft bgs, corresponding to a minimum borehole depth of 135 ft bgs;
- at Area 3, the maximum shaft depth is 142 ft bgs, corresponding to a minimum borehole depth of 192 ft bgs; and
- at Area 4, the maximum shaft depth is 108 ft bgs, corresponding to a minimum borehole depth of 158 ft bgs.

Pore-gas samples from boreholes at each of the experimental shaft areas will be collected using a single straddle packer in advance of the drill bit during borehole advancement to isolate discrete depths (minimum 10-ft intervals) within each borehole. Samples will be submitted for analyses of VOCs and tritium. Upon completion and sampling of each borehole, a moisture-monitoring well will be installed. If vapor phase contamination is confirmed by laboratory analyses, a temporary well will be installed and a vapor-monitoring well installation and sampling plan will be submitted to NMED for review and approval before well installation is completed.

4.4.3 Area 11: SWMU 49-003, Leach Field and Associated Drainlines

An attempt will be made to locate the leach field drainlines using the appropriate method presented in section 4.2. Four vertical boreholes will be advanced at the locations of the drainlines to a minimum depth of 20 ft bgs or 5 ft below the deepest detected contamination based on field screening if beyond the minimum depth. The objective of these boreholes is to characterize vertical contamination beneath the leach field. Borehole locations are presented in Figure 4.4-5.

4.4.4 Area 11: AOC 49-008(c), Area of Potential Soil Contamination

Two vertical boreholes will be advanced at the small-scale shot area, AOC 49-008(c). One borehole will be drilled to intersect the surge bed (base of Qbt 4) at approximately 60 to 80 ft bgs, and one borehole will be drilled to a minimum depth of 35 ft bgs or 10 ft below the deepest detected contamination based on field screening if beyond the minimum depth. The borehole locations are presented in Figure 4.4-5. Objectives of these boreholes include

- characterization of vertical extent associated with the small-scale shot area,
- characterization of the surge bed (base of Qbt 4) at anticipated depths of 60 to 80 ft, and
- determination of the moisture profile beneath the small-scale shot area.

If field moisture measurements indicate conditions observed in native tuff, the boreholes will be abandoned in accordance with the methods presented in section 5.2.4. Pore-gas samples will be collected using a single straddle packer in advance of the drill bit during borehole advancement to isolate discrete depths (minimum 10-ft intervals) within two boreholes at the small scale shot area. Samples will be submitted for analyses of VOCs and tritium. If vapor-phase contamination is confirmed by laboratory analyses, a temporary well will be installed and a vapor-monitoring well installation and sampling plan will be submitted to NMED for review and approval.

The footprint of the former radiochemistry building will be located using the methods presented in section 4.2. Five vertical boreholes will be advanced within the footprint of the radiochemistry building. The boreholes will be advanced to a minimum depth of 10 ft bgs or 5 ft below the deepest detected contamination based on field screening if beyond a depth of 10 ft. The objective of the boreholes is to characterize the vertical extent of contamination beneath the former radiochemistry building.

An attempt will be made to locate the drain and/or sump at the former radiochemistry building using the appropriate method presented in section 4.2. One vertical borehole will be advanced to a minimum depth of 10 ft bgs below the base of the drain and/or sump or 5 ft below the deepest detected contamination based on field screening if beyond a depth of 10 ft. The objective of the borehole is to characterize potential vertical contamination beneath the former radiochemistry building drain.

4.4.5 Area 12: AOC 49-008(d), Bottle House and CPTF, Area of Potential Soil Contamination

The former Bottle House and CPTF will be located using the appropriate method presented in section 4.2. One vertical borehole will be advanced at a location within 10 ft of the former Bottle House to a minimum depth of 120 ft bgs. This depth corresponds to 90 ft below the base of the Bottle House shaft (30 ft bgs). One vertical borehole will be advanced to a minimum depth of 120 ft bgs beneath the location of the former CPTF. Figure 4.4-6 presents the borehole locations. Objectives of these boreholes include the following:

- characterization of vertical extent of contamination beneath the Bottle House and CPTF, and
- characterization of the surge bed (base of Qbt 4) at anticipated depths of 60–80 ft in the Bottle House borehole, if present.

If field moisture measurements are indicative of conditions generally observed in native tuff, the boreholes will be abandoned in accordance with the methods presented in section 5.2.4. Pore-gas samples will be collected using a single straddle packer in advance of the drill bit during borehole advancement to isolate discrete depths (minimum 10-ft intervals) within the borehole at the Bottle House. Samples will be submitted for analyses of VOCs and tritium. If vapor-phase contamination is confirmed by laboratory

analyses, a temporary well will be installed and a vapor-monitoring well installation and sampling plan will be submitted to NMED for review and approval.

4.4.6 Drilling Plan

Advancement of boreholes at MDA AB and Areas 1, 3, and 4 will be achieved by auger to refusal then by the air-rotary drilling method.

Air rotary is the preferred drilling method based on the following.

- Field experience indicates the need to airlift cuttings out of the boreholes to maintain access for future monitoring system installation.
- Drill bit control is a priority to achieve drilling goals and avoid highly contaminated zones around shots.
- Casing advance methods, only available through air rotary, provide better control than with augering.
- Air rotary is the only method capable of coring to depths up to 900 ft.
- Air rotary allows for engineered control of dust and cuttings, minimizing worker exposure to potential hazards.

Air rotary, hollow-stem auger, hand-auger drilling, or a combination of these methods may be used for the boreholes proposed at Area 11 and Area 12.

Boreholes will be drilled in order of difficulty (from simple to complex) to optimize lessons learned and minimize risk to workers, the public, and the environment. Drilling activities should start at Area 11, followed by Area 12, Area 3, Area 1, Area 4, and Areas 2, 2A, and 2B (MDA AB). A site-specific borehole drilling order for MDA AB is presented in section 5.2.1.

All core samples will be field screened for gross alpha, gross beta, and gross gamma activity before release and shipment to the SMO and an analytical laboratory. Additionally, field screening for VOCs will be performed for subsurface samples collected from Areas 11 and 12 per section IV.C.4.c.iii of the Consent Order.

4.4.7 Sampling Plan

Core sampling will be conducted from ground surface to total depth (TD) in all boreholes to describe subsurface stratigraphy, investigate downward migration of surface contamination, and to determine the extent of subsurface contamination associated with each area. All boreholes will be continuously cored to TD. One core barrel sample will be collected from every 10 ft of drill core at MDA AB and Areas 1, 3, and 4 and from every 5 ft of core at Areas 11 and 12. Additional samples will be collected from the following intervals:

- at fractures;
- at the soil/tuff interface, tuff samples;
- at the depth immediately below the base of the disposal unit or facility structure;
- at first encounter with geologic units of different lithology, structural or textural characteristics, or relatively higher or lower permeability;

- From soil or rock types more likely to sorb or retain contaminants than the surrounding lithology, field determination;
- at first encounter with shallow or intermediate saturated zones, if present;
- at intervals suspected of being source or contaminated zones; and
- at the maximum depth of each boring.

The number of samples and intervals for each borehole are presented in Table 4.4-1. All samples will be field screened for gross alpha, gross beta, and gross gamma activity, and screening for VOCs will be performed for subsurface samples collected from Areas 11 and 12 as detailed in section 5.0.

4.4.8 Analysis Plan

The selection of core samples to be submitted to an analytical laboratory will be based on the following criteria:

- The sample exhibiting the highest field screening detection
- The sample obtained from the maximum depth in each boring that displays field screening evidence of contamination
- The sample located at the base of a disposal unit or facility structure
- The sample obtained from the maximum boring depth or total depth (TD) of each borehole
- VOC detections at Areas 11 and 12 only

Additional core samples may be selected based on field observations (such as the presence of fracturing, staining, observable elevated moisture content) or to assess key lithologic or permeability characteristics (e.g., the surge bed at the base of Qbt 4 and the contact between the Tshirege and Otowi Members of the Bandelier Tuff).

All core samples will be submitted to an analytical laboratory and analyzed for explosive compounds, perchlorate, TAL metals, cyanide, isotopic americium, isotopic plutonium, isotopic uranium, and tritium. Subsurface samples from Areas 11 and 12 submitted to an analytical laboratory will also be analyzed for VOCs and SVOCs. Core samples from Area 11, SWMU 49-003, will also be submitted for analyses of iodine-129, strontium-99, and technetium-99. Core samples collected from the CPTF borehole at Area 12 will be submitted to an analytical laboratory for analyses of total petroleum hydrocarbon diesel-range organics.

All new boreholes penetrating the surge bed (exceeding depths of approximately 60 ft) will be subject to geophysical testing, including borehole video, neutron logging, and natural gamma. If borehole video indicates diameter variations, calipers will be used to measure the borehole diameter at depth. Air-permeability measurements will be collected from the deep borehole at Area 2; from one borehole at Areas 1, 3, and 4; and from the deep boreholes at Areas 11 and 12.

Vapor-phase samples will be collected during drilling from the perimeter boreholes at MDA AB and one borehole at each Area 1, 3, and 4; from two boreholes at Area 11; and from one borehole at Area 12 to determine if vapor-phase contamination is present. Tritium and VOC pore-gas samples will be collected from the intervals prescribed in Table 4.4-1 and at TD.

Selected core samples from the deep borehole at Area 2 will be analyzed for stable isotopes (oxygen and hydrogen) and anions (chloride and bromide) to provide information on infiltration rates.

Selected core samples from the 17 vertical boreholes at Areas 1, 2, 2A, 2B, 3, and 4 will be analyzed for hydrogeologic properties such as unsaturated hydraulic conductivity, permeability, and van Genuchten hydraulic properties. Representative samples will be collected from each unit based on field determinations and in areas with more contamination. All 17 boreholes will penetrate the surge bed (base of Qbt 4) if laterally present in each location and in Qbt 3. Based on the stratigraphy encountered in nearby well DT-5A, stratigraphic units potentially present at this depth include the Otowi Member, the Guaje Pumice Bed, and the upper Puye Formation.

A summary of proposed boreholes and sampling is presented in Table 4.4-1. Analytical methods are presented in Table 4.4-2.

Groundwater samples, if encountered during drilling, will be collected and submitted for analyses as presented in Table 4.4-3. No surface-water samples will be collected as part of this work plan.

4.4.9 Groundwater Monitoring

Two regional groundwater monitoring wells will be installed to provide information for refining groundwater flow direction, characterizing the potential for present-day contamination from MDA AB, and providing for long-term monitoring for the potential impact of MDA AB on regional groundwater. Each of the two wells will be located downgradient from MDA AB. One of these planned wells is R-30, which was proposed as part of the “South Canyons Investigation Work Plan” (LANL 2006, 093713). However, R-30 will now be drilled in the context of this investigation. The number and final locations of new regional groundwater monitoring wells will be assessed in consultation with NMED after data on contaminant and moisture distributions are evaluated for the deep borehole drilled at Area 2. All plans for the installation of new regional groundwater monitoring wells will be submitted to NMED for approval.

Additionally, R-27, drilled in Water Canyon in 2005, will be evaluated for suitability as an additional downgradient monitoring well. The existing DT-series wells provide composite groundwater-level data; however, the construction materials and long screen lengths (up to 220 ft) limit the usefulness of the analytical data for monitoring purposes and for determining the flow gradients beneath MDA AB.

Perched-intermediate well R-27i is being installed as part of the “South Canyons Investigation Work Plan” (LANL 2006, 093713, p. 52) to monitor beneath Water Canyon. R-27i will target a perched zone that was penetrated in the Puye Formation above the Cerros del Rio basalt while during drilling of R-27.

4.5 Investigation-Derived Waste

All IDW generated during field-investigation activities may include, but is not limited to, drill cuttings; contaminated soil; contaminated personal protective equipment (PPE), sampling supplies, and plastic; fluids from the decontamination of PPE and sampling equipment; and all other waste that has potentially come into contact with contaminants

All IDW generated during the TA-49 field-investigation activities will be managed in accordance with applicable standard operating procedures (SOPs). These SOPs incorporate the requirements of all applicable EPA and NMED regulations, DOE orders, and Laboratory implementation requirements (LIRs). Appendix B details the IDW management plan.

5.0 INVESTIGATION METHODS

A summary of investigation methods to be implemented is presented in Table 5.0-1. The SOPs used to implement these methods are available on the Laboratory Environmental and Remediation Support Services Division web page at http://www.lanl.gov/environment/all/qa.shtml.

Summaries of the field investigation methods are provided below. Additional procedures may be added as necessary to describe and document quality-affecting activities.

Chemical analyses will be performed in accordance with the analytical statement of work (LANL 2000, 071233). Accredited contract laboratories will use the most recent EPA- and industry-accepted extraction and analytical methods for chemical analyses for analytical suites.

5.1 Field Surveys

The following sections describe the field surveys that will be conducted at Areas 1, 2, 2A, 2B, 3, 4, 11, and 12.

5.1.1 Geodetic Surveys

Geodetic surveys will be conducted by a land surveyor in accordance to the latest version of SOP-03.11, "Coordinating and Evaluating Geodetic Surveys," to locate historical structures and to document field activities such as sampling and excavation locations. The surveyors will use a Trimble GeoXT hand-held global positioning system (GPS) or equivalent for the surveys. The coordinate values will be expressed in the New Mexico State Plane Coordinate System (Transverse Mercator), Central Zone, North American Datum 1983. Elevations will be reported as per the National Geodetic Vertical Datum of 1929. All GPS equipment used will meet the accuracy requirements specified in the SOP.

5.1.2 Geophysical Surveys

Geophysical surveys may be performed at selected sites to verify the location, dimensions, TD, base profile, topography, low elevation point, and downslope end of each shaft at Areas 1, 2, 2A, 2B, 3, 4, 11, and 12 if such cannot be determined using as-built construction drawings and boring logs. The surveys will verify locations determined from engineering drawings, site reconnaissance, and geodetic surveys and refine assessments of the subsurface structures. Geophysical methods employed may include electromagnetic, gravity, and ground-penetrating radar as appropriate to effectively delineate the materials or feature being surveyed.

5.1.3 Radiological Surveys

Radiological field surveys will be conducted at Areas 1, 2, 2A, 2B, 3, 4, 11, and 12 using appropriate field instrumentation for gross alpha and gross beta detection. The surveys will be conducted on a 25-ft grid as presented in section 4.3. Samples exceeding 25 pCi/g alpha or 50 pCi/g beta will be sent for laboratory analyses.

5.2 Subsurface Characterization

5.2.1 Drilling Methods for Boreholes

Boreholes at Areas 1, 2, 2A, 2B, 3, 4, 11, and 12 will be drilled by hollow-stem auger, air-rotary, or hand-auger methods as indicated in section 4.4.6. A brief description of these methods is provided below. More information can be found in SOP-04.01, "Drilling Methods and Drill Site Management." Selected boreholes will be geophysically logged with caliper, camera, neutron, and natural gamma tools according to the current versions of SOP-04.04, "Contract Geophysical Logging," and SOP-07.05, "Subsurface Moisture Measurements Using a Neutron Probe."

5.2.1.1 Hollow-Stem Auger

The hollow-stem auger consists of a hollow-steel shaft with a continuous spiraled steel flight welded onto the exterior of the stem. The stem is connected to an auger bit; when rotated, the auger bit transports cuttings to the surface. The hollow stem of the auger allows insertion of drill rods, split-spoon core barrels, Shelby tubes, and other samplers through the center of the auger so that samples may be retrieved during drilling operations. The hollow stem also acts to case the borehole core temporarily so that a well casing (riser) may be inserted down through the center of the auger once the desired depth is reached, thus minimizing the risk of possible collapse of the borehole. A bottom plug or pilot bit can be fastened onto the bottom of the auger to keep out most of the soil and/or water that have a tendency to clog the bottom of the augers during drilling. Drilling without a center plug is acceptable if the soil plug, formed in the bottom of the auger, is removed before sampling or installing a well casing. The soil plug can be removed by washing out the plug using a side-discharge rotary bit or auguring out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger.

5.2.1.2 Air Rotary

The air-rotary method uses a drill pipe or drill stem coupled to a drill bit that rotates and cuts through soil and rock. The cuttings produced from the rotation of the drill bit are transported to the surface by compressed air, which is forced down the borehole through the drill pipe and returns to the surface through the annular space (between the drill pipe and the borehole wall). The circulation of the compressed air not only removes the cuttings from the borehole, but it also helps to cool the drill bit. The use of air-rotary drilling is best suited for hard-rock formations. In soft unconsolidated formations, casing is driven to keep the formation from caving. When air rotary is used, the air compressor will have an inline organic filter system to filter the air coming from the compressor. The organic filter system shall be inspected regularly to ensure that the system is functioning properly. In addition, a cyclone-velocity dissipater or similar air-containment/dust-suppression system will be used to funnel the cuttings to one location instead of allowing the cuttings to discharge uncontrolled from the borehole. Air rotary that employs the dual-tube (reverse-circulation) drilling system is acceptable because the cuttings are contained within the drill stem and are discharged through a cyclone-velocity dissipater to the ground surface.

5.2.1.3 Hand Auger

Hand augers may be used to bore shallow holes (0 to 15 ft). The hand auger is advanced by turning or pounding the auger into the soil until the barrel is filled. The auger is removed and the sample is dumped out. Motorized units (for one or two operators) may be used and can reach depths up to 30 ft under certain conditions.

5.2.2 Groundwater Monitoring Well Installation

Section IV.C.4.c.vi of the Consent Order requires installation of one groundwater monitoring well, which intersects intermediate perched groundwater, if such groundwater is present beneath the site. If perched groundwater is encountered, this well will be completed as a single-completion well in accordance with the current versions of SOP- 5.01, "Well Construction," and SOP-5.02, "Well Development." A plan for construction of the well will be submitted to NMED for approval before construction begins.

5.2.3 Vapor-Monitoring Well Installation

No vapor-monitoring wells are currently planned. Vapor-phase samples will be collected from selected boreholes as proposed in section 4.4.8 and in accordance with the procedure presented in section 5.3.4. Vapor-monitoring wells will be installed if vapor-phase contamination is confirmed by field screening results. Before vapor well construction, a vapor-monitoring and sampling plan will be submitted to NMED for approval.

5.2.4 Borehole Abandonment

All boreholes will be abandoned according to the most recent version of SOP-5.03, "Monitoring Well and RFI Borehole Abandonment," except those identified for completion as vapor-monitoring wells, moisture-monitoring wells, or groundwater monitoring wells, by one of the following methods.

- Shallow boreholes, with a TD of 20 ft or less, will be abandoned by filling the borehole with bentonite chips and subsequently hydrated. Chips will be hydrated in 1 to 2 ft lifts. The borehole will be visually inspected while the bentonite chips are being added to ensure that bridging does not occur.
- Boreholes greater than 20 ft in depth will be pressure-grouted from the bottom of the borehole to the surface using the tremie pipe method. Acceptable grout materials include cement or bentonite grout, neat cement, or concrete.

The use of backfill materials such as bentonite and grout will be documented in a field logbook with regard to volume (calculated and actual), intervals of placement, and additives used to enhance backfilling. All borehole abandonment information will be provided in the investigation report.

5.3 Sample Collection

5.3.1 Surface Samples

While surface and shallow subsurface samples will be collected during drilling activities, the most common method for collecting these predominantly soil and sediment samples will be consistent with SOP-06.09, "Spade and Scoop Method for the Collection of Soil Samples." Stainless-steel shovels, spades, scoops, and bowls will be used for ease of decontamination. Decontamination will be completed using a dry decontamination method with disposable paper towels and over-the-counter cleaner, such as Fantastik or equivalent. Disposable tools made of polystyrene or Teflon will also be used, if necessary. In some cases, for deeper sample intervals, hand-augering tools, including power augers, will be used to collect shallow subsurface samples if geologic material conditions permit. The tools to be used and their applicability are described in the current version of SOP-06.10, "Hand Auger and Thin-Wall Tube Sampling." If the surface location is at bedrock, an axe or hammer and chisel will be used to collect samples.

Soil and sediment samples will be field screened as described in the following sections and placed in the appropriate sample container(s) as grab samples collected with hand augers, scoops, or chiseling devices in accordance with the sampling guidance document and appropriate SOPs (SOP-01.01 through SOP-01.08).

5.3.2 Subsurface Samples

Following the current version of SOP-06.24, "Sample Collection from Split-Spoon Samplers and Shelby Tube Samplers," and SOP-06.26, "Core Barrel Sampling for Subsurface Earth Materials," subsurface samples will be collected from core extracted in a split-spoon core barrel. Samples collected for chemical analyses will be placed in the appropriate sample containers depending on the analytical method requirement in accordance with the current version of SOP ENV-DO-206, "General Instructions for Field Investigations." The analytical suites for the samples from each borehole will vary according to the data requirements as described in sections 4.4-7 through 4.4-8 of this work plan.

Quality assurance/quality control (QA/QC) samples will include field duplicate samples, rinsate blanks, equipment blanks, trip blanks, and reagent blanks. These samples will be collected following the current version of SOP-01.05, "Field Quality Control Samples," and will comply with a frequency of 10% of total samples collected for field duplicates and rinsate blanks. Trip blanks will be supplied and remain with analytical samples when collecting samples for VOC analyses. QA/QC samples are used to monitor the validity of the sample collection procedures.

Following the current version of SOP-12.01, field documentation of samples collected from fractures will include a detailed physical description of the fracture-fill material and rock matrix sampled. The volumes of fracture-fill and rock-matrix material included in the sample will be estimated from field measurements. Additional samples will be collected from the rock matrix adjacent to the fracture sample material, thus allowing for comparison.

Field documentation will also include detailed borehole logs for each borehole drilled. The borehole logs will document the matrix material in detail and will include the results of all field screening; fractures and matrix samples will be assigned unique identifiers. All field documentation will be completed in accordance with the current version of SOP-12.01.

5.3.3 Groundwater Samples

Perched intermediate groundwater may be encountered while the deep borehole at Area 2 is advanced. If saturation is encountered as a borehole advances, drilling will be stopped to determine whether sufficient water volume is available for analyzing the water quality. Generally, the total water volume required for an analytical sample is approximately 0.5 to 1 L. If this minimum volume of groundwater cannot be collected, the borehole will be advanced to the targeted depth or until saturation is encountered again and the process is repeated, or until the required TD is achieved. A porous cup lysimeter or absorbent membrane will be installed at the depth of saturation to monitor the zone if the borehole is completed for monitoring. Insufficient water-sample volumes from discrete depths will not be composited to make up the required volume for screening analysis.

If a sufficient volume exists, a groundwater sample will be collected and analyzed for TAL metals, explosive compounds, anions, VOCs, SVOCs, perchlorate, radionuclides (by alpha and gamma spectroscopy), alkalinity, nitrates, total organic carbon, total inorganic carbon, and total dissolved solids at a Laboratory-certified analytical laboratory. Typically, results of groundwater screening samples are available within 48 h. During this time, the borehole may be advanced to the targeted depth, and the

perched zone (and subsequent perched zones encountered during drilling) will be isolated to prevent downhole migration.

Geophysical logging will be conducted according to SOP-04.04, "Contract Geophysical Logging," and SOP-05.07, "Operation of LANL Owned Borehole Logging Trailer." Geophysical logging will determine the thickness of the zone of saturation and the characteristics of the perching horizon. A monitoring well design will be submitted to NMED for approval. Following approval of the design, the well will be installed, and a groundwater-monitoring plan will be included in the investigation report or in the appropriate annual update of the IFGMP (LANL 2007, 096665).

Groundwater samples from developed wells will be collected in accordance with SOP-06.01, "Purging and Sampling Methods for Single Completion Wells." After a groundwater sample has been collected and processed, aliquots of the sample are placed in appropriate containers and preserved according to SOP ENV-DO-206, "Sample Container and Preservation." Requirements for sample volume, containerization, hold times, and detection limits are provided in the analytical services statement of work (LANL 2000, 071233).

5.4 Field-Screening Methods

The primary field-screening methods to be used on subsurface samples include (1) visual examination, (2) radiological screening, and (3) headspace vapor screening for VOCs using a photoionization detector (PID).

5.4.1 Radiological Screening

Radiological screening will target gross alpha-, beta-, and gamma-emitting radionuclides. Field screening will be conducted within 1 in. of the sampled material by a radiation control technician. All radiological screening will be conducted using an Eberline E-600 radiation meter with an SHP-380AB alpha/beta scintillation detector, or equivalent. This equipment consists of a dual phosphor plate covered by two mylar windows housed in a light-excluding metal body. The phosphor plate is a plastic scintillator for the detection of beta emissions and is thinly coated with zinc sulfide for detecting alpha emissions. The operational range varies from trace emissions to 1 million disintegrations per min.

Local background levels will be collected, at a minimum, twice daily, once in the morning and once in the afternoon. If more than one site is visited in a day, background levels will be calculated before work begins at each new site. Background will be measured from 10 locations surrounding the site and from known or suspected areas of radiological contamination. An average will be calculated to determine the local background level for the site. Radiological field screening will be conducted in accordance with SOP-10.14, "Performing and Documenting Gross Gamma Radiation Scoping Surveys." All local background checks, background ranges, and calibration procedures will be documented daily in the field logbook in accordance with the current version of SOP MAQ-011, "Logbook Use and Control."

Boreholes completed using mechanical drilling methods will be advanced 25 ft beyond elevated field-screening results for field screen. If elevated field-screening results are recorded within 10 ft of the target depth, the borehole will be advanced using mechanical drilling methods in 5-ft intervals until no elevated field-screening results are recorded over a 10-ft interval.

5.4.2 Vapor Screening for VOCs

Organic vapor screening of subsurface core will conducted using a MiniRAE 2000 portable VOC monitor model PGM-7600 PID, or equivalent, and will be equipped with an 11.7-electron volt lamp and sensitivity reading to 1 part per million (ppm). Before each day's fieldwork begins, the PID will be calibrated to the manufacturer's standard for instrument operation (all daily calibration results will be documented in the field logbook). Field screening for VOCs will be accomplished by headspace analysis at 5-ft intervals in each borehole in accordance with SOP-06.33. The maximum value and ambient air temperature will be recorded in the field borehole or test pit log for each sample. A VOC field-screening result that exceeds the ambient background measurement is defined as greater than 2 times the measured background value.

5.4.3 Laboratory Analytical Methods

The analytical suites required for laboratory analyses vary by area as specified in section 4.5.8 and summarized in Table 4.5-1. All laboratory analytical suites are presented in the statement of work for analytical laboratories (LANL 2000, 071233). Sample collection and analyses will be coordinated with the SMO.

5.4.4 Equipment Decontamination

Equipment for drilling and sampling will be decontaminated before and after drilling and sampling activities (as well as between boreholes) to minimize the potential for cross-contamination. Drilling/exploration equipment that may come into contact with the borehole will be decontaminated by steam cleaning, hot-water pressure washing, or by another method before drilling each new boring. All sampling and measuring equipment, including but not limited to, stainless-steel sampling tools, split-barrel or core samplers, well developing or purging equipment, groundwater quality measurement instruments, and water-level measurement instruments, will be decontaminated in accordance with SOP-01.08, "Field Decontamination of Drilling and Sampling Equipment." The equipment will be pressure-washed with a high-density polyethylene liner on a temporary decontamination pad. Cleaning solutions and wash water will be collected and contained for proper disposal. Decontamination solutions will be sampled and analyzed to determine the final disposition of the wastewater and the effectiveness of the decontamination procedures. All parts of the drilling equipment, including the undercarriage, wheels, tracks, chassis, and cab will be thoroughly cleaned. Air filters on equipment operating in the exclusion zone will be contaminated, removed, and replaced before the equipment leaves the site. Sites identified as radiological control areas based upon surface radiological surveys will have all equipment surveyed by a Health and Safety Radiation Control Division technician before it is released from the site.

6.0 MONITORING AND SAMPLING PROGRAMS

6.1 Groundwater

Section IV.C.4.c.viii of the Consent Order requires monitoring and sampling of the wells associated with MDA AB within the Water Canyon/Cañon de Valle and Ancho Canyon Watersheds containing alluvial, intermediate, and regional groundwater as part of the IFGMP (LANL 2007, 096665). Based on the results of the investigations in this work plan and after completing the installation of additional monitoring wells in the Water Canyon/Cañon de Valle and Ancho Canyon Watersheds, a watershed-specific groundwater-monitoring plan will be submitted to NMED for review and approval. Upon NMED approval, the

requirements of the monitoring plan will apply and supersede the requirements of the Water Canyon/Cañon de Valle and Ancho Canyons Watershed sections of the IFWGMP (LANL 2007, 096665).

6.2 Air

A meteorological station located in the southeastern portion of TA-49 has provided data on air quality and meteorology since 1987. Air monitoring station 23, located at the main gate to TA-49, and air monitoring station 32, located in Area 12, measure levels of airborne radionuclides (tritium, uranium, plutonium, and americium). During the 10-plus yr of operation of air-monitoring station 23, results have indicated tritium concentrations above background on only a few occasions (Purtymun and Stoker 1987, 006688). These events involved tritium levels far below existing air-quality guidelines and are attributed to releases elsewhere at the Laboratory. Air-monitoring station 23 has detected levels of airborne plutonium and americium just above background only during one quarterly sampling period. The concentrations detected were below DOE action guidelines (LANL 1992, 007670 p. 4-44). It is highly probable that the airborne radioactivity was derived from the transport of known low-level soil contamination in Area 2 during dry, windy conditions. Air monitoring continues as part of the Laboratory's annual environmental surveillance program (LANL 2007, 098644).

A series of thermoluminescent dosimeter (TLD) stations located around MDA AB and a second array of background TLDs near well DT-9 have measured penetrating radiation levels at TA-49 for many years. The Laboratory's annual environmental surveillance reports indicate that doses at TA-49 are indistinguishable from regional background levels (LANL 2007, 098644).

6.3 Sediment and Surface Water

A sediment-sampling program was initiated by the Environmental Studies and Assessment Group in 1979. Twelve sediment stations were set up in and around TA-49 (Figure 2.11-4). Sediment sample stations AB-2 and AB-3 are located in drainage areas to the northeast and northwest of Area 2. The remaining 10 stations are scattered around TA-49 in drainage areas. Radiochemical analyses conducted annually at these stations since 1979 have detected cesium-137, plutonium-238, plutonium-239/240, gross alpha, gross beta, gross gamma, and total uranium. Americium-241 and strontium-90 were added to the analytical suite in 1992. The most recent data reported is included in the 2006 Environmental Surveillance Report (LANL 2007, 098644).

Surface-water gauging stations within TA-49 are monitored under the Federal Facilities Compliance Agreement (FFCA) established to regulate stormwater discharges from SWMUs and AOCs (LANL 2006, 093925, p. 52). This monitoring will continue under the FFCA. Surface water and sediment sampling locations for TA-49 are presented on Figure 2.11-4.

7.0 SCHEDULE

The scheduled notice date for NMED to approve this investigation work plan is February 28, 2008. Field activities will not begin before approval of the work plan. The investigation report for SWMUs 49-001(a), 49-001(b), 49-001(c), 49-001(d), 49-001(e), 49-001(f), 49-001(g), 49-003, and AOC 49-008(d) is due May 31, 2010.

8.0 REFERENCES AND MAP DATA SOURCES

8.1 References

The following list includes all documents cited in this plan. 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 Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the 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 Directorate. 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.

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8.2 Map Data Sources

Data sources used in original maps created for this report are described below. Themes used in base layouts for map creation are described first, followed by a separate table describing specialized themes.

8.2.1 Data Sources for Base Themes

Legend Item	Data Source
2-ft elevation contour	Hypsography, 2 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.
10-ft elevation contour	Hypsography, 10 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.
100-ft elevation contour	Hypsography, 100 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.
Fence	Security and Industrial Fences and Gates; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 10 September 2007.
Former Structure	Former Structures of the Los Alamos Site; Los Alamos National Laboratory, Environment and Remediation Support Services Division, EP2007-0587; 1:2,500 Scale Data; 17 September 2007.
Structure	Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 10 September 2007.
Paved road	Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 10 September 2007.
Unpaved road	Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 10 September 2007.
TA boundary	Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 19 September 2007.

8.2.2 Data Source Statements for Specialized Themes

Legend Item	Data Source	Figures
100-year floodpool (Post-Cerro Grande fire model)	Post Fire Floodplains; Los Alamos National Laboratory; ENV Water Quality & Hydrology Group; First edition, 17 May 2004.	4.3-5
Approximate sampling location	Not a feature layer; Graphic layer intended to illustrate approximate sampling sub-reaches for proposed sediment sampling program.	4.3-5

Legend Item	Data Source	Figures
Biointrusion barrier	Polyline Feature, Western and Southern Extents of Biointrusion Barrier Within ET Cover, TA-49 Area 2; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	2.2-2 2.2-5 2.5-1 2.5-2 2.5-3 4.3-2 4.4-1
Borehole	Features: 49-Alpha, 49-Beta, 49-Gamma - Penetrations; Los Alamos National Laboratory, Environment and Remediation Support Services, EP2007-0442; 1:2,500 Scale Data; 16 July 2007. All Other Features - Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Environment and Remediation Support Services Division, EP2007-0613; 27 September 2007.	2.2-5 3.4-1
Core hole	Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Environment and Remediation Support Services Division, EP2007-0613; 27 September 2007.	2.2-1 2.2-2 2.2-3 2.2-4
Deep test well (monitoring well)	Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Environment and Remediation Support Services Division, EP2007-0613; 27 September 2007.	2.11-4 3.4-1
Ditch	Polyline Feature, Delineation of Ditch North of TA-49, Area 5 and West of TA-49, Areas 2, 2A, and 2B; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	4.3-2
Former asphalt pad	Polygon Feature, Asphalt Pad Formerly Covering Experimental Shafts, TA-49 Area 2; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	2.2-2 2.2-5 2.5-1 2.5-2 2.5-3 4.4-1
Former structure (Area 11, Radiochemistry Laboratory only)	Polygon Feature, Approximate Location of Building 49-15, Former Radiochemistry Laboratory, TA-49 Area 11. 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	2.8-1 2.8-2 2.8-3 2.8-4 4.4-5
General SWMU or AOC location (boundary not defined)	Not a feature layer; intended to illustrate extents of area-specific map figures	1.1-2 2.5-4 4.3-5
Low-order stream	Polyline Feature, Illustration of Approximate Location of First-order Drainages Proposed for Sediment Sampling, TA-49; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	4.3-5
Moisture monitoring location	Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Environment and Remediation Support Services Division, EP2007-0613; 27 September 2007.	2.5-4

Legend Item	Data Source	Figures
Pipe dump hole	Point Feature, Approximate Locations of Pipe-Disposal Boreholes, TA-49 Areas 2 and 4; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	2.2-2 2.2-4
Proposed borehole	Point Feature, Approximate Locations Proposed for Vertical Boreholes, TA-49; 1:1,200 Scale Data; Apogen Technologies, 15 October, 2007. ER ID 098702.	4.4-1 4.4-2 4.4-3 4.4-4 4.4-5 4.4-6
Proposed directional borehole (with associated path)	Point Feature, Approximate Locations Proposed for Placement of Directional Boreholes, TA-49; 1:1,200 Scale Data; Apogen Technologies, 15 October, 2007. ER ID 098702. Polyline Feature, Approximate Subsurface Path of Proposed Directional Boreholes, TA-49; 1:1,200 Scale Data, Apogen Technologies, 15 October, 2007. ER ID 098702.	4.4-1
Proposed sampling location	Point Feature, Illustration of Approximate Locations Proposed for Surface Soil Sampling Along Utility Corridors, TA-49 Areas 1, 2, 2A, 2B, 3, 4, and 5; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	4.3-6
Re-graded area	Polygon Feature, Approximate Extent of 1998 Re-grading Operations, TA-49 Areas 2, 2A, and 2B; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	2.2-2 2.2-5 2.5-1 2.5-2 2.5-3 4.3-2 4.4-1
Sampling location with screening-level results Sampling location with decision-level results Sampling location with detected decision-level results Sampling location with nondetected decision-level results Sampling location with decision-level results above BV Sampling location with decision-level results above FV Sampling location with decision-level results detected or detected above FV Sampling location with decision-level results detected or detected above BV/FV Prev. sampling location Prev. sampling location – result above BV/FV	Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Environment and Remediation Support Services Division, EP2007-0613; 27 September 2007.	2.4-1 2.4-2 2.5-1 2.5-2 2.5-3 2.5-5 2.6-1 2.6-2 2.7-1 2.7-2 2.8-2 2.8-3 2.8-4 2.10-2 2.10-3 2.10-4 4.3-1 4.3-2 4.3-3 4.3-4

Legend Item	Data Source	Figures
Sampling location type	Point Feature, Approximate Locations Proposed for Surface Sampling, TA-49; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	4.3-1 4.3-2 4.3-3 4.3-4 4-3.6
Sediment and/or surface-water sampling location	Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Environment and Remediation Support Services Division, EP2007-0613; 27 September 2007.	2.11-4
Shaft Shot type	Point Feature, Approximate Locations of Experimental Shafts, TA-49, Areas 1, 2, 2A, 2B, 3, and 4; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	2.2-1 2.2-2 2.2-3 2.2-4 2.2-5 2.4-1 2.4-2 2.5-1 2.5-2 2.5-3 2.6-1 2.6-2 2.7-1 2.7-2 4.3-1 4.3-2 4.3-3 4.3-4 4.4-1 4.4-2 4.4-3 4.4-4
Stream sampling reach	Not a feature layer; Graphic layer intended to illustrate approximate major sampling reaches for proposed sediment sampling program.	4.3-5
TDR array	Point Feature, Locations of TDR Arrays for Moisture Monitoring, TA-49 Area 2; 1:1,200 Scale Data; Apogen Technologies, 09 October 2002.	2.5-4
Utility corridor (approximate)	Polyline Feature, Approximate Locations of Utility Corridors Between TA-49, Area 5, and Areas 1, 2, 2A, 2B, 3, and 4; 1:1,200 Scale Data; Apogen Technologies, 15 October 2007. ER ID 098702.	4.3-6

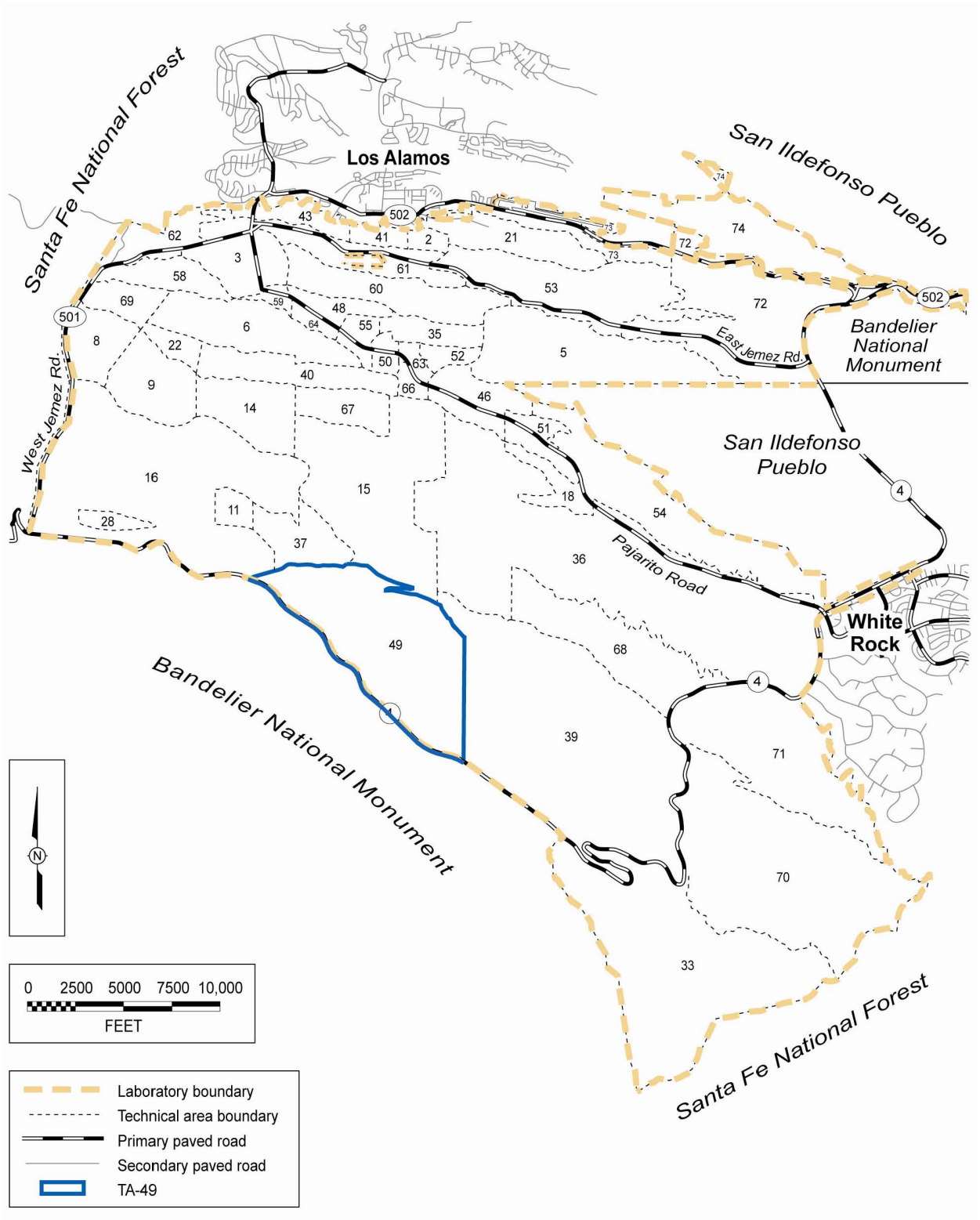
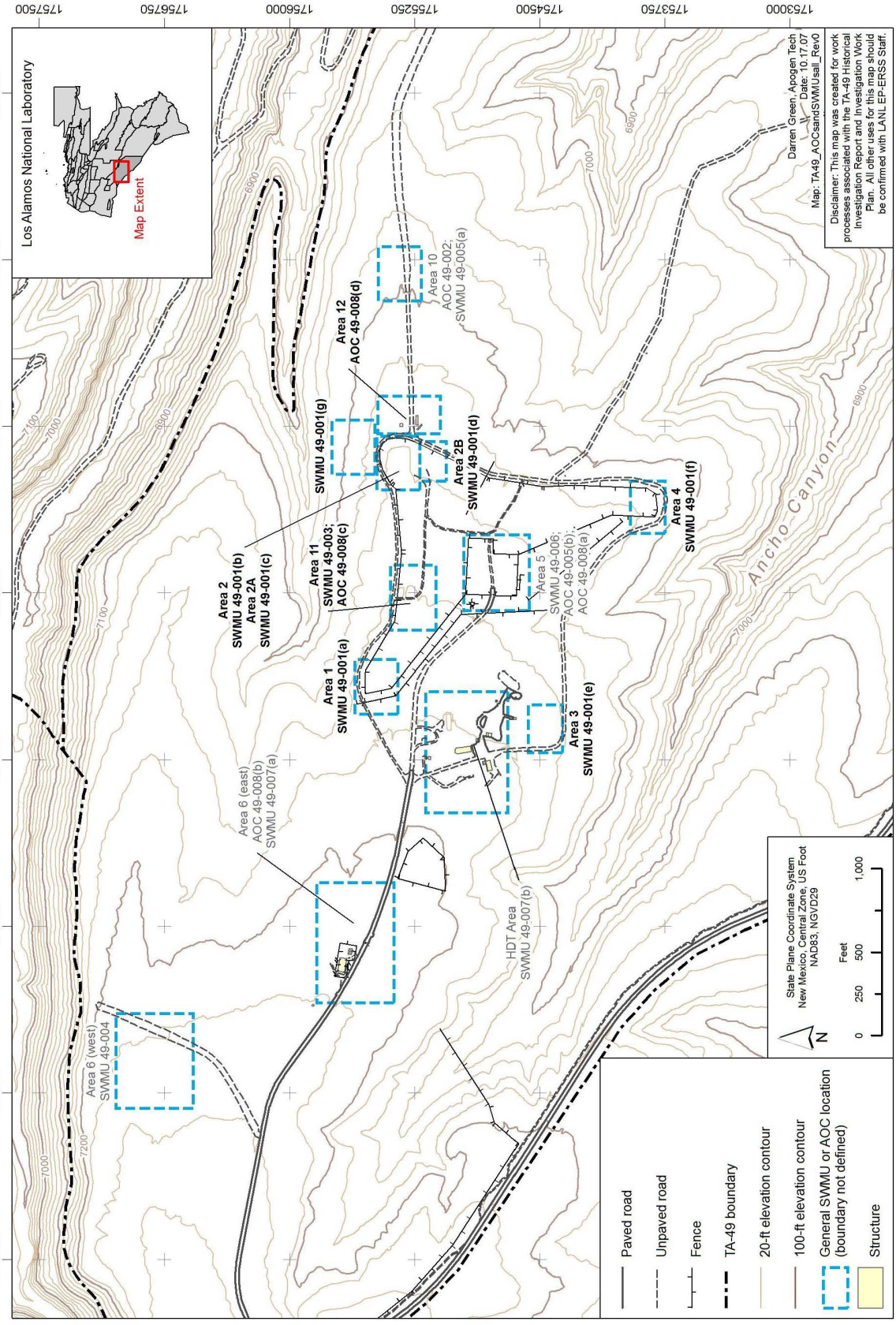


Figure 1.1-1 Location of TA-49



Note: Sites within the NES boundary are in bold.

Figure 1.1-2 TA-49 AOCs and SWMUs

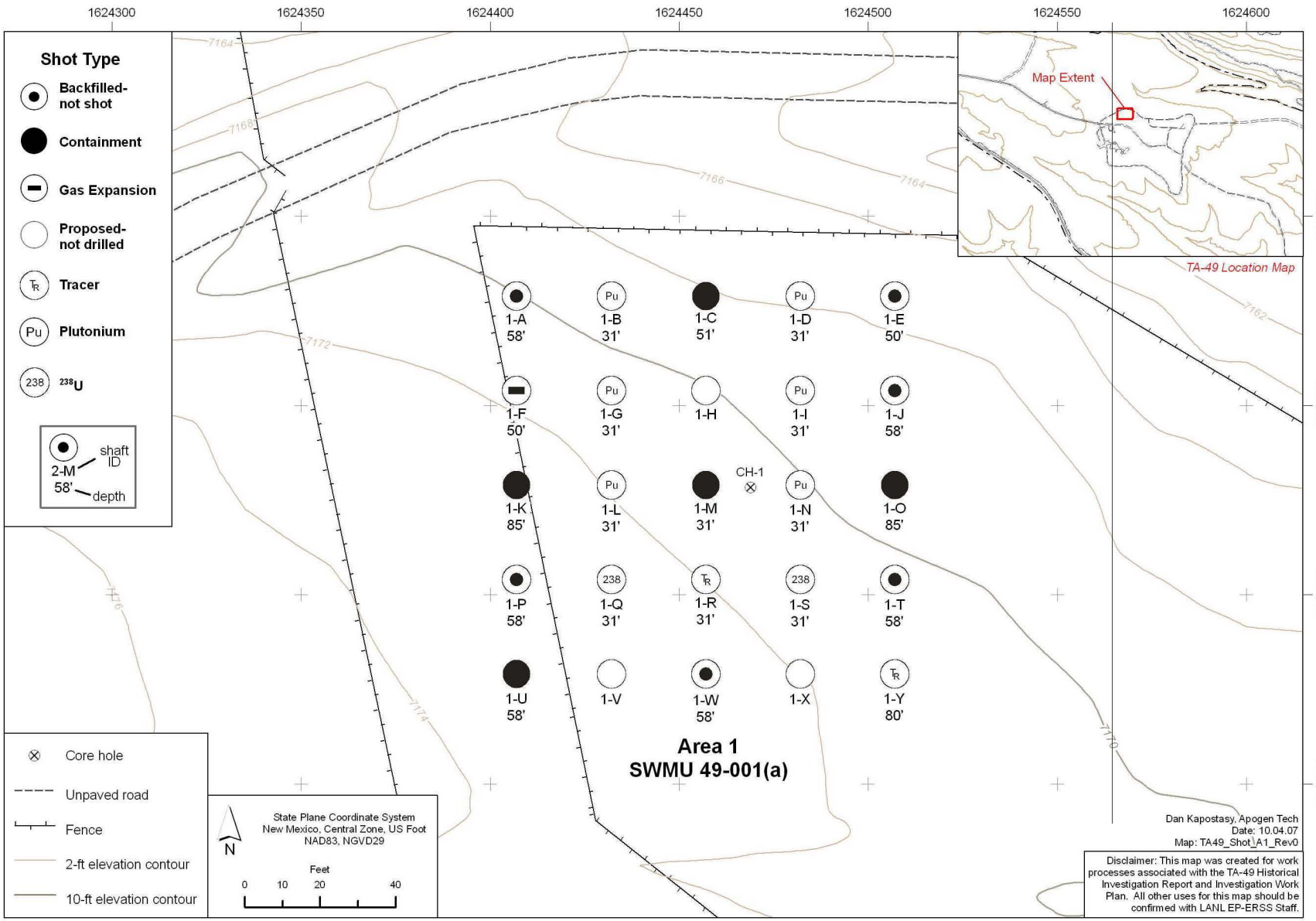


Figure 2.2-1 Area 1 experimental shaft details

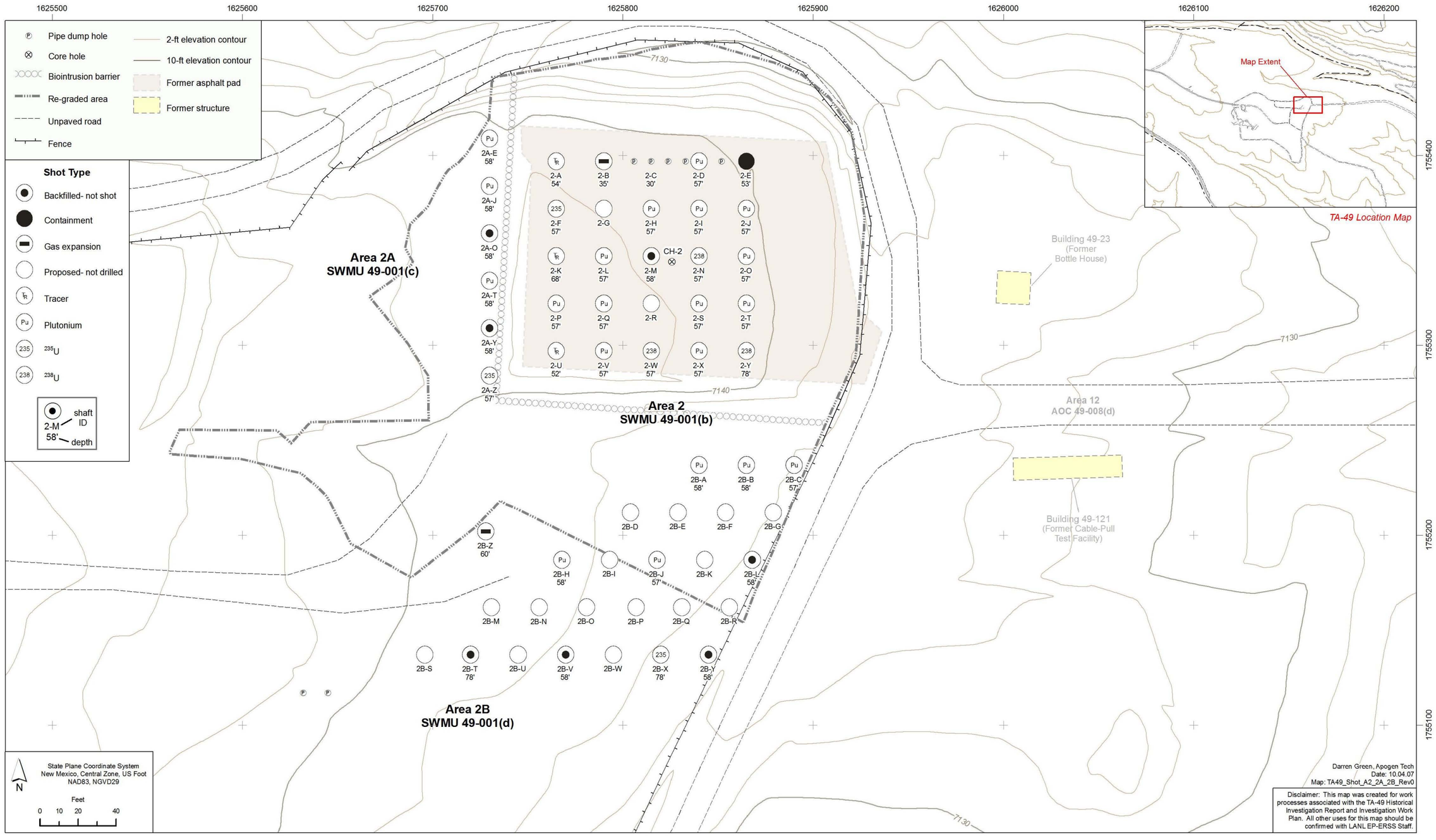


Figure 2.2-2 Areas 2, 2A, and 2B experimental shaft details

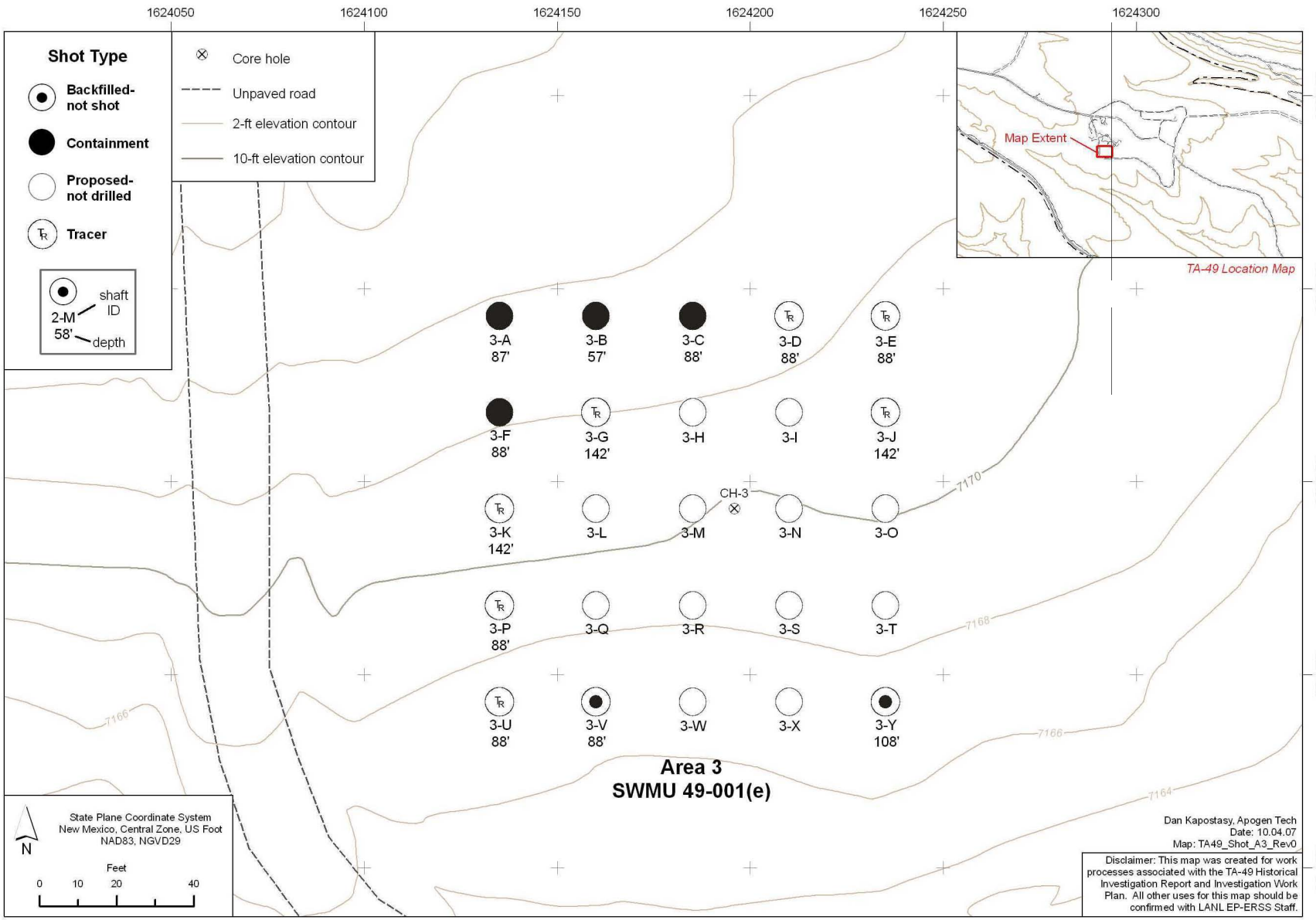


Figure 2.2-3 Area 3 experimental shaft details

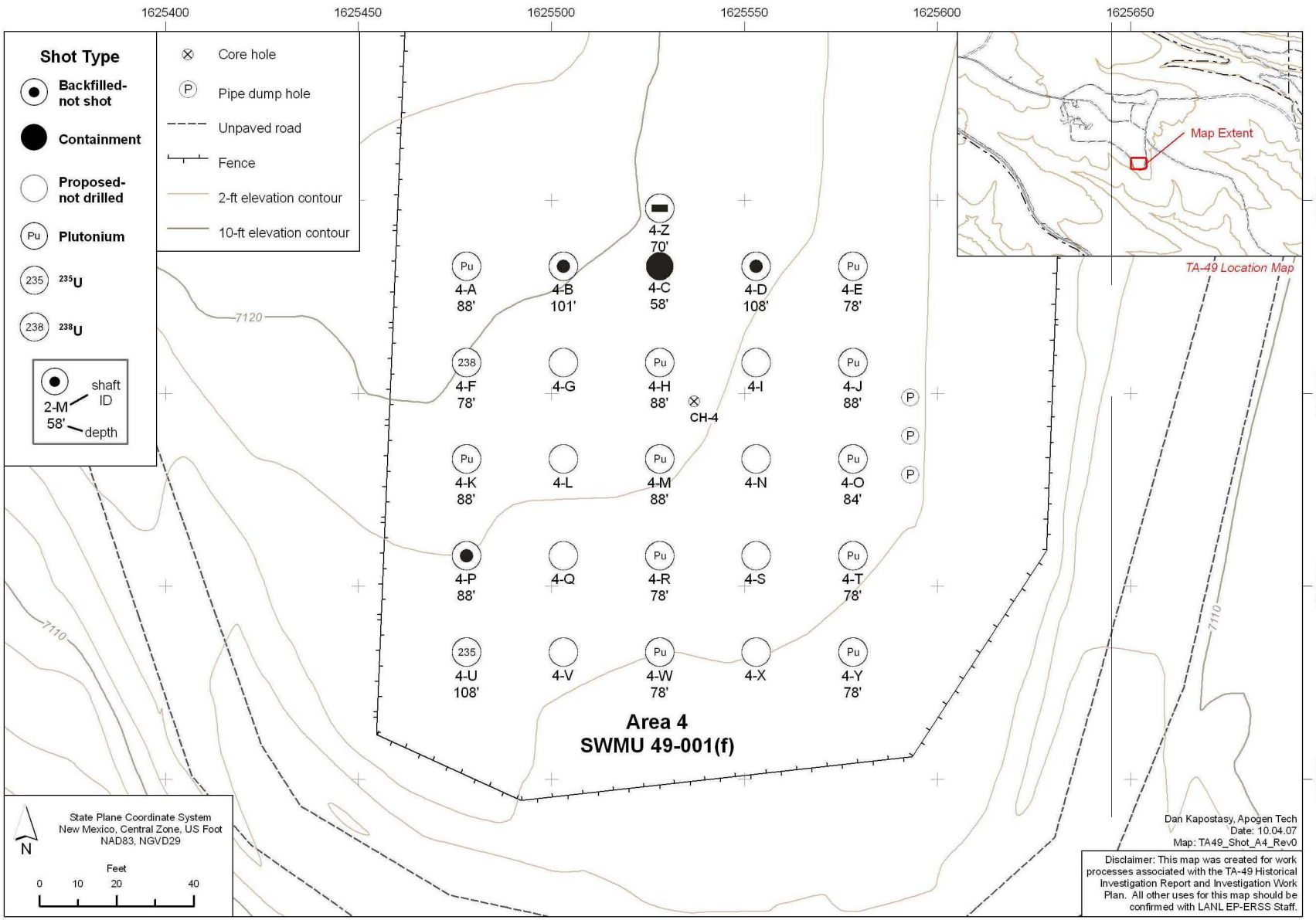


Figure 2.2-4 Area 4 experimental shaft details

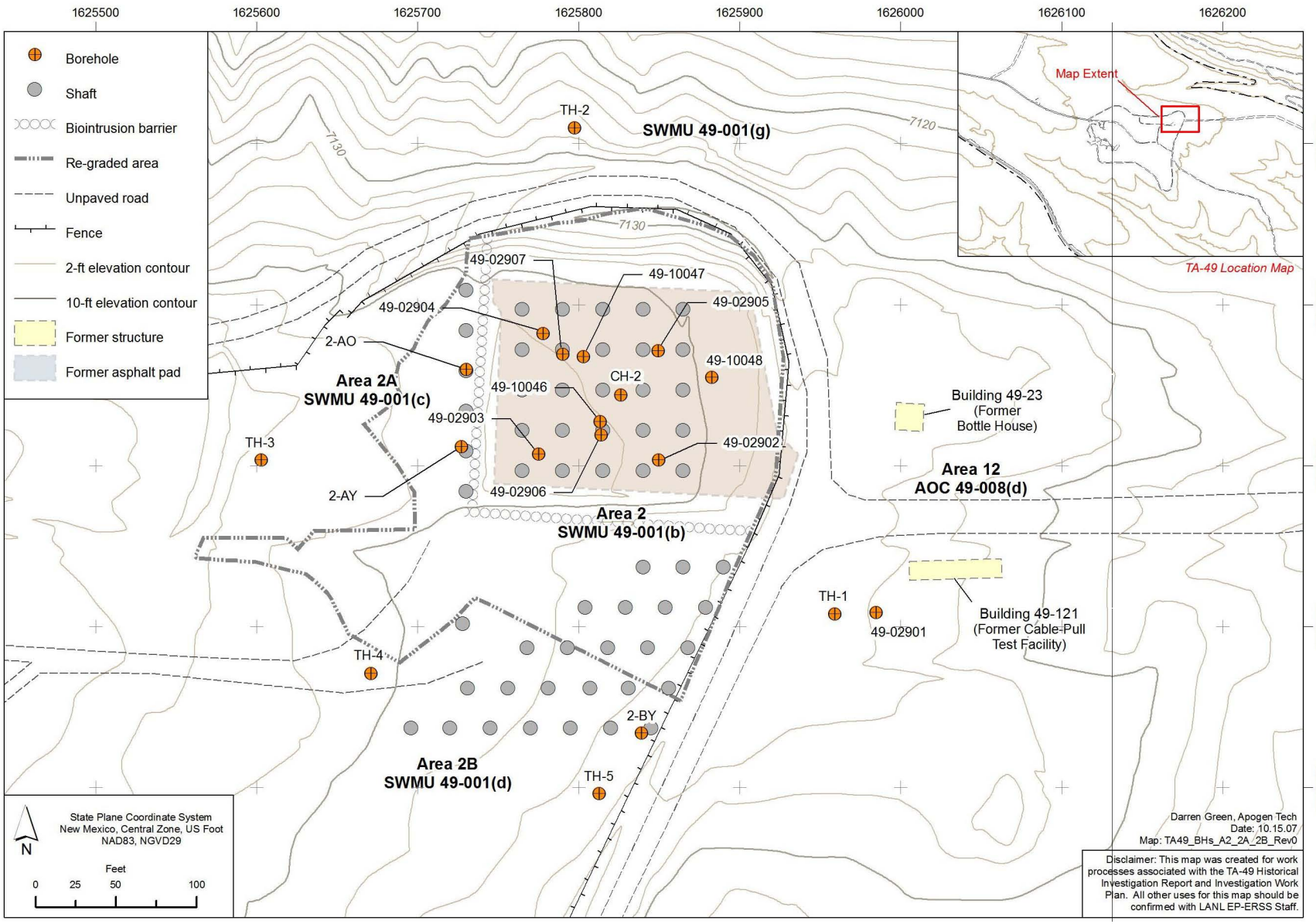
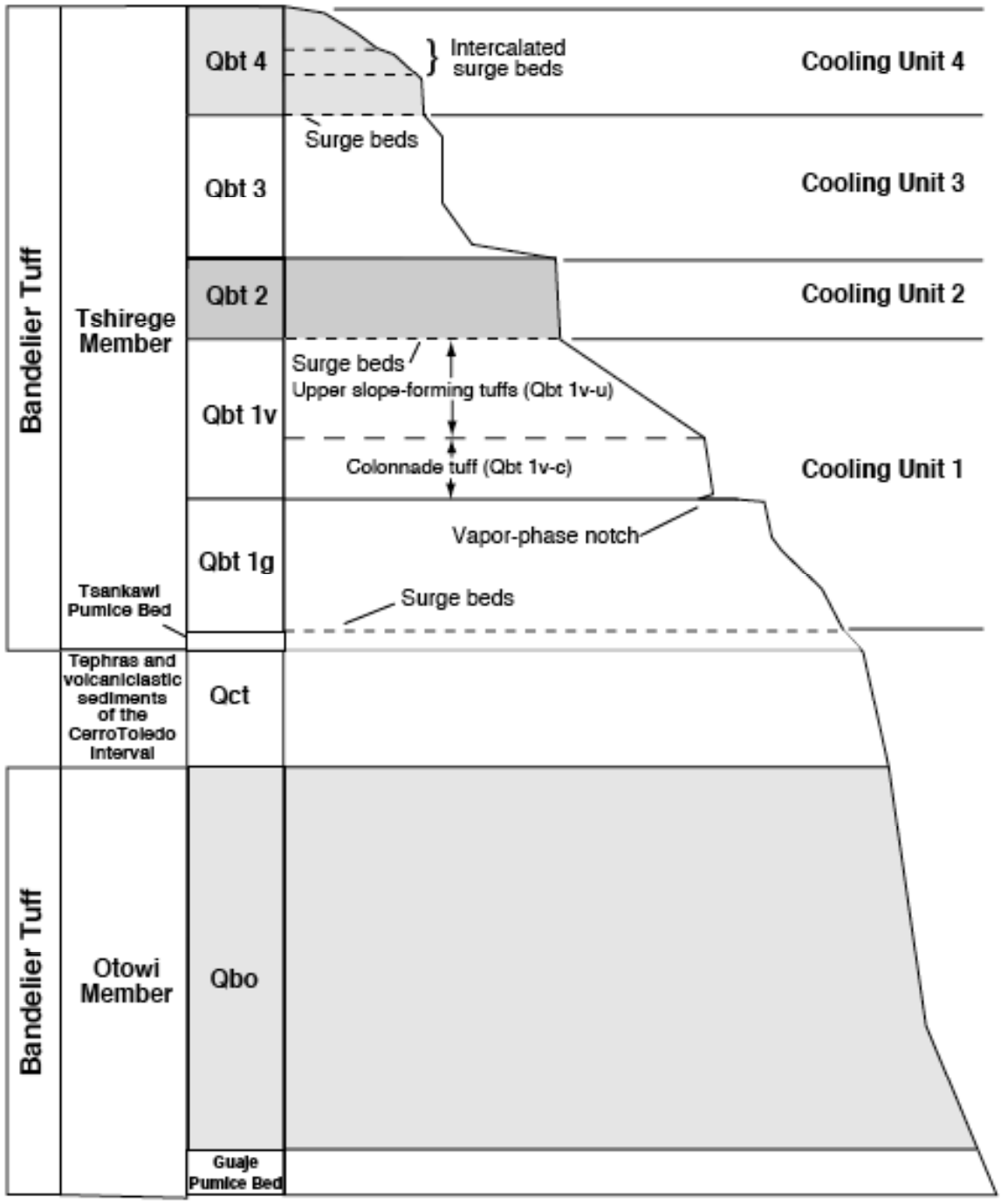


Figure 2.2-5 Areas 2, 2A, 2B, and 12 borehole locations



Source: Broxton and Reneau 1995, 049726, p. 9.

Figure 2.3-1 Stratigraphy of the Bandelier Tuff

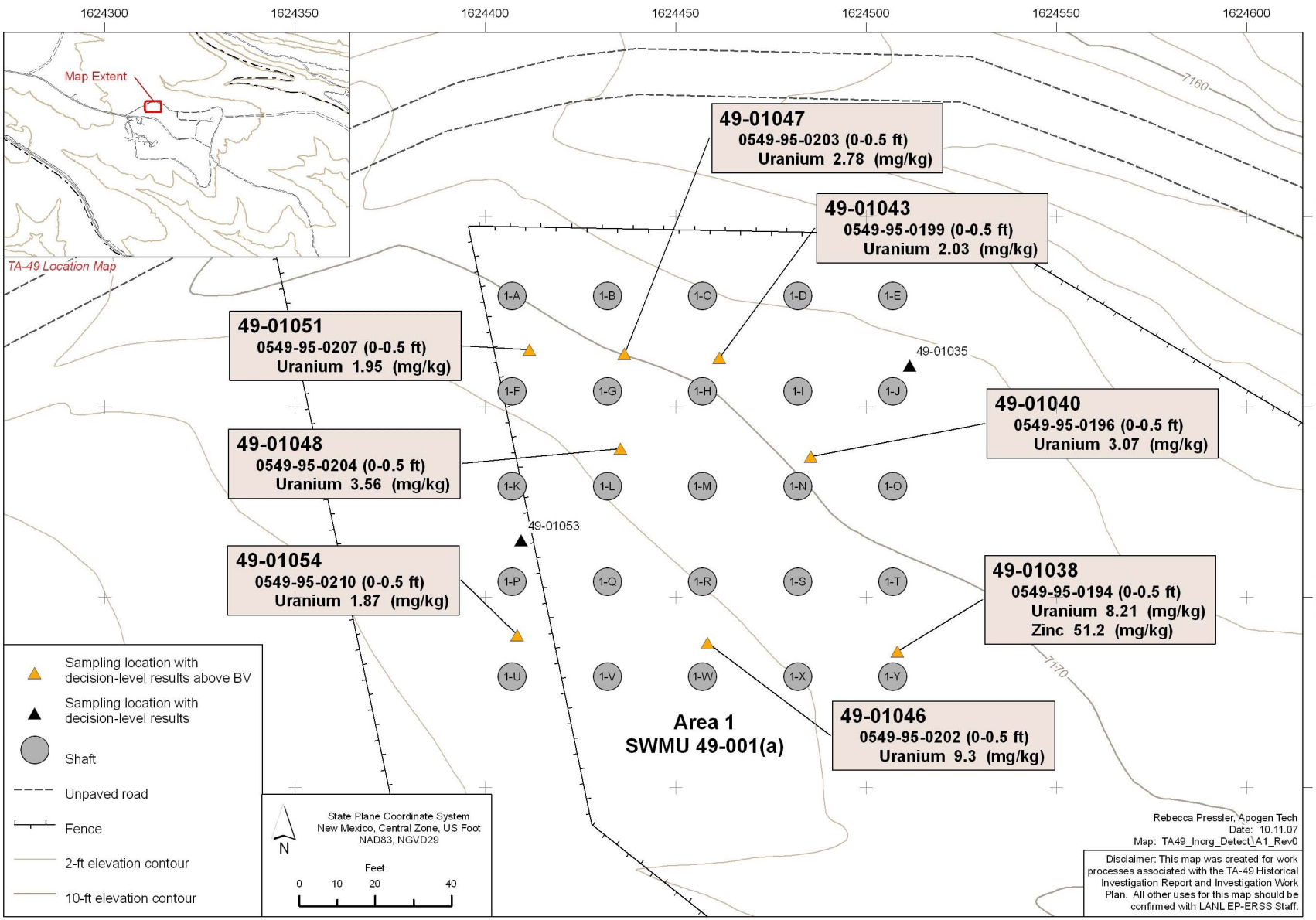


Figure 2.4-1 Area 1 inorganic chemical sampling locations and results above BVs

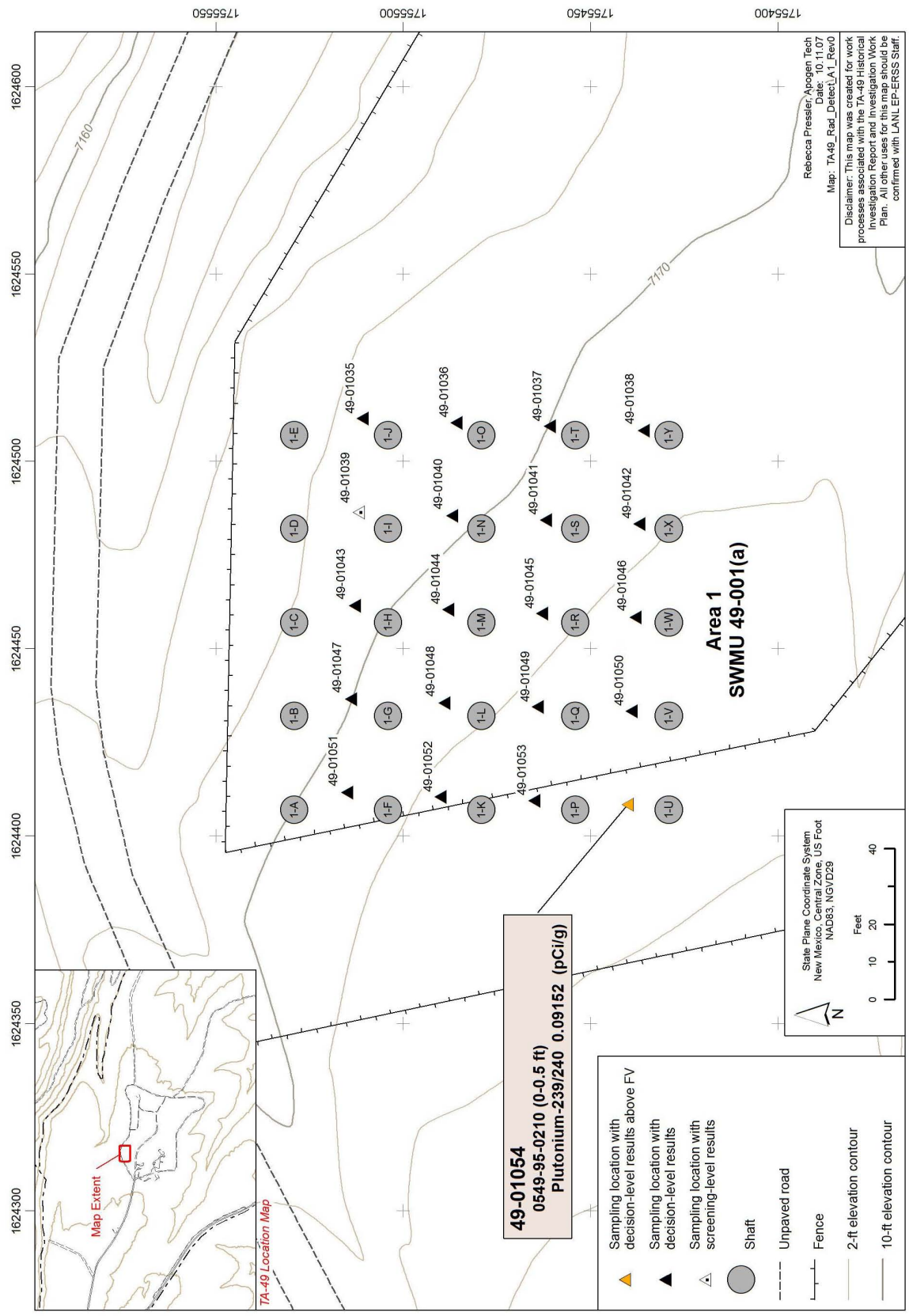


Figure 2.4-2 Area 1 radionuclide sampling locations and results above BVs/FVs

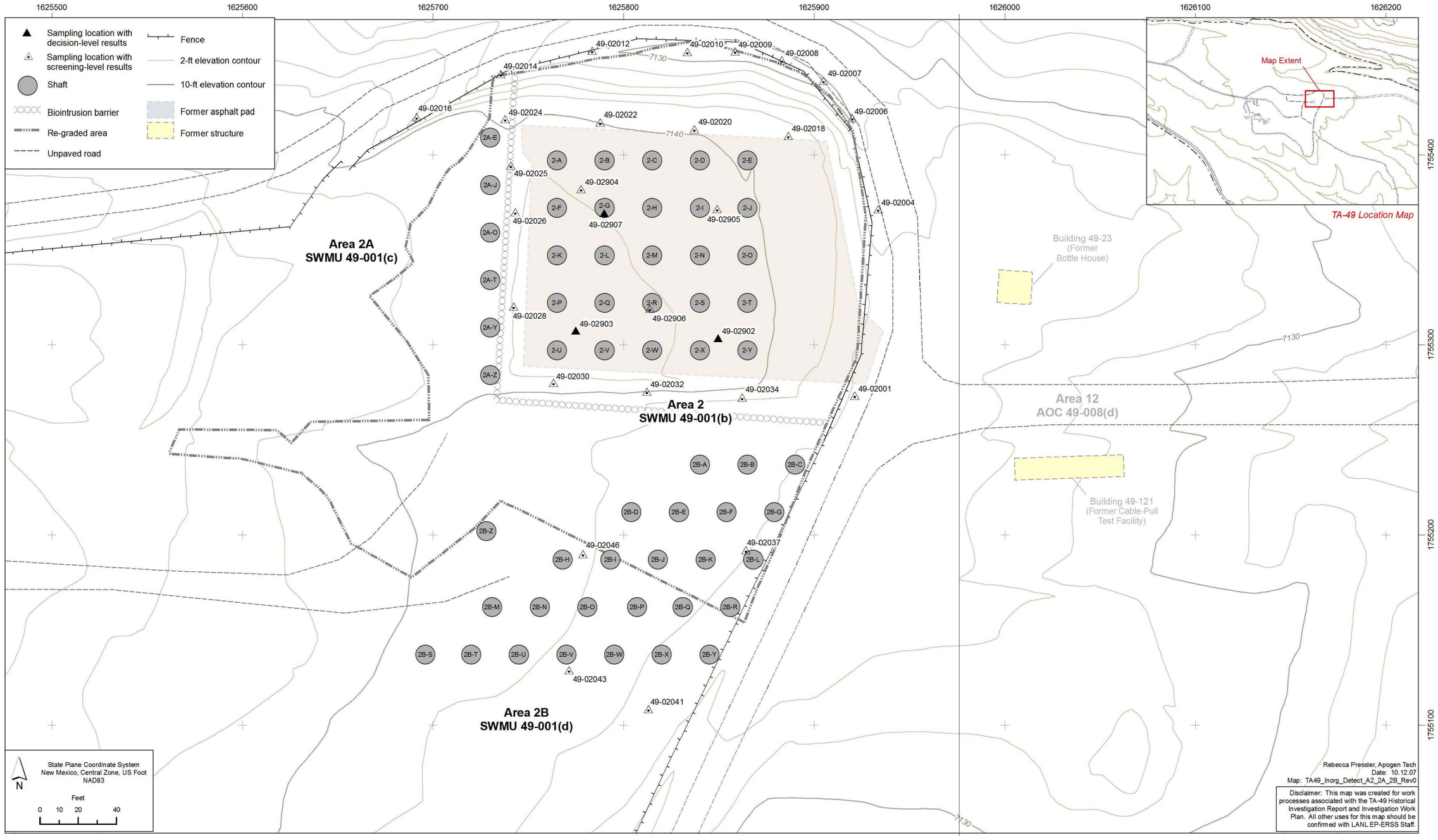


Figure 2.5-1 Areas 2, 2A, and 2B inorganic chemical sampling locations

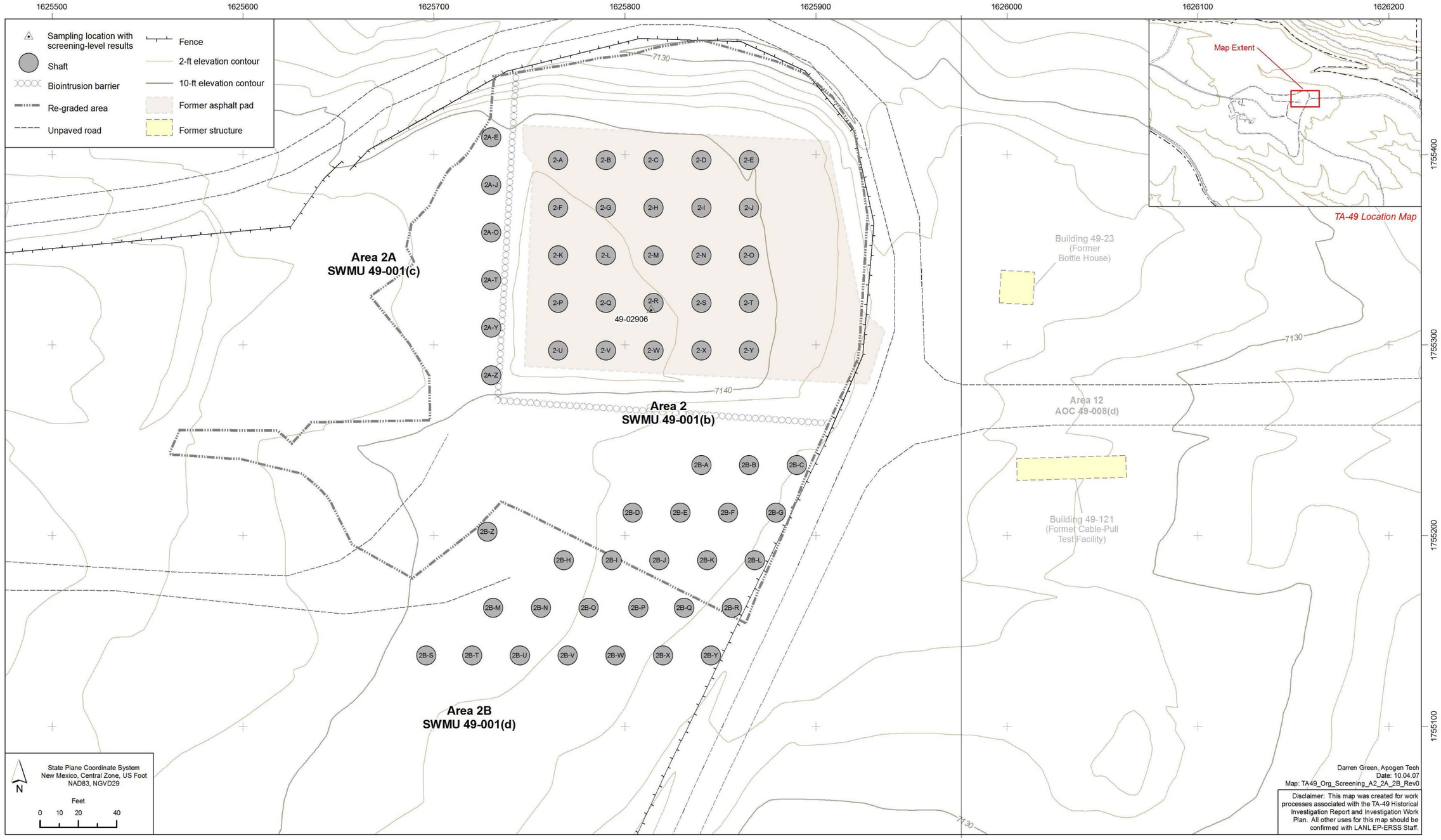


Figure 2.5-2 Areas 2, 2A, and 2B organic chemical sampling locations

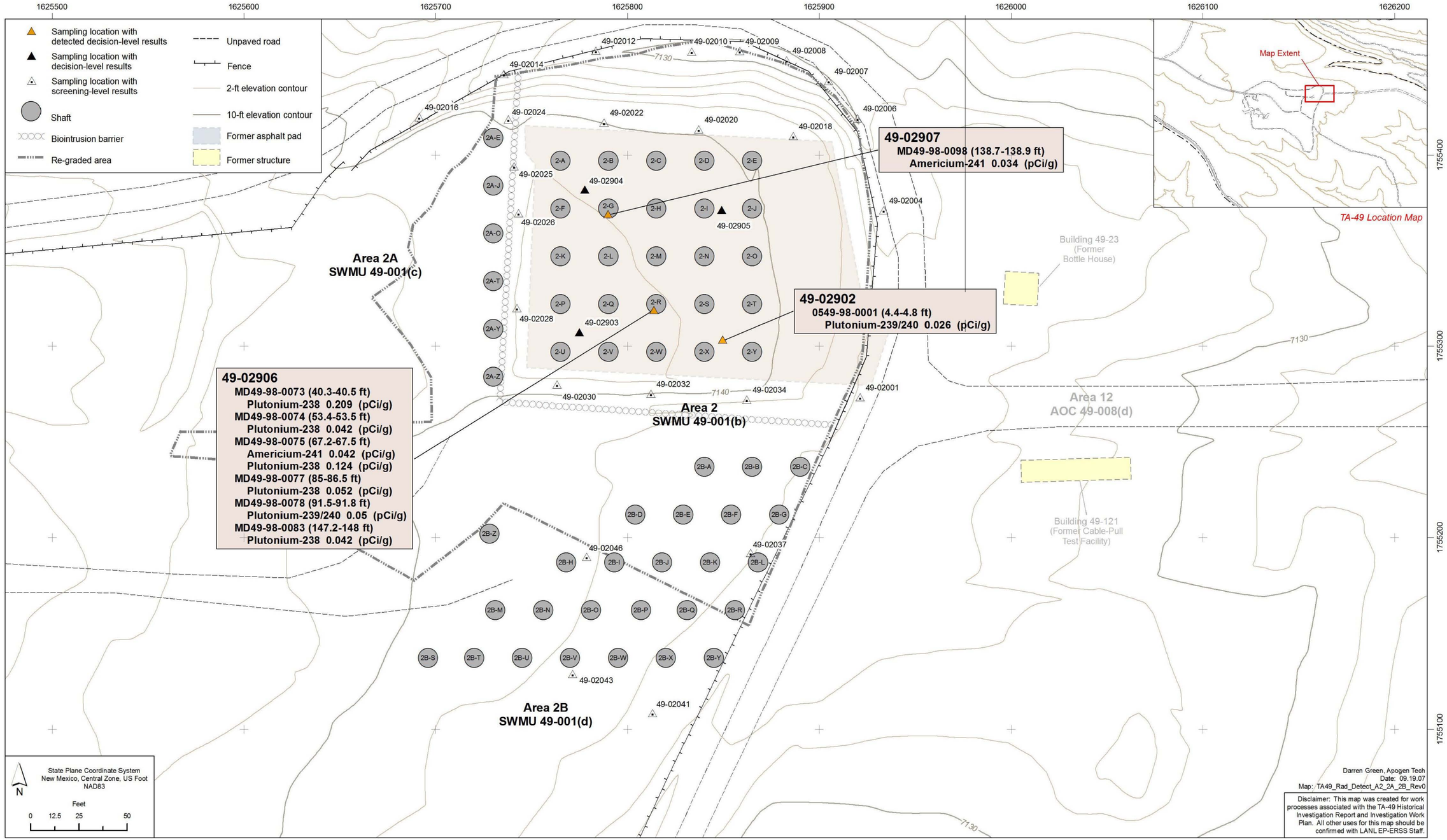


Figure 2.5-3 Areas 2, 2A, and 2B radionuclide sampling locations and results above BVs/FVs

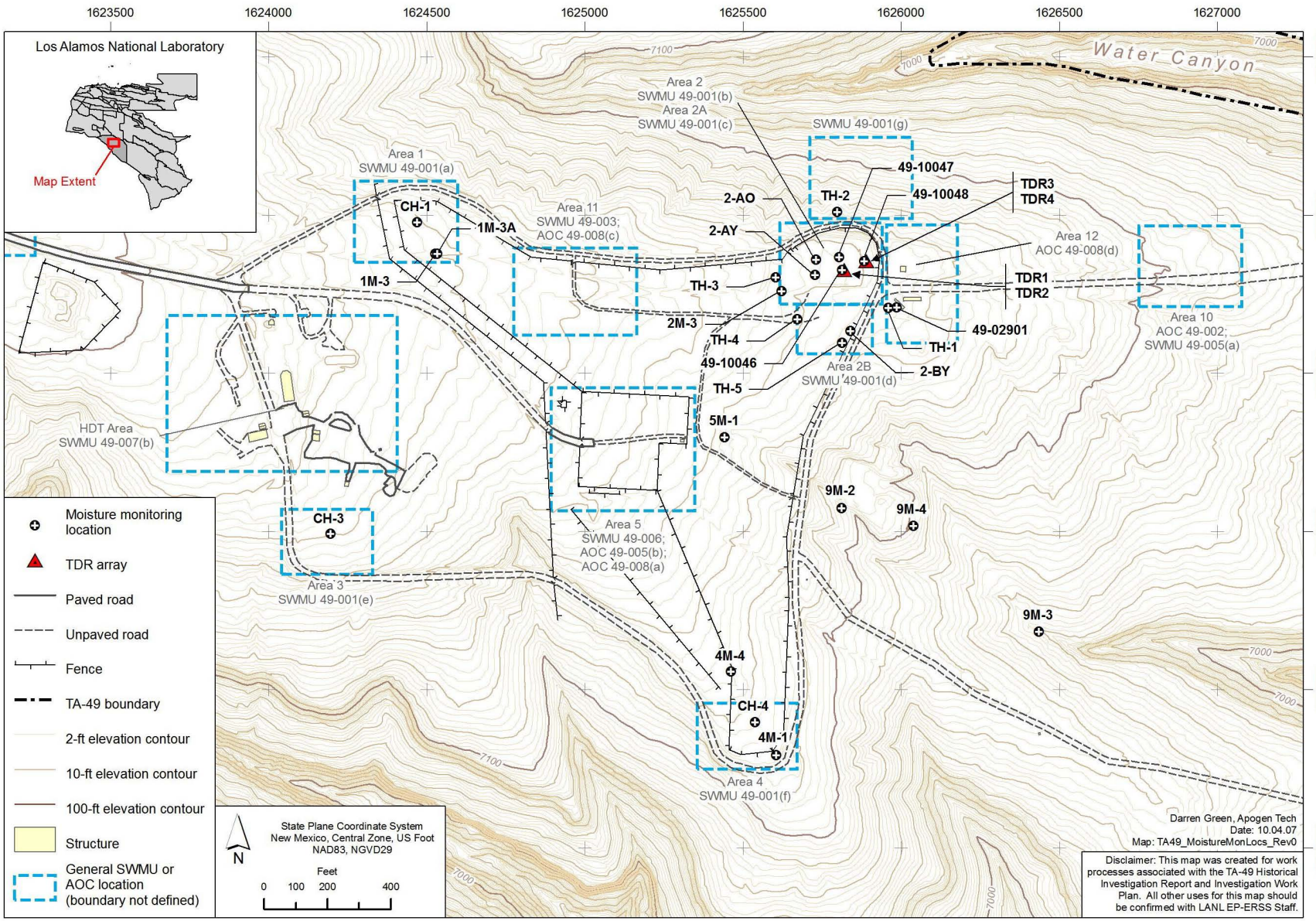


Figure 2.5-4 TA-49 moisture monitoring locations

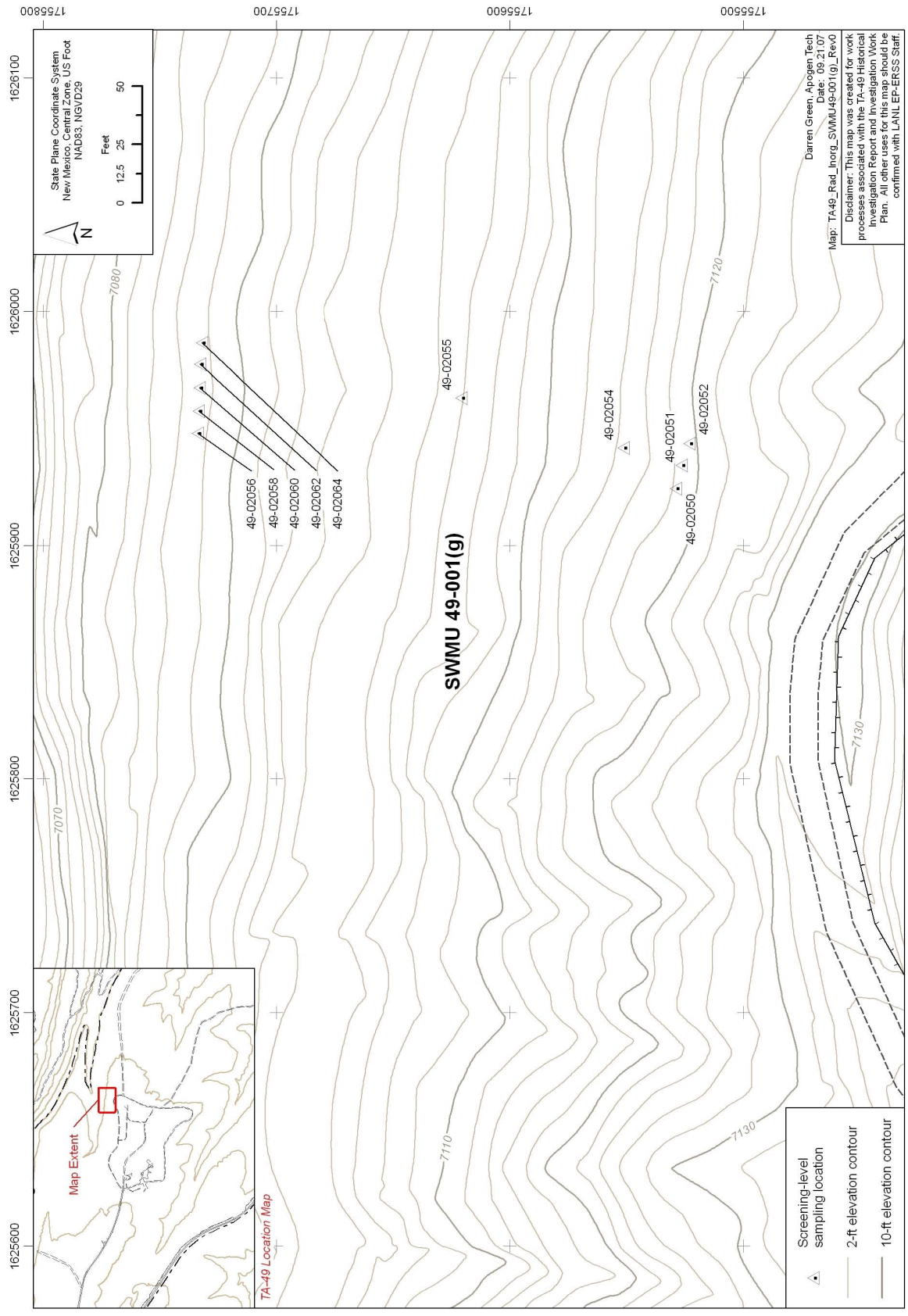


Figure 2.5-5 SWMU 49-001(g) inorganic chemical and radionuclide sampling locations

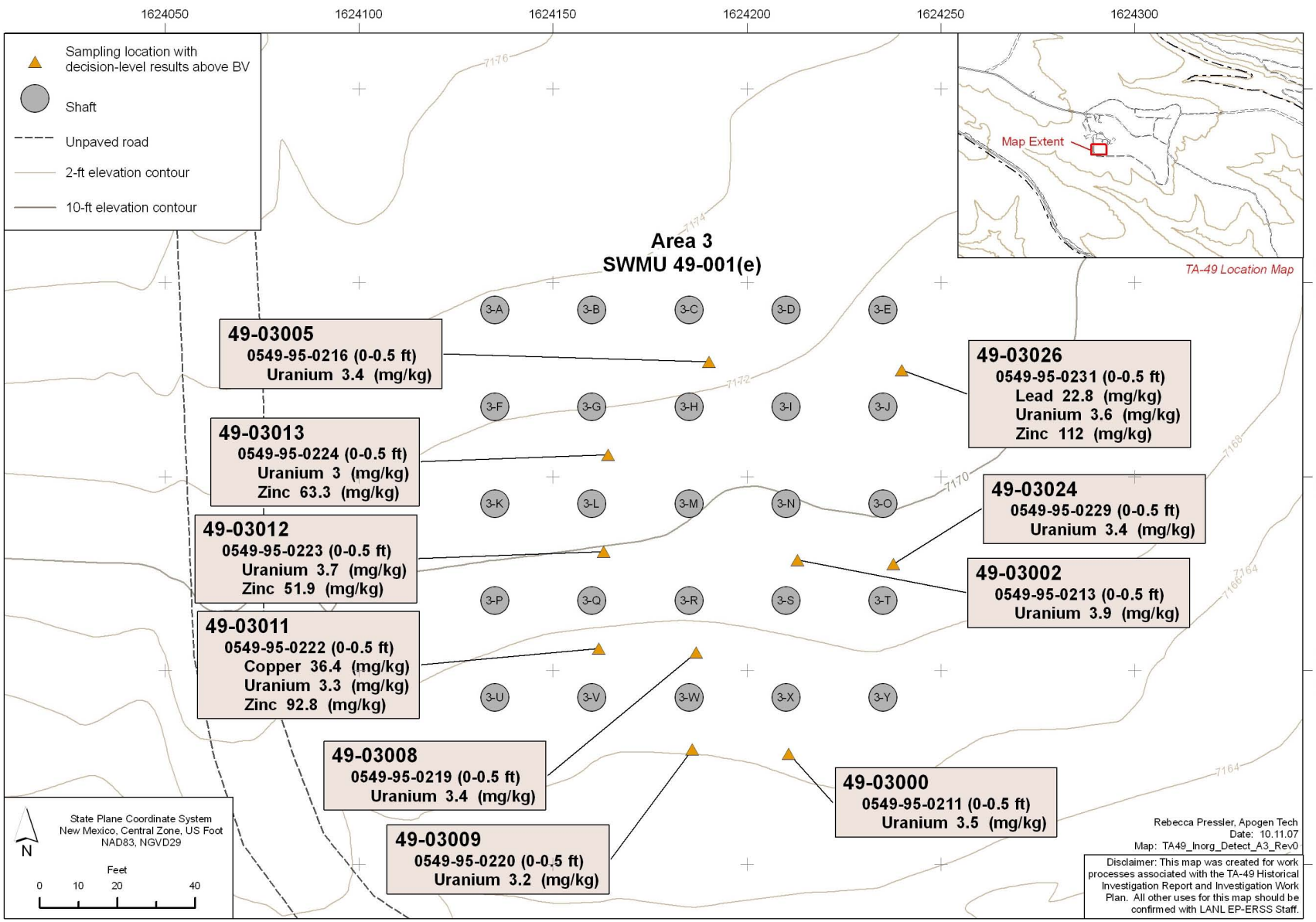


Figure 2.6-1 Area 3 inorganic chemical sampling locations and results above BVs

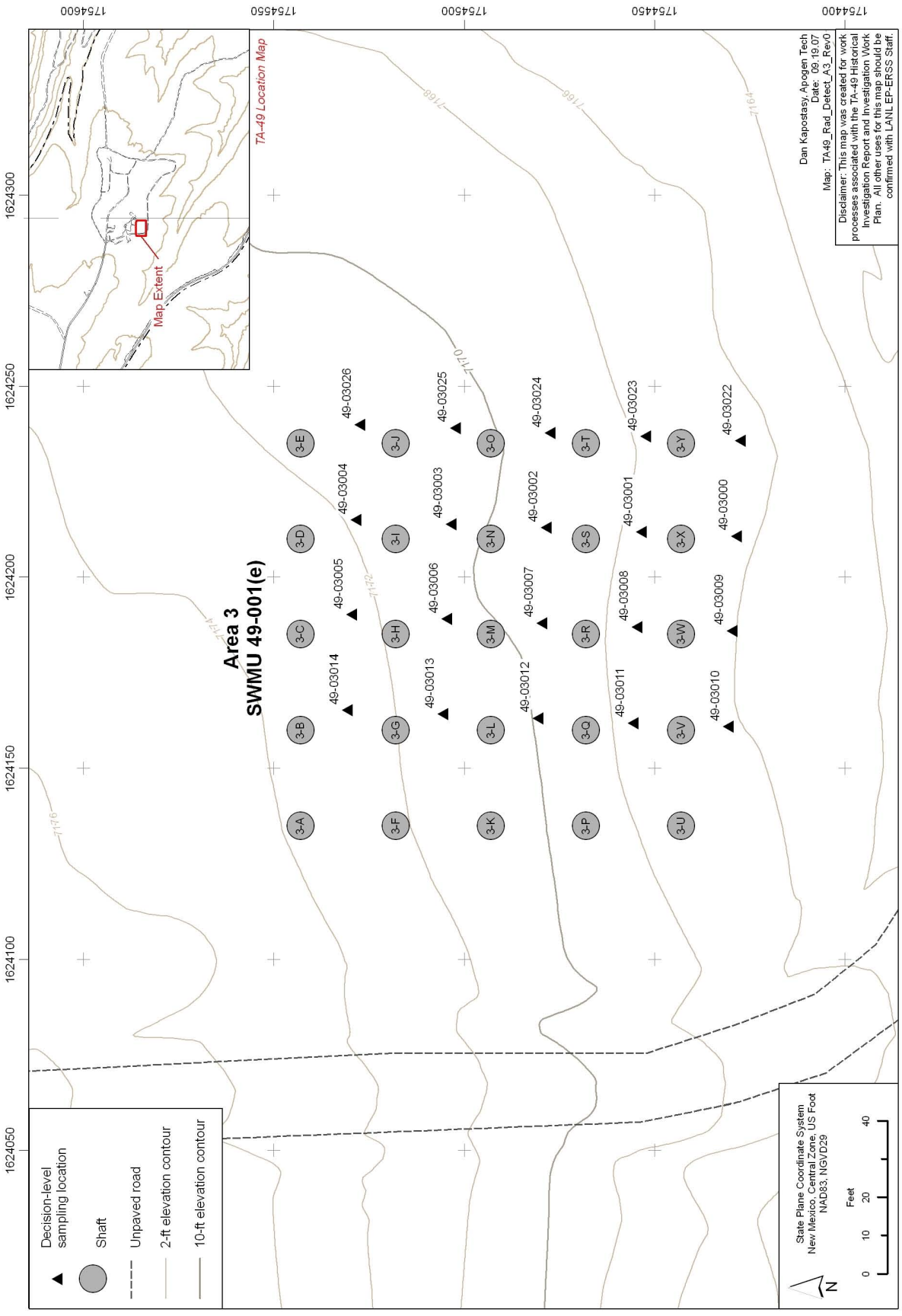


Figure 2.6-2 Area 3 radionuclide sampling locations

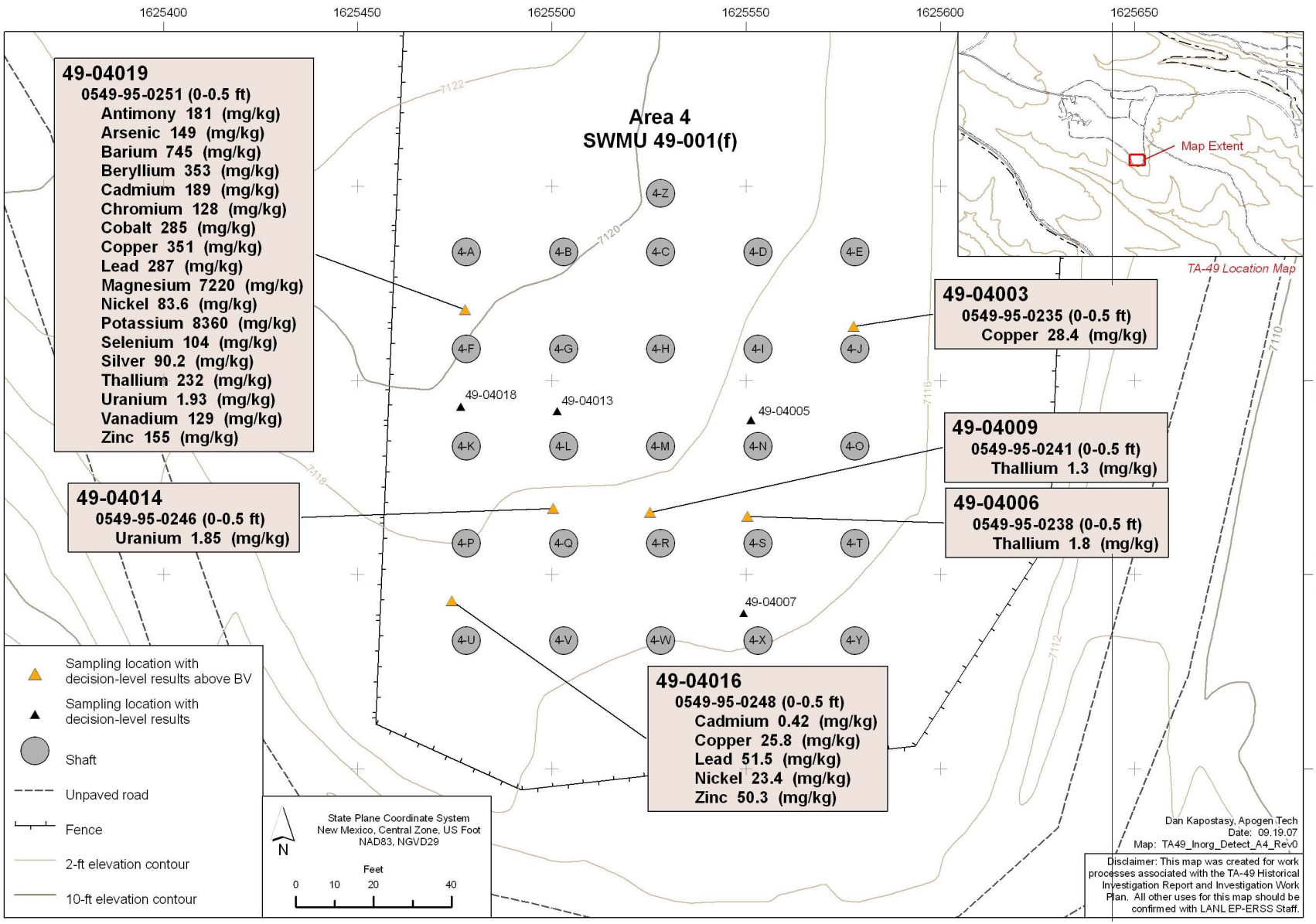


Figure 2.7-1 Area 4 inorganic chemical sampling locations and results above BVs

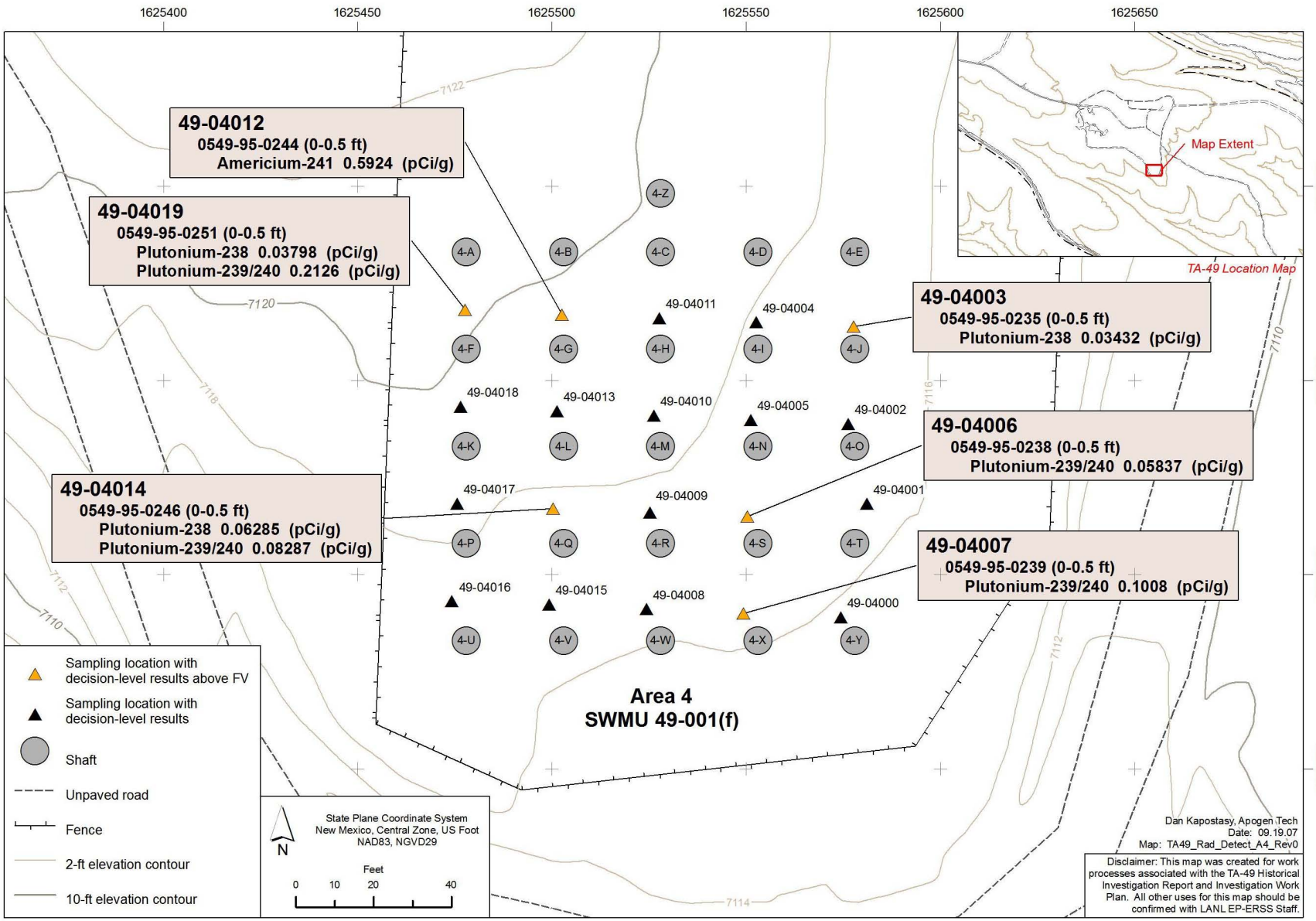


Figure 2.7-2 Area 4 radionuclide sampling locations and results above BVs/FVs

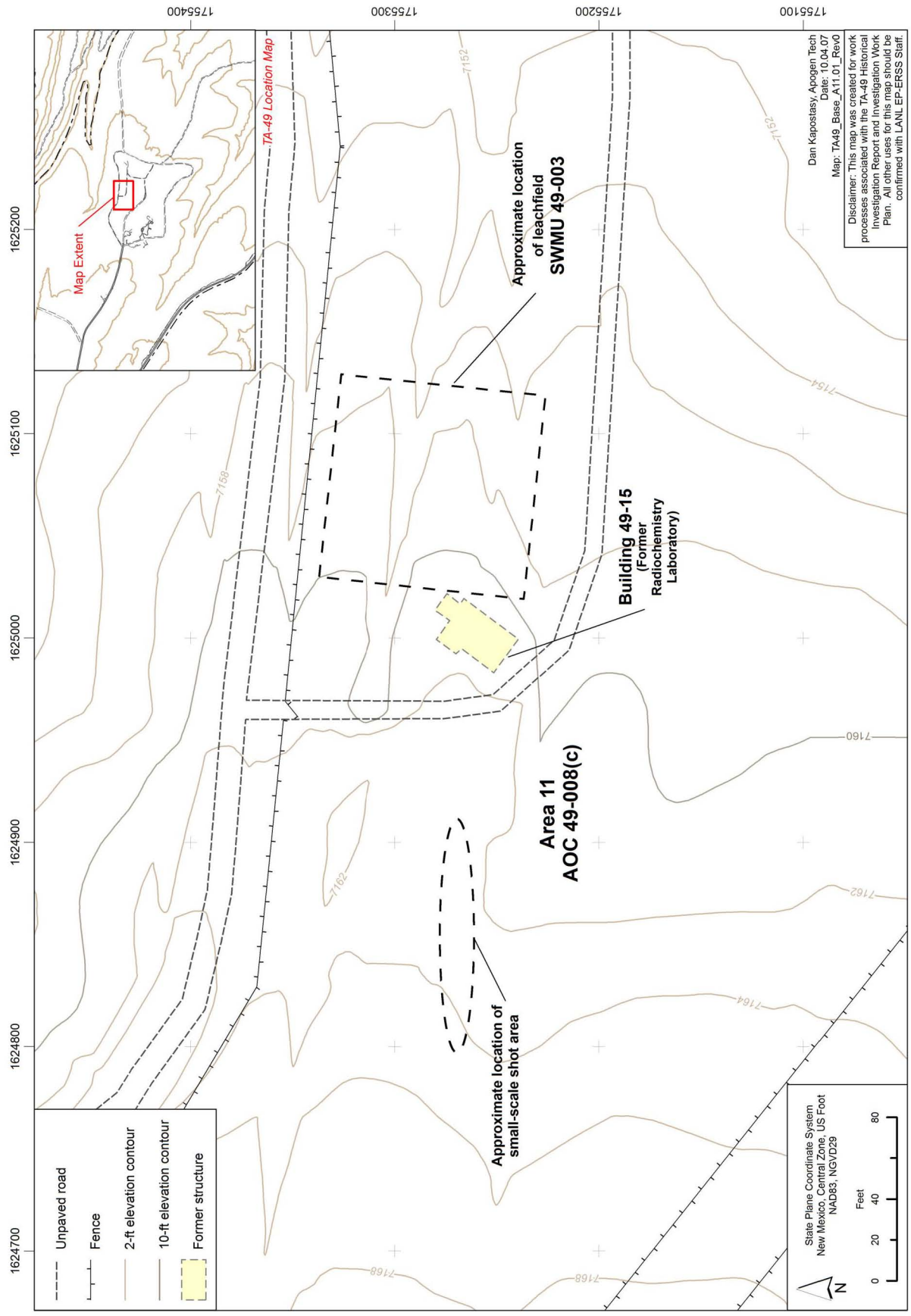


Figure 2.8-1 General site layout of Area 11

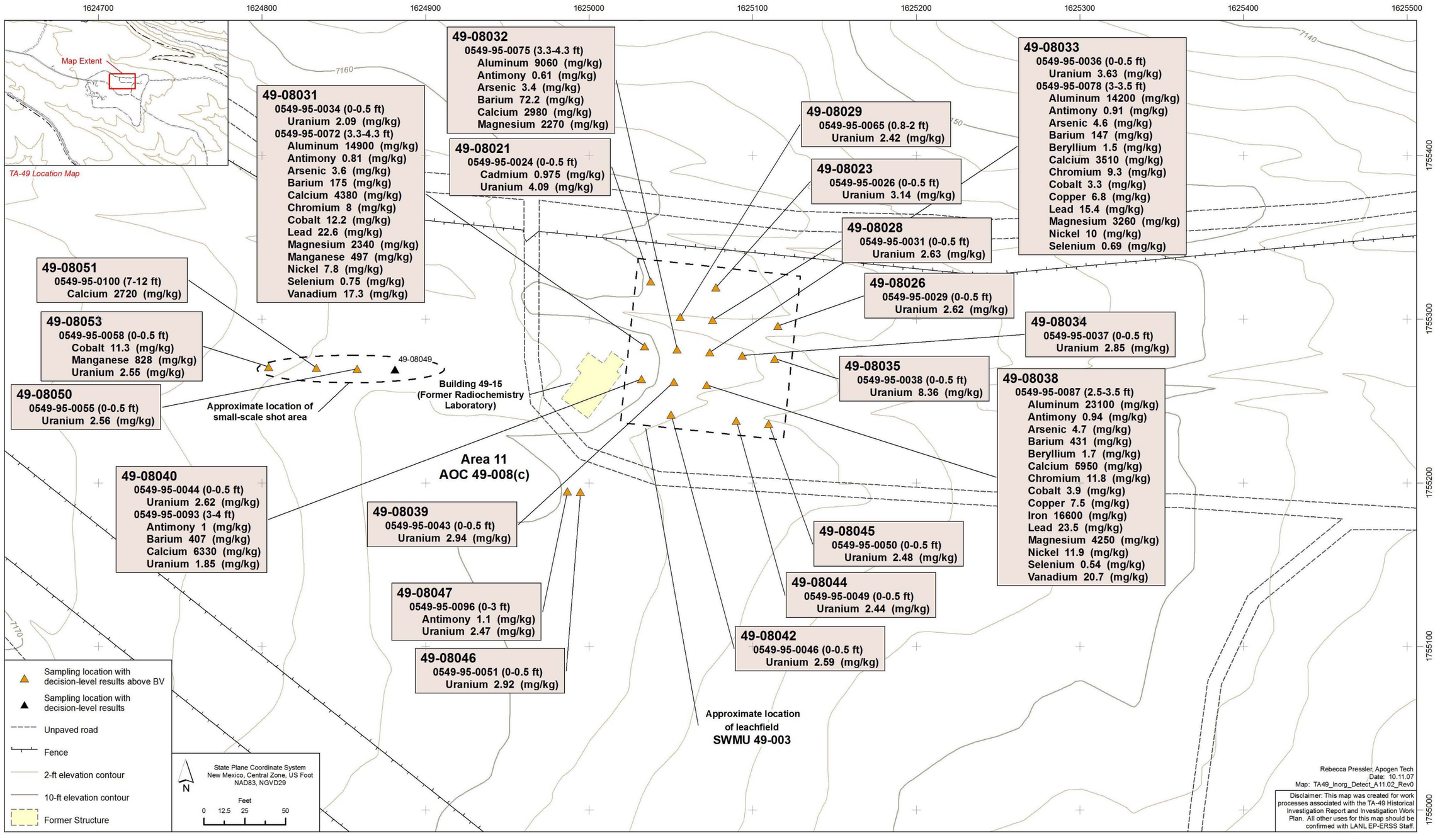


Figure 2.8-2 Area 11 inorganic chemical sampling locations and results above BVs

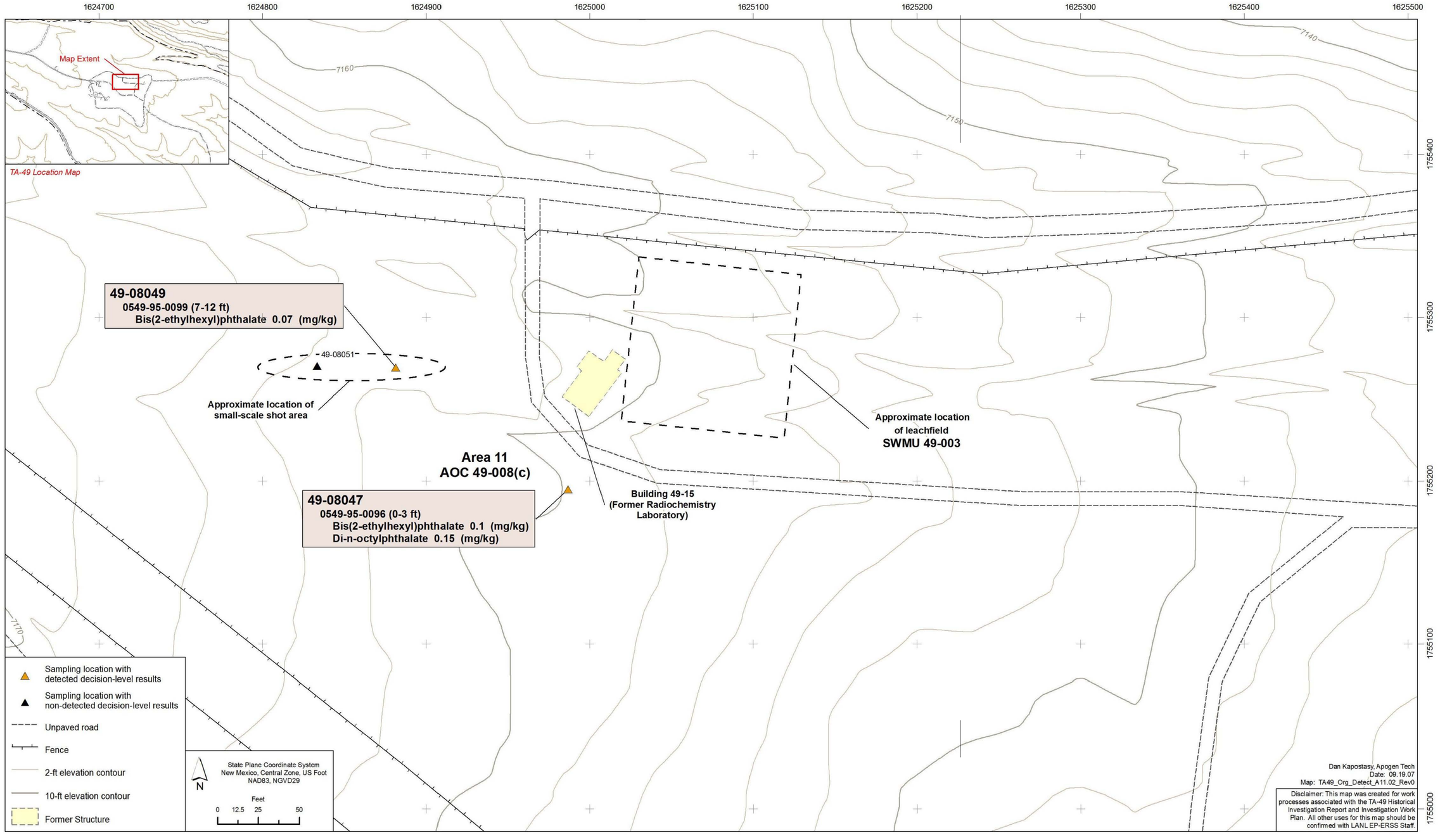


Figure 2.8-3 Area 11 organic chemical sampling locations and detected results

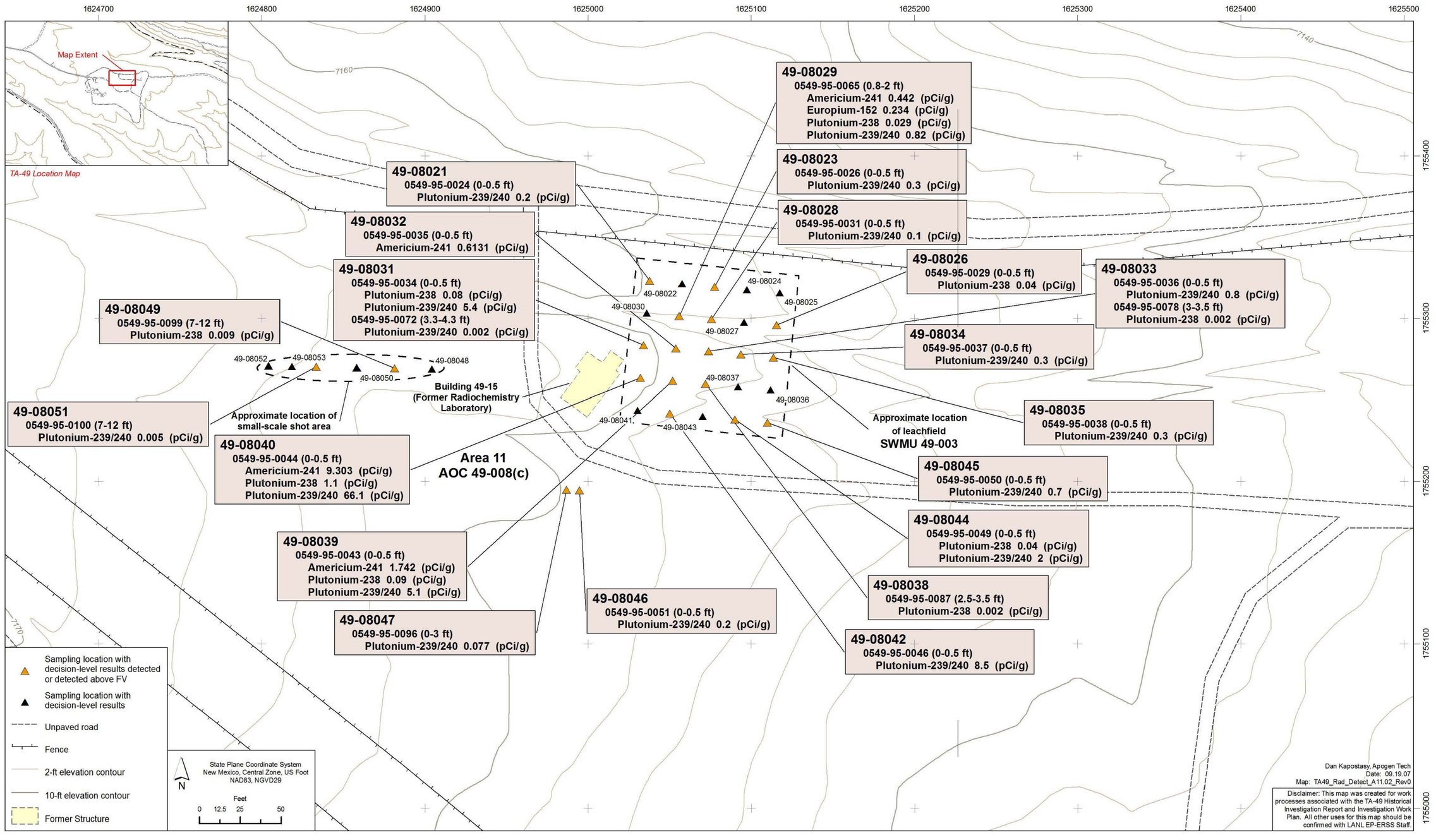


Figure 2.8-4 Area 11 radionuclide sampling locations and results above BVs/FVs

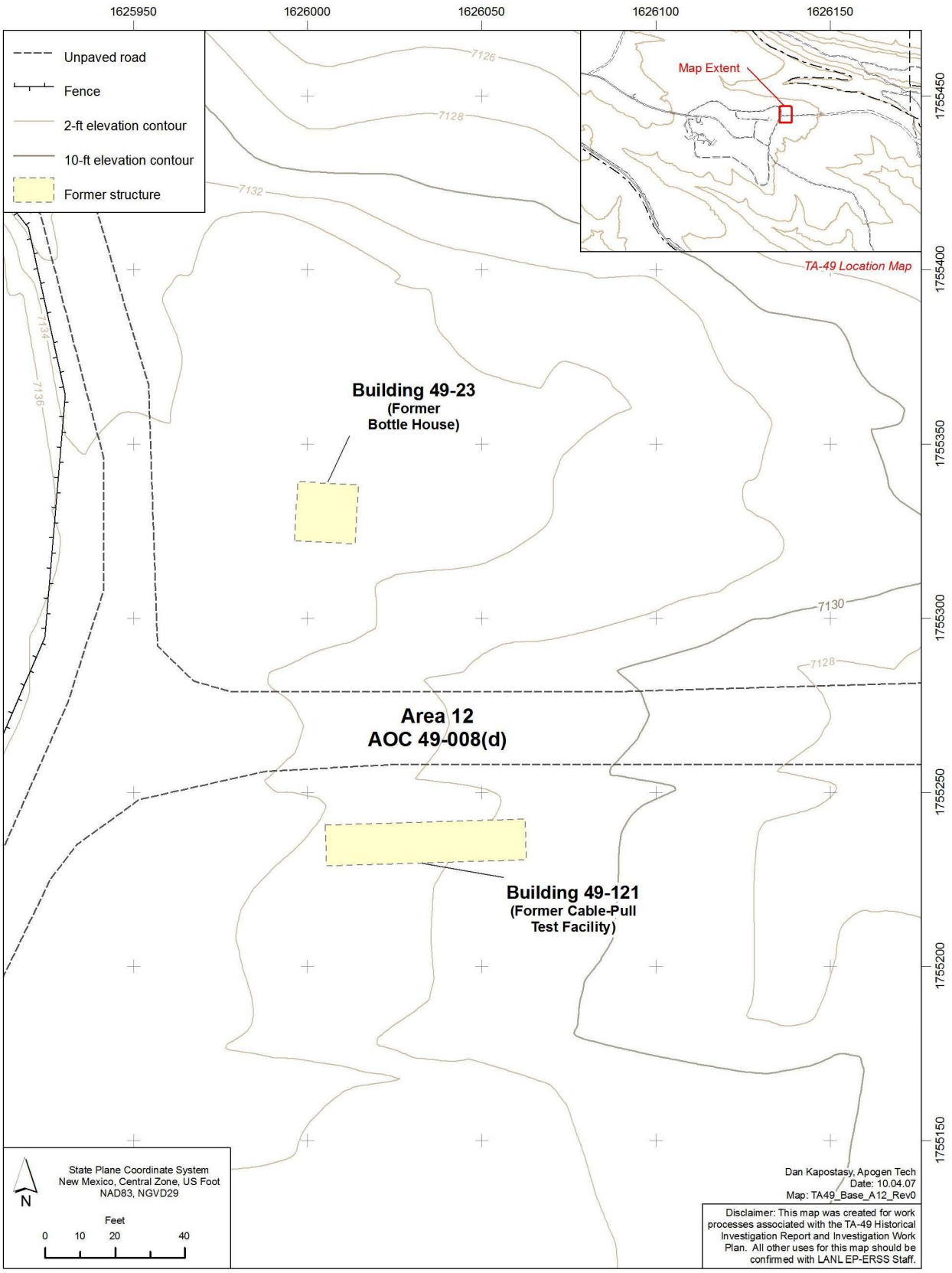


Figure 2.10-1 General site layout of Area 12

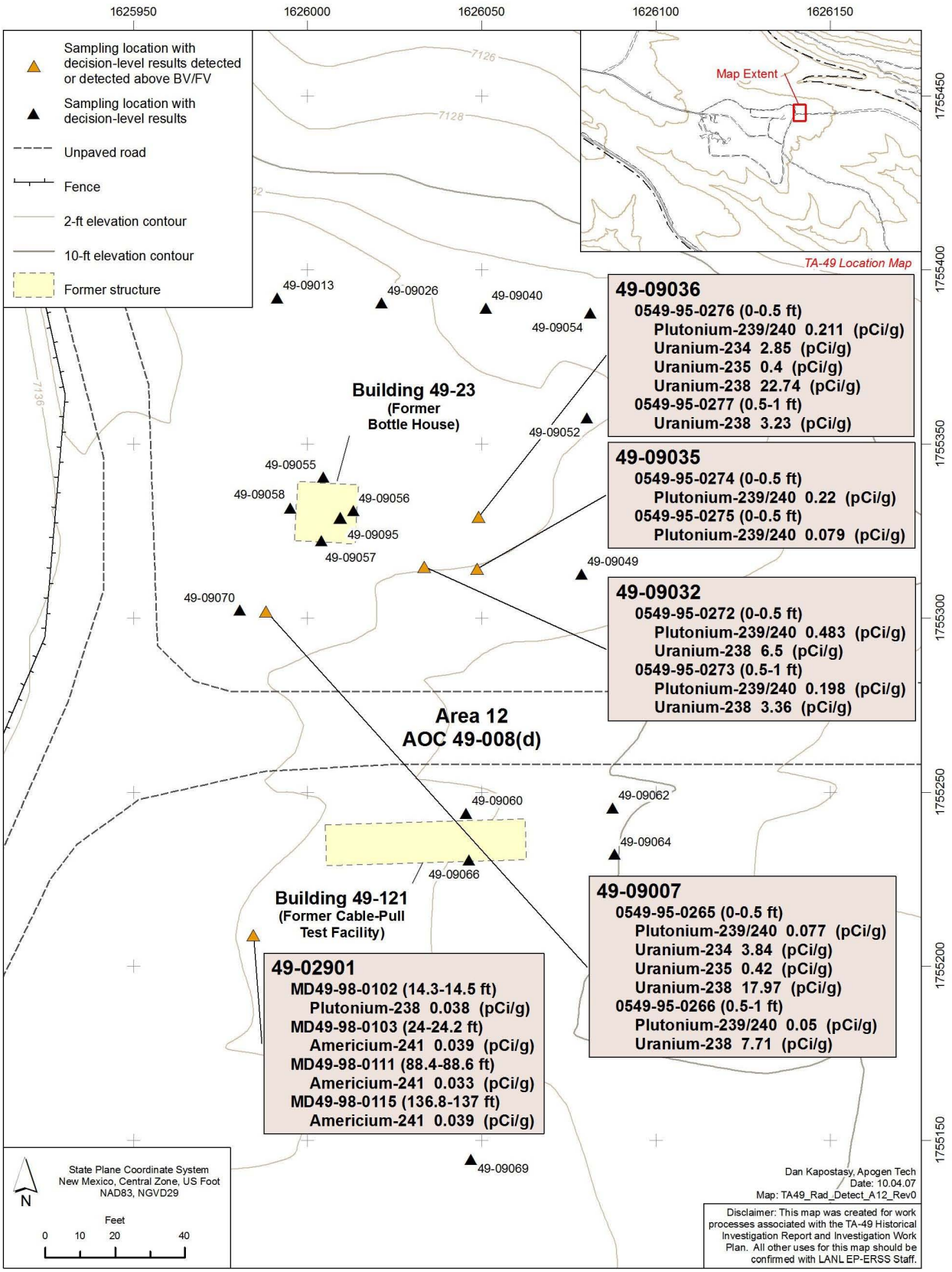


Figure 2.10-2 Area 12 radionuclide sampling locations and results above BVs/FVs

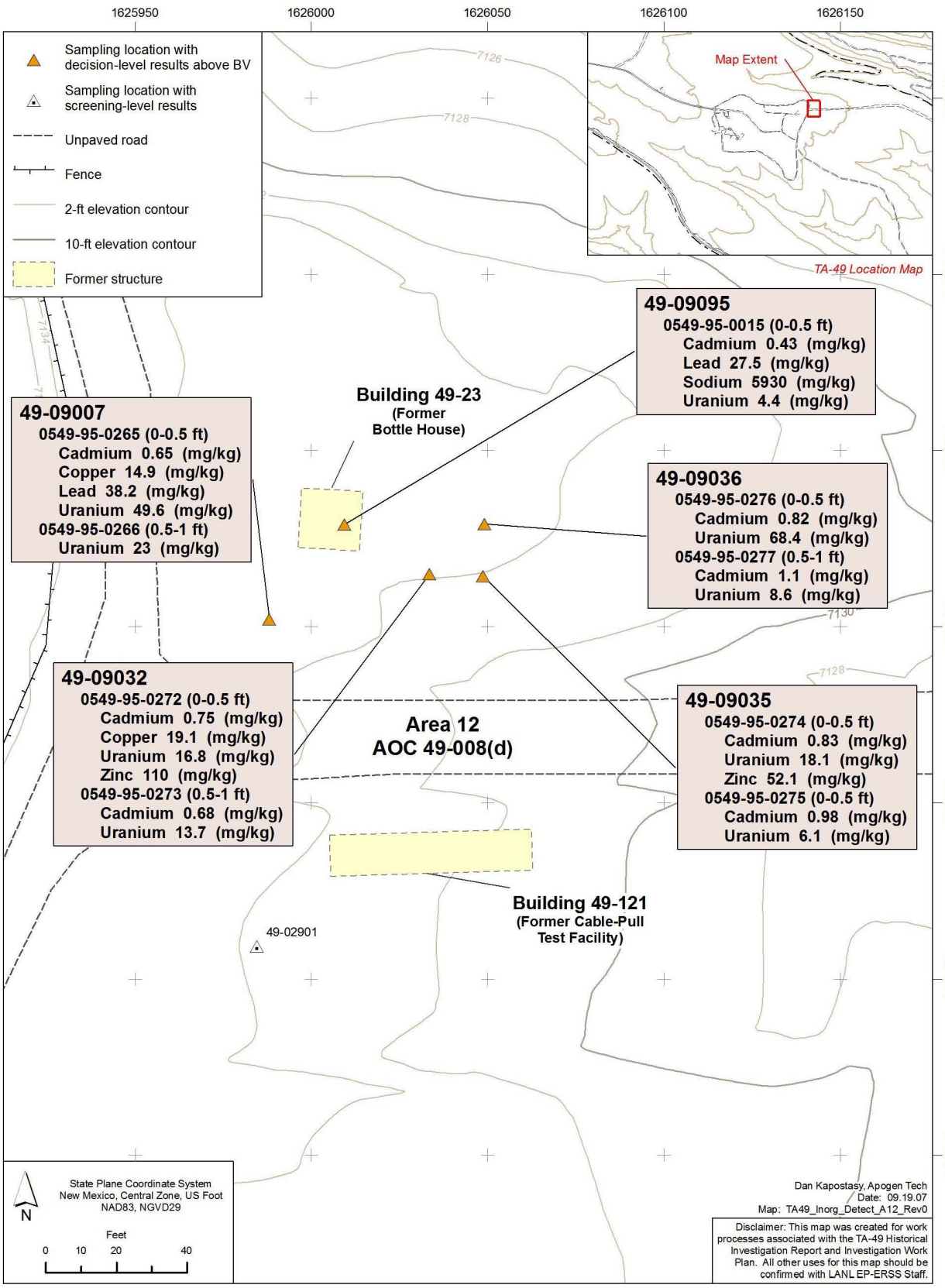


Figure 2.10-3 Area 12 inorganic chemical sampling locations and results above BVs

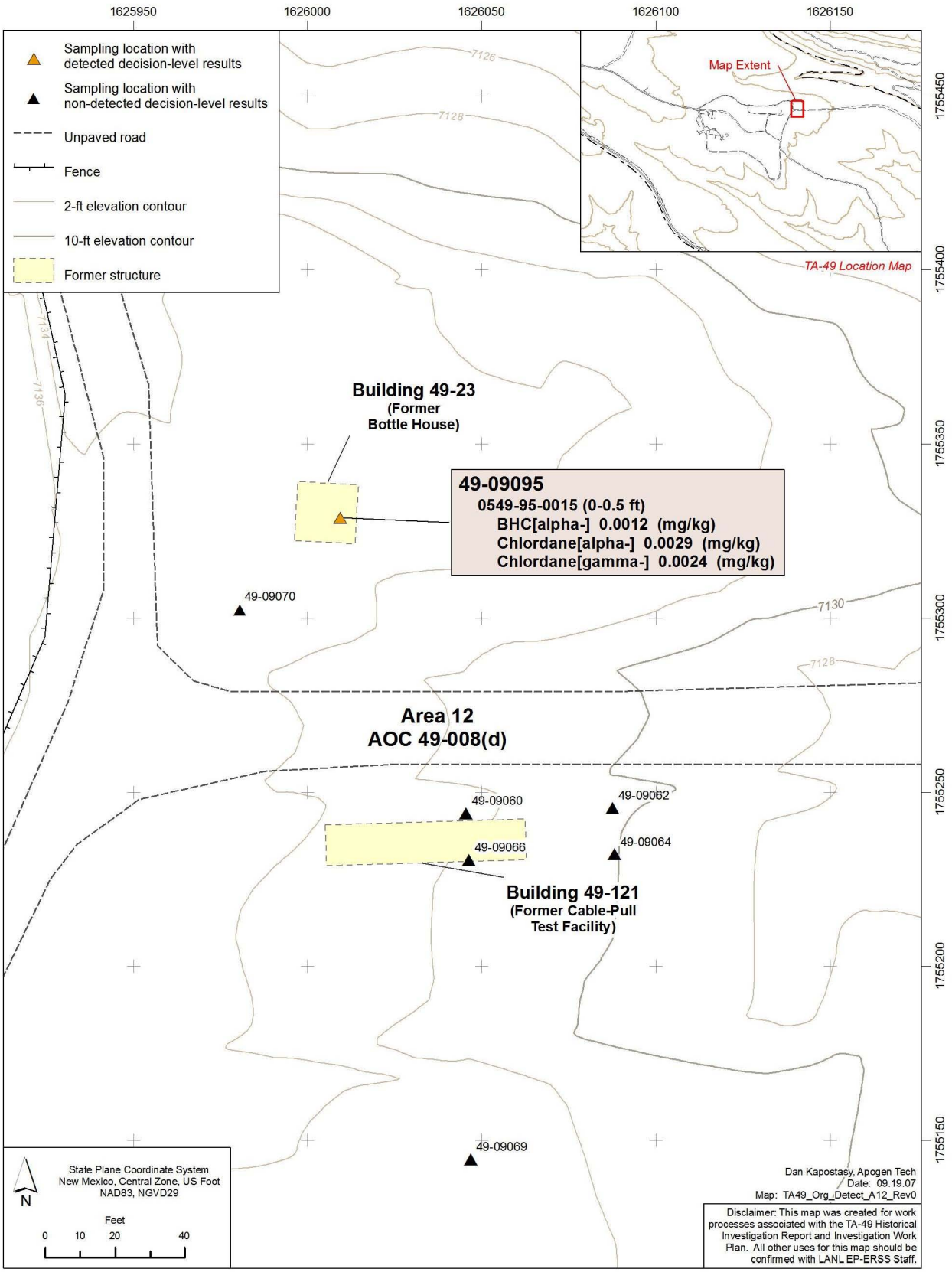
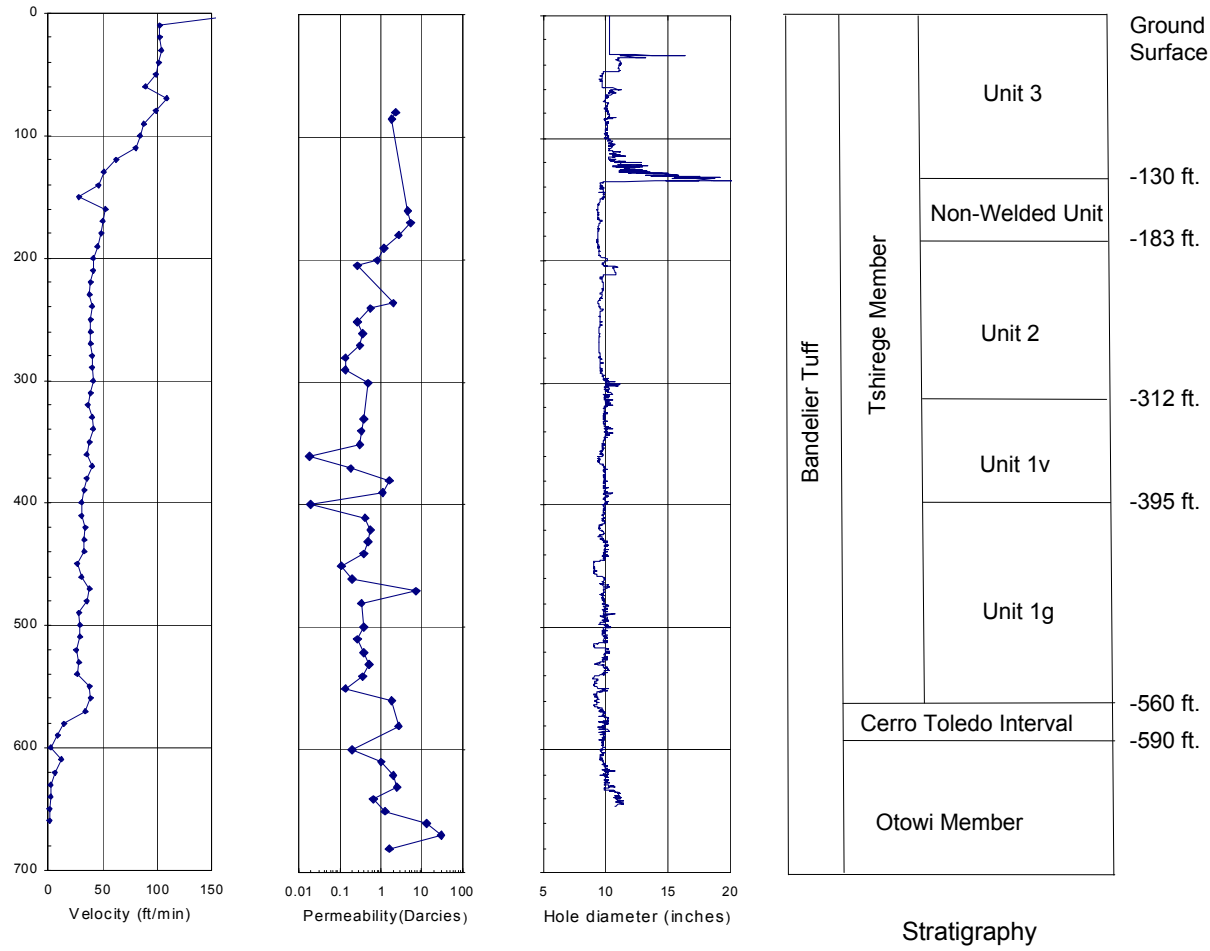
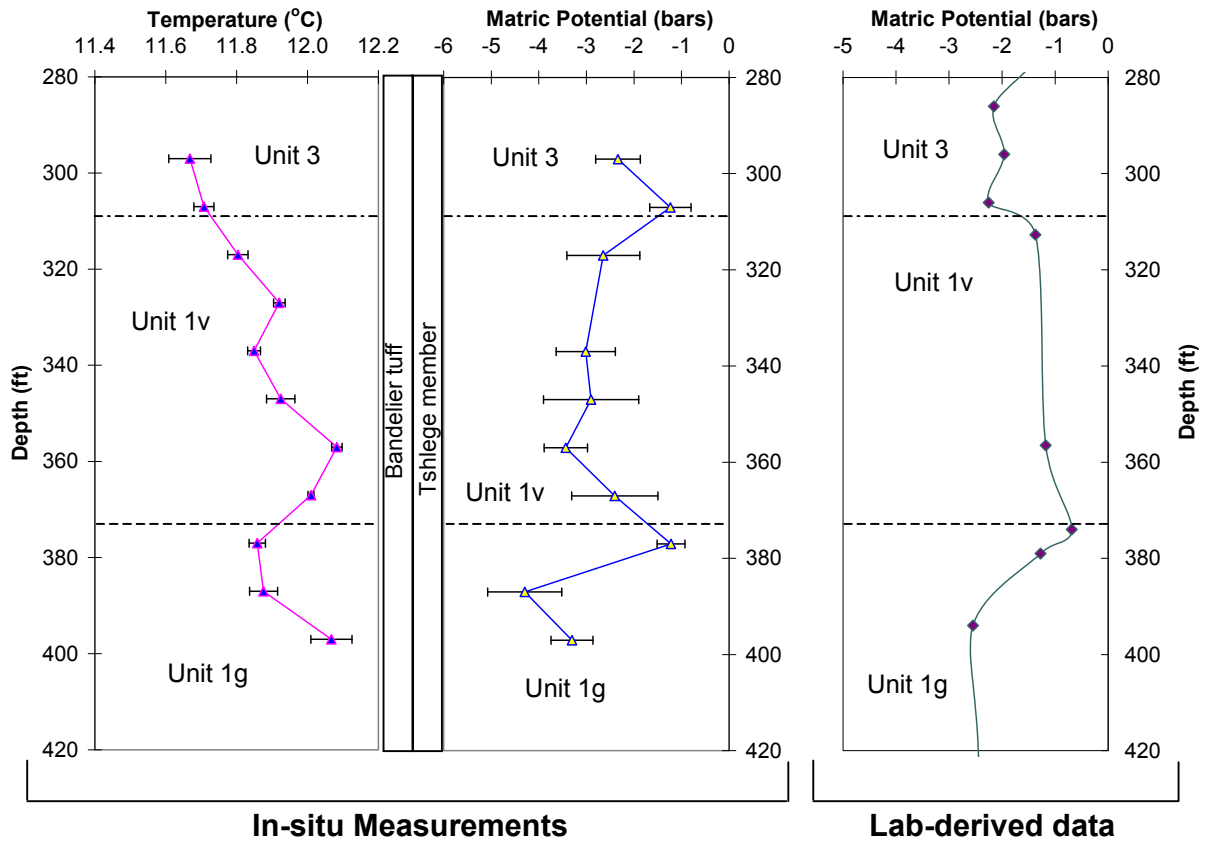


Figure 2.10-4 Area 12 organic chemical sampling locations and detected results



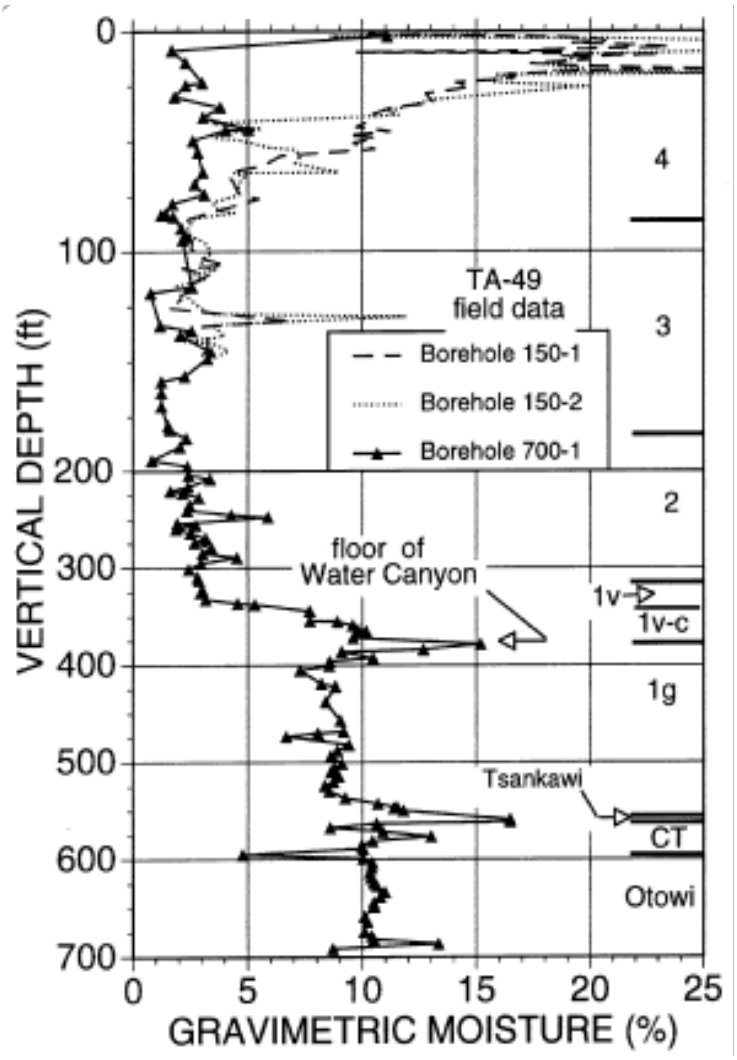
Source: Wykoff et al 1998, 098069, p. 17.

Figure 2.11-1 Air-flow measurement results and stratigraphy for borehole location 49-02901



Source: Neeper and Gilkeson 1996, 070104.

Figure 2.11-2 Average matric potential and temperature results with error bars compared with data from Neeper and Gilkeson



Source: Neeper and Gilkeson 1996, 070104.
Note: Stratigraphic units are indicated at right margin.

Figure 2.11-3 Water content profiles from three deep RFI boreholes at TA-49

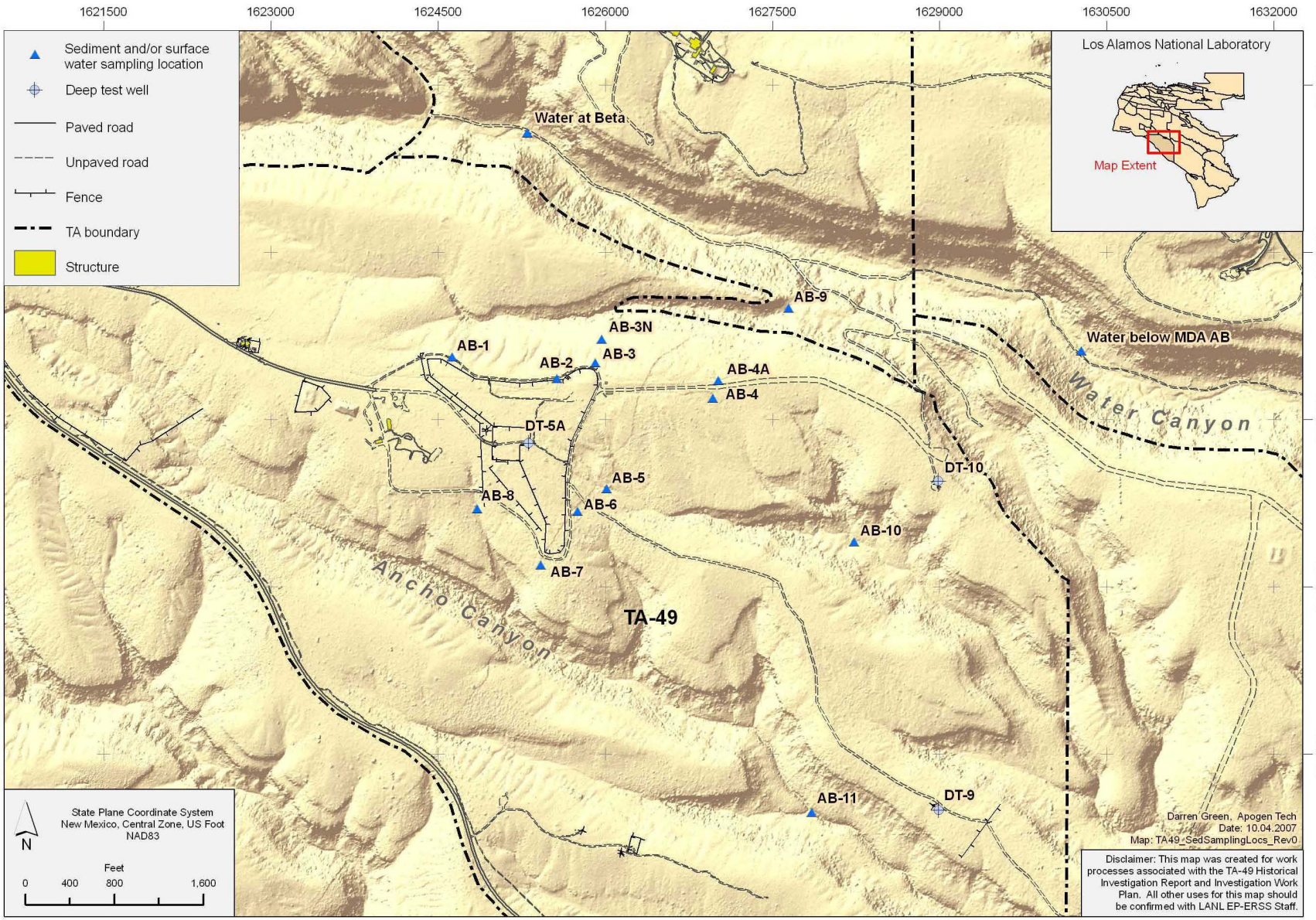
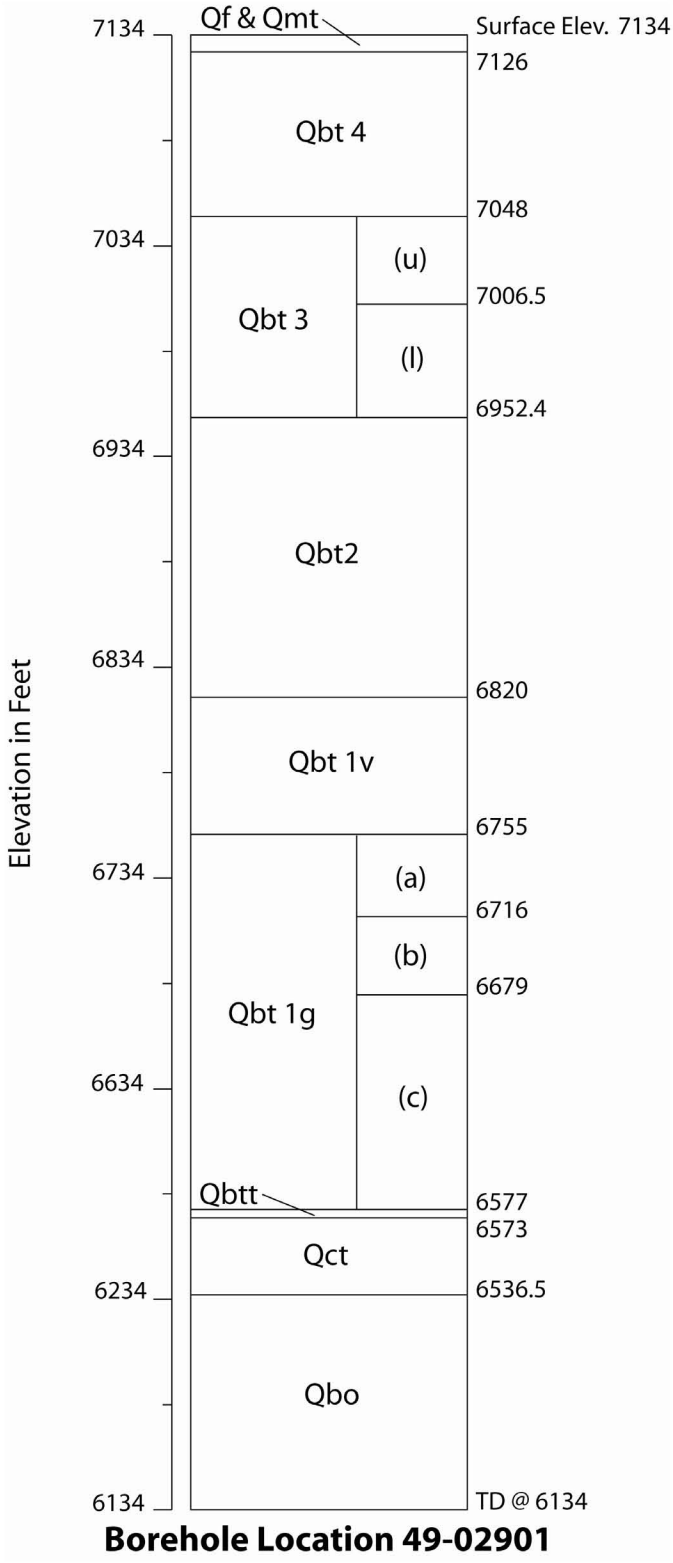


Figure 2.11-4 Sediment sampling locations at TA-49



Source: Adapted from Stimac et al. 2002, 073391.

Figure 3.2-1 Stratigraphy of borehole location 49-02901

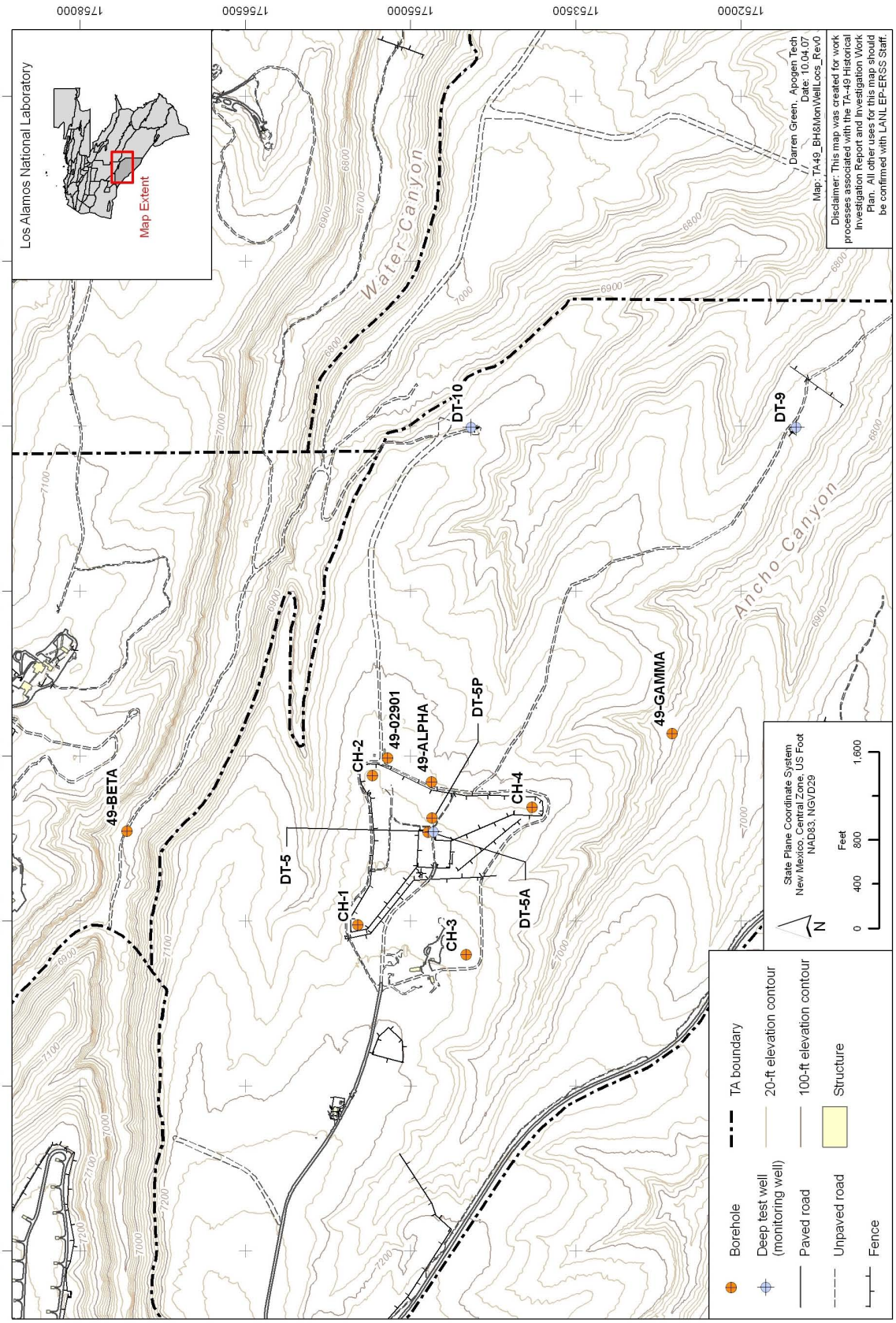
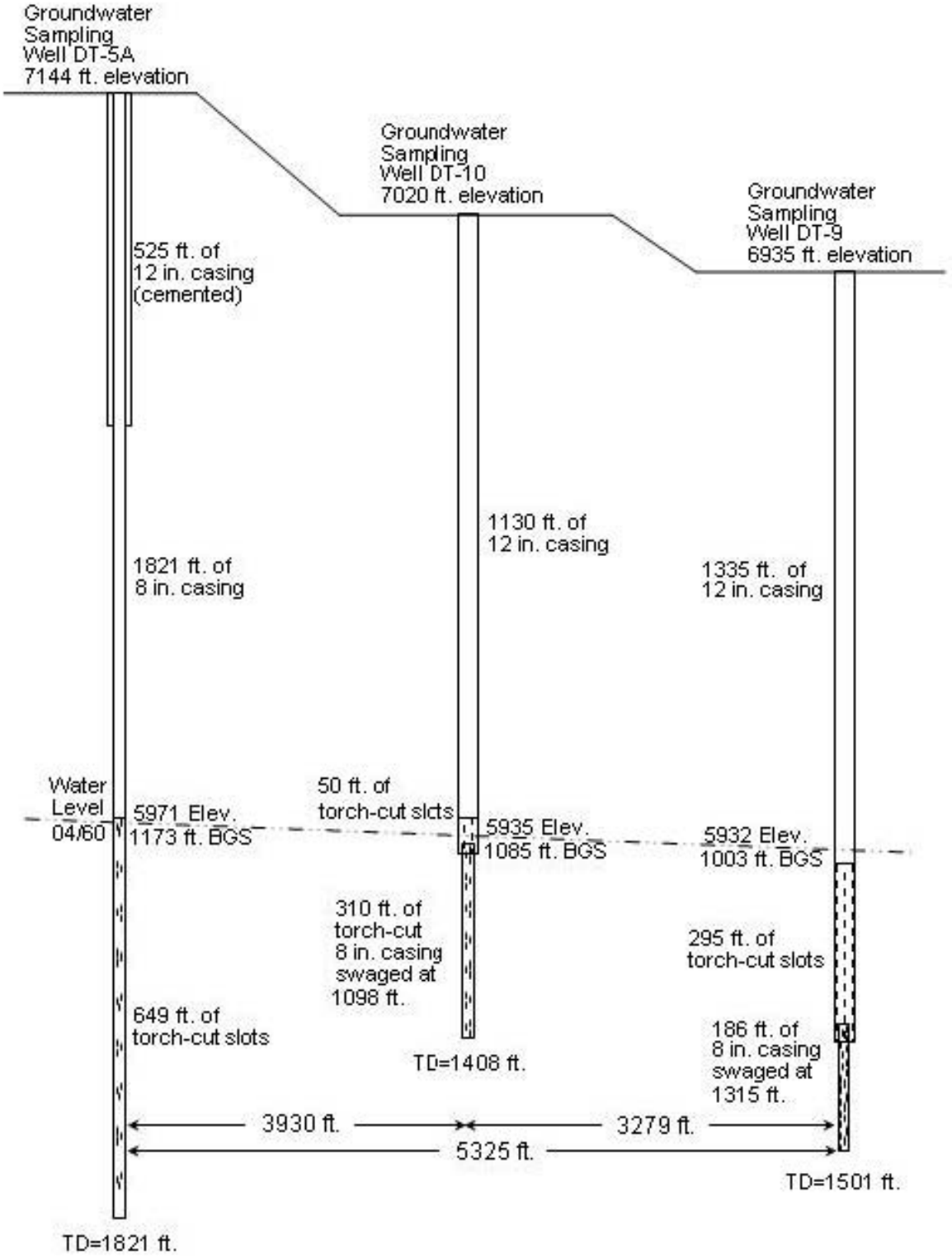
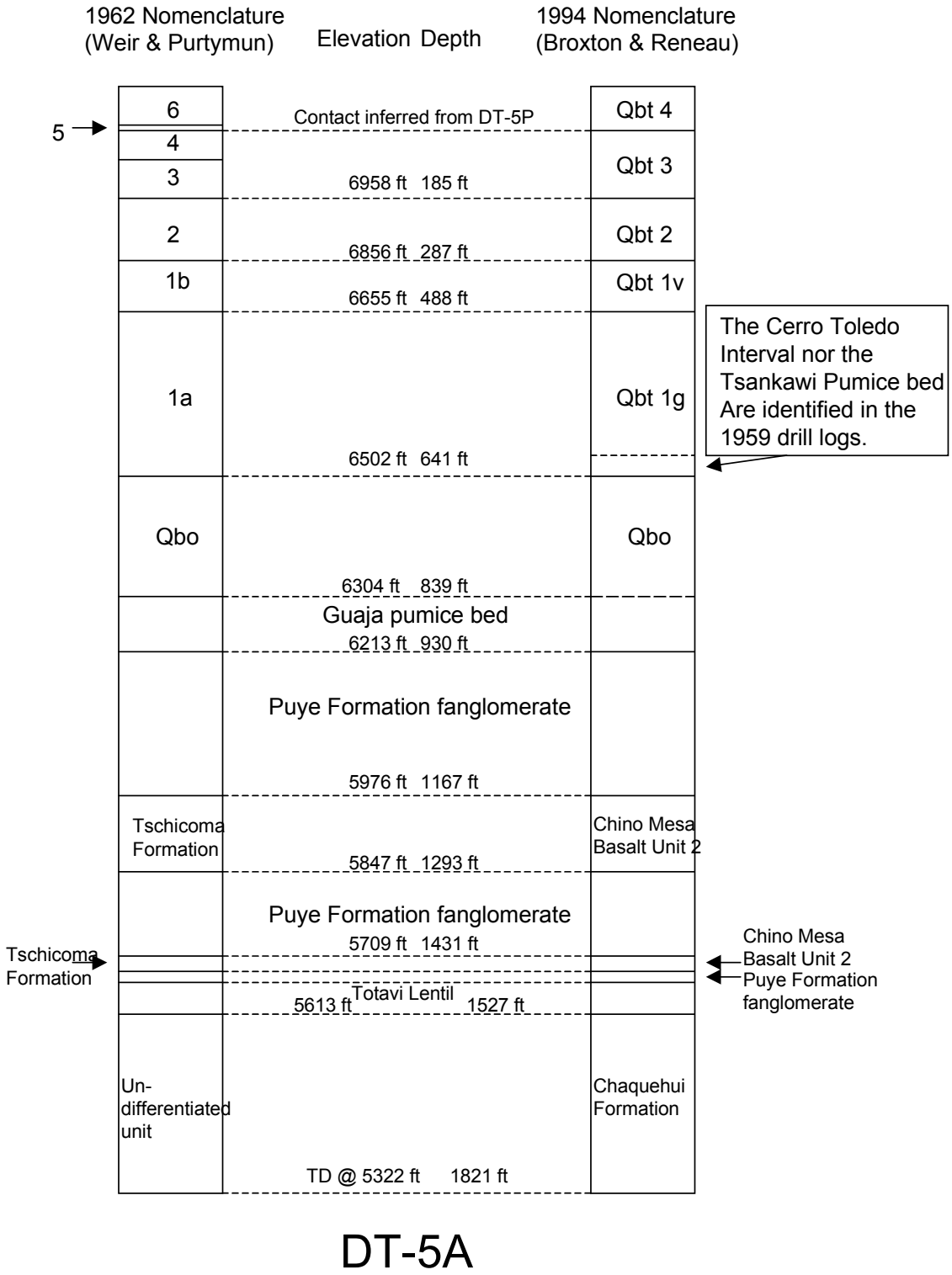


Figure 3.4-1 TA-49 deep test well and select borehole locations



Source: Adapted from Weir and Purtymun 1962, 011890.

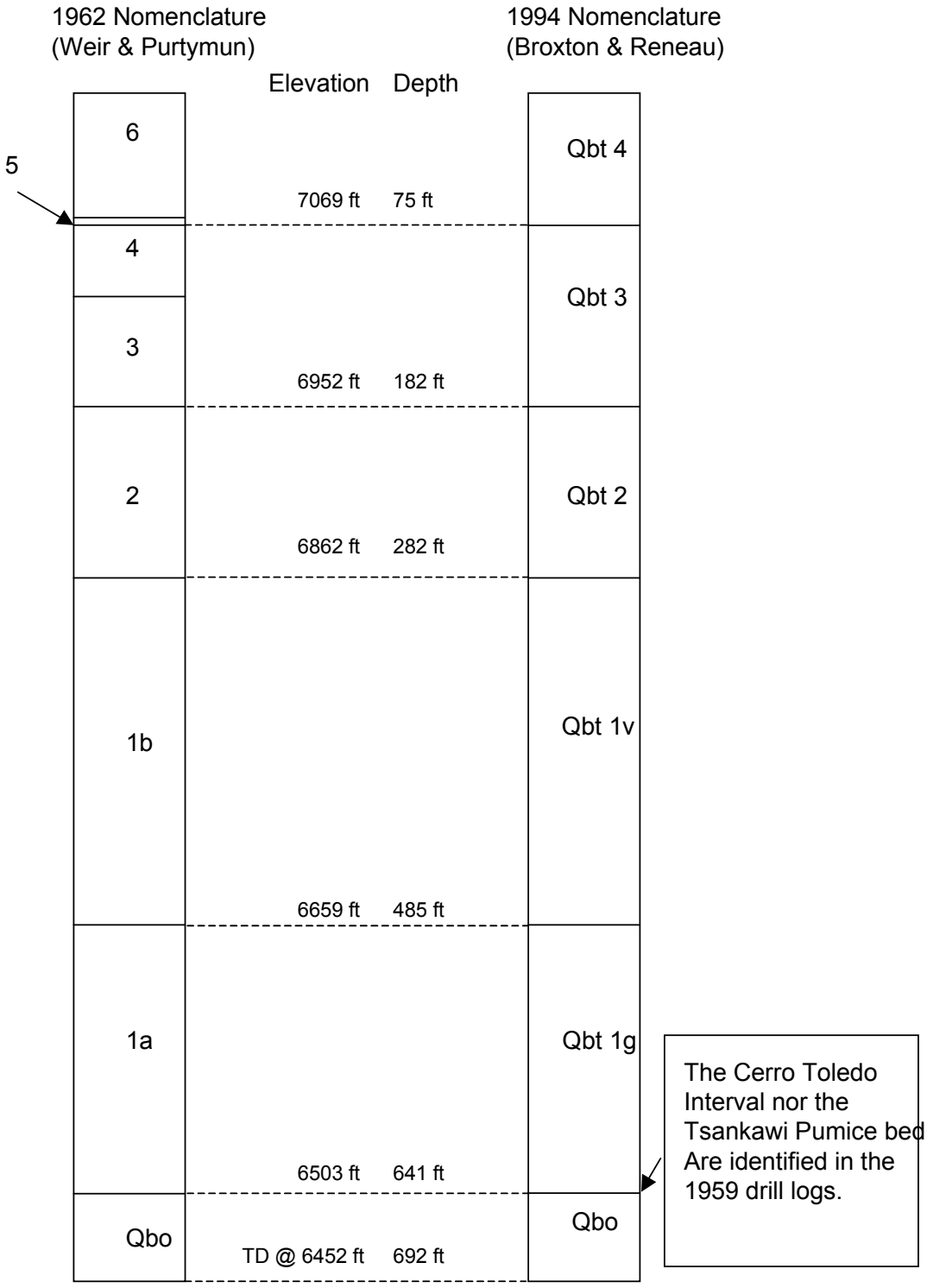
Figure 3.4-2 Deep test well construction detail



DT-5A

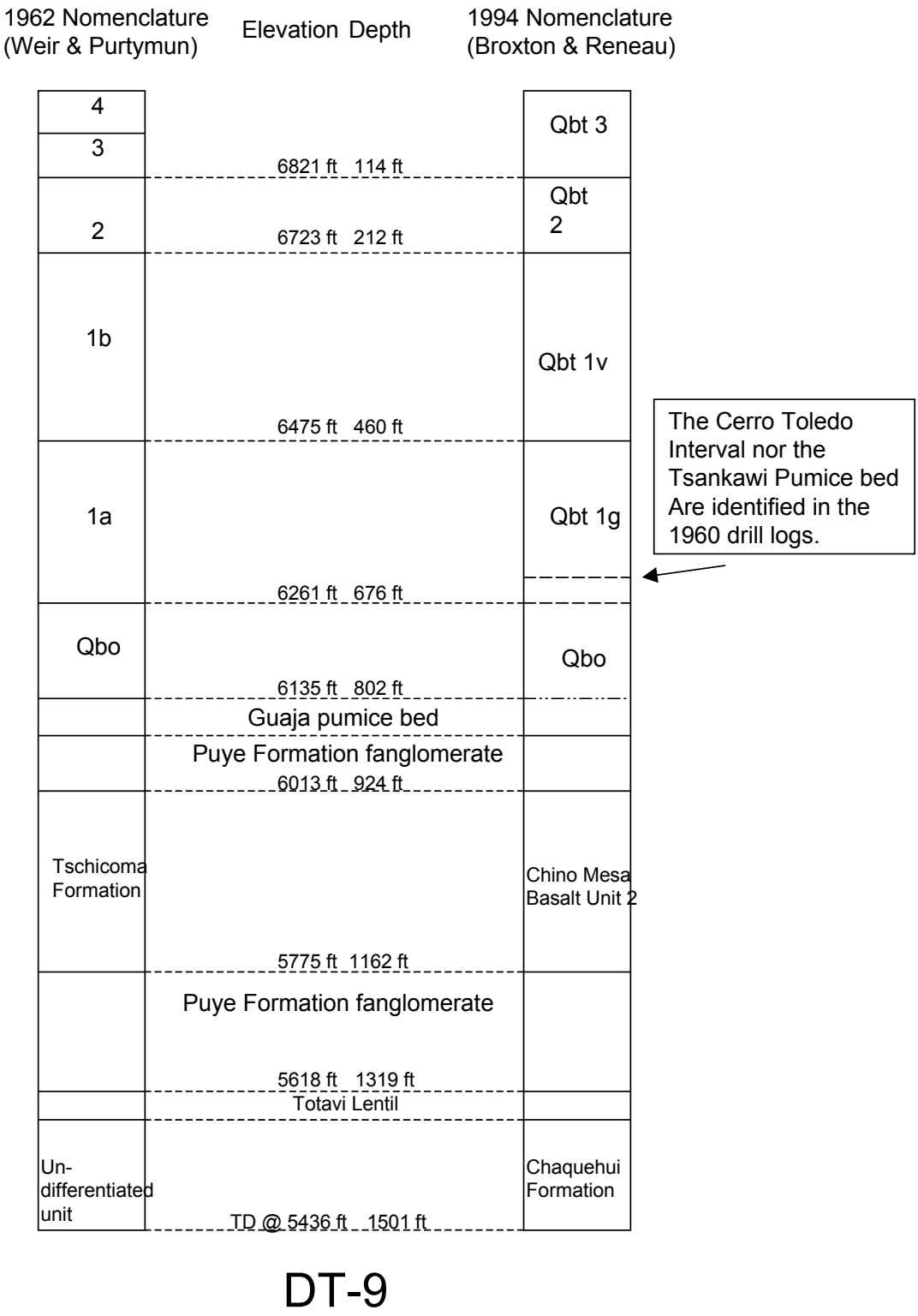
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-1 Stratigraphy of deep test well DT-5A



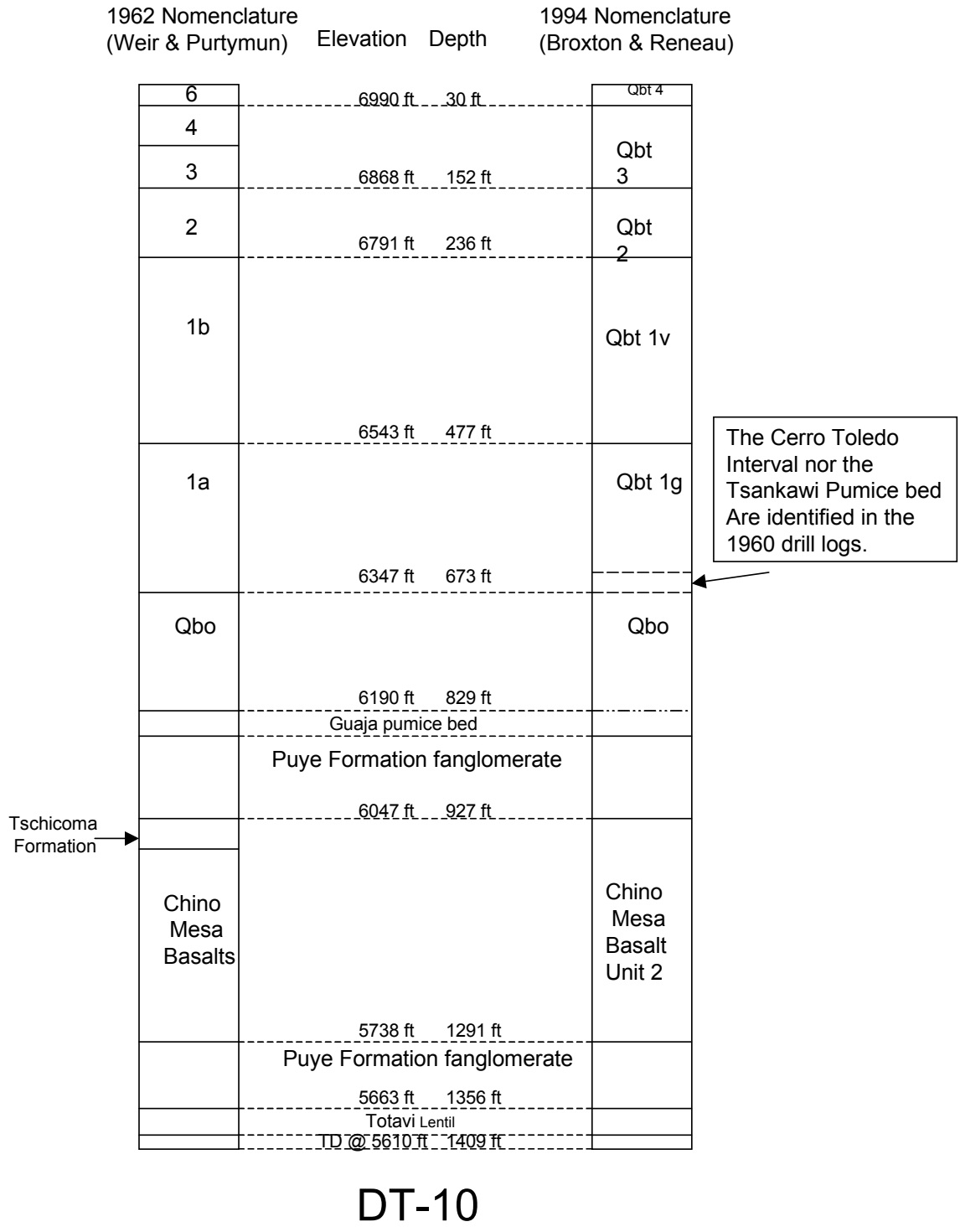
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-2 Stratigraphy units of deep test well DT-5P



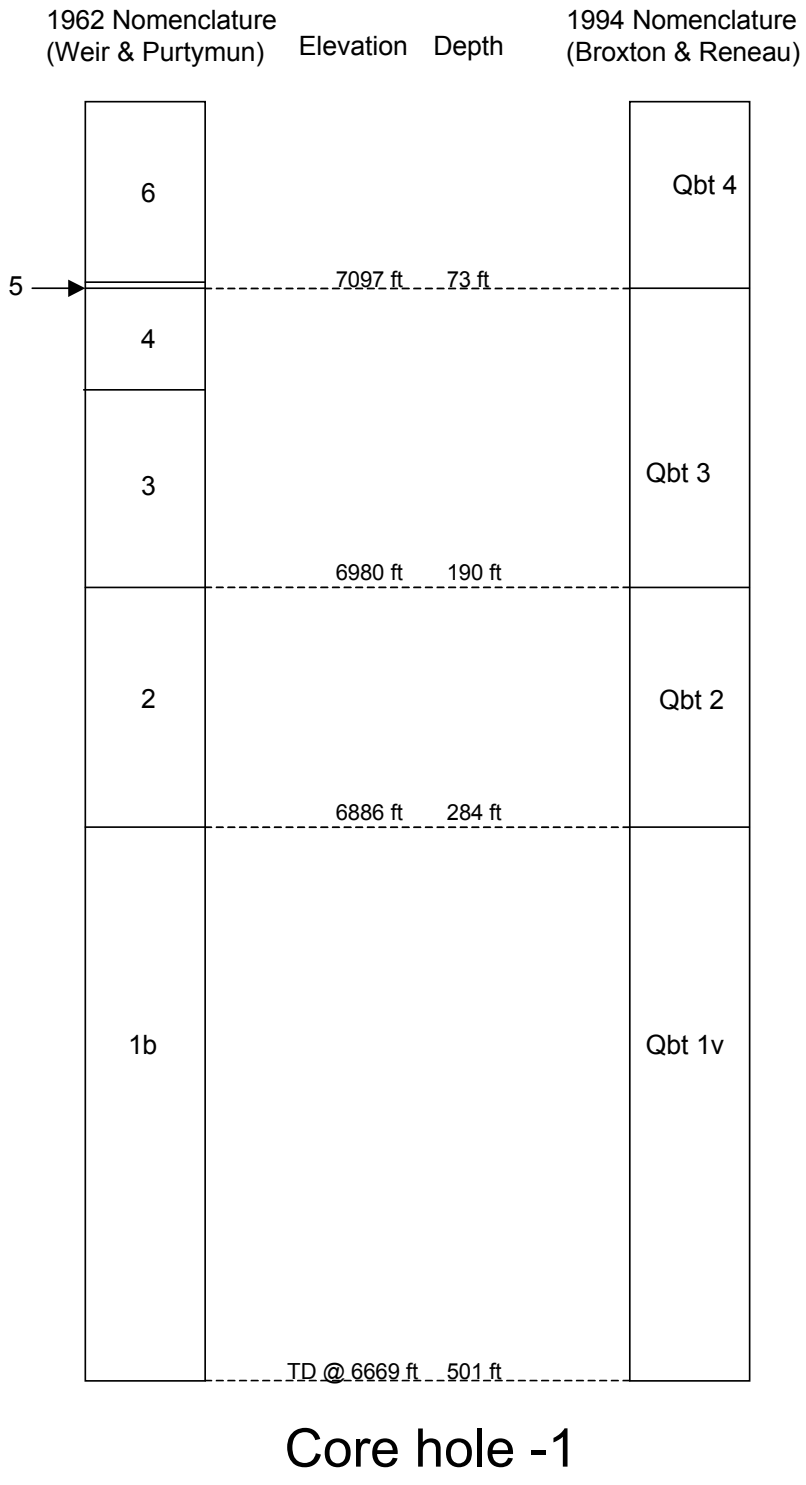
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-3 Stratigraphy units of DT-9



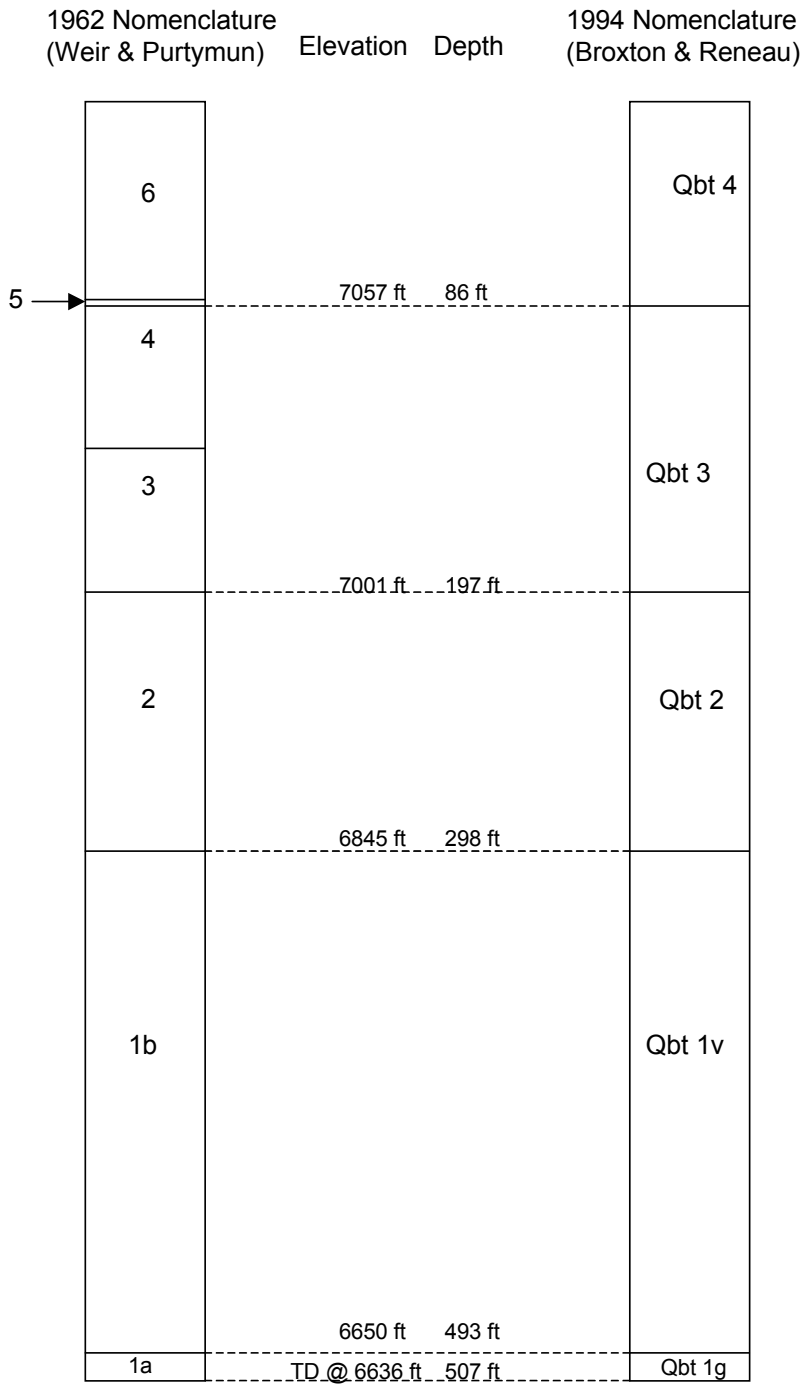
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-4 Stratigraphy of deep test well DT-10



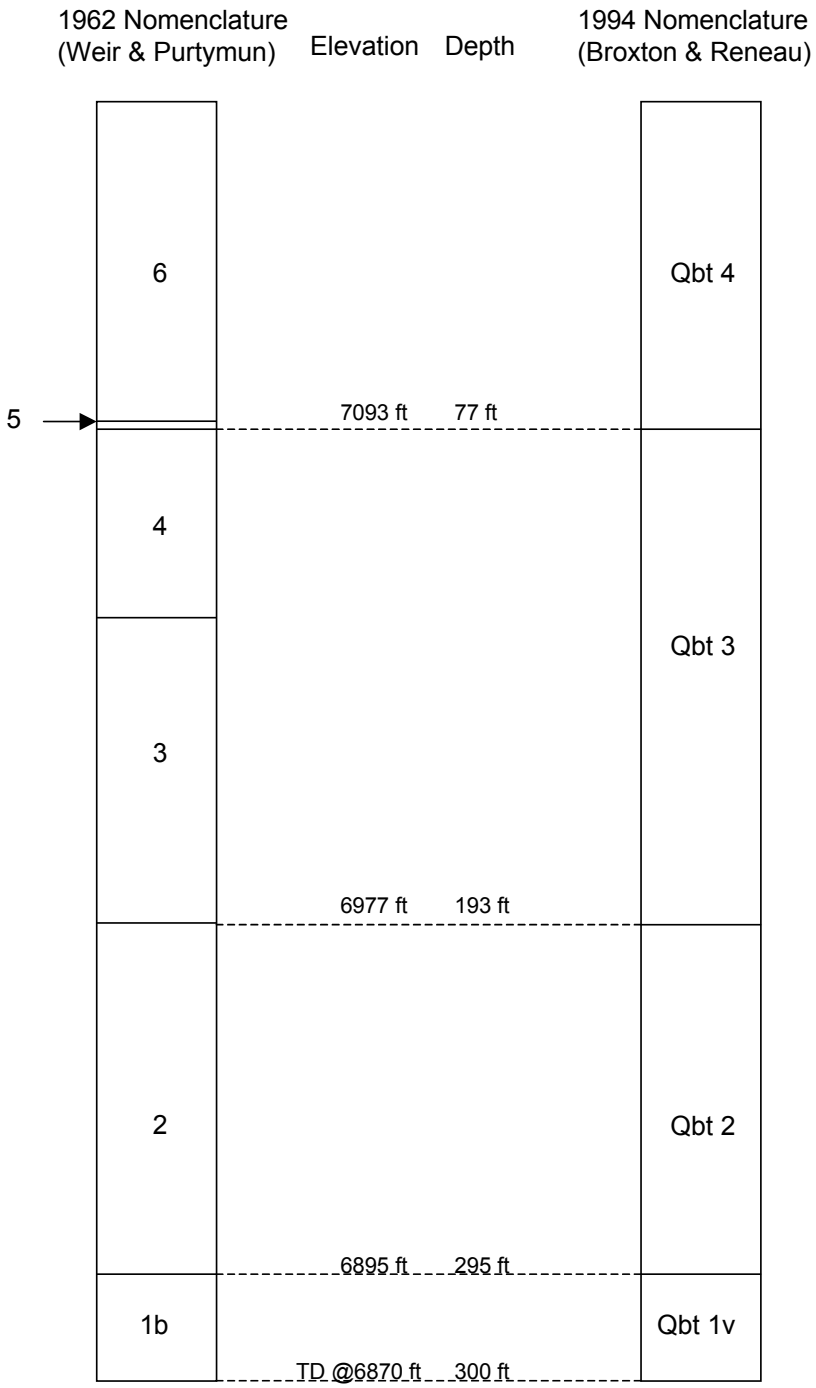
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-5 Stratigraphy of core hole CH-1



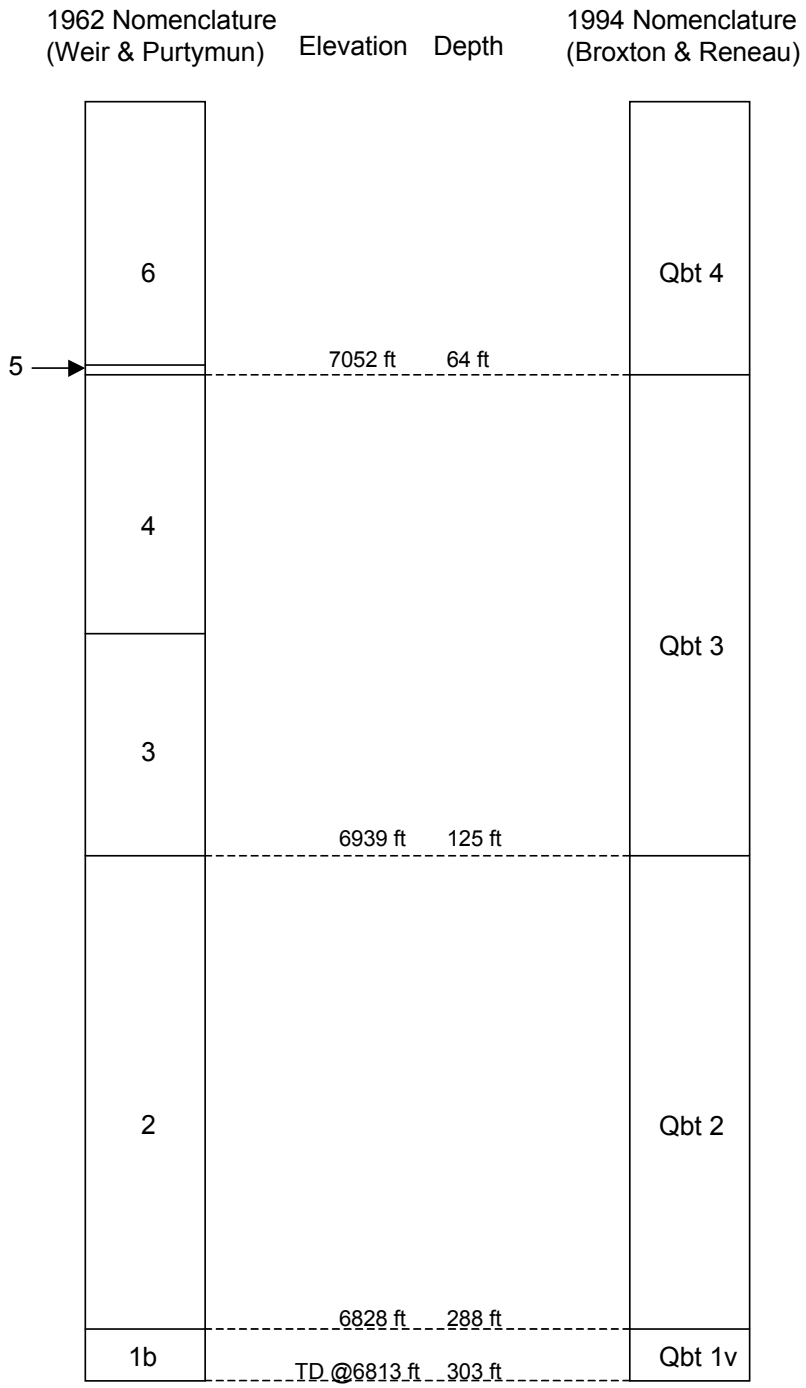
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-6 Stratigraphy of core hole CH-2



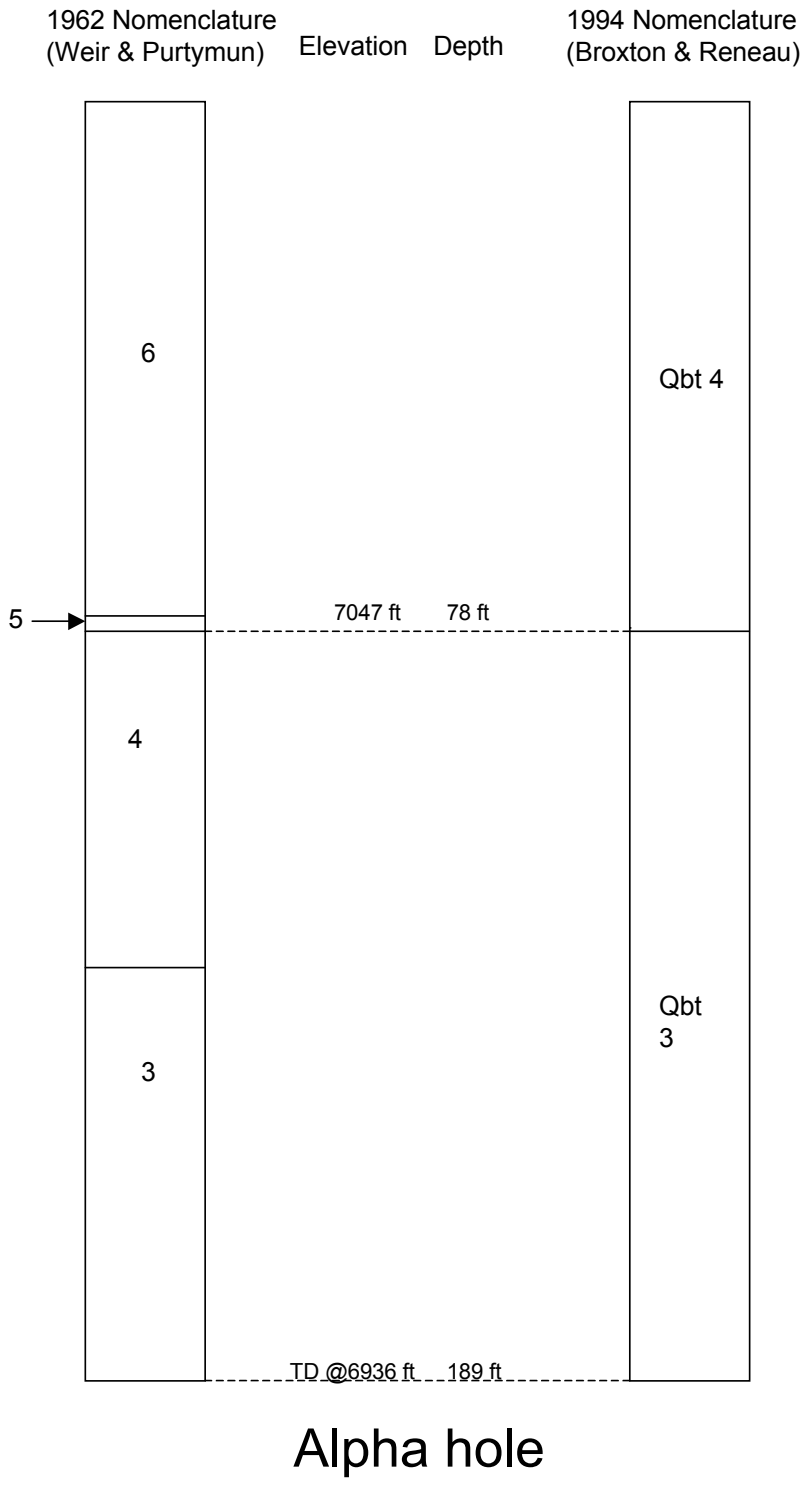
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-7 Stratigraphy of core hole CH-3



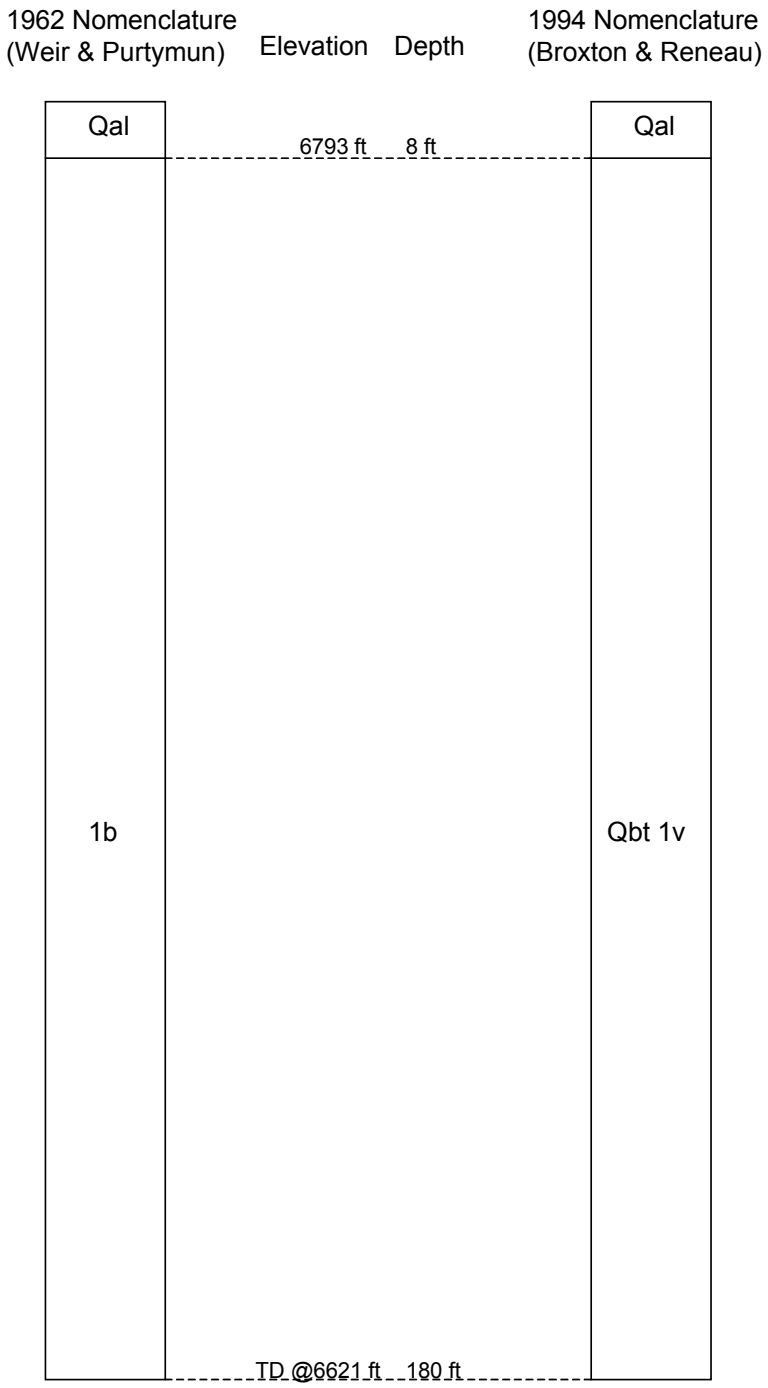
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-8 Stratigraphy of core hole CH-4



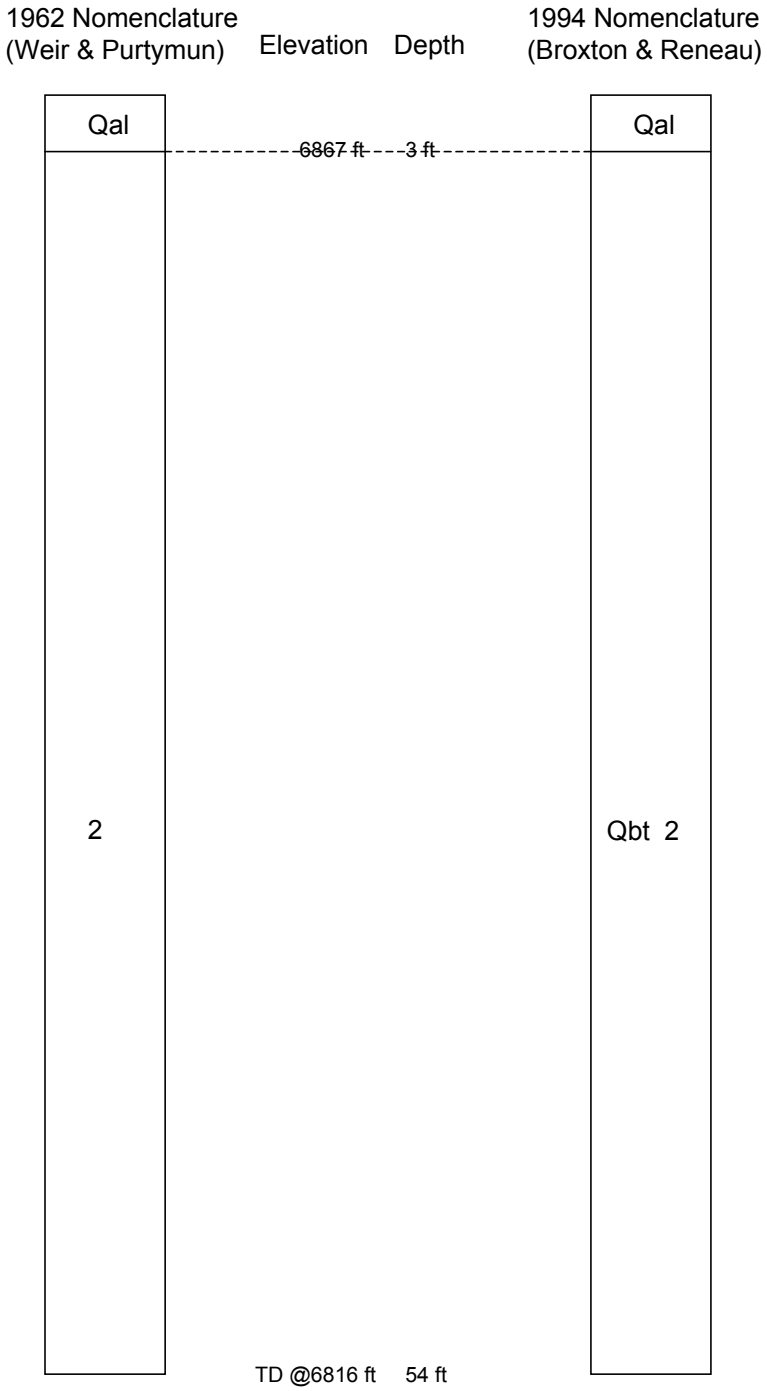
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726).

Figure 3.5-9 Stratigraphy of Alpha hole



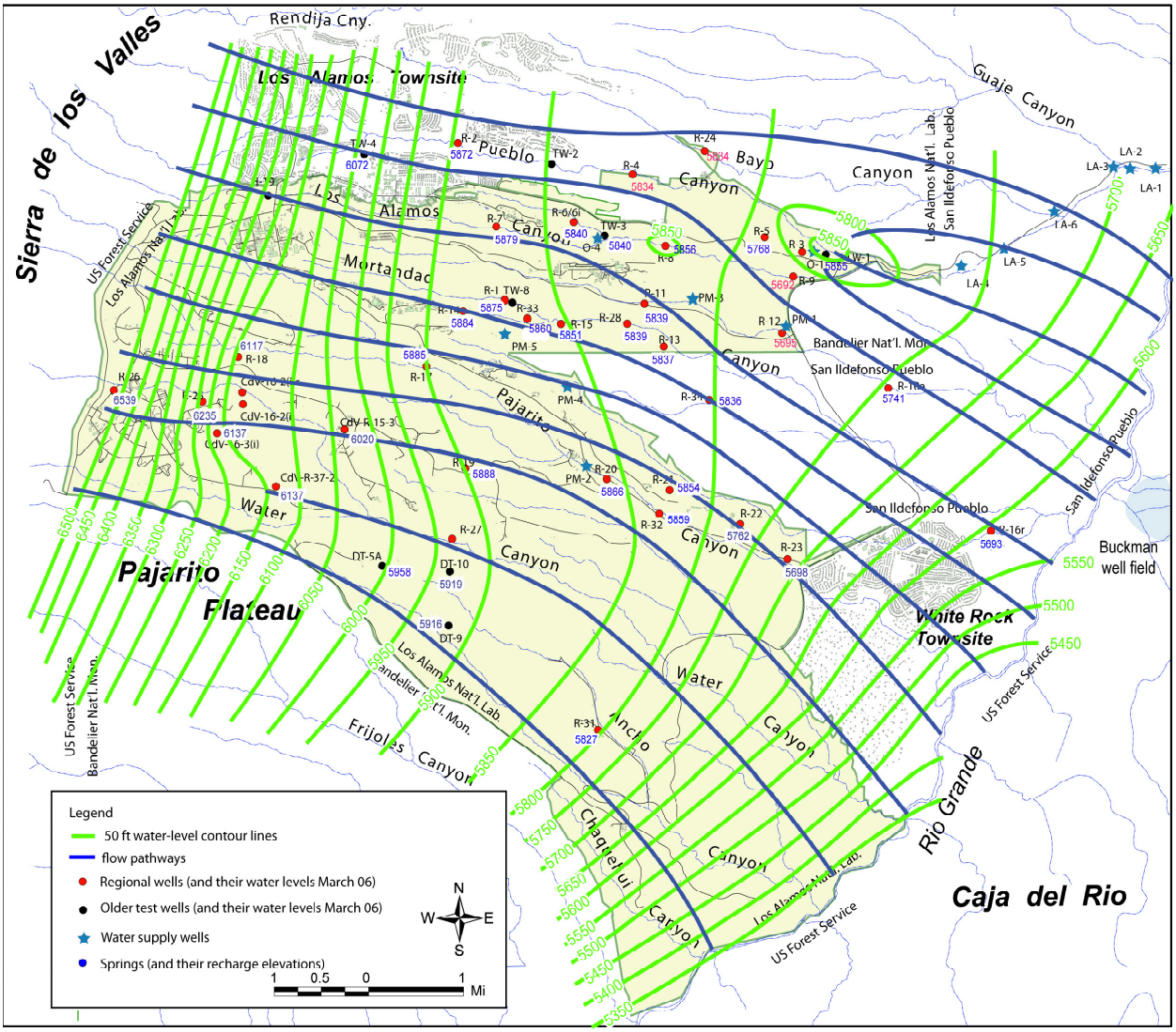
Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-10 Stratigraphy of Beta hole



Source: Adapted from Weir and Purtymun 1962, 011890 and Broxton and Reneau 1995, 049726.

Figure 3.5-11 Stratigraphy of Gamma hole



Source: LANL 2007, 095364, p. C-15.

Figure 3.6-1 Contour map of regional water-table elevations and flow pathways beneath the Pajarito Plateau in March 2006

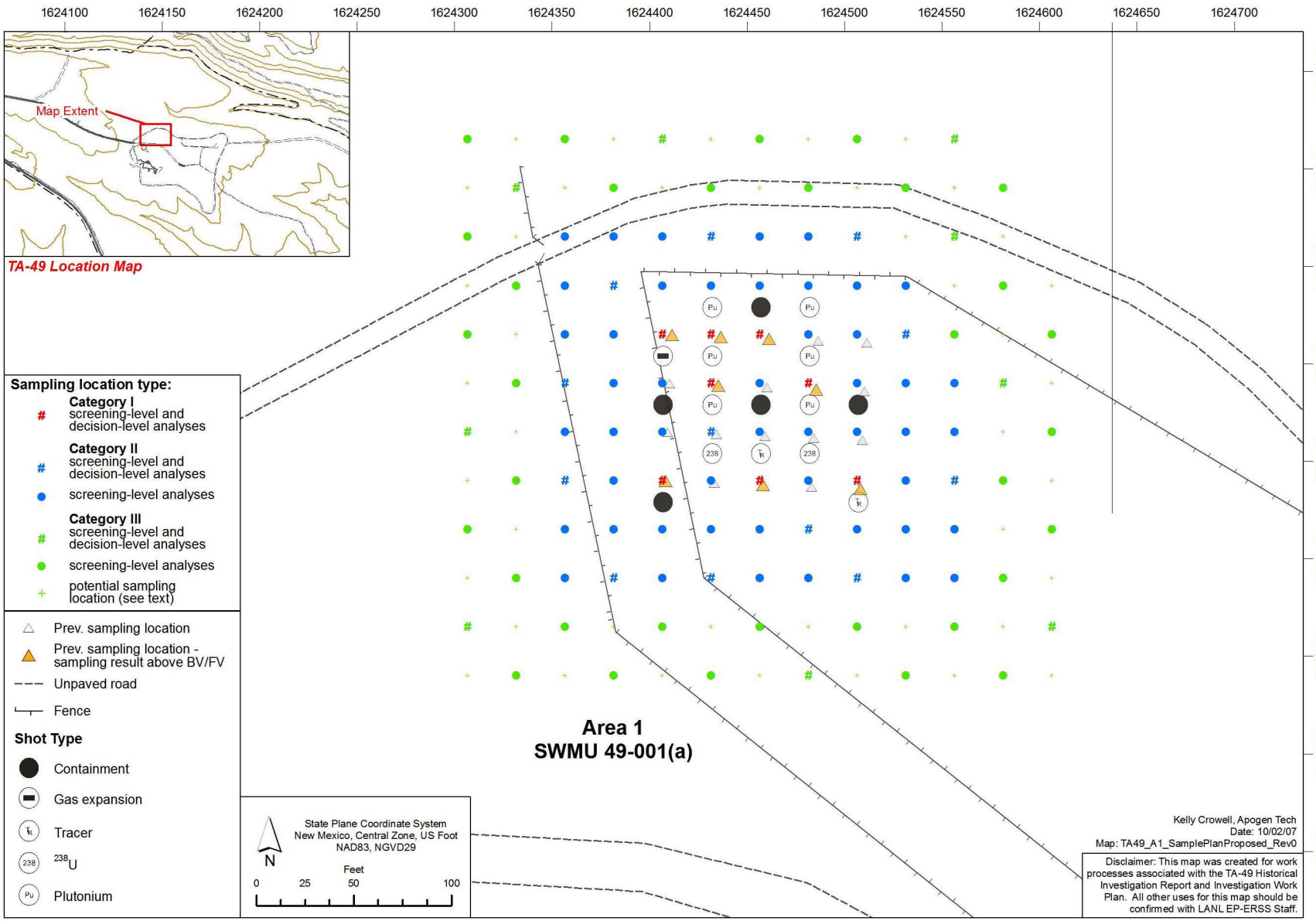


Figure 4.3-1 Area 1: SWMU 49-001(a) proposed surface sampling locations

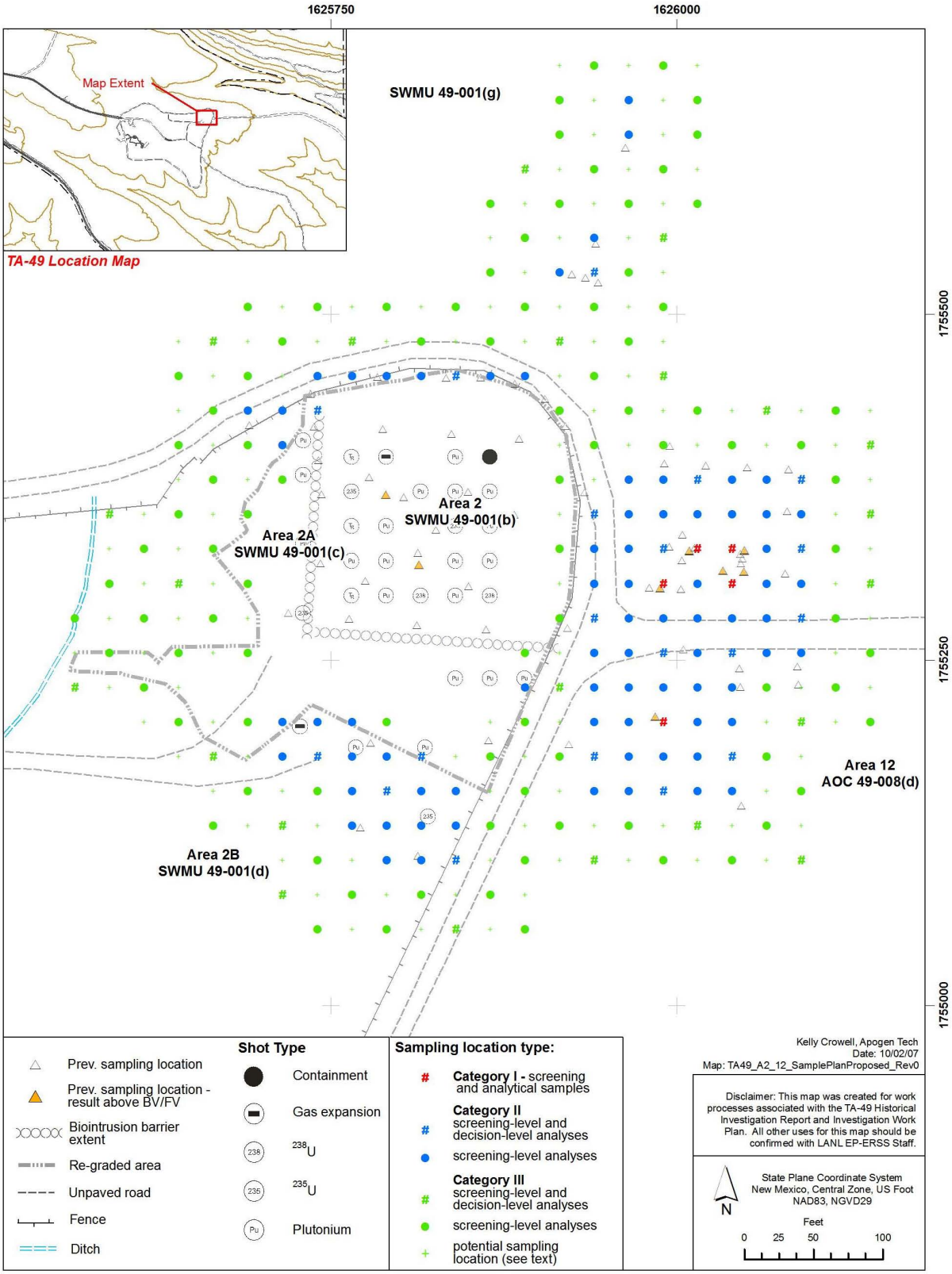


Figure 4.3-2 Areas 2, 2A, 2B, and 12: SWMU 49-001(b), SWMU 49-001(c), SWMU 49-001(d), and AOC 49-008(d) proposed surface sampling locations

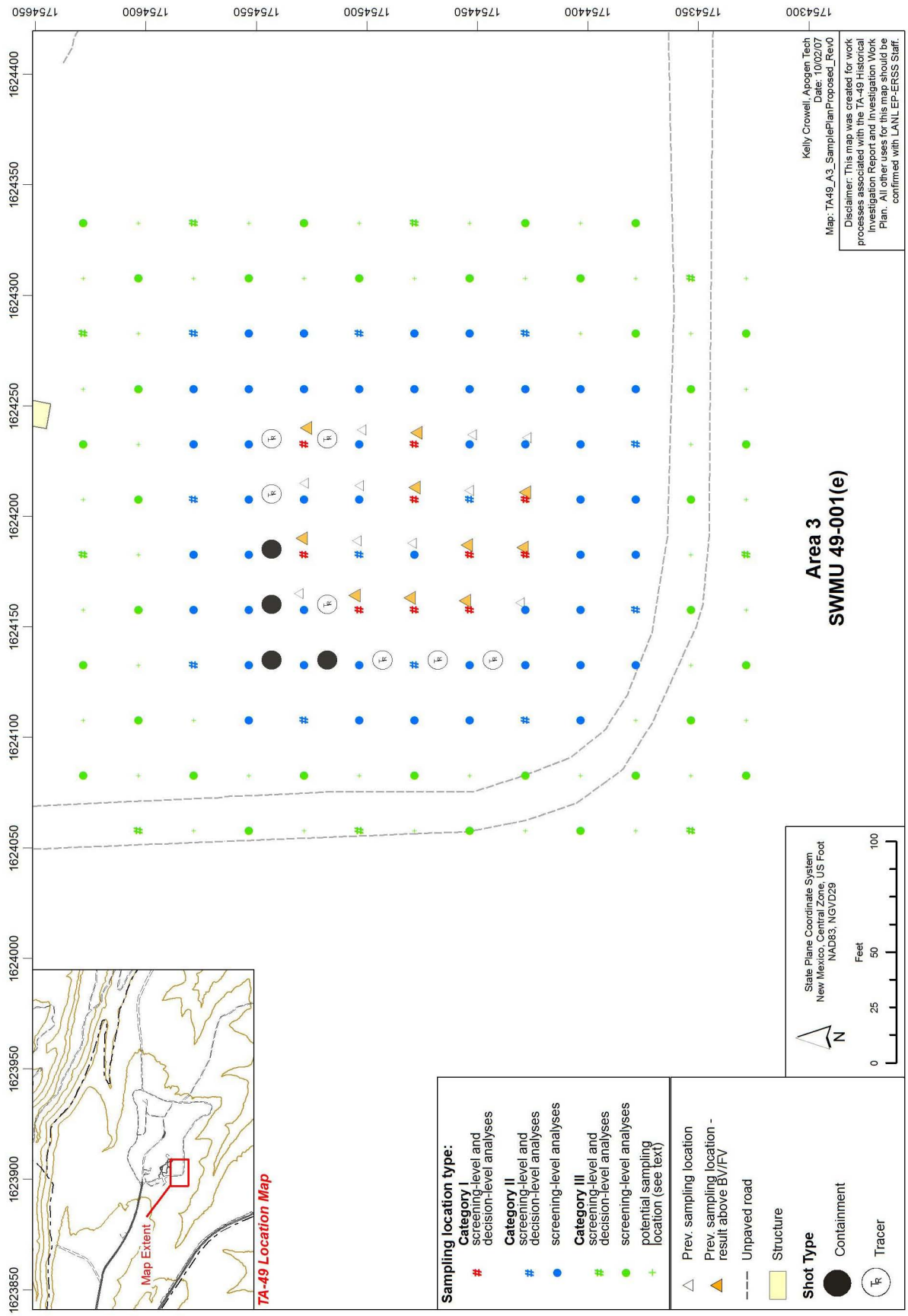


Figure 4.3-3 Area 3: SWMU 49-001(e) proposed surface sampling locations

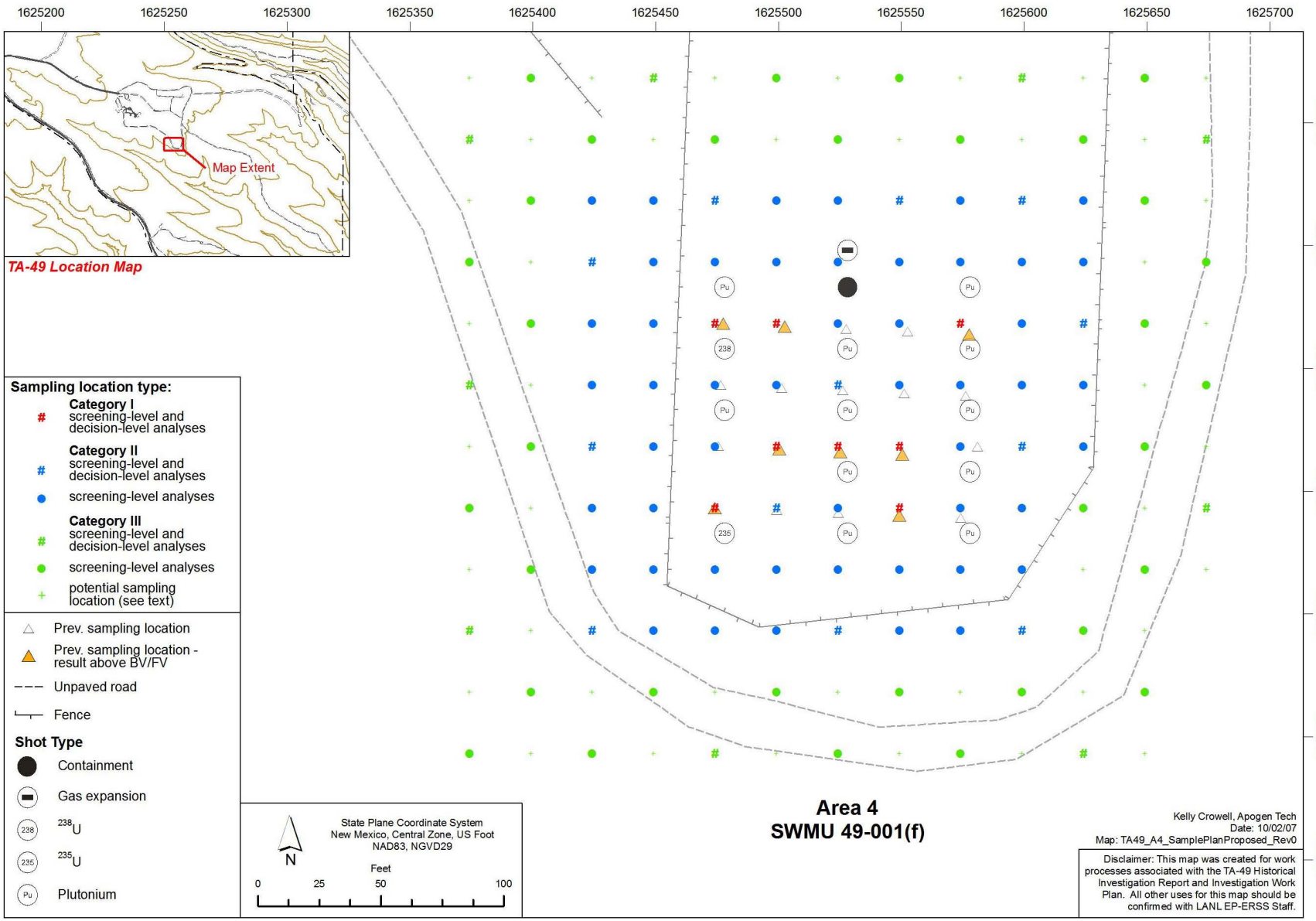


Figure 4.3-4 Area 4: SWMU 49-001(f) proposed surface sampling locations

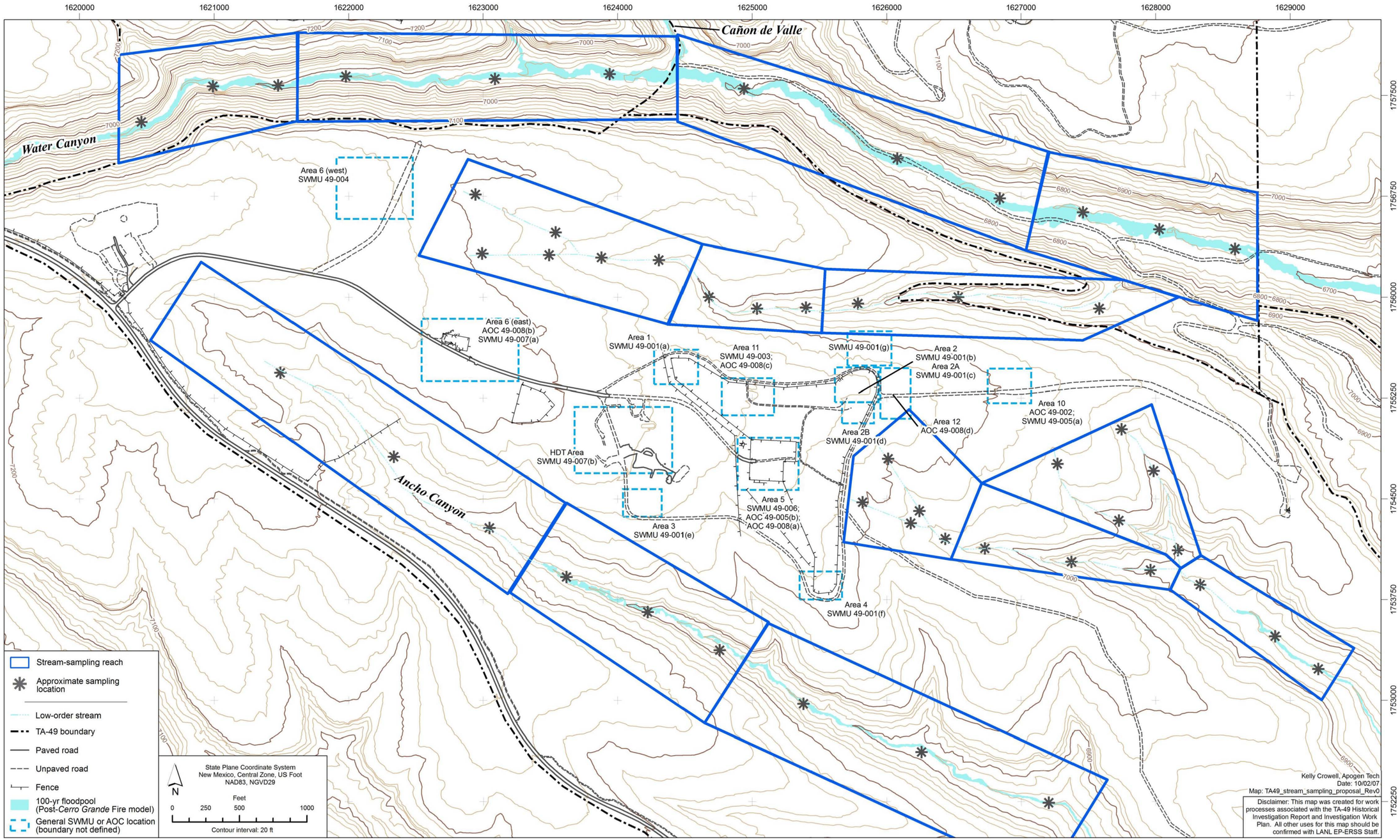


Figure 4.3-5 Proposed sediment sampling locations

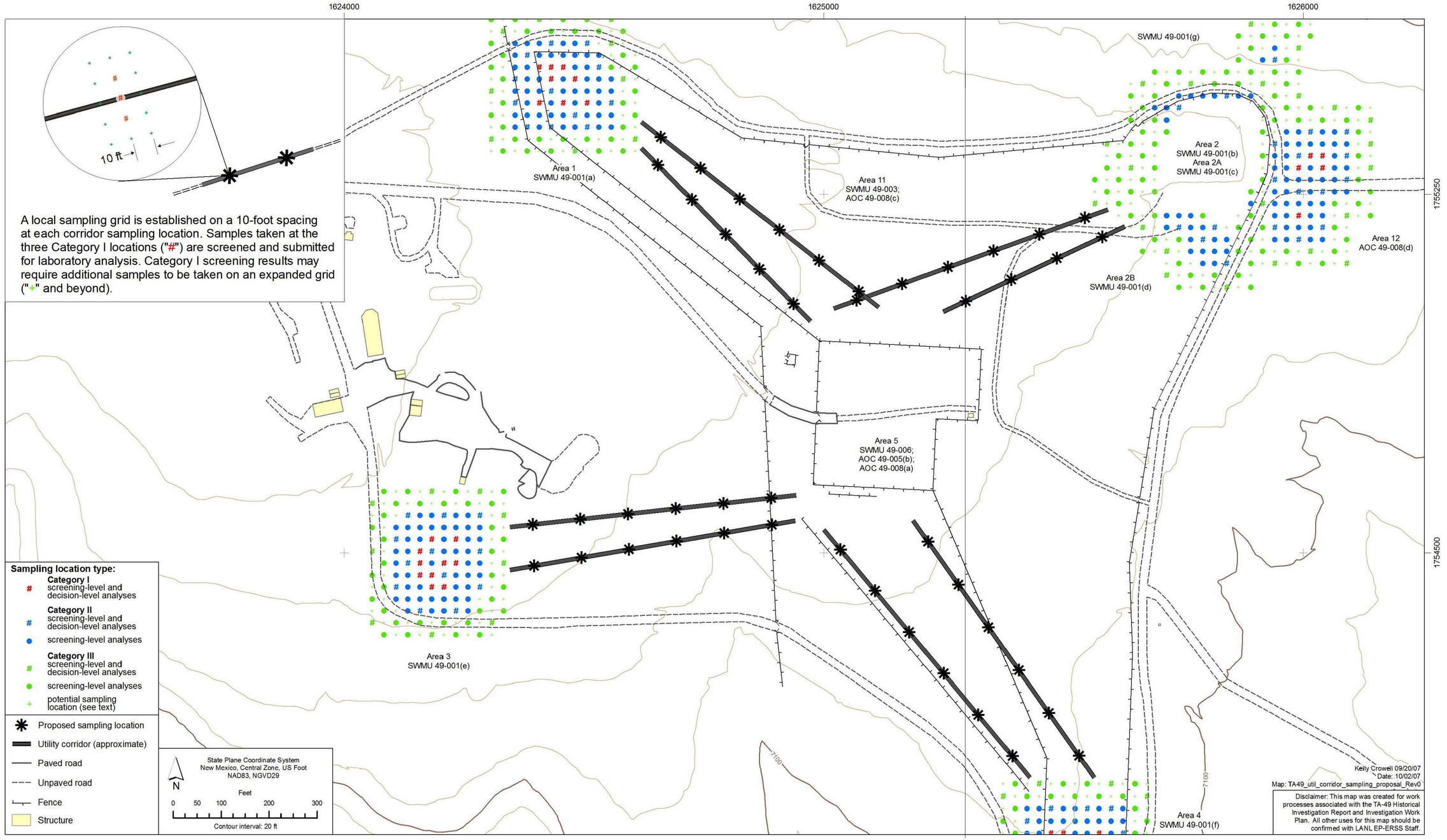


Figure 4.3-6 Overland corridor proposed surface sampling locations

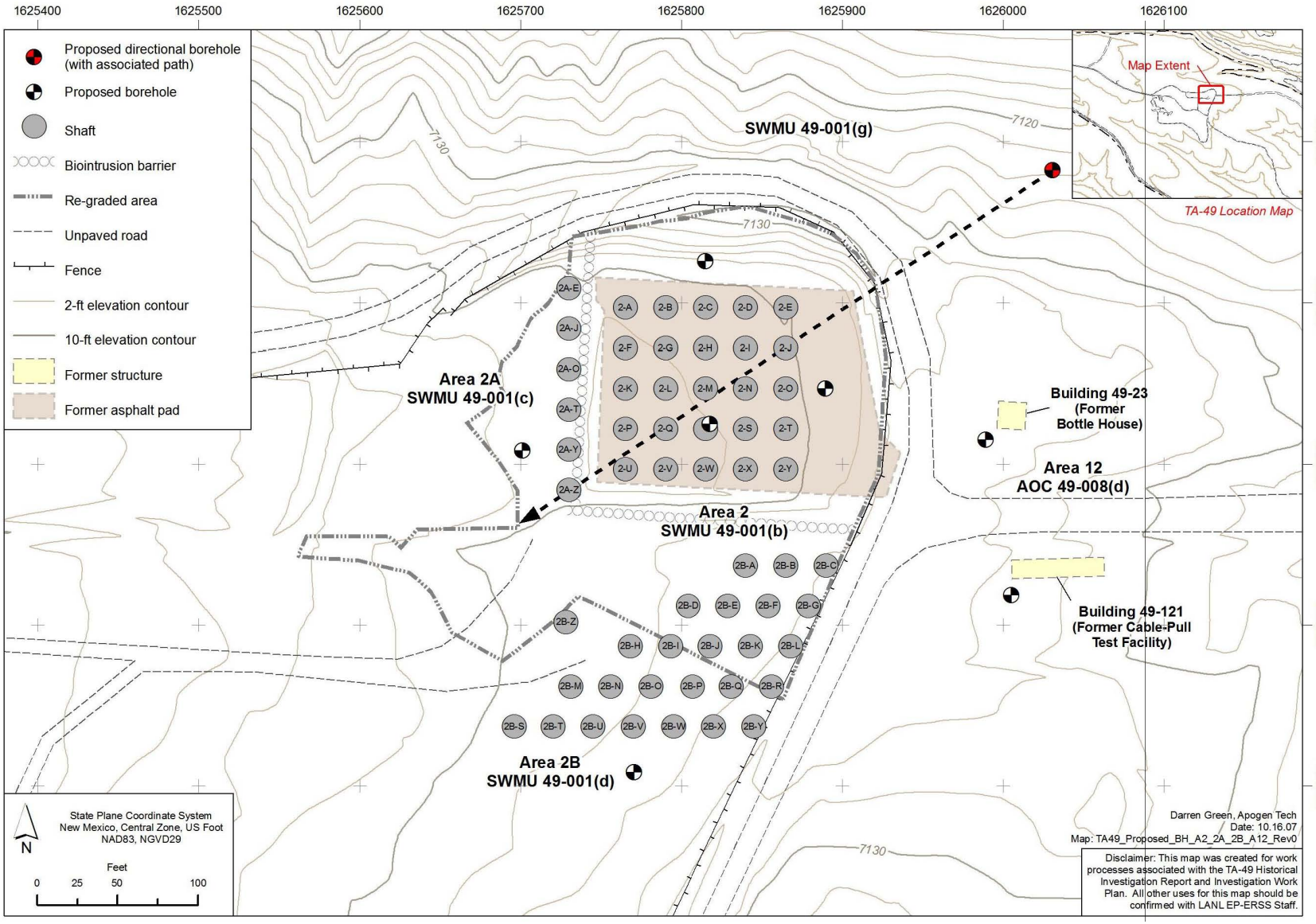


Figure 4.4-1 Areas 2, 2A, 2B, and 12: SWMU 49-001(b), SWMU 49-001(c), SWMU 49-001(d) [MDA AB] and AOC 49-008(d) proposed borehole locations

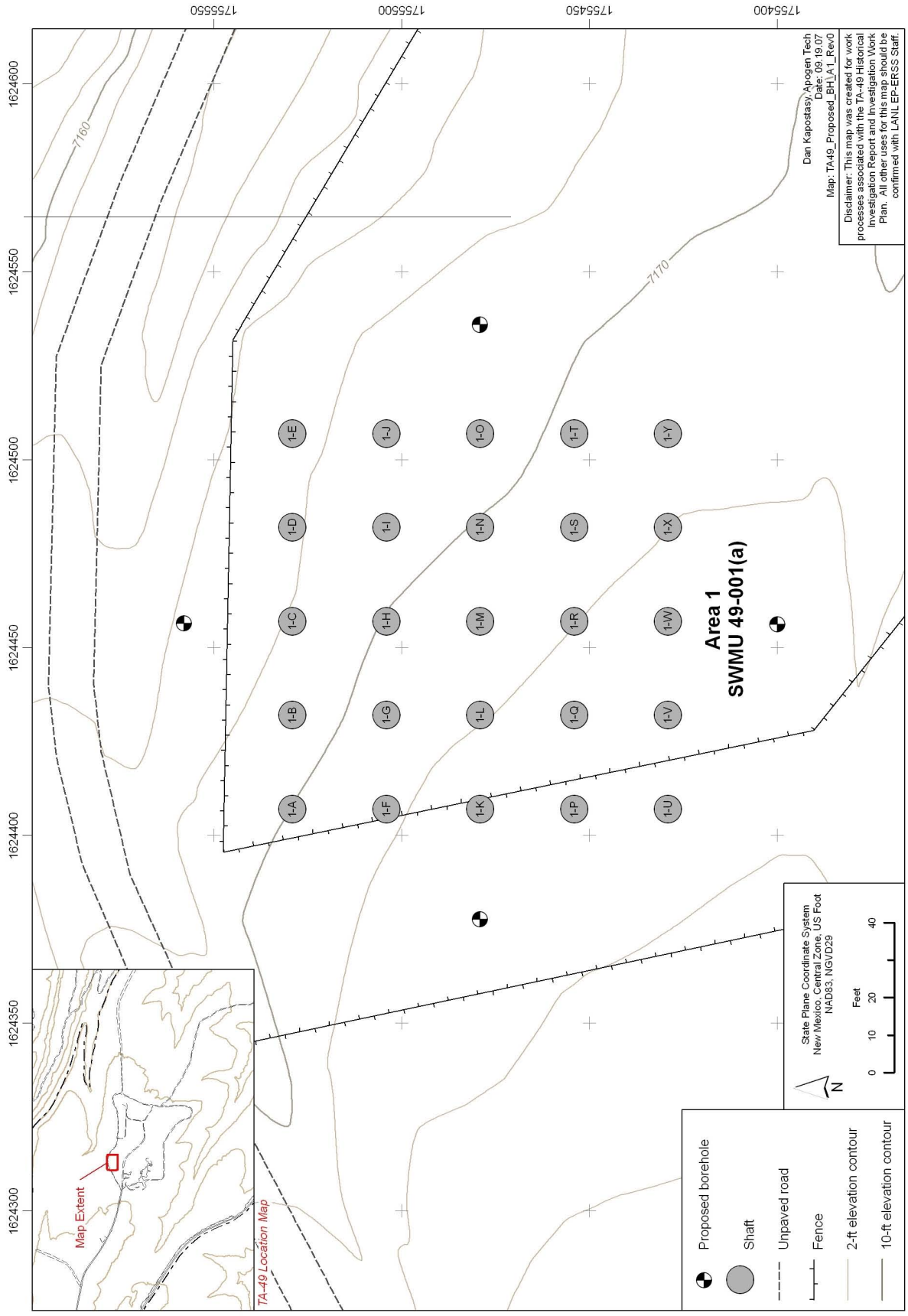


Figure 4.4-2 Area 1: SWMU 49-001(a) proposed borehole locations

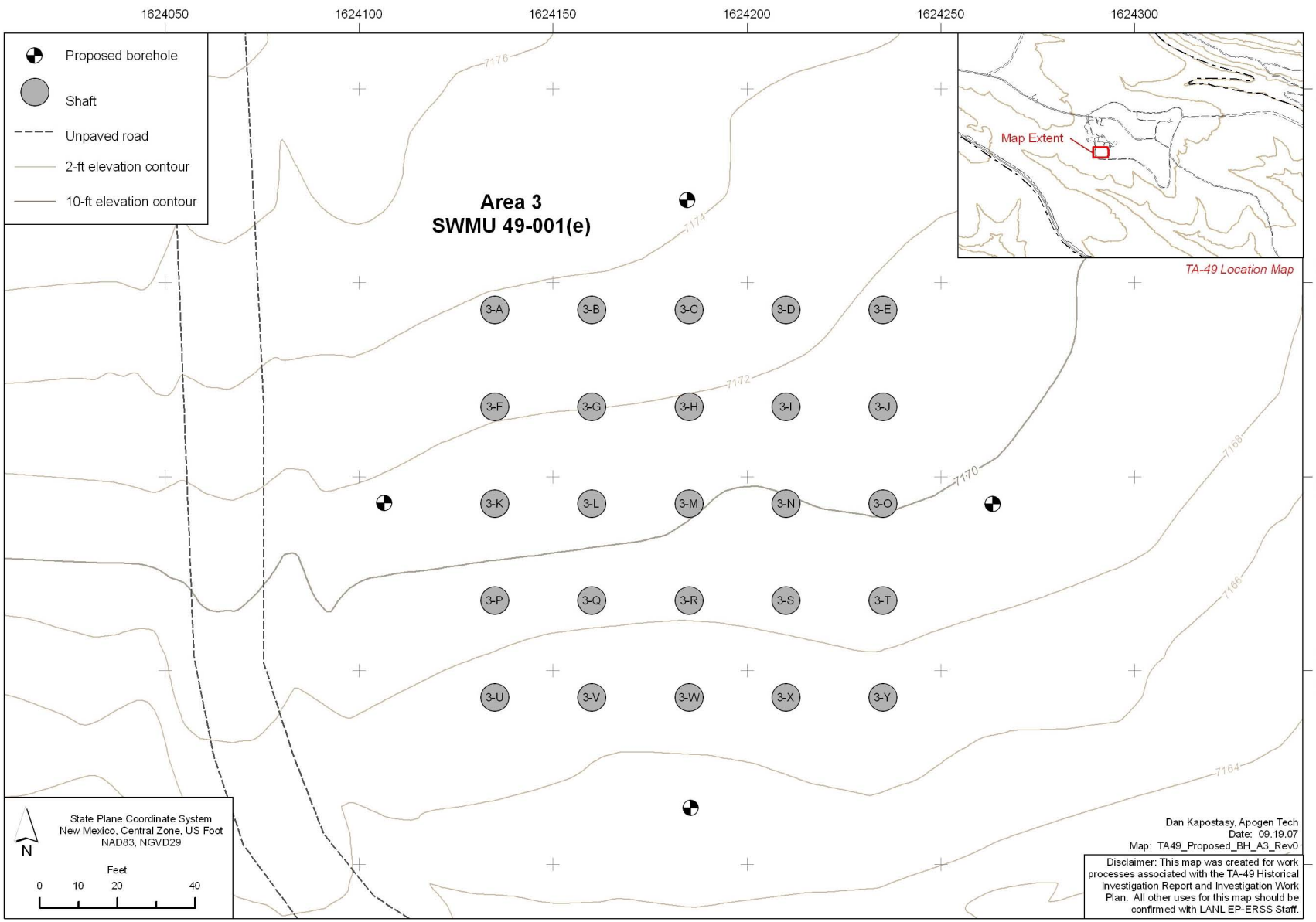


Figure 4.4-3 Area 3: SWMU 49-001(e) proposed borehole locations

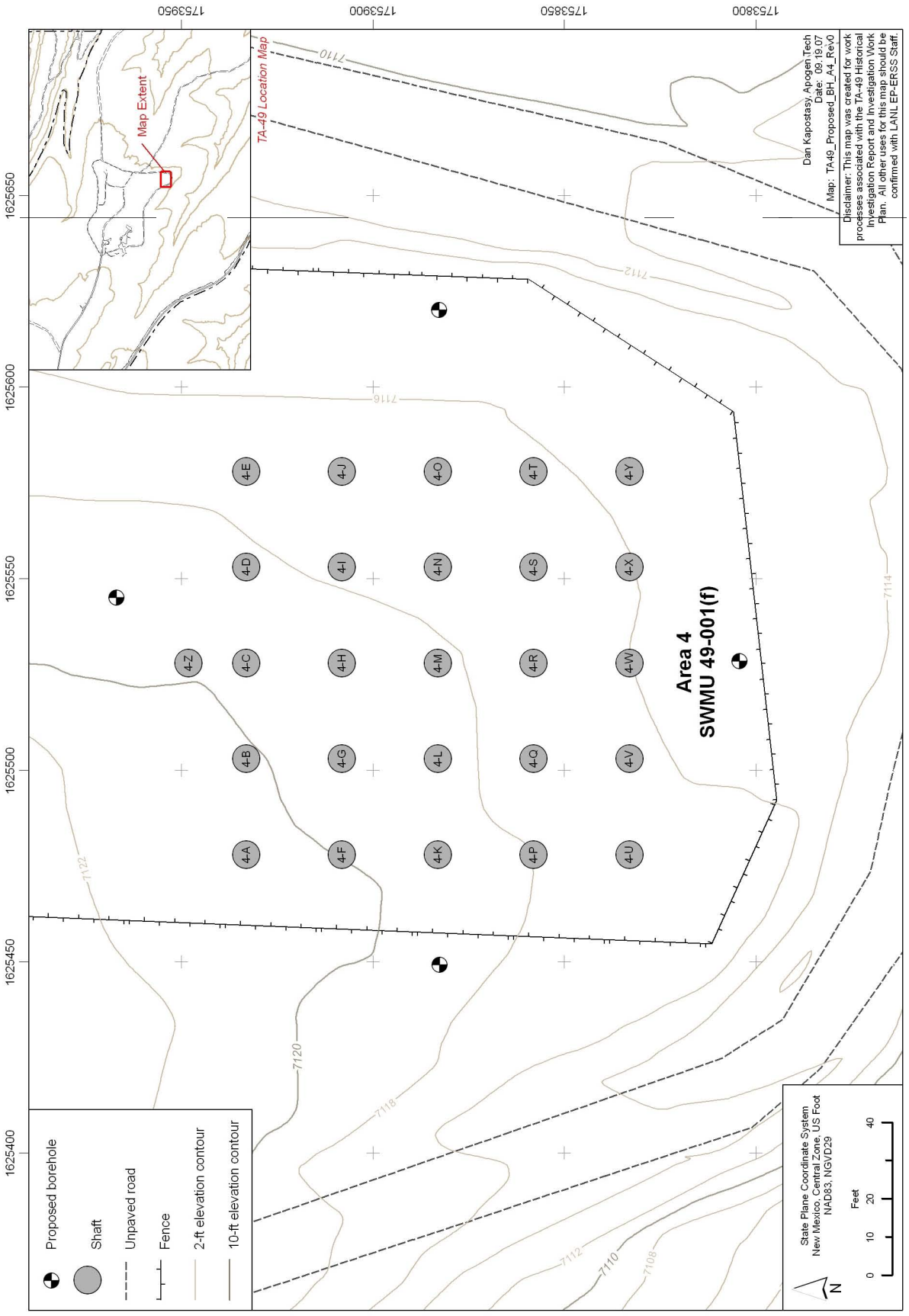


Figure 4.4-4 Area 4: SWMU 49-001(f) proposed borehole locations

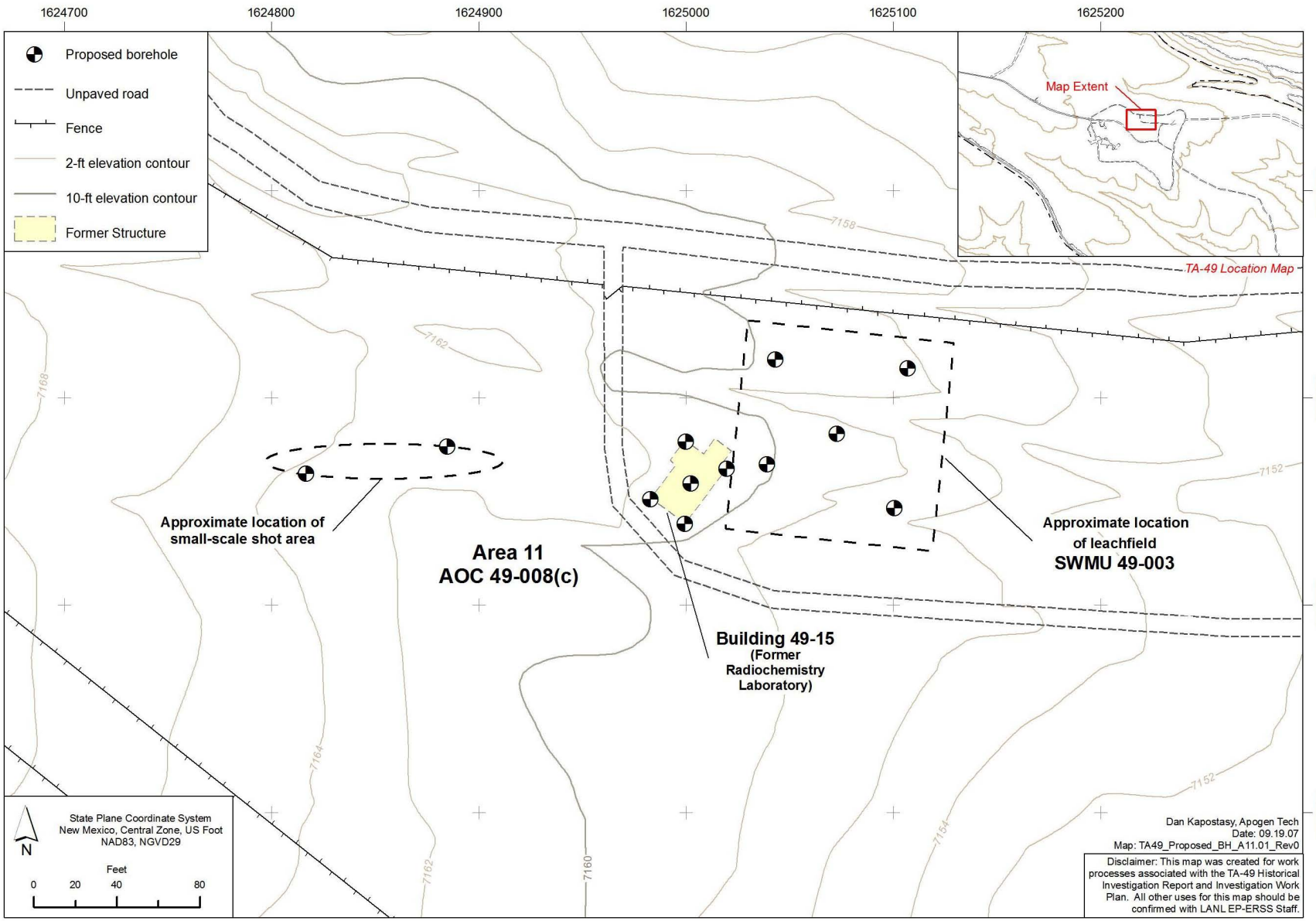


Figure 4.4-5 Area 11: SWMU 49-003, AOC 49-008(c), and the small-scale shot area proposed borehole locations

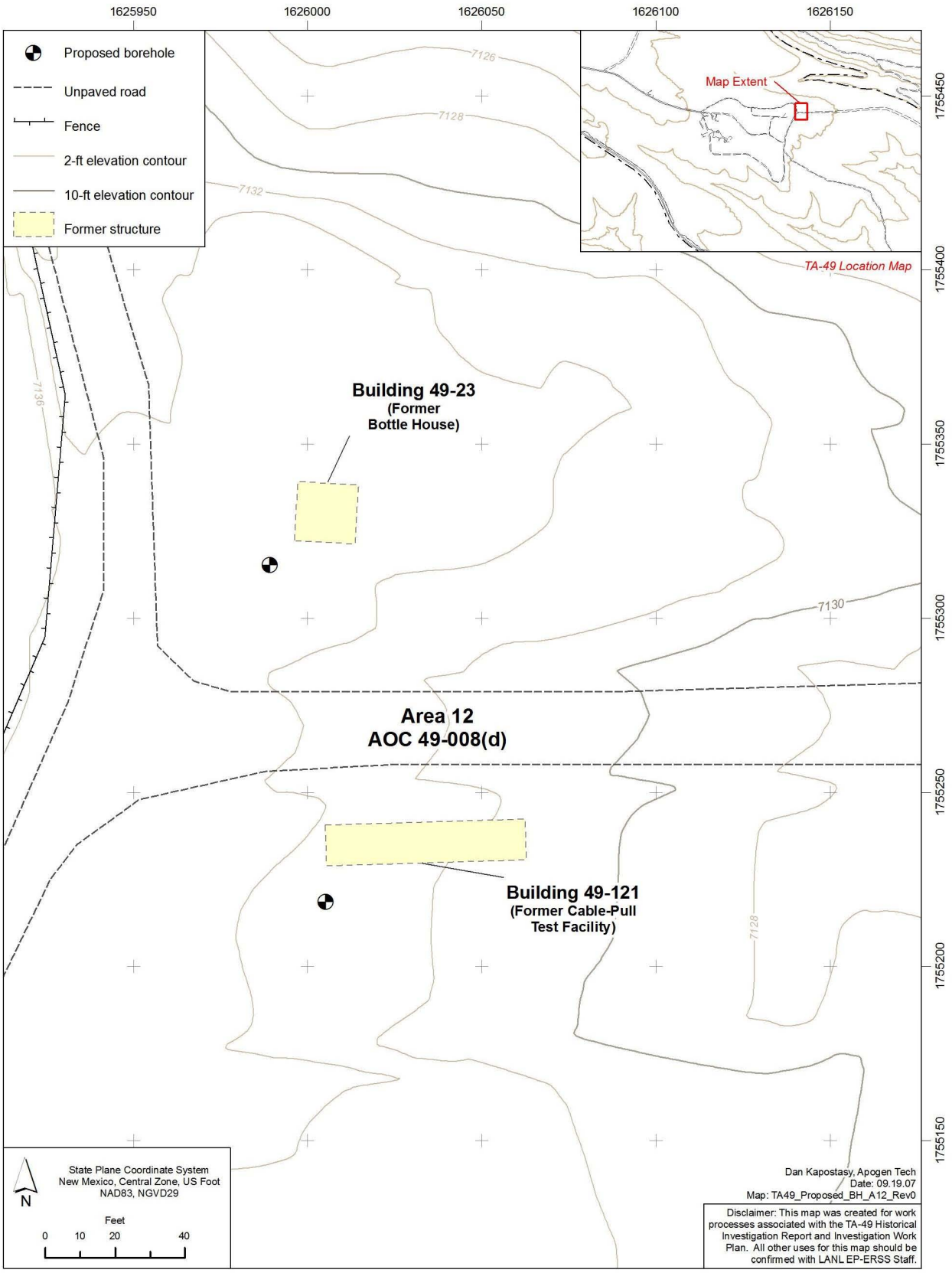


Figure 4.4-6 Area 12: AOC 49-008(d) proposed borehole locations

Table 1.1-1
List of SWMUs and AOCs inside the TA-49 NES Boundary

SWMU/AOC	Description	Comment	Proposed Activity	Reference/Location
SWMU 49-001(a)	Area 1, experimental shafts	This site is included in both the HIR and investigation work plan.	Investigation sampling	Investigation work plan sections 2.4 and 4.4.2
SWMU 49-001(b)	Area 2, experimental shafts	This site is included in both the HIR and investigation work plan.	Investigation sampling	Investigation work plan sections 2.5, 2.5.1, and 4.4.1
SWMU 49-001(c)	Area 2A, experimental shafts	This site is included in both the HIR and investigation work plan.	Investigation sampling	Investigation work plan, sections 2.5, 2.5.1.4, 2.5.2, and 4.4.1
SWMU 49-001(d)	Area 2B, experimental shafts	This site is included in both the HIR and investigation work plan.	Investigation sampling	Investigation work plan, sections 2.5, 2.5.1.4, 2.5.3, and 4.4.1
SWMU 49-001(e)	Area 3, experimental shafts	This site is included in both the HIR and investigation work plan.	Investigation sampling	Investigation work plan sections 2.6 and 4.4.2
SWMU 49-001(f)	Area 4, experimental shafts	This site is included in both the HIR and investigation work plan.	Investigation sampling	Investigation work plan sections 2.7 and 4.4.2
SWMU 49-001(g)	Contaminated surface soil resulting from Area 2 historical operations	This site is included in both the HIR and investigation work plan.	Surface investigation sampling	Investigation work plan, sections 2.5 and 2.5.4
SWMU 49-003	Area 11, leach field and associated drainlines	This site is contained entirely within the boundaries of AOC 49-008(c), which is deferred per Table IV-2 of the Consent Order. Therefore, the investigation of the surface soil contamination for SWMU 49-003 is also deferred as part of AOC 49-008(c). However, an investigation of subsurface contamination is proposed. This site is included in both the HIR and investigation work plan.	Subsurface investigation sampling	Investigation work plan sections 2.8, 2.8.1, 2.8.2, 4.3.1, 4.4.3, and 4.4.8
AOC 49-008(c)	Area 11, soil contamination resulting from historical operations	This site is included in both the HIR and investigation work plan. AOC 49-008(c) is deferred as specified in the Consent Order.	Subsurface investigation sampling	Investigation work plan sections 2.9, 4.3, and 4.4.4
AOC 49-008(d)	Area 12, Bottle House and CPTF	This site is included in both the HIR and investigation work plan.	Investigation sampling	Investigation work plan sections 2.5.1.2, 2.10, and 4.4.5
AOC 49-009	Area 11, suspected underground fuel tank	This site has been approved for NFA by EPA.	None	EPA 2005, 088464; investigation work plan section 2.9.4

Table 2.2-1
TA-49 Borehole Details

Well/ Borehole	Year Drilled	Elevation (ft)	Depth (ft)	Water Level Completion (ft)	Diam. (in.)	Construction Details	Location Northing	Location Easting	Logs[a]	Status
DT-5P	1959	7144	692	Dry	Unknown	na[b]	1754804 N	1625442 E	Geologic only	Grouted and abandoned
DT-5	1959	7143	927[c]	Dry	8	Cased from 0 to 180 ft; Open from 180 to 962 ft	1754842 N	1625310 E	IND, GRN, TEMP	Grouted and abandoned
DT-5A	1959	7144	1821	1173	12	Cased to 1821 ft; pump equipped	1754789 N	1625310 E	LL, IND, ML, SL, GRN, TEMP	Open, sampled quarterly
DT-9	1960	6935	1501	1103	12	Cased to 1501 ft; pump equipped	1751498 N	1628993 E	IND, GRN, SL, TEMP, LL	Open, sampled quarterly
DT-10	1960	7020	1409	1085	12	Cased to 1409 ft; pump equipped	1754448 N	1628994 E	IND, GRN, TEMP, SL	Open, sampled quarterly
CH-1	1959	7170	501	Dry	2	Cased to 500 ft	1755478 N	1624469 E	GR	Open
CH-2	1959	7137	507	Dry	2	Cased to 507 ft., grouted and abandoned	1755344 N	1625826 E	EL, GRN, TEMP	Grouted and abandoned
CH-3	1960	7170	300	Dry	2	Cased from 10 to 300 ft	1754493 N	1624196 E	GR	Open
CH-4	1960	7116	303	Dry	2	Cased to 303 ft	1753898 N	1625537 E	GR	Open
Alpha	1960	7125	189	Dry	24	Cased from 0 to 7 ft, open from 7 to 189 ft	1754807 N	1625769 E	IND, GRN, VL	Grouted and abandoned
Beta	1960	6801	180	Dry	24	Cased from 0 to 13 ft., open from 13 to 180 ft	83+63 S	91+89 E	VL	Open
Gamma	1960	6870	54	Dry	4	Cased from 0 to 8 ft., open from 8 to 54 ft	1752630 N	1626278 E	Geologic only	Grouted and abandoned
TH-1	1980	7135	123	Dry	5	Casing at surface only	1755262 N	1625944 E	GRN	Open
TH-2	1980	7120	123	Dry	5	Casing at surface only	1755507 N	1625802 E	GRN	Open
TH-3	1980	7144	123	Dry	5	Casing at surface only	1755360 N	1625739 E	GRN	Open

Table 2.2-1 (continued)

Well/ Borehole	Year Drilled	Elevation (ft)	Depth (ft)	Water Level Completion (ft)	Diam. (in.)	Construction Details	Location Northing	Location Easting	Logs	Status
TH-4	1980	7143	123	Dry	5	Casing at surface only	1755162 N	1625644 E	GRN	Open
TH-5	1980	7135	123	Dry	5	Casing at surface only	1755132 N	1625833 E	GRN	Open
2A-O	1980	7154	74	Dry	2	Casing to 56 ft; collapsed below 56 ft	1755360 N	1625730 E	GRN	Open
2A-Y	1980	7155	80	Dry	2	Casing to 29 ft; collapsed below 29 ft	1755312 N	1625727 E	GRN	Open
2B-Y	1980	7149	80	Dry	2	Casing to 30 ft; collapsed below 30 ft	1755134 N	1625839 E	GRN	Open
49-02901	1998	7134	700	Dry	8	Casing at surface only	1755209 N	1625985 E	INAA, QXRD, XRF	Open
49-02906	1998	7142	150	Dry	8	Double cased	1755319N	1625814 E	Geologic only	Casing removed and backfilled
49-02907	1998	7141	150	Dry	8	Double cased	1755369 N	1625790 E	Geologic only	Casing removed and backfilled
49-10046	2000	7165	15	Dry	2	Casing to 15 ft	1755327 N	1625813 E	GRN	Open
49-10047	2000	7160	15	Dry	2	Casing to 15 ft	1755368 N	1625803 E	GRN	Open
49-10048	2000	7159	15	Dry	2	Casing to 15 ft	1755355 N	1625883 E	GRN	Open

[a] Geologic logs are available for all holes. Other borehole logs that are available include EL (Electrical), GR (Gamma Ray), GRN (Gamma Ray Neutron), INAA (Instrumental Neutron Activation Analyses), IND (Induction/Electrical and Spontaneous Potential), LL (Lateral), ML (Microlog-Caliper), QXRD (Quantitative X-Ray Diffraction), SL (Sonic), TEMP (Temperature), VL (Video), XRF (X-Ray Fluorescence).

[b] na = Not available.

[c] Weir and Purtymun 1962, 011890; Purtymun 1995, 045344 lists borehole depth at 962 ft.

Table 2.3-1
Human Health Industrial Soil Screening Levels

Chemical	Industrial Soil Screening Level[a]	End Point[b]
Inorganic Chemicals (mg/kg)		
Aluminum	100,000[c]	max
Antimony	454	nc
Arsenic	17.7	ca
Barium	100,000[c]	max
Beryllium	2250[a]	nc
Boron	100,000[c]	max
Cadmium	564	nc
Chromium (total)	100,000[c]	max
Chromium (hexavalent)	3400	nc
Cobalt	20,500	nc
Copper	45,400	nc
Cyanide (total)	13,700	nc
Iron	100,000[c]	max
Lead	800	IEBUK[d]
Manganese	48,400	nc
Mercury	100,000[c]	max
Nickel	22,700	nc
Nitrate-Nitrite as N	100,000[c]	max
Perchlorate	795[e]	nc
Selenium	5680	nc
Silver	5680	nc
Thallium	74.9	nc
Titanium	100,000[c,f]	max
Uranium	200[f]	nc
Vanadium	1140	nc
Zinc	100,000[c]	max
Organic Chemicals (mg/kg)		
Acenaphthene	33,500	nc
Acetone	100,000	max
Acrolein	0.752	nc
Aldrin	1.12	ca
Anthracene	100,000	max
Benzene	25.8	ca
Benzo(a)anthracene	23.4	ca
Benzo(a)pyrene	2.34	ca

Table 1.1-2 (continued)

Chemical	Industrial Soil Screening Level[a]	End Point[b]
Benzo(b)fluoranthene	23.4	ca
Benzo(k)fluoranthene	234	ca
a-BHC (HCH)	3.99	ca
b-BHC (HCH)	14	ca
g-BHC	19.3	ca
Bis(2-chloroethyl) ether	7.45	ca
Bis(2-ethylhexyl) phthalate	1370	ca
Bromobenzene	137	nc
Bromodichloromethane	37.2	ca
Bromomethane	32.8	nc
2-Butanone	48,700	sat
tert-Butyl methyl ether (MTBE)	984	ca
n-Butylbenzene	62.1	sat
tert-Butylbenzene	106	sat
Carbon disulfide	460	sat
Carbon tetrachloride	8.64	ca
Chlordane	71.9	ca
Chlorobenzene	245	sat
Chloroethane	154	ca
Chloroform	9.59	ca
Chloromethane	53.4	ca
b-Chloronaphthalene	27800	nc
2-Chlorophenol	885	nc
o-Chlorotoluene	202	sat
Chrysene	2310	ca
Cumene (isopropylbenzene)	389	sat
DDD	111	ca
DDE	78.1	ca
DDT	78.1	ca
Dibenz(a,h)anthracene	2.34	ca
Dibenzofuran	1620	nc
1,2-Dibromo-3-chloropropane	9.68	nc
Dibromochloromethane	39.5	ca
1,2-Dibromoethane	1.31	ca
1,2-Dichlorobenzene	37.4	sat
1,3-Dichlorobenzene	37.4	sat
1,4-Dichlorobenzene	103	ca
3,3-Dichlorobenzidine	42.6	ca
Dichlorodifluoromethane	211	sat

Table 1.1-2 (continued)

Chemical	Industrial Soil Screening Level[a]	End Point[b]
1,1-Dichloroethane	1420	sat
1,2-Dichloroethane	15.2	ca
cis-1,2-Dichloroethene	300	nc
trans-1,2-Dichloroethene	429	nc
1,1-Dichloroethene	777	nc
2,4-Dichlorophenol	2050	nc
1,2-Dichloropropane	14.9	ca
Dieldrin	1.2	ca
Diethyl phthalate	100,000	max
Dimethyl phthalate	100,000	max
2,4-Dimethylphenol	13700	nc
4,6-Dinitro-o-cresol	68.4	nc
2,4-Dinitrophenol	1370	nc
2,4-Dinitrotoluene	1370	nc
Endrin	205	nc
Ethyl chloride	154	ca
Ethyl methacrylate	52.7	sat
Ethylbenzene	128	sat
Fluoranthene	24,400	nc
Fluorene	26,500	nc
Heptachlor	4.26	ca
Hexachlorobenzene	12	ca
Hexachloro-1,3-butadiene	137	nc
Hexachlorocyclopentadiene	4100	nc
Hexachloroethane	684	nc
HMX	34,200	nc
Indeno(1,2,3-c,d)pyrene	23.4	ca
Isophorone	20,200	ca
Methacrylonitrile	22	nc
Methyl methacrylate	2920	sat
Methylene bromide	785	nc
Methylene chloride	490	ca
Naphthalene	300	nc
Nitrobenzene	147	nc
N-Nitrosodimethylamine	0.376	ca
N-Nitrosodiphenylamine	3910	ca
m-Nitrotoluene	569	sat
o-Nitrotoluene	32.3	ca
p-Nitrotoluene	437	ca

Table 1.1-2 (continued)

Chemical	Industrial Soil Screening Level[a]	End Point[b]
Pentachlorophenol	100	ca
Phenanthrene	20,500	nc
Phenol	100,000	max
Aroclor-1016	41.3	nc
Aroclor-1221	8.26	ca
Aroclor-1232	8.26	ca
Aroclor-1242	8.26	ca
Aroclor-1248	8.26	ca
Aroclor-1254	8.26	ca
Aroclor-1260	8.26	ca
n-Propylbenzene	62.1	sat
Pyrene	30,900	nc
RDX	174	ca
Styrene	100	sat
1,1,1,2-Tetrachloroethane	114	ca
1,1,2,2-Tetrachloroethane	14.6	ca
Tetrachloroethene	31.6	ca
Toluene	252	sat
Toxaphene	17.4	ca
Tribromomethane	2460	ca
1,1,2-Trichloro-1,2,2-trifluoroethane	3280	sat
1,2,4-Trichlorobenzene	269	nc
1,1,1-Trichloroethane	563	sat
1,1,2-Trichloroethane	30.2	ca
Trichloroethylene	1.56	ca
Trichlorofluoromethane	983	sat
2,4,5-Trichlorophenol	68,400	nc
2,4,6-Trichlorophenol	68.4	nc
1,2,3-Trichloropropane	0.209	ca
1,2,4-Trimethylbenzene	213	nc
1,3,5-Trimethylbenzene	69.2	sat
2,4,6-Trinitrotoluene	342	nc
Vinyl acetate	3680	sat
Vinyl chloride (adult)	14	ca
o-Xylene	99.5	sat
Xylenes	82	sat

Table 1.1-2 (continued)

Chemical	Industrial Soil Screening Level[a]	End Point[b]
Radionuclides (pCi/g)p		
Americium-241	180	—
Cesium-137	23	—
Plutonium-238	240	—
Plutonium-239	210	—
Strontium-90	1900	—
Tritium	440,000	—
Uranium-234	1500	—
Uranium-235	87	—
Uranium-238	430	—

[a] SSLs are from the "Technical Background Document for Development of Soil Screening Levels (NMED 2006, 092513).

[b] max = Maximum, sat = saturated, nc = noncarcinogen, c = carcinogen, en = essential nutrient.

[c] SSL exceeds 105 mg/kg.

[d] IEUBK = Integrated exposure uptake biokinetic.

[e] SSL from 2006 Region 6 Risk-Based Human Health Screening Values (http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm).

[f] SSL from 2006 Region 9 Preliminary Remediation Goals (www.epa.gov/region09/waste/sfund/prg).

Table 2.4-1
Summary of Inorganic Chemicals above BVs from Area 1: SWMU 49-001(a)

Sample ID	Location ID	Depth (ft)	Media	Mercury	Thallium	Uranium	Zinc
Soil BV				**0.1**	**0.73**	**1.82**	**48.8**
0549-95-0191	49-01035	0.00–0.50	Soil	—*	1.2 (U)	—	—
0549-95-0194	49-01038	0.00–0.50	Soil	—	1.3 (U)	8.21	51.2
0549-95-0196	49-01040	0.00–0.50	Soil	0.11 (U)	1.4 (U)	3.07	—
0549-95-0199	49-01043	0.00–0.50	Soil	—	1.3 (U)	2.03	—
0549-95-0202	49-01046	0.00–0.50	Soil	—	1.3 (U)	9.3	—
0549-95-0203	49-01047	0.00–0.50	Soil	—	1.3 (U)	2.78	—
0549-95-0204	49-01048	0.00–0.50	Soil	—	1.3 (U)	3.56	—
0549-95-0207	49-01051	0.00–0.50	Soil	0.11 (U)	1.4 (U)	1.95	—
0549-95-0209	49-01053	0.00–0.50	Soil	0.11 (U)	1.3 (U)	—	—
0549-95-0210	49-01054	0.00–0.50	Soil	—	1.4 (U)	1.87	—

Notes: All values in mg/kg. See Appendix A for data qualifier definitions. Decision-level data are summarized in this table.
*— = Not detected above BV.

Table 2.4-2
Summary of Radionuclides Detected above BVs from Area 1: SWMU 49-001(a)

Sample ID	Location ID	Depth (ft)	Media	Plutonium-239/240
Soil BV				**0.054**
0549-95-0210	49-01054	0.00–0.50	Soil	0.092

Notes: All values in pCi/g. Decision-level data are summarized in this table.

Table 2.5-1
Summary of Radionuclides Detected or Detected above BVs at Area 2 SWMU 49-001(b)

Sample ID	Location ID	Depth (ft)	Media	Americium-241	Plutonium-238	Plutonium-239/240
Soil BV				**0.013**	**0.023**	**0.054**
Qbt 2,3,4 BV				**na**[a]	**na**	**na**
0549-98-0001	49-02902	4.40–4.80	Fill	—[b]	—	0.026
MD49-98-0073	49-02906	40.30–40.50	Qbt 4	—	0.209	—
MD49-98-0074	49-02906	53.40–53.50	Qbt 4	—	0.042	—
MD49-98-0075	49-02906	67.20–67.50	Qbt 4	0.042	0.124	—
MD49-98-0077	49-02906	85.00–86.50	Qbt 4	—	0.052	—
MD49-98-0078	49-02906	91.50–91.80	Qbt 3	—	—	0.05
MD49-98-0083	49-02906	147.20–148.00	Qbt 3	—	0.042	—
MD49-98-0098	49-02907	138.70–138.90	Qbt 3	0.034	—	—

Note: All values in pCi/g. Decision-level data are summarized in this table.

[a] na = Not available.

[b] — = Not detected above BV.

Table 2.5-2
Summary of Inorganic Chemical Screening-Level Results at Area 2: SWMU 49-001(b)

Sample ID	Location ID	Depth	Media	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Uranium	Vanadium	Zinc
Soil BV				**29200**	**0.83**	**8.17**	**295**	**1.83**	**0.4**	**6120**	**19.3**	**8.64**	**14.7**	**21500**	**22.3**	**4610**	**671**	**0.1**	**15.4**	**3460**	**1.52**	**1**	**915**	**0.73**	**1.82**	**39.6**	**48.8**
Qbt 2,3,4 BV				**7340**	**0.5**	**2.79**	**46**	**1.21**	**1.63**	**2200**	**7.14**	**3.14**	**4.66**	**14500**	**11.2**	**1690**	**482**	**0.1**	**6.58**	**3500**	**0.3**	**1**	**2770**	**1.1**	**2.4**	**17**	**63.5**
AAA1750	49-02001	0–0.5	Soil	—[a]	<11.2[b]	0.96	58.4	0.35	1.1	—	4.1	—	—	—	6.7	—	—	<0.02	5.1	—	<0.6	<1.4	—	<1	1.9	—	—
AAA1751	49-02004	0–0.5	Soil	—	<11.2	1.2	45.5	0.28	0.99	—	3.6	—	—	—	7.7	—	—	<0.02	5.2	—	<0.6	<1.4	—	<1	1.7	—	—
AAA1752	49-02006	0–0.5	Soil	—	<11.2	1.5	105	0.53	1.1	—	5.8	—	—	—	9.5	—	—	<0.02	6.4	—	<0.6	<1.4	—	<1	3.2	—	—
AAA1753	49-02007	0–0.5	Soil	—	<11.2	1.1	50.8	0.33	0.84	—	4.2	—	—	—	6.4	—	—	<0.02	5.8	—	<0.6	<1.4	—	<1	1.6	—	—
AAA1755	49-02008	0–0.5	Soil	—	<11.2	1.3	47	0.47	0.85	—	5.1	—	—	—	3.6	—	—	<0.02	5.1	—	<0.6	<1.4	—	<1	2.5	—	—
AAA1756	49-02009	0–0.5	Soil	—	<11.2	1.5	86.1	0.3	<0.8	—	5.6	—	—	—	6	—	—	<0.02	4.6	—	<0.6	<1.4	—	<1	2.2	—	—
AAA1757	49-02010	0–0.5	Soil	—	<11.2	1.3	77.2	0.5	1.1	—	5.4	—	—	—	7.9	—	—	<0.02	6.1	—	<0.6	<1.4	—	<1	2.9	—	—
AAA1758	49-02012	0–0.5	Soil	—	<11.2	1.5	46.2	0.35	<0.8	—	2.6	—	—	—	6.7	—	—	<0.02	4	—	<0.6	<1.4	—	<1	1.8	—	—
AAA1761	49-02018	0–0.5	Soil	—	<11.2	1.5	105	0.53	0.81	—	5.7	—	—	—	11.6	—	—	<0.02	6.8	—	<0.6	<1.4	—	<1	2.8	—	—
AAA1762	49-02020	0–0.5	Soil	—	<11.2	0.82	61.9	0.38	<0.8	—	3.9	—	—	—	8.9	—	—	<0.02	4	—	<0.6	<1.4	—	<1	1.8	—	—
AAA1764	49-02022	0–0.5	Soil	—	<11.2	1.3	60.1	0.3	0.82	—	3.3	—	—	—	8.4	—	—	<0.02	5.2	—	<0.6	<1.4	—	<1	2	—	—
AAA1769	49-02030	0–0.5	Soil	—	<11.2	1.3	140	0.5	<0.8	—	6.8	—	—	—	7	—	—	<0.02	4.9	—	<0.6	<1.4	—	<1	1.8	—	—
AAA1770	49-02032	0–0.5	Soil	—	<11.2	1.3	119	0.72	<0.8	—	6	—	—	—	13.1	—	—	<0.02	5.9	—	<0.6	<1.4	—	<1	2.1	—	—
AAA1772	49-02034	0–0.5	Soil	—	<11.2	1.4	115	0.72	1	—	5.8	—	—	—	9.8	—	—	<0.02	8.4	—	<0.6	<1.4	—	<1	2.1	—	—
AAA4642	49-02902	3.2–3.5	Fill	—	—	3.8	228 (J)	—	1.5	—	8.7	—	—	—	14.8	—	—	<0.03	—	—	<0.91	<0.75	—	—	1.799 (J)	—	—
AAB7452	49-02902	3.2–3.5	Fill	18600	<0.32	3.3	235	1.2	<0.07	2480	10.1	<6.7	<3.7	14500	15.2	2530	522	<0.11	<9.5	3060	<0.63	<0.12	<30.2	<0.75	—	27.5	36
AAA4576	49-02902	7.4–7.7	Fill	—	—	3.2	244 (J)	—	<0.87		5.3	—	—	—	—	—	—	<0.03	—	—	<1.1	<0.77	—	—	2.582 (J)	—	—
AAB7451	49-02902	7.4–7.7	Fill	19500	<0.33	2.7	247	1.3	<0.08	3440	28	<3.8	<2.6	10900	10.7	2170	206	<0.12	11.6	2110	<0.65	<0.13	<183	<0.78	—	15.4	22.9
AAA4638	49-02903	2.1–2.7	Soil	—	<5.4	2.8	260	1.4 (J)	1.6	—	9.2	—	—	—	13.8	—	—	<0.03	<10	—	<0.8	<0.72	—	<0.51	1.821 (J)	—	—
AAA4574	49-02903	6.2–7	Soil	—	<5.5	3.4	287	1.7 (J)	2	—	9.6	—	—	—	15.7	—	—	<0.03	11.7	—	<0.93	<0.72	—	<0.52	1.177 (J)	—	—
AAA4641	49-02904	2.4–3	Soil	—	<5.1	3.1	205	1.2 (J)	1.8	—	8.5	—	—	—	14.9	—	—	<0.03	10.4	—	<0.72	<0.67	—	<0.48	1.802 (J)	—	—
AAA4575	49-02904	6.4–7	Soil	—	<6.5	<1.6	181	<0.71	<0.89	—	4.1	—	—	—	4	—	—	<0.04	<5.4	—	<0.92	<0.86	—	<0.62	3.07 (J)	—	—
AAA4640	49-02905	2.5–3	Soil	—	<5.3	<1	65.1	<0.6	<0.72	—	3.9	—	—	—	3.5	—	—	<0.03	<3.9	—	<0.75	<0.7	—	<0.5	0.664 (J)	—	—
AAA4581	49-02905	6.2–6.7	Soil	—	<7.4	<1.7	273	<0.59	<1.4	—	4.4	—	—	—	4.3	—	—	<0.04	<7.3	—	<1	<0.98	—	<0.7	2.071 (J)	—	—
AAA4624	49-02906	5.2–5.7	Qbt 4	—	<5.2	<2.5	237	<1.1	1.3	—	8.3	—	—	—	14.4	—	—	<0.03	<8.5	—	<0.74	<0.69	—	<0.49	1.909 (J)	—	—
AAA4625	49-02906	15.9–16.5	Qbt 4	—	<5.2	<1	<20.6	<0.49	<0.72	—	<1.7	—	—	—	1.6	—	—	<0.03	<4	—	<0.74	<0.69	—	<0.49	0.863 (J)	—	—
AAA4631	49-02906	28.2–28.6	Qbt 4	—	<4.9	<0.75	<14.4	<0.44	<0.67	—	3	—	—	—	2	—	—	<0.03	<3.6	—	<0.69	<0.64	—	<0.46	0.665 (J)	—	—
AAA4630	49-02906	38.3–38.8	Qbt 4	—	<4.7	2.5	<15	<0.57	<0.64	—	3.1	—	—	—	1.5	—	—	<0.03	<3.5	—	<0.66	<0.62	—	<0.44	0.454 (J)	—	—
AAA4627	49-02906	40.5–42.3	Qbt 4	—	<4.7	<2.2	<21.1	<0.51	<0.76	—	2.8	—	—	—	0.8	—	—	<0.03	<3.5	—	<0.66	<0.62	—	<0.44	0.548 (J)	—	—
AAA4622	49-02906	53.5–54	Qbt 4	—	<4.6	<1.1	<21.4	<1	<0.63	—	2.8	—	—	—	1.4	—	—	<0.03	<3.4	—	<0.65	<0.61	—	<0.44	0.428 (J)	—	—
AAA4623	49-02906	67.5–68	Qbt 4	—	<4.4	<0.6	<15.2	<0.46	<0.6	—	2.3	—	—	—	0.91	—	—	<0.03	<3.3	—	<0.62	<0.58	—	<0.42	0.574 (J)	—	—

Table 2.5-2 (continued)

Sample ID	Location ID	Depth	Media	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Uranium	Vanadium	Zinc
Soil BV				**29200**	**0.83**	**8.17**	**295**	**1.83**	**0.4**	**6120**	**19.3**	**8.64**	**14.7**	**21500**	**22.3**	**4610**	**671**	**0.1**	**15.4**	**3460**	**1.52**	**1**	**915**	**0.73**	**1.82**	**39.6**	**48.8**
Qbt 2,3,4 BV				**7340**	**0.5**	**2.79**	**46**	**1.21**	**1.63**	**2200**	**7.14**	**3.14**	**4.66**	**14500**	**11.2**	**1690**	**482**	**0.1**	**6.58**	**3500**	**0.3**	**1**	**2770**	**1.1**	**2.4**	**17**	**63.5**
AAA4628	49-02906	75.5–76.8	Qbt 4	—	<4.4	<0.66	<22.9	<0.44	<0.61	—	<1.9	—	—	—	0.76	—	—	<0.03	<3.3	—	<0.63	<0.59	—	<0.42	0.481 (J)	—	—
AAA4632	49-02906	85–85.5	Qbt 4	—	<4.3	<0.42	<5.6	<0.43	<0.59	—	<1.4	—	—	—	1.1	—	—	<0.03	<3.2	—	<0.61	<0.57	—	<0.41	0.181 (J)	—	—
AAA4637	49-02906	91–91.5	Qbt 4	—	<4.3	<0.41	<7.9	<0.31	<0.59	—	<1.4	—	—	—	5.3	—	—	<0.04	<3.2	—	<0.61	<0.57	—	<0.41	0.202 (J)	—	—
AAA4621	49-02906	107.2–107.7	Qbt 3	—	<4.4	<0.47	<12.3	<0.48	<0.6	—	<1.4	—	—	—	1.4	—	—	<0.03	<3.3	—	<1.6	<0.58	—	<0.41	—	—	—
AAA4635	49-02906	116–117	Qbt 3	—	<4.3	<0.54	<9.3	<0.48	<0.59	—	<1.4	—	—	—	0.89	—	—	<0.03	<3.2	—	<1.6	<0.57	—	<0.41	—	—	—
AAA4633	49-02906	125–126	Qbt 3	—	<4.3	<0.41	<13.4	<0.53	<0.59	—	<1.4	—	—	—	0.62	—	—	<0.03	<3.2	—	<1.6	<0.57	—	<0.41	—	—	—
AAA4636	49-02906	135.2–135.7	Qbt 3	—	<4.4	<0.41	<8.6	<0.51	<0.6	—	<1.4	—	—	—	1.6	—	—	<0.03	<3.3	—	<1.6	<0.58	—	<0.41	—	—	—
AAA4629	49-02906	144.7–145.3	Qbt 3	—	<4.4	<0.78	<5.9	<0.52	<0.6	—	<1.4	—	—	—	5.8	—	—	<0.03	<3.3	—	<1.7	<0.58	—	<0.41	—	—	—
AAA4602	49-02907	5–5.5	Soil	—	<6.6	<2.7	211	<0.72	<0.91	—	5	—	—	—	—	—	—	<0.04	<4.9	—	<0.94	<0.88	—	<0.63	0.546 (J)	—	—
AAA4614	49-02907	14.5–16.5	Qbt 4	—	<5.2	<0.98	<21	<0.71	<0.71	—	<1.7	—	—	—	6.3	—	—	<0.03	<4.1	—	<0.73	<0.68	—	<0.49	0.413 (J)	—	—
AAA4613	49-02907	24.5–25	Qbt 4	—	<5	<0.97	<24.2	1.8 (J)	<0.69	—	3.4	—	—	—	4.8	—	—	<0.03	<5	—	<1.9	<0.66	—	<0.47	0.3 (J)	—	—
AAA4611	49-02907	36.5–37	Qbt 4	—	<4.7	<0.84	<20.5	<0.76	<0.64	—	3.1	—	—	—	3.2	—	—	<0.03	<3.5	—	<1.8	<0.62	—	<0.44	0.333 (J)	—	—
AAA4618	49-02907	47–47.5	Qbt 4	—	<4.3	<0.41	<16	<0.52	<0.59	—	<1.4	—	—	—	3	—	—	<0.03	<3.2	—	<1.6	<0.57	—	<0.41	0.22 (J)	—	—
AAA4606	49-02907	53.5–54.2	Qbt 4	—	<4.5	<0.95	<26.2	<0.86	<0.62	—	<1.6	—	—	—	1.5	—	—	<0.03	<3.4	—	<0.43	<0.6	—	<0.43	0.237 (J)	—	—
AAA4605	49-02907	65.6–66.2	Qbt 4	—	<4.4	<0.42	<17.6	<0.54	<0.6	—	<1.5	—	—	—	<0.42	—	—	<0.03	<3.3	—	<1.7	<0.58	—	<0.42	0.198 (J)	—	—
AAA4603	49-02907	76.5–79	Qbt 4	—	<4.4	<0.71	<10.3	<0.39	<0.6	—	<1.4	—	—	—	0.82	—	—	<0.03	<3.3	—	<1.7	<0.58	—	<0.41	0.141 (J)	—	—
AAA4616	49-02907	84.7–85.2	Qbt 4	—	<4.3	<0.41	<7.9	<0.27	<0.59	—	<1.4	—	—	—	0.68	—	—	<0.03	<3.2	—	<1.6	<0.57	—	<0.41	—	—	—
AAA4609	49-02907	95–95.5	Qbt 3	—	<4.3	<0.41	<7.9	<0.28	<0.59	—	<1.4	—	—	—	0.96	—	—	<0.03	<3.2	—	<1.6	<0.57	—	<0.41	—	—	—
AAA4608	49-02907	106–106.5	Qbt 3	—	<4.4	<0.41	<9.8	<0.28	<0.6	—	<1.4	—	—	—	1.3	—	—	<0.03	<3.3	—	<1.6	<0.58	—	<0.41	—	—	—
AAA4615	49-02907	115.3–115.8	Qbt 3	—	<4.3	<0.54	<6.4	<0.3	<0.59	—	<1.4	—	—	—	0.96	—	—	<0.03	<3.2	—	<1.6	<0.57	—	<0.41	—	—	—
AAA4619	49-02907	125–126.5	Qbt 3	—	<4.4	<0.41	<8.9	<0.6	<0.6	—	<1.4	—	—	—	1.1	—	—	<0.03	<3.2	—	<1.6	<0.57	—	<0.41	—	—	—
AAA4604	49-02907	138–138.7	Qbt 3	—	<4.3	<0.41	<4.9	<0.28	<0.59	—	<1.4	—	—	—	1	—	—	<0.03	<3.2	—	<1.6	<0.57	—	<0.41	—	—	—
AAA4607	49-02907	145–145.6	Qbt 3	—	<4.4	<0.41	<5.9	<0.5	<0.6	—	<1.4	—	—	—	1.3	—	—	<0.03	<3.3	—	<1.7	<0.58	—	<0.41	0.2 (J)	—	—

Notes: All values in mg/kg. Results shaded in gray are greater than or equal to BVs. See Appendix A for data qualifier definitions.

[a] — = Sample was not analyzed or analysis was rejected.

[b] < = Result is not detected at the concentration reported.

Table 2.5-3
TDR Array Descriptions

TDR Number	Array Type	Depth (ft)
TDR1	Vertical, within soil overlaying Bandelier Tuff	6
TDR2	Horizontal, at bottom of topsoil	0.5
TDR3	Vertical, within El Cajete pumice formation	10
TDR4	Horizontal, at bottom of topsoil	0.5

Table 2.5-4
Summary of Inorganic Chemical Screening-Level Results at Area 2A: SWMU 49-001(c)

Sample ID	Location ID	Depth (ft)	Media	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Uranium
Soil BV				**29200**	**0.83**	**8.17**	**295**	**1.83**	**0.4**	**19.3**	**22.3**	**0.1**	**15.4**	**1.52**	**1**	**0.73**	**1.82**
AAA1759	49-02014	0–0.5	Soil	—[a]	<11.2[b]	1.7	113	0.58	<0.8	5.4	9.3	<0.02	4.7	<0.6	<1.4	<1	3.6
AAA1760	49-02016	0–0.5	Soil	—	<11.2	<0.6	58.5	0.37	<0.8	2.9	5.2	<0.02	6.9	<0.6	<1.4	<1	2.5
AAA1765	49-02024	0–0.5	Soil	—	<11.2	1.2	89.5	0.73	<0.8	5.7	11	<0.02	4.6	<0.6	<1.4	<1	1.8
AAA1766	49-02025	0–0.5	Soil	—	<11.2	1.2	80.8	0.69	<0.8	5.6	8.7	<0.02	5.3	<0.6	<1.4	<1	<1.7
AAA1767	49-02026	0–0.5	Soil	—	<11.2	1	82.3	0.59	<0.8	4.2	8.2	<0.02	3.7	<0.6	<1.4	<1	1.4
AAA1768	49-02028	0–0.5	Soil	—	<11.2	1.6	45.4	0.3	<0.8	2.8	7.6	<0.02	4.2	<0.6	<1.4	<1	2.1

Notes: All values in mg/kg. Results shaded in gray are detected above BV.

[a] — = Sample was not analyzed or analysis was rejected.

[b] < = Result is not detected at the concentration reported.

Table 2.5-5
Summary of Radionuclide Screening-Level Results at Area 2A: SWMU 49-001(c)

Sample ID	Location ID	Depth (ft)	Media	Cesium-137	Plutonium-238	Plutonium-239/240	Potassium-40	Radium-226	Thorium-232
Soil BV				**1.65**	**0.023**	**0.054**	**36.8**	**2.59**	**2.33**
AAA1759	49-02014	0–0.5	Soil	0.937	—[a]	—	29.508	2.662	—
AAA1760	49-02016	0–0.5	Soil	<0.725	—	—	30.805	—	3.922
AAA1765	49-02024	0–0.5	Soil	—	—	—	35.172	3.34	—
AAA1766	49-02025	0–0.5	Soil	—	—	—	32.497	2.854	<1.948
AAA1767	49-02026	0–0.5	Soil	—	—	—	41.481	2.748	3.82
AAA1768	49-02028	0–0.5	Soil	1.027	—	—	22.339	1.814	2.67
AAA1759	49-02014	0–0.5	Soil	—	<0.005[b]	0.108	—	—	—
AAA1760	49-02016	0–0.5	Soil	—	—	0.021	—	—	—
AAA1765	49-02024	0–0.5	Soil	—	<0.003	0.044	—	—	—
AAA1766	49-02025	0–0.5	Soil	—	0.013	0.681	—	—	—
AAA1767	49-02026	0–0.5	Soil	—	<0.009	0.331	—	—	—
AAA1768	49-02028	0–0.5	Soil	—	<0.005	0.044	—	—	—

Notes: All values in pCi/g. Results shaded in gray are detected above BVs.

[a] — = Sample was not analyzed or analysis was rejected.

[b] < = Result is not detected at the concentration reported.

Table 2.5-6
Summary of Inorganic Chemical Screening-Level Results at Area 2B: SWMU 49-001(d)

Sample ID	Location ID	Depth (ft)	Media	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Uranium
Soil BV				**29200**	**0.83**	**8.17**	**295**	**1.83**	**0.4**	**19.3**	**22.3**	**0.1**	**15.4**	**1.52**	**1**	**0.73**	**1.82**
AAA1773	49-02037	0–0.5	Soil	—[a]	<11.2[b]	2.2	87.9	0.57	<0.8	4.9	7.2	<0.02	3.2	<0.6	<1.4	<1	1.7
AAA1775	49-02041	0–0.5	Soil	—	<11.2	<0.6	52.6	0.45	<0.8	3.7	13.2	<0.02	<2.8	<0.6	<1.4	<1	1.4
AAA1776	49-02043	0–0.5	Soil	—	<11.2	1.1	51.8	0.47	<0.8	4.6	7.9	<0.02	3.6	<0.6	<1.4	<1	1.6
AAA1777	49-02046	0–0.5	Soil	—	<11.2	1.8	66.3	0.55	<0.8	5.8	21.5	0.02	7.8	<0.6	<1.4	<1	1.7

Note: All values in mg/kg.

[a] — = Sample was not analyzed or analysis was rejected.

[b] < = Result is not detected at the concentration reported.

Table 2.5-7
Summary of Radionuclide Screening-Level Results at Area 2B: SWMU 49-001(d)

Sample ID	Location	Depth (ft)	Media	Cesium-137	Plutonium-238	Plutonium-239/240	Potassium-40	Radium-226	Thorium-232
Soil BV				**1.65**	**0.023**	**0.054**	**36.8**	**2.59**	**2.33**
AAA1773	49-02037	0–0.5	Soil	—[a]	—	—	29.635	2.617	<2.418[b]
AAA1775	49-02041	0–0.5	Soil	1.021	—	—	31.172	<1.526	2.539
AAA1776	49-02043	0–0.5	Soil	0.804	—	—	33.901	—	—
AAA1777	49-02046	0–0.5	Soil	1.135	—	—	26.183	—	3.374
AAA1773	49-02037	0–0.5	Soil	—	<0.002	0.051	—	—	—
AAA1775	49-02041	0–0.5	Soil	—	<0.003	0.037	—	—	—
AAA1776	49-02043	0–0.5	Soil	—	<0.002	0.049	—	—	—
AAA1777	49-02046	0–0.5	Soil	—	<0.009	0.384	—	—	—

Notes: All values in pCi/g. Results shaded in gray are detected above BVs.

[a] — = Sample was not analyzed or analysis was rejected.

[b] < = Result is not detected at the concentration reported.

Table 2.5-8
Summary of Inorganic Chemical Screening-Level Results at SWMU 49-001(g)

Sample ID	Location ID	Depth (ft)	Media	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Uranium
Soil/Fill BV				**0.83**	**8.17**	**295**	**1.83**	**0.4**	**19.3**	**22.3**	**0.1**	**15.4**	**1.52**	**1**	**0.73**	**1.82**
AAA1779	49-02050	0–0.5	Soil	<11.2*	0.86	76	0.36	<0.8	5.7	6.1	0.03	5.5	<0.6	<1.4	<1	3.1
AAA1781	49-02051	0–0.5	Soil	<11.2	1.5	142	0.65	1.3	6.3	11.5	0.02	7.5	<0.6	<1.4	<1	4.1
AAA1782	49-02052	0–0.5	Soil	<11.2	0.81	103	0.43	0.81	5.6	12.6	<0.02	5.7	<0.6	<1.4	<1	3.1
AAA1783	49-02054	0–0.5	Soil	<11.2	0.94	76.3	0.31	0.89	3.6	5.9	<0.02	3.6	<0.6	<1.4	<1	2.7
AAA1784	49-02055	0–0.5	Soil	<11.2	1.2	115	0.86	1	7.1	10.1	0.02	6.4	<0.6	<1.4	<1	2.5
AAA1785	49-02056	0–0.5	Soil	<11.2	1.2	111	0.54	1	6.6	10.8	<0.02	3.7	<0.6	<1.4	<1	4.6
AAA1786	49-02058	0–0.5	Soil	<11.2	1.1	103	0.59	0.89	7.6	8.1	<0.02	5.8	<0.6	<1.4	<1	2.8
AAA1787	49-02060	0–0.5	Soil	<11.2	3.5	171	0.7	1.2	7.5	16.5	0.03	6.2	<0.6	<1.4	<1	4.8
AAA1788	49-02062	0–0.5	Soil	<11.2	1.3	124	0.52	0.85	6.1	14.3	<0.02	3.1	<0.6	<1.4	<1	4.3
AAA1789	49-02064	0–0.5	Soil	<11.2	1.8	146	0.48	<0.8	5.8	19	0.03	5.3	<0.6	<1.4	<1	5.3

Notes: All values in mg/kg. Results shaded in gray are detected above BVs.

* < = Result is not detected at the concentration reported.

Table 2.5-9
Summary of Radionuclide Screening-Level Results at SWMU 49-001(g)

Sample ID	Location ID	Depth (ft)	Media	Cesium-137	Plutonium-238	Plutonium-239/240	Potassium-40	Radium-226	Thorium-232
Soil BV				**1.65**	**0.023**	**0.054**	**36.8**	**2.59**	**2.33**
AAA1779	49-02050	0–0.5	Soil	—[a]	0.053	3.007	41.982	2.826	4.438
AAA1781	49-02051	0–0.5	Soil	1.245	0.054	3.079	31.094	—	<2.55[b]
AAA1782	49-02052	0–0.5	Soil	1.299	0.249	13.723	36.501	<1.519	—
AAA1783	49-02054	0–0.5	Soil	—	0.013	0.492	36.454	1.869	<2.518
AAA1784	49-02055	0–0.5	Soil	—	<0.01	0.261	21.093	3.463	—
AAA1785	49-02056	0–0.5	Soil	1.151	<0.005	0.178	23.817	3.288	—
AAA1786	49-02058	0–0.5	Soil	—	<0.004	0.082	34.819	2.182	3.375
AAA1787	49-02060	0–0.5	Soil	1.276	0.028	1.304	<2.963	3.271	<3.048
AAA1788	49-02062	0–0.5	Soil	1.206	0.011	0.454	34.047	1.834	<2.683
AAA1789	49-02064	0–0.5	Soil	1.797	0.022	1.009	30.587	2.361	3.713

Notes: All values in pCi/g. Results shaded in gray are detected above BVs.
[a] — = Sample was not analyzed or analysis was rejected.
[b] < = Result is not detected at the concentration reported.

Table 2.6-1
Summary of Inorganic Chemicals above BVs at Area 3: SWMU 49-001(e)

Sample ID	Location ID	Depth (ft)	Media	Antimony	Cadmium	Copper	Lead	Uranium	Zinc
Soil BV				**0.83**	**0.4**	**14.7**	**22.3**	**1.82**	**48.8**
0549-95-0211	49-03000	0.00–0.50	Soil	5.5 (U)	0.59 (U)	—*	—	3.5	—
0549-95-0213	49-03002	0.00–0.50	Soil	5.5 (U)	0.59 (U)	—	—	3.9	—
0549-95-0216	49-03005	0.00–0.50	Soil	5.5 (U)	0.59 (U)	—	—	3.4	—
0549-95-0219	49-03008	0.00–0.50	Soil	5.6 (U)	0.59 (U)	—	—	3.4	—
0549-95-0220	49-03009	0.00–0.50	Soil	5.5 (U)	0.59 (U)	—	—	3.2	—
0549-95-0222	49-03011	0.00–0.50	Soil	5.7 (U)	0.6 (U)	36.4	—	3.3	92.8 (J)
0549-95-0223	49-03012	0.00–0.50	Soil	5.5 (U)	0.59 (U)	—	—	3.7	51.9 (J)
0549-95-0224	49-03013	0.00–0.50	Soil	5.5 (U)	0.58 (U)	—	—	3	63.3 (J)
0549-95-0229	49-03024	0.00–0.50	Soil	5.5 (U)	0.58 (U)	—	—	3.4	—
0549-95-0231	49-03026	0.00–0.50	Soil	5.5 (U)	0.58 (U)	—	22.8 (J-)	3.6	112 (J)

Notes: All values in mg/kg. See Appendix A for data qualifier definitions. Decision-level data are summarized in this table.
*— = Not detected above BV.

Table 2.7-1
Summary of Inorganic Chemicals above BVs at Area 4: SWMU 49-001(f)

Sample ID	Location ID	Depth (ft)	Media	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Magnesium	Mercury	Nickel	Potassium	Selenium	Silver	Thallium	Uranium	Vanadium	Zinc
Soil BV				**0.83**	**8.17**	**295**	**1.83**	**0.4**	**19.3**	**8.64**	**14.7**	**22.3**	**4610**	**0.1**	**15.4**	**3460**	**1.52**	**1**	**0.73**	**1.82**	**39.6**	**48.8**
0549-95-0235	49-04003	0.00–0.50	Soil	—*	—	—	—	—	—	—	28.4	—	—	—	—	—	—	—	1.2 (U)	—	—	—
0549-95-0237	49-04005	0.00–0.50	Soil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.4 (U)	—	—	—
0549-95-0238	49-04006	0.00–0.50	Soil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.8 (J)	—	—	—
0549-95-0239	49-04007	0.00–0.50	Soil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.4 (U)	—	—	—
0549-95-0241	49-04009	0.00–0.50	Soil	—	—	—	—	—	—	—	—	—	—	1.1 (U)	—	—	—	—	1.3 (J)	—	—	—
0549-95-0245	49-04013	0.00–0.50	Soil	—	—	—	—	—	—	—	—	—	—	0.11 (U)	—	—	—	—	1.3 (U)	—	—	—
0549-95-0246	49-04014	0.00–0.50	Soil	—	—	—	—	—	—	—	—	—	—	0.11 (U)	—	—	—	—	1.3 (U)	1.85	—	—
0549-95-0248	49-04016	0.00–0.50	Soil	—	—	—	—	0.42 (J)	—	—	25.8 (J)	51.5 (J+)	—	0.11 (U)	23.4	—	—	—	1.4 (U)	—	—	50.3
0549-95-0250	49-04018	0.00–0.50	Soil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.3 (U)	—	—	—
0549-95-0251	49-04019	0.00–0.50	Soil	181 (J-)	149	745	353	189	128 (J)	285	351	287 (J+)	7220 (J-)	—	83.6	8360	104 (J-)	90.2	232	1.93	129	155

Notes: All values in mg/kg. See Appendix A for data qualifier definitions. Decision-level data are summarized in this table.
*— = Not detected above BV.

Table 2.7-2
Summary of Radionuclides Detected or Detected above FVs from Area 4: SWMU 49-001(f)

Sample ID	Location ID	Depth (ft)	Media	Americium-241	Plutonium-238	Plutonium-239/240
Soil FV				**0.013**	**0.023**	**0.054**
0549-95-0235	49-04003	0.00–0.50	Soil	—*	0.03432	—
0549-95-0238	49-04006	0.00–0.50	Soil	—	—	0.05837
0549-95-0239	49-04007	0.00–0.50	Soil	—	—	0.1008
0549-95-0244	49-04012	0.00–0.50	Soil	0.5924	—	—
0549-95-0246	49-04014	0.00–0.50	Soil	—	0.06285	0.08287
0549-95-0251	49-04019	0.00–0.50	Soil	—	0.03798	0.2126

Notes: All values in pCi/g. Decision-level data are summarized in this table.
*— = Not detected above FV.

Table 2.8-1
Summary of Inorganic Chemicals above BVs at Area 11: SWMU 49-003

Sample ID	Location ID	Depth (ft)	Media	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Selenium	Uranium	Vanadium
Soil BV				**29200**	**0.83**	**8.17**	**295**	**1.83**	**0.4**	**6120**	**19.3**	**8.64**	**14.7**	**21500**	**22.3**	**14.7**	**21500**	**22.3**	**4610**	**671**	**15.4**
Qbt 2,3,4 BV				**7340**	**0.5**	**2.79**	**46**	**1.21**	**1.63**	**2200**	**7.14**	**3.14**	**4.66**	**14500**	**11.2**	**4.66**	**14500**	**11.2**	**1690**	**482**	**6.58**
0549-95-0024	49-08021	0.00–0.50	Soil	—*	5.3 (U)	—	—	—	0.975	—	—	—	—	—	—	—	—	—	—	4.09	—
0549-95-0026	49-08023	0.00–0.50	Soil	—	5.2 (U)	—	—	—	0.52 (U)	—	—	—	—	—	—	—	—	—	—	3.14	—
0549-95-0029	49-08026	0.00–0.50	Soil	—	5.29 (U)	—	—	—	0.529 (U)	—	—	—	—	—	—	—	—	—	—	2.62	—
0549-95-0031	49-08028	0.00–0.50	Soil	—	5.19 (U)	—	—	—	0.519 (U)	—	—	—	—	—	—	—	—	—	—	2.63	—
0549-95-0065	49-08029	0.80–2.00	Soil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.42	—
0549-95-0034	49-08031	0.00–0.50	Soil	—	5.07 (U)	—	—	—	0.507 (U)	—	—	—	—	—	—	—	—	—	—	2.09	—
0549-95-0072	49-08031	3.30–4.30	Qbt 4	14900	0.81 (J-)	3.6	175	—	—	4380	8	12.2	—	—	22.6	2340	497 (J+)	7.8 (J)	0.75 (J)	—	17.3
0549-95-0075	49-08032	3.30–4.30	Qbt 4	9060	0.61 (J-)	3.4	72.2	—	—	2980	—	—	—	—	—	2270	—	—	0.46 (U)	—	—
0549-95-0036	49-08033	0.00–0.50	Soil	—	5.21 (U)	—	—	—	0.521 (U)	—	—	—	—	—	—	—	—	—	—	3.63	—
0549-95-0078	49-08033	3.00–3.50	Qbt 4	—	0.91 (J-)	4.6	147	1.5	—	3510	9.3	3.3 (J)	6.8	—	15.4	3260	—	10	0.69 (J)	—	—
0549-95-0037	49-08034	0.00–0.50	Soil	—	5.26 (U)	—	—	—	0.526 (U)	—	—	—	—	—	—	—	—	—	—	2.85	—
0549-95-0038	49-08035	0.00–0.50	Soil	—	5.26 (U)	—	—	—	0.526 (U)	—	—	—	—	—	—	—	—	—	—	8.36	—
0549-95-0087	49-08038	2.50–3.50	Qbt 4	23100	0.94 (J-)	4.7	431	1.7	—	5950	11.8	3.9 (J)	7.5	16600	23.5	4250	—	11.9	0.54 (J)	—	20.7
0549-95-0043	49-08039	0.00–0.50	Soil	—	5.23 (U)	—	—	—	0.523 (U)	—	—	—	—	—	—	—	—	—	—	2.94	—
0549-95-0044	49-08040	0.00–0.50	Soil	—	5.16 (U)	—	—	—	0.516 (U)	—	—	—	—	—	—	—	—	—	—	2.62	—
0549-95-0093	49-08040	3.00–4.00	Soil	—	1 (J-)	—	407	—	—	6330	—	—	—	—	—	—	—	—	—	1.85	—
0549-95-0046	49-08042	0.00–0.50	Soil	—	5.44 (U)	—	—	—	0.544 (U)	—	—	—	—	—	—	—	—	—	—	2.59	—
0549-95-0049	49-08044	0.00–0.50	Soil	—	5.18 (U)	—	—	—	0.518 (U)	—	—	—	—	—	—	—	—	—	—	2.44	—
0549-95-0050	49-08045	0.00–0.50	Soil	—	5.6 (U)	—	—	—	0.56 (U)	—	—	—	—	—	—	—	—	—	—	2.48	—

Notes: All values in mg/kg. See Appendix A for data qualifier definitions. Decision-level data are summarized in this table.
*— = Not detected above BV.

Table 2.8-2
Summary of Radionuclides Detected or Detected above FVs at Area 11: SWMU 49-003

Sample ID	Location ID	Depth (ft)	Media	Americium-241	Cesium-137	Europium-152	Plutonium-238	Plutonium-239/240
Soil FV				**0.013**	**1.65**	**na**[a]	**0.023**	**0.054**
Qbt 2,3,4 BV				**na**	**na**	**na**	**na**	**na**
0549-95-0024	49-08021	0.00–0.50	Soil	—[b]	—	—	—	0.2
0549-95-0026	49-08023	0.00–0.50	Soil	—	—	—	—	0.3
0549-95-0029	49-08026	0.00–0.50	Soil	—	—	—	0.04	—
0549-95-0031	49-08028	0.00–0.50	Soil	—	—	—	—	0.1
0549-95-0065	49-08029	0.80–2.00	Soil	0.442	0.138	0.234	0.029	0.82
0549-95-0034	49-08031	0.00–0.50	Soil	—	—	—	0.08	5.4
0549-95-0072	49-08031	3.30–4.30	Qbt 4	—	—	—	—	0.002
0549-95-0035	49-08032	0.00–0.50	Soil	0.6131	—	—	—	—
0549-95-0036	49-08033	0.00–0.50	Soil	—	—	—	—	0.8
0549-95-0078	49-08033	3.00–3.50	Qbt 4	—	—	—	0.002	—
0549-95-0037	49-08034	0.00–0.50	Soil	—	—	—	—	0.3
0549-95-0038	49-08035	0.00–0.50	Soil	—	—	—	—	0.3
0549-95-0087	49-08038	2.50–3.50	Qbt 4	—	—	—	0.002	—
0549-95-0043	49-08039	0.00–0.50	Soil	1.742	—	—	0.09	5.1
0549-95-0044	49-08040	0.00–0.50	Soil	9.303	—	—	1.1	66.1
0549-95-0093	49-08040	3.00–4.00	Soil	—	—	—	0.005	0.041
0549-95-0046	49-08042	0.00–0.50	Soil	—	—	—	—	8.5
0549-95-0049	49-08044	0.00–0.50	Soil	—	—	—	0.04	2
0549-95-0050	49-08045	0.00–0.50	Soil	—	—	—	—	0.7

Notes: All values in pCi/g. Decision-level data are summarized in this table.

[a] na = Not available.

[b] — = Not detected or not detected above FV.

Table 2.9-1
Summary of Inorganic Chemicals above BVs at Area 11: AOC 49-008(c)

Sample ID	Location ID	Depth (ft)	Media	Antimony	Cadmium	Calcium	Cobalt	Manganese	Selenium	Uranium
Soil BV				**0.83**	**0.4**	**6120**	**8.64**	**671**	**1.52**	**1.82**
Qbt 2,3,4 BV				**0.5**	**1.21**	**2200**	**3.14**	**482**	**0.3**	**2.40**
0549-95-0051	49-08046	0.00–0.50	Soil	5.48 (U)	0.548 (U)	—*	—	—	—	2.92
0549-95-0096	49-08047	0.00–3.00	Soil	1.1 (J-)	—	—	—	—	—	2.47
0549-95-0099	49-08049	7.00–12.00	Qbt 4	—	—	—	—	—	0.44 (U)	—
0549-95-0055	49-08050	0.00–0.50	Soil	5.11 (U)	0.511 (U)	—	—	—	—	2.56
0549-95-0100	49-08051	7.00–12.00	Qbt 4	—	—	2720	—	—	0.44 (U)	—
0549-95-0058	49-08053	0.00–0.50	Soil	5.17 (U)	0.517 (U)	—	11.3	828	—	2.55

Notes: All values in mg/kg. See Appendix A for data qualifier definitions. Decision-level data are summarized in this table.
*— = Not detected above BV.

Table 2.9-2
Summary of Organic Chemicals Detected at Area 11: AOC 49-008(c)

Sample ID	Location ID	Depth (ft)	Media	Bis 2-ethylhexyl)phthalate	Di-n-octylphthalate
0549-95-0096	49-08047	0.00–3.00	Soil	0.1 (J)	0.15 (J)
0549-95-0099	49-08049	7.00–12.00	Qbt 4	0.07 (J)	—*

Notes: All values in mg/kg. See Appendix A for data qualifier definitions. Decision-level data are summarized in this table.
*— = Not detected.

Table 2.9-3
Summary of Radionuclides Detected or Detected above FVs at Area 11: AOC 49-008(c)

Sample ID	Location ID	Depth (ft)	Media	Plutonium-238	Plutonium-239/240
Soil FV				**0.023**	**0.054**
Qbt 2,3,4 BV				**na**[a]	**na**
0549-95-0051	49-08046	0.00–0.50	Soil	—[b]	0.2
0549-95-0096	49-08047	0.00–3.00	Soil	0.002	0.077
0549-95-0099	49-08049	7.00–12.00	Qbt 4	0.009	—
0549-95-0100	49-08051	7.00–12.00	Qbt 4	—	0.005

Notes: All values in pCi/g. Decision-level data are summarized in this table.
[a] na = Not available.
[b] — = Not detected or not detected above FV.

Table 2.10-1
Summary of Inorganic Chemicals above BVs from Area 12: AOC 49-008(d)

Sample ID	Location ID	Depth (ft)	Media	Cadmium	Copper	Lead	Sodium	Uranium	Zinc
Soil BV				**0.4**	**14.7**	**22.3**	**915**	**1.82**	**48.8**
0549-95-0265	49-09007	0.00–0.50	Soil	0.65	14.9	38.2 (J+)	—	49.6	—
0549-95-0266	49-09007	0.50–1.00	Soil	—*	—	—	—	23	—
0549-95-0272	49-09032	0.00–0.50	Soil	0.75	19.1	—	—	16.8	110
0549-95-0273	49-09032	0.50–1.00	Soil	0.68	—	—	—	13.7	—
0549-95-0274	49-09035	0.00–0.50	Soil	0.83	—	—	—	18.1	52.1
0549-95-0275	49-09035	0.00–0.50	Soil	0.98	—	—	—	6.1	—
0549-95-0276	49-09036	0.00–0.50	Soil	0.82	—	—	—	68.4	—
0549-95-0277	49-09036	0.50–1.00	Soil	1.1	—	—	—	8.6	—
0549-95-0015	49-09095	0.00–0.50	Soil	0.43 (J)	—	27.5 (J+)	5930	4.4	—

Notes: All values in mg/kg. See Appendix A for data qualifier definitions. Decision-level data are summarized in this table.
*— = Not detected above BV.

Table 2.10-2
Summary of Organic Chemicals Detected at Area 12: AOC 49-008(d)

Sample ID	Location ID	Depth (ft)	Media	alpha-BHC	alpha-Chlordane	gamma-Chlordane
0549-95-0015	49-09095	0.00–0.50	Soil	0.0012 (J)	0.0029 (J)	0.0024 (J)

Notes: All values in mg/kg. See Appendix A for data qualifier definitions. Decision-level data are summarized in this table.

Table 2.10-3
Summary of Radionuclides Detected or Detected above BVs/FVs at Area 12: AOC 49-008(d)

Sample ID	Location ID	Depth (ft)	Media	Americium-241	Plutonium-238	Plutonium-239/240	Uranium-234	Uranium-235	Uranium-238
Soil BV/FV				**0.013**	**0.023**	**0.054**	**2.59**	**0.2**	**2.29**
Qbt 2,3,4 BV				**na**[a]	**na**	**na**	**1.98**	**0.09**	**1.93**
MD49-98-0102	49-02901	14.30–14.50	Qbt 4	—[b]	0.038	—	—	—	—
MD49-98-0103	49-02901	24.00–24.20	Qbt 4	0.039	—	—	—	—	—
MD49-98-0111	49-02901	88.40–88.60	Qbt 3	0.033	—	—	—	—	—
MD49-98-0115	49-02901	136.80–137.00	Qbt 3	0.039	—	—	—	—	—
0549-95-0265	49-09007	0.00–0.50	Soil	—	—	0.077	3.84	0.42	17.97
0549-95-0266	49-09007	0.50–1.00	Soil	—	—	0.05	—	—	7.71
0549-95-0272	49-09032	0.00–0.50	Soil	—	—	0.483	—	—	6.5
0549-95-0273	49-09032	0.50–1.00	Soil	—	—	0.198	—	—	3.36
0549-95-0274	49-09035	0.00–0.50	Soil	—	—	0.22	—	—	—
0549-95-0275	49-09035	0.00–0.50	Soil	—	—	0.079	—	—	—
0549-95-0276	49-09036	0.00–0.50	Soil	—	—	0.211	2.85	0.4	22.74
0549-95-0277	49-09036	0.50–1.00	Soil	—	—	—	—	—	3.23

Notes: All values in pCi/g. Decision-level data are summarized in this table.

[a] na = Not available.

[b] — = Not detected above BV/FV.

Table 2.10-4
Summary of Inorganic Chemical Screening-Level Results at Area 12: AOC 49-008(d)

Sample ID	Location ID	Depth	Media	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Uranium
Qbt 2,3,4 BV				**0.5**	**2.79**	**46**	**1.21**	**1.63**	**7.14**	**11.2**	**0.1**	**6.58**	**0.3**	**1**	**1.1**	**2.4**
AAA4594	49-02901	2.3–6.5	Qbt 4	<0.62*	<2.2	197	1.1	2.3	11.9	12.4	<0.02	10.9	<0.45	<1.1	<0.27	5.42
AAA4567	49-02901	14.1–15.2	Qbt 4	<0.61	<0.82	<27.3	<0.72	<0.64	3	3.4	<0.02	<4.4	<0.41	<1	<0.2	5.18
AAA4553	49-02901	24.5–25	Qbt 4	<0.67	<0.8	<24.2	<1.1	<0.6	2.8	2.1	<0.02	<4.9	<0.4	<1	<0.22	4.61
AAA4554	49-02901	34.6–36	Qbt 4	<0.6	<0.8	<10	<0.2	<0.7	<1.8	0.77	<0.02	<2	<0.4	<1	<0.2	2.94
AAA4564	49-02901	44.6–46.5	Qbt 4	<0.61	<0.83	<14.4	<0.2	<0.61	<1.9	0.8	<0.02	<1.9	<0.4	<1	<0.2	4.39
AAA4562	49-02901	55–56.3	Qbt 4	<0.61	<0.8	<8.5	<0.21	<0.6	<1.5	<0.43	<0.02	<2.8	<0.4	<1	<0.2	4.78
AAA4557	49-02901	63.9–65	Qbt 4	<0.61	<0.82	<12.6	<0.36	<0.73	<0.96	<0.35	<0.02	<1.2	<0.41	<1	<0.2	5.01
AAA4563	49-02901	69.5–70.2	Qbt 4	<0.6	<0.82	<13.8	<0.28	<0.62	<1.6	0.69	<0.02	<1.2	<0.41	<1	<0.2	4.76
AAA4561	49-02901	78.2–79	Qbt 4	<0.62	<0.82	<4.9	<0.22	<0.61	<0.82	2	<0.02	<1.2	<0.41	<1	<0.21	4.88
AAA4555	49-02901	88.6–89.4	Qbt 3	<0.61	<1.1	<8.1	<0.23	<0.62	<0.82	11.8	<0.02	<1.2	<0.41	<1	<0.2	4.86
AAA4566	49-02901	93.5–94.8	Qbt 3	<0.6	<0.82	<8.7	<0.21	<0.61	<2	2.8	0.06	<1.2	<0.41	<1	<0.2	5.45
AAA4560	49-02901	116–116.7	Qbt 3	<0.61	<0.83	<9.5	<0.37	<0.62	<0.83	2.7	<0.02	<1.2	<0.41	<1	<0.2	3.66
AAA4593	49-02901	133–134	Qbt 3	<0.61	<0.82	<6.1	<0.35	<0.62	<0.82	2.5	<0.02	<1.2	<0.47	<1	<0.2	5.28
AAA4559	49-02901	136–136.7	Qbt 3	<0.6	<0.82	<8.1	<0.43	<0.61	<0.82	2.8	<0.02	<1.2	<0.41	<1	<0.2	6.29
AAA4565	49-02901	145.6–147.9	Qbt 3	<0.61	<0.82	<4.9	<0.28	<0.62	<0.82	2.1	<0.02	<1.2	<0.41	<1	<0.2	4.33

Notes: All values in mg/kg. Results shaded in gray are detected above BVs.
* < = Result is not detected at the concentration reported.

Table 2.10-5
Summary of PCBs Screening-Level Results at Area 12: AOC 49-008(d)

Sample ID	Location ID	Depth	Media	Aroclor-1242	Aroclor-1254	Aroclor-1260	Aroclors (Mixed)
0549-95-0006	49-09060	0–0.5	Soil	<0.25*	<0.25	<0.25	<0.25
0549-95-0007	49-09062	0–0.5	Soil	<0.22	<0.22	<0.22	<0.22
0549-95-0008	49-09064	0–0.5	Soil	<0.22	<0.22	<0.22	<0.22
0549-95-0009	49-09066	0–0.5	Soil	<0.24	<0.24	<0.24	<0.24
0549-95-0010	49-09069	0–0.5	Soil	<0.22	<0.22	<0.22	<0.22

Note: All values in mg/kg.
* < = Result is not detected at the concentration reported.

Table 2.10-6
Summary of Radionuclide Screening-Level Results at Area 12: AOC 49-008(d)

Sample ID	Location ID	Depth	Media	Americium-241	Cesium-137	Gross Alpha	Gross Beta	Gross Gamma	Plutonium-238	Plutonium-239/240
Qbt 2,3,4 BV				**na**[a]	**na**	**na**	**na**	**na**	**na**	**na**
Qbt 1v BV				**na**	**na**	**na**	**na**	**na**	**na**	**na**
Qbt 1g, Qct, Qbo BV				**na**	**na**	**na**	**na**	**na**	**na**	**na**
AAA4594	49-02901	2.3–6.5	Qbt 4	<0.11[b]	<0	<9.1	<-5.08	<-2.4	<0.105	<0.021
AAA4558	49-02901	8.6–8.8	Qbt 4	<0	<0	<0	29.06	7.3	—[c]	—
AAA4567	49-02901	14.1–15.2	Qbt 4	<0.1	<0	<-9.1	32.41	6.9	<0.092	<0.0092
AAA4419	49-02901	23.5–24	Qbt 4	<0	<0	<18.2	28.97	6.2	—	—
AAA4553	49-02901	24.5–25	Qbt 4	<0.04	<0	<18.2	103.86	6.1	1.38	<0.0701
AAA8142	49-02901	24.5–25	Qbt 4	—	0.037	<-40	5.5	13	—	—
AAA4425	49-02901	29.8–30	Qbt 4	<0	<0	<9.1	29.58	<-3.9	—	—
AAA4554	49-02901	34.6–36	Qbt 4	<0.04	<0	<18.2	<16.68	<-1.1	<0.086	<0.0187
AAA7869	49-02901	39.2–39.4	Qbt 4	<0.15	<0.08	<0	<4.47	<-1.1	—	—
AAA4564	49-02901	44.6–46.5	Qbt 4	<0.07	<0	<9.1	<-18.49	<-1.1	<0.0157	<0
AAA7872	49-02901	49.7–49.9	Qbt 4	<0.11	<0	<9.1	<2.7	<0	—	—
AAA8145	49-02901	49.7–49.9	Qbt 4	—	<0.0011	<-50	8	14	—	—
AAA4562	49-02901	55–56.3	Qbt 4	—	—	—	—	—	<0.0392	<0
AAA4557	49-02901	63.9–65	Qbt 4	<0	<0	<-18.2	<-7.82	<-9	<0.062	<0.0069
AAA4563	49-02901	69.5–70.2	Qbt 4	<0	<0	<0	<-26.82	<-0.3	<0.0364	<0.0496
AAA7880	49-02901	74.1–74.3	Qbt 4	—	—	<27.3	<3.78	<-5.6	—	—
AAA4561	49-02901	78.2–79	Qbt 4	<0	<0	<-9.1	<2.23	<-5.2	<0.101	<0
AAA7881	49-02901	83–83.4	Qbt 4	<-0.17	<-0.09	<0	<11.18	<-5.5	—	—
AAA4556	49-02901	84.2–84.4	Qbt 4	<-0.22	<-0.09	<18.2	45.74	<2	—	—
AAA8143	49-02901	84.2–84.4	Qbt 4	—	0.0385	<-120	8	15	—	—
AAA4555	49-02901	88.6–89.4	Qbt 3	<0	<0	<36.4	<4.29	<-10	<0.226	<0.0169
AAA7910	49-02901	89.2–89.4	Qbt 3	—	—	<18.2	47.97	<0.3	—	—
AAA7886	49-02901	93.2–93.4	Qbt 3	<-0.13	<0.04	<0	<10.06	<-1.6	—	—

Table 2.10-6 (continued)

Sample ID	Location ID	Depth	Media	Americium-241	Cesium-137	Gross Alpha	Gross Beta	Gross Gamma	Plutonium-238	Plutonium-239/240
Qbt 2,3,4 BV				**na**[a]	**na**	**na**	**na**	**na**	**na**	**na**
Qbt 1v BV				**na**	**na**	**na**	**na**	**na**	**na**	**na**
Qbt 1g, Qct, Qbo BV				**na**	**na**	**na**	**na**	**na**	**na**	**na**
AAA4566	49-02901	93.5–94.8	Qbt 3	<0	<0	<-9.1	<-15.65	<-8.3	<0.0457	<0.0176
AAA4560	49-02901	116–116.7	Qbt 3	<-0.1	<-0.04	<0	<-3.35	<-1.4	<0.289	<0
AAA8144	49-02901	116–116.2	Qbt 3	—	0.0363	<-80	11	13	—	—
AAA7901	49-02901	118.7–118.9	Qbt 3	<-0.31	<-0.08	<18.2	26.73	<-1	—	—
AAA4593	49-02901	133–134	Qbt 3	<-0.31	<-0.12	<54.6	50.03	<-2.1	<0.071	<0
AAA7909	49-02901	133–133.2	Qbt 3	—	—	<9.1	29.58	<-1	—	—
AAA4559	49-02901	136–136.7	Qbt 3	<-0.31	<-0.11	<-9.1	<16.77	<-1.9	<0.081	<0.0087
AAA7917	49-02901	138–138.2	Qbt 3	<-0.17	<-0.07	<0	31.3	<-1.8	—	—
AAA4565	49-02901	145.6–147.9	Qbt 3	<-0.31	<-0.15	<-9.1	<-3.35	<-2.7	0.181	<-0.0109
AAA7905	49-02901	148.6–148.8	Qbt 3	<0.03	<0	<36.4	<-18.06	<-2.3	—	—
AAA8146	49-02901	148.6–148.8	Qbt 3	—	<0.0109	<-90	7.3	11	—	—
AAA7906	49-02901	156.5–156.9	Qbt 3	<0	<0	<-18.2	<-10.06	<-2.2	—	—
AAA7911	49-02901	159–159.2	Qbt 3	<0	<0	<18.2	33.44	<-0.6	—	—
AAA7912	49-02901	164–164.2	Qbt 3	<0	<0	<9.1	<16.16	<-0.4	—	—
AAA7764	49-02901	170.2–170.4	Qbt 3	<0.03	<0.24	<36.4	<2.06	<-1.8	—	—
AAA7916	49-02901	179.2–179.4	Qbt 3	—	—	<27.3	<16.07	<-3.1	—	—
AAA7767	49-02901	181–181.2	Qbt 2	<0	<0.01	<0	52.54	<0.5	—	—
AAA7769	49-02901	185–185.2	Qbt 2	<0.32	<0.14	<9.1	<8.34	<1.7	—	—
AAA7771	49-02901	188.7–188.9	Qbt 2	<0	<0.09	<-18.2	<3.35	<1.8	—	—
AAA7773	49-02901	195–195.2	Qbt 2	<0	<0.02	<-9.1	26.82	<0.9	—	—
AAA7775	49-02901	197.7–197.9	Qbt 2	<0	<0.12	<-9.1	<-8.94	<2.2	—	—
AAA7779	49-02901	204.2–204.4	Qbt 2	<0.2	<0.3	<0	<-3.35	<2.8	—	—
AAA7782	49-02901	208.3–208.5	Qbt 2	<0	<0.16	<0	<-4.47	<2.5	—	—
AAA7784	49-02901	216–216.2	Qbt 2	<0.02	<0.32	<9.1	<-12.9	<3.3	—	—
AAA7787	49-02901	220.8–221	Qbt 2	<0	<0.17	<36.4	<0.94	<0.5	—	—

Table 2.10-6 (continued)

Sample ID	Location ID	Depth	Media	Americium-241	Cesium-137	Gross Alpha	Gross Beta	Gross Gamma	Plutonium-238	Plutonium-239/240
Qbt 2,3,4 BV				**na**[a]	**na**	**na**	**na**	**na**	**na**	**na**
Qbt 1v BV				**na**	**na**	**na**	**na**	**na**	**na**	**na**
Qbt 1g, Qct, Qbo BV				**na**	**na**	**na**	**na**	**na**	**na**	**na**
AAA7788	49-02901	222.7–222.9	Qbt 2	<0.14	<0	<18.2	<5.5	<-0.1	—	—
AAA7790	49-02901	227.5–227.7	Qbt 2	<0	<0	<0	<-10.48	<0.9	—	—
AAA7791	49-02901	234.9–235.1	Qbt 2	<0	<0	<18.2	<-3.44	<-0.4	—	—
AAA7793	49-02901	240.5–240.7	Qbt 2	<0	<0	<9.1	<21.75	<0.6	—	—
AAA7794	49-02901	245.5–245.7	Qbt 2	<0	<0	<0	<-13.41	<0	—	—
AAA7798	49-02901	248–248.2	Qbt 2	<0.06	<0	<-9.1	<-6.71	<0.1	—	—
AAA7800	49-02901	254.1–254.3	Qbt 2	<0	<0	<-9.1	<-2.23	<-0.7	—	—
AAA7799	49-02901	255.8–256	Qbt 2	<0.11	<0	<9.1	<-0.6	<-1.1	—	—
AAA7801	49-02901	259.6–259.8	Qbt 2	<0	<0	<9.1	<6.1	<0.2	—	—
AAA7804	49-02901	264–264.2	Qbt 2	<0	<0	<27.3	<-16.34	<0.6	—	—
AAA8025	49-02901	269–269.2	Qbt 2	<0.34	<0	<9.1	<-1.72	<-0.5	—	—
AAA8030	49-02901	274–274.2	Qbt 2	<0	<0	<36.4	<-4.65	<1.1	—	—
AAA8032	49-02901	279.4–279.6	Qbt 2	<0.01	<0	<9.1	<-19.6	<0.2	—	—
AAA8033	49-02901	285–285.2	Qbt 2	<0	<0	<0	<20.12	<1.6	—	—
AAA8036	49-02901	289.5–289.7	Qbt 2	<0.01	<0	<18.2	<-4.56	<1	—	—
AAA8037	49-02901	295.1–295.3	Qbt 2	<0.06	<0	<18.2	<14.44	<0.4	—	—
AAA8040	49-02901	301.1–301.3	Qbt 2	<0.11	<0	<18.2	<16.68	<3.1	—	—
AAA8041	49-02901	305.8–306	Qbt 2	<0.25	<0	<27.3	<-2.93	<2.6	—	—
AAA8045	49-02901	309.2–309.4	Qbt 2	<0.24	<0	<9.1	23.99	<2.8	—	—
AAA8046	49-02901	312.5–312.7	Qbt 2	<0.18	<0	<54.6	<1.97	<3.1	—	—
AAA8048	49-02901	322.5–322.7	Qbt 1v	<0.08	<0	<36.4	<15.47	<2.8	—	—
AAA8051	49-02901	324.8–325	Qbt 1v	<0	<0	<-9.1	<-38	<2.7	—	—
AAA8054	49-02901	332–332.2	Qbt 1v	<0.2	<0	<18.2	<16.68	<2.3	—	—
AAA8055	49-02901	336.2–336.4	Qbt 1v	<-0.08	<0.5	<-18.2	<10.06	<1.3	—	—
AAA8056	49-02901	337.2–337.4	Qbt 1v	<-0.18	<0.24	<0	34.65	<1.2	—	—

Table 2.10-6 (continued)

Sample ID	Location ID	Depth	Media	Americium-241	Cesium-137	Gross Alpha	Gross Beta	Gross Gamma	Plutonium-238	Plutonium-239/240
Qbt 2,3,4 BV				**na**[a]	**na**	**na**	**na**	**na**	**na**	**na**
Qbt 1v BV				**na**	**na**	**na**	**na**	**na**	**na**	**na**
Qbt 1g, Qct, Qbo BV				**na**	**na**	**na**	**na**	**na**	**na**	**na**
AAA8057	49-02901	344.2–344.4	Qbt 1v	<-0.04	<0.28	<-18.2	<11.18	<3.5	—	—
AAA8059	49-02901	354.2–354.4	Qbt 1v	<0.02	<0.25	<27.3	<-11.87	<0.6	—	—
AAA8060	49-02901	355–355.2	Qbt 1v	<-0.18	<0.29	<-9.1	<7.82	<2.6	—	—
AAA8062	49-02901	359–359.2	Qbt 1v	<-0.18	<-0.05	<-18.2	<17.88	<2.5	—	—
AAA8065	49-02901	363.8–364	Qbt 1v	<-0.18	<0.31	<-27.3	<-30.18	<1.7	—	—
AAA8066	49-02901	365–365.2	Qbt 1v	<0.05	<0.09	<0	<-5.59	<-1.7	—	—
AAA8069	49-02901	372–372.4	Qbt 1v	<0.17	<0.31	<0	<-22.36	<-3	—	—
AAA8071	49-02901	378.4–378.6	Qbt 1v	<-0.12	<-0.21	<0	<-25.71	<-5.3	—	—
AAA8074	49-02901	384–384.2	Qbt 1g	<0.56	<-0.24	<9.1	<-16.25	<-1.6	—	—
AAA8075	49-02901	386.2–386.4	Qbt 1g	<-0.09	<0.01	<27.3	<-8.52	<-1.8	—	—
AAA8076	49-02901	392.5–392.7	Qbt 1g	<-0.06	<0.19	<18.2	<-12.38	<-0.9	—	—
AAA8078	49-02901	396–396.2	Qbt 1g	<-0.08	<-0.19	<-9.1	<-17.88	<-0.4	—	—
AAA8079	49-02901	400.6–400.8	Qbt 1g	<-0.12	<-0.24	<18.2	<-11.27	<-2.2	—	—
AAA8084	49-02901	405.2–405.4	Qbt 1g	<-0.01	<-0.24	<0	<-20.12	<-0.5	—	—
AAA8082	49-02901	419.2–419.4	Qbt 1g	<0	<0	<-27.3	<-13.41	<2.4	—	—
AAA8083	49-02901	421.8–422	Qbt 1g	<0.51	<0	<-27.3	<8.94	<1.1	—	—
AAA8088	49-02901	425.6–425.8	Qbt 1g	—	—	<-27.3	<-5.59	<2.1	—	—
AAA8089	49-02901	437.8–438	Qbt 1g	<0	<0	<-18.2	<6.71	<2.3	—	—
AAA8092	49-02901	443–443.2	Qbt 1g	—	—	<-45.5	<-39.12	<1.4	—	—
AAA8099	49-02901	457–457.2	Qbt 1g	<0	<0	<18.2	<-32.5	<1.9	—	—
AAA8102	49-02901	468.2–468.4	Qbt 1g	<0.39	<0	<9.1	<-43.08	<3	—	—

Notes: All values in pCi/g. Results shaded in gray are detected.

[a] na = Not available.

[b] — = Not analyzed or analysis rejected.

[c] < = Result is not detected at the concentration reported.

Table 2.11-1
Results of Hydrologic Laboratory Analyses
of the Tshirege Member of the Bandelier Tuff at TA-49

Laboratory Sample No.	Field No.	Stratigraphic Unit[d]	Depth (ft)	Approximate pH	Moisture Content		Specific Gravity	Dry Unit Weight (g/cc)	Specific Retention (%)	Porosity (%)	Specific Yield (%)	Coefficient of Permeability (gpd/ft^2)
					Dry Weight (%)	Volume (%)						
60-NM 11[c]	CH-1	Qbt_6	15	7.5			2.57	1.19	19.2	53.7	34.5	2
15[c]	CH-3	Qbt_6	20		1.5	1.9	2.58	1.24	27.3	51.9	24.6	0.1
59-NM 197	2-W	Qbt_6	30		0.6	0.8	2.57	1.28	16.3	50.2	33.9	3
197[h]	2-W	Qb_{t6}	30		-	-	-	-	-	-	-	[a]3
60-NM 6	2-O	Qbt_6	30		1.0	1.1	2.58	1.17	16.2	54.7	38.5	6
6[h]	2-O	Qbt_6	30		-	-	-	-	-	-	-	[a]5
7	1-A	Qbt_6	30		0.6	0.8	2.58	1.26	17.7	51.2	33.5	4
7[h]	1-A	Qbt_6	30		-	-	-	-	-	-	-	[a]4
21	3-A	Qbt_6	30	7.8	3.9	4.7	2.58	1.21	23.0	53.1	30.1	0.9
21[h]	3-A	Qbt_6	30									[a].2
18[c]	CH-4	Qbt_6	33	7.8			2.57	1.31	20.5	49.0	28.5	1
1	4-U	Qbt_6	40				2.53	1.35	20.0	46.6	26.6	2
1[h]	4-U	Qbt_6	40									[a]2
59-NM 196	2-D	Qbt_6	55		2.0	3.0	2.56	1.5	16.8	41.4	24.6	1
196h	2-D	Qbt_6	55									[a]2
60-NM 9	2-F	Qbt_6	56		1.9	2.6	2.57	1.38	15.4	46.3	30.9	4
9[h]	2-F	Qbt_6	56									[a]3
8	1-A	Qbt_6	58		3.0	4.7	2.55	1.58	19.8	38.0	18.2	0.9
8[h]	1-A	Qbt_6	58									[a]1
22	3-A	Qbt_6	58		0.8	1.2	2.57	1.48	19.5	42.4	22.9	1
22[h]	3-A	Qbt_6	58									[a].8
2	4-U	Qbt_6	60				2.58	1.26	17.9	51.2	33.3	1
59-NM 198	4-A	Qbt_6	64		6.6	8.7	2.57	1.32	24.6	48.6	24.0	0.9
198[h]	4-A	Qbt_6	64									[a]2
60-NM 10	4-U	Qbt_5	61				2.55	1.57				[b]59
59-NM 199	4-A	Qbt_5	66				2.58	1.47				[b]34
60-NM 3	4-U	Qbt_4	67		0.3	0.4	2.56	1.17	11.7	54.3	42.6	13
3[h]	4-U	Qbt_4	67									[a]13
5	4-U	Qbt_4	82		0.3	0.4	2.57	1.33	14.7	48.2	33.5	4
5[h]	4-U	Qbt_4	82									[a]4
23	3-A	Qbt_4	88	7.7	0.5	0.7	2.57	1.33	11.6	48.2	36.6	5
23[h]	3-A	Qbt_4	88									[a]8
4	4-U	Qbt_4	104		1.3	2.2	2.54	1.71	21.8	32.7	10.9	0.3
4[h]	4-U	Qbt_4	104									[a].4
29	Alpha	Qbt_3	135	7.9	2.2	2.9	2.56	1.32	14.2	48.4	34.2	22
28	Alpha	Qbt_3	175		0.2	0.3						
16[c]	CH-3	Qbt_2	195		0.1	0.2	2.54	1.59	11.3	37.4	26.1	2
13[c]	CH-2	Qbt_2	197				2.55	1.83	12.3	28.2	15.9	0.2
19[c]	CH-4	Qbt_2	202		0.1	0.2	2.54	2.05	17.3	19.3	2.0	0.04
17[c]	CH-3	Qbt_2	203		0.1	0.2	2.55	2.02	20.2	20.8	0.6	0.08
31[c]	CH-2	Qbt_2	235		0.1	0.2	2.57	1.84	20.8	28.4	7.6	0.2
12[c]	CH-1	Qbt_2	265	7.7			2.56	1.85	14.4			0.2
14[c]	CH-2	Qbt_2	270				2.55	1.84	13.9	27.8	13.9	0.3
20[c]	CH-4	Qbt_2	274	7.7	0.1	0.2	2.56	1.81	17.2	29.3	12.1	0.2

Note: Excerpt from table in Weir and Purtymun 1962, 011890.

[a] Horizontal permeability parallel to axes of 6-in. sidewall cores.

[b] Repacked samples.

[c] Vertical cores.

[d] Stratigraphic unit is indicative of the 1962 nomenclature.

[h] Horizontal cores cut from larger samples.

Table 4.3-1
Analytical Suites for Surface Investigations

Chemical Class	Analytical Suite	Analytical Method
Inorganic Chemicals	TAL Metals	EPA Methods 6010B, 6020, and 7471A
Radionuclides	Iodine-129	HASL 300 (alpha spectroscopy)
	Isotopic Americium	HASL 300 (alpha spectroscopy)
	Isotopic Plutonium	HASL 300 (alpha spectroscopy)
	Isotopic Uranium	HASL 300 (alpha spectroscopy)
	Strontium-90	EPA 905.0
	Technetium-99	HASL 300 (alpha spectroscopy)
	Tritium	EPA Method 906.0

Table 4.4-1
Summary of Proposed Boreholes and Sampling

Proposed Borehole Dimensions			Analyses, Number of Samples, and Proposed Intervals							
Area	Borehole ID	Depth (ft)	HE, Perchlorate, TAL metals, Cyanide, Isotopic Americium, Isotopic Plutonium, Isotopic Uranium, Tritium	VOCs, SVOCs	Diesel-Range Organics	Vapor-Phase Sampling (proposed intervals)	Geophysical, Video, and Neutron Logging	Borehole Air Permeability Testing	Stable Isotopes and Anions	Hydrogeologic Properties and/or Fractures
1	1	135	10	—[a]	—	Surge bed	X[b]	X	—	2
	2	135	10	—	—	—	X	—	—	2
	3	135	10	—	—	—	X	—	—	2
	4	135	10	—	—	—	X	—	—	2
2	Deep	900	45	—	—	Surge bed, Qbt 2/ Qbt 1v contact, Qbt 1v/Qbt 1g contact, Qbt t and/or Qct	X	X	Intervals TBD[c]	15
MDA AB	1	130	10	—	—	Surge bed	X	X	—	2
	2	130	10	—	—	—	X	—	—	2
	3	130	10	—	—	—	X	—	—	2
	4	130	10	—	—	—	X	—	—	2
	Directional	TBD	TBD	—	—	TBD	X	—	—	TBD
3	1	192	15	—	—	Surge bed	X	X	—	3
	2	192	15	—	—	—	X	—	—	3
	3	192	15	—	—	—	X	—	—	3
	4	192	15	—	—	—		—	—	3
4	1	158	12	—	—	Surge bed	X	X	—	2
	2	158	12	—	—	—	X	—	—	2
	3	158	12	—	—	—	X	—	—	2
	4	158	12	—	—	—	X	—	—	2

Table 4.4-1 (continued)

Proposed Borehole Dimensions			Analyses, Number of Samples, and Proposed Intervals							
Area	Borehole ID	Depth (ft)	HE, Perchlorate, TAL metals, Cyanide, Isotopic Americium, Isotopic Plutonium, Isotopic Uranium, Tritium	VOCs, SVOCs	Diesel-Range Organics	Vapor-Phase Sampling (proposed intervals)	Geophysical, Video, and Neutron Logging	Borehole Air Permeability Testing	Stable Isotopes and Anions	Hydrogeologic Properties and/or Fractures
11	Leach Field 1	20	4	4	—	—	—	—	—	—
	Leach Field 2	20	4	4	—	—	—	—	—	—
	Leach Field 3	20	4	4	—	—	—	—	—	—
	Leach Field 4	20	4	4	—	—	—	—	—	—
	Shot Area 1	80	4	4	—	Surge bed	X	X	—	—
	Shot Area 2	35	4	4	—	12 ft bgs (base of shot)	—	—	—	—
	RadChem 1	10	2	2	—	—	—	—	—	—
	RadChem 2	10	2	2	—	—	—	—	—	—
	RadChem 3	10	2	2	—	—	—	—	—	—
	RadChem 4	10	2	2	—	—	—	—	—	—
	RadChem 5	10	2	2	—	—	—	—	—	—
	RadChem Drain/Sump	10	2	2	—	—	—	—	—	—
12	Bottle House	80	4	4	—	30 ft bgs (base of shaft), surge bed	X	X	—	—
	CPTF	25	2	2	2	—	—	—	—	—

[a] — = Not proposed.

[b] X = Analysis will be performed.

[c] TBD = To be determined.

Table 4.4-2
Analytical Methods for Preliminary Surface and Subsurface Characterization

Analytical Method	Analytical Description	Analytical Suite
Inorganic Methods		
EPA Method 300	Ion chromatography	Anions (nitrates)
EPA SW-846: 9045C	Electrometric	pH
EPA SW-846: 9012A	Colorimetric	Cyanide
EPA SW-846: 6010B/6020	Inductively Coupled Plasma Emission Spectrometry—Atomic Emission Spectroscopy	Aluminum, antimony, arsenic, barium, beryllium, boron, calcium, cadmium, cobalt, chromium, copper, iron, lead, lithium, magnesium, manganese, nickel, potassium, selenium, silicon, sodium, silver, thallium, titanium, uranium, vanadium, and zinc (TAL metals)
EPA SW-846: 6850	Liquid Chromatography/ Mass Spectrometry	Perchlorate
EPA SW-846:7471A	Cold Vapor atomic absorption	Mercury (TAL metal)
Organic Methods		
EPA SW-846:8321A	Liquid Chromatography/ Mass Spectrometry	Explosives
EPA SW-846:8270C	Gas Chromatograph/ Mass Spectrometry	SVOCs
EPA SW-846:8260B	Gas Chromatograph/ Mass Spectrometry	VOCs
EPA SW-846:8082	Gas Chromatograph	PCBs
EPA SW-846:8081A	Gas Chromatograph	Organochlorinated pesticides
EPA SW-846:8015B	Gas Chromatograph	Total petroleum hydrocarbons-diesel range organic
Radionuclide Methods		
EPA 901.1	Gamma Spectroscopy	Gamma-emitting radionuclides (e.g., cesium-137)
HASL-300	Chemical Separation/Alpha Spectroscopy	Isotopic plutonium, isotopic uranium, americium-241
EPA 906	Liquid Scintillation	Tritium
HASL-300	Low Energy Gamma Spectroscopy	Iodine-129
HASL-300	Low Energy Gamma Spectroscopy	Technetium-99
EPA 905.0	Gel Permeation Chromatography	Strontium-90

Table 4.4-3
Analytical Suites for Groundwater Samples

Chemical Class	Analytical Suite	Analytical Method
Inorganic Chemicals	Perchlorate	EPA Method 6850
	TAL Metals	EPA Methods 6010B, 6020, and 7471A
	Total Cyanide	EPA Method 9012A
Organic Chemicals	Diesel/Oil Range Organics	
	Explosive Compounds (NMED list)	EPA Method 8321A_MOD
	SVOCs	EPA Method 8270C
	VOCs	EPA Method 8260B
Radionuclides	Isotopic Americium	HASL 300 (alpha spectroscopy)
	Isotopic Plutonium	HASL 300 (alpha spectroscopy)
	Isotopic Uranium	HASL 300 (alpha spectroscopy)
	Tritium	EPA Method 906.0
Other Measurements	General Inorganics	(Varies)
	TKN	EPA Method 351.1
	NO_3/NO_2	EPA Method 353.3
	TOC	EPA Method 9060
	Stable Isotopes	No test method
Field Parameters	Dissolved Oxygen	
	pH	
	Specific Conductance	
	Turbidity	
	Water levels	

Table 5.0-1
Summary of Investigation Methods

Method	Summary
Spade and Scoop Collection of Soil Samples	This method is typically used to collect shallow (e.g., approximately 0 to 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 to15 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 3 to 4 in. inner diameter), creating a vertical hole that 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.
Headspace Vapor Screening	Individual soil, rock, or sediment samples may be field-screened for VOCs 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 PID probe into the container and measuring and recording any detected vapors. Photoionization detectors must use lamps with voltage of 10.6 eV or higher.
Handling, Packaging, and Shipping of Samples	Field team member 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 the samples to either the 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 are 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. Site attributes (e.g., former and proposed soil-sampling locations, sediment-sampling locations) are located by using a GPS. Horizontal locations will be measured to the nearest 0.5 ft. The survey results for this field event will be presented as part of the investigation report. Sample coordinates will be uploaded into the Environmental Restoration Database.
Field QC Samples	Field QC samples are collected as directed in Consent Order 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 VOC analysis. Trip blanks containers of certified clean sand are opened and kept with the other sample containers during the sampling process.

Table 5.0-1 (continued)

Method	Summary
Field Decontamination of Drilling and Sampling Equipment	Dry decontamination is the preferred method to minimize generating liquid waste. Dry decontamination may include the use of a wire brush or other tool to remove soil or other material adhering to the sampling equipment, followed by use of a commercial cleaning agent (nonacid, waxless cleaners) and paper wipes. Dry decontamination may be followed by wet decontamination if necessary. Wet decontamination may include washing with a nonphosphate 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 QA. Specific requirements for each sample are printed on the sample collection logs provided by the SMO (size and type of container (glass, amber glass, polyethylene, preservative, etc.). All samples are preserved by placing them into 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.
Management, Characterization, and Storage of IDW	IDW is managed, characterized, and stored in accordance with an approved waste characterization strategy form that documents site history, field activities, and the characterization approach for each waste stream managed. Waste characterization shall be adequate to comply with on-site or off-site waste acceptance criteria. All stored IDW will be marked with appropriate signage and labels, as appropriate. Drummed IDW will be stored on pallets to prevent the containers from deterioration. Generators are required to reduce the volume of waste generated as much as technically and economically feasible. Means to store, control, and transport each potential waste type and classification shall be determined before field operations that generate waste begin A waste storage area shall be established before generating waste. Waste storage areas located in controlled areas of the laboratory shall be controlled as needed to prevent inadvertent addition or management of wastes by unauthorized personnel. Each container of waste generated shall be individually labeled as to waste classification, item identification number, and radioactivity (if applicable) immediately following containerization. All waste shall be segregated by classification and compatibility to prevent cross-contamination. See Appendix B for additional information.
Geodetic Surveys	This method describes the methodology for coordinating and evaluating geodetic surveys and establishing QA/QC for geodetic survey data. The procedure covers evaluating geodetic survey requirements, preparing to perform a geodetic survey, performing geodetic survey field activities, preparing geodetic survey data for QA review, performing QA review of geodetic survey data, and submitting geodetic survey data.
Hollow Stem Auger Drilling Methods	In this method, hollow-stem augers (sections of seamless pipe with auger flights welded to the pipe) act as a screw conveyor to bring cuttings of sediment, soil, and/or rock to the surface. Auger sections are typically 5 ft in length and have outside diameters of 4.25 to 14 in. Drill rods, split-spoon core barrels, Shelby tubes, and other samplers can pass through the center of the hollow-stem auger sections for collection of discrete samples from desired depths. Hollow-stem augers are used as temporary casings when setting wells to prevent cave-ins of the borehole walls.
Gross Gamma Radiation Scoping Surveys	This method describes the process for performing and documenting gross gamma radiation scoping surveys in buildings and soil. Scoping surveys are conducted after an assessment of the site history is completed and consist of judgmental measurements based on historical site information and data. If the scoping survey locates contamination, a characterization survey is typically performed.

Appendix A

Acronyms and Abbreviations, Glossary,
Metric Conversion Table, and Data Qualifier Definitions

A-1.0 ACRONYMS

AK	acceptable knowledge
amsl	above mean sea level
AOC	area of concern
bgs	below ground surface
BV	background value
CH	core hole
cpm	counts per minute
CPTF	Cable Pull Test Facility
CSM	conceptual site model
D&D	decontamination and decommissioning
DOE	Department of Energy [U.S]
DOT	Department of Transportation [U.S.]
dpm	disintegration(s) per minute
DRO	diesel range organics
EP	Environmental Programs
EPA	Environmental Protection Agency [U.S.]
ET	evapotranspiration
FFCA	Federal Facility Compliance Act
FV	fallout value
GPR	ground penetrating radar
GPS	global positioning satellite
HE	high explosives
HIR	historical investigation report
HMX	high-melting explosive [also 1,3,5,7-tetranitro-1,3,5,7-tetrazocine]
HWA	Hazardous Waste Act
HWFP	Hazardous Waste Facility Permit
IDW	investigation-derived waste
IM	interim measure
LANL	Los Alamos National Laboratory
MDA	material disposal area
NES	nuclear environmental site
NFA	no further action
NMED	New Mexico Environment Department

NMSA	New Mexico Statues Annotated
NPDES	National Pollutant Discharge Elimination System
OU	operable unit
PCB	polychlorinated biphenyl
PID	photoionization detector
PPE	personal protective equipment
ppm	part per million
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive [also hexahydro-1,3,5-trinitro-1,3,5-triazine]
RFI	RCRA facility investigation
SMO	Sample Management Office
SNM	special nuclear material
SOP	standard operating procedure
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWSC	Sanitary Wastewater Systems Consolidation
TA	technical area
TD	total depth
TLD	thermoluminescent dosimeter
TDR	time-domain reflectometry
TAL	target analyte list [EPA]
TCLP	toxicity characteristic leaching procedure
TNT	2,4,6-trinitrotoluene
TPH	total petroleum hydrocarbons
VCA	voluntary corrective action
VCP	vitrified clay pipe
VOC	volatile organic compound
WAC	waste acceptance criteria
WCSF	waste characterization strategy form
WWTP	wastewater treatment plant
XRF	x-ray fluorescence

A-2.0 GLOSSARY

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

aquifer—An underground geological formation (or group of formations) containing water that is the source of groundwater for wells and springs.

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

analysis—A critical evaluation, usually made by breaking a subject (either material or intellectual) down into its constituent parts, then describing the parts and their relationship to the whole. Analyses may include physical analysis, chemical analysis, toxicological analysis, and knowledge-of-process determinations.

analyte—The element, nuclide, or ion a chemical analysis seeks to identify and/or quantify; the chemical constituent of interest.

analytical method—A procedure or technique for systematically performing an activity.

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.

background value (BV)—A statistically derived concentration (i.e., the upper tolerance limit [UTL]) of a chemical used to represent the background data set. If a UTL cannot be derived, either the detection limit or maximum reported value in the background data set is used.

canyon—A stream-cut chasm or gorge, the sides of which are composed of cliffs or a series of cliffs rising from the chasm's bed. Canyons are characteristic of arid or semiarid regions where downcutting by streams greatly exceeds weathering.

catchment—(1) A structure, such as a basin or reservoir, used for collecting or draining water. (2) The amount of water collected in such a structure. (3) A catching or collecting of water, especially rainwater.

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

chemical of potential concern (COPC)—A detected chemical compound or element that has the potential to adversely affect human receptors as a result of its concentration, distribution, and toxicity.

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.

Compliance Order on Consent (Consent Order)—For the Environmental Remediation and Surveillance Program, an enforcement document signed by the New Mexico Environment Department, the U.S. Department of Energy, and the Regents of the University of California on March 1, 2005, which prescribes the requirements for corrective action at Los Alamos National Laboratory. The purposes of the Consent Order are (1) to define the nature and extent of releases of contaminants at, or from, the facility; (2) to identify and evaluate, where needed, alternatives for corrective measures to clean up

contaminants in the environment and prevent or mitigate the migration of contaminants at, or from, the facility; and (3) to implement such corrective measures. The Consent Order supersedes the corrective action requirements previously specified in Module VIII of the Laboratory's Hazardous Waste Facility Permit.

Consent Order—See Compliance Order on Consent.

consolidated unit—A group of solid waste management units (SWMUs), or SWMUs and areas of concern, which generally are geographically proximate and have been combined for the purposes of investigation, reporting, or remediation.

contaminant—(1) Chemicals and radionuclides present in environmental media or on debris above background levels. (2) According to the March 1, 2005, Compliance Order on Consent (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 Consent Order, the term "contaminant" does not include radionuclides or the radioactive portion of mixed waste.)

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.

data validation—A systematic process that applies a defined set of performance-based criteria to a body of data and that may result in the qualification of the data. The data-validation process is performed independently of the analytical laboratory that generates the data set and occurs before conclusions are drawn from the data. The process may include a standardized data review (routine data validation) and/or a problem-specific data review (focused data validation).

decommissioning—The permanent removal of facilities and their components from service after the discontinued use of structures or buildings that are deemed no longer useful. Decommissioning must take place in accordance with regulatory requirements and applicable environmental policies.

decontamination—The removal of unwanted material from the surface of, or from within, another material.

detect (detection)—An analytical result, as reported by an analytical laboratory, that denotes a chemical or radionuclide to be present in a sample at a given concentration.

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.

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.

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 Restoration (ER) Project—A Los Alamos National Laboratory project established in 1989 as part of a U.S. Department of Energy nationwide program, and precursor of today's Environmental Remediation and Surveillance (ERS) Program. This program is designed (1) to investigate hazardous and/or radioactive materials that may be present in the environment as a result of past Laboratory operations, (2) to determine if the materials currently pose an unacceptable risk to human health or the environment, and (3) to remediate (clean up, stabilize, or restore) those sites where unacceptable risk is still present.

facility—All contiguous land (and structures, other appurtenances, and improvements on the land) used for treating, storing, or disposing of hazardous waste. A facility may consist of several treatment, storage, or disposal operational units. For the purpose of implementing a corrective action, a facility is all the contiguous property that is under the control of the owner or operator seeking a permit under Subtitle C of the Resource Conservation and Recovery Act.

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 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 constituent (hazardous waste constituent)—According to the March 1, 2005, Compliance Order of Consent (Consent Order), any constituent identified in Appendix VIII of Part 261, Title 40 Code of Federal Regulations (CFR) (incorporated by 20.4.1.200 New Mexico Administrative Code [NMAC]) or any constituent identified in 40 CFR 264, Appendix IX (incorporated by 20.4.1.500 NMAC).

Hazardous Waste Facility Permit—The authorization issued to Los Alamos National Laboratory (the Laboratory) by the New Mexico Environment Department that allows the Laboratory to operate as a hazardous waste treatment, storage, and disposal facility.

HSWA module—See Module VIII.

infiltration—(1) The penetration of water through the ground surface into subsurface soil. (2) The technique of applying large volumes of wastewater to land to penetrate the surface and percolate through the underlying soil.

intermittent stream—A stream that flows only in certain reaches as a result of the channel bed's losing and gaining characteristics.

laboratory control sample (LCS)—A known matrix that has been spiked with compound(s) representative of target analytes. LCSs are used to document laboratory performance, and the acceptance criteria for LCSs are method-specific.

LANL (Los Alamos National Laboratory) data validation qualifiers—The Los Alamos National Laboratory data qualifiers which are defined by, and used, in the Environmental Remediation and Surveillance (ERS) Program validation process. The qualifiers describe the general usability (or quality) of data. For a complete list of data qualifiers applicable to any particular analytical suite, consult the appropriate ERS standard operating procedure.

material disposal area (MDA)—A subset of the solid waste management units at Los Alamos National Laboratory (the Laboratory) that include disposal units such as trenches, pits, and shafts. Historically, various disposal areas (but not all) were designated by the Laboratory as MDAs.

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.

method detection limit (MDL)—The minimum concentration of a substance that can be measured and reported with a known statistical confidence that the analyte concentration is greater than zero. After subjecting samples to the usual preparation, the MDL is determined by analyzing those samples of a given matrix type that contain the analyte. The MDL is used to establish detection status.

migration—The movement of inorganic and organic chemical species through unsaturated or saturated materials.

migration pathway—A route (e.g., a stream or subsurface flow path) for the potential movement of contaminants to environmental receptors (plants, humans, or other animals).

model—A schematic description of a physical, biological, or social system, theory, or phenomenon that accounts for its known or inferred properties and may be used for the further study of its characteristics.

Module VIII—Module VIII of the Los Alamos National Laboratory (the Laboratory) Hazardous Waste Facility Permit. This permit allows the Laboratory to operate as a hazardous-waste treatment, storage, and disposal facility. From 1990 to 2005, Module VIII included requirements from the Hazardous and Solid Waste Amendments. These requirements have been superceded by the March 1, 2005, Compliance Order on Consent (Consent Order).

National Pollutant Discharge Elimination System—The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits to discharge wastewater or storm water, and for imposing and enforcing pretreatment requirements under the Clean Water Act.

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

operable units (OUs)—At Los Alamos National Laboratory, 24 areas originally established for administering the Environmental Remediation and Surveillance Program. Set up as groups of potential release sites, the OUs were aggregated according to geographic proximity for the purposes of planning and conducting Resource Conservation and Recovery Act (RCRA) facility assessments and RCRA facility investigations. As the project matured, it became apparent that there were too many areas to allow efficient communication and to ensure consistency in approach. In 1994, the 24 OUs were reduced to 6 administrative field units.

outfall—A place where effluent is discharged into receiving waters.

permit—An authorization, license, or equivalent control document issued by the U.S. Environmental Protection Agency or an approved state agency to implement the requirements of an environmental regulation.

polychlorinated biphenyls (PCBs)—Any chemical substance 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.

quality assurance/quality control—A system of procedures, checks, audits, and corrective actions set up to ensure that all U.S. Environmental Protection Agency research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.

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.

radioactive material—For purposes of complying with U.S. Department of Transportation regulations, any material having a specific activity (activity per unit mass of the material) greater than 2 nanocuries per gram (nCi/g) and in which the radioactivity is evenly distributed.

radionuclide—Radioactive particle (human-made or natural) with a distinct atomic weight number.

RCRA facility investigation (RFI)—A Resource Conservation and Recovery Act (RCRA) investigation that determines if a release has occurred and characterizes the nature and extent of contamination at a hazardous waste facility. The RFI is generally equivalent to the remedial investigation portion of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process.

regional aquifer—Geologic material(s) or unit(s) of regional extent whose saturated portion yields significant quantities of water to wells, contains the regional zone of saturation, and is characterized by the regional water table or potentiometric surface.

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

Resource Conservation and Recovery Act—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.).

runoff—The portion of the precipitation on a drainage area that is discharged from the area.

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

sample—A portion of a material (e.g., rock, soil, water, or air), which, alone or in combination with other portions, is expected to be representative of the material or area from which it is taken. Samples are typically either sent to a laboratory for analysis or inspection or are analyzed in the field. When referring to samples of environmental media, the term field sample may be used.

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.

soil—(1) A material that overlies bedrock and has been subject to soil-forming processes. (2) A sample media group that includes naturally occurring and artificial fill materials.

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 March 1, 2005, Compliance Order on Consent (Consent Order), any discernible site at which solid waste has been placed at any time, and from which the New Mexico Environment Department 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.

split-spoon sampler—A hollow, tubular sampling device below a drill stem that is driven by a weight to retrieve soil samples. The core barrel can be opened to remove samples. This is a sampling method commonly used with auger drilling. The split-spoon sampler can be driven into the ground or can be advanced inside hollow-stem augers.

standard operating procedure—A document that details the officially approved method(s) for an operation, analysis, or action, with thoroughly prescribed techniques and steps.

surface sample—A sample taken at a collection depth that is (or was) representative of the medium's surface during the period of investigative interest. A typical depth interval for a surface sample is 0 to 6 in. for mesa-top locations, but may be up to several feet in sediment-deposition areas within canyons.

target analyte—A chemical or parameter, the concentration, mass, or magnitude of which is designed to be quantified by a particular test method.

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.

transport (transportation)—(1) The movement of a hazardous waste by air, rail, highway, or water. (2) The movement of a contaminant from a source through a medium to a receptor.

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

U.S. Department of Energy—The federal agency that sponsors energy research and regulates nuclear materials for weapons production.

U.S. Environmental Protection Agency (EPA)—The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure the protection of human health and the environment.

vadose zone—The zone between the land surface and the water table within which the moisture content is less than saturation (except in the capillary fringe) and pressure is less than atmospheric. Soil pore space also typically contains air or other gases. The capillary fringe is included in the vadose zone.

A-3.0 METRIC CONVERSION

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)

A-4.0 DATA QUALIFIER DEFINITIONS

Data Qualifier	Definition
U	The analyte was analyzed for but not detected.
J	The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis.
J+	The analyte was positively identified, and the result is likely to be biased high.
J-	The analyte was positively identified, and the result is likely to be biased low.
UJ	The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit.
R	The data are rejected as a result of major problems with quality assurance/quality control (QA/QC) parameters.

Appendix B

Management Plan for Investigation-Derived Waste

B-1.0 INTRODUCTION

This appendix describes the management of investigation-derived waste (IDW) generated during the investigation of sites comprising Technical Area (TA) 49 at Los Alamos National Laboratory (LANL or the Laboratory). This waste is generated during field-investigation activities and may include, but is not limited to, drill cuttings; contaminated soil; contaminated personal protective equipment (PPE), sampling supplies, and plastic; fluids from the decontamination of PPE and sampling equipment; and all other waste that has potentially come into contact with contaminants.

B-2.0 INVESTIGATION-DERIVED WASTE

All IDW generated during the nuclear environmental site (NES) TA-49 field-investigation activities will also be managed in accordance with applicable 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). Two SOPs are applicable to the characterization and management of IDW:

- SOP-5022, "Characterization and Management of Environmental Restoration Project Waste," and
- SOP-5023, "Waste Characterization."

These SOPs are available at http://www.lanl.gov/environment/all/qa.shtml.

All IDW will be placed in a hazardous waste accumulation area until it is characterized. If the IDW is found not to be hazardous, the waste will be stored in an appropriate nonhazardous storage area.

Investigation activities will be conducted in a manner that minimizes the generation of waste. Waste minimization will be accomplished by implementing the requirements of the Environmental Programs Directorate's portion of the "Los Alamos National Laboratory Hazardous Waste Minimization Report" (LANL 2006, 096015). This report is updated annually to meet a requirement of Module VIII of the Laboratory's Hazardous Waste Facility Permit, which was issued by the EPA on May 23, 1990, and modified on May 19, 1994 (EPA 1990, 001585; EPA 1994, 044146).

The waste streams that will be generated and managed during the field investigation at TA-49 sites are described below. Container and storage requirements will be detailed in the waste characterization strategy form (WCSF) and approved before waste generation.

B-2.1 Drill Cuttings

The drill cuttings waste stream will consist of cuttings from boreholes that will be drilled in, and around, TA-49 sites. Drill cuttings will be collected and initially placed in containers at a hazardous waste accumulation area until the cuttings are characterized. If the drill cuttings are found not to be hazardous, they will be stored in an appropriate nonhazardous storage area. The drill cuttings waste stream will be characterized using analytical results from core samples and augmented by direct sampling of the containerized cuttings, if necessary. Potential contaminants of concern include radionuclides, inorganic chemicals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and high explosives (HE). The maximum detected concentrations of radionuclides will be compared with the background or fallout values (BVs/FVs). If the maximum detected concentrations exceed these values, the drill cuttings will be designated as low-level radioactive waste. Maximum concentrations of toxicity

characteristic leaching procedure (TCLP) constituents will be compared with 20 times the TCLP regulatory level. If the concentrations are less than 20 times the regulatory level, the drill cuttings will be designated as nontoxicity characteristic nonhazardous waste. If the concentrations exceed 20 times the regulatory level, the drill cuttings will be sampled and analyzed by TCLP to determine whether the cuttings are a toxicity characteristic hazardous (or mixed) waste. Based on the results of previous investigations, the Laboratory expects the majority of these drill cuttings to be designated as nonhazardous, nonradioactive waste that will be either used for cover material at TA-54 or disposed of at an off-site disposal facility permitted for the disposal of industrial waste. Potentially, some drill cuttings may be designated as low-level radioactive or mixed waste because of the presence of depleted uranium, metals, and/or HE. Low-level waste will be disposed of at TA-54 or off-site at a licensed facility. Mixed waste will be sent to an off-site facility permitted for treating and/or disposing of mixed waste. If the concentration of HE in the waste characterizes it as detonable, the waste will be treated by open burning or open detonation on or off-site to remove the reactivity characteristic of HE. The waste will then be sent to an off-site facility for further treatment, if needed, or disposal.

B-2.2 Soil

Soil waste stream will be placed into containers appropriate to the waste volume generated (drums and/or rolloff containers), secured, and temporarily stored at a hazardous waste accumulation area until it is characterized. If the soil waste stream is found not to be hazardous, the waste will be stored in an appropriate nonhazardous storage area. Potential contaminants of concern include radionuclides, inorganic chemicals, VOCs, SVOCs, and HE. The maximum detected concentrations of radionuclides will be compared with the BVs/FVS. If the maximum concentrations exceed these values, the soil will be designated as low-level radioactive waste. Maximum concentrations of TCLP constituents will be compared with 20 times the TCLP regulatory level. If the concentrations are less than 20 times the regulatory level, the soil will be designated as nontoxicity characteristic nonhazardous waste. If the concentrations exceed 20 times the regulatory level, the soil will be sampled and analyzed by TCLP to determine whether it is a toxicity characteristic hazardous (or mixed) waste. Based on the results of previous investigations, the Laboratory expects these wastes to be designated as nonhazardous, nonradioactive waste that will be either used for cover material at TA-54 or disposed of at an off-site disposal facility permitted for the disposal of industrial waste. Potentially, some soil may be designated as low-level radioactive or mixed waste because of the presence of depleted uranium, metals, and/or HE. Low-level waste will be disposed of on-site at TA-54 or off-site at a licensed facility. Mixed waste will be sent to an off-site facility permitted for the treatment and/or disposal of mixed waste. If the concentration of HE in the waste characterizes it as detonable, the waste will be treated by open burning or open detonation on-site or off-site to remove the reactivity characteristic of HE. It will be sent to an off-site facility for further treatment, if needed, or disposal.

B-2.3 Spent Personal Protective Equipment and Disposable Sampling Supplies

The spent PPE waste stream will consist of PPE that has come into contact with contaminated environmental media (e.g., core and/or drill cuttings) and that cannot be decontaminated. The bulk of this waste stream will consist of protective clothing such as coveralls, gloves, shoe covers, and (if required) respirator cartridges. Spent PPE will be collected in containers at personnel decontamination stations, secured, and temporarily stored at a hazardous waste accumulation area until it is characterized. If the PPE is found not to be hazardous, the PPE waste will be stored in an appropriate nonhazardous storage area. Characterization of this waste stream will be performed through acceptable knowledge (AK) of the waste materials, the methods of generation, and the levels of contamination observed in the associated environmental media. The Laboratory expects spent PPE to be designated as nonhazardous,

nonradioactive waste that will be disposed of at an off-site disposal facility permitted for the disposal of industrial waste.

The disposable sampling supplies waste stream will consist of all equipment and materials that are necessary for collecting samples and that have come into direct contact with contaminated environmental media and cannot be decontaminated. This waste stream also includes residues associated with field test kits and wastes associated with dry decontamination activities. The latter will consist primarily of paper and plastic items collected in bags at a hazardous waste accumulation area until it is characterized. If the waste is found not to be hazardous, it will be stored in an appropriate nonhazardous storage area. Characterization of this waste stream will be performed through AK of the waste materials, the methods of generation, and the levels of contamination observed in the associated environmental media. The Laboratory expects disposable sampling supplies to be designated as nonhazardous, nonradioactive waste, with the exception of residues from some field test kits, which will be deemed hazardous. Nonhazardous wastes will be disposed of at an off-site disposal facility permitted for the disposal of industrial waste; hazardous wastes will be sent to an off-site facility permitted for the treatment and/or disposal of hazardous waste.

B-2.4 Decontamination Fluids

The decontamination fluids waste stream will consist of liquid wastes from decontamination activities (e.g., decontamination solutions and rinse waters). Following waste-minimization practices, the Laboratory employs dry decontamination methods to the extent possible. If dry decontamination cannot be performed, liquid decontamination wastes will be collected in containers at the point of generation and transferred to accumulation drums. Decontamination fluids will be accumulated in drums, and temporarily stored at a hazardous waste accumulation area until it is characterized. If this waste stream is found not to be hazardous, the waste will be stored in an appropriate nonhazardous storage area. The Laboratory expects that the majority of decontamination fluids will be designated as nonhazardous, nonradioactive liquid waste. A potential exists for some decontamination rinsate to be designated as low-level radioactive or mixed waste at several of the sites because of presence of radionuclides, metals, and/or HE. Nonhazardous and radioactive liquid wastes may be treated and discharged by several Clean Water Act-permitted on-site treatment facilities, provided the waste meets the facility's waste acceptance criteria (WAC). Mixed waste and waste that do not meet the WAC of Laboratory treatment facilities will be sent to permitted off-site treatment facilities.

B-2.5 Returned or Excess Samples

Soil samples either returned from or obtained but not submitted to the analytical laboratory will be containerized in a 5-gal. bucket or 55-gal. drum and stored at a hazardous waste accumulation area until it is characterized. If this waste stream is found not to be hazardous, the waste will be stored in an appropriate nonhazardous storage area. 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.

The selection of waste containers will be based on the appropriate U.S. Department of Transportation (DOT) requirements and the type and amount of IDW planned to be generated. Immediately following containerization, each waste container will be individually labeled by waste classification, item identification number, radioactivity (if applicable), and date generated. Waste containers will be managed in clearly marked and appropriately constructed waste accumulation areas. Waste accumulation area

posting, regulated storage duration, and inspection requirements will be based on the type of IDW and its classification.

B-2.6 Spent Immunoassay Test Kits (D-TECH)

Sampling containers and materials from used test kits include glass ampules, soil, and miscellaneous plastic/Teflon. Because of the solvents present, this waste is assumed to be hazardous based on its ignitability. This waste will be stored in an appropriate container at a waste accumulation area until a final waste determination is made. Nonhazardous wastes will be disposed of at an off-site disposal facility permitted for the disposal of industrial waste; hazardous wastes will be sent to an off-site facility permitted for the treatment and/or disposal of hazardous waste.

B-3.0 WASTE MANAGEMENT

All wastes will be managed in accordance with applicable federal, state, DOE, and Laboratory requirements. The IDW waste streams, expected waste types, estimated waste volumes, and other data are listed in Table B-3.0-1.

All waste drums and containers (rolloff bins) will remain at a registered hazardous waste accumulation area until analytical results have been received and waste characterization completed shows that the waste is nonhazardous.

Before field-investigation activities begin, a WCSF will be prepared and approved as required by the current version of SOP-5023. The WCSF will provide detailed information about IDW characterization, management, containerization, and potential volume generation for each subaggregate.

The IDW will be characterized through existing data and/or documentation, direct sampling of the IDW, or sampling of the media being investigated (e.g., surface soil, subsurface soil). If sampling is necessary, the procedures will be described in a sampling and analysis plan that will be developed in conjunction with the WCSF.

Some wastes will be characterized on the basis of AK rather than direct waste analysis. The AK characterization will consist of the results of analyzing the environmental media associated with each waste stream. For example, spent PPE and disposable sampling supplies that have potentially come into contact with contaminated media will be characterized based on the analytical results for samples of that media. Similarly, borehole drill cuttings will be characterized by the analytical results for the core samples from that borehole. If decontamination fluids are to be sent off-site for disposal, they will be sampled to demonstrate compliance with the WAC of the receiving facility.

B-4.0 WASTE CONTAINERS AND TRANSPORTATION

The selection of waste containers will be based on both the appropriate DOT requirements and the type and amount of IDW anticipated to be generated. Immediately following containerization, each waste container will be individually labeled to identify the waste classification, the item identification number, its radioactivity (if applicable), and the date of generation. Waste containers will be managed in clearly marked and appropriately constructed waste accumulation areas. Waste accumulation area postings, regulated storage duration, and inspection requirements will be based on IDW type and classification. The wastes will be stored in accordance with Laboratory hazardous and mixed waste requirements documents.

Transportation of IDW will comply with appropriate DOT requirements. Transportation and disposal requirements will be detailed in the WCSF and approved prior to the generation of waste.

B-5.0 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 Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the 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 Directorate. 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 10, 1990. "Module VIII of RCRA Permit No. NM0890010515, issued to Los Alamos National Laboratory, Los Alamos, New Mexico," EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, 001585)

EPA (U.S. Environmental Protection Agency), April 19, 1994. "Module VIII of RCRA Permit No. NM0890010515, EPA, Region 6, New Requirements Issued to Los Alamos National Laboratory, Los Alamos, New Mexico," EPA Region 6, Hazardous Waste Management Division, Dallas, Texas. (EPA 1994, 044146)

LANL (Los Alamos National Laboratory), November 2006. "Los Alamos National Laboratory Hazardous Waste Minimization Report," Los Alamos National Laboratory document LA-UR-06-8175, Los Alamos, New Mexico. (LANL 2006, 096015)

Table B-3.0-1
Generation and Management of the Estimated
Investigation-Derived Waste for TA-49 NES

Waste Stream	Expected Waste Type	Estimated Volume*	Characterization Method	On-Site Management	Expected Disposition
Drill Cuttings	Industrial waste, nonhazardous, nonradioactive	6 yd^3	Analytical results from waste samples and core samples	Accumulation in 55-gal. drums, covered rolloff containers, or yd^3 soft-sided containers	Permitted off-site facility for which waste meets acceptance criteria
Soil*	Industrial waste, nonhazardous, nonradioactive	1.2 yd^3	Analytical results from waste samples	Accumulation in covered rolloff containers	Permitted off-site facility for which waste meets acceptance criteria
Spent PPE and Disposable Sampling Supplies	Industrial waste, nonhazardous, nonradioactive	0.98 yd^3	AK	Accumulation in 55-gal. drums	Permitted off-site facility for which waste meets acceptance criteria
Decontamination Fluids	Liquid waste, nonhazardous or low-level radioactive	142 gal.	Analytical results from waste samples	Accumulation in 55-gal. drums	On-site Clean Water Act-permitted treatment facility for which waste meets acceptance criteria
Returned or Excess Samples	Industrial waste, nonhazardous, nonradioactive	1yd^3	AK from sample analytical data and method of generation	Accumulation in a 5-gal. bucket or 55-gal. drum, stored on Laboratory property	Permitted off-site facility for which waste meets acceptance criteria
Spent Immunoassay Test Kits (D-TECH)	Liquid waste, hazardous, nonradioactive	3.7 gal.	AK–spent soil and acetone	Accumulation in a 55-gal. drum	Permitted off-site industrial waste facility for which waste meets acceptance criteria
	Liquid waste, nonhazardous, nonradioactive	70.3 gal.	AK–glass ampules, miscellaneous plastic/Teflon	Accumulation in 55-gal. drums	Permitted off-site facility for which waste meets acceptance criteria

*Sample depths, numbers, and/or locations are yet to be determined.

Appendix C

Alpha and Beta Speciation Threshold Determination

C-1.0 INTRODUCTION

This appendix discusses the methods used to determine gross alpha and gross beta threshold concentrations for which samples will be sent for analytical speciation by isotopic alpha or isotopic beta analyses. Because gross alpha and gross beta analyses can be conducted quickly, their analyses can be used to identify areas that have been impacted by lab activities and to direct ongoing sampling. These threshold concentrations represent the estimated total alpha and beta activities caused by naturally-occurring isotopes present in soils at Los Alamos National Laboratory (LANL or the Laboratory). The threshold concentrations to be used at Technical Area (TA) 49 to determine samples for additional analyses are 25 pCi/g for gross alpha and 50 pCi/g for gross beta.

The half-lives of radionuclides produced from the radioactive decay of uranium-238, uranium-235, and thorium-232 are much shorter than those of their respective parents. As a result, the rate of decay of the parent and progeny radionuclides come into equilibrium. This condition, known as secular equilibrium, exists in unimpacted soils and rock at the Laboratory. When secular equilibrium is present, the activities of the parent radionuclide and all progeny will be the same. The principal of secular equilibrium is used to determine the total alpha and beta activity expected in unimpacted soils at the Laboratory and then to determine the threshold at which alpha and beta activity rise above background levels.

The decay of three naturally occurring radionuclides, uranium-238, uranium-235, and thorium-232, and their alpha particle emitting progeny account for over 99.5% of alpha particle activity in unimpacted soils at the Laboratory. The beta particle emitting daughter radionuclides resulting from the decay from these same three radionuclides and naturally occurring potassium-40 account for over 95% of beta particle activity in unimpacted soils at the Laboratory. Fallout from atmospheric testing of nuclear weapons in the 1950s accounts for the remaining alpha and beta particle activity in unimpacted soils at the Laboratory.

A defensible and laboratory-wide set of background data were collected and characterized in the Laboratory background study (LANL 1998, 059730). These results form the basis for determining threshold values for speciation of gross alpha and gross beta analyses. Threshold values from the Laboratory background study then are compared to sediment environmental monitoring data collected at TA-49 to ensure the reasonableness of the statistically derived values.

C-2.0 GROSS ALPHA GROSS BETA THRESHOLD DETERMINATION

Threshold values are statistically derived using the same analytical data used to generate the Laboratory background study (LANL 1998, 059730). In the Laboratory background study, 24 sediment samples received analyses of uranium-238, uranium-235, and thorium-232. These three isotopes and their progeny form three long-lived naturally occurring decay chains. Potassium-40 was also analyzed in the 24 sediment samples, which is the other major naturally occurring contributor to beta activity. Isotopic uranium, isotopic thorium, and potassium-40 results from these 24 sediment samples are presented in Table C-2.0-1. The samples were not analyzed for the fallout isotopes cesium-137 or strontium-90; therefore, they are not included in the gross alpha/beta threshold calculations. The uranium-238 decay chain includes eight alpha-emitting radionuclides and six beta-emitting radionuclides in secular equilibrium. The uranium-235 decay chain includes seven alpha-emitting radionuclides and four beta-emitting radionuclides in secular equilibrium. The thorium-232 decay chain includes six alpha-emitting radionuclides and four beta-emitting radionuclides in secular equilibrium. Potassium-40 decays by beta directly to the stable calcium-40. Table C-2.0-2 summarizes the number of alpha and beta-emitting progeny produced by each naturally occurring decay chain. The sum of alpha and

beta-emitting radionuclides for each sediment sample used in the background study is presented in Table C-2.0-3.

Several data preparation steps are needed before statistical calculations can be performed on the background data. First, the sums of alpha and beta-emitting radionuclides are determined for each sample using the decay chain and assuming secular equilibrium. Next, the data must be evaluated to determine whether the sums of alpha and beta-emitting radionuclides are derived from a single population. This can be demonstrated by fitting the background data to a standard statistical distribution. The fit of the sum of alpha emittors from the long-lived decay chains, the sum of the beta emittors from the long-lived decay chains, and potassium-40 can each be fitted to a normal statistical distribution as shown in Figures C-2.0-1, C-2.0-2, and C-2.0-3. Probability plots of the sums of alpha emittors from the long-lived decay chains, the sum of the beta emittors from the long-lived decay chains, and potassium-40 are also presented in Figures C-2.0-1, C-2.0-2, and C-2.0-3. In each probability plot, normality may be assumed because the Anderson-Darling test statistic is small (significantly less than 1) and the corresponding p-value is greater than a significance level of 0.05 (otherwise stated, the 95% confidence limit) thus accepting the null hypothesis that the distribution is normal (the null hypothesis is rejected if the p-value is less than the significance level).

Because the sum of the alpha-emitting isotopes from the long lived decay chains, the sum of the beta-emitting isotopes from the long-lived decay chains, and potassium-40 are each normally distributed, upper threshold limit (UTL) values are calculated for each using Equation C-2.0-1 (LANL 1998, 059730). The k-factor is 1.714 with 24 samples in the data set at a 95% confidence interval (EPA 2006, 098701, Table A-2).

$$UTL_{0.95} = \text{mean} + (\text{standard deviation} \times \text{k-factor}). \qquad \textbf{Equation C-2.0-1}$$

UTLs for each alpha-emitting isotope from the long-lived decay chains, for beta-emitting isotopes from the long-lived decay chains, and potassium-40 are calculated using the summarized data presented in Table C-2.0-3. UTLs calculated for each normally distributed suite of isotopes are presented in Table C-2.0-4.

C-3.0 REVIEW OF UTL REASONABLENESS

MDA AB canyon sediment samples collected during 2001, 2002, 2003, and 2004 were analyzed for gross alpha, gross beta, isotopic uranium, isotopic thorium, isotopic plutonium, and isotopic beta analyses. Refer to Table 3.8-3 in the historical investigation report (HIR) (LANL 2007, 098492) for isotopic alpha and isotopic beta analytical results. Table C-3.0-1 presents the gross alpha and gross beta analytical results associated with these isotopic analyses. Correlating these results to their UTLs indicate that one sample from MDA AB-3, and one sample from MDA AB-3N would have been speciated for isotopic alpha and no samples would have been speciated for isotopic beta at the UTL values. Graphs showing the correlation of isotopic and gross analyses are presented in Figures C-3.0-1 and C-3.0-2.

The gross beta UTL of 50 pCi/g does not exclude any samples from speciation that contained elevated beta-emitting radionuclides. The gross alpha UTL of 25 pCi/g excluded three samples that contained plutonium-239/240 and americium-241 above fallout values (FVs). The following assumptions made in the determination of the gross alpha and gross beta UTLs suggest that comparison of project-specific data to the UTLs is justified.

- Secular equilibrium assumes a closed system. Some radionuclides in the decay chain (e.g., radon-220), are gasses, while others are more or less soluble in water. For the purposes of determining UTLs, the media evaluated are assumed to be part of a closed system.

- Gross alpha and gross beta analyses are not 100% efficient. Some proportion of alpha and beta particles emitted are not counted because of sampling, preparation, and analysis losses. Corrections performed during analysis are not capable of compensating for all of the losses.
- Several uranium-235 and uranium-238 results were not detected and are qualified with "U". These nondetected values have been incorporated into the statistical data set without modification.
- Background values (BVs) of several radionuclides of concern, including plutonium-239/240 and americium-241, are small compared to concentrations of isotopic uranium and thorium present in background samples at the Laboratory. Small concentration increases that put isotopic plutonium and americium over BVs are not always translated into gross alpha or gross beta results above UTL values.

Manual review of the sediment data presented in Figures C-3.0-1 and C-3.0-2 indicate that a project-specific gross alpha UTL value of 25 pCi/g captured two of five plutonium-239/240 and two of five americium-241 results with concentrations above FVs.

Where Category 2 or Category 3 gross alpha analyses exceed 25 pCi/g, the samples will be submitted for laboratory analyses of isotopic alpha-emitting radionuclides including americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Where any gross beta analyses exceed 50 pCi/g, the samples will be submitted for laboratory analyses of isotopic beta-emitting radionuclides including iodine-129, strontium-90, and technetium-99. If either gross alpha or gross beta exceed their respective project-specific threshold values in Category 3 analyses, the samples collected from that location will receive analysis of target analyte list (TAL) metals and gamma-emitting radionuclides.

C-4.0 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 Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

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EPA (U.S. Environmental Protection Agency), February 2006. "Data Quality Assessment: Statistical Methods for Practitioners," EPA QA/G-9S, EPA/240/B-06/003, Office of Environmental Information, Washington, D.C. (EPA 2006, 098701)

LANL (Los Alamos National Laboratory), September 22, 1998. "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-98-4847, Los Alamos, New Mexico. (LANL 1998, 059730)

LANL (Los Alamos National Laboratory), October 2007. “Historical Investigation Report for Sites at Technical Area 49 Inside the Nuclear Environmental Site Boundary,” Los Alamos National Laboratory document LA-UR-07-6078, Los Alamos, New Mexico. (LANL 2007, 098492)

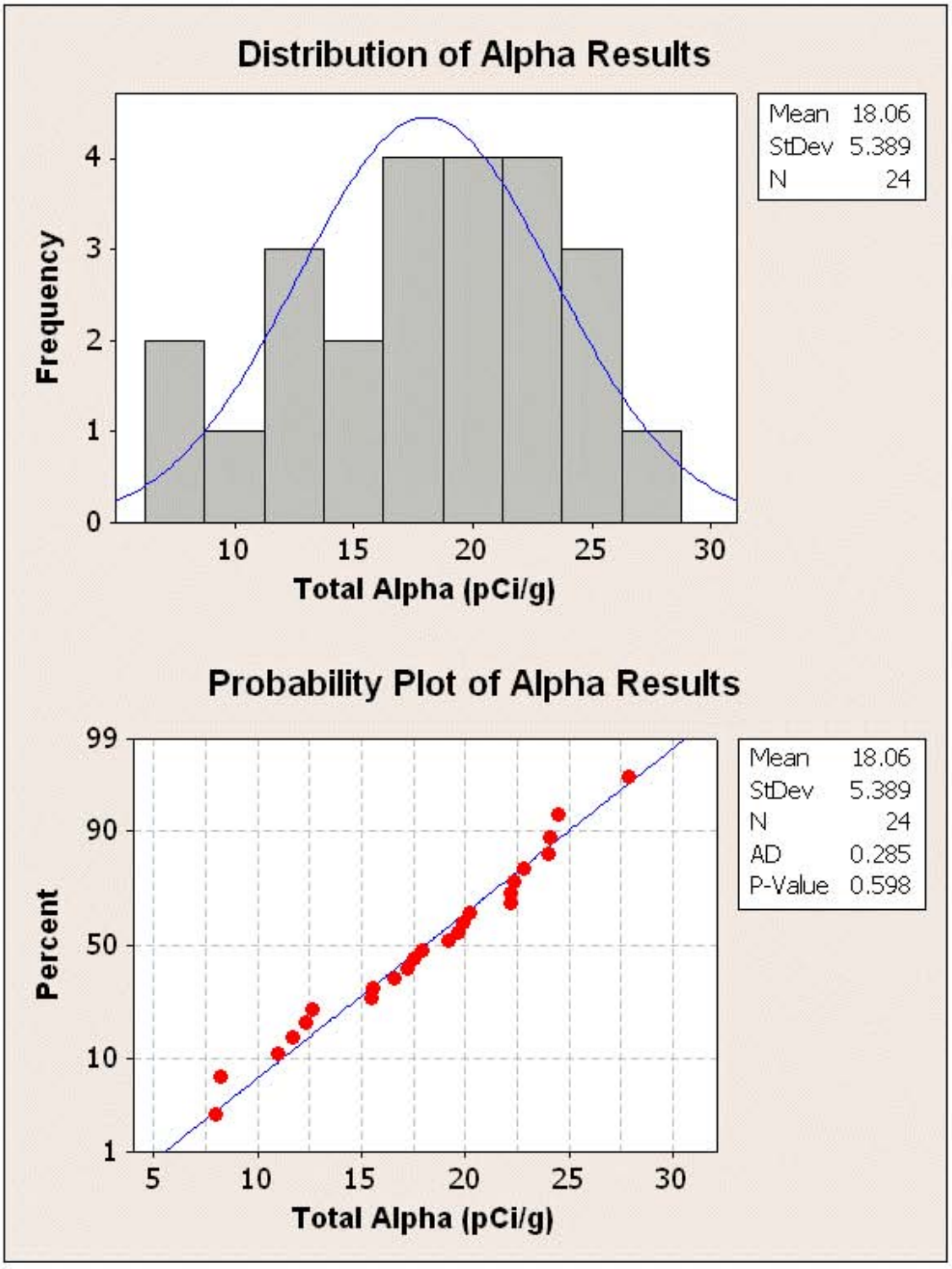

Figure C-2.0-1 Distribution and probability plot of total alpha results

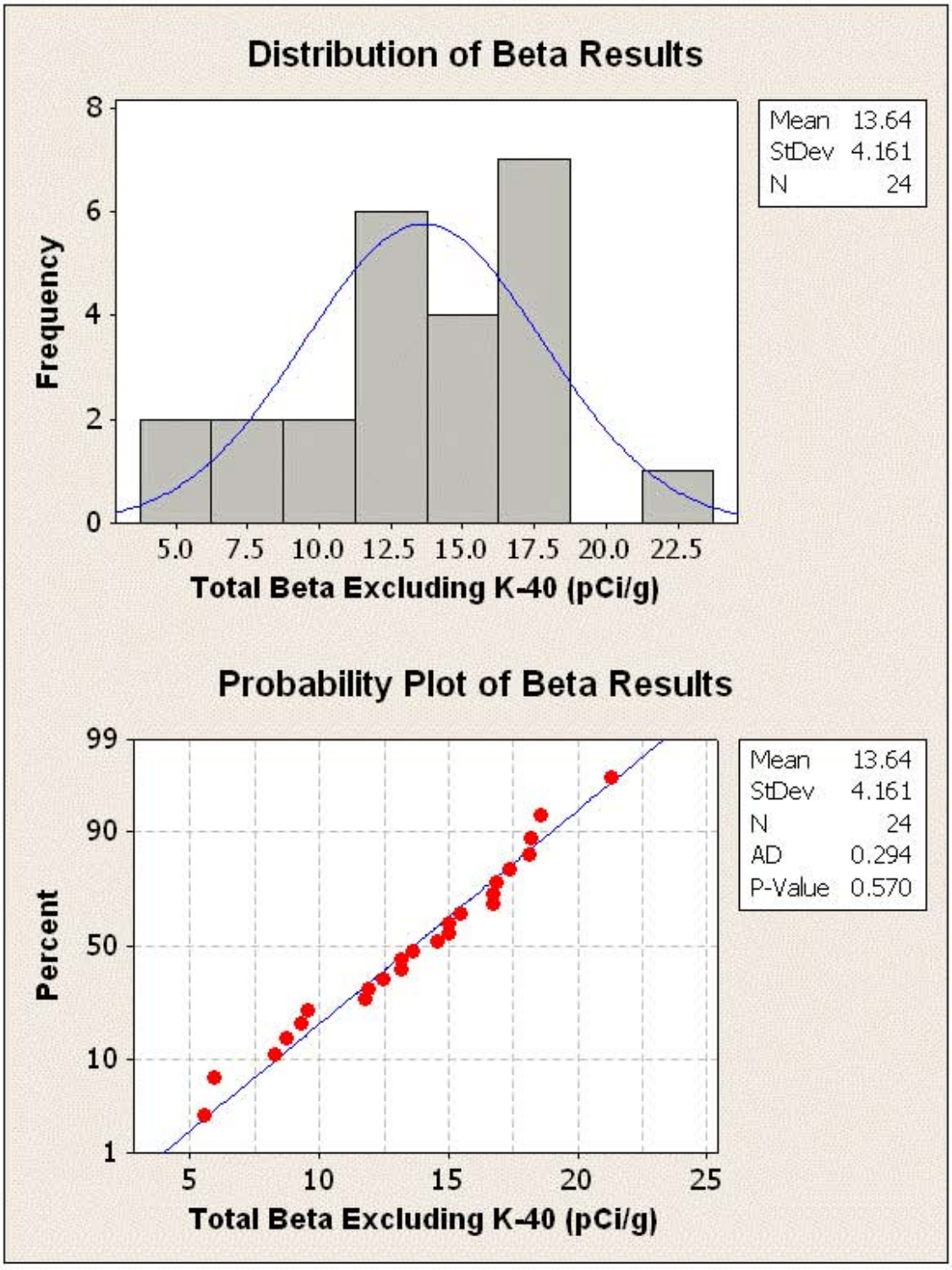

Figure C-2.0-2 Distribution and probability plot of decay chain beta results

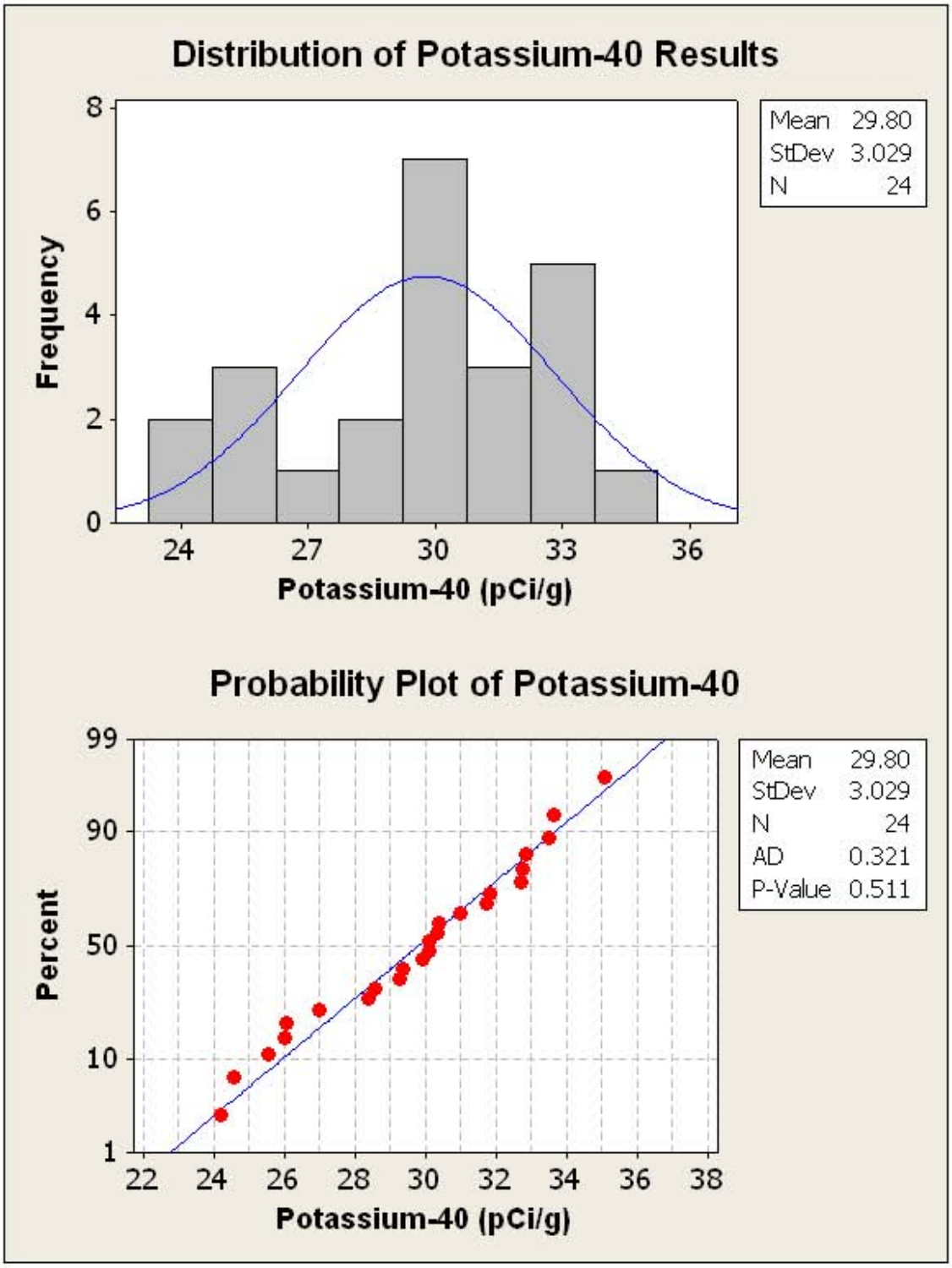

Figure C-2.0-3 Distribution and probability plot of potassium-40 results

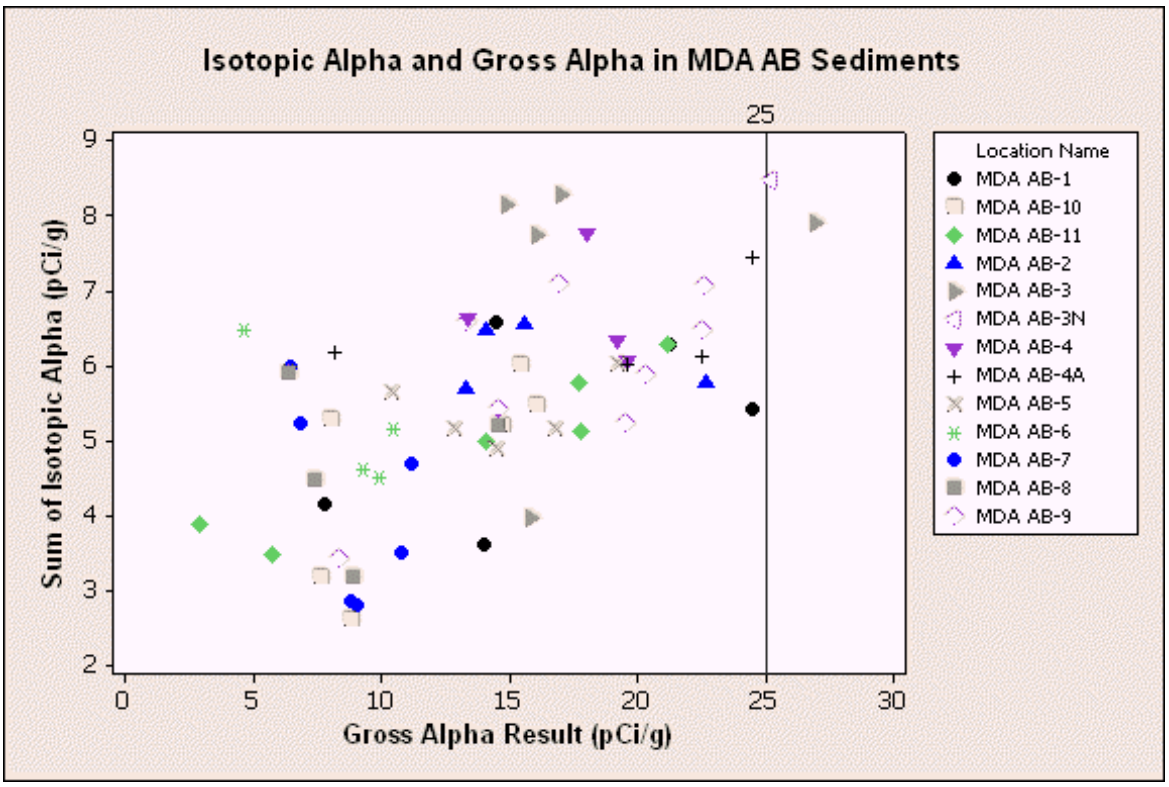

Figure C-3.0-1 Correlation of isotopic alpha and gross alpha analyses in MDA AB sediment

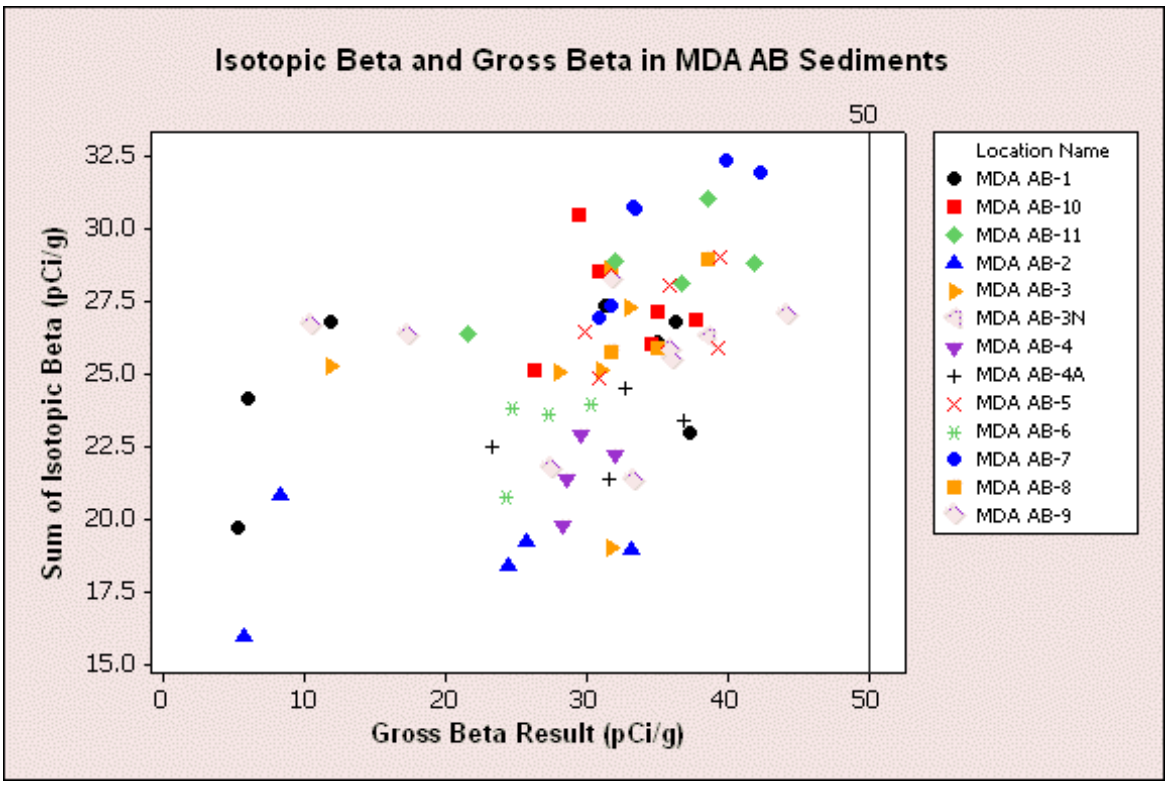

Figure C-3.0-2 Correlation of isotopic beta and gross beta analyses in MDA AB sediment

Table C-2.0-1
Background Study Sample Results

Sample ID	Media	Analyte	Result (pCi/g)
04GU-96-0001	Sediment	Potassium-40	31
04GU-96-0002	Sediment	Potassium-40	28.38
04GU-96-0003	Sediment	Potassium-40	30.11
04GU-96-0004	Sediment	Potassium-40	28.59
04GU-96-0005	Sediment	Potassium-40	29.91
04GU-96-0006	Sediment	Potassium-40	29.28
04GU-96-0007	Sediment	Potassium-40	24.21
04LA-96-0050	Sediment	Potassium-40	30.37
04LA-96-0051	Sediment	Potassium-40	24.57
04LA-96-0052	Sediment	Potassium-40	32.86
04LA-96-0053	Sediment	Potassium-40	32.79
04LA-96-0054	Sediment	Potassium-40	33.65
04LA-96-0055	Sediment	Potassium-40	33.53
04LA-96-0056	Sediment	Potassium-40	29.39
04PU-96-0010	Sediment	Potassium-40	35.1
04PU-96-0011	Sediment	Potassium-40	31.85
04PU-96-0012	Sediment	Potassium-40	30.12
04PU-96-0013	Sediment	Potassium-40	32.75
04PU-96-0014	Sediment	Potassium-40	31.76
04PU-96-0015	Sediment	Potassium-40	30.41
04PU-96-0016	Sediment	Potassium-40	26.98
04PU-96-0017	Sediment	Potassium-40	26.08
04PU-96-0018	Sediment	Potassium-40	26.03
04PU-96-0019	Sediment	Potassium-40	25.53
04GU-96-0001	Sediment	Thorium-232	1.54
04GU-96-0002	Sediment	Thorium-232	1.65
04GU-96-0003	Sediment	Thorium-232	1.43
04GU-96-0004	Sediment	Thorium-232	1.83
04GU-96-0005	Sediment	Thorium-232	0.99
04GU-96-0006	Sediment	Thorium-232	1.8
04GU-96-0007	Sediment	Thorium-232	1.23
04LA-96-0050	Sediment	Thorium-232	1.36
04LA-96-0051	Sediment	Thorium-232	0.94
04LA-96-0052	Sediment	Thorium-232	2.02
04LA-96-0053	Sediment	Thorium-232	1.32
04LA-96-0054	Sediment	Thorium-232	1.38
04LA-96-0055	Sediment	Thorium-232	1.99

Table C-2.0-1 (continued)

Sample ID	Media	Analyte	Result (pCi/g)
04LA-96-0056	Sediment	Thorium-232	1.86
04PU-96-0010	Sediment	Thorium-232	0.89
04PU-96-0011	Sediment	Thorium-232	1.01
04PU-96-0012	Sediment	Thorium-232	1.55
04PU-96-0013	Sediment	Thorium-232	1.41
04PU-96-0014	Sediment	Thorium-232	1.23
04PU-96-0015	Sediment	Thorium-232	1.12
04PU-96-0016	Sediment	Thorium-232	1.29
04PU-96-0017	Sediment	Thorium-232	0.66
04PU-96-0018	Sediment	Thorium-232	2.03
04PU-96-0019	Sediment	Thorium-232	1.88
04GU-96-0001	Sediment	Uranium-235	0.12
04GU-96-0002	Sediment	Uranium-235	0.15
04GU-96-0003	Sediment	Uranium-235	0.12
04GU-96-0004	Sediment	Uranium-235	0.13
04GU-96-0005	Sediment	Uranium-235	0.1
04GU-96-0006	Sediment	Uranium-235	0.13
04GU-96-0007	Sediment	Uranium-235	0.06 (U)
04LA-96-0050	Sediment	Uranium-235	0.14
04LA-96-0051	Sediment	Uranium-235	0.11
04LA-96-0052	Sediment	Uranium-235	0.16
04LA-96-0053	Sediment	Uranium-235	0.13
04LA-96-0054	Sediment	Uranium-235	0.12
04LA-96-0055	Sediment	Uranium-235	0.14
04LA-96-0056	Sediment	Uranium-235	0.14
04PU-96-0010	Sediment	Uranium-235	0.06 (U)
04PU-96-0011	Sediment	Uranium-235	0.06
04PU-96-0012	Sediment	Uranium-235	0.06 (U)
04PU-96-0013	Sediment	Uranium-235	0.06 (U)
04PU-96-0014	Sediment	Uranium-235	0.06 (U)*
04PU-96-0015	Sediment	Uranium-235	0.06 (U)
04PU-96-0016	Sediment	Uranium-235	0.06
04PU-96-0017	Sediment	Uranium-235	0.06 (U)
04PU-96-0018	Sediment	Uranium-235	0.06 (U)
04PU-96-0019	Sediment	Uranium-235	0.06 (U)
04GU-96-0001	Sediment	Uranium-238	1.4
04GU-96-0002	Sediment	Uranium-238	1.7
04GU-96-0003	Sediment	Uranium-238	1.4
04GU-96-0004	Sediment	Uranium-238	1.5

Table C-2.0-1 (continued)

Sample ID	Media	Analyte	Result (pCi/g)
04GU-96-0005	Sediment	Uranium-238	0.86
04GU-96-0006	Sediment	Uranium-238	1.5
04GU-96-0007	Sediment	Uranium-238	1.1
04LA-96-0050	Sediment	Uranium-238	1.5
04LA-96-0051	Sediment	Uranium-238	0.75
04LA-96-0052	Sediment	Uranium-238	2.1
04LA-96-0053	Sediment	Uranium-238	1.3
04LA-96-0054	Sediment	Uranium-238	1.2
04LA-96-0055	Sediment	Uranium-238	1.6
04LA-96-0056	Sediment	Uranium-238	1.7
04PU-96-0010	Sediment	Uranium-238	0.74
04PU-96-0011	Sediment	Uranium-238	0.84
04PU-96-0012	Sediment	Uranium-238	1.5
04PU-96-0013	Sediment	Uranium-238	1.1
04PU-96-0014	Sediment	Uranium-238	0.06 (U)
04PU-96-0015	Sediment	Uranium-238	1.2
04PU-96-0016	Sediment	Uranium-238	1.3
04PU-96-0017	Sediment	Uranium-238	0.51
04PU-96-0018	Sediment	Uranium-238	1.7
04PU-96-0019	Sediment	Uranium-238	1.5 (U)

*U = The result is not detected at the concentration reported.

Table C-2.0-2
Background Study Statistics

Analyte	Media	Number of Alpha Progeny	Number of Beta Progeny
Potassium-40	Sediment	0	1
Thorium-232	Sediment	6	4
Uranium-235	Sediment	7	4
Uranium-238	Sediment	8	6

Table C-2.0-3
Background Study Sample Results Summation

Sample ID	Matrix	Total Alpha (pCi/g)	Beta (pCi/g) from Potassium-40	Beta (pCi/g) from Decay Chain	Total Beta (pCi/g)
04GU-96-0001	Sediment	19.88	31	15.04	46.04
04GU-96-0002	Sediment	22.85	28.38	17.4	45.78
04GU-96-0003	Sediment	19.22	30.11	14.6	44.71
04GU-96-0004	Sediment	22.39	28.59	16.84	45.43
04GU-96-0005	Sediment	12.66	29.91	9.52	39.43
04GU-96-0006	Sediment	22.21	29.28	16.72	46
04GU-96-0007	Sediment	15.5	24.21	11.76	35.97
04LA-96-0050	Sediment	19.64	30.37	15	45.37
04LA-96-0051	Sediment	11.66	24.57	8.7	33.27
04LA-96-0052	Sediment	27.94	32.86	21.32	54.18
04LA-96-0053	Sediment	17.93	32.79	13.6	46.39
04LA-96-0054	Sediment	17.52	33.65	13.2	46.85
04LA-96-0055	Sediment	24.12	33.53	18.12	51.65
04LA-96-0056	Sediment	24.04	29.39	18.2	47.59
04PU-96-0010	Sediment	10.94	35.1	8.24	43.34
04PU-96-0011	Sediment	12.36	31.85	9.32	41.17
04PU-96-0012	Sediment	20.22	30.12	15.44	45.56
04PU-96-0013	Sediment	16.58	32.75	12.48	45.23
04PU-96-0014	Sediment	8.22	31.76	5.52	37.28
04PU-96-0015	Sediment	15.54	30.41	11.92	42.33
04PU-96-0016	Sediment	17.26	26.98	13.2	40.18
04PU-96-0017	Sediment	7.95	26.08	5.94	32.02
04PU-96-0018	Sediment	24.5	26.03	18.56	44.59
04PU-96-0019	Sediment	22.2	25.53	16.76	42.29

Table C-2.0-4
Background Study UTL Calculations

Analytes	Calculation	UTL at 95% Confidence (pCi/g)
Decay Chain Isotopic Alpha-Emitting Radionuclides	19.31 + (5.825 x 1.714)	29.3
Decay Chain Isotopic Beta-Emitting Radionuclides	13.64 + (4.161 x 1.714)	20.8
Potassium-40 Beta	29.80 + (3.029 x 1.714)	35.0

Table C-3.0-1
Gross Alpha and Gross Beta Results in MDA AB Sediments

Year	Analyte	Location Name	Result (pCi/g)
2001	Gross alpha	MDA AB-1	7.77
2001	Gross alpha	MDA AB-1	14
2001	Gross alpha	MDA AB-10	7.6
2001	Gross alpha	MDA AB-11	21.2
2001	Gross alpha	MDA AB-2	22.7
2001	Gross alpha	MDA AB-3	15.8
2001	Gross alpha	MDA AB-3N	25.2
2001	Gross alpha	MDA AB-4	19.6
2001	Gross alpha	MDA AB-4A	22.5
2001	Gross alpha	MDA AB-5	19.2
2001	Gross alpha	MDA AB-6	9.31
2001	Gross alpha	MDA AB-7	9.09
2001	Gross alpha	MDA AB-8	8.9
2001	Gross alpha	MDA AB-9	22.6
2001	Gross beta	MDA AB-1	36.3
2001	Gross beta	MDA AB-1	31.4
2001	Gross beta	MDA AB-10	37.8
2001	Gross beta	MDA AB-11	36.8
2001	Gross beta	MDA AB-2	33.2
2001	Gross beta	MDA AB-3	33
2001	Gross beta	MDA AB-3N	38.6
2001	Gross beta	MDA AB-4	32.1
2001	Gross beta	MDA AB-4A	31.6
2001	Gross beta	MDA AB-5	39.3
2001	Gross beta	MDA AB-6	30.4
2001	Gross beta	MDA AB-7	33.5
2001	Gross beta	MDA AB-8	35.1
2001	Gross beta	MDA AB-9	44.3
2002	Gross alpha	MDA AB-1	24.5
2002	Gross alpha	MDA AB-10	8.81
2002	Gross alpha	MDA AB-11	17.7
2002	Gross alpha	MDA AB-2	13.3
2002	Gross alpha	MDA AB-3	26.9
2002	Gross alpha	MDA AB-4	18
2002	Gross alpha	MDA AB-4A	24.5
2002	Gross alpha	MDA AB-5	14.5
2002	Gross alpha	MDA AB-6	10.5
2002	Gross alpha	MDA AB-7	10.8

Table C-3.0-1 (continued)

Year	Analyte	Location Name	Result (pCi/g)
2002	Gross alpha	MDA AB-8	14.6
2002	Gross alpha	MDA AB-9	20.3
2002	Gross beta	MDA AB-1	11.9
2002	Gross beta	MDA AB-10	30.9
2002	Gross beta	MDA AB-11	32
2002	Gross beta	MDA AB-2	8.22
2002	Gross beta	MDA AB-3	11.9
2002	Gross beta	MDA AB-4	28.6
2002	Gross beta	MDA AB-4A	36.9
2002	Gross beta	MDA AB-5	35.9
2002	Gross beta	MDA AB-6	27.3
2002	Gross beta	MDA AB-7	39.9
2002	Gross beta	MDA AB-8	38.6
2002	Gross beta	MDA AB-9	10.4
2003	Gross alpha	MDA AB-1	14.5
2003	Gross alpha	MDA AB-10	8.04
2003	Gross alpha	MDA AB-11	2.91
2003	Gross alpha	MDA AB-2	15.6
2003	Gross alpha	MDA AB-3	16.1
2003	Gross alpha	MDA AB-4	13.4
2003	Gross alpha	MDA AB-4A	8.2
2003	Gross alpha	MDA AB-5	10.4
2003	Gross alpha	MDA AB-6	4.62
2003	Gross alpha	MDA AB-7	6.45
2003	Gross alpha	MDA AB-8	6.41
2003	Gross alpha	MDA AB-9	13.3
2003	Gross beta	MDA AB-1	37.3
2003	Gross beta	MDA AB-10	26.3
2003	Gross beta	MDA AB-11	21.6
2003	Gross beta	MDA AB-2	25.8
2003	Gross beta	MDA AB-3	31.8
2003	Gross beta	MDA AB-4	28.3
2003	Gross beta	MDA AB-4A	23.3
2003	Gross beta	MDA AB-5	30.9
2003	Gross beta	MDA AB-6	24.3
2003	Gross beta	MDA AB-7	30.9
2003	Gross beta	MDA AB-8	31.7
2003	Gross beta	MDA AB-9	27.5
2004	Gross alpha	MDA AB-1	21.3

Table C-3.0-1 (continued)

Year	Analyte	Location Name	Result (pCi/g)
2004	Gross alpha	MDA AB-10	15.4
2004	Gross alpha	MDA AB-11	17.8
2004	Gross alpha	MDA AB-2	14.1
2004	Gross alpha	MDA AB-3	17
2004	Gross alpha	MDA AB-4	19.2
2004	Gross alpha	MDA AB-4A	19.6
2004	Gross alpha	MDA AB-5	12.8
2004	Gross alpha	MDA AB-6	9.89
2004	Gross alpha	MDA AB-7	11.2
2004	Gross alpha	MDA AB-8	7.42
2004	Gross alpha	MDA AB-9	22.5
2004	Gross beta	MDA AB-1	35.1
2004	Gross beta	MDA AB-10	34.7
2004	Gross beta	MDA AB-11	42
2004	Gross beta	MDA AB-2	24.4
2004	Gross beta	MDA AB-3	31.1
2004	Gross beta	MDA AB-4	29.6
2004	Gross beta	MDA AB-4A	32.8
2004	Gross beta	MDA AB-5	29.9
2004	Gross beta	MDA AB-6	24.7
2004	Gross beta	MDA AB-7	33.4
2004	Gross beta	MDA AB-8	31.7
2004	Gross beta	MDA AB-9	35.9