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Date: January 12, 2005
 Refer To: ER2005-0024

Mr. James Bearzi
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SUBJECT: REPLACEMENT SECTIONS FOR APPROVED INVESTIGATION WORK PLAN FOR MATERIAL DISPOSAL AREA G, SOLID WASTE MANAGEMENT UNIT 54-013(b)-99, AT TECHNICAL AREA 54, REVISION 1

Dear Mr. Bearzi:

On November 5, 2004, the New Mexico Environment Department approved the "Investigation Work Plan for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99, at Technical Area 54, Revision 1," with modifications.

Attached are the following replacement sections to the work plan:

- The main text of the investigation work plan
- Appendix A, Acronyms, Glossary, and Metric Conversions
- Appendix H, Investigation-Derived Waste Management

These sections incorporate NMED comments in the November 5, 2004, letter and LANL's responses to the notice of disapproval for the work plan dated October 15, 2004. The replacement sections will be used by our field crews to implement the work plan.

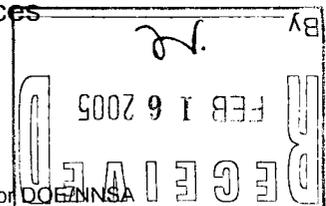
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Sincerely,

David McInroy, Deputy Project Director
 Environmental Stewardship
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Sincerely,

David Gregory, Project Manager
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Technical Area 54, Revision 1

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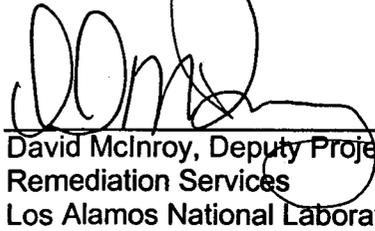
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REMEDATION SERVICES (RRES-RS) PROJECT
TECHNICAL REPRESENTATIVES**

Document Title: **Investigation Work Plan for Material Disposal Area G, Solid
Waste Management Unit 54-013(b)-99, at Technical Area 54,
Revision 1**

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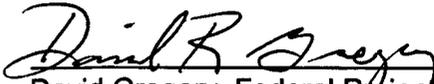

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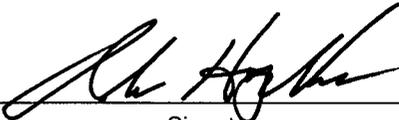
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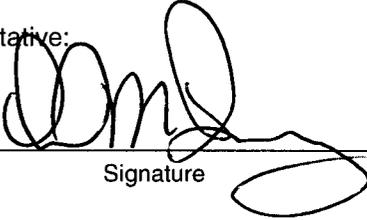
Investigation Work Plan for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99, at Technical Area 54, Revision 1

December 2004

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Updated December 2004
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**Investigation Work Plan for
Material Disposal Area G,
Solid Waste Management Unit
54-013(b)-99, at Technical Area 54,
Revision 1**

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Prepared by
Environmental Stewardship–Remediation Services

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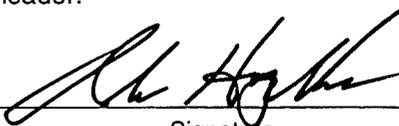
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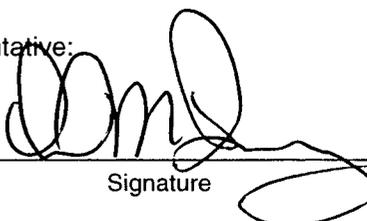
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Responsible DOE representative:

David Gregory		Federal Project Director	DOE-LASO	1/13/05
Printed Name	Signature	Title	Organization	Date

EXECUTIVE SUMMARY

This investigation work plan presents the scope of work approved by the New Mexico Environment Department (NMED) for completing the investigation of Material Disposal Area (MDA) G, consolidated Solid Waste Management Unit (SWMU) 54-013(b)-99, which consists of SWMUs 54-013(b), 54-014(b-d), 54-015(k), 54-017, 54-018, 54-019, and 54-020. These SWMUs are located within Area G at Technical Area 54 at Los Alamos National Laboratory (the Laboratory). This work plan also describes the sampling activities and analytical results for historical MDA G investigations.

The objectives of the investigation activities are to complete the determination of the nature and extent of the contamination identified during past investigations, including the MDA G Phase I Resource Conservation and Recovery Act (RFI) fieldwork conducted at MDA G, and to collect additional information on the hydrogeologic properties and other physical characteristics of the vadose zone beneath the MDA G disposal units.

Evaluation of environmental data generated during the Phase I RFI consisted of comparisons of site data with background values in environmental media, evaluation of correlations among environmental measurements, and evaluation of spatial plots of contaminant concentrations in surface and subsurface environmental media. The following contaminants were identified as being associated with MDA G.

- Americium-241, cesium-137, cobalt-60, europium-152, plutonium-238, plutonium-239, strontium-90, thorium-230, tritium, uranium-234, uranium-235, and uranium-238 were detected in subsurface core beneath the pits, trenches, and shafts.
- Antimony, cadmium, cyanide, mercury, molybdenum, selenium, silver, thallium, and vanadium had detected concentrations and/or detection limits above background in subsurface core beneath the pits, trenches, and shafts.
- Tritium was detected in surface flux samples and pore gas.
- Volatile organic compounds (VOCs) were detected in pore-gas samples collected from monitoring boreholes, surface flux, and ambient-air samples.
- Methoxychlor was detected in channel sediments.
- Americium-241, cobalt-60, plutonium-238, plutonium-239, and tritium were elevated with respect to background values in channel sediments. Beryllium, cobalt, mercury, selenium, and silver were not detected above background values in sediment samples; however, the detection limits for some samples were elevated above background values. Cadmium was statistically different from background.

Additional data are required to determine the following:

- the vertical extent of tritium in the subsurface along the southern fence line near the high-activity tritium disposal shafts;
- the vertical extent of the vapor-phase VOCs beneath the pits at the eastern boundary of Area G and in the area of Pits 25 and 26;
- the extent of radionuclides and inorganic chemicals beneath and adjacent to several disposal units; and
- the presence of perchlorate, nitrate, and high-explosives contamination in borehole samples.

Additional samples from Cañada del Buey and Pajarito Canyon are also needed to further characterize sediment downgradient from Area G.

This work plan specifies drilling thirty-four vertical and three angled boreholes adjacent to or under the disposal units and collecting samples to supplement the Phase I RFI data for determining the nature and extent of contamination.

In addition, continued monitoring of new and existing boreholes is required to track the stability and migration patterns of VOC and tritium vapor plumes.

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1.0 INTRODUCTION

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

The Laboratory's Environmental Stewardship–Remediation Services (ENV-RS) project is participating in a national effort by the DOE to clean up sites and facilities formerly involved in weapons research and production. The goal of ENV-RS is to ensure that past operations under DOE do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve that goal, ENV-RS is currently investigating sites potentially contaminated by past Laboratory operations. The sites under investigation are either solid waste management units (SWMUs) or areas of concern (AOCs).

The SWMU discussed in this report [consolidated SWMU 54-013(b)-99, which consists of SWMUs 54-013(b), 54-014(b–d), 54-015(k), 54-017, 54-018, 54-019, and 54-020] contains both hazardous and radioactive components. The New Mexico Environment Department (NMED) regulates through the State of New Mexico Hazardous Waste Act (NMHWA) over sites with hazardous waste or certain hazardous constituents, including the hazardous waste portion of mixed waste (i.e., waste contaminated with both radioactive and hazardous constituents). Radionuclides are regulated under DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management."

NMED enforces the Hazardous and Solid Waste Amendments (HSWA) Module VIII of the Laboratory's Hazardous Waste Facility Permit, hereafter referred to as Module VIII. Module VIII specifies conditions and requirements for investigation and cleanup activities performed by ENV-RS at the Laboratory. The US Environmental Protection Agency (EPA) issued Module VIII on May 23, 1990, and revised it on May 19, 1994 (EPA 1990, 01585; EPA 1994, 44146). NMED is currently revising the Laboratory's Hazardous Waste Facility Permit. The corrective action requirements contained in Module VIII are to be replaced by a Compliance Order on Consent (Consent Order) negotiated by the NMED, DOE, and UC. This Consent Order will replace an Order previously issued by NMED to DOE and UC on November 26, 2002 (NMED 2002, 75910). This work plan was prepared and approved in accordance with the requirements of the proposed Consent Order published by NMED on September 1, 2004.

In accordance with the November 26, 2002, Order, the Laboratory submitted the "Investigation Work Plan for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99, at Technical Area 54, Revision 1" (LANL 2004, 87440) to NMED in June 2004. NMED disapproved this work plan and issued a notice of disapproval on September 14, 2004 (NMED 2004, 87581). The Laboratory responded to NMED's comments on October 15, 2004 (LANL 2004, 87582), and NMED approved the work plan with modifications on November 5, 2004 (NMED 2004, 87583). The approved scope of work consists of the work originally proposed in the June 2004 work plan as modified by the Laboratory's October 15, 2004, response to NMED's notice of disapproval and NMED's November 5, 2004, approval letter. This updated work plan consolidates the modifications to the original work plan so the entire approved scope of work is present in a single document.

Material Disposal Area (MDA) G [SWMU 54-013(b)-99] is located at Technical Area (TA-) 54 Area G on a mesa in the east-central portion of the Laboratory (Figure 1). During the 1950s, the Laboratory, with approval of the US Atomic Energy Commission and upon the recommendation of the US Geological Survey, selected Mesita del Buey, within TA-54, for underground disposal of Laboratory-derived waste

(Rogers 1977, 05707; Rogers 1977, 05708, p. G-1). Since then, the main waste storage and disposal facilities for the Laboratory have been located at TA-54. MDA G, which is located within TA-54 Area G, is one of four inactive material disposal areas on Mesita del Buey between Pajarito Canyon (south) and Cañada del Buey (north) (Figure 2).

MDA G consists of inactive subsurface units within Area G and includes 32 pits, 194 shafts, and 4 trenches (Figure 3) with depths ranging from 10 to 65 ft below the original ground surface. The pits, trenches, and shafts at Area G are constructed in unit 2 (caprock) and unit 1 (subsurface) of the Tshirege Member of the Bandelier Tuff, a consolidated tuff unit. The regional aquifer is estimated to be at an average depth of approximately 900 ft below ground surface (bgs) at Area G, based on data from wells at the Laboratory and the predictions of the hydrogeologic conceptual model for the Pajarito Plateau (LANL 1998, 59599). The topography of Area G is relatively flat. Portions of the MDA G disposal units are covered with concrete to house ongoing waste-management activities conducted at Area G; surface runoff from the site is controlled and discharges into drainages to the north (towards Cañada del Buey) and the south (towards Pajarito Canyon). Stormwater and sediment monitoring stations are distributed throughout Area G and in the drainages around Area G.

Historically, MDA G was used for the storage and disposal of low-level radioactive waste (LLW) and transuranic (TRU) radioactive waste and certain radioactively contaminated infectious waste, asbestos-contaminated material, and polychlorinated biphenyls (PCBs) and for the retrievable storage of TRU waste. Disposal of hazardous waste no longer occurs at MDA G; however, disposal of LLW and radioactively contaminated PCB waste continues at Area G. The locations of the subsurface SWMUs were determined by analyzing data from two global positioning system (GPS) surveys conducted by Johnson Controls, Inc., in 1994 and by the Laboratory in 1998 (LANL 2003, 75908) and by reviewing as-built drawings (LASL, LANL 1977–1989, 76099). The shafts and the corners of the disposal pits and trenches were surveyed in 1994.

Many of the shafts are marked with brass caps. Some of the pits, shafts, or trenches show no visible surface expressions because much of Area G's surface has been covered with crushed tuff, asphalt, or temporary structures.

The depth of the disposal units, described in the approved RFI work plan for Operable Unit (OU) 1148 (LANL 1992, 07669), is based on historical records; however, no elevation data were documented. The subsequent placement of the cover material over the disposal units has increased the elevations across the site. The elevation of the disposal units at the time of excavation has been estimated from the tuff/soil interface identified in the Phase I RFI borehole logs. Figure 3 shows the locations of the pits, trenches, and shafts as well as other site surface features and topographical lines. The entire 65-acre fenced surface area of Area G is an active RCRA-permitted hazardous waste storage area where mixed wastes are managed under interim status.

This updated investigation work plan (hereafter, the work plan) presents the results of historical investigations (including the Phase I RFI) of MDA G and presents the scope of work approved by NMED to complete the investigation of MDA G. This work plan includes background information on the site, the site conditions, the scope of activities needed to complete the investigation, the investigation methods, and the anticipated schedule for completing the field activities. Appendix A includes a list of acronyms and defines terms used in this report. Appendix B describes the historical RFI activities and analytical results for MDA G, including data interpretation to establish if releases had occurred from the disposal units and to make a preliminary determination of the nature and extent of the contamination. Appendix C, on a CD attached to inside back cover of this work plan, provides all data from the Phase I RFI. Appendix D describes the statistical analyses that support data interpretation. Appendix E includes a history of pore-gas monitoring at MDA G. Appendix F includes borehole profiles and logs. Appendix G

describes the basis for the MDA G waste inventory. The updated Appendix H describes the management of investigation-derived wastes (IDW).

Investigation Objectives

The objectives of this work plan for MDA G are to

- present the current knowledge of the nature and extent of hazardous waste constituents and/or radionuclide releases to the environment based on existing data, particularly those collected during the Phase I RFI;
- establish the rationale for additional data collection and analysis, including justifications for deviating from the scope of work presented in the September 1, 2004, proposed Consent Order issued by NMED to DOE and UC; and
- identify appropriate methods and protocols for collecting, analyzing, and evaluating data to finalize the characterization of MDA G.

The former Environmental Restoration (ER) Project, now ENV-RS, conducted MDA G Phase I RFI fieldwork from 1993 to 2003. The results of these investigations are described in the historical investigation report (HIR) in Appendix B. Based on an evaluation of existing environmental data collected for MDA G, several data requirements were identified that must be addressed to define the nature and extent of contamination in the environment and to evaluate potential risks to human and ecological receptors. These data requirements are described in section 4 of this work plan.

2.0 BACKGROUND

2.1 Operational History

MDA G is a decommissioned (i.e., removed from service) subsurface MDA established for disposing of low-level radioactive waste, certain radioactively contaminated infectious waste, asbestos-contaminated material, and PCBs. It was also used for the retrievable storage of TRU waste. MDA G began operations in 1957. The operational history of MDA G is summarized in the approved RFI work plan for OU 1148 (LANL 1992, 07669, pp. 5-179 to 5-200) and in section B-2.0 of Appendix B of this work plan. The performance assessment and composite analysis report (LANL 1997, 63131) and safety analysis report for Area G (LANL 1995, 63300) present additional information on MDA G.

MDA G consists of 32 pits, 194 shafts, and 4 trenches (Figure 3) that were excavated into the overlying soil in unit 2 (caprock) and unit 1 (subsurface) of the Tshirege Member of the Bandelier Tuff. The pits, shafts, and trenches are unlined. Table 1 provides information about the disposal unit(s), including their related SWMU designation and descriptions of the disposal unit(s). During operation (i.e., when receiving waste), the pits and trenches remained open to the atmosphere. When active, the shafts remained covered and locked with steel lids for safety and security. When operations ceased, the remaining capacity of the pits, shafts, and trenches was backfilled with clean, crushed, compacted tuff and closed. The disposal shafts were then capped with a concrete plug and marked with a brass cap.

2.2 Land Use

MDA G is located within Area G in an industrial area of TA-54, which is currently the primary site at the Laboratory for waste management activities. The Laboratory does not anticipate that land use at TA-54

will change in the foreseeable future. Public access to the site is restricted by fencing, locked gates, and limited entry onto Pajarito Road and TA-54. Under present-day conditions, only Laboratory employees or contractors may enter the site for site-management activities (i.e., installing best management practices), waste-management operations, or environmental sample collection.

2.3 Relationship to Other SWMUs and AOCs

To evaluate the potential impact of MDA G and to make sound decisions regarding the need for and nature of effective remedies, it is important to understand, at least qualitatively, the potential impact of nearby SWMUs and AOCs at MDA G. The most significant SWMUs/AOCs near MDA G, in terms of contaminant inventory and physical size, are surface storage areas at Area G and subsurface units at MDA L and MDA H (Figure 2). Area G contains active and inactive waste management units, some of which are subject to RCRA corrective action, while others are subject to RCRA operating requirements. Area G is a Class 2 nuclear facility. MDA L is located approximately 1 mi west of Area G near the center of Mesita del Buey; this 2.5-acre site was the Laboratory's primary chemical waste disposal facility from the early 1960s until it was decommissioned in 1986. Investigations to date have revealed vapor-phase volatile organic compounds (VOCs) and tritium in pore gas (LANL 2003, 80901; Appendix B). In addition to MDA L, Area L (which sits on the surface above MDA L) contains 12 surface operating units. The operating units located at the surface of Area L [54-001(a-e), 54-002, 54-008, 54-009, 54-012(b), 54-014(a), and 54-015(g, i)] are operated under interim status authority, and the liquid storage areas are double contained.

MDA H is located 1.6 mi west of Area G. The 0.3-acre site functioned as the Laboratory's primary disposal area for classified, solid-form waste from 1960 through August 1986. The RFI results indicate that tritium and VOCs have been released in vapor phase from the subsurface shafts (LANL 2002, 73270). The corrective measure study report for MDA H was submitted to NMED on May 31, 2003 (LANL 2003, 76039).

2.4 Contaminant Transport and Potential Receptors

The inventory of wastes disposed at MDA G includes radionuclides, inorganic chemicals, and organic chemicals. The relevant release and transport processes associated with these wastes are a function of chemical-specific properties, the physical form and/or container associated with a waste, and the nature of the transport process. The transport of tritium and VOCs, for example, occurs primarily in the gas phase and by diffusion or advection in air (including pore gas). Relatively water-soluble contaminants are susceptible to release and transport through infiltration of water through buried wastes. Some of these contaminants may be transported through root uptake of grasses, shrubs, and trees (e.g., strontium-90). Contaminants with relatively low water solubility are probably released from subsurface wastes only by some physical disturbance such as excavation by burrowing animals. The primary potential release and transport mechanisms for contaminants in subsurface wastes at MDA G include the following:

- *Volatilization, diffusion, and dispersion in air.* Gas or vapor-phase contaminants diffuse from waste and mix with air in the shafts or pits, then diffuse through the air-filled pores in the subsurface rock. Migration of gas- or vapor-phase contaminants from tuff into ambient air may occur by diffusion or by advection driven by barometric pressure changes.
- *Dissolution and advective transport in water.* Rain or melting snow on the surface moves down through the trenches, shafts, and pits, dissolves contaminants, and slowly transports dissolved contaminants through the subsurface rock. Transport in tuff may be facilitated by the presence of

fractures, particularly when fractures have coatings with low conductivity or when sufficient liquid saturates the matrix adjacent to the fracture where flow occurs.

- *Biotic perturbation and translocation of contaminants in subsurface wastes.* Plants grow into the waste and incorporate contaminants into their surface biomass; contaminants are deposited onto the soil surface as biomass decays. Burrowing animals excavate contaminated wastes and release them onto the soil surface as burrow spoils. Surface contamination may be transported back into the subsurface by burrow collapse or dissolution in surface water infiltrating the soil or be transported away from the site by suspension in air or surface-water runoff.

In addition to the processes described above, which are discussed in the context of buried wastes, contaminants may also have impacted environmental media from releases that occurred during the operation of MDA G. Dissolution of contaminants in infiltrating water, for example, may have been more prevalent during site operations when pits, trenches, and shafts were open for waste disposal, and probably occurred at the maximum depths of each unit where water may have accumulated. Contaminants may also have been released to surface soil during the period when wastes were actively disposed of at MDA G.

Receptors potentially exposed directly to contamination from MDA G include site workers at Area G and TA-54 and biota at the site. Potentially, site workers may be exposed to contaminants through inadvertent soil ingestion, inhalation of suspended soil (dust), dermal absorption from soil on the skin, and external irradiation. Inhalation of gas-phase contaminants such as tritium and/or VOCs emanating from the site into the atmosphere is also a potential route of exposure. Ecological receptors may also be exposed through these pathways as well as through plant-root uptake and the food web; in addition, burrowing animals may be exposed to higher concentrations of gas-phase contaminants in subsurface burrows.

Perched groundwater has not been encountered beneath Mesita del Buey at Area G (LANL 1998, 59599, p. 17). No perched water was observed in 153 ft of drilling (to a depth of 6675 ft above sea level [asl]) in the deepest Phase I RFI borehole (borehole 54-01111 [Figure 4; Appendix F]). No perched water was observed in 883 ft of drilling (to an elevation of 5767 ft asl) in characterization well R-22 or in 800 ft of drilling (to an elevation of 5680 ft asl) in well R-21 (Figure 5). Well R-22 is approximately 500 ft east and downgradient of Area G and characterizes subsurface conditions below Area G. Therefore, the potential for exposure of receptors through a water-mediated pathway is unlikely.

Data from other wells at the Laboratory and predictions of the hydrogeologic conceptual model for the Pajarito Plateau place the regional aquifer at approximately 850 to 950 ft below Area G (5870 to 5770 ft asl) (LANL 1998, 59599). Because of the depth to the regional aquifer and the low moisture content in the subsurface (less than 2% by volume in the upper 100 ft of the vadose zone in areas that are undisturbed by disposal pits, trenches, shafts, and asphalt cover [LANL 1995, 56834]), it is unlikely that contamination from MDA G will reach the regional aquifer in the foreseeable future; however, this pathway will be evaluated in the MDA G investigation report and the corrective measures study (CMS).

2.5 MDA G Waste Inventory

Waste disposal records for MDA G are found in un-numbered disposal logbooks (LASL, LANL 1966–1996, 76036). These logbooks were used to record information on the types of waste, dates of operation, locations, and volumes of waste placed in MDA G. The records are incomplete and do not provide information on the specific inventory deposited in each disposal pit, trench, or shaft at MDA G; however, the records provide a collective estimate of the inventory of the waste. An estimate of the types and quantities of waste disposed of at MDA G was compiled from a database included in the OU 1148

data report (LANL 1992, 23247); the inventories are presented in Appendices 4-A and 4-B, respectively, of the 1992 Laboratory report and are summarized in Appendix G of this work plan.

2.6 Summary of Historical Investigations

2.6.1 Pre-RFI Field Investigations

On May 7, 1985, the Laboratory received a Compliance Order from the New Mexico Environmental Improvement Division (NMEID, now NMED) that addressed numerous waste management issues at the Laboratory (NMEID 1985, 75885). The 1985 Order specified the following six tasks that involved site-investigation activities in and around Area G.

- Task 1: Measure the intrinsic permeability of the tuff
- Task 2: Determine the soil-moisture characteristic curves
- Task 3: Determine the unsaturated hydraulic conductivity of the Bandelier Tuff
- Task 4: Analyze the infiltration and redistribution of meteoric water into the tuff
- Task 5: Characterize the core and pore gas in the vadose zone
- Task 6: Analyze the potential presence of perched water

The results and outcomes of the above six tasks are described in a hydrogeologic assessment of Areas G and L in TA-54 (LANL 1987, 76068, pp. 6-2–6-7), which was submitted to NMED in 1987 in response to the 1985 Compliance Order/Schedule. These investigations and the associated findings are described in section B-2.2 of Appendix B of this work plan.

2.6.2 Phase I RFI Investigations

Phase I RFI activities included sampling of ambient air, channel sediments, subsurface core, and pore gas. Phase I RFI results are reviewed and interpreted in section 2.6.3 of this work plan; the data are summarized in Appendix B and included in Appendix C (on CD attached to the inside back cover of this report).

VOC surface flux was measured across Area G in two surveys conducted in August 1993 and August 1994 using a surface flux chamber and EMFLUX surface adsorbent cartridges (Figures B-8 and B-9). Details of the surface flux chamber investigations are reported in Eklund (1995, 56033). Details of the EMFLUX surface adsorbent cartridges investigations are presented in two Quadrel Services reports (1993, 63868; 1994, 63869) and in Trujillo et al. (1998, 58242). During the summers of 1993 and 1994, tritium flux was measured at 142 locations on and near the surface of Area G (Eklund 1995, 56033).

Between September 1993 and May 1995, 156 core samples were collected from 10 vertical and 10 angled boreholes drilled near MDA G disposal units and submitted to an off-site contract laboratory for analysis. Depth intervals for sample collection and analytical suites varied by borehole and are described in section B-3.3 of Appendix B. The depths of these boreholes ranged from 38.5 ft to 153 ft bgs. The borehole locations and trajectories are shown on Figure 4 and are described by depth, declination, and adjacent disposal units in Table B-14. A total of 20 boreholes were drilled during the Phase I RFI. Borehole 54-01113 was inadvertently advanced into a disposal unit and was abandoned at 17.5 ft bgs. The two samples collected and analyzed for this borehole are not included in the data review in this work plan.

In 1994, 113 channel sediment samples were collected from drainages leading from Area G (Figure B-2; LANL 1996, 54462) from depths between 0 in. and 10 in. using stainless steel trowels. Sixteen field-duplicate samples were also collected from the drainages; local background samples were collected from ten locations in two channels that drain portions of Mesita del Buey not used for waste management. Sediment samples were collected from seven to ten locations in each of the Area G drainages. All samples were field-screened by the Laboratory's mobile radiological analysis laboratory. Screening was used to identify 59 samples to be submitted to an off-site contract laboratory for analysis, including 4 samples from each of the drainage channels. These samples were analyzed for inorganic chemicals (target analyte list [TAL] metals and cyanide), organic chemicals (PCBs and pesticides), radionuclides by gamma spectroscopy, americium-241, tritium, isotopic thorium, strontium-90, isotopic uranium, and isotopic plutonium (LANL 1996, 54462).

Additionally, in 1994, 16 ambient-air samples were collected for 8 days at 2 sampling locations along the northern perimeter of Area G (Figure B-6). The samples were analyzed for VOCs, and this sampling event is described in section B-3.1.2 of Appendix B.

Sampling of subsurface pore-gas for VOCs has been ongoing at Area G from 1992 to the present. Currently, there are 12 boreholes available for such sampling, including 4 MDA G Phase I RFI boreholes and 8 boreholes installed by Facility Waste Operations (FWO) at Area G. Each quarter, SUMMA canister samples are collected from a minimum of two pore-gas well monitoring ports. These samples are collected to evaluate changes in the VOC plume based on a defined quarterly sampling schedule presented in the prior year's annual report (LANL 2003, 80901). In addition, since 1997, the pore-gas monitoring program has been aided and directed by soil-gas screening using the photoacoustic radiometry (PAR) method, which employs a Brüel and Kjaer (B&K) Multigas Analyzer, Model 1302. Currently, all MDA G monitoring ports available are screened for soil gas quarterly using the B&K. MDA G pore-gas monitoring activities are described in section B-3.3 of Appendix B and in Appendix E of this work plan.

In 2003, 13 pore-gas samples collected from boreholes 54-01110 and 54-01111 (adjacent to the tritium disposal shafts) were analyzed for tritium.

2.6.3 Phase I RFI Results

The nature and extent of contamination potentially released from MDA G as determined from the results of Phase I RFI activities are as follows.

1. Review and analysis of certain radionuclides (americium-241, cesium-137, cobalt-60, europium-152, plutonium-238, plutonium-239, strontium-90, thorium-230, and uranium-234, uranium-235, and uranium-238) in tuff beneath the pits, trenches, and shafts indicate infrequent detections of radionuclides below the disposal units. Phase I RFI data do not indicate a release of radionuclides from the disposal units because no pattern of detections was observed from the borehole samples. However, Phase I RFI coverage was insufficient to conclude that no releases occurred.
2. Review and analysis of certain inorganic chemicals (antimony, cadmium, cyanide, mercury, molybdenum, selenium, silver, thallium, and vanadium) in tuff beneath the pits, trenches, and shafts indicate infrequent detections of inorganic chemicals above background levels below the disposal units. Phase I RFI data cannot determine whether a release of inorganic chemicals occurred from the disposal units because of elevated detection limits (DLs) and insufficient coverage.

3. Review and analysis of tritium beneath the disposal units indicate tritium has been released into the tuff. The vertical extent of contamination has not been defined.
4. VOCs (primarily 1,1,1-trichloroethane [TCA]) were detected in subsurface pore gas, indicating a release. The vertical extent of contamination has not been defined.
5. Channel sediments contain low concentrations of methoxychlor. Americium-241, cobalt-60, plutonium-238, plutonium-239, and tritium were elevated with respect to background values (BVs) in channel sediments. Beryllium, cobalt, mercury, selenium, and silver were not detected above background values; however, the DLs for some samples were elevated above BVs. Cadmium was detected above background levels. The nature of the release is defined, but the extent is not defined.
6. Surface flux and ambient-air sampling results indicate VOCs and tritium are being released into the atmosphere from the subsurface.

A detailed review of the Phase I RFI data is presented in section B-3.0 of Appendix B. Phase I RFI data are presented in Appendix C (on the CD attached to the inside back cover of this report).

The information presented in sections B-2.0 and B-3.0 of Appendix B is summarized and interpreted in this section to describe the current understanding of the nature and extent of environmental contamination. Based on this interpretation, data requirements related to defining the nature and extent of contaminant releases from MDA G are identified.

2.6.3.1 Interpretation of Phase I RFI Sediment Data

Inorganic chemicals. Several inorganic chemicals were detected above sediment BVs in the drainage channels surrounding Area G in one to three samples but were not statistically different from the background data sets. The DLs for beryllium, cobalt, mercury, selenium, and silver exceeded their respective sediment BVs (Table B-8), and, as a result, these inorganic chemicals are retained as COPCs. Spatial trends for these five inorganic COPCs cannot be defined since they were not detected. Cadmium was detected above BV and determined to be statistically higher than background.

Data from sediment samples in the White Rock land transfer parcel reach CDB-4 (approximately 5000 ft from Area G [LANL 2000, 68739]), indicate no contaminants exist in post-1942 sediments in this reach of Cañada del Buey. The available data cannot definitively determine whether a release of inorganic chemicals from MDA G in channel sediments has occurred because of elevated DLs for some inorganic chemicals. Therefore, the extent of inorganic contamination in channel sediments is not defined.

Radionuclides. Americium-241, cesium-137, plutonium-238, plutonium-239, and tritium were detected above BVs, and cobalt-60 (which has no BV) was detected in channel sediment samples downgradient of Area G (Table B-9). Other radionuclides were not detected at concentrations statistically different from sediment BVs or were not detected.

Contamination in the drainages around Area G probably results from mesa-top surface-water runoff, which is attributed to releases associated with surface activities or surface exposure of contaminated material. The channel sediment data support the conceptual model that surface contamination is transported away from the location of origin by surface water (as either solute or sediment).

Americium-241, cobalt-60, plutonium-238, and plutonium-239 were detected at low concentrations in all of the drainage areas surrounding Area G (Figure B-3). Americium-241 exceeded the BV in 12 of 59

samples; cesium-137 was detected in 4 of 59 samples; cobalt-60 was detected in 3 of 59 samples; plutonium-238 exceeded the BV in 39 of 59 samples; and plutonium-239 exceeded the BV in 20 of 59 samples. Plutonium-238 was detected at a concentration of 1.48 pCi/g near the main channel in Cañada del Buey. This concentration is probably associated with runoff from Pits 6 and 7. Contaminated topsoil from TA-01, with plutonium concentrations reportedly as high as 20 pCi/g, was used as cover material for Pits 6 and 7. The plutonium-238 concentration of 1.48 pCi/g is located directly to the north and downgradient of these pits.

Radionuclide contamination in the major drainages downgradient from Area G was further evaluated by sampling conducted in lower Cañada del Buey. Sampling in the White Rock land transfer parcel, reach CDB-4 (LANL 2000, 68739), indicated no radionuclide contamination in sediments from lower Cañada del Buey.

Organic chemicals. Methoxychlor was the only organic chemical detected in channel sediments. This pesticide was detected in 14 channel sediment samples with the highest detection of 0.0589 mg/kg (Figure B-4). To help define the extent of methoxychlor contamination downgradient of Area G, analytical results of samples collected from lower Cañada del Buey (reach CDB-4 [LANL 2000, 68739]) were reviewed. Methoxychlor was not detected.

Nature and Extent of Channel Sediment Contamination

A release of methoxychlor into channel sediments is indicated by the data. Sediment samples collected downgradient of Area G in Cañada del Buey resulted in concentrations of methoxychlor at or below those found in channel sediments near Area G. The Phase I RFI data establish the spatial extent of potential surface releases of organic chemicals from MDA G.

A release of radionuclides is indicated by frequent low-level detects in drainages surrounding Area G. A higher concentration (plutonium-238 at 1.48 pCi/g; BV = 0.006 pCi/g) to the northeast of Area G in Cañada del Buey is probably associated with water runoff from contaminated soil used to cover Pits 6 and 7. No sampling was conducted in reach CDB-3, which is the closest downgradient reach to Cañada del Buey, and only limited sampling was conducted in reach PA-4 in Pajarito Canyon; therefore, supplemental sampling for radionuclides is proposed in these two reaches.

Phase I RFI data are not sufficient to determine whether a release of inorganic chemicals into channel sediments surrounding Area G has occurred because DLs for some inorganic chemicals are elevated, and a spatial trend cannot be established. Therefore, supplemental sampling for inorganic chemicals is proposed in two reaches in Cañada del Buey (reach CDB-3E) and Pajarito Canyon (reach PA-4).

2.6.3.2 Interpretation of Phase I RFI Subsurface Tuff Data

Inorganic chemicals. Antimony, selenium, and vanadium were detected at concentrations above tuff BVs in one or more borehole(s) at two out of three consecutive sampling depths (Figure B-15). Mercury was detected above BV. Antimony, mercury, selenium, and vanadium are retained as COPCs (Appendix B). Cadmium, cyanide, molybdenum, silver, and thallium were also identified as COPCs because their DLs were greater than BVs. Cyanide and molybdenum were detected but no background data exist. The detected concentrations occurred infrequently across the site in shallow and deep subsurface samples from both vertical and angled boreholes. Phase I RFI borehole coverage was not sufficient to conclude that no releases occurred.

Radionuclides. Americium-241, cesium-137, cobalt-60, europium-152, plutonium isotopes, thorium-230, and uranium isotopes were detected at low concentrations in tuff (Figure B-16). A large number of results

indicating detections of uranium-234 and uranium-238 were rejected because the quality of the data was questionable. These data have been plotted and are presented in Appendix D (Figures D-11 and D-12). The rejected sampling results are graphically similar to background levels, indicating no release of uranium-234 or uranium-238 has occurred from the subsurface SWMUs at MDA G.

Tritium data for tuff indicate a release of tritium in the subsurface, with concentrations higher in the south-central portions of the site near the high-activity tritium disposal shafts. Data from subsurface tuff are not adequate to define the boundaries of diffused tritium in the subsurface, but tritium pore-gas data indicate releases to the atmosphere are highest in this same area.

The radionuclide detections occurred infrequently across the site in shallow and deep subsurface samples from both vertical and angled boreholes. Phase I RFI coverage was sufficient to conclude that release of tritium has occurred. However, Phase I RFI data for other radionuclides are not sufficient to determine whether a release has occurred.

Organic chemicals. Twenty-two organic chemicals were detected in samples collected below MDA G (Figure B-17), most at trace concentrations (i.e., less than or slightly above the estimated quantitation limit [EQL]). Among the more predominant constituents were acetone, detected in 14% of the samples, and bis(2-ethylhexyl)phthalate, detected in 6% of the samples. Aroclor-1254 was detected only once, with a concentration of 0.12 mg/kg. Organic chemical detection in tuff occurred at trace levels and sporadically across the site; therefore, no additional sampling for extent is warranted.

The low-level concentrations of VOCs in the core samples are consistent with the conceptual model, which shows that the VOCs are present in the subsurface pore gas and do not adsorb strongly with the solid tuff matrix. The nature and extent of VOCs is best defined by the pore-gas sampling results, discussed in section B-3.3 of Appendix B of this work plan.

Nature and Extent of Subsurface Contamination

The number and locations of Phase I RFI samples of core are not sufficient to support conclusions regarding the nature and extent of contamination beneath the disposal units. Although 19 boreholes were drilled for the Phase I RFI investigation, many geographic areas of MDA G were not sampled. No Phase I RFI subsurface data are associated with Pits 7, 8, 12, 13, 24, 26, 28 through 30, and 35 through 37, or Shafts 189 through 192, 196, C1, C-12, and C-13.

Along with the analytical suites required for Phase I RFI tuff samples, additional suites may be appropriate, given the nature of the disposed wastes at MDA G. Nitrates and perchlorate, which are very soluble and susceptible to migration with infiltrating surface water, were not analyzed in Phase I RFI core samples. Nitrates are associated with fertilizers and are also a common breakdown product of most nitrogen-containing organic materials. Perchlorate-containing chemicals have been widely used as oxidizers in a variety of chemical processes, and perchloric acid is a strong acid commonly used in laboratories. Because of their mobility and potential occurrence in disposed waste at MDA G, nitrates and perchlorate in MDA G core samples need to be analyzed. Some high-explosive (HE) compounds are also relatively soluble in water and subject to transport from the disposed waste. However, the presence of HE in appreciable quantities in the disposed waste is not expected because it has always been Laboratory policy to "flash" (burn) HE-contaminated material prior to disposal. However, since inventory records for MDA G are incomplete, HE will be added to the analytical suite for subsurface tuff samples to be collected according to this approved work plan. A review of waste inventory records does not indicate the presence of dioxins or furans in the disposed waste and does not provide evidence that chemicals had been burned (Appendix G). However, because the inventory is not complete, tuff samples collected directly beneath the disposal units will be analyzed for dioxins and furans.

Some strata, specifically units of the Tshirege Member of the Bandelier Tuff, contain fractures that can act as conduits for the migration of liquid- and vapor-phase contaminants in the vadose zone. Information from fractured rock that can be used to evaluate the potential role of fractures in contaminant migration includes fracture density, fracture apertures, the strike and dip of fractures, and the presence and characteristics of fracture coating and fill. Where fractures are encountered during coring of boreholes, a comparison of chemical concentration data from tuff immediately adjacent to a fracture with tuff farther from the fracture can also provide valuable information on the role of fractures in contaminant transport from MDA G disposal units.

2.6.3.3 Interpretation of Phase I RFI Subsurface Tritium Data

Core samples from 19 boreholes, subsurface pore-gas sampling results, and surface-flux emission measurements were analyzed for tritium during the Phase I RFI. Figure 6 shows borehole sample concentrations of tritium by elevation, adjusted for the angle of the boreholes, as necessary. Tritium was observed at elevated levels both above and below the base of the tritium shafts (maximum depth of 65 ft). Individual borehole plots of tritium concentration by depth (Figure 7) show how tritium concentrations vary between boreholes. Boreholes 54-01111 and 54-01120 show decreasing trends at depth. Borehole 54-01111 is located near the tritium shafts on the south-central side of Area G, and borehole 54-01120 is located near the tritium shafts on the north side.

Individual vertical profiles of tritium concentration for all boreholes are shown in Appendix D, Figures D-7 through D-10. Three of the vertical borehole profiles for tritium (54-01112, 54-01114, and 54-01128) show an increasing trend with depth, which may be explained by the shallow depths of these boreholes. These three boreholes have an average depth of 70 ft and are not located near the disposal shafts. Data from deeper boreholes closer to the tritium disposal shafts vertically bound the extent of tritium contamination. These deeper boreholes (54-01106, 54-01115, 54-01116, and 54-01117) show a decreasing trend with depth.

Pore gas samples were collected and analyzed for tritium in boreholes 54-01110 and 54-01111. These boreholes are located adjacent to the high-concentration tritium shafts (150 through 160) within the south-central perimeter at Area G, and the RFI tuff samples from these boreholes contain the highest concentrations of tritium directly adjacent to the tritium disposal shafts. Tritium concentrations decrease with depth. Figure 8 shows concentrations of tritium found in core samples in both pCi/g and pCi/L from boreholes 54-01110 and 54-01111. The core samples reported in pCi/g reflect the tritium concentration per mass of the sample, and the results reported in pCi/L reflect the concentration of tritium in the recovered core moisture. Both results indicate decreasing trends in concentration with depth; however, the core sample data were not adequate to define the boundaries of tritium in the subsurface.

To further define extent, subsurface pore gas was sampled from these boreholes in January 2003 and analyzed for tritium. These results are shown in Table B-21. As discussed above, results of the RFI core samples analyzed for tritium indicate a decreasing trend at depth. This conclusion, however, is not mirrored by the 2003 pore-gas sample data for tritium, which do not indicate a decreasing trend in vapor phase tritium concentrations with depth. Based on this finding, release of tritium into the subsurface has not been vertically bounded.

Tritium disposal shafts are located in two regions of Area G, immediately west of Pad 1 on the north side of Area G, and within the south-central perimeter of Area G (Figure B-7). The tritium data from subsurface sampling indicate diffusive vapor-phase tritium emanating from the tritium disposal shafts. The greatest concentration of tritium in tuff occurs at a subsurface depth of approximately 5 ft bgs, with most of the high tritium concentrations in tuff located between 40 to 75 ft bgs.

Flux emission data (Eklund 1995, 56033) show tritium emanating from the two source areas. The highest measured flux was near Shafts 150, 151, and 154 on the south-central perimeter of Area G. These tritium disposal units were active from 1976 to 1986. The flux rates ranged between 300,000 and 13,000,000 pCi/m²/min (Figure 9). This high flux area is consistent with the high subsurface tritium levels identified at borehole 54-01110 (adjacent to Shaft 154) and borehole 54-01111 (adjacent to Shafts 150 and 151) (Figure B-7). Flux data also reveal that a small quantity of tritiated water vapor has migrated beyond the Area G fence line, toward Pajarito Canyon, from the area of the south-central tritium disposal shafts. However, data collected farther from the shaft fields show laterally decreasing tritium concentrations (Figure 9).

The flux-chamber data are consistent with the conceptual model, which shows that tritium diffuses from subsurface sources through the tuff and emanates from the surface of the mesa. With increasing distance from the source, diffusion and loss through the surface of the mesa results in decreasing tritium concentrations (Eklund 1994, 56033).

Nature and Extent of Tritium in Subsurface Media

Subsurface media data from the MDA G Phase I RFI indicate a release of tritium from the disposal units into the surrounding tuff. During the Phase I investigations, core samples were collected for tritium analyses. Tritium in core is analyzed by EPA Method 906.0, which measures activity from 5 mL of water extracted from the core sample. At gravimetric moisture contents less than 10%, a 3-in. length of 2-in.-diameter core will yield less water than the minimum required volume of 5 mL. To reach the necessary volume, deionized water is added to the extracted water. The reported activity and uncertainty resulting from the dilution are corrected. The loss of any moisture from a core sample before analysis at low moisture contents may increase the uncertainty of the measurement. Furthermore, the method requires grinding the core material thoroughly to pass it through a fine mesh before extracting the water such that significant moisture loss is inevitable. Given these limitations, ENV-RS has concluded that tritium contamination at MDAs is best characterized in low moisture content environments by using sorbent materials to extract and retain in situ subsurface-water samples.

Boreholes 54-01110 and 54-01111 are located in an area with the highest levels of tritium flux within Area G. Analysis of pore gas collected from these boreholes in early 2003 showed an increasing trend in tritium concentration with depth, with levels as high as 3.8×10^9 pCi/L. Therefore, additional data are required to define the vertical extent and analyze the transport pathways of tritium contamination associated with disposal Shafts 150 through 160 in south-central Area G.

2.6.3.4 Evaluation of Subsurface Pore-Gas and VOC Surface-Flux Data

Only infrequent trace-level detections of VOCs were found in core samples. The subsurface media at Area G (volcanic tuff) contain almost no organic carbon, have low moisture content, and have low specific surface area. Consequently, VOCs do not sorb to the tuff in detectable concentrations and exist primarily in the vapor phase.

Two flux emission studies were completed as part of MDA G investigations in 1993 and 1994 (Eklund 1995, 56033; Trujillo et al. 1998, 58242). Both studies concluded that the highest VOC emissions are over disposal Pits 1 through 5. Additionally, a smaller area of elevated VOC emissions was identified inside the south-central perimeter of Area G associated with Pits 25 and 26.

Surface flux data were collected from the mesa top in 1993 and from the mesa tops and slopes in 1994 by Trujillo et al. (1998, 58242). The results showed that TCA was present in 97% of the 245 samples, with

emission rates in the hundreds to thousands of $\text{ng}/\text{m}^2/\text{min}$ at many locations. The highest values reported for other VOCs ranged between the tens and hundreds of $\text{ng}/\text{m}^2/\text{min}$. TCA, trichloroethene (TCE), tetrachloroethene (PCE), and 1,1-dichloroethene were measured at high flux rates primarily on the east end of Area G, while Freon 113 was most prevalent in the western area around Pits 25 through 29, 32, 33, and 35. The 1994 flux data from the slopes showed much lower flux rates than those of the 1993 samples from the mesa top. Again, TCA was the most prevalent VOC, and PCE was the second. Unlike at the mesa top, 1,1-dichloroethene was the only other VOC detected. Flux data from the canyons showed virtually no detected VOCs.

Trujillo et al. (1998, 58242) performed further data collection and analysis in discrete regions within Area G. The sections were labeled G-1 through G-8 and occupy approximately 10 acres each (Figure 10). VOC emission rates were determined for each of the eight sections. The highest mean emission rate for all detected VOCs was observed in section G-5 (Figure 11), representing approximately 42% of the MDA G VOC emissions. The contributions of specific VOCs to the total emission from section G-5 are presented in Figure 12. This figure shows that the dominant VOC is TCA, which contributed approximately 77% of the total VOC emissions.

The presence of TCA as the dominant VOC and the locations of highest concentrations demonstrate how surface flux emissions are an expression of the lateral extent of subsurface VOCs. Figure 13 shows the surface flux measurement of TCA across Area G and the lateral extent of the surface expression of the vapor plume.

Pore-gas monitoring is the most effective method to define the nature and extent of subsurface VOC contamination at depth associated with MDAs. Both the B&K screening results and SUMMA canister analytical results indicate that the highest concentrations of vapor-phase VOCs are nearest to the source areas (the disposal units in eastern Area G). Concentrations of vapor-phase VOCs decrease in all directions away from the source areas. TCA has consistently been the most prevalent VOC detected and is the best indicator of the extent of the plume. As discussed in section B-3.3 of Appendix B, the B&K screening results show a strong correlation with the analytical results from SUMMA canister samples.

B&K screening data for TCA are available for all ports in all MDA G pore-gas monitoring wells, providing data that define the extent of VOCs. Figure 14 shows vertical profiles of TCA concentrations based on quarterly B&K and SUMMA results by depth for two boreholes within the plume. Borehole 54-02009 is located near the southern end of the eastern VOC area, and borehole 54-01117 is located at the north end of the eastern VOC area. Figure 15 shows the lateral extent of the VOCs as determined by B&K pore-gas monitoring results during fiscal year (FY) 2001.

The data show that TCA concentrations decrease with depth (Figure 14), and TCA is detected at low concentrations in the east end of Area G (Figure 15). No concentrated areas of elevated TCA have been detected, indicating that VOCs have not been released from a single, large point source but rather from numerous sources within the disposal pits from which vapor has diffused throughout the subsurface. A complete discussion of historical and present pore-gas sampling methodologies is provided in Appendix E.

The following statements can be made with respect to the nature and extent of subsurface VOCs.

- VOCs are transported primarily in the vapor phase.
- The VOC detections are concentrated in the first five waste disposal pits at the east end of Area G and an area inside the south-central perimeter of Area G.

- The major contaminant is TCA.
- The degradation of the primary vapor-phase components is limited.
- The VOCs have changed very little in location or content over time.

Nature and Extent of Subsurface Pore Gas and VOC Surface Flux

The concentrations and lateral extent of VOC vapors in subsurface tuff have been defined. Vapor-phase VOCs have been identified in two areas at Area G closely associated with the earliest MDA G disposal pits: Pits 1 through 5 and Pits 25 and 26. The dominant VOC is TCA. The lateral boundary of VOCs is defined by pore-gas monitoring and the results of two separate studies of surface flux emissions at TA-54.

The detectable VOC concentrations are known to extend to at least 153 ft bgs. The VOCs are expected to extend to 300 ft bgs to the top of the Cerros del Rios basalt where the VOCs are diffused into the atmosphere because of the barometric venting properties of the basalt (Neeper 1997, 70936; Stauffer et al. 2000, 69794). Additional vertical diffusion of VOCs beneath the basalt may occur but would be expected at very low concentrations since most of the transport would be laterally through the basalt to the atmosphere. Although the approximate dimensions of the two MDA G VOC source areas have been defined, they continue to experience small fluctuations both in size and concentration. Continued monitoring is required to track the stability of the plume, its migration, or the potential for a release from the source areas.

Currently, four vertical boreholes near the eastern VOC source area (54-01117, 54-01121, 54-02009, and 54-02032) are monitored quarterly. Three of these boreholes are located on the perimeter, and one is located in the center of the plume (Figure B-12). However, these boreholes are relatively shallow (85 to 156 ft). VOC pore-gas sampling of the 37 proposed boreholes is recommended to finalize characterization of the plumes.

2.6.3.5 Evaluation of Ambient-Air Contamination

Radionuclides. Ambient-air particulate samples were collected at nine regional air-monitoring network (AIRNET) locations on the perimeter of Area G and analyzed for radionuclides. Nonvolatile radionuclides (americium-241, plutonium-238, plutonium-239, uranium-234, uranium-235, and uranium-238) were reported at elevated concentrations relative to regional air stations by the Laboratory's Environmental Surveillance Program (2002, 73876). The data corroborated the conceptual model of air as a transport pathway for resuspended particulate contamination.

Atmospheric water vapor was also collected at the nine AIRNET locations and analyzed for tritium. Tritium concentrations at Area G were found to be consistently elevated relative to regional air-monitoring stations. The air stations nearest the tritium disposal shafts showed the highest concentrations. The data indicate vapor-phase releases of tritium are occurring from MDA G disposal units; therefore, tritium is being vented from the surface of the site. (Section 2.6.3.3 provides an analysis of the subsurface tritium data.)

Organic chemicals. Ambient-air samples were collected to determine VOC concentrations at two locations on the north fence line of Area G and a background location at Bandelier National Monument. The north fence line was chosen for sampling because the wind direction is predominantly from the south. The data are consistent with emission of VOCs from the known MDA G subsurface source areas, and TCA is the

dominant VOC emission. It is possible some of the detected VOCs are from other ambient-air sources, including emissions related to surface waste-management activities.

Nature and Extent of Contamination in Ambient Air

Radionuclide and organic chemical Phase I RFI data for ambient air at Area G do not indicate that any additional data are needed to identify the nature and extent of contamination in ambient air.

Concentrations of both radionuclides and organic chemicals are elevated in samples collected from perimeter air-monitoring stations at Area G compared with the regional AIRNET locations. However, these elevated concentrations appear to be limited to the immediate vicinity of Area G.

3.0 SITE CONDITIONS

This section discusses aspects of the environmental setting at Area G that are important for assessing the potential impacts of contaminated surface and subsurface media, including

- the semiarid climate with low precipitation and high evapotranspiration rate that limits the amount of moisture percolating into the disposal units and subsequently limits the amount of moisture available to leach radionuclides or hazardous waste constituents;
- the thick, relatively dry unsaturated zone that greatly restricts or prevents downward migration of contaminants in the liquid phase through the vadose zone to the regional aquifer; and
- the canyon-mesa terrain that affects atmospheric conditions and ecological habitats.

3.1 Surface Conditions

Area G is located in the eastern area of Mesita del Buey at TA-54 (Figure 2). Mesita del Buey is a 100- to 140-ft-high finger-shaped mesa that trends southeast. The elevation of Mesita del Buey ranges from 7210 to 7280 ft asl at Area G. The mesa varies in width from 500 to 1000 ft and is bounded by Cañada del Buey (to the north) and Pajarito Canyon (to the south). The topography at Area G is relatively flat and narrow, with steep sides draining into Cañada del Buey to the north and Pajarito Canyon to the south. The north-facing slope of the mesa has a gentler gradient than the south-facing slope. The south-facing slope of Mesita del Buey is almost vertical near the rim and slopes more gently toward the canyon floor approximately 100 ft below.

Because MDA G is located within Area G, the surface is regularly modified to accommodate ongoing waste storage and management operations. A very limited portion of the area can be considered undisturbed with respect to vegetation, erosional features, and soil formation. Most of Area G consists of asphalt paved roads and storage areas, graded roads, buildings, utilities, stormwater drainages, shaft caps, and vegetated pit and trench covers. The current surface waste-management area and topography of Area G are shown in Figure 16.

3.1.1 Soils

The soils of Mesita del Buey are derived from the weathering of the Tshirege Member tuffs (phenocrysts and phenocryst fragments, devitrified glass, and minor lithic fragments) and from wind-blown sources. Soils on the flanks of the mesa are developed on Tshirege Member tuffs and colluvium with additions from wind-blown and water-transported sources. Native soils have been disturbed by waste-management

operations over much of the surface of Mesita del Buey, but when present, native soils are generally thickest near the center of the mesa and thinner toward the edges.

In general, soils on the mesa surface are thin and poorly developed; they tend to be sandy near the surface and more clay-like beneath the surface. More highly developed soil profiles exist on the north-facing slopes; they tend to be richer in organic matter. Soil profiles on the south-facing slopes tend to be more poorly developed. Soil-forming processes have been identified along fractures in the upper part of the mesa, and the translocation of clay minerals from surface soils into fractures has been described at Mesita del Buey. A discussion of soils in the Los Alamos area can be found in the approved installation work plan for the former ER Project (LANL 1998, 62060, pp. 2-6-2-21).

The original soils near Area G were poorly developed, as is typical of soils derived from Bandelier Tuff and formed under semiarid climate conditions (Nyhan 1978, 5702). In general, undisturbed soils on the mesa tops consist of the Carjo loam, the Hackroy loam, and the Seaby loam. At Area G, natural or undisturbed surficial soil cover is limited as a result of disposal unit and cover construction.

Canyon bottoms near Area G (Cañada del Buey and Pajarito Canyon) are covered with colluvium and alluvium that has eroded from the tuff and soils on the mesa top and canyon walls. The canyon rims and slopes are composed of soils from the Hackroy-Rock outcrop complex; canyon bottoms are composed of the Tocal, a very fine, sandy loam. Since disposal activities began at Area G, Cañada del Buey has experienced a period of accretion, and eroded soils from Area G as well as other areas at TA-54 have been deposited on the canyon bottom and stream banks. Potentially, these soils can be redistributed downstream during storm runoff events. The drainages between the mesa and canyon bottoms were sampled during the Phase I RFI; the canyon bottoms will be investigated under separate canyon work plans.

3.1.2 Surface Water

No perennial streams flow on Mesita del Buey; water flows only as stormwater and snowmelt runoff on the mesa and in small drainages off the mesa to the north and the south. Stormwater flows at a number of points along the perimeter of TA-54, as identified and characterized in a report prepared for the Laboratory's National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit (LANL 2002, 74009). Therefore, flooding at the site is not a concern. As a result of runoff, surface erosion occurs primarily as shallow sheet erosion on the relatively flat parts of the mesa and as channel erosion in major drainages from the mesa top. Runoff from summer storms reaches a maximum in less than 2 hr and lasts less than 24 hr. By contrast, runoff from spring snowmelt occurs over a period of several weeks at a low discharge rate. The amount of eroded material transported in runoff waters is generally higher during summer rainfall events than during snowmelt (LANL 1997, 63131, p. 2-33).

3.2 Subsurface Conditions

3.2.1 Stratigraphy

In 1995, the former ER Project drilled, cored, and sampled 19 boreholes near the MDA G disposal units to characterize potential contaminant releases and transport in the subsurface. Borehole logs from the site provide detail on the stratigraphy below the ground surface to a depth of approximately 150 ft (boreholes 54-01111 and 54-01121) and are included in Appendix F. The locations and depths of municipal well PM-2 and characterization wells R-20, R-21, and R-22 were also used to infer the stratigraphy (Figure 17). Figure 18 shows an east-west cross-section beneath and near Area G. The

stratigraphy beneath Area G includes the Bandelier Tuff and the Cerros del Rio basalt. The regional aquifer is primarily Santa Fe Group, Puye Formation, and Cerros del Rio basalts.

Bandelier Tuff

With reference to the Bandelier Tuff, the term *welding* is used to differentiate between tuffs that are uncompacted and porous (nonwelded) and those that are more compacted and dense (welded). In the field, the degree of welding in tuff is quantified by the degree of flattening of pumice fragments (a higher degree of flattening and elongation equals a higher degree of welding). Petrographically, welded tuffs show adhesion (welding) of grains, while nonwelded tuffs do not. The term *devitrified* is applied to tuff whose volcanic glass has crystallized. Figure 19 shows the generalized stratigraphy of the Bandelier Tuff.

Tshirege Member

The Tshirege Member of the Bandelier Tuff is a compound-cooling unit that resulted from several successive ash-flow deposits separated by periods of inactivity, which allowed for partial cooling of each unit. Properties related to water flow and contaminant migration (e.g., density, porosity, degree of welding, fracture content, and mineralogy) vary both vertically and laterally as a result of the localized emplacement temperature, thickness, gas content, and composition.

Tshirege Member Unit 2. Unit 2 of the Tshirege Member of the Bandelier Tuff is a competent, resistant unit that forms the surface of Mesita del Buey. Its thickness varies from 35 ft to 40 ft at Area G (Appendix F). Where it is exposed, unit 2 forms nearly vertical cliffs on the sides of the mesa. The rock is described as a moderately welded ash-flow tuff composed of crystal-rich, devitrified pumice fragments in a matrix of ash, shards, and phenocrysts (primarily potassium feldspar [sanidine] and quartz).

Unit 2 is extensively fractured as a consequence of contraction during post-depositional cooling. The cooling-joint fractures are visible on mesa edges and on the walls of pits. In general, the fractures dissipate at the bottom of unit 2. On average, fractures in unit 2 are nearly vertical. Mean spacing between fractures ranges between 1.9 ft and 2.6 ft, and the fracture width ranges between less than 0.03 in. and 0.51 in. with a median width of 0.12 in. The fractures are typically filled with clays to a depth of about 9.9 ft; smectites are the dominant clay minerals present. Smectites are known for their tendency to swell when water is present and for their ability to strongly bind certain elements, both of which have implications for transport in fractures. Opal and calcite may occur throughout the fractured length, usually in the presence of tree and plant roots (live and decomposed); the presence of both the minerals and the roots indicates some water at depth in fractures.

At the base of unit 2 is a series of thin, less than 3.9-in.-thick, discontinuous, crystal-rich, fine- to coarse-grained surge deposits. Bedding structures are often observed in these deposits. The surge beds mark the base of unit 2.

Tshirege Member Unit 1v. Tshirege Member unit 1v is a vapor-phase-altered cooling unit underlying unit 2. This unit forms sloping outcrops, which contrast with the near-vertical cliffs of unit 2. Unit 1v is further subdivided into units 1vu and 1vc.

Unit 1vu. The uppermost portion of unit 1v consists of devitrified and vapor-phase-altered ash-fall and ash-flow tuff, and the unit has been designated unit 1vu, where "u" signifies upper. Its thickness varies from 60 ft to 75 ft at Area G. Unit 1vu is unconsolidated at its base and becomes moderately welded nearer the overlying unit 2. Only the more prominent cooling fractures originating in unit 2 continue into the more welded upper section of unit 1vu but terminate in the less consolidated lower section. More typically, fractures in unit 2 do not extend into unit 1vu.

Unit 1vc. Beneath unit 1vu is unit 1vc, where "c" stands for colonnade, named for the columnar jointing visible in cliffs formed from this unit. Unit 1vc is a poorly welded, devitrified ash-flow tuff at its base and top and becomes more welded in its interior. Unit 1vc is approximately 25 ft thick at Area G.

Tshirege Member Unit 1g. The basal contact of unit 1vc is marked by a rapid change (within 0.7 ft vertical) from devitrified (crystallized) matrix in unit 1vc to vitric (glassy) matrix in the underlying unit 1g. Vitric pumices in unit 1g stand out in relief on weathered outcrops, while devitrified pumices above this interval are weathered out. In outcrop, this devitrification interval forms a prominent erosional recess termed the *vapor-phase notch*. No depositional break is associated with the vapor-phase notch; the abrupt transition indicates this feature is the base of the devitrification that occurred in the hot interior of the cooling ash-flow sheet after emplacement.

Unit 1g is a vitric, pumiceous, nonwelded ash-flow tuff underlying the devitrified unit 1vc. It is about 140 ft thick at Area G. Few fractures are observed in the visible outcrops of this unit, and the weathered cliff faces have a distinctive Swiss-cheese appearance because of the softness of the tuff. The uppermost 5 ft to 20 ft of unit 1g are iron-stained and slightly welded. This portion of unit 1g is resistant to erosion, helping to preserve the vapor-phase notch in outcrop. A distinctive pumice-poor surge deposit forms the base of unit 1g.

Tsankawi Pumice Bed

The Tsankawi Pumice Bed is the basal air-fall deposit of the Tshirege Member of the Bandelier Tuff. It is a thin bed of gravel-sized vitric pumice with a thickness of about 3 ft at Area G.

Cerro Toledo Interval

The Cerro Toledo interval consists of thin beds of tuffaceous sandstones, paleosols, siltstones, ash, and pumice falls; the Cerro Toledo interval separates the Tshirege and Otowi Members of the Bandelier Tuff. The Cerro Toledo interval also includes localized gravel- and cobble-rich fluvial deposits predominantly derived from intermediate composition lavas eroded from the Jemez Mountains west of the Pajarito Plateau. This interval varies between 15 ft and 30 ft thick at Area G.

Otowi Member

The Otowi Member tuffs are about 80 ft thick at Area G. The tuffs are a massive, nonwelded, pumice-rich, and mostly vitric ash flow. The pumices are fully inflated, supporting tubular structures that have not collapsed as a result of welding. The matrix is an unsorted mix of glass shards, phenocrysts, perlite clasts, and minute, broken pumice fragments.

The Guaje Pumice Bed is the basal air-fall deposit of the Otowi Member of the Bandelier Tuff. The thickness of the unit has been measured at 10 ft at Area G. The pumice bed is nonwelded but brittle. Pumice tubes are partially filled with silica cement.

Cerros del Rio Basalts (Tb 4)

In the vicinity of TA-54, the Cerros del Rio basalts lie directly beneath the Otowi Member of the Bandelier Tuff (Figure 18). In characterization well R-32, the basalts are 636 ft thick, and in R-22 they are 983 ft thick. In both wells, the regional water table occurs within these basalts. Local borehole cores from Area G show that the basalts consist of both angular rubble and dense, fractured masses, with zones of

moderately to very porous lavas. Deeper drilling at R-22 showed a wide variety of lithologies within the basalts, including massive flows, interflow rubble or scoria zones, sediments, and paleosols.

Puye Formation (Tpf, Tpp) and Older Fanglomerate

The Puye Formation is a conglomerate deposit derived primarily from volcanic rocks to the west, with varying lithologies including stream channel and overbank deposits, ash and pumice beds, debris flows, and lahar deposits. Well tests on the plateau confirm that the unit is very heterogeneous with both high and low permeability zones present (LANL 2003, 76059). The formation is poorly lithified and probably does not have open fractures.

As shown in Figure 18, the Puye Formation thins from west to east beneath TA-54. At PM-2, the Puye Formation (including fanglomerate, pumiceous units and ancestral Rio Grande deposits) is approximately 800 ft thick; at characterization well R-23, the Puye Formation is completely absent. Recent drilling across the plateau has indicated that the Puye Formation is frequently underlain by alluvial fan deposits, similar in lithology to the Puye Formation, yet considerably older. These deposits are of considerable thickness at PM-2, were penetrated at R-22 (approximately 80 ft thick), and were absent at R-23. The Puye Formation was also encountered at R-16 (351 ft thick); the water table occurs within the Puye Formation at this location.

Totavi Lentil Deposits (Tpt)

The Totavi Lentil is an ancestral Rio Grande deposit composed of coarse gravels and sands with abundant quartzite. The deposit has been alternatively conceptualized as a series of distinct north-south trending ribbons and a continuous thin sheet at the base of the Puye Formation. Like the overlying Puye Formation, it has both high- and low-permeability zones (LANL 2003, 76059).

Santa Fe Group (Tsf, Tf, and Ts) and Santa Fe-Age Basalts (Tb 1 and Tb 2)

The Santa Fe Group is an alluvial-fan deposit consisting of medium to fine sands and clays. Numerous north-south trending faults are present in the Santa Fe Group. Santa Fe Group rocks are deep below Area G (1500 ft bgs at PM-2) and were not penetrated by R-20, R-22, or R-32. Most water-supply wells on the eastern edge of the Pajarito Plateau and elsewhere in the basin are completed in these rocks. The Santa Fe Group units are characterized with the lowest permeability compared with the other units in the regional aquifer.

Basaltic lava flows occurred during the time the Santa Fe Group was deposited; these basalts occur both within the Santa Fe Group and within the pre-Puye Formation sands, gravels, and conglomerates penetrated by R-20 and R-22. These old basalts appear to have fewer open fractures than the younger Cerros Del Rio basalts.

3.2.2 Hydrogeology

The proposed hydrogeologic conceptual model for the Pajarito Plateau (LANL 1998, 59599) is presented in Figure 20. The model predicts that infiltration of water into the subsurface, and subsequent transport of water, vapor, and solutes through the upper regions of the vadose zone, are heavily influenced by surface conditions such as topography, surface-water flow, and microclimate. According to model predictions, movement through deeper layers, including the regional aquifer, is influenced only weakly by surface conditions and is influenced more by the hydraulic characteristics of aquifer rocks, regional groundwater

flow patterns, and stresses induced by water-supply production. The following sections provide an overview of infiltration rates and groundwater occurrence in the vicinity of Area G.

Infiltration

Surface and near-surface conditions (topography, precipitation, surface runoff) control water infiltration to the subsurface and the transport of contaminants into the shallow subsurface. In this respect, the behavior of mesas and canyons forming the plateau differ from one another (LANL 1998, 59599). Mesas are generally dry, both on the surface and within the rock forming the mesa. Canyons range from wet to relatively dry; the wettest canyons contain continuous streams and perennial groundwater in the canyon-bottom alluvium. Dry canyons have only occasional stream flow and may lack alluvial groundwater.

Relatively small volumes of water move beneath mesa tops under natural conditions because of low rainfall, runoff into canyons, high evaporation, and efficient water use by vegetation. Liquid water generally infiltrates the mesa after precipitation or snowmelt, and water vapor generally moves upward, undergoing evapotranspiration along the top and sides of the mesa. Air readily circulates through the mesa-top units because of the relatively dry pore spaces and the topographic relief. Air circulation may be driven by temperature variations, barometric pumping, or surface winds. This circulation process promotes atmospheric evaporation, which may extend deep within the mesa and further inhibit downward liquid-water flow.

Mesita del Buey is one of the drier mesas at the Laboratory and the Pajarito Plateau. Infiltration into the mesa appears to be very low, possibly only 0.04 in./yr (LANL 1997, 63131), and occurs during snowmelts or intense summer thunderstorms, which leads to slightly higher moisture content within the uppermost few meters of the mesa surface. During dry periods, evapotranspiration removes moisture from the surface of the mesa; permeable zones such as fractures and surge beds act as conduits for air and aid in drying the mesa.

Groundwater

Groundwater beneath the Laboratory occurs in the regional aquifer (at depths ranging from 1200 to 600 ft bgs) and in perched intermediate and shallow aquifers. With the exception of TA-16, perched groundwater has been detected only in wells beneath relatively wet canyons (e.g., Los Alamos Canyon) as (1) shallow alluvial aquifers that occur in some wet canyons (generally at depths less than 100 ft), and (2) deeper intermediate perched aquifers that occur in zones separated from both alluvial and regional groundwater by unsaturated rock. Data indicate that dry mesas such as Mesita del Buey show no evidence of perched groundwater beneath the mesa. However, alluvial and intermediate perched aquifers in adjacent canyons may cause increased moisture contents within the vadose zone at the base of the mesa.

Perched Intermediate Waters

Observations of perched intermediate water are rare on the Pajarito Plateau. Perched waters are thought to form mainly at horizons where properties of the medium change dramatically, such as at paleosol horizons containing clay or caliche. It is not known whether perched water bodies are isolated or connected and to what degree they may influence travel times and pathways for contaminants in the vadose zone. Although perched intermediate groundwater has been observed in some locations elsewhere on the plateau, none has been observed in the characterization wells in the vicinity of Area G (R-16, R-20, R-21, R-22, [LANL 1998, 59599]). Well R-22 is located 500 ft east of Area G and

characterizes the subsurface conditions below Area G. No perched groundwater was observed in 153 ft of drilling in the deepest MDA G Phase I RFI borehole drilled to date (borehole 54-01111).

Regional Aquifer

The regional aquifer of the Pajarito Plateau is the only local aquifer capable of supplying municipal water on a large scale (Purtymun 1984, 06513). The regional aquifer extends throughout the Española Basin (an area roughly 2300 mi²) and reaches its maximum thickness beneath the Pajarito Plateau (over 9800 ft thick) (Cordell 1979, 76049).

Depths to the regional aquifer range between 1200 ft along the western edge of the plateau and about 600 ft along the eastern edge. Beneath Area G, the water-table elevation is approximately 5830 ft (5767 ft asl at R-22; 5860 ft asl at R-32) or approximately 830 ft bgs. Figure 21 depicts water-table elevations across the plateau, i.e., a contour map of hydraulic head data (water-table elevations) collected from the regional aquifer.

Groundwater flow in the regional aquifer between TA-54 and the Rio Grande (approximately 4 mi) occurs primarily in the Santa Fe Group. Pump test results in individual water supply wells throughout the plateau indicate the hydraulic conductivity (K) of the Santa Fe Group along the eastern edge of the plateau is the lowest of any aquifer unit ([average K for Los Alamos (LA) well field = 0.7 ft/day] Purtymun 1995, 15344). More recent analysis of water-level trends over a 55-yr span indicates that these K estimates, although accurate locally, may be higher than the large-scale, effective permeability of the Santa Fe Group (0.2 ft/day) because of the flow impedance of north-south trending faults. Assuming a porosity of 20% (typical of sedimentary rocks [Freeze and Cherry 1979, 64057]) and the measured gradient of 0.02, pore-water velocities in this portion of the aquifer would be slow (approximately 0.07 ft/yr to 0.23 ft/yr [LANL 2003, 76059]). Travel times within the regional aquifer (Santa Fe Group rocks) from Mesita del Buey to the Rio Grande would be on average over 1000 yr.

Vadose Zone

The region beneath the ground surface and above the regional aquifer is called the vadose (unsaturated) zone. The source of moisture in the vadose zone beneath TA-54 is infiltrating precipitation; however, most of the precipitation is removed as runoff or evaporation and transpiration in the upper region of the vadose zone (LANL 1997, 63131). The subsurface movement of the remaining water (often referred to as recharge) is predominantly vertical in direction and is influenced by properties and conditions of the vadose zone.

The geologic property of the Bandelier Tuff that most influences the vertical fluid flow in the vadose zone is the degree of welding. Welded tuffs tend to have less matrix porosity and more fractures than nonwelded tuffs. Fractures in welded tuff may include relatively close-spaced cooling joints as well as tectonic fractures. Although nonwelded tuffs also have fractures, they are generally less abundant than in welded tuffs.

Several competing effects determine the moisture content and fluid flux in welded, devitrified tuff. While water moves slowly through the unsaturated tuff matrix, it can move relatively rapidly through fractures if nearly saturated conditions exist (LANL 1997, 63131). Generally, field moisture content in the upper 100 ft of tuff at Area G is less than 2% by volume in areas undisturbed by disposal pits, trenches, and shafts and, most notably, asphalt cover. Where disposal activities have disturbed some areas, near-surface moisture content increases up to approximately 25% because of the absence of plant evapotranspiration and suppression of atmospheric venting by installation of large asphalt surfaces

(LANL 1995, 56834). At these saturation levels, most of the fractures beneath Area G are completely dry, and the water can be found only in the tuff matrix. When substantial infiltration occurs from the ground surface, the fractures become wet and conduct water. However, modeling studies for Area G predict that when fractures disappear at contacts between stratigraphic subunits such as the Cerro Toledo interval, fracture moisture is absorbed into the tuff matrix if fracture fills are encountered or if the coatings are interrupted (LANL 1997, 63131, p. SD2C-1).

The average volumetric moisture content of the Area G subsurface is presented in Figure 22. Borehole 54-01111 is located along the south-central boundary of the site, and borehole 54-01117 is located in the northeast corner of Area G. Together, they provide a general characterization of moisture contents beneath Area G. These data, collected through the neutron logging of environmental characterization boreholes over five years, show the control of subsurface moisture by atmospheric processes and lithological horizons described above. The deeper spike in moisture contents occurs at the base of unit 1vc that contains the vapor-phase notch, which is the vertical limit of devitrification in unit 1 that occurred in the interior of the ash-flow during cooling. The vapor-phase notch contains volcanic glass mostly destroyed by devitrification and has a fine, sugary texture. In addition, numerous vertical fractures in unit 1vc terminate in this zone. These characteristics allow moisture to accumulate in this zone.

4.0 SCOPE OF ACTIVITIES

This section identifies the specific activities that will be performed during the field investigation of MDA G. These activities were approved by NMED in accordance with Section III.M of the September 1, 2004, proposed Consent Order. Implementation of these activities will satisfy the requirements in Section IV.C.1.c of the September 1, 2004, proposed Consent Order for investigation of MDA G.

4.1 MDA G Investigation Activities

The field investigation of MDA G will consist of the following activities. The methods used to conduct each of these activities are identified and discussed in section 5 of this work plan.

- Three angled and thirty-four vertical boreholes will be installed at the locations shown in Figure 23. Boreholes will be advanced at the angles and to the depths and lengths specified in Table 2.
- Continuous core samples will be collected from each borehole. Core will be visually inspected, field-screened, and geologically logged. Borehole logs will be prepared for each borehole.
- Field screening for radiological contamination will be continuous for all recovered borehole material. Headspace screening for organic vapors will be conducted at 10-ft intervals. Screening for high explosives will be conducted at the lowest base elevation of the adjacent disposal unit and at the total depth (TD) of the borehole.
- Tuff samples will be collected at a depth equal to the lowest base elevation of the adjacent disposal unit and at the TD of the borehole. Focused samples will be collected based on field indicators of potential contamination at the interval from the lowest base elevation of the pits to the TD of the borehole. The following field indicators will be used to bias sample collection: evidence of contamination (for example, staining, elevated moisture content, elevated radioactivity, organic vapor screening results, and HE screening results), lithologic contacts, structural features, fractures, fracture-fill material, surge beds, or a higher permeability unit.

- The analyte suite for all samples includes isotopic uranium, isotopic plutonium, americium-241, strontium-90, gamma spectroscopy, TAL metals, boron, molybdenum, perchlorate, nitrates, and cyanide (Table 2). In addition, samples collected at the lowest base elevation of the adjacent disposal unit will include dioxins, furans, and VOCs. Twenty percent of the samples screened for HE will be analyzed for explosive compounds.
- Vapor samples for tritium and VOCs will be collected at the lowest base elevation of the adjacent disposal unit and at the TD of the borehole.
- Subsurface vapor samples will be collected from borehole 15 at approximately 100 ft, 200 ft, 300 ft, abandonment of auger drilling (approximately 400 ft), and TD (700 ft).
- Groundwater samples will be collected if perched water is encountered.
- Preliminary sample locations for all proposed boreholes are shown in the cross sections presented in Figures 24 through 43.

4.2 Justification for Alternative Scope of Work

The scope of work contained in this work plan differs from the specific investigation requirements contained in Section IV.C.1.c of the September 1, 2004, proposed Consent Order. The June 2004 MDA G work plan proposed alternate investigation requirements and provided justifications for these alternate requirements. In accordance with Section III.M.1 of the September 1, 2004, proposed Consent Order, these alternate requirements were approved by NMED, and these approved alternate requirements, rather than the requirements of the proposed Consent Order, become applicable and enforceable. The alternate requirements proposed by the Laboratory and approved by NMED are summarized in Table 3, along with a brief justification for the alternate approach. The following subsections provide additional details related to these justifications.

4.2.1 Number, Locations, and Depths of Boreholes

The September 1, 2004, proposed Consent Order requirements specify installation of one boring directly adjacent to the downslope end of each disposal shaft, at the downslope end of each row of disposal shafts, at the low elevation point of each pit, every 3600 sq ft in a shaft field, and every 60 ft along a shaft row. The Laboratory's approach differs from this requirement in its use of vertical and angled boreholes whose locations are based on analysis of the results of previous investigations as well as physical features of the disposal units. Table 4 summarizes how the existing and approved borehole locations differ from the Order-specified borehole locations for each pit, trench, and shaft field. The Laboratory's approach differs from that specified in the proposed Consent Order in terms of specific borehole locations, but ultimately the approaches of both the Laboratory and Consent Order result in the characterization of potential releases from each pit, trench, and shaft field.

The Laboratory justifies its alternate approach on the basis of evaluating existing data to determine those additional data specifically needed to complete the characterization of the nature and extent of contamination and the characterization of migration pathways to receptors to assess the potential present-day and future risk posed by the site. This evaluation of data is presented in section 2 and yields five data requirements to determine

1. the vertical extent of tritium in the subsurface along the southern fence line near the high-activity tritium disposal shafts;

2. the vertical extent of the vapor-phase VOCs beneath the pits on the eastern boundary of Area G and the sources of VOCs in the area of Pits 25 and 26;
3. the extent of radionuclides and inorganic chemicals beneath and adjacent to several previously uncharacterized disposal units;
4. the nature and extent of perchlorate, nitrate, HE, dioxins, and furans in the subsurface; and
5. the potential presence of perched groundwater beneath MDA G.

Additional samples from Cañada del Buey and Pajarito Canyon are needed to further characterize sediment that is downgradient from Area G and will be collected as part of ENV-RS investigations of Cañada del Buey and Pajarito Canyon.

These data requirements were considered, along with access constraints and other limitations, to identify the borehole locations and specifications shown in Figure 23 and Table 2, respectively. Figure 23 shows a plan view of MDA G with approximate locations of boreholes with respect to existing buildings, disposal trenches, pits, and shafts. The discussion of each approved borehole presented below provides a detailed justification for the Laboratory's approach.

Borehole 1. Located between Pits 1 and 3 (Figure 24). This borehole will be advanced adjacent to regions of maximum depth of disposal. In addition to addressing data requirements 1 and 2, this borehole will augment Phase I RFI boreholes 54-01126 and 54-01128 to characterize these disposal units.

Borehole 2. Located north of Pit 6 at the western end of the pit (Figure 25). This borehole will be advanced alongside existing borehole 54-01112 north of Pit 6.

Borehole 3. Located between Pits 7 and 24 at the approximate location of the deepest portion of the pits (Figure 26).

Borehole 4. Located centrally along the east side of Pit 8 (Figure 27). This angled borehole will be advanced to the northwest beneath Pits 8, 9, and 10. This borehole will augment data from Phase I RFI borehole 54-01108 to characterize these disposal units beneath their maximum depths.

Borehole 5. Located south of Shaft C12 (Figure 28). This vertical borehole will be used to characterize Shafts C1–C10 and C12 and Pits 12 and 13.

Borehole 6. Located southwest of Pit 20 (Figure 29). This angled borehole will be advanced to the northwest beneath the maximum depths of Pits 18 and 20. In addition to addressing data requirements 1 and 2, this borehole will augment Phase I RFI borehole 54-01115 to characterize these disposal units.

Borehole 7. Located between Pits 21 and 22 (Figure 30). This borehole will be advanced vertically beyond the Cerro Toledo interval and adjacent to the maximum depth of disposal in both pits. No Phase I RFI boreholes were sited near these disposal units.

Borehole 8. Located northwest of Pit 26 (Figure 31). This angled borehole will be advanced to the southeast beneath the maximum depths of disposal of Pits 25 and 26. This borehole will target the lowest base elevation of the pits. In addition to addressing data requirements 1 and 2, this borehole will augment Phase I RFI borehole 54-01106 to characterize these disposal units.

Borehole 9. Located between Pits 27 and 28 (Figure 32). This borehole will be advanced vertically beyond the Cerro Toledo interval and adjacent to the maximum depth of disposal in both pits. In addition

to addressing data requirements 1 and 2, this borehole will augment Phase I RFI borehole 54-01105 to characterize these disposal units.

Borehole 10. Located between Pits 29 and 30 (Figure 33). This borehole will be advanced vertically beyond the Cerro Toledo interval and adjacent to the maximum depth of disposal in both pits. No Phase I RFI boreholes were sited near these disposal units.

Borehole 11. Located between Pits 32 and 33 (Figure 34). This borehole will be advanced vertically adjacent to the maximum depth of Pits 32 and 33 and will augment Phase I RFI borehole 54-01102 to characterize these disposal units.

Borehole 12. Located between Pits 35 and 36 (Figure 35). This borehole will be advanced vertically beyond the Cerro Toledo interval and adjacent to the maximum depth of disposal in both pits. No Phase I RFI boreholes were sited near these disposal units.

Borehole 13. Located between Pits 36 and 37 (Figure 36). This borehole will be advanced vertically beyond the Cerro Toledo interval and adjacent to the maximum depth of disposal in both pits. No Phase I RFI boreholes were sited near these disposal units.

Borehole 14. Located between Pits B and C (Figure 37). This borehole will be advanced vertically adjacent to both pits. In addition to addressing data requirements 1 and 2, this borehole will augment Phase I RFI borehole 54-01111 to characterize these disposal units.

Borehole 15. Located between Pits 12 and 13 (Figure 38). This borehole will be advanced vertically through the Cerro Toledo interval and adjacent to the maximum depth of disposal in both pits. No Phase I RFI boreholes were sited near these disposal units. This borehole will be extended to a depth of 700 ft to determine whether perched groundwater is present beneath MDA G. Previous drilling experience at the Laboratory indicates the borehole can be drilled to approximately 300 ft with an auger. Rotary-drilling methods will then be used to reach the 700-ft level.

Borehole 16. Located west of Pit 22, at the north end of Shafts 157–160 (Figure 39). In addition to addressing data requirements 1 and 2, this borehole will augment Phase I RFI borehole 54-01110 to characterize these disposal units.

Borehole 17. Located west of Pit 22, at the south end of the Shafts 157–160 (Figure 40). In addition to addressing data requirements 1 and 2, this borehole will augment Phase I RFI borehole 54-01110 to characterize these disposal units.

Borehole 18. Located west of Pit 4, near the cluster of Shafts 1–112 (Figure 41). This borehole will be advanced vertically and will augment Phase I RFI boreholes 54-01116 and 54-01117 to characterize these disposal units.

Borehole 19. Located west of Shafts 200–233 (Figure 42). This borehole will be advanced vertically and will augment Phase I RFI borehole 54-01121.

Borehole 20. Located east of Pit 19 (Figure 43). This borehole will be advanced adjacent to the maximum depth of Pit 19 beyond the Cerro Toledo interval. No Phase I RFI boreholes are associated with this disposal unit.

Borehole 21. Located south of Pits 1 and 3 (Figure 44). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI boreholes 54-01126 and 54-01128.

Borehole 22. Located north of Pit 2 (Figure 45) beyond the MDA G boundary fence. This borehole will be advanced beyond the Cerro Toledo interval. No Phase I RFI boreholes are associated with this disposal unit.

Borehole 23. Located north and east of Pit 2 beyond the MDA G boundary fence (Figure 46). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI borehole 54-01123.

Borehole 24. Located north and west of Pit 2 beyond the MDA G boundary fence (Figure 47). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI borehole 54-01117.

Borehole 25. Located between Pits 2 and 4 toward the eastern end at the maximum depth of the pits (Figure 48). This borehole will be advanced adjacent to the maximum depths of Pits 2 and 4 and will augment Phase I RFI borehole 54-01123.

Borehole 26. Located between Pits 4 and 5 near the maximum pit depth (Figure 49). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI borehole 54-01125.

Borehole 27. Located north of Pit 6 at least 250 ft beyond the MDA G boundary fence at the base of the mesa (Figure 50). This borehole will be advanced beyond the Cerro Toledo interval. No Phase I RFI boreholes were drilled near this location.

Borehole 28. Located north of Pit 6 at the eastern end of the pit (Figure 51). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI borehole 54-01113.

Borehole 29. Located between Pits 8 and 9 at the south end of the pit (Figure 52). This borehole will be advanced beyond the Cerro Toledo interval. No Phase I RFI boreholes were drilled near this location.

Borehole 30. Located between Pits 10 and 12 at the north end of the pit (Figure 53). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI borehole 54-01108.

Borehole 31. Located at the south end of Pit 16 (Figure 54). This borehole will be advanced beyond the Cerro Toledo interval. No Phase I RFI boreholes were drilled near this location.

Borehole 32. Located at the southeast end of Pit 17 (Figure 55). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI borehole 54-01115.

Borehole 33. Located between Pits 29 and 30 at the eastern end (Figure 56). This borehole will be advanced beyond the Cerro Toledo interval. No Phase I RFI boreholes were drilled near this location.

Borehole 34. Located at the south end of Pit 33 (Figure 57). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI borehole 54-01102.

Borehole 35. Located between Pits 35 and 29 (Figure 58). This borehole will be advanced beyond the Cerro Toledo interval. No Phase I RFI boreholes were drilled near this location.

Borehole 36. Located at the north end of Trenches A-D (Figure 59). This borehole will be advanced beyond the Cerro Toledo interval.

Borehole 37. Located at the south end of Trenches A-D (Figure 60). This borehole will be advanced beyond the Cerro Toledo interval and will augment Phase I RFI borehole 54-01111.

Table 2 provides a summary of the 37 approved boreholes. All boreholes will be located so they pass no closer than 15 ft from any disposal unit. Before selecting the final location of these boreholes, Laboratory engineering drawings will be examined to ensure the boreholes will not be advanced through the disposal units.

The maximum depth at which Phase I RFI inorganic chemicals were detected above background values beneath MDA G was 129 ft bgs. The proposed target depths will be sufficient to establish the vertical extent of contamination beneath MDA G. If radiological contamination, organic vapors, or HE are detected using screening equipment, the borehole will advance until no elevated screening results are obtained for at least 25 ft, or a decreasing concentration gradient is observed that approaches detection limits or ambient background.

Under fracture-flow conditions, detection of residual contamination in tuff is uncertain, and establishing the vertical and horizontal extent of such contamination is inherently subjective, even with respect to concentrations relative to background or a decreasing concentration gradient. The sample locations, depths, and sampling design (paired samples of fracture fill and surrounding intact tuff) of the proposed boreholes were specified to supplement existing tuff data beneath the MDA G disposal units and determine whether contamination may have migrated through fractures. The depths for collection of samples beneath the disposal units are consistent with this approach.

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. An additional sample will be collected from the rock matrix adjacent to the fracture sample material to allow for comparison. The fractures and matrix samples are paired and will be assigned unique identifiers.

4.2.2 Subsurface Vapor-Phase Sampling

Section IV.C.1.c.iii, Item 7 of the September 1, 2004, proposed Consent Order specifies that each new boring will be completed as a vapor-monitoring well. The Laboratory's approved approach is to select certain new boreholes for completion as vapor-monitoring wells based on the results of pore-gas sampling performed in each new borehole. The Laboratory will collect subsurface pore-gas samples for VOC and tritium analysis from each new borehole.

The investigation vapor monitoring and sampling plan (section 6.0) will be based on the results of this sampling. The boreholes will remain open until the decision to install vapor-monitoring wells is made. A minimum of two tritium and VOC pore-gas samples will be collected from the 12 existing pore-gas monitoring wells and proposed boreholes 1 through 37 at two depths: (1) the lowest base level of the corresponding disposal pit, shaft, or trench and (2) the TD of the borehole. The Laboratory's justification for the alternate approach is that the presence of an existing MDA G subsurface vapor-monitoring network makes it unnecessary to complete each new borehole as a vapor-monitoring well.

Based on the results of the above pore-gas sampling, the Laboratory will identify those boreholes that will be completed as vapor-monitoring wells. The Laboratory will then prepare an investigation vapor monitoring and sampling plan for MDA G that will be submitted to NMED within 90 days of completing the borehole drilling.

4.2.3 Field Screening

Section IV.C.1.c.iv, Item 2, of the September 1, 2004, proposed Consent Order specifies that core samples collected during the MDA G investigation be screened using the methods described in Section

IX.B of the proposed Consent Order. Section IX.B.2.d of the proposed Consent Order specifies that all core samples be screened by (1) visual examination; (2) headspace vapor screening for VOCs; and (3) metals screening using x-ray fluorescence (XRF). Additional screening for release-specific characteristics, such as pH and HE, shall be conducted where appropriate. Section IV.C.1.c.iv of the proposed Consent Order indicates that screening results for the samples shall be used to identify samples to be submitted for laboratory analysis.

The Laboratory's approved field screening approach will be to (1) visually examine all samples for evidence of contamination; (2) screen for organic vapors at 10 ft intervals; (3) screen for radiological contamination; (4) screen for nitroaromatic explosives (e.g., trinitrotoluene [TNT]) and nitramine explosives (for example, 1,3,5-trinitro-1,3,5-triazacyclohexane [RDX]).

This approach differs from that specified in the Order by not using the Order-specified field-screening methods for metals as a basis for identifying samples to be submitted for laboratory analysis. Alternatively, screening for radiological contamination will be included as a method to bias sample collection.

Radioactivity

The MDA G work plan specifies radiation screening of all samples. All core will be continuously screened in the field for alpha, beta, and gamma radiation. There is no effective real-time field method to screen for tritium. Therefore, field screening for tritium is not useful for determining which samples should be submitted for laboratory analysis.

High Explosives

Core collected at the base of the pits and TD of the boreholes will be screened for nitroaromatic explosives (e.g., TNT) and nitramine explosives (e.g., RDX). Because real-time qualitative results will be obtained in the field with the immunoassay test kits, 20% of the screened core samples will be submitted to an off-site contract laboratory for analysis of explosive compounds to verify immunoassay field-screening results and to define the nature and extent of explosive compound contamination.

4.2.4 Analytical Suites

Section IV.C.1.c.iv of the proposed Consent Order requires all borehole samples to be submitted for laboratory analysis of pH, VOCs, semivolatle organic compounds (SVOCs), explosive compounds, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The Laboratory's approved alternate approach is to submit all samples for laboratory analysis of isotopic uranium, isotopic plutonium, americium-241, strontium-90, gamma spectroscopy, TAL metals, boron, molybdenum, perchlorate, nitrates, and cyanide. The sample collected in each borehole at the lowest depth of the corresponding disposal unit and at the TD of the borehole will be submitted for analysis of VOCs, dioxins, and furans. The Laboratory's approach differs from that specified in the proposed Consent Order in that no samples will be submitted for laboratory analysis of pH, SVOCs, and PCBs; only selected samples will be submitted for analysis of explosive compounds.

The Laboratory's justification for the alternate approach is that existing analytical results and historical information may be used to identify the analytical suite needed to complete characterization of the nature and extent of contamination. This information was used to screen the list of analytes specified in the proposed Consent Order and to identify those analytes not appropriate for analysis for contaminants present at MDA G, those for which nature and extent have already been established, and those for which

analysis is appropriate only for selected depth intervals. The approved analytical suite is discussed in the following paragraphs, which provide justification for the Laboratory's alternate approach.

Analysis of tuff samples for pH is not appropriate considering the low moisture content of the tuff and will not be performed. Samples will not be analyzed for total uranium but will be analyzed for isotopic uranium, which may be used to calculate total uranium.

Subsurface core samples collected during the Phase I RFI were submitted for analysis of SVOCs, PCBs, and pesticides. The results of this sampling indicate that the nature and extent of SVOC, PCB, and pesticide contamination is established for MDA G (section 2), and no additional sampling for these constituents is required.

5.0 INVESTIGATION METHODS

The current versions of the SOPs applicable to the investigation methods proposed in this plan are presented in Table 5. Additional procedures may be added as necessary to describe and document quality-affecting activities.

5.1 Methods for Drilling and Sampling Proposed Boreholes 1 through 37

5.1.1 Drilling Protocol

All boreholes will be drilled using the hollow-stem auger method to allow for collecting undisturbed samples of core and subsurface vapors within the Tshirege Member of the Bandelier Tuff. Each borehole will be logged with caliper, camera, neutron, and natural gamma tools according to SOP-5.07, Revision 0.

Borehole 15 will be drilled to a depth of 700 ft bgs. It will serve both to characterize Pits 12 and 13 and to determine whether perched groundwater is present below MDA G. Hollow-stem auger drilling will be used until refusal. Upon drill refusal, air-rotary drilling will be used to complete the borehole. The coupling of these drilling methods is practical and allows the objectives of the sampling for this borehole to be met. The borehole will be logged with caliper, camera, neutron and natural gamma tools according to SOP-5.07, Revision 0.

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

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 drilling 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 also helps to cool the drill bit. The air-rotary drilling method is best suited for hard rock formations. In soft unconsolidated formations, casing is driven to keep the formation from caving. When using air rotary, the air compressor will have an in-line organic filter system to filter the air coming from the compressor. The organic filter system will be inspected regularly to ensure it is functioning properly. In addition, a cyclone-velocity dissipator 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 dissipator to the ground surface.

Boreholes 1 through 37 are plotted relative to disposal units in Figures 23 through 60. The depths, angles, analytical suites, and sampling protocols for each borehole are described in Table 2. Each borehole will be cored continuously using a split-barrel sampler to TD. The core will be screened, visually inspected, and geologically logged. The TD of boreholes may increase if elevated contaminant concentrations are detected using field screening instruments. The proposed location of each borehole (Figure 23) has been determined by Laboratory engineering drawings. The exact location of each borehole will be determined after a field survey which will consider how disposal unit boundaries, utilities, surface conditions, and access restrictions could affect drilling and site operations.

5.1.2 Collection of Tuff Samples

Boreholes 1 through 37 will be cored continuously and geologically logged to TD following SOP-4.01, Revision 1, and SOP-12.01, Revision 4. Continuous core subsurface tuff samples will be analyzed for lithologic and structural features. In addition, the elevation of the weathered tuff surface will be recorded to aid in surface mapping activities. Subsurface tuff samples will be collected from core provided from a split- spoon core barrel into sealed sleeves or core-protect bags to preserve core moisture following SOP-6.26, Revision 1.

A minimum of two tuff samples will be collected from each borehole for laboratory analysis. The first sample will be collected from a depth equivalent to the base of the nearest adjacent subsurface unit, and the second will be collected from TD. The second sample for borehole 15 will be collected from a depth of approximately 200 ft bgs. Table 2 lists the analytical suites of the samples and the disposal unit(s) that each borehole characterizes. Additional discretionary samples may be collected between the disposal unit and TD based on field screening results.

Field documentation of samples collected from fractures will include a detailed physical description of the fracture-fill material and rock-matrix sampled according to SOP-12.01, Revision 4 and Section IV.C.1e.iv of the proposed Consent Order. The volumes of fracture-fill and rock-matrix material included in the sample will be estimated from field measurements. An additional sample will be collected from the rock matrix adjacent to the fracture sample material, thus allowing for comparison. Paired fracture sampling is discussed further in section 5.3.

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. The fracture and matrix samples will be assigned unique identifiers.

Quality assurance/quality control (QA/QC) samples will include field duplicate samples to evaluate the reproducibility of the sampling technique and rinsate blanks to evaluate decontamination procedures. These samples will be collected following SOP-1.05, Revision 1.

5.1.3 Field Screening

The field screening methods to be used include (1) visual examination, (2) radionuclide screening for alpha, beta, and gamma radiation, and (3) organic vapor screening. Additional screening, such as HE, will be conducted where appropriate.

Radionuclide screening will target gross alpha, beta, and gamma radiation. Field screening for alpha, beta, and gamma radiation will be conducted within 6 in. from the core material. All instrument background checks, background ranges, and calibration procedures will be documented daily in the field logbooks.

Vapor screening of subsurface core for VOCs will be conducted using a photoionization detector (PID) equipped with a 11.7 electron volt (eV) lamp and will follow SOP-06.33. The PID will provide resolution to 1 part per million. The maximum value and the ambient-air temperature will be recorded on the field boring or test pit log for each sample. The PID will be calibrated each day to the manufacturer's standard for instrument operation (all daily calibration results will be documented in the field logbooks). Field screening for VOCs will be performed using headspace analysis at 10-ft intervals in each borehole.

HE screening will be accomplished using immunoassay kits for both nitroaromatics (TNT) and nitramines (RDX). Field team members will use EPA Method 4050 (TNT) and 4051 (RDX) for guidance. In general, the method is performed using an extract of a soil sample. The test is interpreted by comparing the color produced by a sample to the response produced by a reference reaction.

The boreholes will be advanced 25 ft beyond any detection of contamination by field screening. If contamination is detected within 25 ft of the target depth, the borehole will be advanced in 10 ft intervals until no contamination is detected by field screening.

5.2 Collection of Sediment Samples

Sediment samples will be collected following the standard reach investigation procedures detailed in the work plans for Sandia Canyon and Cañada del Buey (LANL 1999, 64617) and for Pajarito Canyon (LANL 1998, 59577). The sampling activities will include field mapping, sample selection, field screening for gross radiation, and sample collection in reaches CDB-3E and PA-4 (Figure 61).

5.3 Collection of Paired Fracture Samples

Empirical evidence of the role of fractures in facilitating contaminant transport in tuff will be obtained by collecting paired samples of fracture material and tuff matrix when tuff fractures are encountered during drilling. Because fracture fill may not be present, or may exist in minute quantities, fracture samples will include 3 in. of tuff both above and below the fracture. Each fracture sample will be described in detail and photographed. To compare contaminant concentrations between fractured and unfractured tuff, a second sample of unfractured tuff will be collected 24 in. above the fracture sample (Figure 62). This method of fracture collection and analysis provides information about potential preferred pathways of contaminant transport beneath MDA G.

5.4 Collection of Pore Gas for VOC and Tritium Analyses

Pore-gas samples will be collected from boreholes 1 through 37 at the depth equivalent to the bottom of the nearest adjacent disposal units and from the bottom of the borehole for analysis of VOCs and tritium according to SOP-6.31, Revision 1. The deep sample from borehole 15 will be collected at approximately 200 ft bgs. Each interval will be purged prior to sampling until measurements of carbon dioxide and

oxygen are stable. Subsurface vapor samples will be collected in SUMMA canisters and submitted for analysis using EPA Method TO-14 for VOCs. In situ subsurface water samples will be collected on silica gel in sealed columns and submitted for analysis using EPA Method 906.0 for tritium.

QA/QC samples for VOCs and tritium in pore gas will consist of an equipment blank and field duplicate. The equipment blank will be collected through the packer sampling apparatus, after sampling and purge decontamination, to detect potential cross-contamination. The field duplicate sample will indicate the precision of collection and analysis. These samples will be collected following SOP-1.05, Revision 1.

5.5 Neutron Logging of Proposed Boreholes

Each proposed borehole will be moisture-logged using a neutron probe after drilling. Logging will be conducted at 1-ft intervals to TD, following SOP-7.05, Revision 1.

5.6 Collection of Perched Water Samples

During drilling operations, zones of elevated moisture content, localized saturation, and groundwater may be encountered. These zones may not be assignable to either an alluvial or the regional groundwater system and may represent a localized phenomenon. The Laboratory's decision process for characterizing these zones is presented in the attached flowchart shown in Figure 63 and described in the following text.

If saturation is encountered as a borehole advances, drilling will be stopped to determine whether sufficient water volume is available to analyze the water quality. These analyses may include metals, anions, perchlorate, alkalinity, organic carbon, total inorganic carbon, and total dissolved solids. Generally the total volume required is approximately 0.5 to 1 L. Of this volume, 100 mL is unfiltered and unpreserved; another 100 mL is filtered and preserved with nitric acid. If this minimum volume of groundwater cannot be collected, the borehole will be drilled to the planned TD or until saturation is encountered again and the process is repeated. A porous cup lysimeter or absorbent membrane will be installed at the depth of saturation to monitor the zone. Insufficient water-sample volumes from discrete depths will not be composited to make the required volume for screening analysis.

If sufficient volume exists, a groundwater sample will be collected and analyzed for the above water-quality constituents on a rapid turnaround basis at a Los Alamos National Laboratory geochemistry laboratory. Typically, results of groundwater screening samples are available in the R-well drilling program within 48 hr. During this time, the borehole will be advanced to the base of saturation, or the perching horizon, and then drilling will be halted. If possible, the perching horizon will be identified and not penetrated. This activity will determine the thickness of the zone of saturation and the characteristics of the perching horizon. Borehole drilling will cease, a monitoring well will be designed, and the design will be submitted to NMED for approval. Following approval of the design, the well will be installed. A borehole will be drilled adjacent to the well and the saturated zone isolated with a double-wall casing-advancement drilling method to isolate the known saturated zone.

5.7 Borehole Completion

Once boreholes are drilled, core sampled, and initial pore-gas samples are collected, specific boreholes will be completed as vapor-monitoring boreholes. FLUTE soil-gas sampling positive-pressure membranes will be installed, and the borehole will be identified in the vapor-monitoring plan. Figure 64 shows a schematic of the proposed membrane in the boreholes, showing port depths and construction. The remaining boreholes will be backfilled and abandoned according to SOP-5.03, Revision 2, Monitoring Well and RFI Borehole Abandonment.

6.0 MONITORING AND SAMPLING PROGRAM

An investigation vapor-monitoring and sampling plan is due to NMED within 90 days of completing borehole drilling. The current quarterly pore-gas monitoring program will continue until NMED approves an interim monitoring plan and a permit modification. In addition, a groundwater monitoring plan will be submitted if producible quantities of water are identified during the drilling activities. No other monitoring and sampling programs related to possible releases from MDA G are ongoing or proposed at this time.

6.1 Post-Phase I RFI Groundwater Monitoring

Pursuant to the NMED-approved hydrogeologic work plan for the Laboratory (LANL 1998, 59599), the Laboratory and the DOE installed five characterization wells in the vicinity of Areas L and G: well R-20 in Pajarito Canyon, upgradient of Areas L and G; well R-21 in Cañada del Buey between Areas L and G; well R-22 on the mesa top east of MDA G; well R-32 in Pajarito Canyon, downgradient of Area L; and well R-23 in Pajarito Canyon downgradient of MDA G (Figure 5). The Laboratory prepared completion reports for wells R-20 and R-32 and submitted them to NMED in June 2003. DOE prepared the report for well R-21 and submitted it to NMED in June 2003. Planned and completed sample rounds for each well are summarized below.

R-20

Three rounds of characterization samples were collected from three screening intervals at regional well R-20 on March 15, 2004; May 4, 2004; and September 8, 2004. The fourth and final characterization-sampling event is scheduled for December 2004, after which R-20 will be used for surveillance sampling. In compliance with the characterization effort, full analytical suites have been collected at R-20.

R-21

Groundwater samples were collected during two characterization rounds at regional R-21, a single-screen well, on March 31, 2004; June 30, 2004; September 23, 2004; and December 14, 2004. Full analytical suites will be collected during the characterization phase. Future sampling is scheduled for October 2004 and February 2005. After the four characterization sampling rounds are completed, R-21 will be used for surveillance monitoring.

R-22

Groundwater samples were collected at regional well R-22 during four characterization rounds on March 6, 2001; June 20, 2001, November 30, 2001, and February 27, 2002, and three surveillance rounds on July 8, 2002; November 18, 2003; and June 21, 2004. Five screened intervals at R-22 access the regional aquifer. Selected screens are currently sampled for surveillance purposes. Future surveillance activities will include the upper three or four screens of R-22; the frequency and analytical suites will be determined by the proposed Consent Order.

R-23

Samples were collected during four characterization rounds at single-screen regional well R-23 on December 17, 2003; March 23, 2004; June 29, 2004; and September 24, 2004. In accordance with the characterization effort, full analytical suites have been collected. In the future, R-23 will be used for surveillance purposes; the sampling frequency and analytical suites will be determined by the proposed Consent Order.

R-32

Samples were collected during three characterization rounds from two screens set in the regional aquifer at R-32 on March 17, 2004; May 5, 2004; and September 21, 2004. One additional round is scheduled for December 2004. In accordance with the characterization effort, full analytical suites have been collected. In the future, R-32 will be used for surveillance purposes; the sampling frequency and analytical suites will be determined by the proposed Consent Order.

7.0 SCHEDULE

NMED approved the MDA G investigation work plan with modifications on November 5, 2004 (LANL 2004, 87583). An investigation vapor-monitoring and sampling plan is due to NMED within 90 days of completing borehole drilling. The investigation report is scheduled to be submitted to NMED on September 8, 2005.

8.0 REFERENCES

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Copies of the reference sets are maintained at the NMED Hazardous Waste Bureau; the DOE Los Alamos Site Office; EPA, Region 6; and ENV-RS project. The sets were developed to ensure that the administrative authority has all material needed to review this document, and they are updated periodically as needed. Documents previously submitted to the administrative authority are not included.

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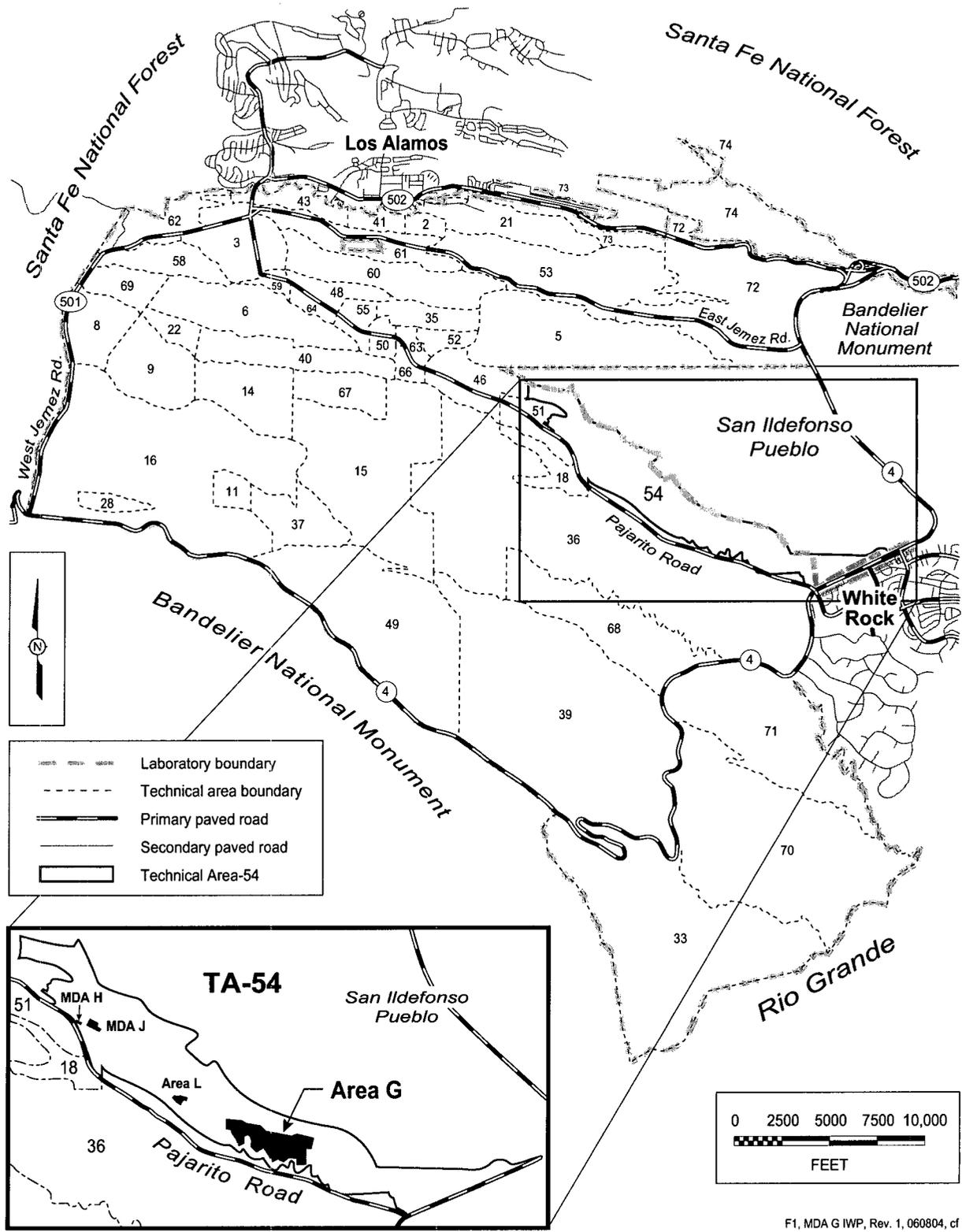
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F1, MDA G IWP, Rev. 1, 060804, cf

Figure 1. Location of Area G in TA-54 with respect to Laboratory technical areas and surrounding land holdings

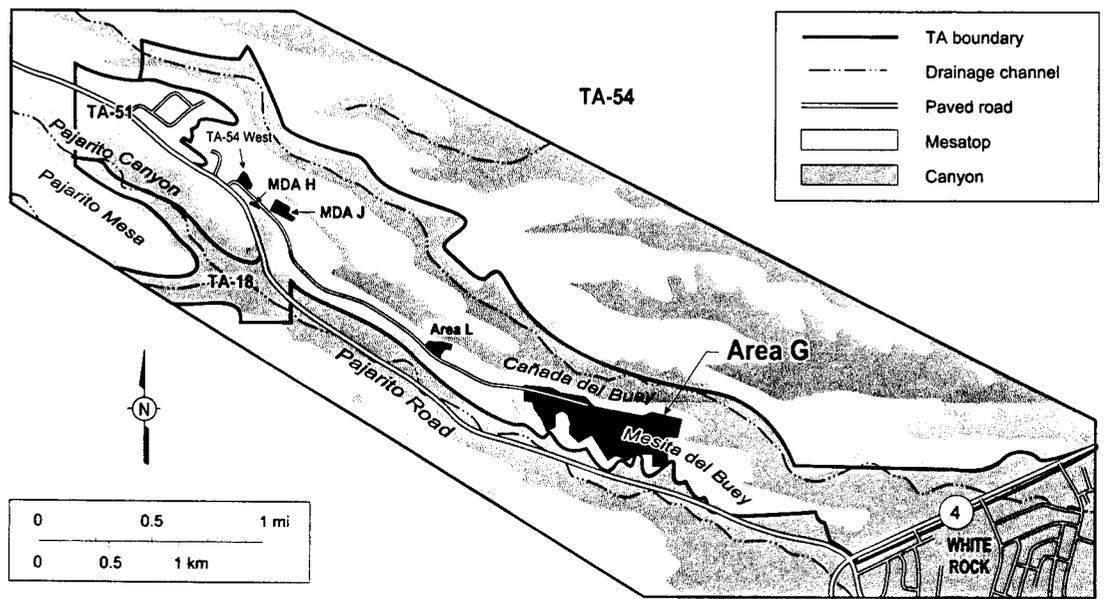


Figure 2. Location of Area G in TA-54

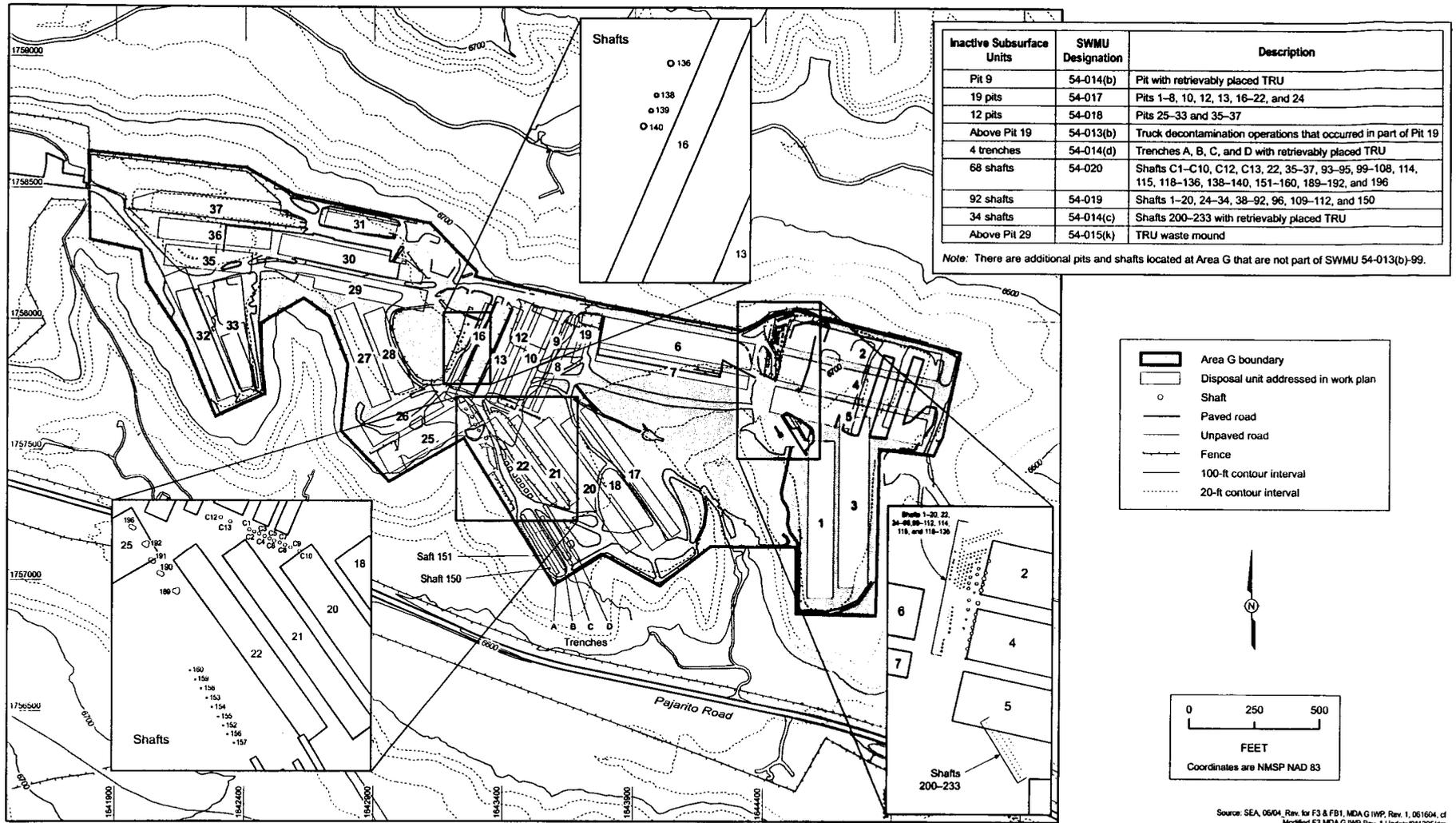
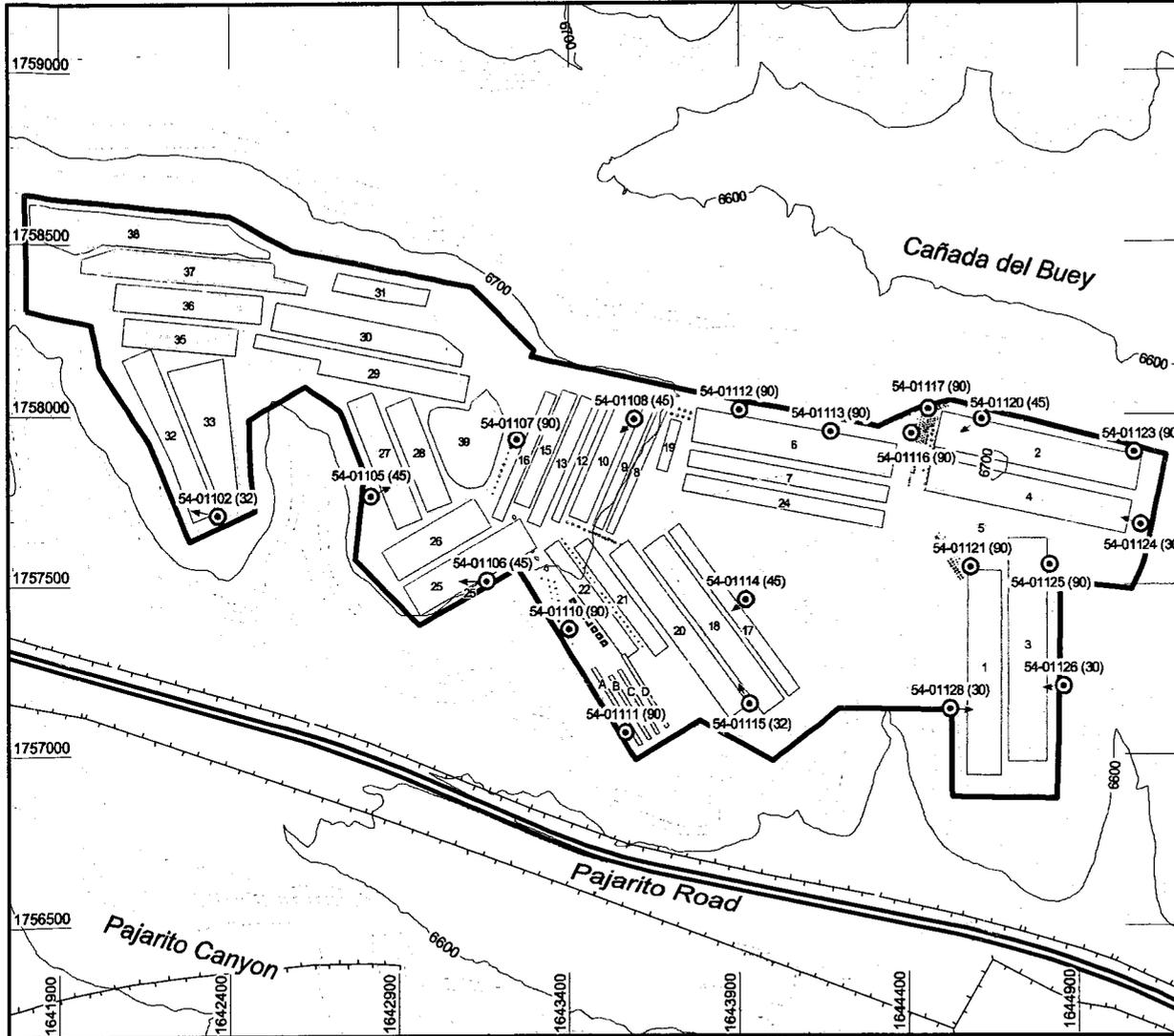


Figure 3. Locations of Area G subsurface units



- Area G boundary
- Disposal unit
- Borehole location*
- 54-12345(25) Location ID
- Borehole trajectory
- Paved road
- Fence (main security)
- 100-ft contour interval
- 20-ft contour interval

* Arrows indicate direction of drilling for boreholes and numbers in parentheses after borehole location IDs show inclination (in degrees) from ground surface.

Scale: 1:5,000
Coordinates are NMSP NAD 83

Source: SEA_Rev. for F4, MDA G IWP, Rev. 1, 061604, of Modified F4 MDA G IWP Rev. 1 Update/010405/rjm

Figure 4. Locations of MDA G Phase I RFI boreholes

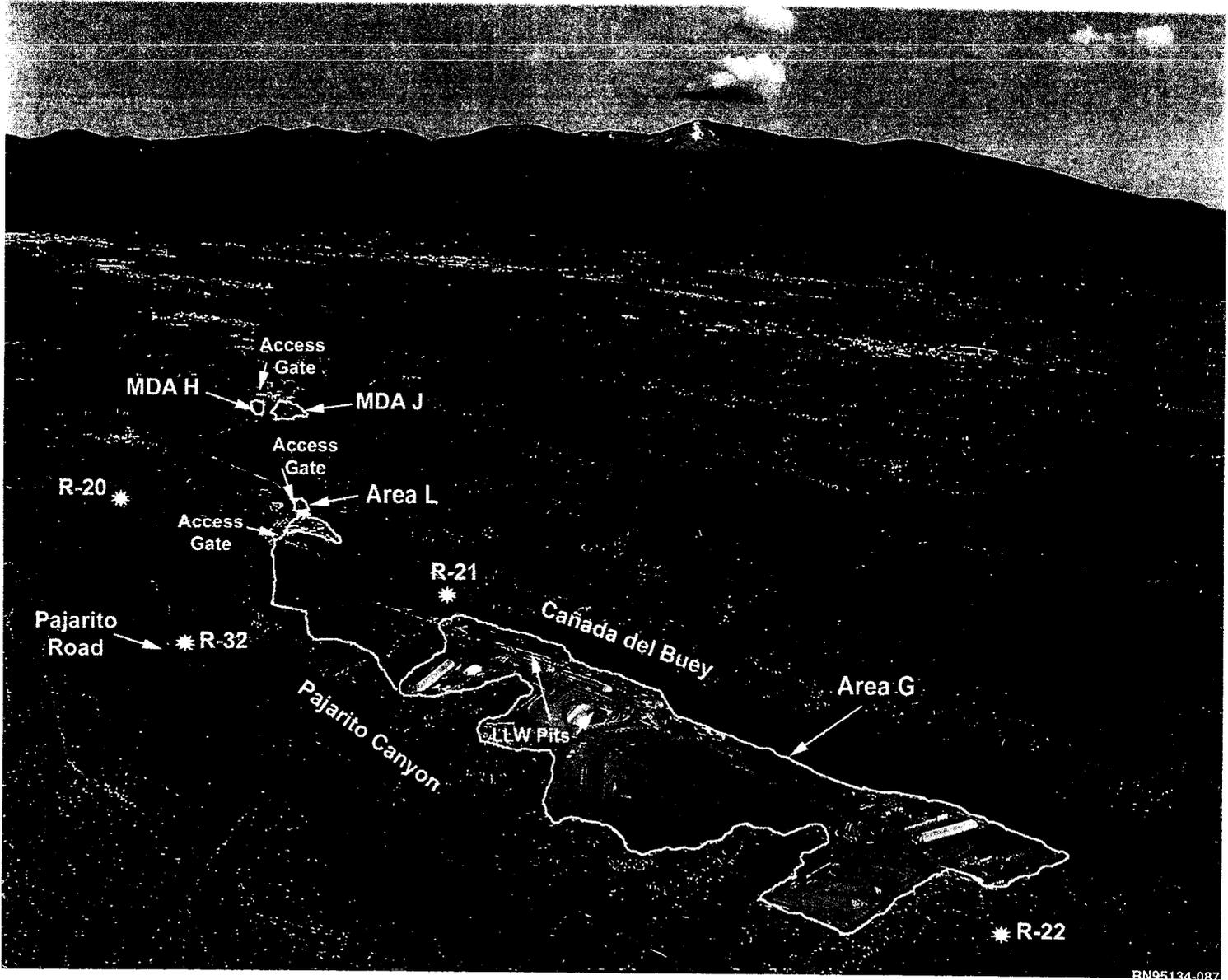
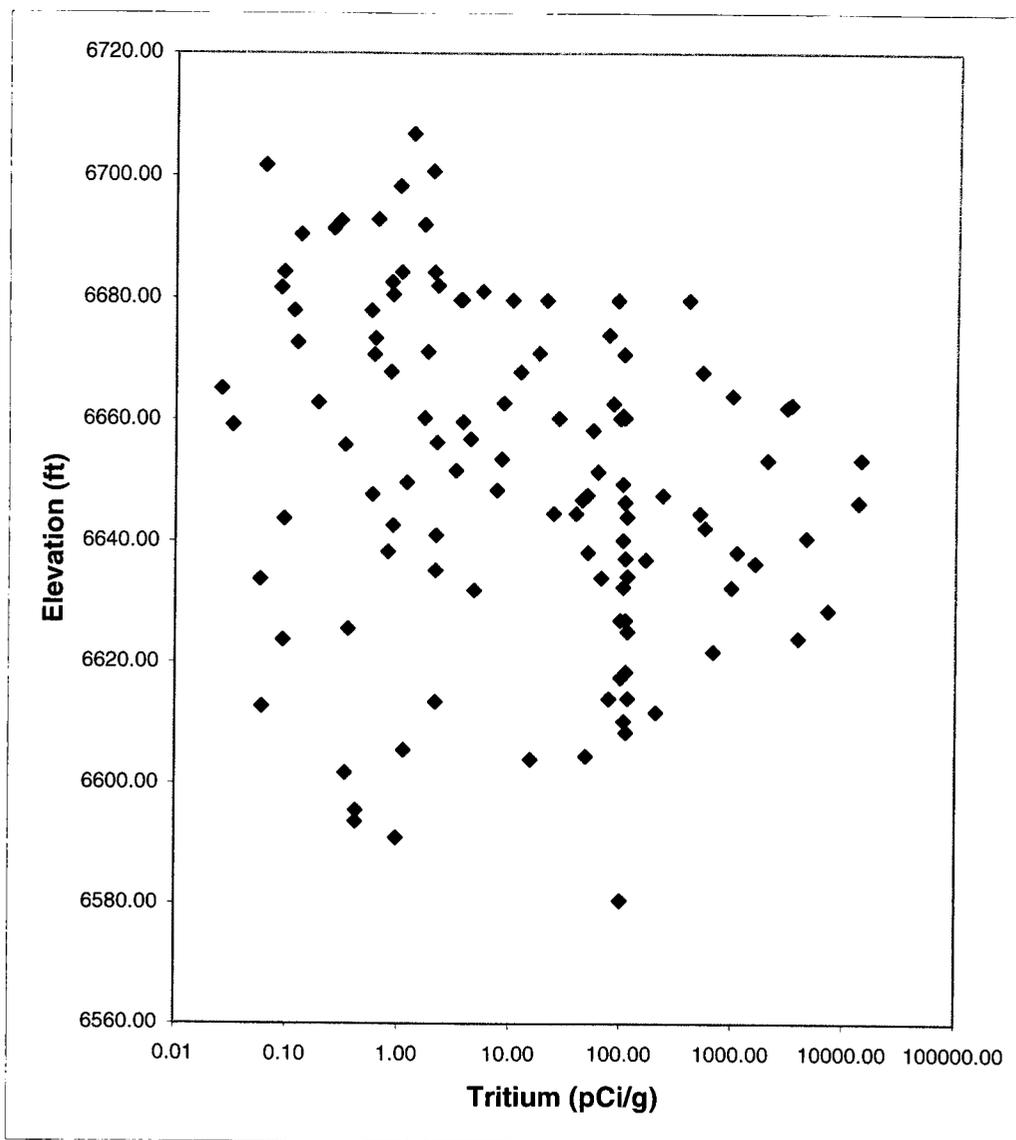
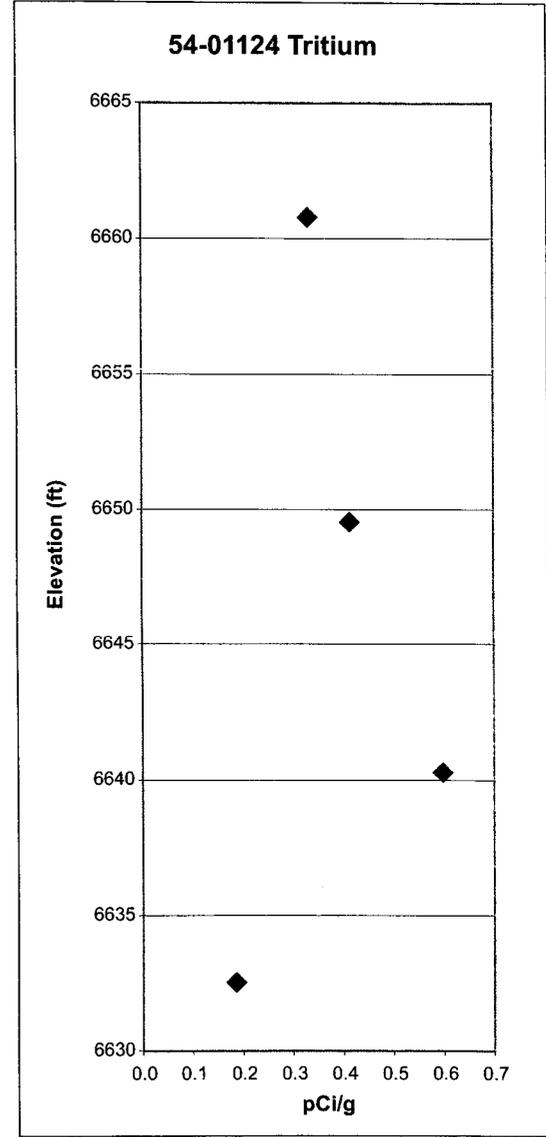
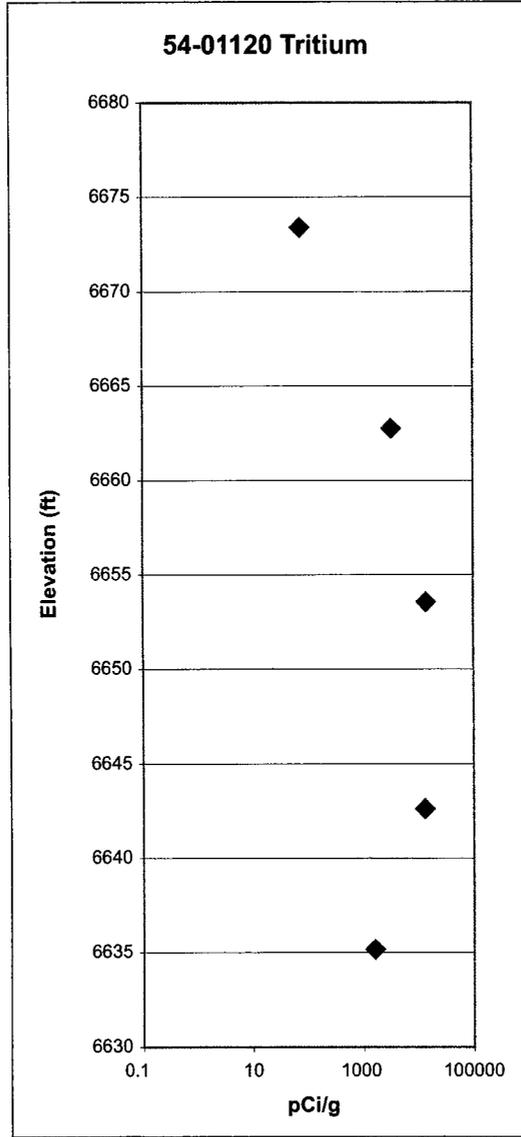
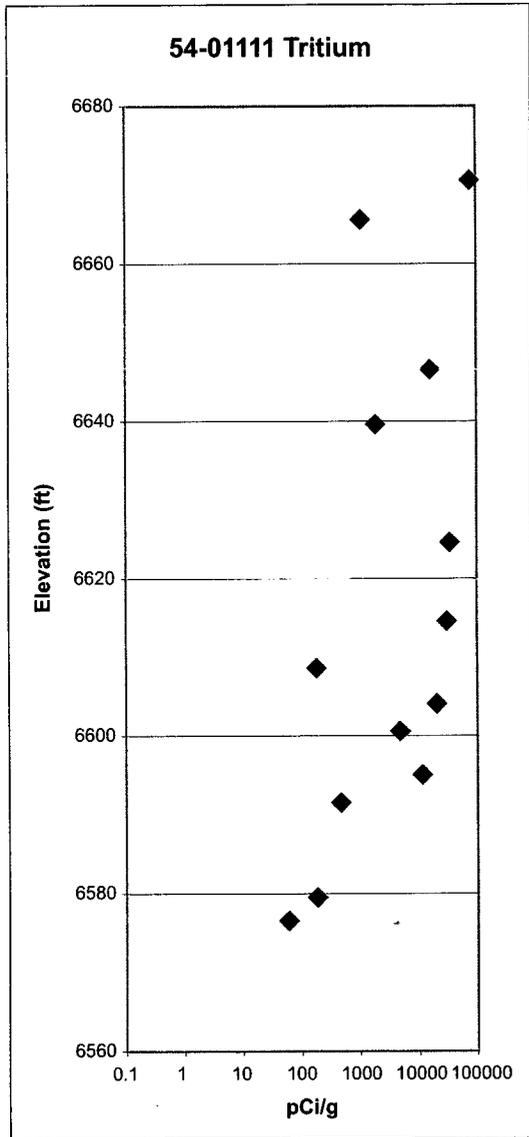


Figure 5. Aerial photograph of Mesita del Buey showing waste management areas, gates, and characterization wells in the vicinity of Area G



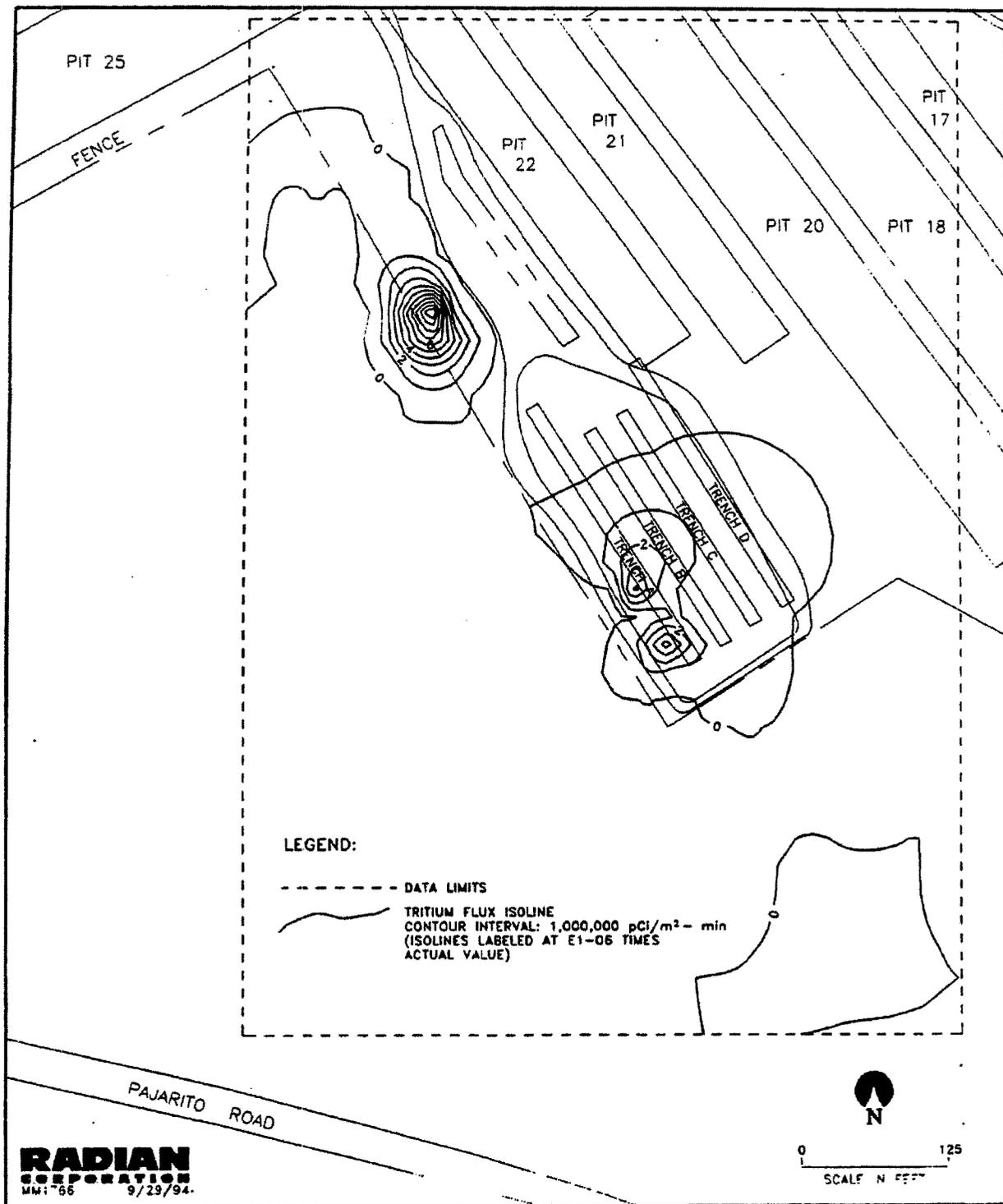
Note: A logarithmic scale was used to better show the distribution.

Figure 6. Composite of all borehole samples for tritium, plotted by elevation



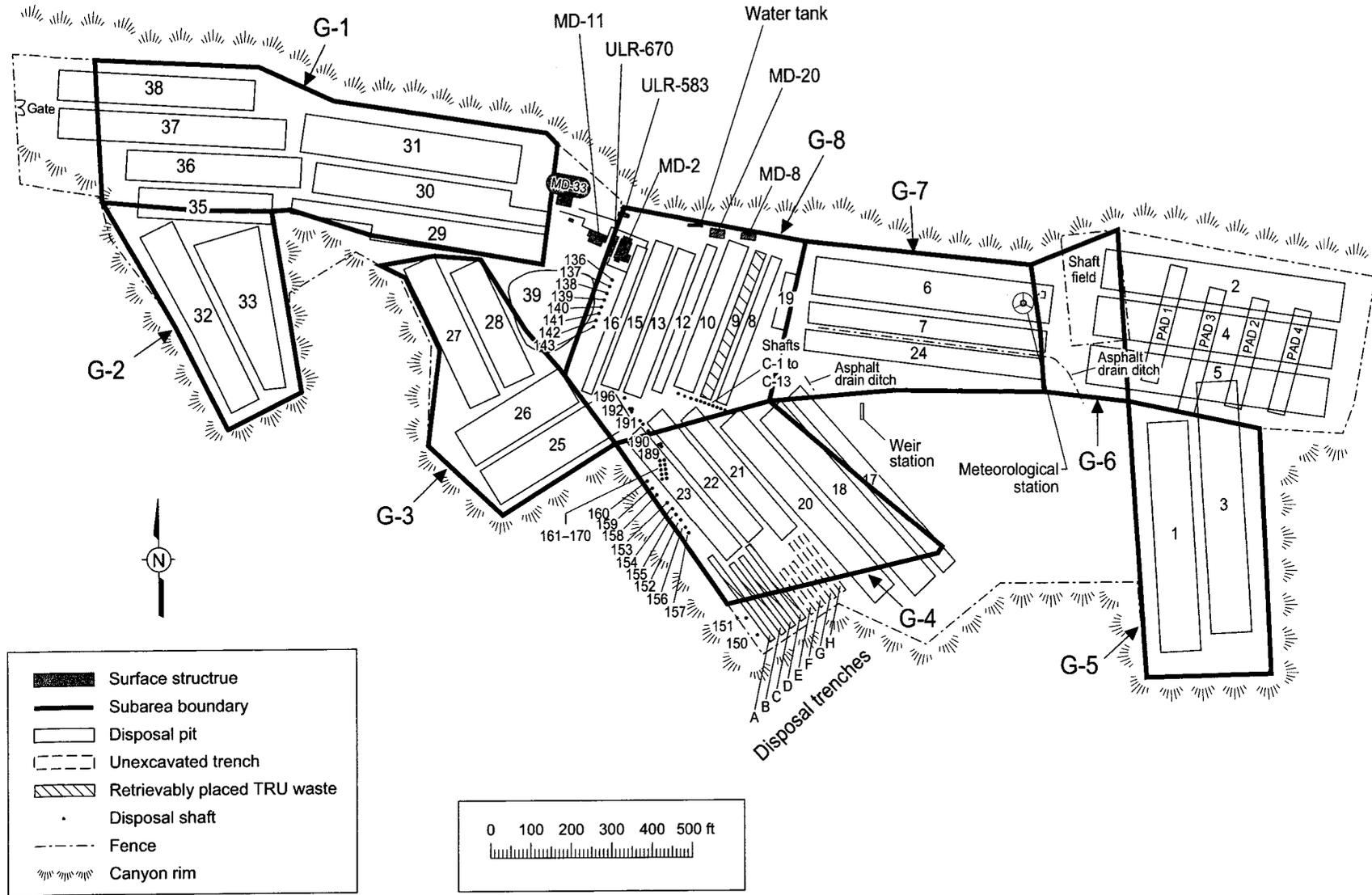
Note: A logarithmic scale was used to better show the distribution.

Figure 7. Individual tritium plots for three MDA G boreholes



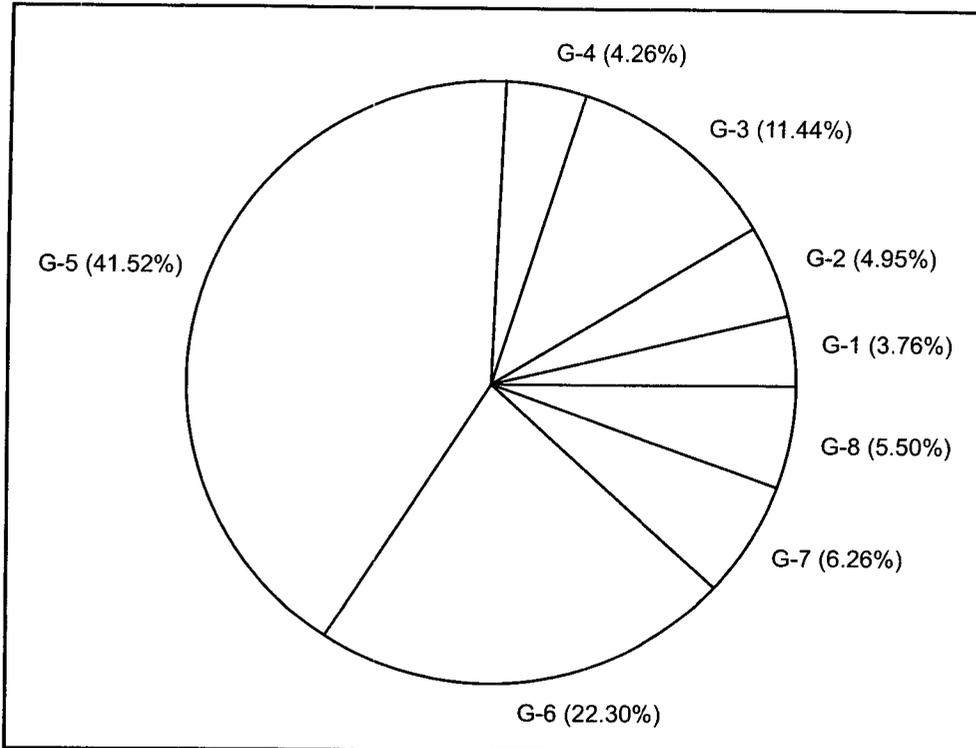
Note: Emissions decrease as distance from shafts increases (Eklund 1994, 56033).

Figure 9. Tritium flux isoline contours for highest tritium emissions from MDA G over south-central tritium shafts



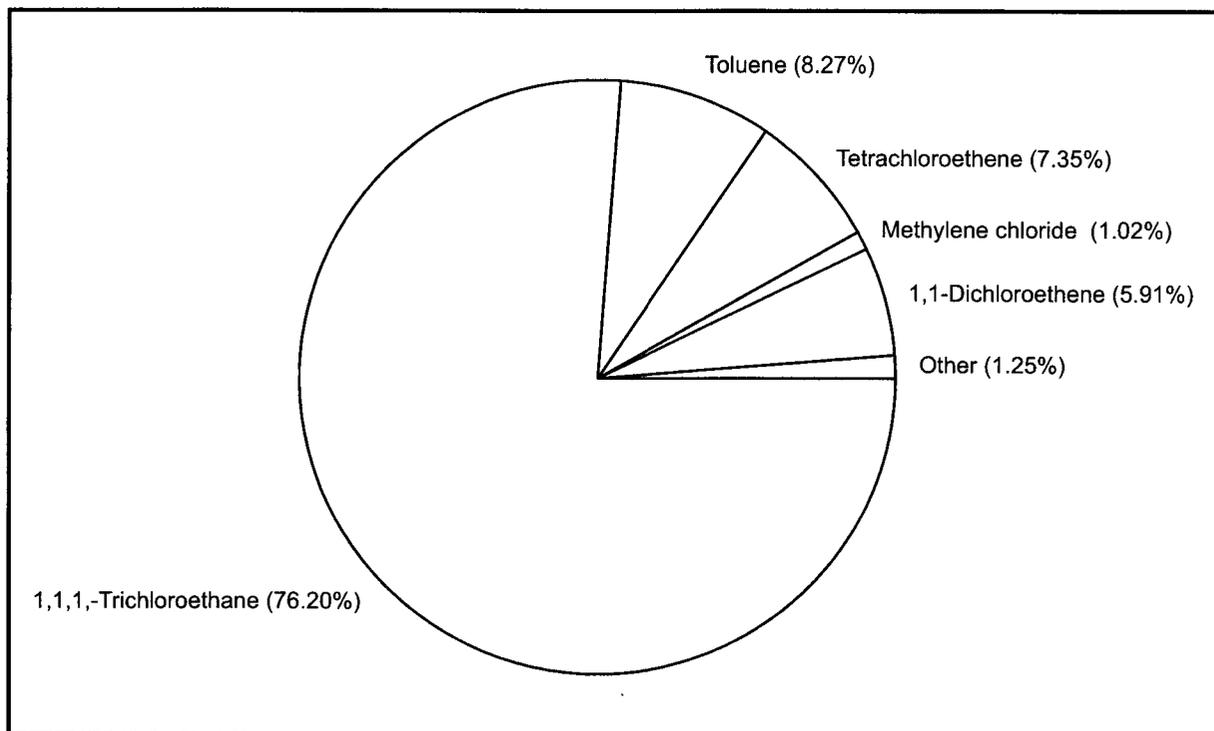
F6.1-9 / TA-54 RFI RPT / 020100 / PTM
Rev. for F10, MDA G IWP, Rev. 1, 061404, cf

Figure 10. Locations of subareas for Area G VOC flux measurements



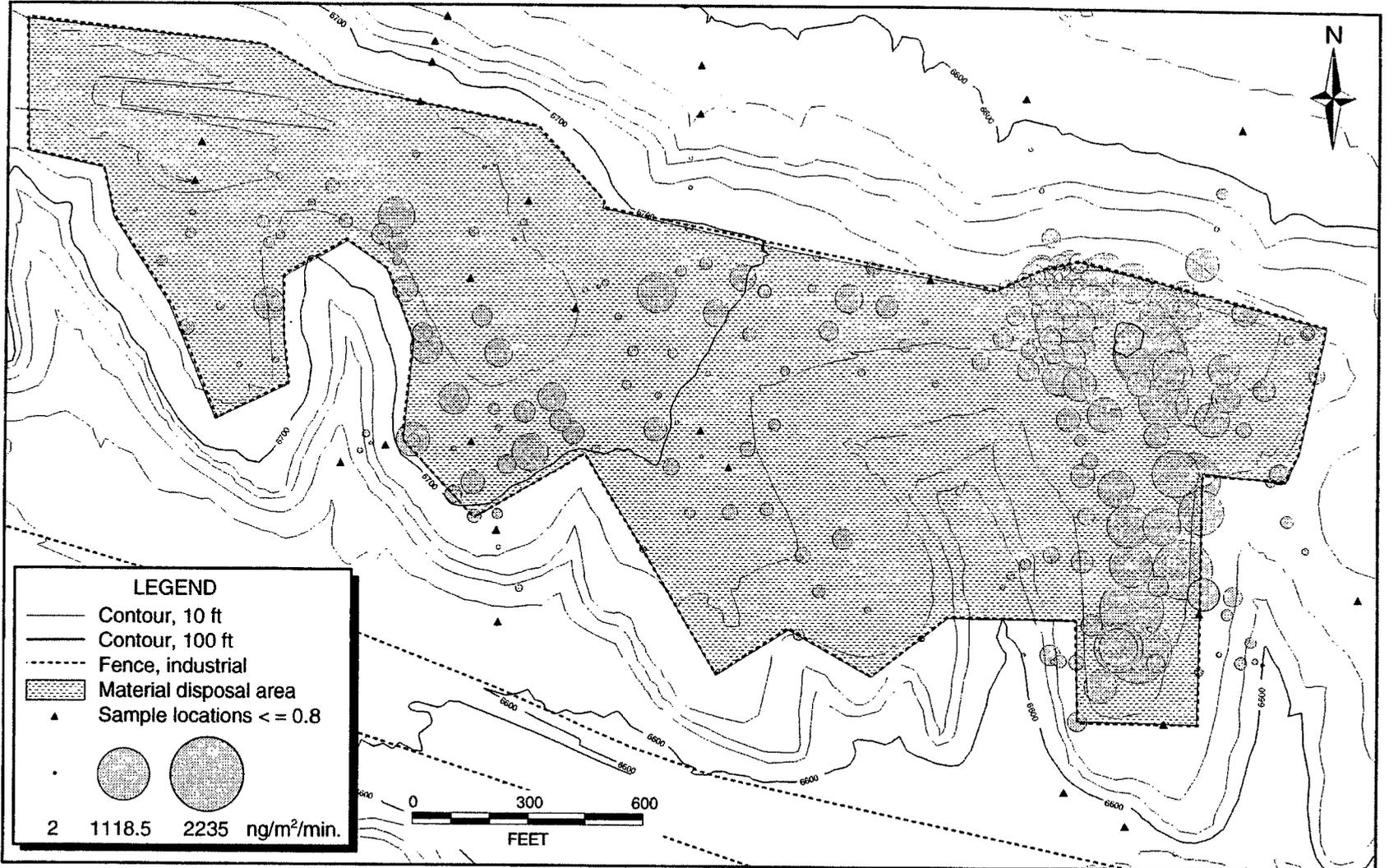
F6.1-10 / TA-54 RFI RPT / 020100 / PTM

Figure 11. Distribution (by percentage) of subareas (Figure 10) venting to the atmosphere from MDA G



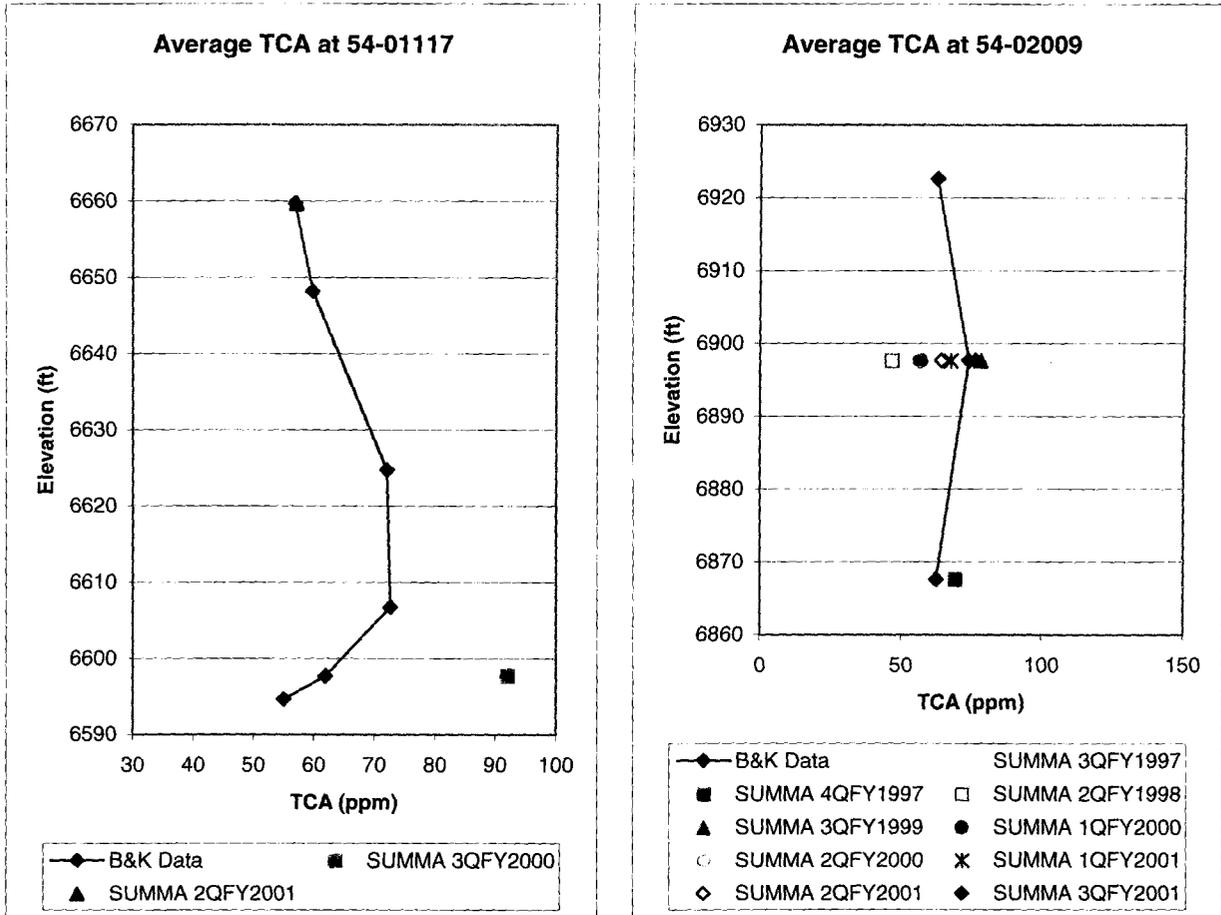
F6.1-11 / TA-54 RFI RPT / 021500 / PTM

Figure 12. Distribution (by percentage) of VOCs venting to the atmosphere from MDA G section G-5



Source: Trujillo et al. 1998, 58242

Figure 13. Surface flux concentrations (EMFLUX) of TCA from MDA G



Note: Average B&K screening data are represented by the line plot, and quarterly SUMMA results are shown as individual points.

Figure 14. Average TCA concentration, by depth

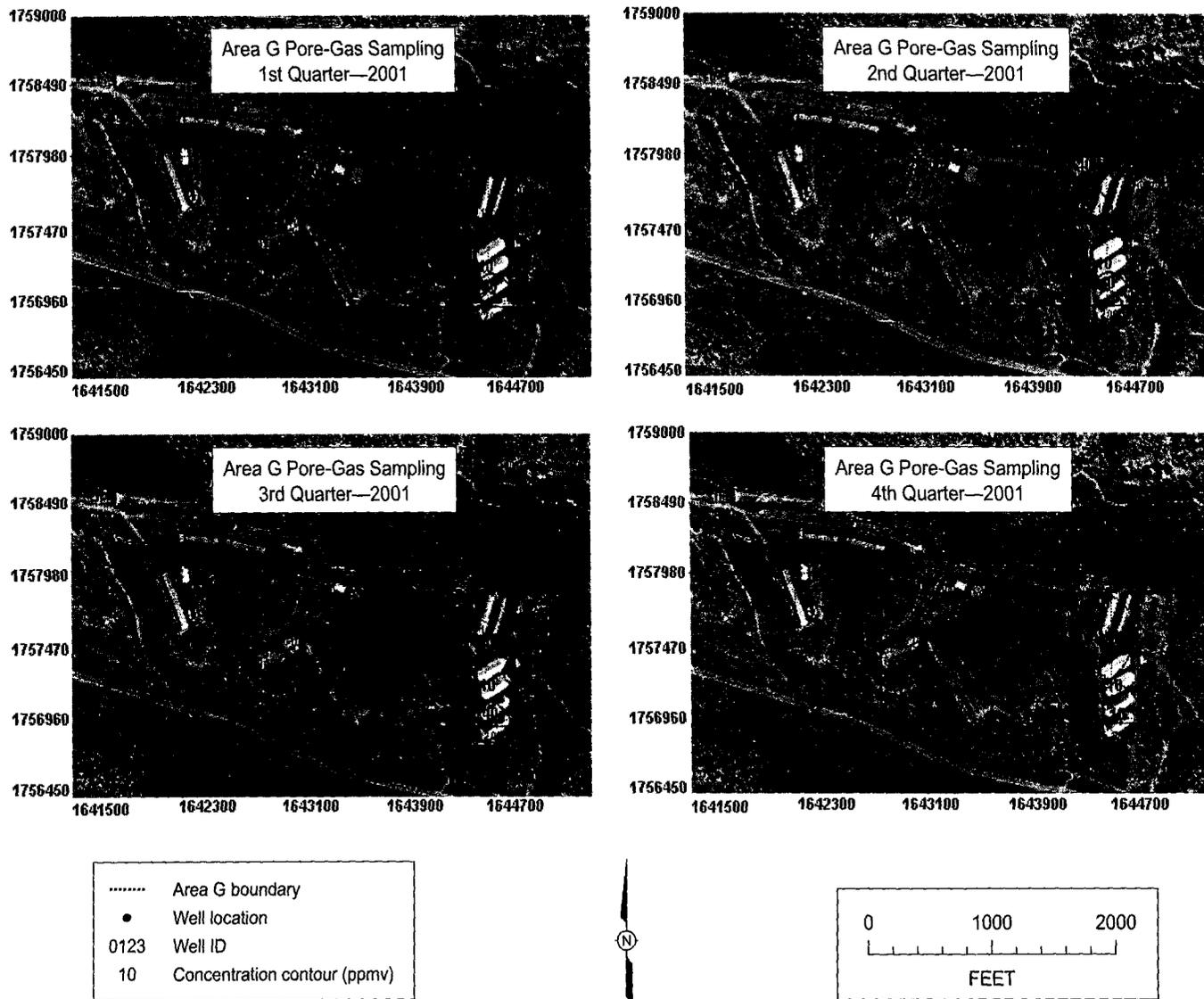
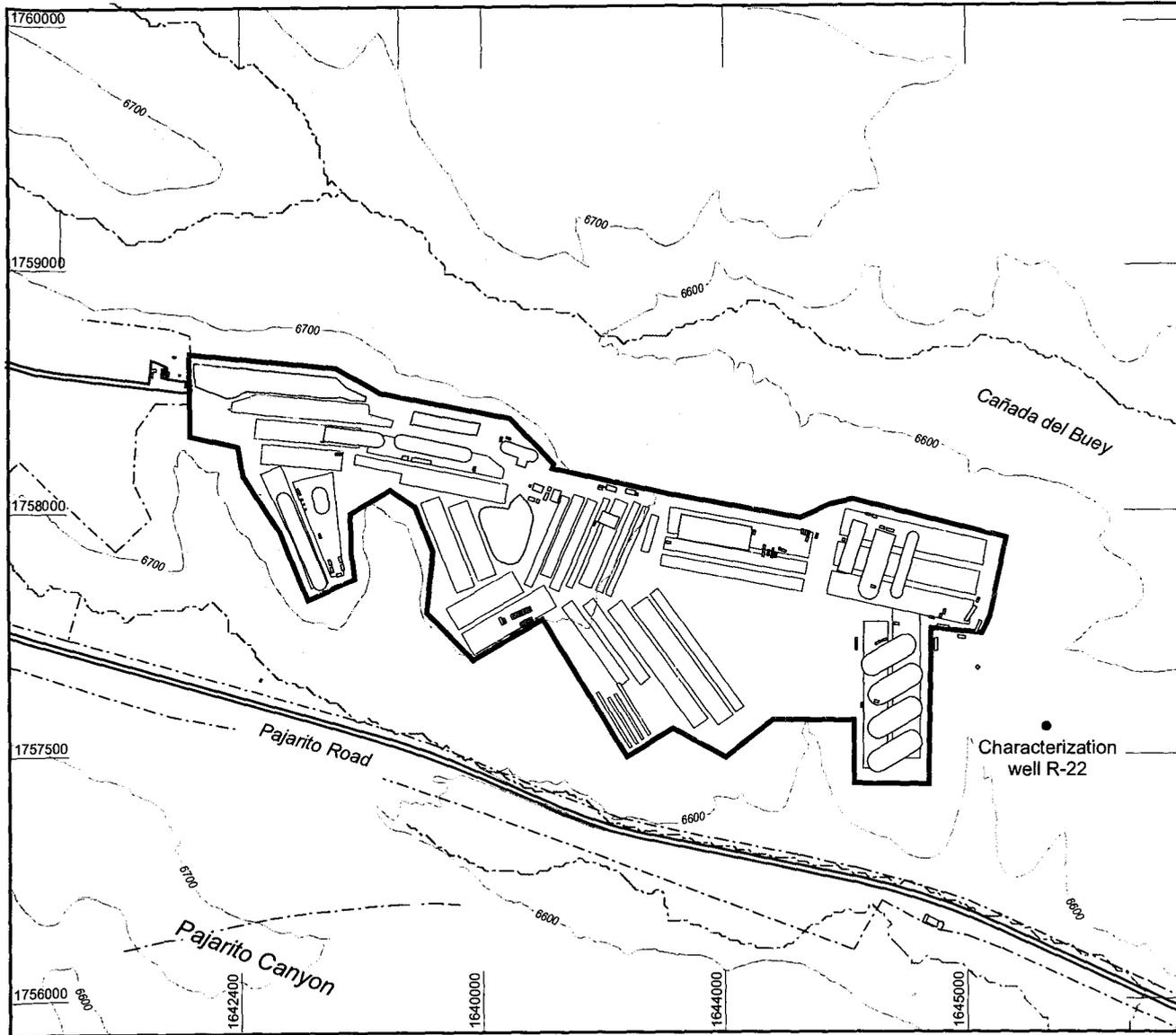
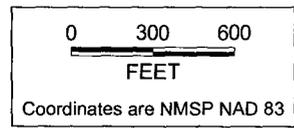


Figure 15. Lateral extent of the eastern VOC plume indicated by B&K TCA results during FY2001 and locations of Area G pore-gas monitoring boreholes



-  Area G boundary
-  Structure
-  Active disposal pit
-  Decommissioned disposal pit
-  Major paved road
-  Drainage channel
-  Fence (main security)
-  100-ft contour interval
-  20-ft contour interval



Source: GISLab map 200757, 082703, DW
 Rev. for F16, MDA G IWP, Rev. 1, 061304, cf
 Modified F16 MDA G IWP Rev. 1 Update/010405/rlm

Figure 16. Waste management areas and topography at Area G

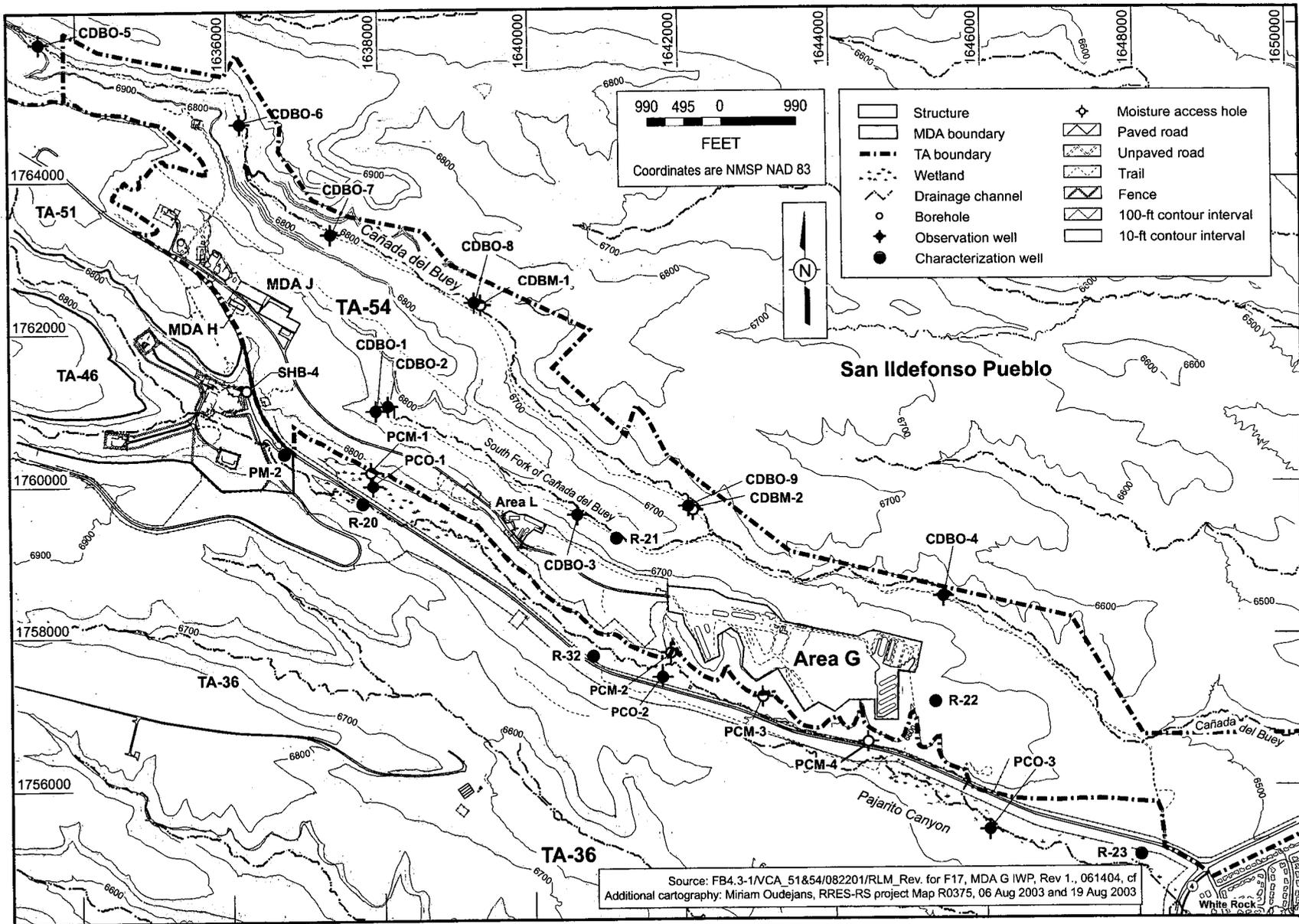
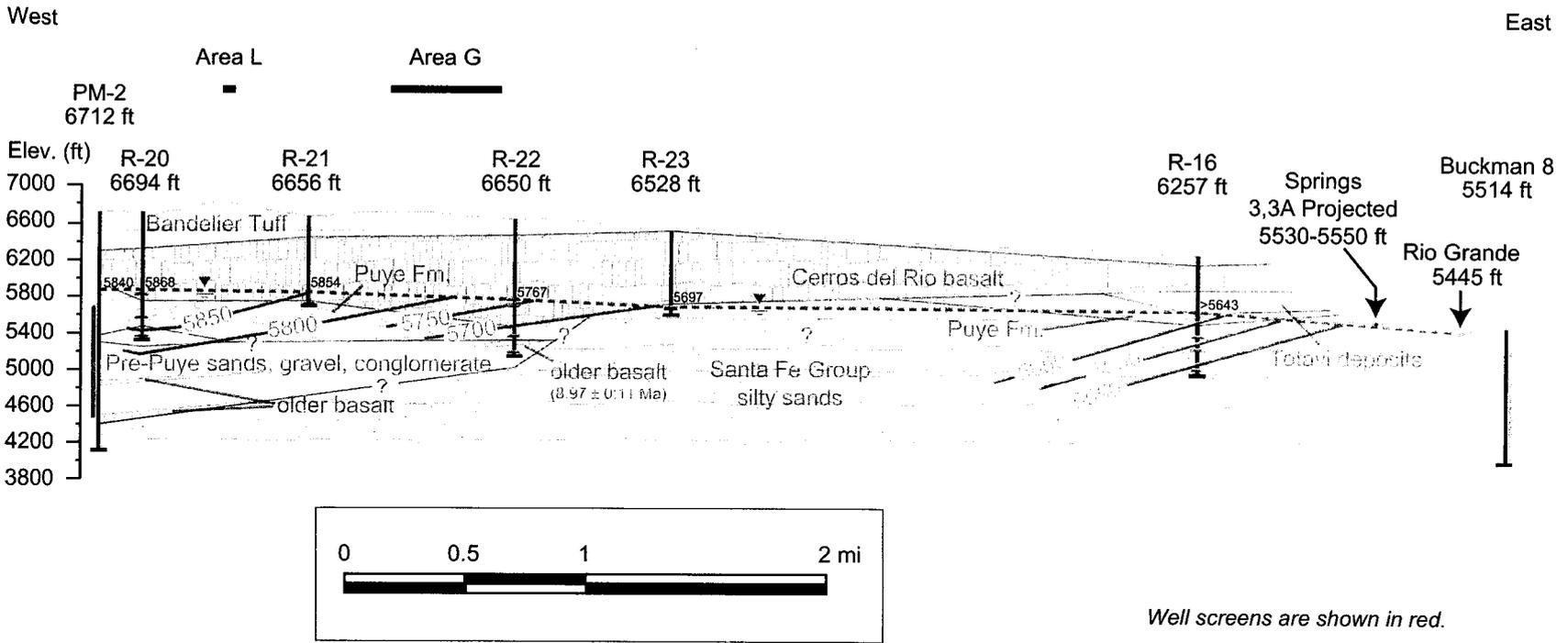
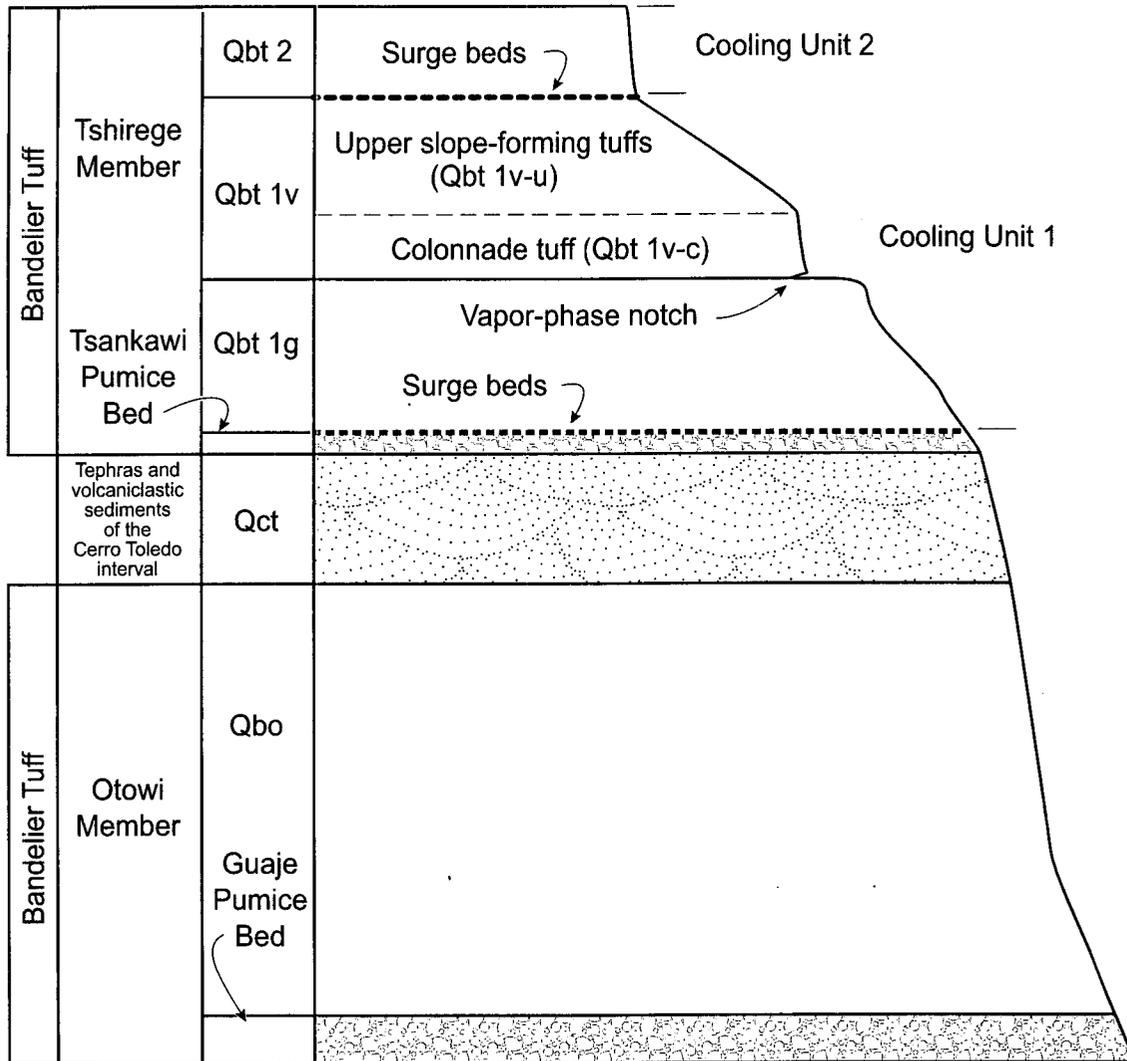


Figure 17. Locations of wells and boreholes used to locate alluvial, perched, and regional groundwater at TA-54



Source: Dave Broxton, 2003_Rev. for F18, MDA G IWP, Rev.1, 060904, cf

Figure 18. Hydrogeologic cross section through Pajarito Plateau, near TA-54



F19, MDA G IWP Rev.1, 052504, cf

Figure 19. Generalized stratigraphy of Bandelier Tuff at TA-54

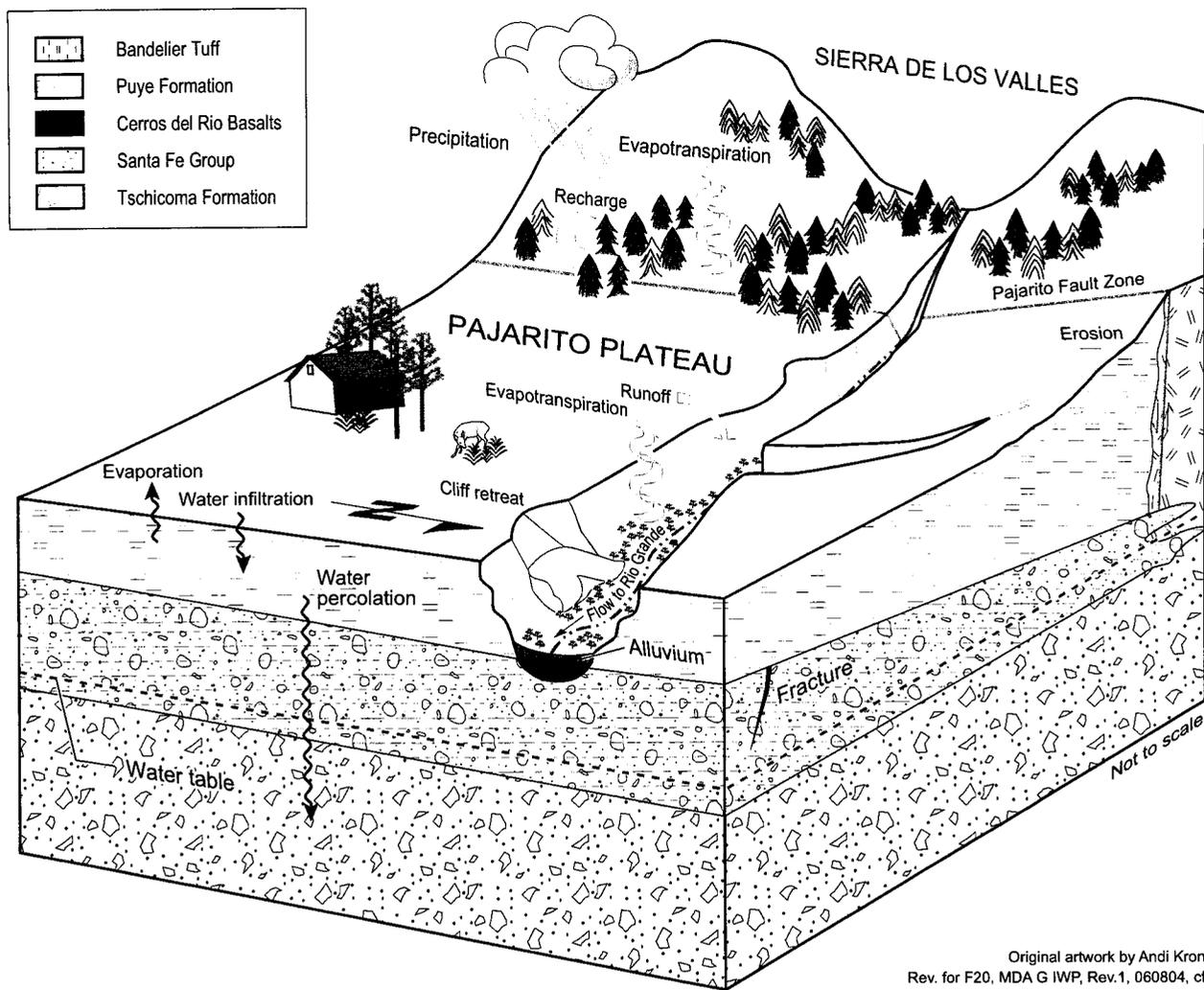
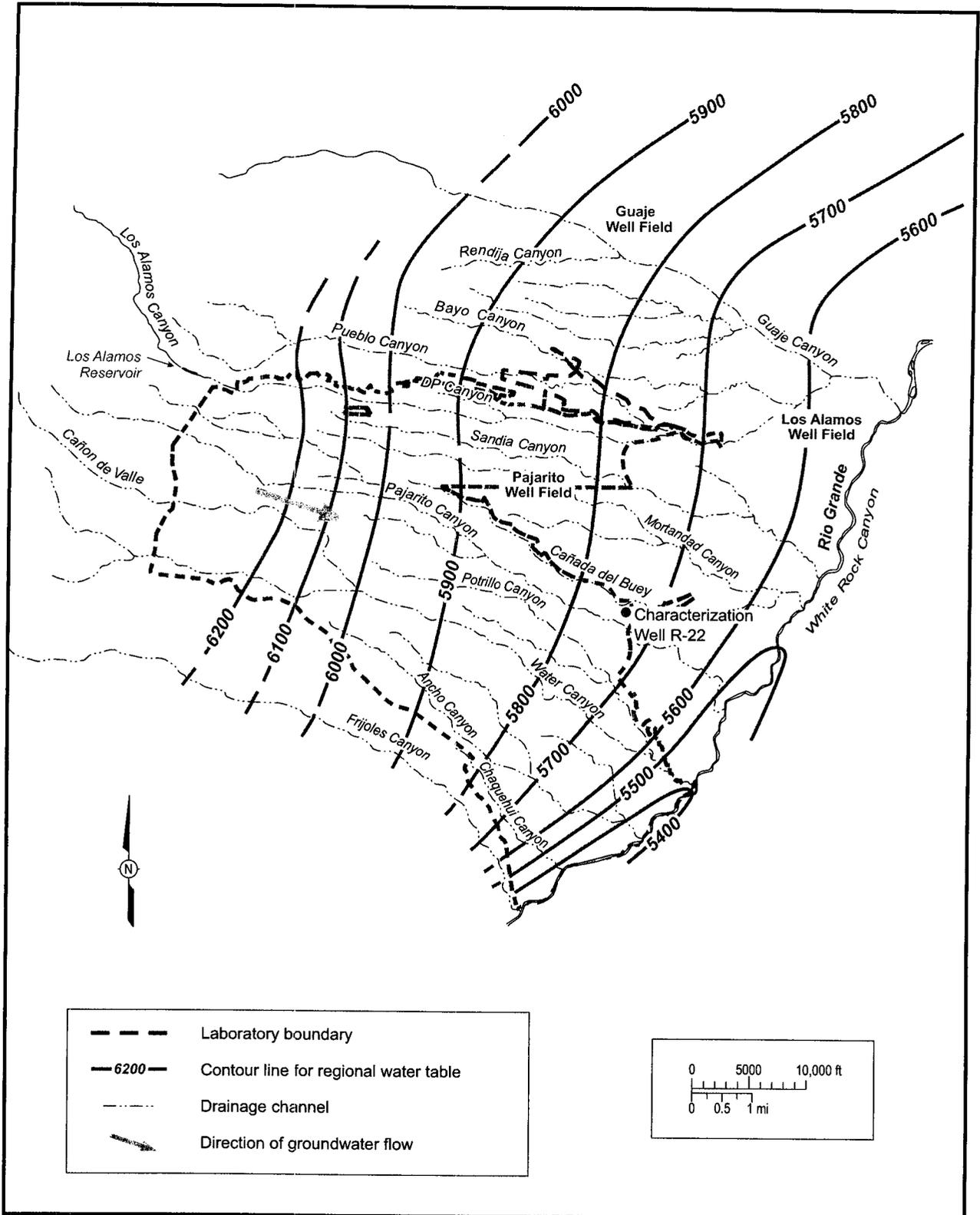


Figure 20. Hydrogeologic conceptual model for the Pajarito Plateau



Source: A. Kron_Rev. for F21, MDA G IWP, Rev. 1, 061004, cf

Figure 21. Water table elevations across the Pajarito Plateau

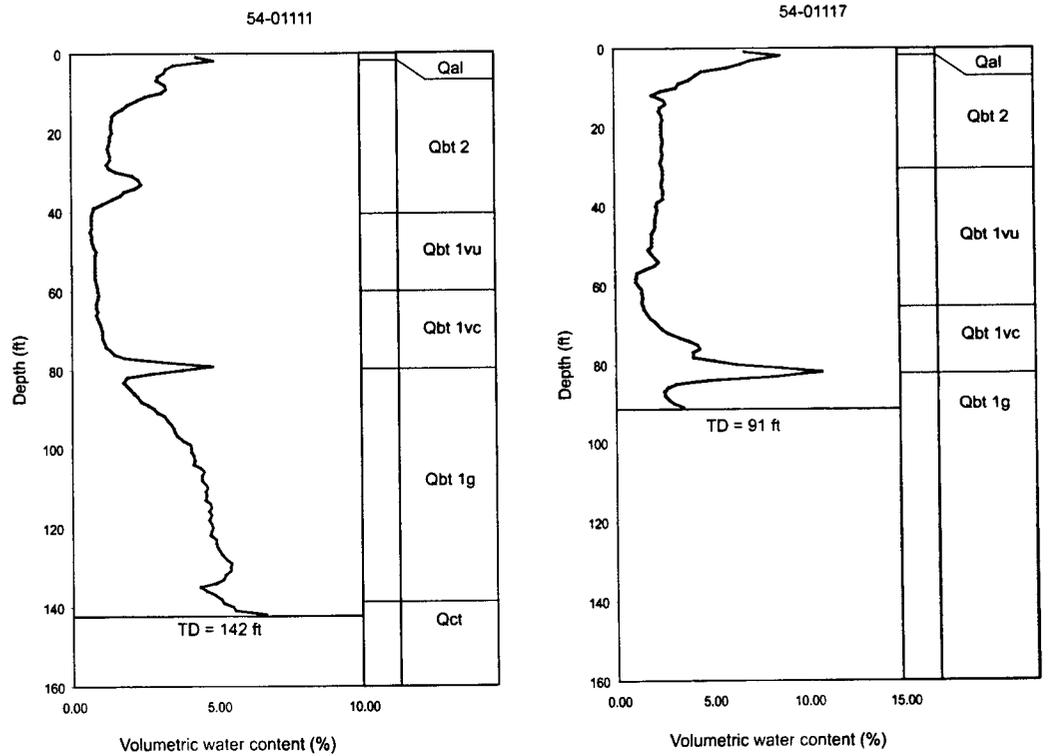


Figure 22. Average volumetric water content in boreholes 54-01111 and 54-01117, 1996–2000

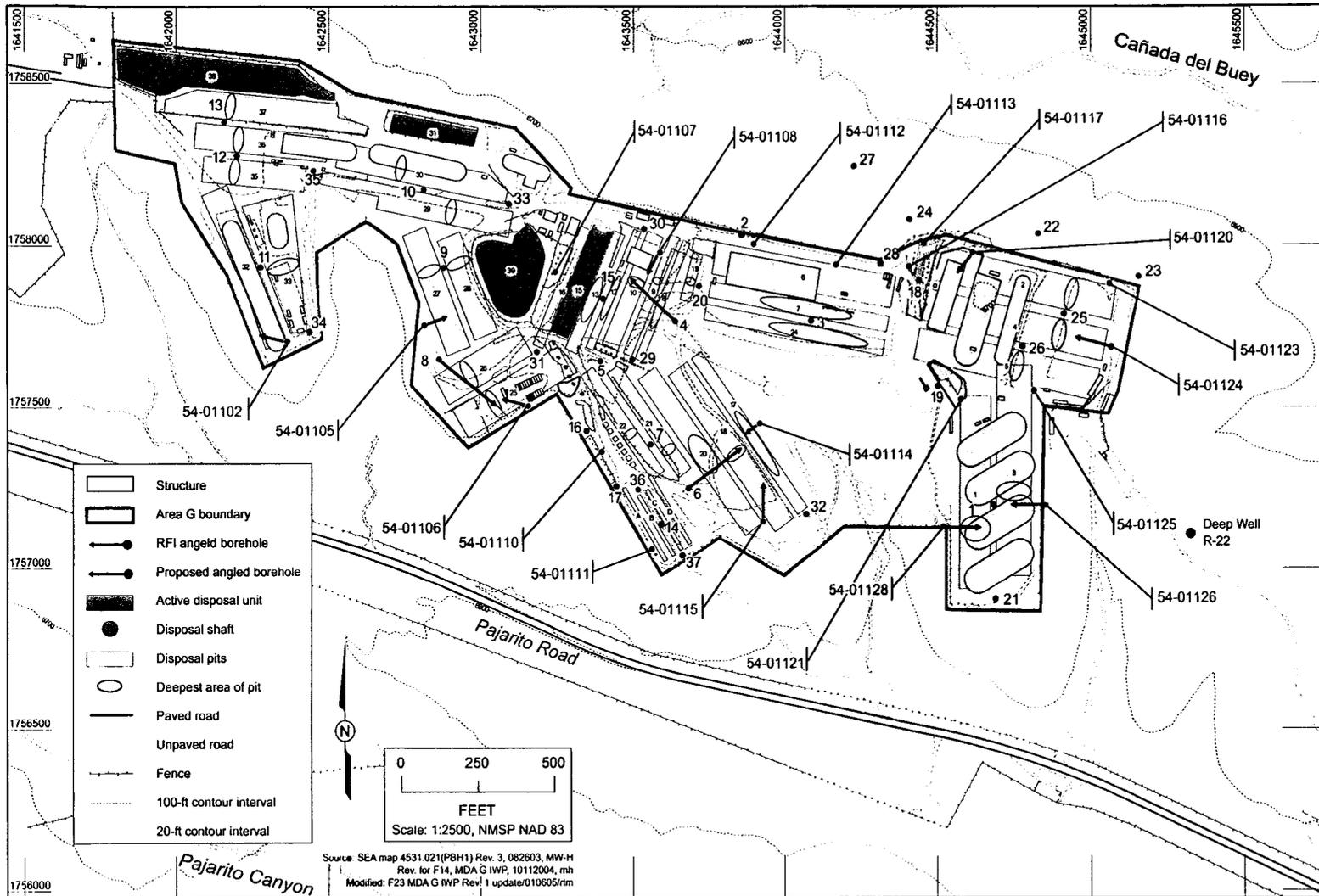


Figure 23. Locations and cross sections of the proposed boreholes in relation to the disposal units and the existing boreholes at MDA G

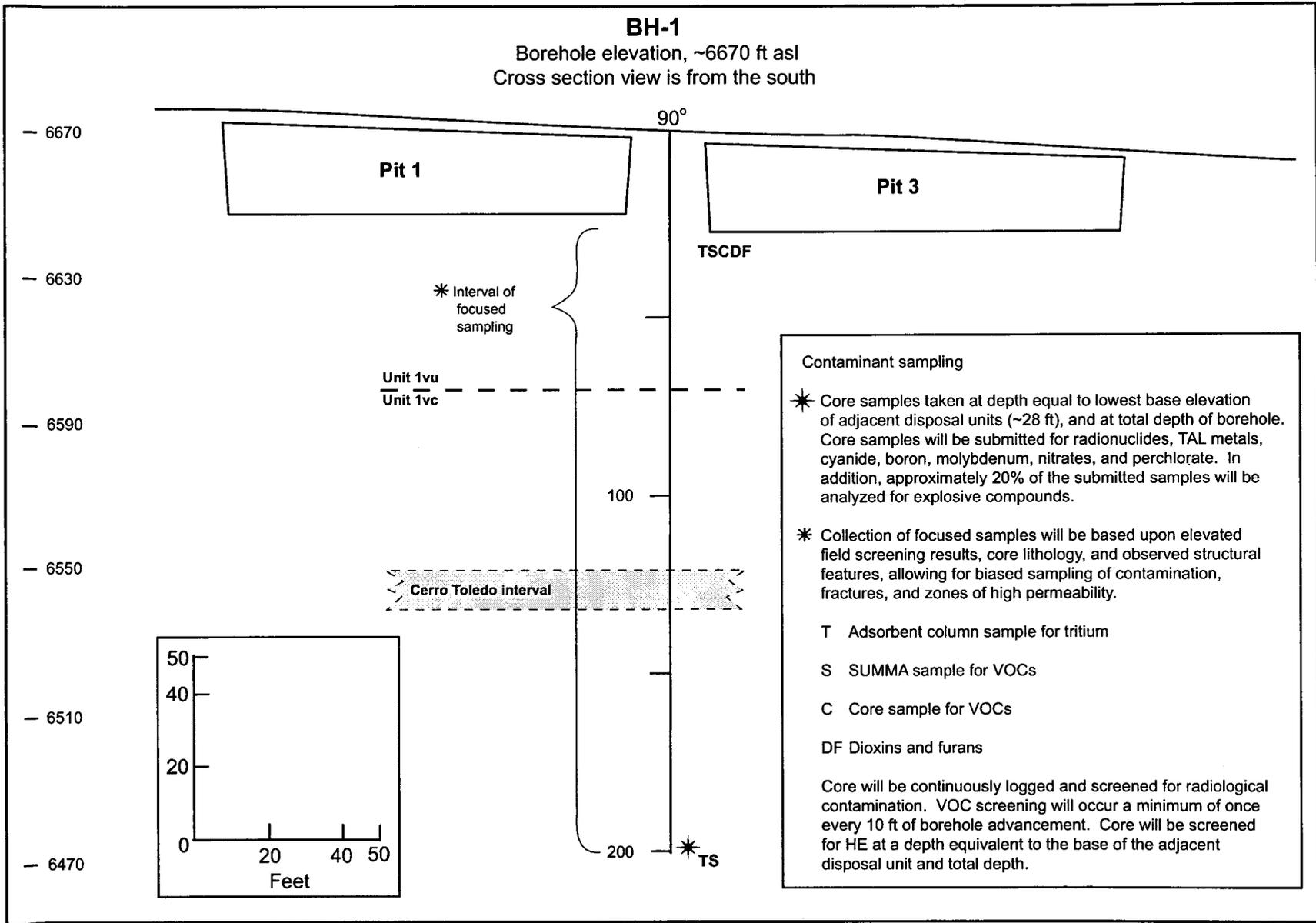


Figure 24. Profile of MDA G proposed borehole 1 with planned sample locations

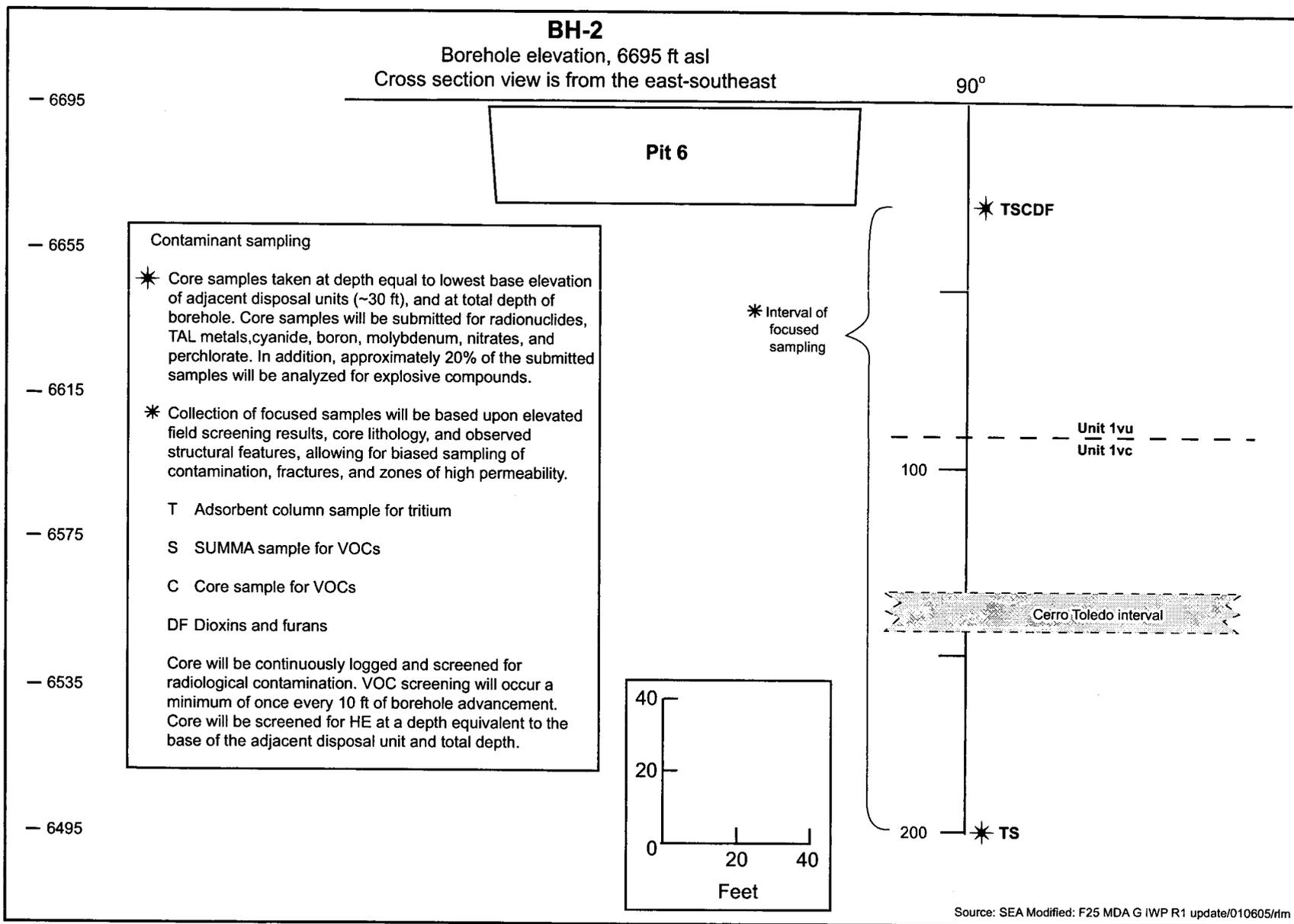


Figure 25. Profile of MDA G proposed borehole 2 with planned sample locations

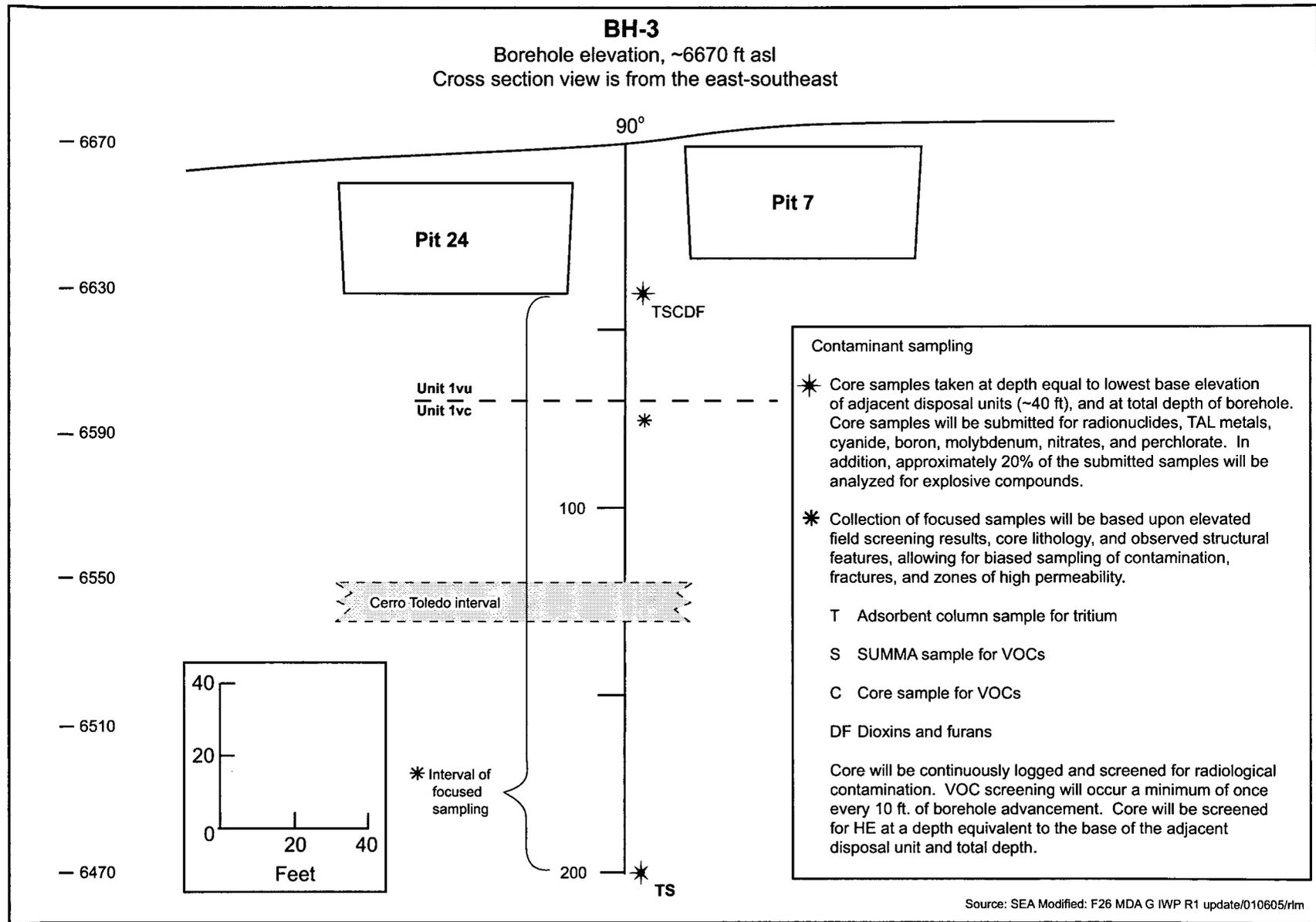


Figure 26. Profile of MDA G proposed borehole 3 with planned sample locations

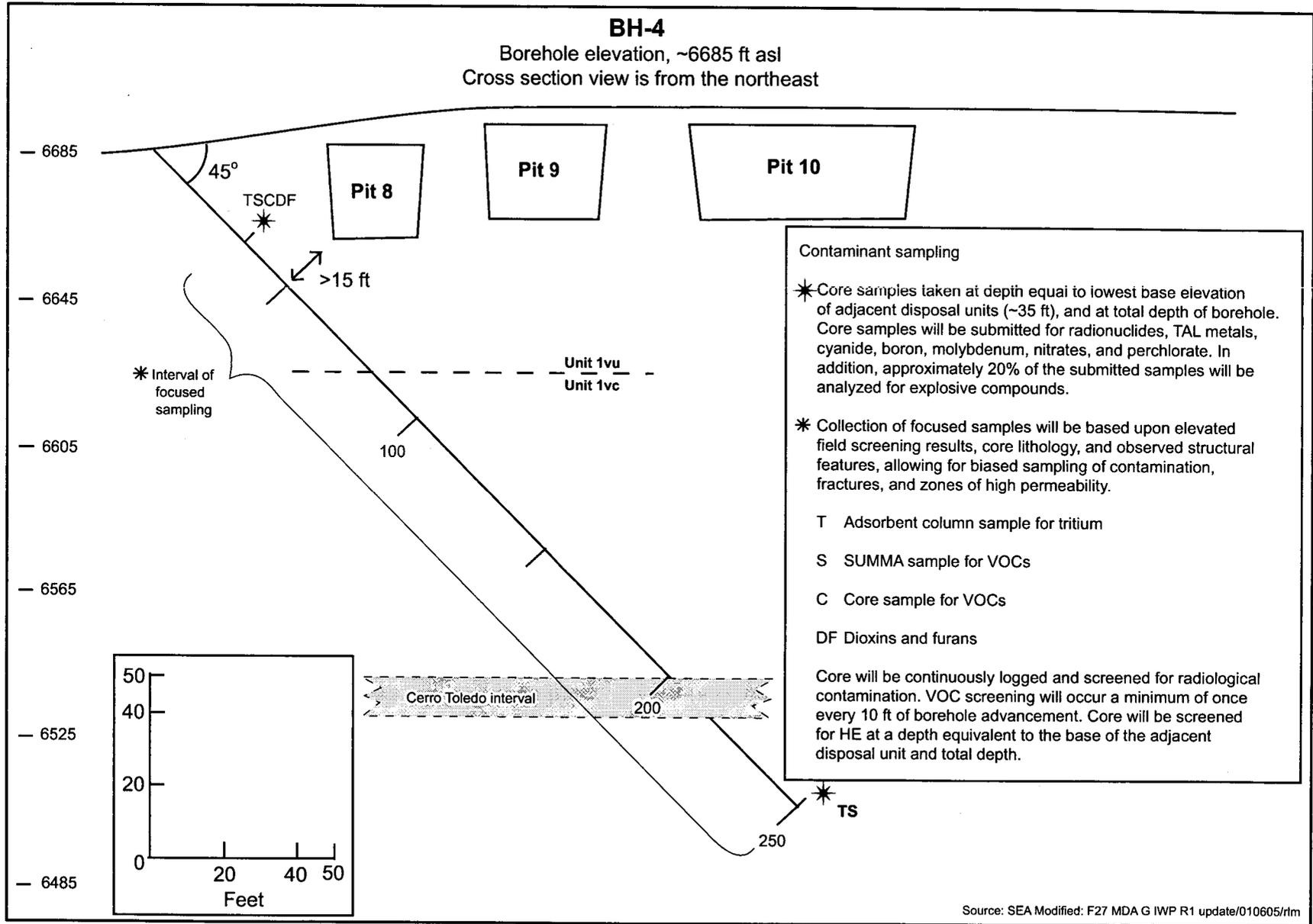


Figure 27. Profile of MDA G proposed borehole 4 with planned sample locations

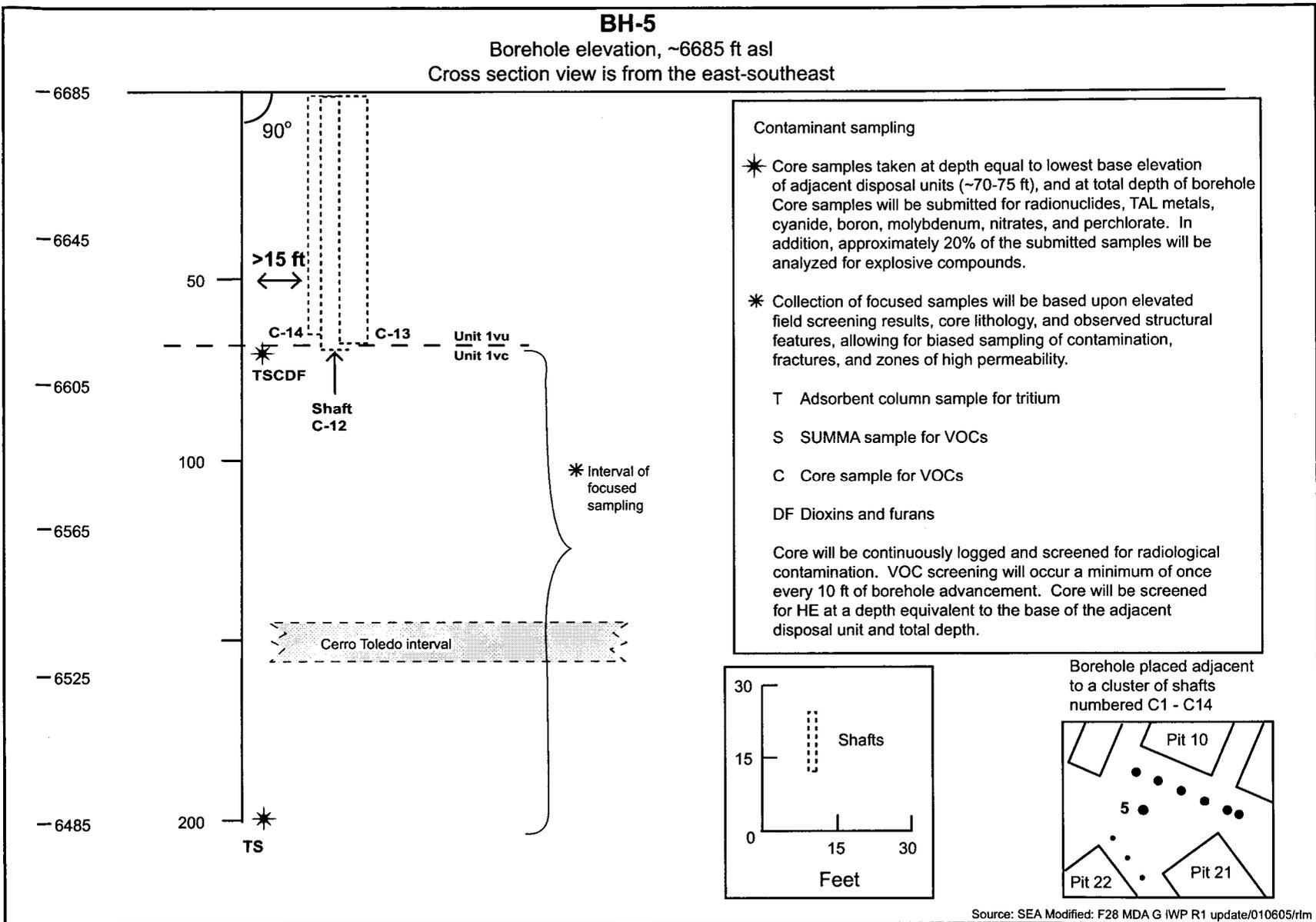


Figure 28. Profile of MDA G proposed borehole 5 with planned sample locations

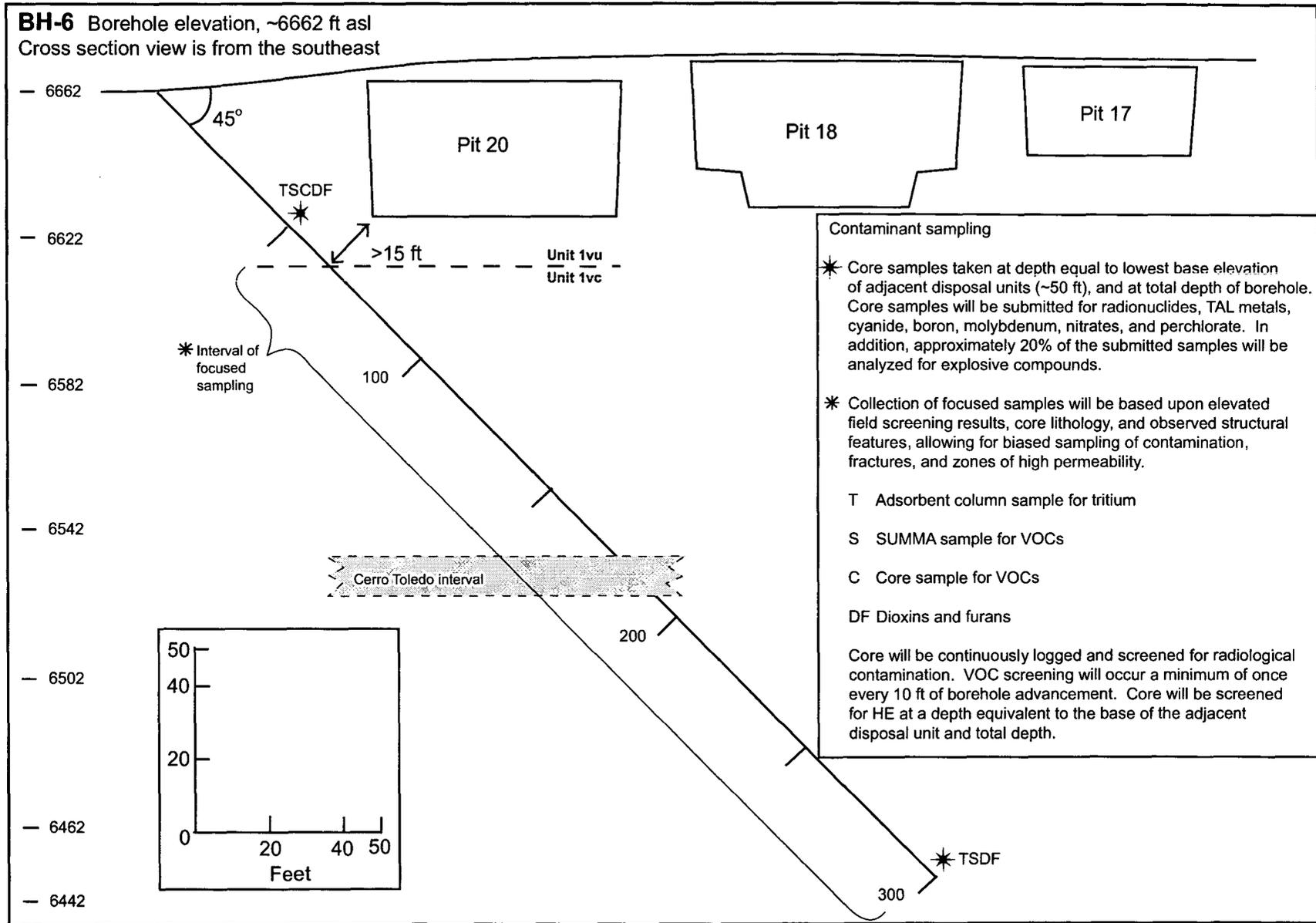
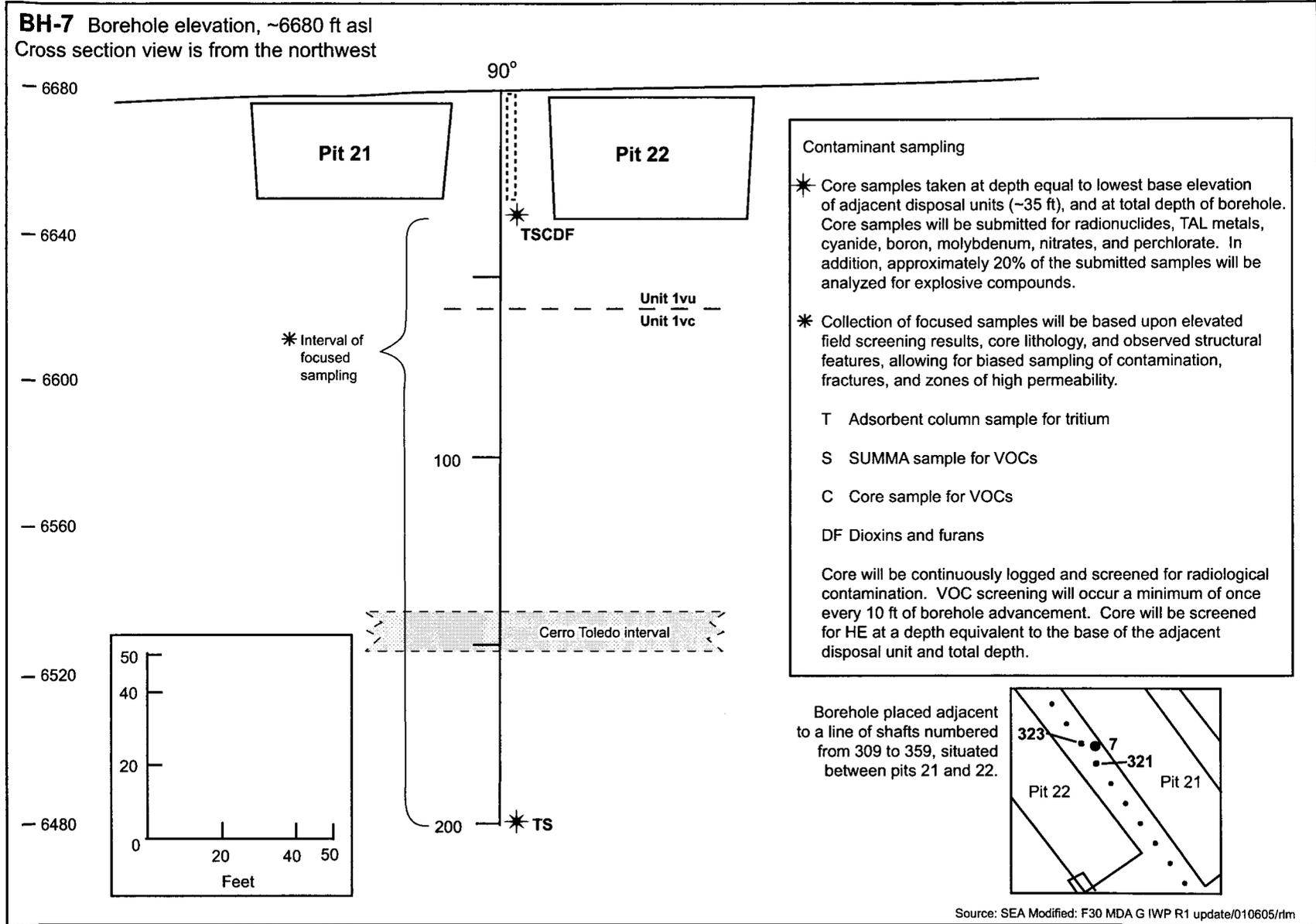


Figure 29. Profile of MDA G proposed borehole 6 with planned sample locations



Source: SEA Modified: F30 MDA G IWP R1 update/010605/rfm

Figure 30. Profile of MDA G proposed borehole 7 with planned sample locations

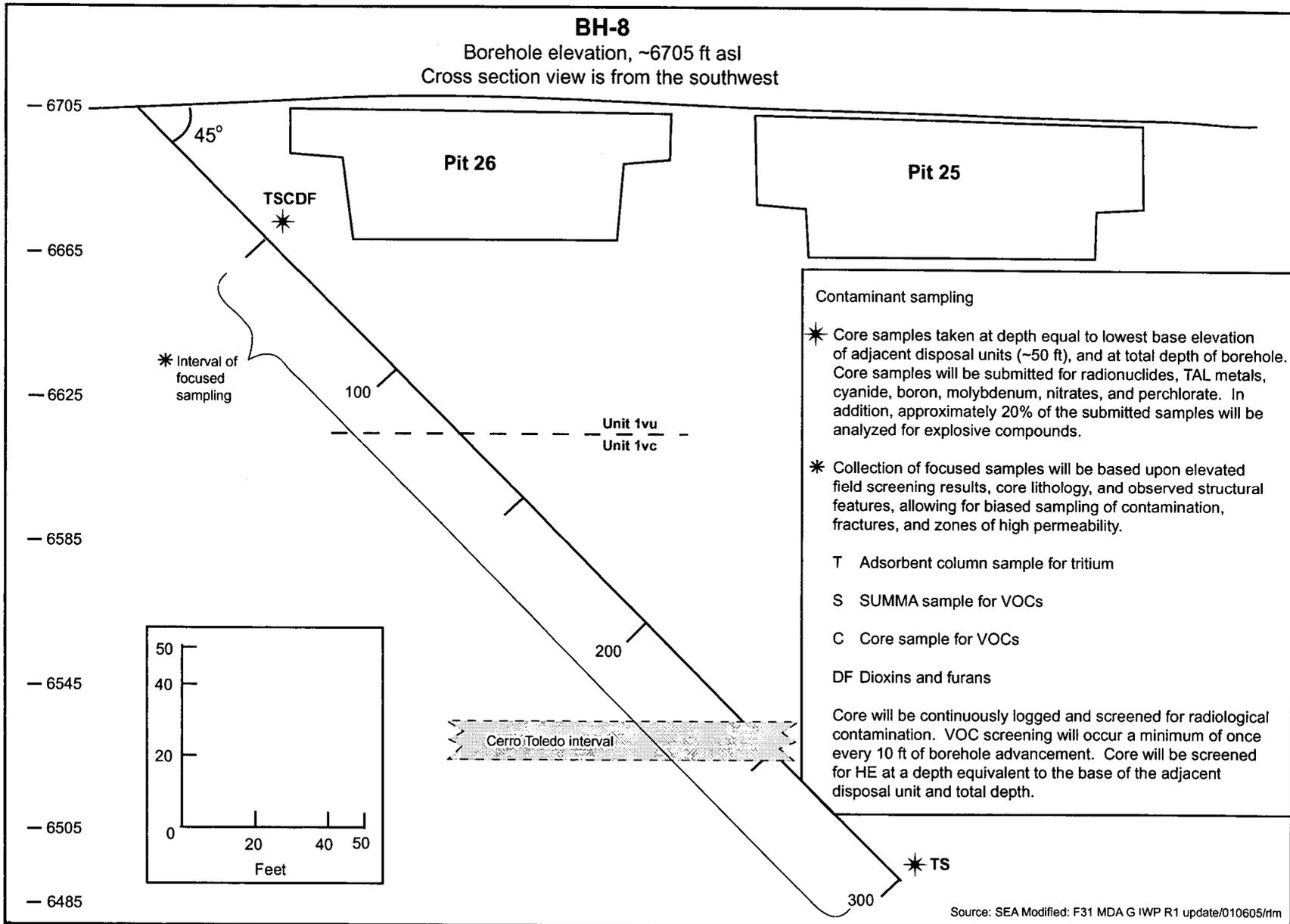


Figure 31. Profile of MDA G proposed borehole 8 with planned sample locations

Source: SEA Modified: F31 MDA G IWP R1 update/010605/rlm

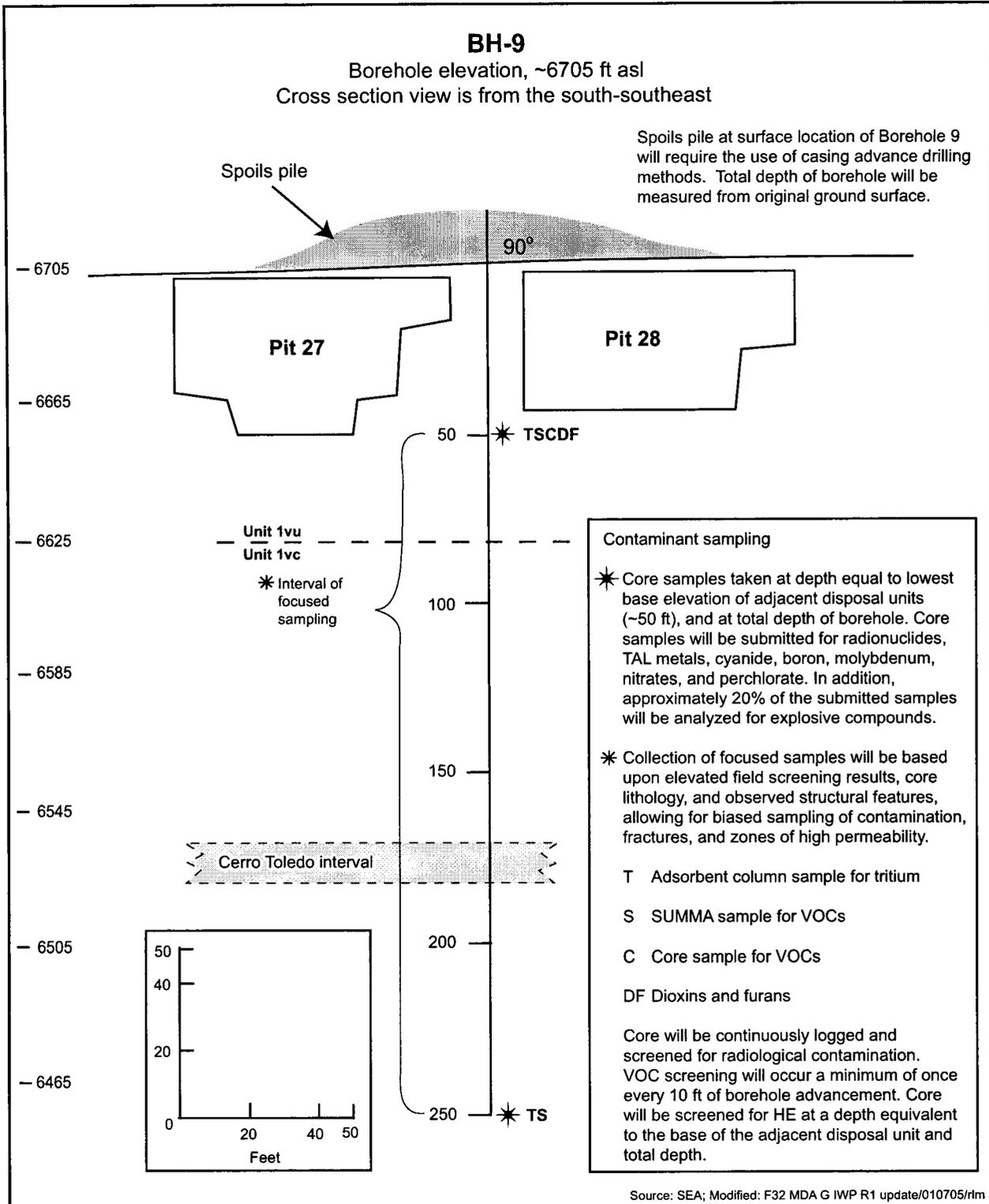


Figure 32. Profile of MDA G proposed borehole 9 with planned sample locations

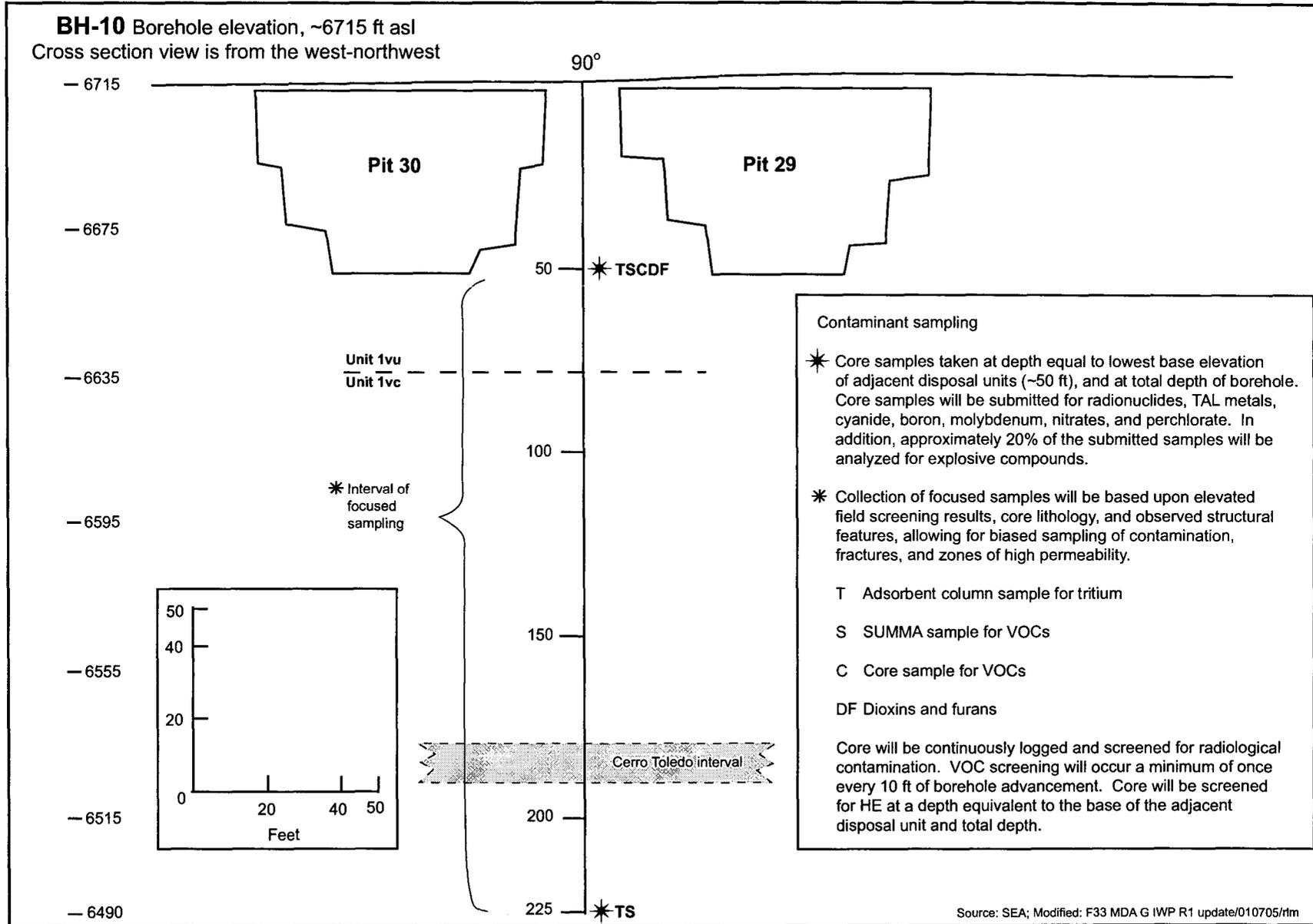
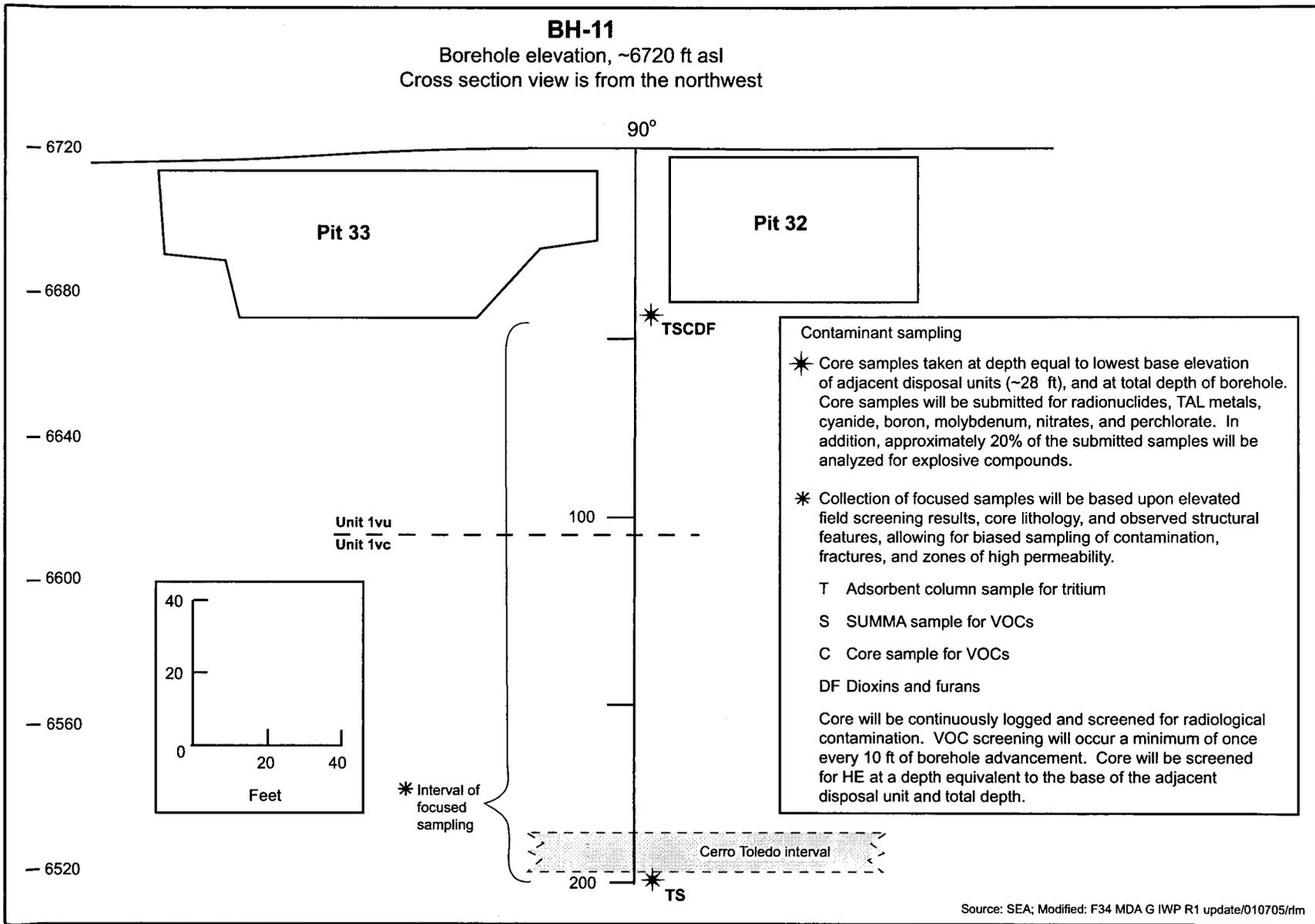


Figure 33. Profile of MDA G proposed borehole 10 with planned sample locations



Source: SEA; Modified: F34 MDA G IWP R1 update/010705/rfm

Figure 34. Profile of MDA G proposed borehole 11 with planned sample locations

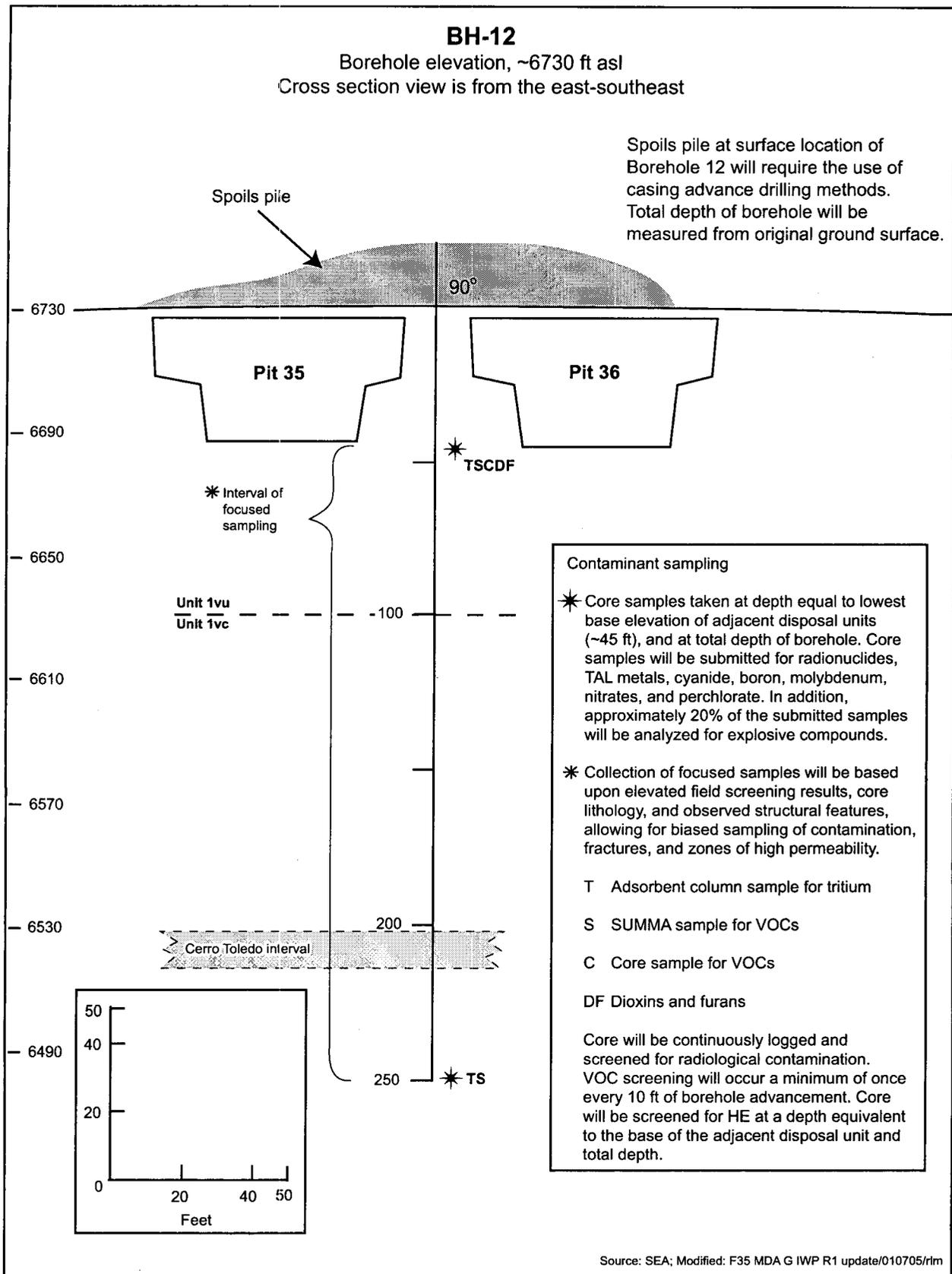


Figure 35. Profile of MDA G proposed borehole 12 with planned sample locations

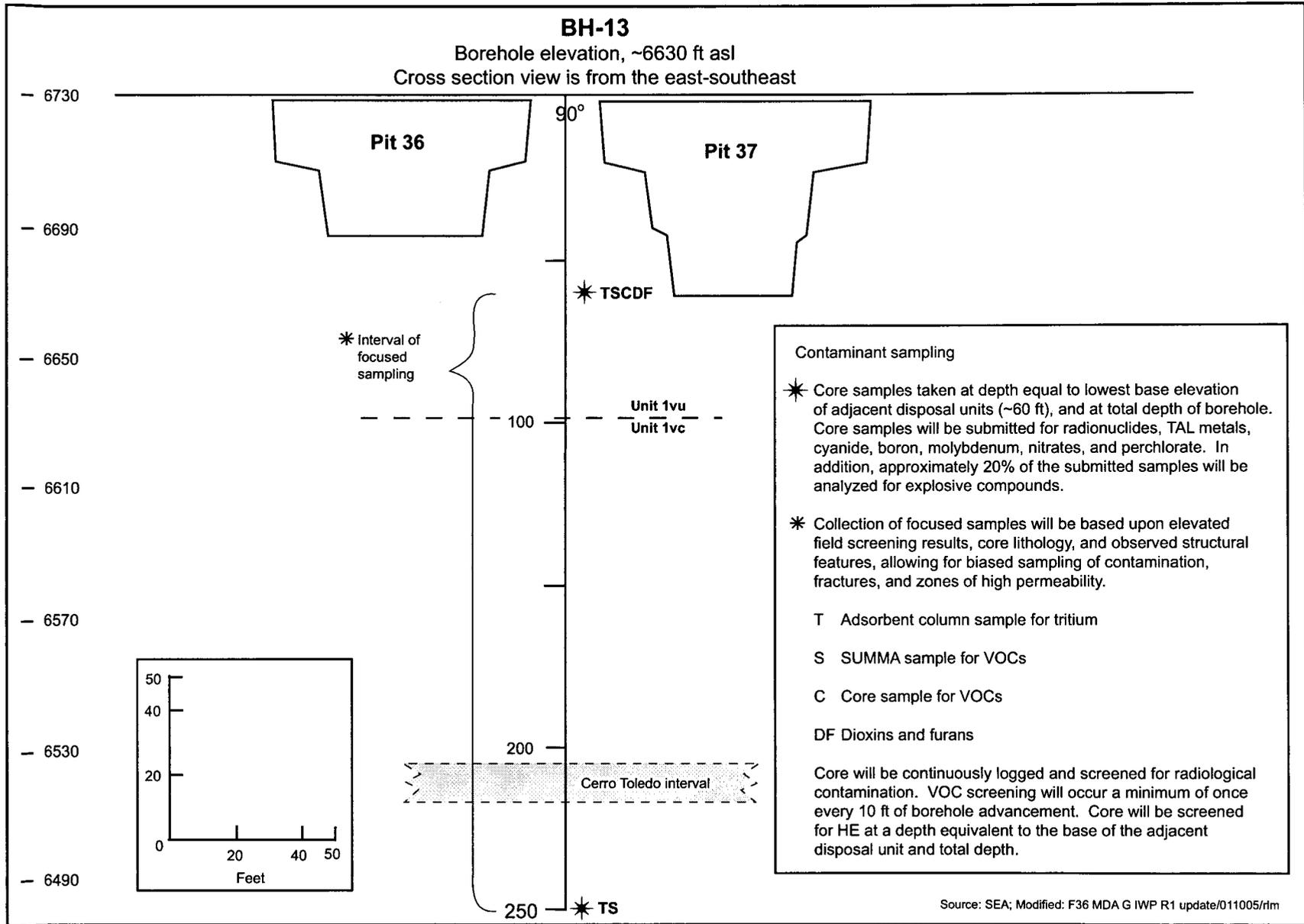


Figure 36. Profile of MDA G proposed borehole 13 with planned sample locations

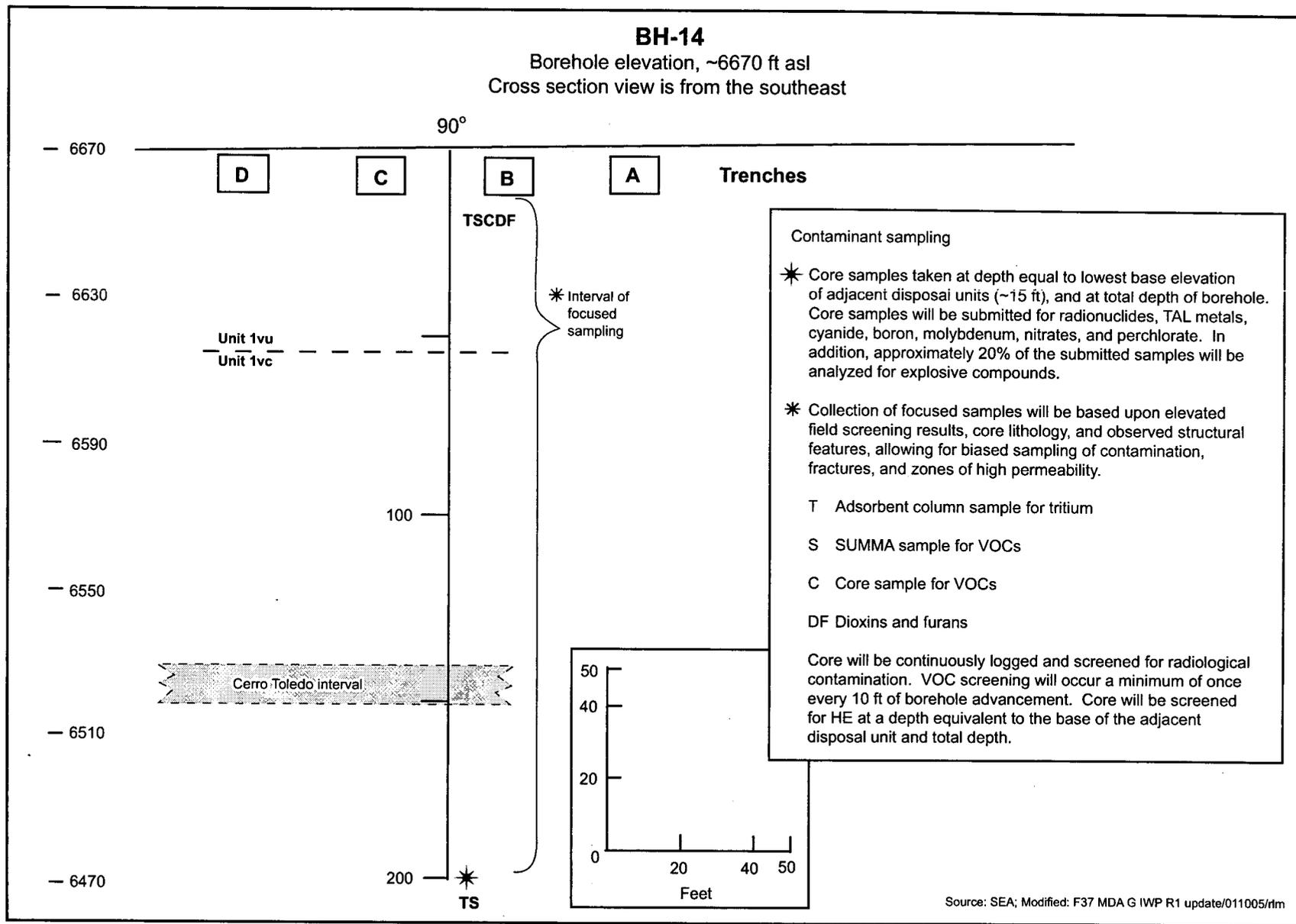


Figure 37. Profile of MDA G proposed borehole 14 with planned sample locations

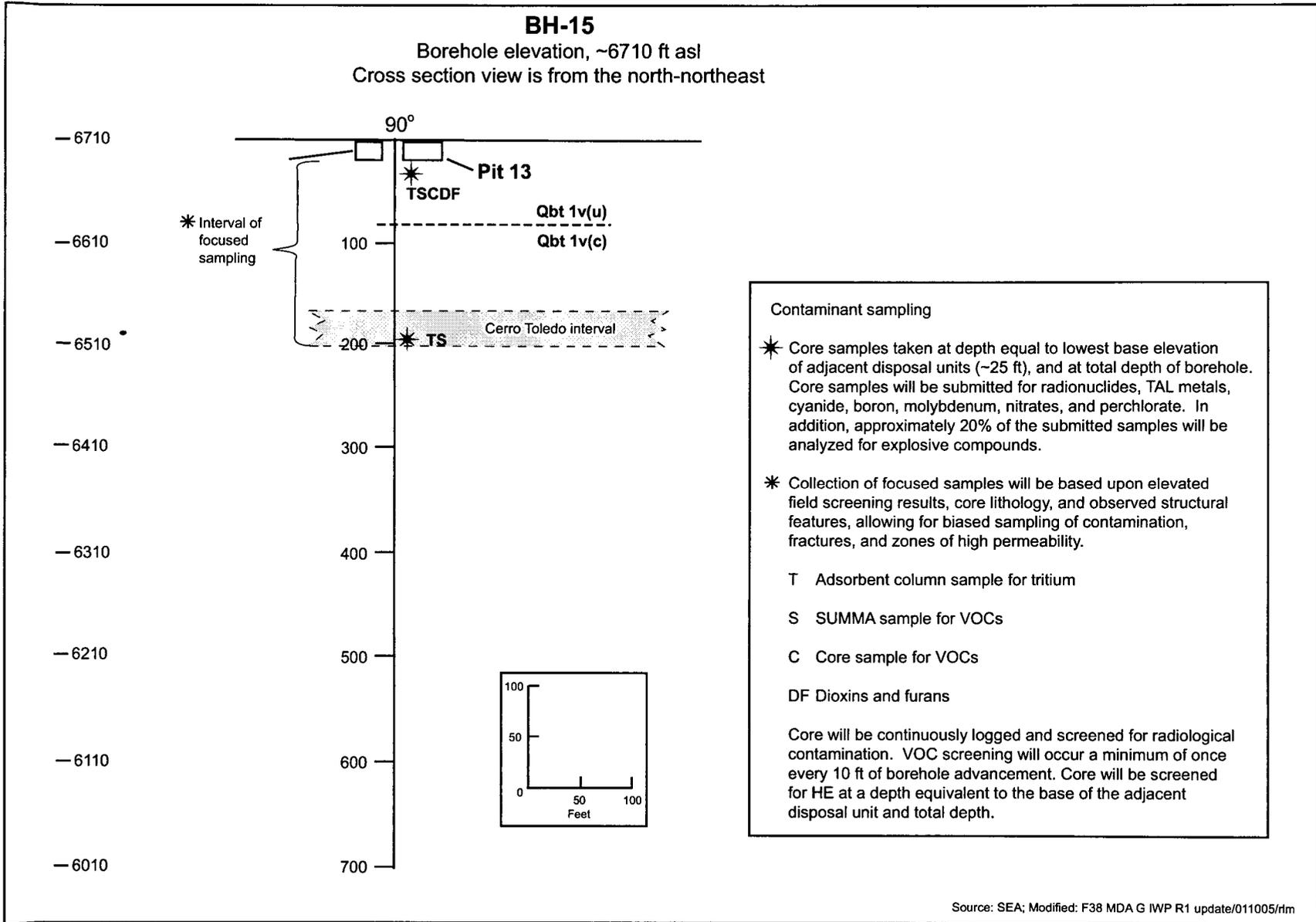


Figure 38. Profile of MDA G proposed borehole 15 with planned and focused sample locations

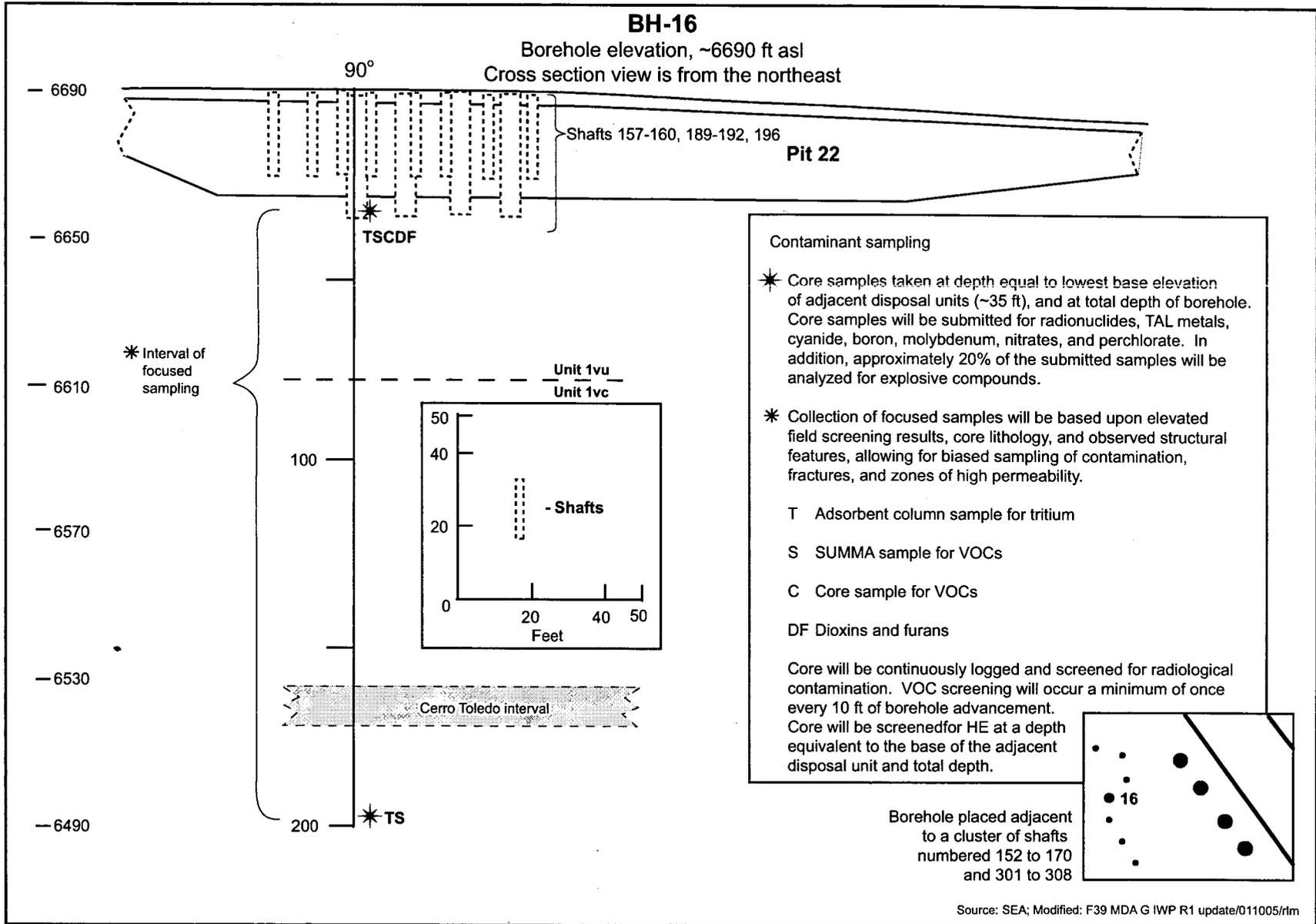


Figure 39. Profile of MDA G proposed borehole 16 with planned sample locations

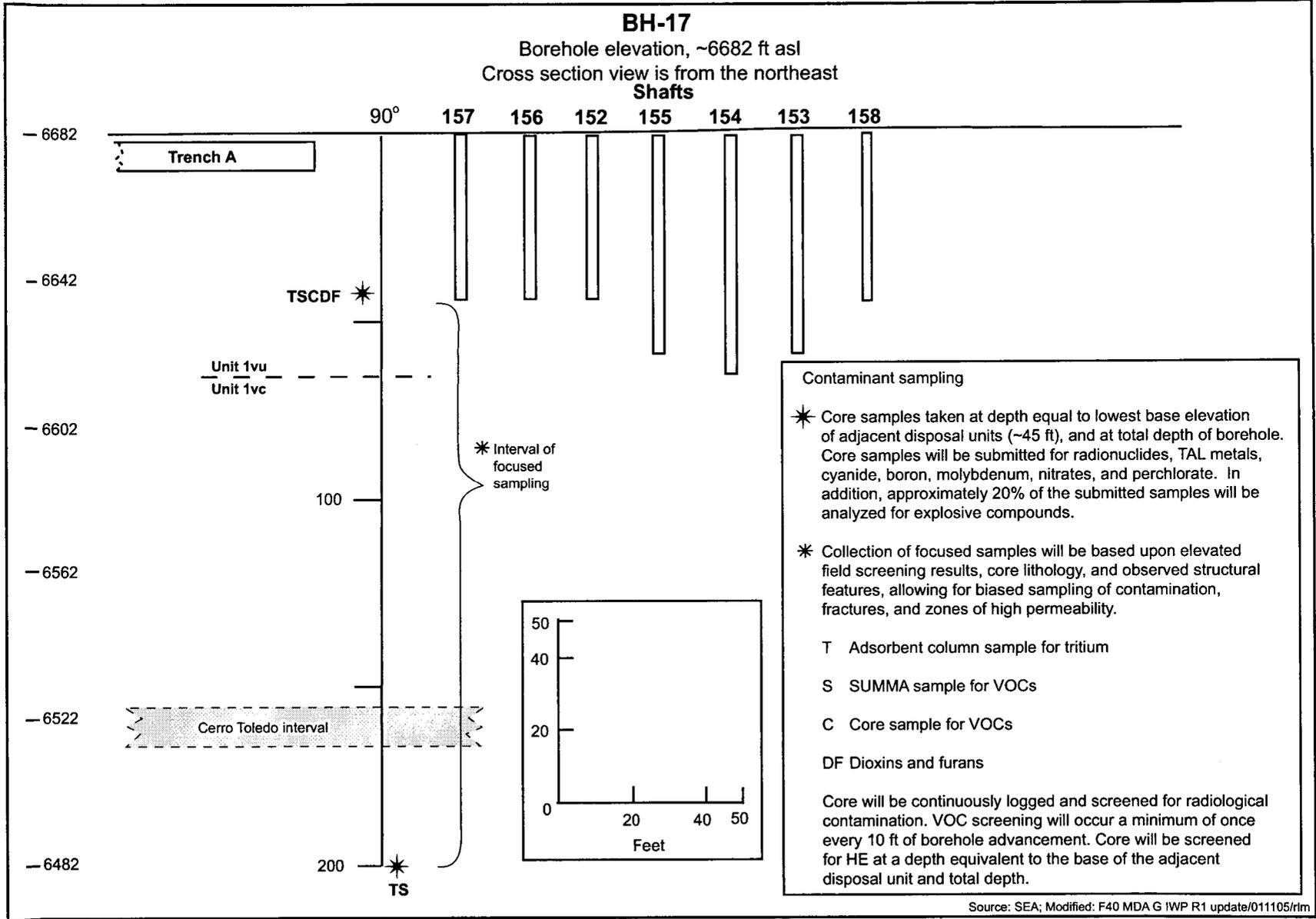


Figure 40. Profile of MDA G proposed borehole 17 with planned sample locations

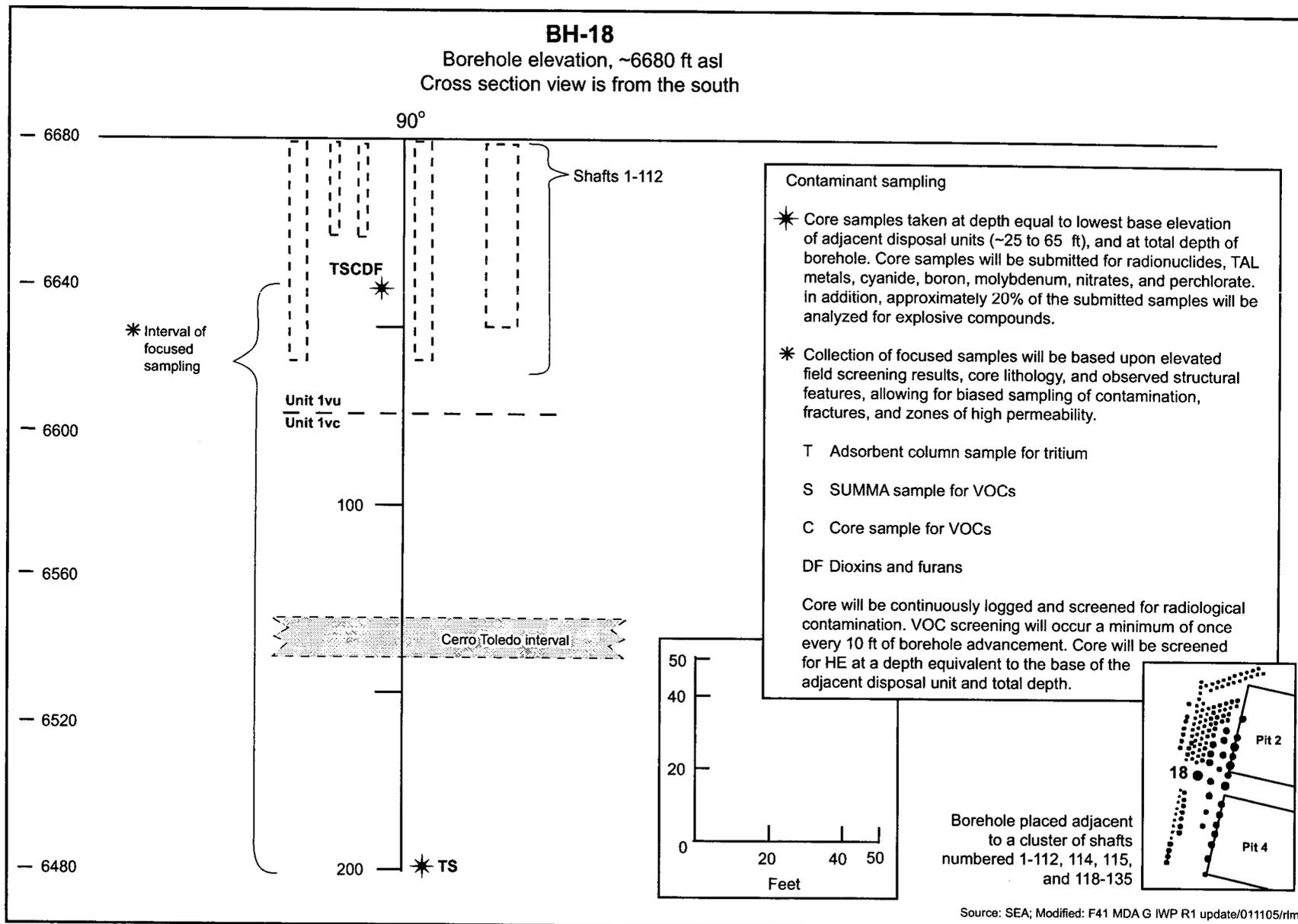


Figure 41. Profile of MDA G proposed borehole 18 with planned sample locations

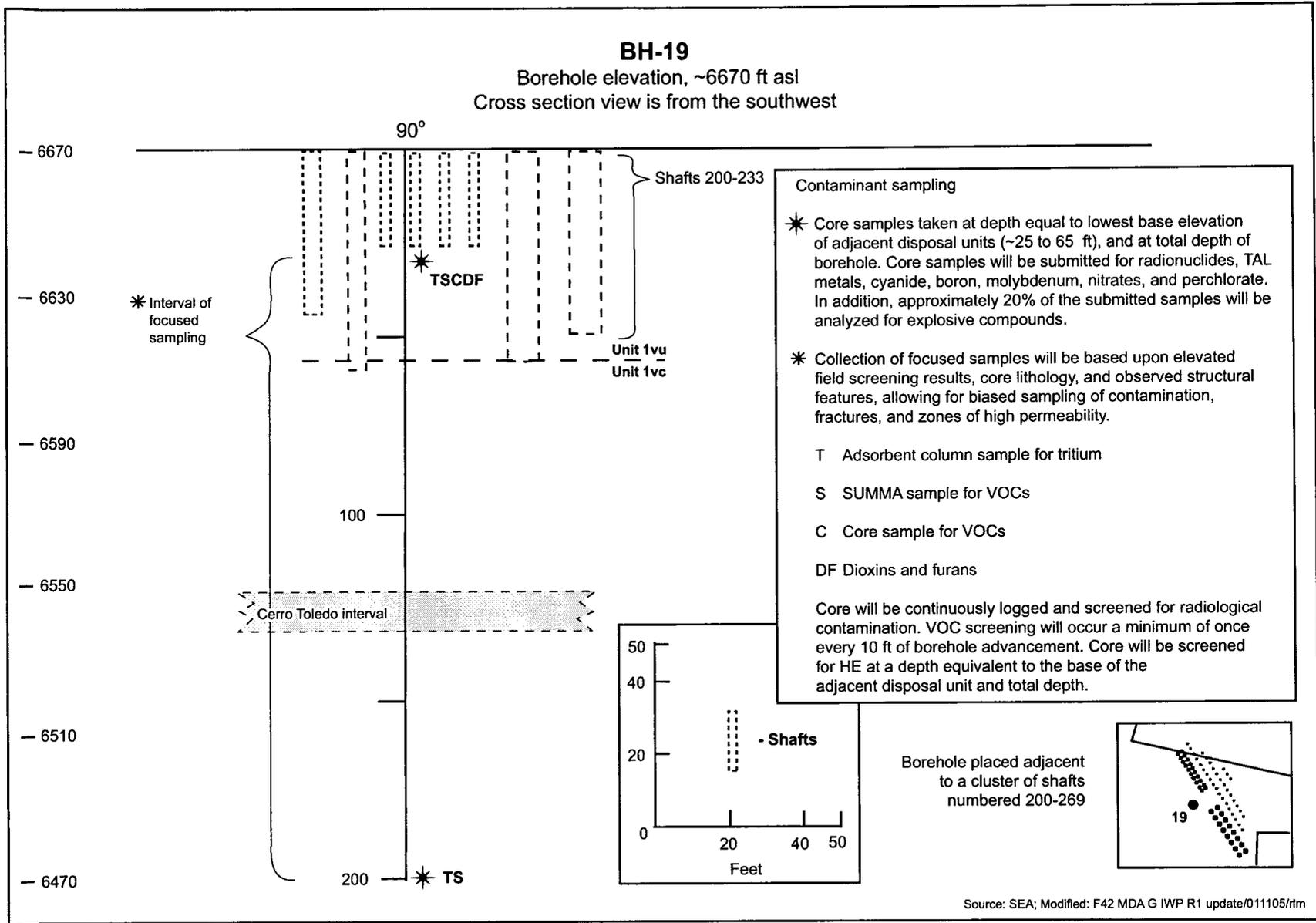


Figure 42. Profile of MDA G proposed borehole 19 with planned sample locations

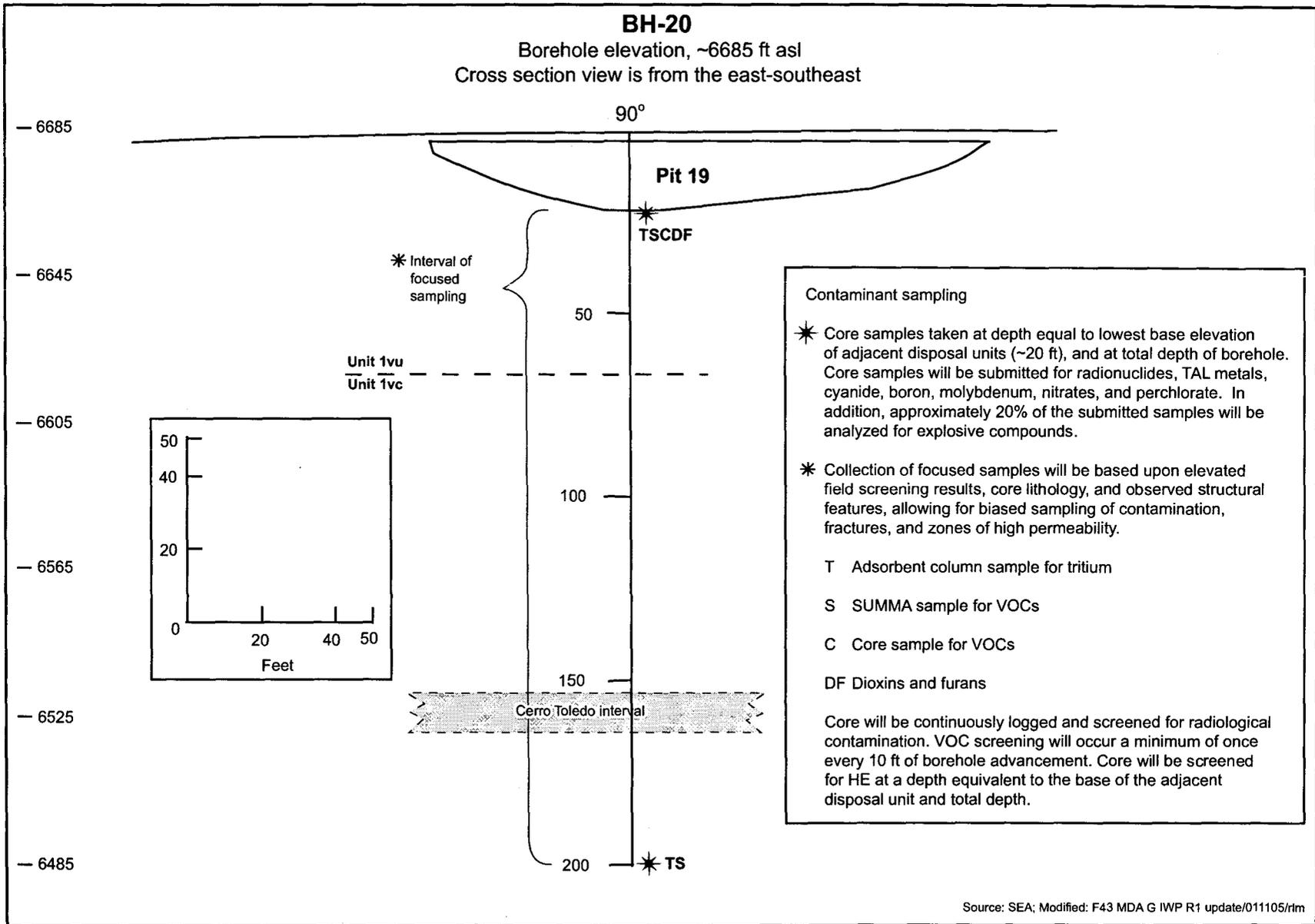


Figure 43. Profile of MDA G proposed borehole 20 with planned sample locations

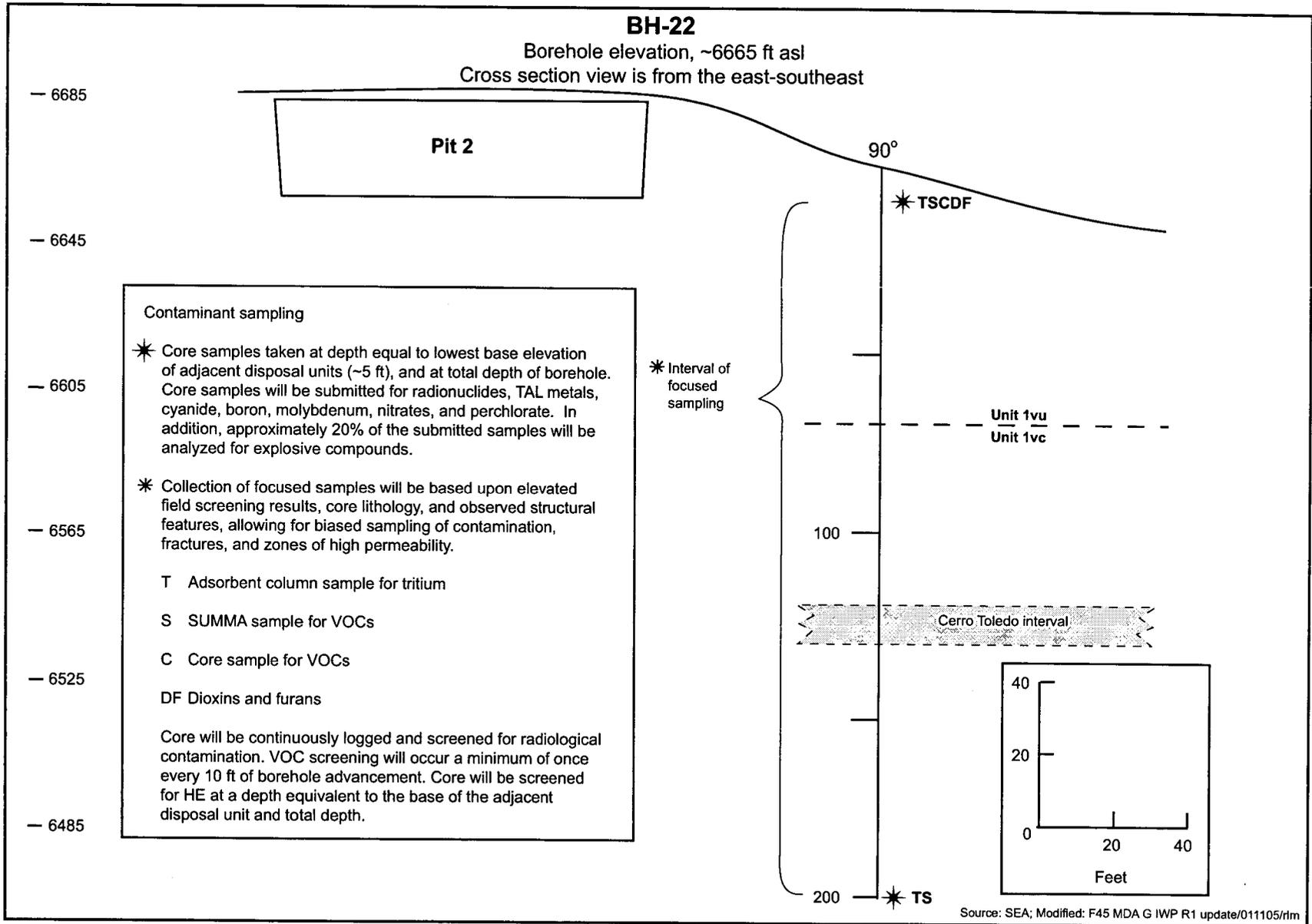


Figure 45. Profile of MDA G proposed borehole 22 with planned sample locations

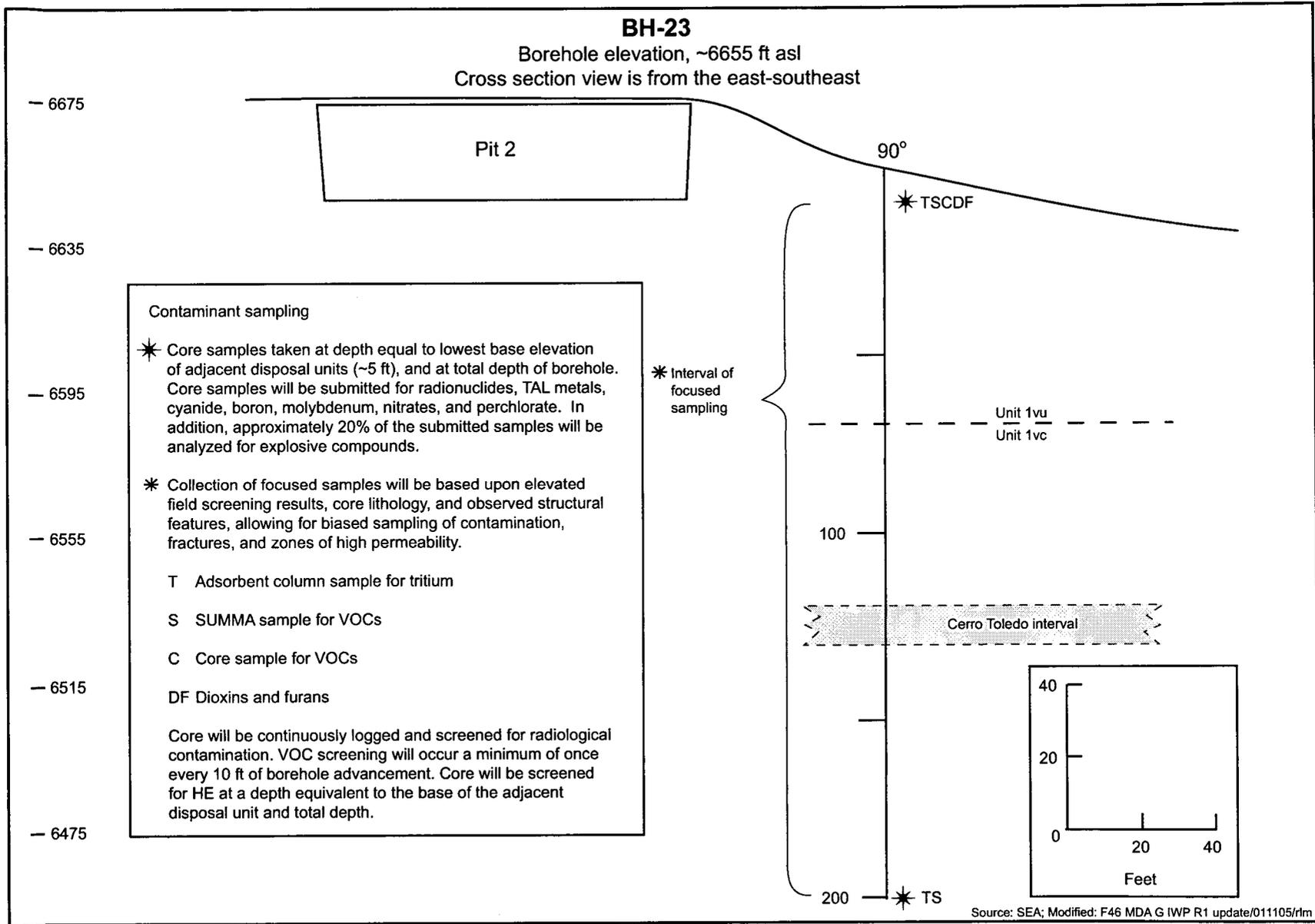


Figure 46. Profile of MDA G proposed borehole 23 with planned sample locations

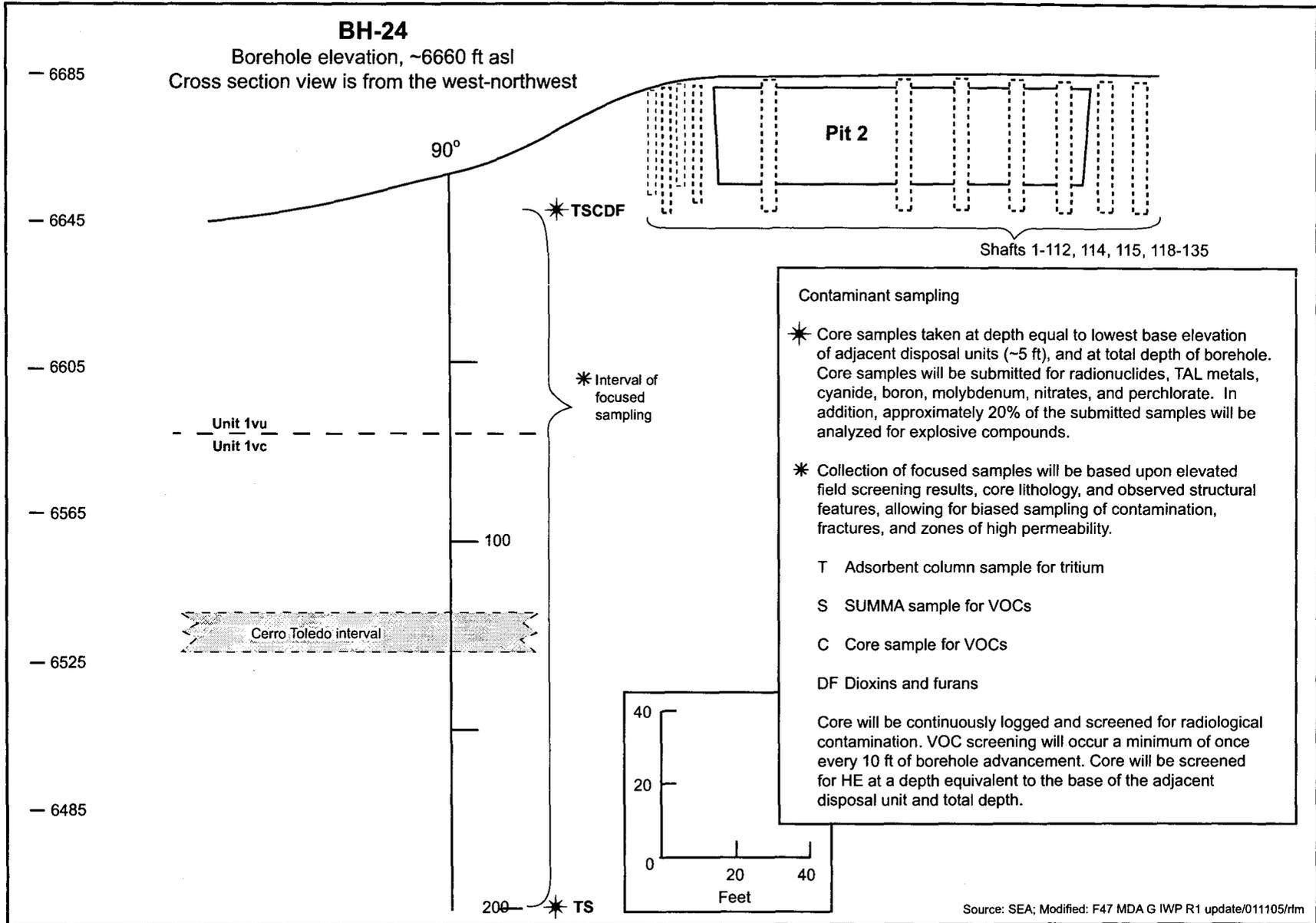


Figure 47. Profile of MDA G proposed borehole 24 with planned sample locations

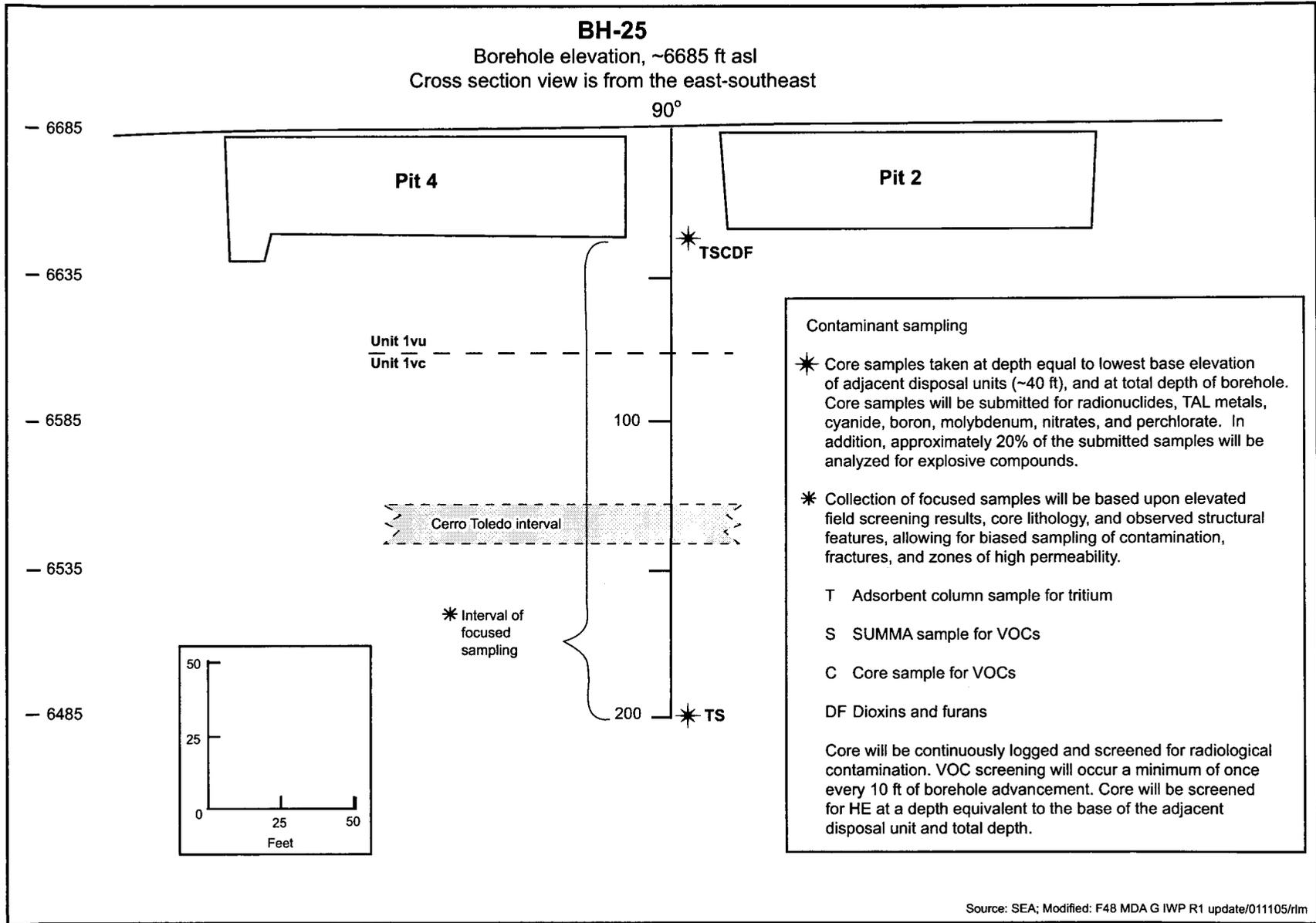


Figure 48. Profile of MDA G proposed borehole 25 with planned sample locations

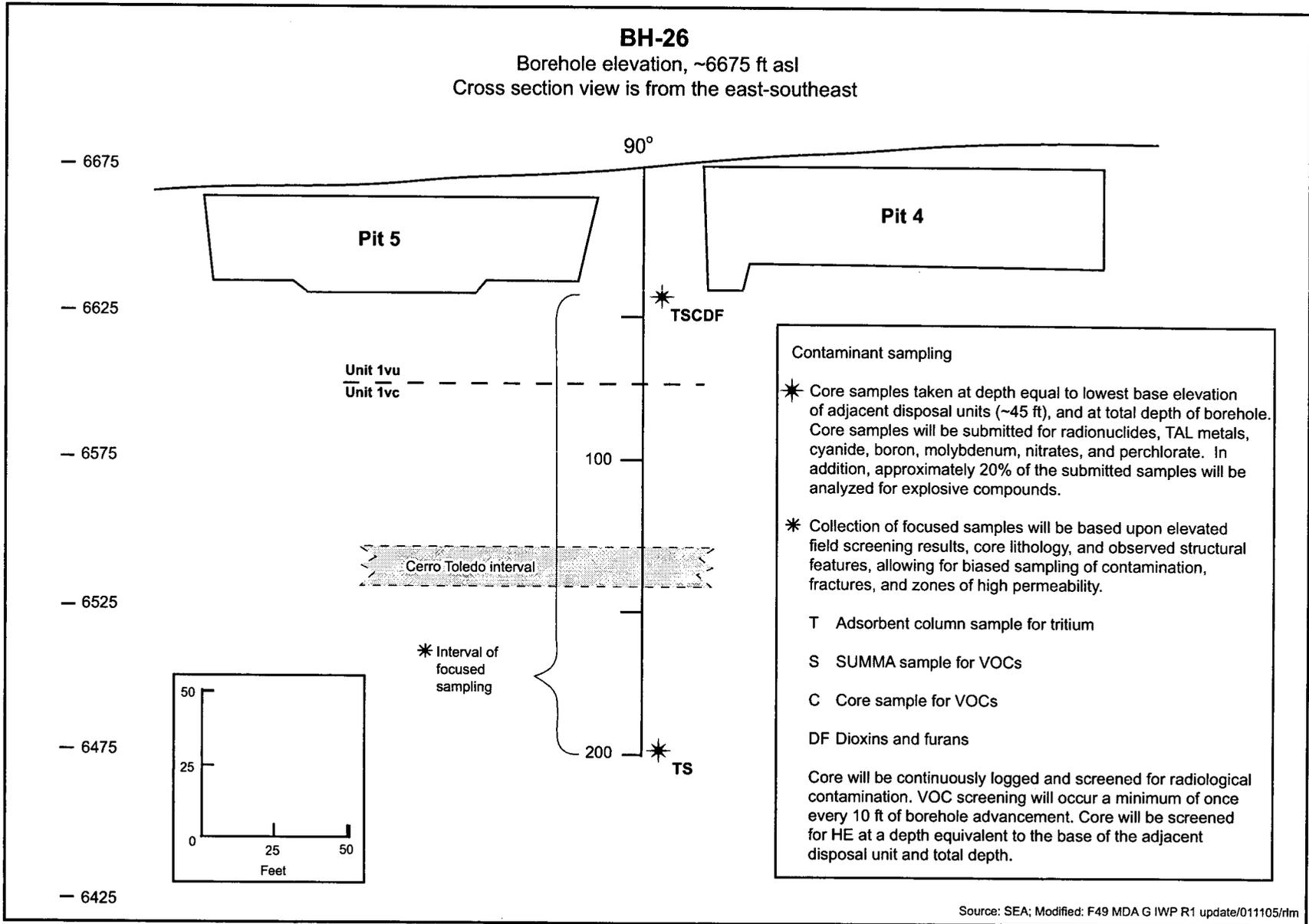


Figure 49. Profile of MDA G proposed borehole 26 with planned sample locations

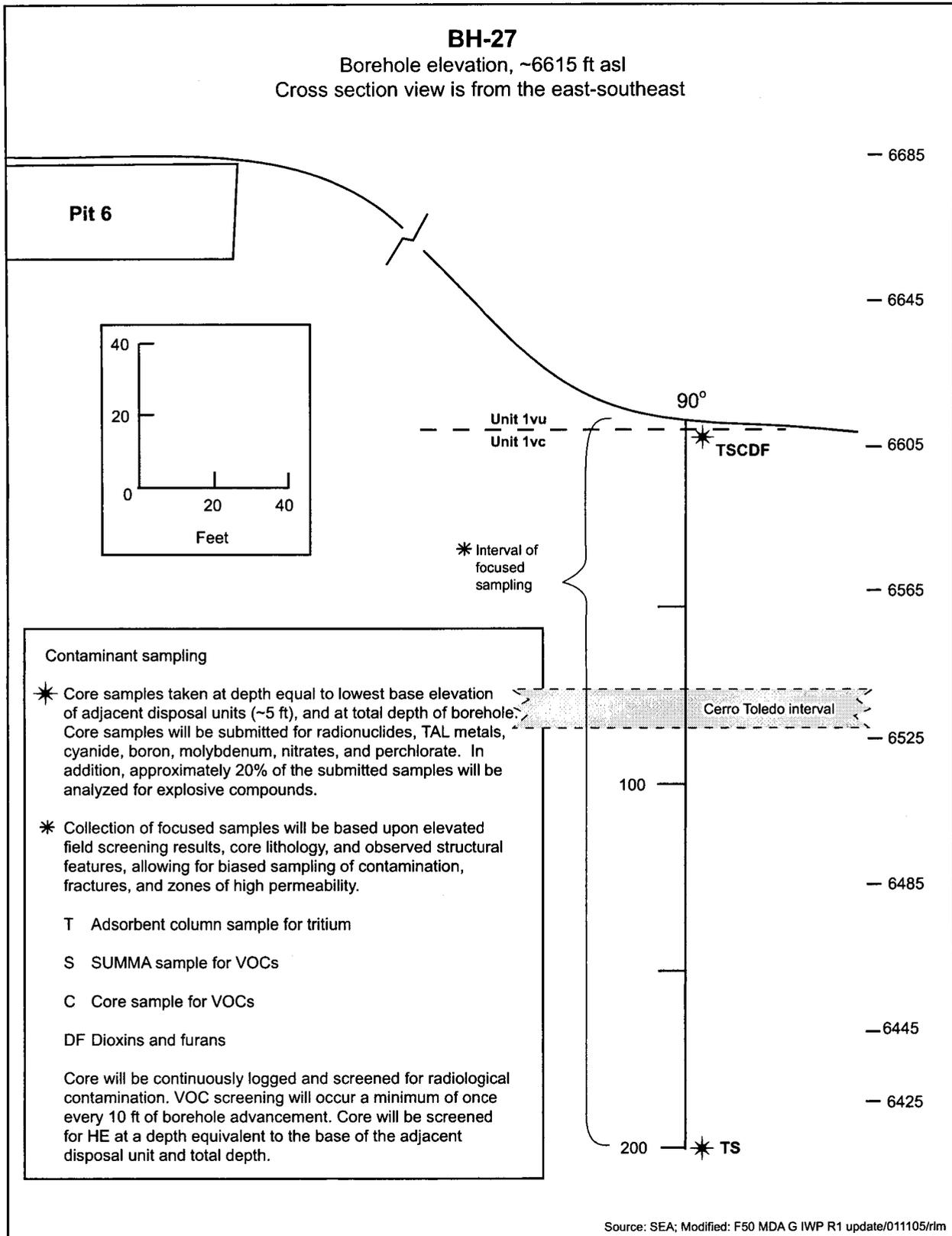
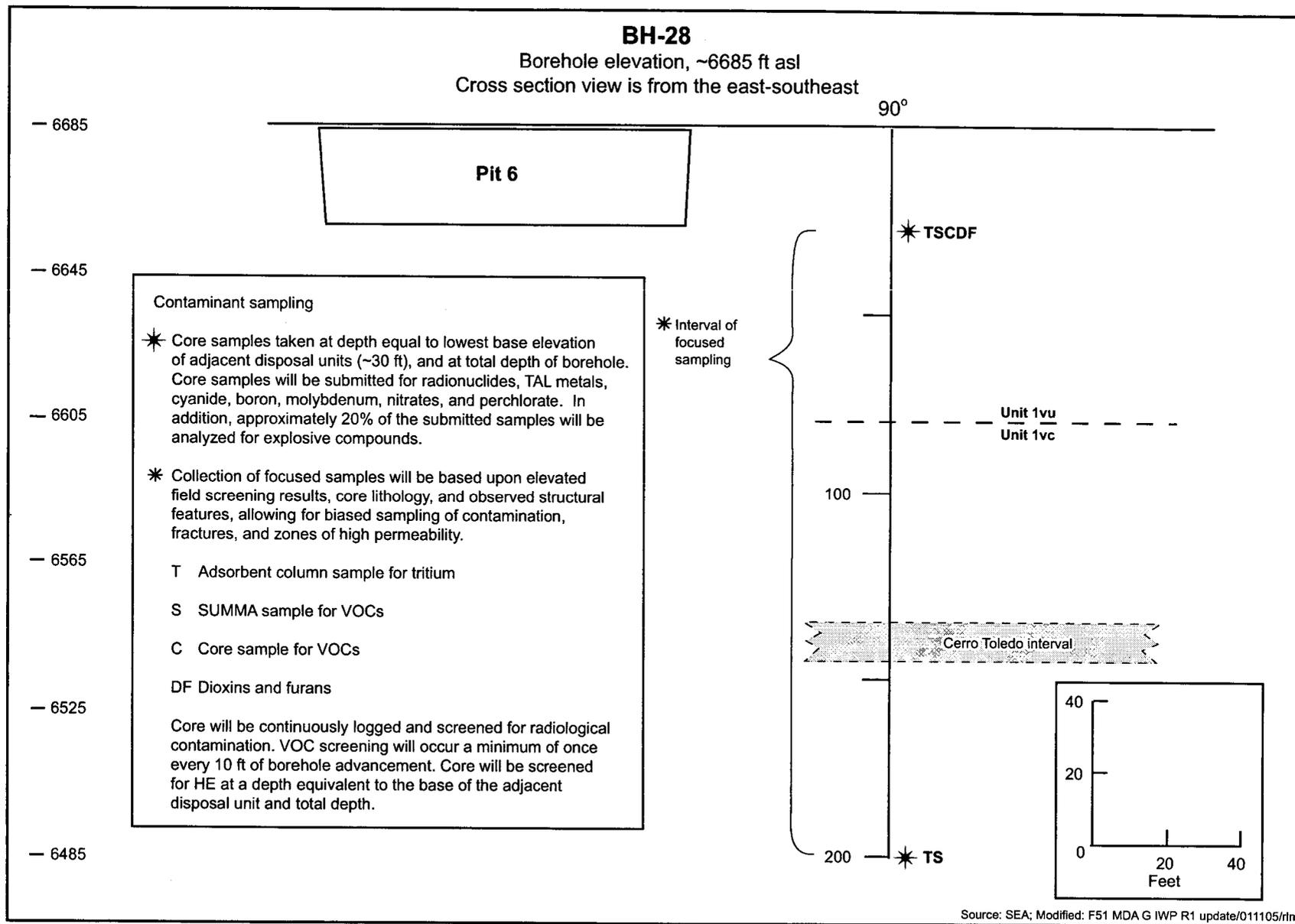


Figure 50. Profile of MDA G proposed borehole 27 with planned sample locations



Source: SEA; Modified: F51 MDA G IWP R1 update/011105/rlm

Figure 51. Profile of MDA G proposed borehole 28 with planned sample locations

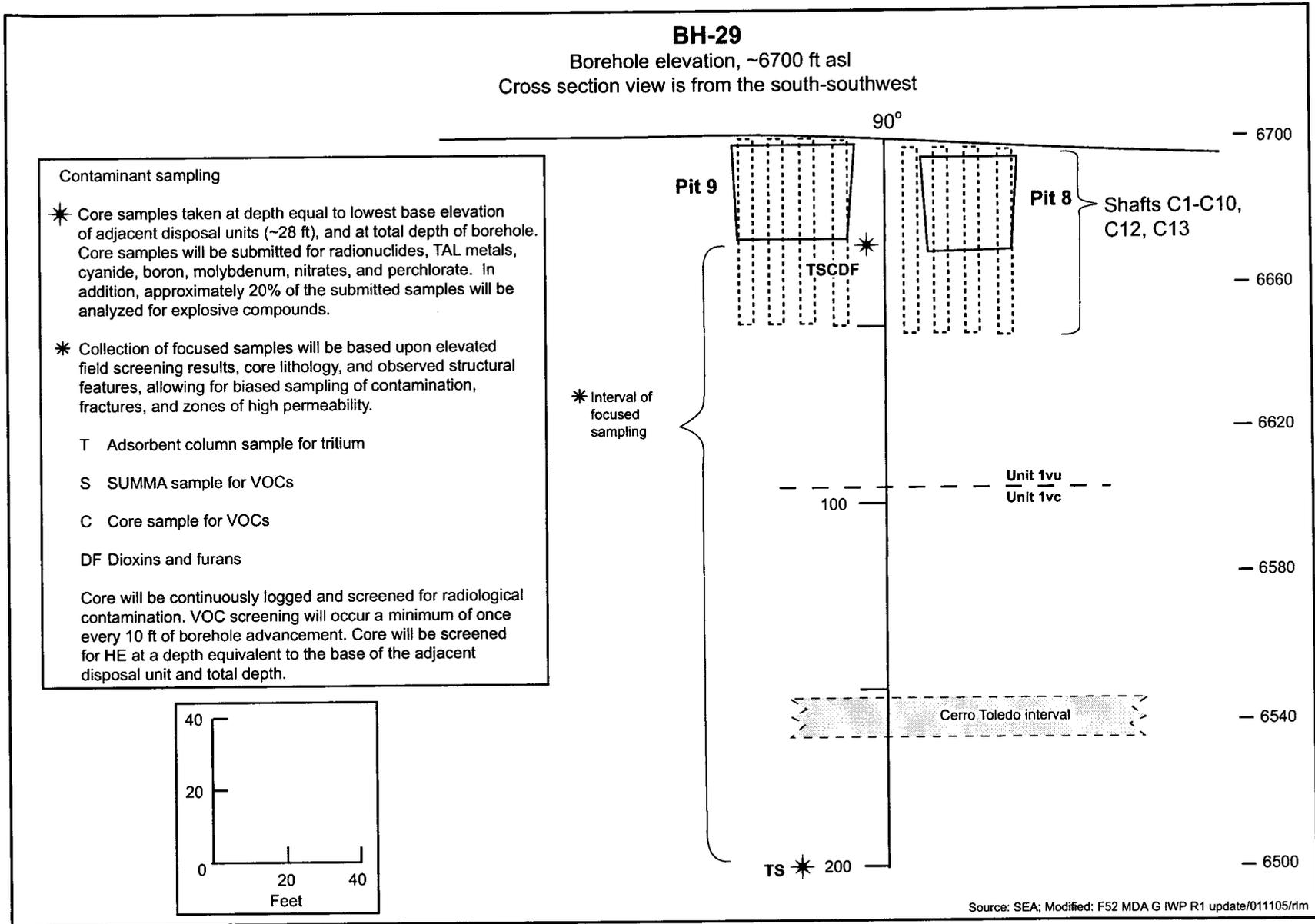


Figure 52. Profile of MDA G proposed borehole 29 with planned sample locations

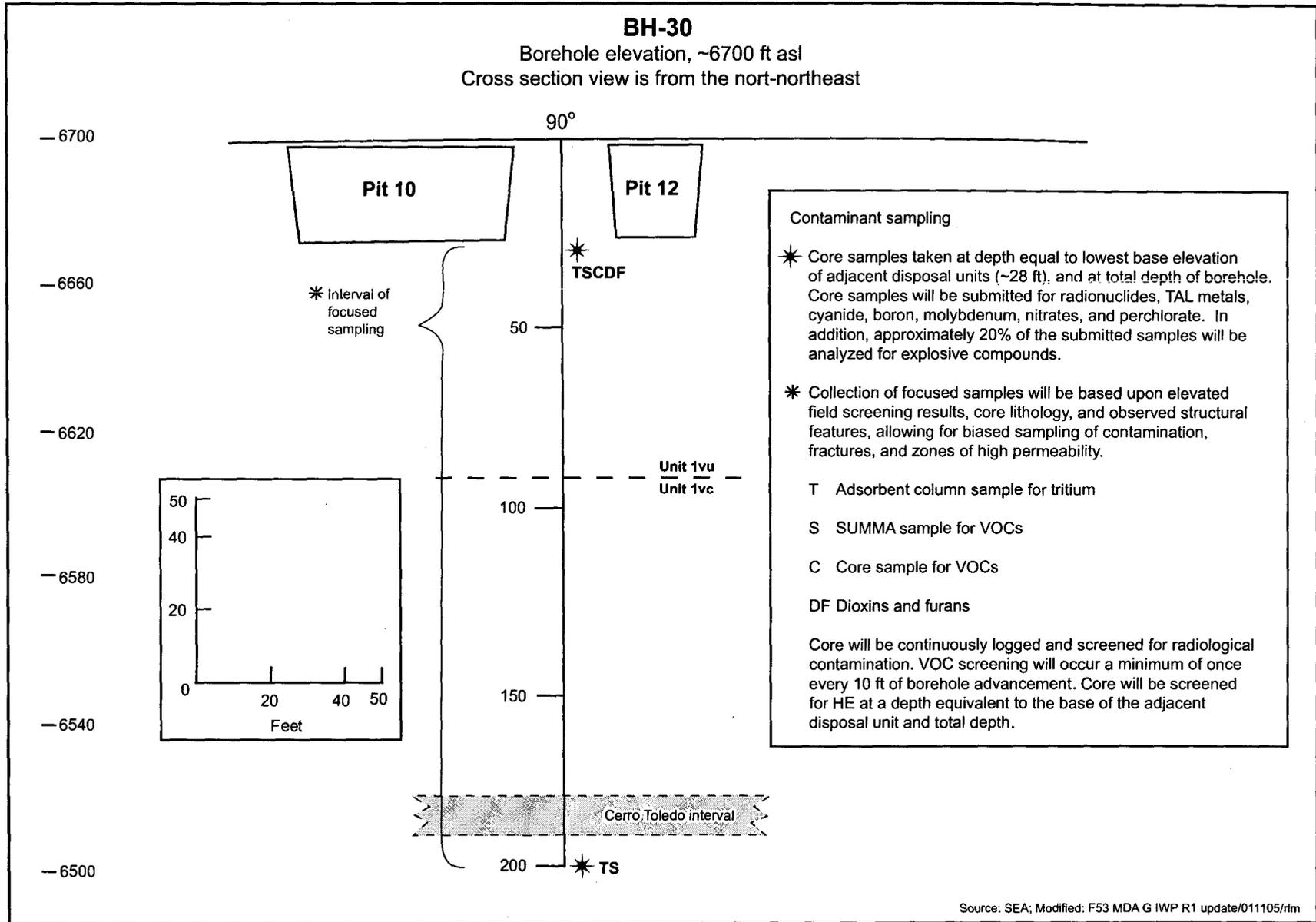


Figure 53. Profile of MDA G proposed borehole 30 with planned sample locations

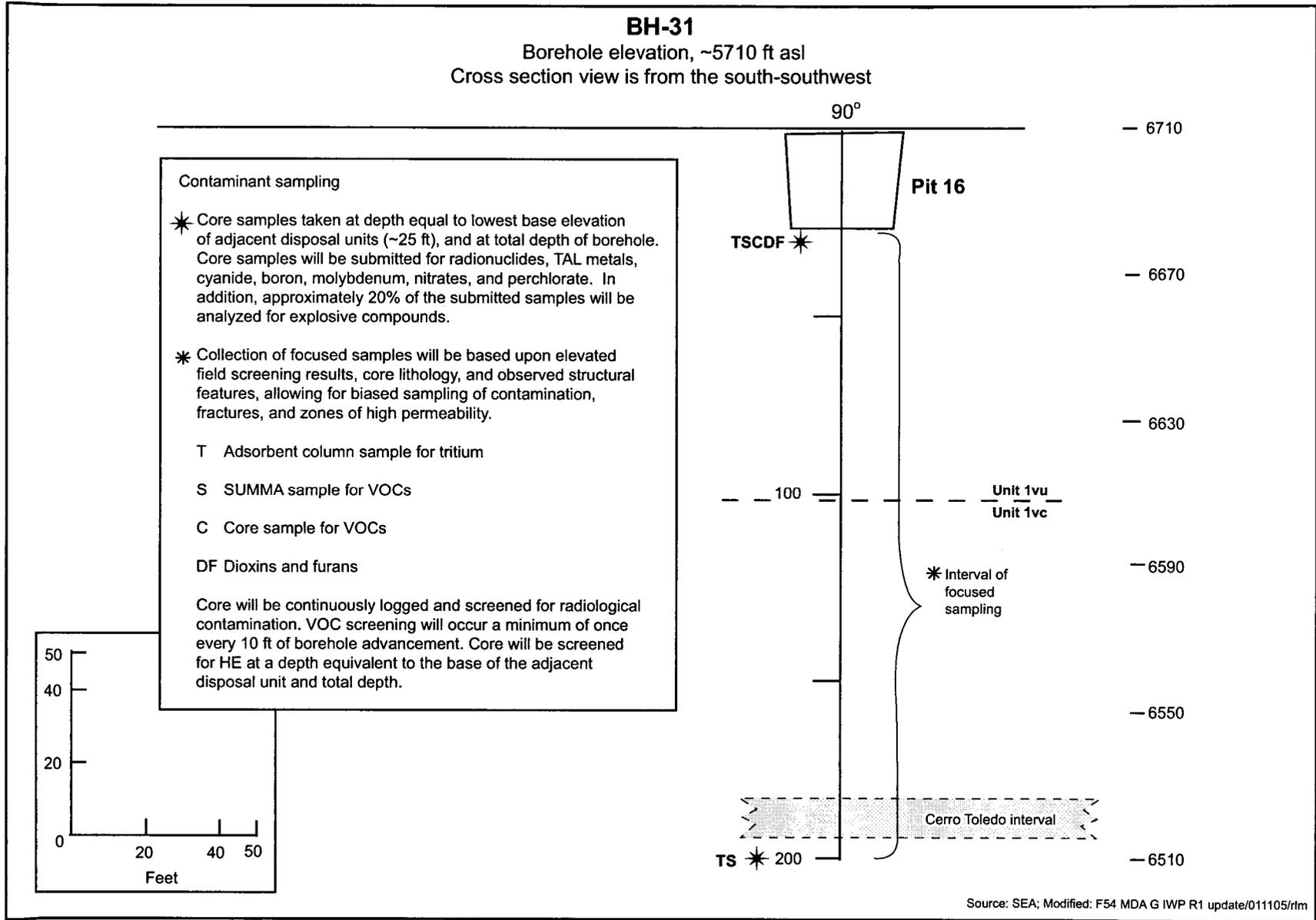


Figure 54. Profile of MDA G proposed borehole 31 with planned sample locations

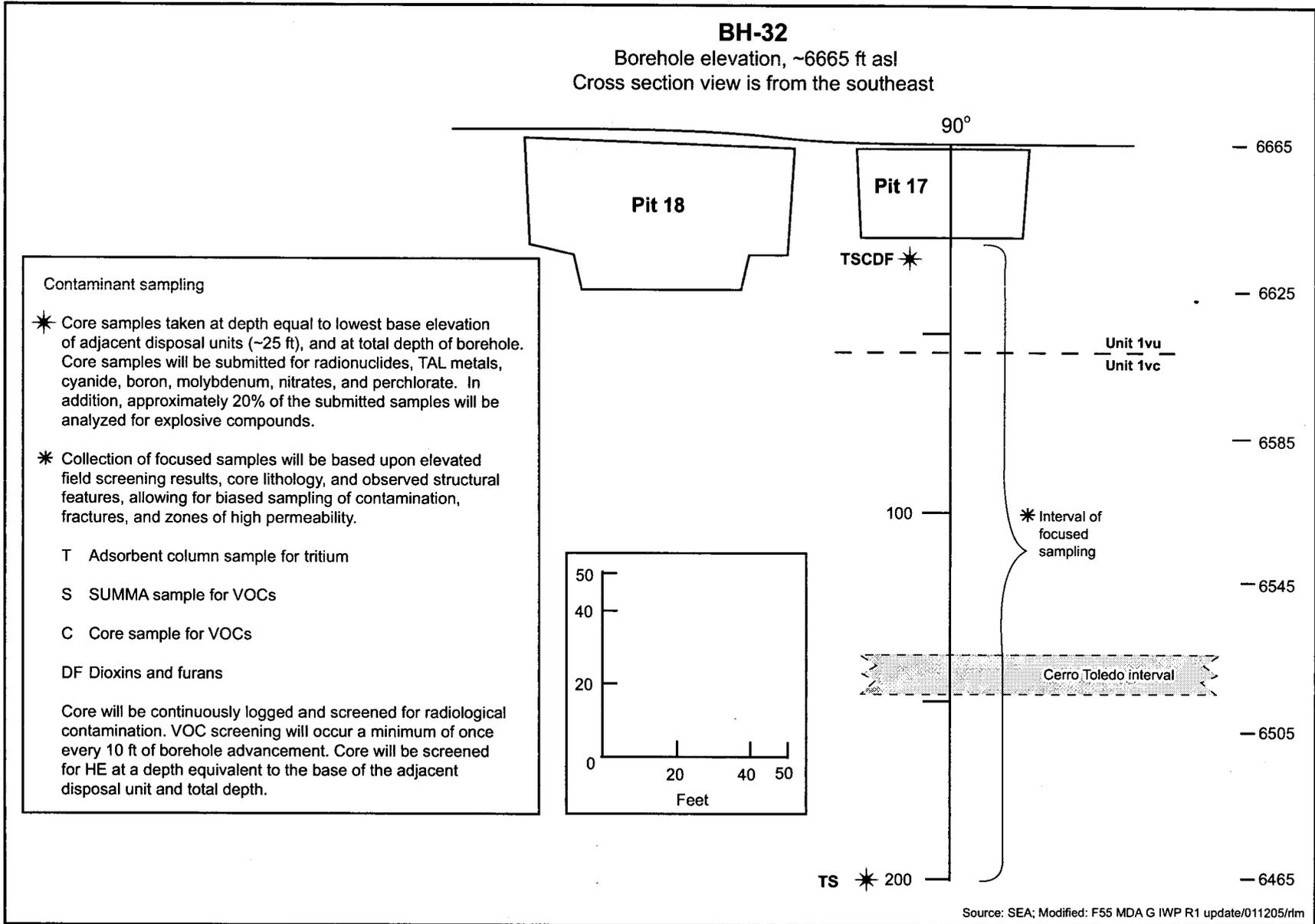


Figure 55. Profile of MDA G proposed borehole 32 with planned sample locations

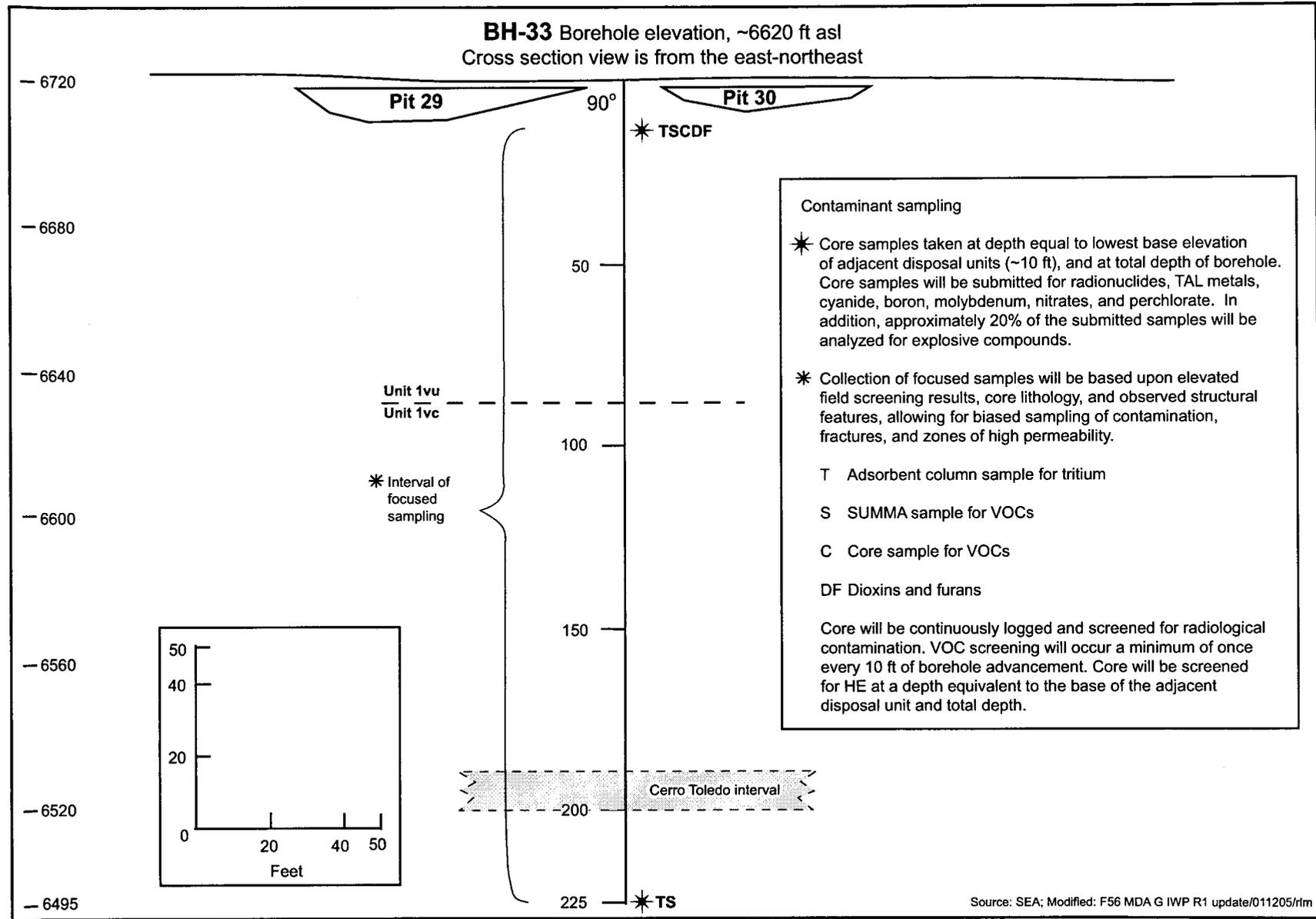


Figure 56. Profile of MDA G proposed borehole 33 with planned sample locations

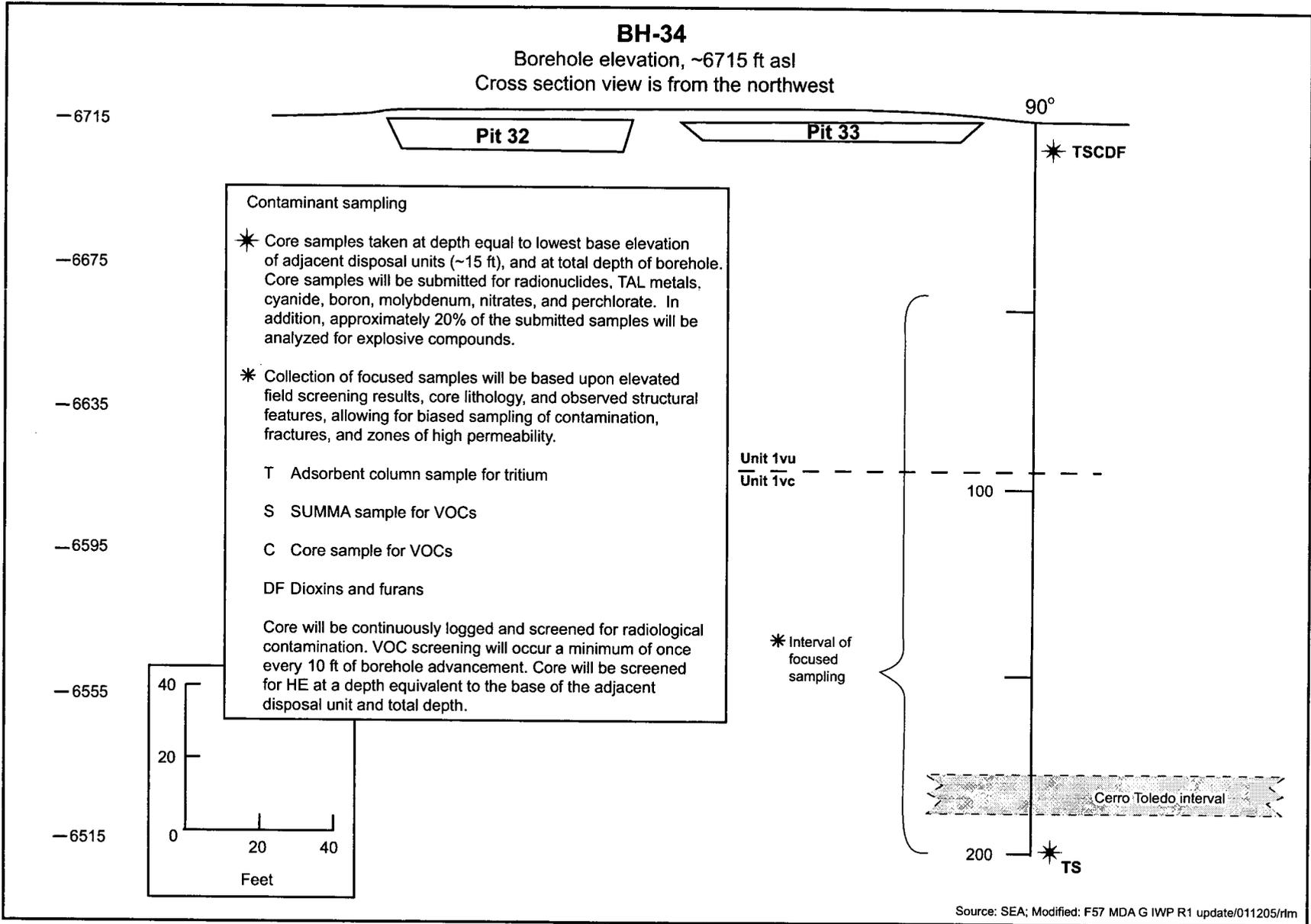


Figure 57. Profile of MDA G proposed borehole 34 with planned sample locations

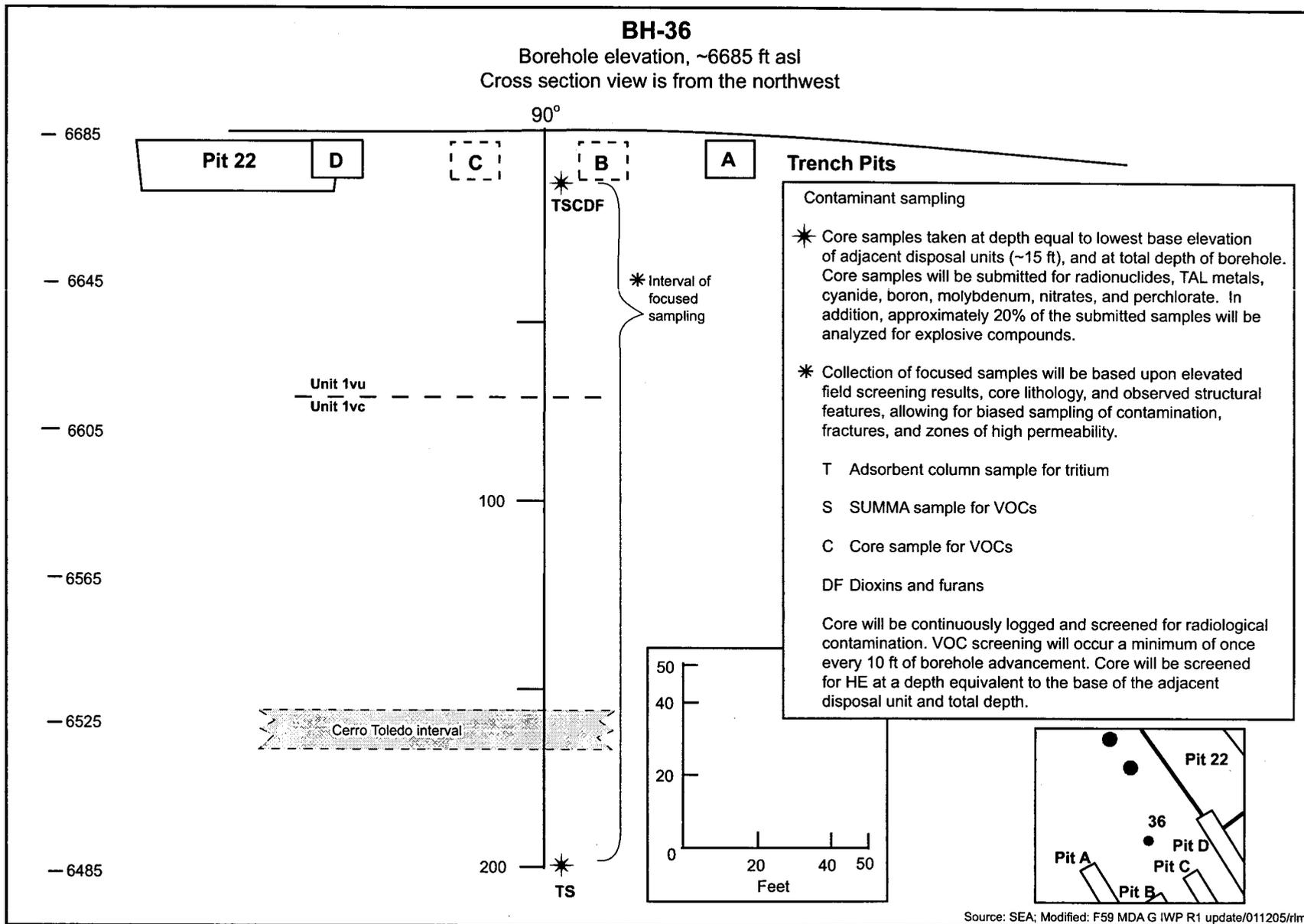
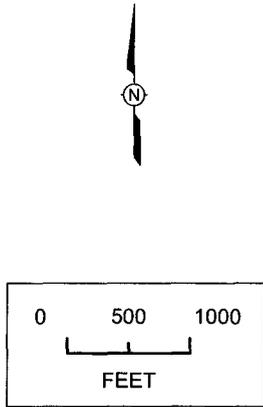
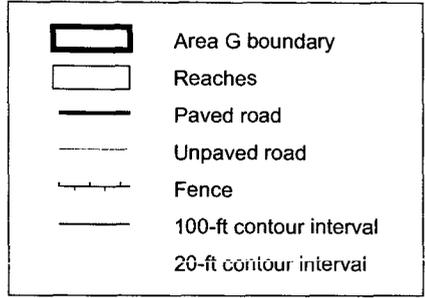
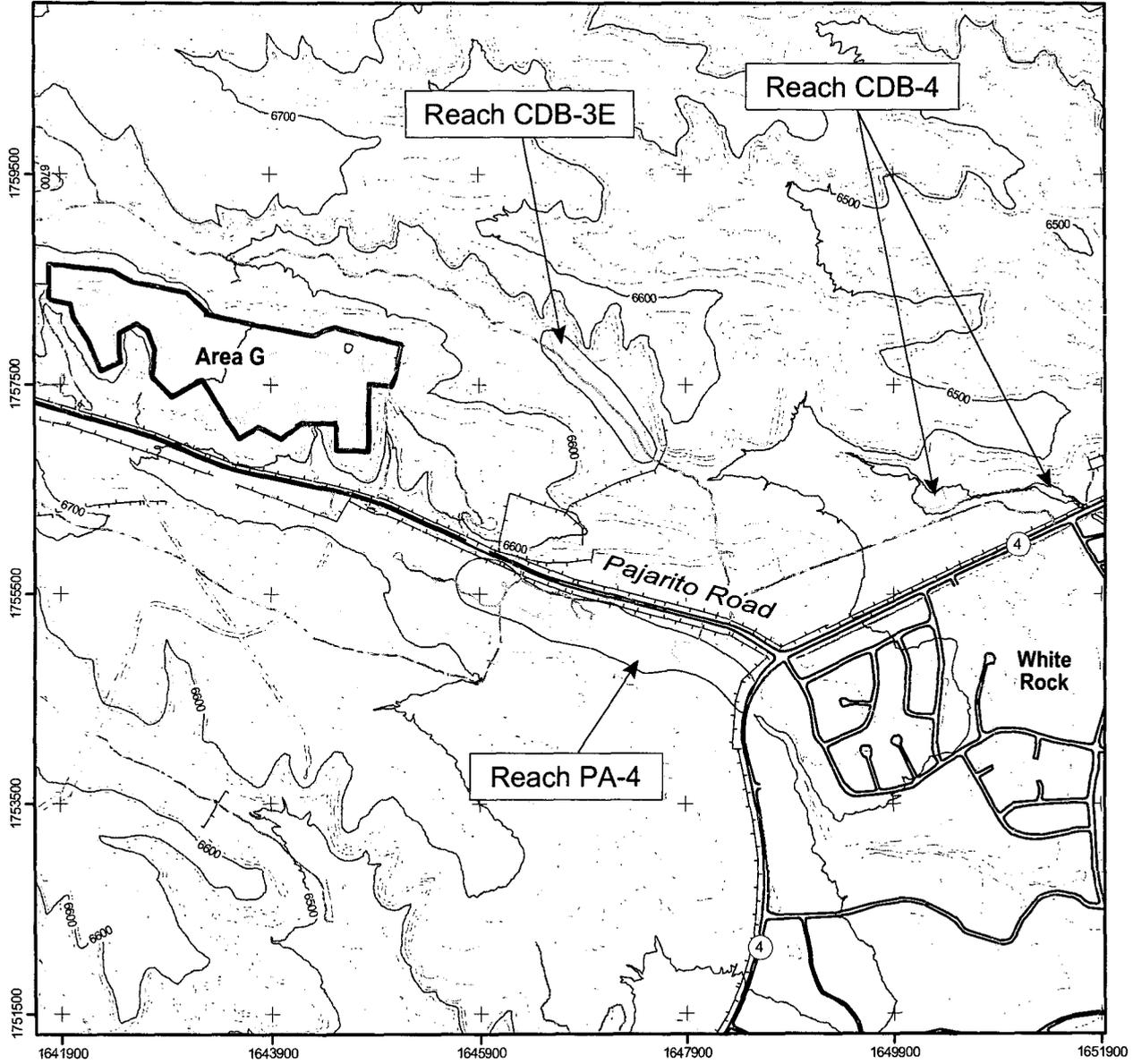


Figure 59. Profile of MDA G proposed borehole 36 with planned sample locations



Coordinates are NMSP NAD 83

Source: SEA map 4531.021(12) Rev. 1, 090801, MW-H
Rev. for F44, MDA G IWP, Rev. 1, 061404, cf
MDA G IWP Update, 121604, rlm

Figure 61. Locations of reaches downgradient of Area G

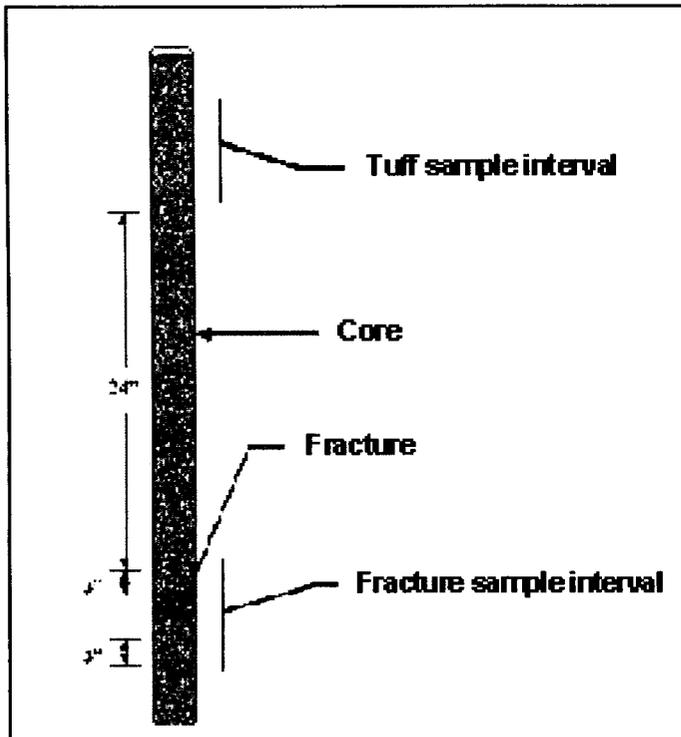
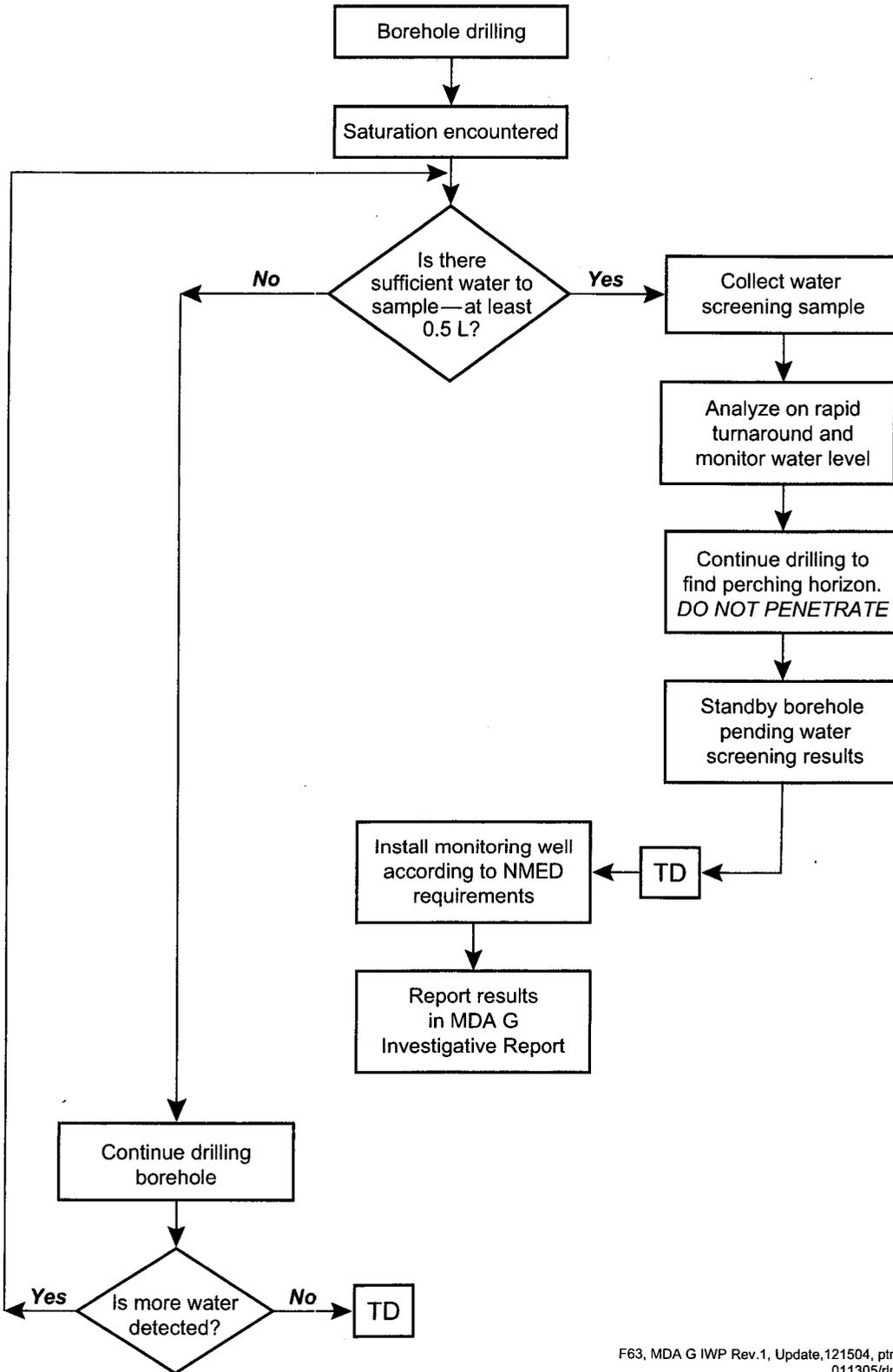
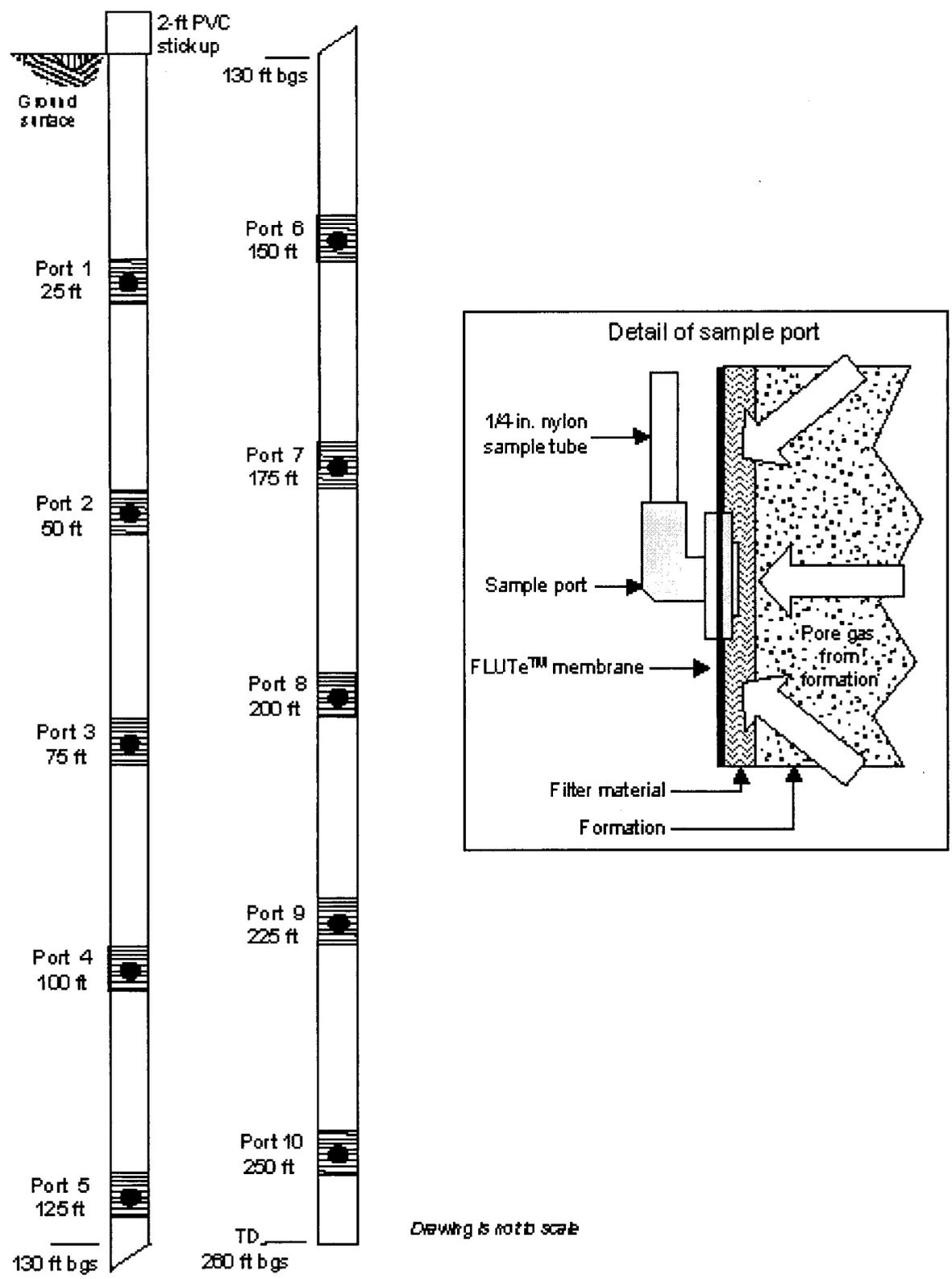


Figure 62. Paired fracture sampling diagram



F63, MDA G IWP Rev.1, Update, 121504, ptm
011305/rjm

Figure 63. MDA G perched groundwater flow chart



F30, MDA L MWP Rev. 1, 121503, PTM, 121503, CI
 Rev. for F46, MDA G MWP, Rev. 1, 051704, c7F6+, Rev. 1 Update, 121704, rim

Figure 64. General diagram for construction of a vapor-monitoring borehole

**Table 1
SWMUs at Area G**

Inactive Subsurface Units	SWMU Designation	Description
Pit 9	54-014(b)	Pit with retrievably placed TRU
19 pits	54-017	Pits 1–8, 10, 12, 13, 16–22, 24
12 pits	54-018	Pits 25–33, 35–37
Above Pit 19	54-013(b)	Truck decontamination operations that occurred on surface of Pit 19
4 trenches	54-014(d)	Trenches A, B, C, D with retrievably placed TRU
68 shafts	54-020	Shafts C1–C10, C12, C13, 22, 35–37, 93–95, 99–108, 114, 115, 118–136, 138–140, 151–160, 189–192, 196
92 shafts	54-019	Shafts 1–20, 24–34, 38-92, 96, 109–112, 150
34 shafts	54-014(c)	Shafts 200–233 with retrievably placed TRU
Above Pit 29	54-015(k)	TRU waste mound

Note: There are additional pits and shafts located at Area G that are not part of SWMU 54-013(b)-99.

Table 2
Summary of Proposed Borehole Drilling and Sampling at Area G

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
1 (between Pits 1 and 3)	Vertical	200	Vertical extent of contamination associated with Pits 1 and 3	One sample collected at the base of Pit 1. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
2 (north of Pit 6)	Vertical	200	Vertical extent of contamination associated with Pit 6	One sample collected at the base of Pit 6. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
3 (between Pits 7 and 24)	Vertical	200	Vertical extent of contamination associated with Pits 7 and 24	One sample collected at the base of Pit 24. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
4 (east of Pits 8, 9, and 10)	Angle 45°	177	Vertical extent of contamination associated with Pits 8, 9, and 10	One sample collected at the base of Pit 8. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
5 (south of Shaft C12)	Vertical	200	Vertical extent of contamination associated with Pits 13, 21, 22, Shafts C1-C10, and C12	One sample collected at the base of Shaft C12. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
6 (southwest corner of Pit 20)	Angle 45°	212	Vertical extent of contamination associated with Pits 18, 20, 21, and 22	One sample collected at the base of Pit 20. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
7 (between Pits 21 and 22)	Vertical	200	Vertical extent of contamination associated with Pits 21 and 22	One sample collected at the base of Pit 22. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
8 (northwest of Pit 26)	Angle 45°	212	Vertical extent of contamination associated with Pits 25 and 26	One sample collected at the base of Pit 26. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
9 (between Pits 27 and 28)	Vertical	250	Vertical extent of contamination associated with Pits 27 and 28	One sample collected at the base of Pit 28. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
10 (between Pits 29 and 30)	Vertical	225	Vertical extent of contamination associated with Pits 29 and 30	One sample collected at the base of Pit 30. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
11 (between Pits 32 and 33)	Vertical	200	Vertical extent of contamination associated with Pits 32 and 33	One sample collected at the base of Pit 32. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
12 (between Pits 35 and 36)	Vertical	250	Vertical extent of contamination associated with Pits 35 and 36	One sample collected at the base of Pit 36. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
13 (between Pits 36 and 37)	Vertical	250	Vertical extent of contamination associated with Pits 36 and 37	One sample collected at the base of Pit 37. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
14 (between Trenches B and C)	Vertical	200	Vertical extent of contamination associated with Trenches B and C	One sample collected at the base of Trench B. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
15 (between Pits 12 and 13)	Vertical	700	Vertical extent of contamination associated with Pits 12 and 13 The borehole will be extended to 700 ft bgs to confirm presence or absence of perched groundwater	One sample collected at the base of Pit 12. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at ~200 ft.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and ~200 ft

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
16 (west of Pit 22)	Vertical	200	Vertical extent of contamination associated with Shafts 157–160, 189–192, and 196, and Pit 22	One sample collected at the base of Pit 22. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
17 (west of Trench A)	Vertical	200	Vertical extent of contamination associated with Shafts 150, 151, 152–160, and Trench A	One sample collected at the base of Shaft 157. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
18 (west of Pit 4)	Vertical	200	Vertical extent of contamination associated with Shafts 1–112 and Pit 4	One sample collected at the base of Pit 4. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
19 (west of Shafts 200–233)	Vertical	200	Vertical extent of contamination associated with Shafts 200–233	One sample collected at the base of Shafts 200–233. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
20 (east of Pit 19)	Vertical	200	Vertical extent of contamination associated with Pit 19	One sample collected at the base of Pit 19. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
21 (south of Pits 1 and 3)	Vertical	200	Vertical extent of contamination associated with Pits 1 and 3	One sample collected at the base of Pit 1. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
22 (north of Pit 2, outside fence)	Vertical	200	Vertical extent of contamination associated with Pit 2	One sample collected at the base of Pit 2. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
23 (northeast of Pit 2, outside fence)	Vertical	200	Vertical extent of contamination associated with Pit 2	One sample collected at the base of Pit 2. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
24 (northwest of Pit 2, outside fence)	Vertical	200	Vertical extent of contamination associated with Pit 2, Shafts 1-112, 114, 115, and 118-135	One sample collected at the base of Pit 2. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
25 (between Pits 2 and 4)	Vertical	200	Vertical extent of contamination associated with Pits 2 and 4	One sample collected at the base of Pit 2. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
26 (between Pits 4 and 5)	Vertical	200	Vertical extent of contamination associated with Pits 4 and 5	One sample collected at the base of Pit 5. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
27 (north of Pit 6, outside fence)	Vertical	200	Vertical extent of contamination associated with Pit 6	One sample collected at the base of Pit 6. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
28 (northeast of Pit 6)	Vertical	200	Vertical extent of contamination associated with Pit 6	One sample collected at the base of Pit 6. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
29 (between Pits 8 and 9)	Vertical	200	Vertical extent of contamination associated with Pits 8, 9, 20, 21, and Shafts C1-C10, C12, and C13	One sample collected at the base of Pit 9. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
30 (between Pits 10 and 12)	Vertical	200	Vertical extent of contamination associated with Pits 10 and 12	One sample collected at the base of Pit 12. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
31 (south end of Pit 16)	Vertical	200	Vertical extent of contamination associated with Pit 16, 25, and 26	One sample collected at the base of Pit 16. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
32 (south end of Pit 17)	Vertical	200	Vertical extent of contamination associated with Pit 17	One sample collected at the base of Pit 17. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
33 (between Pits 29 and 30)	Vertical	225	Vertical extent of contamination associated with Pits 29 and 30	One sample collected at the base of Pit 30. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
34 (south end of Pit 33)	Vertical	200	Vertical extent of contamination associated with Pit 33	One sample collected at the base of Pit 33. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
35 (between Pits 29 and 35)	Vertical	200	Vertical extent of contamination associated with Pits 29, 35, and 36	One sample collected at the base of Pit 35. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD
36 (north end of Trenches A-D)	Vertical	200	Vertical extent of contamination associated with Trenches A-D	One sample collected at the base of Trench B. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

Table 2 (continued)

Borehole ID ^{a,b,c}	Borehole Type	Approximate Depth (ft bgs)	Rationale ^d	Core Sampling	Core Sample Analytical Suite ^{e,f,g}	Pore-Gas Sampling
37 (south end of Trenches A-D)	Vertical	200	Vertical extent of contamination associated with Trenches A-D	One sample collected at the base of Trench C. Additional samples may be collected between this depth and TD based on field indicators. One sample collected at TD.	Boron, cyanide, dioxins/furans, molybdenum, nitrates, perchlorate, TAL metals, VOCs, and radionuclides Boron, cyanide, molybdenum, nitrates, perchlorate, TAL metals, and radionuclides	VOC and tritium sample at depth nearest adjacent disposal unit and at TD

^a Proposed borehole IDs correlate with numbered boreholes on maps.

^b Disposal unit dimensions have been determined by reviewing historical documents, and Area G GIS data.

^c Proposed boreholes are located so that they will pass no closer than 15 ft to any disposal unit.

^d Any disposal unit that a borehole will pass beneath, or may capture data relating to, is included as an associated disposal unit.

^e All boreholes will be screened for organic vapors and radionuclides at 10-ft intervals.

^f Additional samples for fixed laboratory analysis may be collected based on screening, lithology, fractures, and staining.

^g Twenty percent of HE screening samples will be analyzed for explosive compounds.

Table 3
Summary of Approved Alternatives to NMED Order Specifications and Justification for Alternative

Item	NMED Order Specification	LANL Alternative and Differences from Order	Justification for LANL Alternative
1	<p>One boring, or the number defined in the Department-approved MDA G work plan, shall be advanced directly adjacent to the down-slope end of each disposal pit, one boring at the down-slope end of each row of disposal shafts, and one boring at the low elevation point of each pit.</p> <p>One boring per every 3,600 square ft, or as defined in the Department-approved MDA G work plan, shall be advanced in a shaft field and one boring per every 60 ft shall be advanced in a shaft row. (Order Section IV.C.1.c.iii, Paragraphs 1 and 2)</p>	<p>Three angled and 34 vertical boreholes at locations shown in Figure 23 to augment 9 angled and 10 vertical boreholes installed during Phase I RFI. Where possible, proposed boreholes have been planned to pass as close as possible to the deepest portions of adjacent disposal units identified from as-built drawings.</p>	<p>Proposed and Phase I boreholes are sufficient to meet objectives of investigation. Section 4.2.1 presents a detailed discussion of the proposed boreholes. See also Table 4 below.</p>
2	<p>Three TA-54-specific wells, or the number defined in the Department-approved MDA G work plan, shall be advanced that intersect the regional aquifer at locations approved by the Department. Two wells shall be located in Cañada del Buey, upgradient of MDA G and MDA L and between MDA G and MDA L, respectively. One well shall be located in Pajarito Canyon downgradient of MDA L. The Respondents shall include information on regional wells associated with TA-54 that have already been installed in the work plan to be submitted to the Department. The Department will determine whether these wells are adequate to characterize the extent of groundwater contamination associated with TA-54. (Order Section IV.C.1.c.iii, Paragraph 9)</p>	<p>No characterization wells will be installed as part of the MDA G investigation. Existing characterization wells R-20, R-21, R-22, and R-32 will be used for groundwater monitoring. Locations of these boreholes differ from those specified in the Order. Wells R-21 and R-32 were installed downgradient of Area L (Figure 5), well R-20 upgradient of Area L, and well R-22 downgradient of Area G.</p>	<p>These wells were installed as part of the NMED-approved hydrogeologic work plan for the Laboratory to characterize regional groundwater in the vicinity of TA-54. No additional wells are needed to evaluate potential impacts to the regional aquifer from MDA G. Well completion reports for R-20, R-21, and R-32 were submitted to NMED by LANL and DOE in May and June 2003.</p>
3	<p>Soil and rock samples shall be obtained from each boring at ten-ft intervals and from the bedrock directly below the base elevation of each pit or shaft. A sample shall also be obtained at the maximum depth of each boring. (Order Section IV.C.1.c.iv, Paragraph 1)</p>	<p>Continuous core samples will be collected from each borehole.</p>	<p>Collection of continuous core provides better stratigraphic data than samples collected at discrete intervals.</p>
4	<p>A minimum of six cores shall be obtained from selected borings, at depths approved by the department, for permeability testing in accordance with Section IX.B of this Order. (Order Section IV.C.1.c.iv, Paragraph 4)</p>	<p>No core samples will be taken for permeability measurements of the tuff beneath MDA G disposal units.</p>	<p>Both field and laboratory permeability measurements have been taken previously at Area G and reported to the NMED by the Laboratory and DOE (LANL 1987, 76068).</p>

Table 3 (continued)

Item	NMED Order Specification	LANL Approved Alternative and Differences from Order	Justification for Alternative
5	A minimum of two samples from each boring shall be selected for submittal for laboratory analysis. The samples submitted for laboratory analyses shall be analyzed for VOCs, SVOCs, pH, explosive compounds, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, and cyanide. (Order Section IV.C.1.c.iv, Paragraph 5)	A minimum of two samples will be collected from each borehole, as specified in the Order (Table 2). Core samples will not be analyzed for SVOCs, pH, and PCBs; and limited samples will be analyzed for VOCs, explosive compounds, dioxins, and furans.	The Laboratory's justification for analytical suites is presented in section 4.2.4. Based on the Phase I RFI data, the nature and extent of subsurface SVOC and PCB contamination have been established (section 2). Pore-gas monitoring will be the primary method used to determine the nature and extent of subsurface VOC contamination, with limited VOC analysis of core samples, because the results are more representative (section 2).
6	An investigation vapor monitoring and sampling work plan shall be submitted to the Department for approval as part of the MDA G investigation work plan. (Order Section IV.C.1.c.vi, Paragraph 2)	A separate vapor-monitoring and sampling plan is not included as part of the work plan. Subsurface vapor samples will be collected from each borehole immediately after drilling activities are completed. Boreholes advanced using air-rotary drilling will be resampled approximately one month later. Based on analysis of these results, specific boreholes will be identified for completion as vapor-monitoring boreholes.	Design of a vapor-monitoring program should be based on evaluation of subsurface vapor data. Completion of all boreholes as vapor-monitoring wells is not necessary to implement an effective monitoring program. See section 4.2.2 for additional details.
7	Vapor sampling shall be conducted at MDA G in each existing and newly constructed vapor well and boring specified in the approved work plan. (Order Section IV.C.1.c.vi, Paragraph 3)	Vapor sampling will not be conducted in each existing borehole. Vapor sampling will be conducted at each newly constructed boring. Existing pore-gas monitoring boreholes will be sampled per the existing permit requirements.	A sampling schedule for existing boreholes has been established as part of the Hazardous Waste Facility Permit. Sampling of the existing boreholes will continue until the permit is modified.

Table 4
Comparison of Borehole Locations Specified in September 1, 2004, NMED Proposed Consent Order
and Existing and Proposed Boreholes

Pit/Trench/ Shaft Field	Borehole Locations Specified in Order	Phase I RFI and Proposed WP Boreholes to Meet Order Specifications	Deviations from Order
Pit 1	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01121, 54-01128, and proposed boreholes 1 and 21	None
Pit 2	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01120 and 54-01123, and proposed boreholes 22, 23, 24, and 25	None
Pit 3	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01125, 54-01126, and proposed boreholes 1 and 21	None
Pit 4	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01124, and proposed boreholes 18, 25, and 26	None
Pit 5	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01125 and proposed borehole 26	Two boreholes adjacent to the lowest point. Pit surface level and slope indeterminable; therefore no borehole at downslope end.
Pit 6	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01112 and 54-01113, and proposed boreholes 2, 27, and 28	Two vertical and two angled boreholes adjacent to pit. Pit surface level and slope indeterminable; therefore no borehole at downslope end.
Pit 7	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 3 and 20	None
Pit 8	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 4 and 29	None
Pit 9	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01108 and proposed boreholes 4 and 29	None
Pit 10	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01108 and proposed boreholes 4, 5, and 30	None
Pit 12	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 15 and 30	None
Pit 13	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed borehole 15	One vertical borehole adjacent to lowest point in pit. Pit surface is level, slope indeterminable, and access is restricted at ends; therefore no borehole at downslope end.

Table 4 (continued)

Pit/Trench/ Shaft Field	Borehole Locations Specified in Order	Phase I RFI and Proposed WP Boreholes to Meet Order Specifications	Deviations from Order
Pit 16	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01107 and proposed borehole 31	None
Pit 17	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01114 and proposed borehole 32	One borehole angled beneath lowest point in pit.
Pit 18	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01115 and proposed borehole 6	One borehole angled beneath lowest point in pit, and one borehole angled beneath downslope end of pit.
Pit 19	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed borehole 20	One vertical borehole adjacent to lowest point in pit. Pit surface level, slope indeterminable, and access is restricted at ends; therefore no borehole at downslope end.
Pit 20	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01115 and proposed boreholes 6 and 29	None
Pit 21	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 5, 6, 7, and 29	None
Pit 22	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 5 and 7	None
Pit 24	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed borehole 3	One borehole adjacent to lowest point in pit. Pit surface level, slope indeterminable, and access is restricted at ends; therefore no borehole at downslope end.
Pit 25	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01106 and proposed boreholes 8 and 31	None
Pit 26	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 8 and 31	None
Pit 27	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01105 and proposed borehole 9	None
Pit 28	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed borehole 9	One vertical borehole adjacent to the lowest point in pit. Pit surface level, slope indeterminable, and access is restricted at ends; therefore no borehole at downslope end.
Pit 29	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 10, 33, and 35	None
Pit 30	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 10 and 33	None

Table 4 (continued)

Pit/Trench/ Shaft Field	Borehole Locations Specified in Order	Phase I RFI and Proposed WP Boreholes to Meet Order Specifications	Deviations from Order
Pit 32	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01102 and proposed borehole 11	None.
Pit 33	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 11 and 34	None
Pit 35	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 12 and 35	None
Pit 36	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 12, 13, and 35	None
Pit 37	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed borehole 13	One vertical borehole adjacent to lowest point in pit. Pit surface level, slope indeterminable, and access is restricted at ends; therefore no borehole at downslope end
Trench A	Downslope end and low elevation point, 20 ft below the lowest base elevation	54-01111 and proposed borehole 17	None
Trench B	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 14, 36, and 37	None
Trench C	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 14, 36, and 37	None
Trench D	Downslope end and low elevation point, 20 ft below the lowest base elevation	Proposed boreholes 14, 36, and 37	None
Shafts 1-112, 114, 115, 118-135	One borehole per every 3,600 ft ² in a shaft field, and one borehole per 60 ft in a shaft row	54-01116, 54-01117, and proposed boreholes 18 and 24	Four vertical boreholes on perimeter of shaft field.
Shafts 136, 138-140,	One borehole per every 3,600 ft ² in a shaft field, and one borehole per 60 ft in a shaft row	54-01107	One vertical borehole located in center of shaft row.
Shafts 150, 151	One borehole per every 3,600 ft ² in a shaft field, and one borehole per 60 ft in a shaft row	54-01111 and proposed borehole 17	None

Table 4 (continued)

Pit/Trench/ Shaft Field	Borehole Locations Specified in Order	Phase I RFI and Proposed WP Boreholes to Meet Order Specifications	Deviations from Order
Shafts 152-160	One borehole per every 3,600 ft ² in a shaft field, and one borehole per 60 ft in a shaft row	54-01110 and proposed borehole 17	None
Shafts 189-192, 196	One borehole per every 3,600 ft ² in a shaft field, and one borehole per 60 ft in a shaft row	Proposed borehole 16	One vertical borehole adjacent to shaft row.
Shafts 200-233	One borehole per every 3,600 ft ² in a shaft field, and one borehole per 60 ft in a shaft row	54-01121 and proposed borehole 19	Two vertical boreholes adjacent to the shaft field.
Shafts C1-C10, C12, C13	One borehole per every 3,600 ft ² in a shaft field, and one borehole per 60 ft in a shaft row	Proposed boreholes 5 and 29	None

Table 5
Summary of Applicable Standard Operating Procedures

Procedure	Title	Summary
SOP 1.01	General Instructions for Field Investigations	This standard operating procedure (SOP) provides an overview of instructions regarding activities to be performed before, during, and after field investigations completed by the Los Alamos National Laboratory Environmental Stewardship–Remediation Services (ENV-RS) project. It is assumed that field investigations involve standard sampling equipment, personal protective equipment, waste-management, and site-control equipment/materials. Procedure covers: pre-mobilization activities, mobilization to the site, documentation and sample collection activities, sample media evaluation, surveying, and completing lessons learned.
SOP 1.02	Sample Containers and Preservation	This SOP describes the specific requirements/process for sample containers, preservation techniques, and holding times as specified by field regulations and guidance documents. The use of specific types of sample container, and preservation techniques is mandatory for hazardous site investigations because the integrity of any sample is diminished over time. Physical factors (light, pressure, temperature, etc.), chemical factors (changes in pH, volatilization, etc.), and biological factors may alter the original quality of the sample. Because the various target parameters are uniquely altered at varying rates, distinct sample containers, preservation techniques, and holding times have been established to maintain sample integrity for a reasonable and acceptable period of time. Procedure covers: documenting SOP deviations, using proper sample containers and preservatives, performing data entry, implementing containment procedures, preserving samples, implementing holding times, completing documentation, implementing post-operation activities, and performing lessons learned.
SOP 1.03	Handling, Packaging and Transporting Field Samples	This SOP directs field team members in the preparation of environmental and waste characterization samples for transportation to the Sample Management Office (SMO) or an approved radiation screening laboratory. In general, samples taken for the Remediation Services Project are expected to have a low concentration of potential contaminants, although higher concentrations will be present in some cases. These low-concentration samples that do not satisfy the Department of Transportation (DOT) hazard-class definitions are classified as environmental samples and are not subject to DOT regulations. Historical data, knowledge of processes, and field screening results will assist the team members in making decisions as to whether a sample can be designated as "environmental" or needs to be treated as a DOT-regulated material. Procedure covers: transportation of environmental and DOT-regulated samples.
SOP 1.04	Sample Control and Field Documentation	This SOP describes the process for documenting samples collected for the ENV-RS project using sample control and field documentation, specifically, container labels, sample collection logs, chain of custody (COC)/request for analysis forms, and daily activity log forms or field notebooks. Procedure covers: performing request notification, generating sample control and field documentation, completing sample collection logs, using field chain of custody forms, delivering samples to the sample management office, delivering samples to another analytical laboratory, using custody seals, collecting the samples, completing sample control and field documentation, completing field investigation summaries, and performing field closeouts.

Table 5 (continued)

Procedure	Title	Summary
SOP 1.05	Field Quality Control Samples	This SOP describes the requirements for the collection of field quality control (QC) samples to ensure the reliability and validity of field and laboratory data. Field QC samples shall be collected as described in this procedure and taken to the Los Alamos National Laboratory SMO with the regular field samples for subsequent chemical and physical testing. Procedure covers: pre-operation activities, collecting and preparing each type of QC sample including equipment rinsate blank, field duplicate, and trip blank.
SOP 1.06	Management of Environmental Restoration Project Wastes	This SOP describes the process for managing waste generated during corrective action activities. This procedure outlines the preparation, approval, and retention of all required documents associated with waste generation. Procedure covers: waste identification and characterization, waste minimization/recycling, waste generation/storage, segregation, waste treatment, authorized release limits, packaging/transportation, disposal options, and specific ENV-RS project policies including area of contamination policy, environmental media, and contained in policy.
SOP 1.08	Field Decontamination of Drilling and Sampling Equipment	This SOP describes the process for the general field decontamination of drilling and sampling equipment. It is intended to help ensure the integrity of soil, sediment, rock, water, and other samples collected from potentially contaminated sites and to minimize the potential for cross contamination between sampling locations. Implementation of this procedure will help protect site and community personnel, requiring that equipment not be removed from a controlled area without proper decontamination. Procedure covers: set up of dry and wet decontamination areas, drilling/excavation equipment decontamination, and sampling equipment decontamination.
SOP 3.11	Coordinating and Evaluating Geodetic Surveys	This SOP describes the methodology for coordinating and evaluating geodetic surveys and establishing quality assurance (QA) and control for geodetic survey data. 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.
SOP 4.01	Drilling Methods and Drill Site Management	This SOP describes the drilling methods and drilling-package implementation to meet subsurface sampling requirements. Various drilling methods have been developed to achieve successful subsurface contact for retrieving suitable formation, gas, and water samples. These include, but are not limited to, solid-stem augering, hollow-stem augering, direct rotary drilling, reverse rotary drilling, cable-tool drilling, and hand augering.
SOP 4.04	Contract Geophysical Logging	This SOP states the responsibilities and describes the general process for obtaining borehole logging data of acceptable quality regardless of logging system or logging contractor, to meet site-characterization and/or subsurface-sampling requirements of the investigation. Borehole-logging techniques are used in situ to determine physical, chemical, geological, and hydrological conditions in an open borehole. Procedure covers: pre-contract considerations, pre-operation activities, borehole geophysical logging activities, and post-operation activities. Main concerns during logging activities are: monitoring the logging equipment as it emerges from the borehole or before it leaves the work site for contamination, verifying field calibration both immediately before and immediately after a logging run or runs with a given logging tool, and ensuring that the logging equipment is decontaminated between sampling events.

Table 5 (continued)

Procedure	Title	Summary
SOP 5.03	Monitoring Well and RFI Borehole Abandonment	This SOP describes the process for monitoring well and RFI borehole abandonment. Procedures described in this SOP are consistent with acceptable practice for monitoring well and borehole abandonment under RCRA (Resource Conservation and Recovery Act) facility investigation (RFI) guidance. Procedure covers: monitoring well and RFI borehole abandonment, placement of the appropriate sealing and fill material, options for destroying monitoring wells and RFI boreholes in urban areas and near active technical areas, and reporting requirements.
SOP 5.07	Operation of LANL Owned Borehole Logging Trailer	This SOP describes the process for operation and maintenance of the borehole video/geophysics logging trailer. Procedure covers: running the borehole video camera system, running the borehole caliper tool, running the borehole conductivity/resistivity (induction) tool, running the gamma tool, and running the borehole spontaneous potential/single point resistance tool.
SOP 6.01	Purging and Sampling Methods for Single Completion Wells	This SOP describes methods used for evacuating stagnant water from a well bore in sufficient quantities so that the water samples that are collected afterwards are representative of the formation interval open to the well bore. Groundwater that is stagnant in the well bore is subject to chemical reactions that may significantly alter the composition of the formation water. Prior to collecting a representative ground water sample for laboratory analysis, ground water must be purged. Procedure covers: preliminary activities, pre-operation field activities, well purging operations, water sampling operations, and post-operation activities.
SOP 6.03	Sampling for Volatile Organic Compounds in Groundwater	This SOP states the responsibilities and describes the process for sampling for volatile organic compounds (VOCs) in groundwater. This SOP also describes the selection of equipment and materials used in the sampling process. The objectives are to collect valid samples for volatile organic analysis (VOA) and to subject samples to the least amount of turbulence and subsequent possible aeration. Procedure covers: conducting pre-operation activities, sampling, preparing documentation, and conducting post-operation activities.
SOP 6.09	Spade and Scoop Method for the Collection of Soil Samples	This SOP describes the process for spade-and-scoop collection of shallow (i.e., typically 0 to 12 in.) soil 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 or portion of a composite sample. Procedure covers: pre-sampling activities, sampling activities, and post sampling activities.
SOP 6.10	Hand Auger and Thin-Wall Tube Sampler	This SOP states the responsibilities and describes the process for collecting surface and subsurface (up to about 15 ft) soil samples with a hand auger and thin-wall tube sampler. This procedure describes the selection and use of sampling methods and equipment at sites that may include contamination with hazardous or radioactive materials. Procedure covers: pre-sampling activities, sampling activities, collecting field duplicates, and post sampling activities.
SOP 6.24	Sample Collection from Split-Spoon Samplers and Shelby-Tube Samplers	This SOP states the responsibilities and describes the process for collecting soil and sediment samples using either split-spoon samplers or Shelby-tube samplers. A split-spoon sampler is used to take subsurface soil or sediment samples by forcefully driving the sampler into the soil or sediment at the bottom of a borehole. The Shelby tube is a similar type of sampling apparatus. The split spoon is a multi-piece sampler; the Shelby tube is a single-piece metal tube of thinner gauge. Procedure covers: pre-sampling activities, sampling activities, and post sampling activities.

Table 5 (continued)

Procedure	Title	Summary
SOP 6.26	Core-Barrel Sampling for Subsurface Earth Materials	This SOP describes the process for collecting core-barrel samples of subsurface earth materials. This procedure is limited to sampling of subsurface sediments for radionuclides (including tritium), metals, polychlorinated biphenyls, total petroleum hydrocarbons, and volatile and semivolatile organic compounds. The field team may sample for other constituents under this SOP (or modifications thereof) at the discretion of the field team leader and project leader. Procedure covers: pre-sampling activities, sampling activities, and post sampling activities.
SOP 6.31	Sampling of Subatmospheric Air	This SOP describes the process of sampling subatmospheric air from vapor ports in monitoring wells and boreholes. Procedure covers: pre-sampling activities, B&K sampling to detect and quantify gaseous organic concentration in air, SUMMA sampling (a passive collection and containment system of laboratory-quality air samples), adsorbent column sampling, sampling through the packer system (a sampling system that uses inflatable bladders to seal off a desired interval in an open borehole, or at the end of drill casing, in order to obtain a sample from a discrete section), and post sampling activities.
SOP 6.33	Headspace Vapor Screening with a Photoionization Detector	This SOP describes the process for screening headspace vapor for volatile organic compounds (VOC) in soil samples with a photoionization detector (PID). The PID is a portable, nonspecific, vapor/gas detector employing the principle of photoionization to detect and measure real-time concentrations of a variety of chemical compounds, both organic and inorganic, in air. Procedure covers: performing field calibration, operating, and post operating activities.
SOP 7.05	Subsurface Moisture Measurements Using a Neutron Probe	This SOP describes the process of collecting subsurface moisture measurements using a neutron probe for the Los Alamos National Laboratory ENV-RS project. A neutron probe is used to measure the subsurface moisture, utilizing a probe containing a source of high-energy neutrons and a slow neutron detector. Procedure covers: performing a daily field standard count, preparing instrument for field measurements, taking a field measurement, and documenting the results of the field measurement.
SOP 10.08	Operation of the Spectrace 9000 Field-Portable X-Ray Fluorescence Instrument	This SOP describes the process for operating and using the Spectrace 9000 field-portable x-ray fluorescence (XRF) analyzer to screen for hazardous, or potentially hazardous, inorganic materials. The data that are generated allow for rapid evaluation of the extent of contamination. Samples are analyzed for elements of atomic number 13 (aluminum) through 92 (uranium), with proper x-ray source selection and instrument calibration. Environmental applications include measuring elemental metals in soils and on filters and measuring lead in paint. XRF spectroscopy is a nondestructive qualitative and quantitative analytical technique used to determine the elemental composition of solid, liquid, thin film, and powder samples. Procedure covers: performing initial setup, using probe, perform preoperational checks, handle and present samples, perform data quality assurance/quality control, and recording and documenting results.

Table 5 (continued)

Procedure	Title	Summary
SOP 12.01	Field Logging, Handling, and Documentation of Borehole Materials	<p>This SOP prescribes the specific borehole material management methods to be followed, and documentation to be prepared, during handling and field logging of selected borehole materials identified in the site guidance documents and waste characterization strategy form. This procedure is limited to the activities necessary to take custody of core and cuttings from drill rig personnel, conduct field screening, remove time sensitive analytical samples and subsamples for preliminary characterization, complete photo documentation when necessary, perform field structural and lithologic description, and mark, package, and temporarily store the borehole materials at a drill site borehole material storage trailer. This procedure describes the handling of the subset of borehole materials to be curated from the time they are withdrawn from the borehole to the time they are ready to be transported to the ENV-RS Field Support Facility (FSF) for curating and archiving. For the purposes of this SOP, borehole material may also refer to other solid materials, such as drive samples or augured materials. Procedure covers: borehole material staging, temporary packaging of time sensitive analytical samples, measurement and determination of material loss, marking core (depth notation and stripes), core photography, core logging, removal of analytical samples (core), and core box loading and storing.</p>

Appendix A

Acronyms, Glossary, and Metric Conversion Table

A-1.0 ACRONYMS

AIRNET	air monitoring network
AK	acceptable knowledge
AOC	area of concern
asl	above sea level
B&K	Brüel and Krajer
bgs	below ground surface
BV	background value
CMR	Chemistry and Metallurgy Research
CMS	corrective measures study
COC	chain of custody
COPC	chemical of potential concern
D&D	decontamination and decommissioning
DL	detection limit
DOE	Department of Energy
DOT	Department of Transportation
ENV-ECR	Environmental Stewardship–Environmental Characterization and Remediation
ENV-RS	Environmental Stewardship–Remediation Services
EP	extraction procedure
EPA	Environmental Protection Agency
ER	environmental restoration
ER	Environmental Restoration Project
EQL	estimated quantitation limit
eV	electron volt
FSF	Field Support Facility
FV	fallout value
FWO	Facility Waste Operations
FY	fiscal year
GCMS	gas chromatograph/mass spectrometer
GPS	global positioning system
HE	high explosive
HIR	historical investigation report
HSWA	Hazardous and Solid Waste Amendments of 1984
HWA	Hazardous Waste Act

IDW	investigation-derived waste
LANL	Los Alamos National Laboratory
LIR	Laboratory Implementation Requirement
LLW	low-level radioactive waste
MAP	mixed activation products
MDA	material disposal area
MFP	mixed fission products
MRAL	mobile radiological analysis laboratory
NIOSH-VOST	National Institute of Occupational Safety and Health-volatile organic sample train
NMED	New Mexico Environment Department
NMEID	New Mexico Environmental Improvement Department (Name of NMED before January 1, 1991)
NMHWAA	New Mexico Hazardous Waste Act
OU	operable unit
PAR	photoacoustic radiometry
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
PN	property number
ppb	parts per billion
ppbv	parts per billion by volume
PPE	personal protective equipment
ppm	parts per million
ppmv	parts per million by volume
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RDX	1,3,5-trinitro-1,3,5-triazacyclohexane
RFI	RCRA facility investigation
RPF	Records Processing Facility
RRES-MAQ	Risk Reduction and Environmental Stewardship–Meteorology and Air Quality
SDGCMS	solvent desorption gas chromatograph/mass spectrometer
SOP	standard operating procedure
SOW	statement of work

SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWO	Solid Waste Operations
TA	technical area
TAL	target analyte list (EPA)
TCA	1,1,1-trichloroethane
TCLP	toxicity characteristic leaching
TCE	trichloroethene
TD	total depth
TDGCMS	thermal desorption gas chromatograph/mass spectrometer
TNT	trinitrotoluene
TRU	transuranic
TWISP	Transuranic Waste Inspection and Storage Project
UC	University of California
UTL	upper tolerance limit
VOA	volatile organic analysis
VOC	volatile organic compound
WCSF	Waste Characterization Strategy Form
WFM	Waste Facility Management
WRS	Wilcoxon Rank Sum (test)
XRF	x-ray fluorescence

A-2.0 GLOSSARY

background value (BV)—The upper tolerance limits (UTLs) of background sample results, calculated as the upper 95% confidence limit for the 95th percentile. When a UTL cannot be calculated, either the detection limit or the maximum reported value is used as a BV; BVs are used as simple threshold numbers to identify potentially contaminated site sample results that are greater than background levels in that geological sample medium (or group of media). Most inorganic chemicals and radionuclides have BVs.

calibration—Process used to identify the relationship between the true (reference) analyte concentration or other variable and the response of a measurement instrument, chemical analysis method, or other measurement systems.

chemical of potential concern (COPC)—A chemical detected at a site that has the potential to adversely affect human *receptors* because of its concentration, distribution, and mechanism of toxicity. A COPC remains a concern until *exposure* pathways and receptors are evaluated in a site-specific human health risk assessment.

data validation—Systematic process that applies a defined set of performance-based criteria to a body of data and may result in 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 comprise a standardized data review (routine data validation) and/or a problem-specific data review (focused data validation).

detection limit (DL)—Minimum concentration that can be determined by a single measurement by an instrument; it implies a specified statistical confidence that the analytical concentration is greater than zero.

groundwater—Water in a subsurface saturated zone; water beneath the regional water table.

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

model—Mathematical approximation of a physical, biological, or social system.

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

quality assurance (QA)—All those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily in service.

quality control (QC)—(1) All those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements. QC is the process through which actual quality performance is measured and compared with standards. (2) All methods and procedures used to obtain accurate and reliable results from environmental sampling and analysis. Includes rules for when, where, and how samples are taken; sample storage, preservation and transport; and the use of blanks, duplicates, and split samples during the analysis.

radionuclide—Nuclide (species of atom) that exhibits radioactivity.

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

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

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 (including the abandonment or discarding of barrels, containers, and other closed receptacles that contain any hazardous wastes or hazardous constituents).

Resource Conservation and Recovery Act (RCRA)—The Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976. (40 CFR 270.2)

sample—Portion of a material (e.g., rock, soil, water, air), which, alone or in combination with other samples, is expected to be representative of the material or area from which it is taken. Samples are typically 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; or a mass that is accumulated by any other natural agent and that forms in layers on the earth's surface such as sand, gravel, silt, mud, fill, or loess. (2) A solid material that is not in solution and either is distributed through the liquid or has settled out of the liquid.

standard operating procedure (SOP)—Document that details the method for an operation, *analysis*, or action with thoroughly prescribed techniques and steps, and is officially approved as the method for performing certain routine or repetitive tasks.

stratigraphy — The science dealing with the succession, age, composition, and history of strata.

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

technical area (TA)—The Laboratory established technical areas as administrative units for all its operations.

topography—Physical configuration of the land surface in an area.

total propagated uncertainty (TPU)—The range of concentrations (expressed as plus or minus the measured concentration) that include the theoretical or true concentration of an analyte with a specific degree of confidence. Radiochemical results are required to be accompanied by sample-specific uncertainty bounds (TPU) that reflect the 67% confidence level (1-sigma TPU). The TPU includes not only the measurement or counting error but also the technique-specific error term that includes uncertainty values for each contributing measurement process and a sample-specific contribution reflecting specific chemical recoveries, detectors used, etc. All radiochemical result uncertainties incorporate terms for technique-related and sample-specific measurement errors.

tuff—compacted deposit of volcanic ash and dust that contains rock and mineral fragments accumulated during an eruption.

US Department of Energy (DOE)—Federal agency that sponsors energy research and regulates nuclear materials for weapons production.

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

vadose zone—The unsaturated zone. Portion of the subsurface above the water table in which pores are not fully saturated.

welded tuff—A volcanic deposit hardened by the action of heat, pressures from overlying material, and hot gases.

A-3.0 METRIC CONVERSION TABLE

Metric to US Customary Unit Conversions

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

Appendix H

Investigation-Derived Waste Management

This appendix to the work plan describes how waste generated during the investigation of Material Disposal Area (MDA) G at Los Alamos National Laboratory (LANL or the Laboratory) will be managed. Investigation-derived waste (IDW) is solid waste generated during field investigations and may include, but is not limited to, drill cuttings, contaminated personal protective equipment (PPE), sampling supplies and plastic, fluids from the decontamination of PPE and sampling equipment, and all other wastes that may potentially come in contact with contaminants.

Certain field investigation activities may also displace media indigenous to the environment. This includes groundwater, surface water, surface and subsurface soils, rocks, bedrock, and gravel. In most cases, environmental media is not subject to Resource Conservation and Recovery Act (RCRA) regulation because it does not meet the definition of solid waste; i.e., it is not discarded, abandoned, recycled, or inherently waste-like. The Laboratory does not expect any of the environmental media or IDW generated under this investigation to be characterized as hazardous waste. A best management practice established at the Laboratory, for displaced nonhazardous environmental media requires returning the environmental media to its point of origin (e.g., sample collection location or geologic horizon within a borehole) when doing so is determined to be fully protective of human health and the environment, compliant with regulatory requirements, and consistent with Laboratory waste minimization goals.

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

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

These SOPs may be found at the following URL: <http://erproject.lanl.gov/documents/procedures.html>.

The ENV-Remediation Services (ENV-RS) Waste Minimization Awareness Plan will be implemented during field investigations at MDA G in order to minimize waste generation. This plan is updated annually as a requirement of Module VIII of the Laboratory's Hazardous Waste Facility Permit.

The IDW waste streams associated with the investigation of MDA G are identified in Table H-1 and are briefly described below. Table H-1 also summarizes the waste types, estimated volumes, characterization methods, methods of on-site management, and expected disposition path for each of the following waste streams.

Drill cuttings. This waste stream will consist of cuttings from boreholes drilled and instrumented for vapor monitoring at MDA G. Drill cuttings will be collected and containerized at the point of generation (i.e., at the drill rig). The drill cutting waste stream will be characterized with analytical results from core samples augmented by direct sampling of the containerized waste, if needed. Contaminants of concern are expected to include inorganic metals, volatile organic compounds, and radionuclides. The maximum detected concentrations of radionuclides will be compared with background/fallout values. If maximum concentrations are above background/fallout values, the waste 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 limit. If concentrations are less than 20 times the limit, the waste cuttings will be designated nonhazardous by characteristic. If concentrations exceed 20 times the regulatory limit, the waste will be sampled and analyzed using the TCLP to determine if it is hazardous by characteristic. If listed waste constituents are detected in tuff samples, the

maximum concentrations will be compared to NMED soil screening levels (SSLs). If concentrations are less than SSLs, a "no longer contained in" determination will be requested from NMED. If concentrations exceed SSLs, the wastes will be designated as listed hazardous waste. Based on the results of previous investigations, the Laboratory expects these wastes to be designated as low-level radioactive waste (LLW) that will be disposed of at Technical Area (TA-) 54, Area G.

Drill cuttings from boreholes not instrumented for vapor monitoring may be returned to the boreholes in accordance with the Laboratory's best management practice for nonhazardous environmental media described above. These cuttings will be containerized and held in a staging area adjacent to the borehole, pending the decision to instrument or plug/abandon the borehole. If the decision is made to abandon the borehole then, based on the characterization results, these cuttings may be used as backfill following a last-out, first-in approach. Bentonite will be mixed with the cuttings so the hydraulic conductivity of the backfill material is less than that of the adjacent media, thus limiting the possibility of the boreholes acting as vertical conduits for water movement. Otherwise, the cuttings will be declared waste and managed as part of the drill cuttings waste stream.

Spent PPE. This waste stream will consist of PPE that has come in contact with contaminated environmental media (i.e., 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, and shoe covers. Spent PPE will be collected in containers at personnel decontamination stations. Characterization of this waste stream will be performed through acceptable knowledge of the waste materials, the methods of generation, and the levels of contamination observed in the environmental media. The Laboratory expects these wastes to be designated as LLW that will be disposed of at Area G of TA-54.

Disposable sampling supplies. This waste stream will consist of all equipment and materials necessary for collection of samples that come into direct contact with contaminated environmental media and that cannot be decontaminated. This waste stream also includes wastes associated with dry decontamination activities. This waste stream will consist primarily of paper and plastic items collected in bags at the sampling location and transferred to accumulation drums. Characterization of this waste stream will be performed through acceptable knowledge of the waste materials, the methods of generation, and the levels of contamination observed in the environmental media. The Laboratory expects these wastes to be designated as LLW that will be disposed of at Area G in TA-54.

Decontamination fluids. This waste stream will consist of liquid wastes from decontamination activities (i.e., decontamination solutions and rinse waters). Consistent with 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. If less than 6 gal. per day of decontamination fluids are generated and these are determined to be nonhazardous, they may be disposed of by discharge to the ground in accordance with an existing Notice of Intent for discharge to groundwater approved by the NMED Ground Water Quality Bureau. Otherwise, the decontamination fluids waste stream will be accumulated in drums and characterized with analytical results from direct sampling of the containerized waste. The Laboratory expects these wastes would be designated as nonhazardous liquid waste that would be sent to the radioactive liquid waste treatment facility at TA-50 for disposal.

Prior to the start of field investigation activities, a Waste Characterization Strategy Form (WCSF) will be prepared and approved per requirements of SOP 01.10. The WCSF will provide detailed information on IDW characterization, management, containerization, and possible volumes. IDW characterization will be completed through review of existing data and/or documentation, by direct sampling of the IDW, and/or by sampling the media being investigated (i.e., surface soil, subsurface soil, etc.). If sampling is necessary, it will be described in a sampling and analysis plan developed in conjunction with the WCSF.

The selection of waste containers will be based on appropriate Department of Transportation requirements, waste types, and estimated volumes of IDW to be generated. Immediately following containerization, each waste container will be individually labeled with a unique identification number and with information regarding waste classification, item(s), radioactivity (if applicable), and date generated. The wastes will be contained in clearly marked and appropriately constructed waste accumulation areas. Waste accumulation area postings, regulated storage duration, and inspection requirements will be based on the type of IDW and its classification. Container and storage requirements will be detailed in the WCSF and approved prior to waste being generated.

Table H-1
Summary of Estimated IDW Generation and Management

Waste Stream	Expected Waste Type	Estimated Volume	Characterization Method	On-Site Management	Expected Disposition
Drill cuttings ^a	LLW	140 yd ³	Analytical results from core and waste samples	55-gal. drums or covered roll-off containers	Disposal at TA-54, Area G and/or return to borehole
Spent PPE	LLW	40 yd ³	Acceptable knowledge (AK)	Accumulation in 55-gal. drums	Disposal at TA-54, Area G
Disposable sampling supplies	LLW	2 yd ³	AK	Accumulation in 55-gal. drums	Disposal at TA-54, Area G
Decontamination fluids (<6 gal. per day)	Non-hazardous	<6 gal./day ^b	AK	Discharge to ground	Discharge to ground
Decontamination fluids (>6 gal. per day)	Non-hazardous	<55 gal.	Analytical results from waste samples	Accumulation in 55-gal. drums	Treatment at TA-50 Radioactive Liquid Waste Treatment Facility

^a Estimated total volume of cuttings expected to be generated.

^b Dry decontamination methods will be used to the maximum extent possible, and only minimal amounts of decontamination fluids are expected to be generated.

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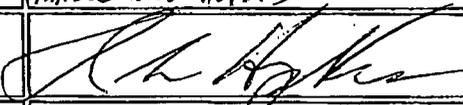
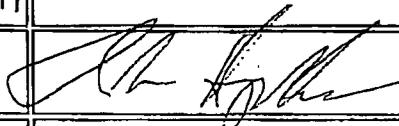
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