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Corrective Measures Evaluation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99, at Technical Area 54, Revision 2

Los Alamos
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EXECUTIVE SUMMARY

This report documents the corrective measures evaluation (CME) conducted for Material Disposal Area (MDA) G, Consolidated Unit 54-013(b)-99, located within Area G, at Los Alamos National Laboratory's Technical Area 54 (TA-54). MDA G comprises all subsurface pits, trenches and shafts located within the disposal units. The low-level waste disposal units are regulated by the U.S. Department of Energy (DOE).

Area G includes all Resource Conservation Recovery Act–permitted surface units and all other operational buildings or structures at TA-54. MDA G is located within the boundary of Area G.

This CME is part of a comprehensive, integrated approach to remediation and closure of all subsurface units at Area G.

The goal of the CME is to recommend a corrective measures alternative for closure of the Consolidated Unit 54-013(b)-99 Solid Waste Management Units (SWMUs) and to address releases from the SWMUs in accordance with the Compliance Order on Consent (the Consent Order). The performance assessment and composite analysis for Area G will establish the technical requirements for closure needed to meet the performance objectives for radiological protection of the public from radionuclides disposed of at the site. These technical requirements will be incorporated into the design of the final remedy during the corrective measures implementation phase of the project.

Retrievably stored transuranic (TRU) waste will be removed before the implementation of the preferred remedy. If DOE determines that removal of portions of the retrievable TRU waste is unsafe for workers or is cost prohibitive relative to risk reduction benefits, DOE may propose incorporating this waste into the corrective actions at MDA G through regulatory options available per DOE Order 435.1

The objectives of this CME are to (1) provide stakeholders and regulators with an evaluation of corrective measure alternatives expected to be protective of human health and the environment, (2) describe how alternatives will be monitored to ensure the effectiveness of the corrective measure implemented, and (3) identify the recommended corrective measure to the regulators.

A conceptual site model (CSM) was developed to evaluate primary and secondary release mechanisms from the source areas. Current and future exposure pathways were identified and technologies were evaluated to reduce potential exposure. The CSM identified two source areas: (1) pits and shafts and (2) the vadose zone. The remedial action objectives for these source areas are as follows:

- Prevent human health and ecological exposure through excavation, biointrusion, and erosion of the waste
- Prevent human health and ecological exposure through excavation and biointrusion of the contaminated surface soils and subsurface soils
- Prevent groundwater from being impacted above a regulatory standard from diffusion of volatile organic compounds through pore gas

Technologies were first screened for applicability to MDA G and then combined into corrective measure alternatives. Potential technologies were screened to eliminate any technology that (1) does not meet the threshold criteria defined in Section VII.D.4.a of the Consent Order, (2) is not feasible to implement, (3) is unlikely to perform satisfactorily or reliably, or (4) does not achieve the corrective action objectives within a reasonable time frame. The technology screening included a review of site data and the CSM to identify conditions that limit or promote the use of certain technologies; waste characteristics that limit the effectiveness or feasibility of technologies; and the level of technology development, performance record and inherent construction, and operations and maintenance requirements for each technology considered. The general types of technologies evaluated in this report that may be appropriate for MDA G include containment, in situ treatment, source removal, and ex situ treatment of waste.

Technologies were originally screened against the threshold criteria for the pits and shafts and for the vadose zone. The technologies that passed the threshold criteria were then screened against the balancing criteria in Section VII.D.4b of the Consent Order. These technologies were then ranked against the balancing criteria, and the highest-ranking technologies were combined into alternatives. The alternatives were screened against the balancing criteria and combined by source area into a recommended alternative.

The recommended alternative includes constructing an evapotranspiration cover over the pits and shafts and constructing and operating a soil-vapor extraction system to achieve remedial action objectives. The recommended alternative assumes all existing surface structures, including concrete foundations and asphalt, will be removed before the selected remedy is implemented.

The recommended alternative meets the remedial action objectives. The remedy selected was based on the ability of the recommended alternative to (1) achieve cleanup objectives in a timely manner, (2) protect human and ecological receptors, (3) control or eliminate the sources of contaminants, (4) control migration of released contaminants, and (5) manage remediation waste in accordance with state and federal regulations.

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1.0 INTRODUCTION

This report documents the corrective measures evaluation (CME) conducted for Material Disposal Area (MDA) G, Consolidated Unit 54-013(b)-99, at Los Alamos National Laboratory (LANL or the Laboratory). MDA G subsurface disposal units are located within the boundaries of Area G at Technical Area 54 (TA-54) (Figures 1.0-1 and 1.0-2). This CME is developed and submitted pursuant to the March 2005 Compliance Order on Consent (Consent Order).

The Laboratory is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by Los Alamos National Security, LLC. The Laboratory is located in north-central New Mexico, approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers 40 mi^2 of the Pajarito Plateau, which consists of a series of fingerlike mesas that are 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 above mean sea level (amsl). The eastern portion of the Pajarito Plateau stands 300 ft to 1000 ft above the Rio Grande.

The Laboratory is divided into numerous technical areas based upon facility operations. Several of the TAs include material disposal areas where waste was previously disposed. MDA G comprises all subsurface pits, trenches, and shafts located within the boundary of Area G. Included in the definition of MDA G is Consolidated Unit 54-013(b)-99. Consolidated Unit 54-013(b)-99 contains nine solid waste management units (SWMUs): 54-013(b), 54-014(b), 54-014(c), 54-014(d), 54-015(k), 54-017, 54-018, 54-019, and 54-020. One SWMU [54-013(b)] is aboveground. The remaining eight SWMUs [54-014(b), 54-014(c), 54-014(d), 54-015(k), 54-017, 54-018, 54-019, and 54-020] are subsurface. These SWMUs were used for the disposal of low-level radioactive waste (LLW), radioactively contaminated infectious waste, asbestos-contaminated material, and polychlorinated biphenyls (PCBs). Consolidated Unit 54-013(b)-99 also includes subsurface units used for the retrievable storage of transuranic (TRU) waste. The subsurface units and SWMU 54-013(b), which compose MDA G, are collocated with Resource Conservation Recovery Act– (RCRA-) regulated units and LLW disposal units. The LLW disposal units are regulated by the DOE.

Area G is identified in blue in Figure 1.0-3. Area G includes all RCRA-permitted surface units and all other operational buildings or structures at TA-54. MDA G is located within the boundary of Area G.

The definitions above are used when referencing MDA G and Area G throughout the CME report.

The objectives of this CME are to evaluate potential remedial alternatives to address the hazardous wastes and hazardous constituents released from the SWMUs and regulated units at MDA G and to recommend a preferred remedy that is protective of human health and the environment and attains appropriate cleanup goals for these wastes and constituents. To meet these objectives, the long-term performance of various containment, treatment, and excavation technologies was assessed in accordance with U.S. Environmental Protection Agency (EPA), DOE, and New Mexico Environment Department (NMED) risk and dose assessment guidance.

The regulatory framework at MDA G is complex. The Laboratory's ongoing management of hazardous and mixed wastes in permitted surface container storage units at Area G is regulated by the NMED under a Hazardous Waste Facility Permit (HWFP) issued pursuant to the New Mexico Hazardous Waste Act (HWA). There are seven outdoor container storage units (CSUs) and two indoor CSUs that will be closed under the Laboratory's HWFP to facilitate corrective action at MDA G.

The Consent Order addresses corrective action for the hazardous component of wastes disposed of in SWMUs and regulated units at MDA G. The Consent Order fulfills the corrective action requirements in Sections 3004(u) and (v) and 3008(h) of the federal RCRA; Sections 74-4-4(A)(5)(h) and (i), 74-4-4.2(B), and 7-7-10(E) of the HWA; and the federal and state implementing regulations in the Code of Federal Regulations, Title 40 (40 CFR) Part 264, Subpart F, and the New Mexico Administrative Code (NMAC), Section 20.6.2.3103, respectively. The integration of the Consent Order with the HWFP is described in Section III.W of the Consent Order. The Consent Order is the sole enforceable instrument for corrective action relating to the Laboratory except as provided in Section III.W.1.

The requirements of the Consent Order do not apply to radionuclides, including but not limited to source, special nuclear, or byproduct material as defined in the Atomic Energy Act of 1954 (AEA), as amended, or the radioactive portion of mixed waste. Historic and operating LLW disposal units and transuranic (TRU) waste storage units are exclusively regulated by the DOE under the AEA. DOE's authority to regulate nuclear safety is governed by the provisions of 10 CFR Parts 830 through 835. Pursuant to these regulations, DOE is required to review and approve all activities and work related to radionuclides, including activities and work under the Consent Order.

The regulated units at MDA G are a small subset of the SWMUs. A "regulated unit" is defined in 40 CFR 264.90(a)(2) as "any landfill, surface impoundment, waste pile or land treatment facility that received wastes after July 26, 1982 or that certified closure after July 26, 1983." Closure under Subpart F of Parts 264 and 265 for regulated units is prescriptive, including design requirements for caps for land disposal units and postclosure care (including cap maintenance and groundwater monitoring). The EPA recognized that complex sites, such as MDA G, are potentially subject to two different sets of RCRA requirements that apply to a single release if both regulated units and SWMUs have contributed to the release. To avoid unnecessary impediments to cleanups while ensuring that both SWMUs and regulated units are cleaned up in a manner that is protective of human health and the environment, 40 CFR 264.110(c) provides EPA and authorized states such as New Mexico with the discretion to prescribe alternative closure requirements. MDA G meets the requirements for the application of 40 CFR 264.110(c) for the following reasons:

- MDA G has four regulated units situated among eight subsurface SWMUs, and both types of units have likely contributed to the releases indentified during site investigation.
- The alternative closure and postclosure requirements for MDA G are set out in the Consent Order, which is an "enforceable document" as defined in 40 CFR 270.1(c)(7).

Two source areas are addressed in this CME:

- the MDA G SWMUs and regulated units (pits and shafts)
- the vadose zone

Remediation and closure of MDA G requires integration of solutions that address waste and regulatory issues specific to MDA G. To achieve remediation and closure requires the use of recent and historical characterization data as a basis for defining the nature and extent of contamination at MDA G. The CME identifies technologies that are appropriate to address any potential unacceptable future risk from MDA G. Finally, this CME screens the technologies, based on known performance data that have demonstrated the technologies' abilities to meet regulatory threshold and other qualitative screening criteria, and recommends an alternative as the proposed remedy.

This CME report is organized according to the Consent Order requirements. Table 1.0-1 summarizes the Consent Order requirements and identifies where the applicable requirements are addressed within this report. Section 1 provides an overview of the CME. Section 2 provides a brief site history, describes the relationship among Area G and the MDA G surface and subsurface units, discusses the waste inventory, and summarizes the results of previous investigations. Section 3 describes surface and subsurface site conditions. Section 4 summarizes the conceptual site model (CSM) and includes a description of sources, pathways, and receptors. Section 5 details the regulatory criteria for the CME, including applicable cleanup standards, risk-based screening levels, and risk-based cleanup goals for each pertinent medium at MDA G subsurface units. In section 6, the potential corrective measure technologies are identified and evaluated for applicability at MDA G. The retained technologies are screened against the threshold criteria in section 7. Technologies that pass the threshold criteria are evaluated further in section 8 against the balancing criteria. Retained technologies are combined into alternatives and evaluated for each of the two areas in section 8.5. The recommended corrective measures alternative is discussed in section 9. The design criteria to meet cleanup objectives are presented in section 10, the proposed schedule is provided in section 11, and references and map data sources are presented in section 12.

2.0 BACKGROUND INFORMATION

TA-54 is situated in the east-central portion of the Laboratory on Mesita del Buey (Figure 1.0-1). TA-54 includes four MDAs designated as G, H, J, and L; a waste characterization, container storage, and transfer facility (TA-54 West); active radioactive waste storage and disposal operations at Area G; active hazardous and mixed-waste storage operations at Area L; and administrative and support areas (Figure 1.0-2). The transfer facility is located at the western end of TA-54. MDAs H and J are located approximately 500 ft and 1000 ft (150 m and 305 m) southeast of the transfer facility, respectively. MDA L is located approximately 1 mi (1.6 km) southeast of the transfer facility. MDA G subsurface units are located within Area G approximately 0.5 mi (0.8 km) southeast of MDA L.

Mesita del Buey is a 100- to 140-ft-high finger-shaped mesa that trends southeast. The elevation of Mesita del Buey ranges from 6750 to 6670 ft at Area G. The mesa is approximately 500 ft wide and is bounded by the basin of Cañada del Buey (450 ft to the north) and the basin of Pajarito Canyon (360 ft to the south) (Figure 1.0-2).

Area G is a 63-acre (25-ha) fenced site, containing 333 active and inactive waste disposal units, that lies within the boundaries of TA-54 (Figure 1.0-2). Area G contains 35 pits, 294 shafts, and 4 trenches. The regulatory category of each disposal unit is shown in Table 2.0-1 and Figure 1.0-3. Consolidated Unit 54-013(b)-99 is located within Area G and consists of nine inactive SWMUs: 54-013 (b), 54-014 (b), 54-014(c), 54-014 (d), 54-015(k), 54-017, 54-018, 54-019, and 54-020 (Figure 2.0-1). Table 2.0-2 identifies and describes each SWMU, including the type of waste managed or stored. There are eight inactive MDA G subsurface SWMUs that comprise 32 pits, 196 shafts, 4 trenches, and retrievable TRU waste in corrugated metal pipes overlying Pit 29. These disposal units range from 8 ft to 65 ft (2.4 to 20 m) below the original ground surface.

The following subsections provide a summary of site information. Further information about current site conditions at MDA G is described in detail in the approved investigation work plan (LANL 2004, 087833, pp. 14−21) and report(LANL 2005, 090513), the approved supplemental sampling investigation work plan (LANL 2006, 094803), the MDA G investigation report (LANL 2005, 090513, pp. 9, 11−16) and addendum (LANL 2007, 096110, p. 1), and the annual periodic monitoring reports for pore gas (e.g., LANL 2010, 108496). These documents describe the site and include information on the disposal units, waste inventories, characterization activities, analytical results from sampling, and assessments of potential present-day risks to human health and the environment.

2.1 Site History

Wastes historically disposed of at MDA G included operational and nonroutine wastes, plus demolition debris. Operational wastes consisted of a wide range of materials including compactable trash (e.g., paper, cardboard, and plastic), rubber, glass, disposable protective clothing, solidified powders and ash, animal tissue, and suspect radioactive waste. Nonroutine waste included classified waste, uranium chips from LANL shops, and pieces of heavy equipment such as dump trucks. Demolition debris included equipment and scrap metal, demolition debris, soil, concrete, asphalt, asbestos, and PCB-contaminated materials.

The nature of the waste disposed of at MDA G has changed over the facility's lifetime. Waste that under current definitions is considered to be TRU was disposed of at the facility through 1970. Since then, the vast majority of TRU waste generated at the Laboratory has been segregated and retrievably stored for permanent disposal at the Waste Isolation Pilot Plant, (WIPP), although small amounts of TRU waste were disposed of at MDA G between 1971 and 1979.

Mixed wastes have also been historically disposed of at MDA G. A mixed waste is a waste that contains both hazardous waste subject to the HWA and RCRA, and source, special nuclear or byproduct material subject to the AEA. Waste that under current definitions qualifies as mixed LLW (MLLW) was placed in MDA G pits and shafts through 1985. Mixed TRU waste was routinely disposed of at MDA G before 1971; smaller quantities of mixed TRU waste were disposed of between 1971 and 1979. Since 1986, when the EPA affirmed its authority over the regulation of the hazardous component of MLLW, the vast majority of MLLW has been segregated from LLW and sent off-site for treatment and/or disposal. Small amounts of MLLW were inadvertently placed in a single pit and shaft between 1986 and 1990. No mixed waste has been disposed of at MDA G since 1990. In addition to LLW, MDA G was previously authorized to dispose of low-level contaminated-PCB solid waste.

MDA G contains 229 inactive subsurface waste management units (Figure 1.0-3). Tables 2.1-1 through 2.1-3 summarize the operational history, unit dimensions, waste volumes, and description of waste received at each pit, trench, and shaft at MDA G (LANL 2005, 090513, pp. 53−55).

On a volume basis, most of the waste at MDA G has been placed in the pits. Before the mid-1990s, the waste was typically placed into the pits in lifts; each layer of waste was covered with uncontaminated crushed tuff and compacted using heavy equipment. Most waste placed in pits was packaged in plastic bags and cardboard boxes. The waste packaging requirements and disposal pit operations used before the mid-1990s are generally expected to confer structural stability to the pits. Layering waste and crushed tuff and compacting these layers with heavy equipment effectively filled void spaces within the waste and provided an even, consolidated surface for the disposal of more waste. The result has been infrequent and minor cases of settlement; no significant subsidence has been observed at Area G.

To more efficiently use the available pit disposal capacity, disposal procedures were modified in the mid-1990s. Since that time, all waste other than bulk soils and debris is required to be placed in metal containers before disposal. The containers used to date have included steel drums, B-25 waste containers, compactor boxes, and transportainers. These containers are stacked in the disposal units to maximize usage of the available disposal capacity. Bulk materials are placed directly in the disposal pits and may be used to fill void spaces between and within waste containers.

The waste disposed in the shafts is generally placed in small metal cans or 30- to 85-gal. drums, depending upon the nature of the waste. The packages are lowered into the shafts and stacked on top of one another. Crushed tuff may be added as backfill around the waste packages, thereby reducing void spaces in the disposal units. In general, backfilling the disposal shafts is expected to adequately stabilize the waste. However, isolated instances of subsidence near the shafts have been observed during the 50-yr history of the facility.

During active operations (i.e., when waste was being received), the pits and trenches remained open to the atmosphere and the shafts were covered and locked with steel lids after disposal. When active operations ceased, any remaining capacity of the pits, shafts, and trenches was filled with clean crushed tuff. Portions of the waste disposal units at MDA G have been covered with asphalt, and much of the surface, above the MDA G subsurface units, is currently being used for the active storage of RCRA MLLW and TRU waste (LANL 1992, 007669, pp. 5−179).

As discussed above, the Consent Order addresses corrective action for the hazardous component of wastes disposed of in SWMUs and regulated units at MDA G. The requirements of the Consent Order do not apply to radionuclides, which are solely within the DOE’s regulatory authority.

2.2 Area G Inventory

The information in Tables 2.1-1 and 2.1-3 provides a summary of the disposal inventory for the pits and shafts, respectively.

Pre-1970 TRU waste is assumed to contain hazardous constituents (LANL 2004, 087833, pp. G-3−G-9). Waste disposal records indicate that significant portions of the TRU waste generated at the Laboratory after 1970 are mixed with hazardous constituents. The mixed TRU waste consists of combustible and noncombustible fractions. Combustible waste includes items such as rags, plastic, paper, and rubber. Examples of noncombustible waste include glass, scrap metal, graphite, salts, and equipment such as glove boxes. Other categories or types of waste that were generated include cement paste generated when treated liquid waste or sludges were solidified in cement before disposal; chemical treatment sludge, and, PCB-contaminated waste.

Additionally, 12 disposal shafts contain PCB-contaminated waste that would be classified as Toxic Substances Control Act (TSCA) waste.

2.3 Site Description

2.3.1 Surface 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 developed soil profiles exist on the north-facing slopes and they tend to be higher in organic matter. Soil profiles on the south-facing slopes tend to be 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 (Newman 1996, 054399).

The original soils near Area G were also poorly developed, as is typical of soils derived from Bandelier Tuff and formed under semiarid climate conditions (Nyhan et al. 1978, 005702, p. 24). In general, undisturbed soils on the mesa tops are composed 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 construction.

Canyon bottoms (i.e., Cañada del Buey and Pajarito Canyon) near Area G 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; the 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 along stream banks. Potentially, these soils may be redistributed downstream during storm runoff events.

2.3.2 Subsurface Geology

A brief description of the site-specific geology at MDA G is summarized in this section. A generalized stratigraphic column for the east end of MDA G is shown in Figure 2.3-1. Appendix E, section E-1.1, describes the site-wide geology for the entire TA-54 site. North-south cross sections in the vicinity of MDA G are shown in Figures E-1.1-3 and E-1.1- 4.

The facilities and disposal pits of TA-54 are sited on Mesita del Buey, an erosional highstand of Bandelier Tuff on the Pajarito Plateau. The caprock of TA-54 is formed of moderately welded tuff of Unit 2 (Qbt 2) of the Tshirege Member of the Bandelier Tuff. Below the surface, tuff and sedimentary units pass from Qbt 2 into nonwelded devitrified Tshirege tuff (Qbt 1v), nonwelded vitric Tshirege tuff (Qbt 1g), thin basal Tshirege Tsankawi fall deposits (Qbtt), Cerro Toledo sediments (Qct) of variable thickness, Otowi Member nonwelded vitric ash flows (Qbo), and Guaje Pumice Bed (Qbog) fall deposits. Beneath the tuff and sediment is a thick and varied sequence of volcanic rocks of the Cerros del Rio volcanic field (Tb 4), ranging in composition from basalt to dacite. Although this volcanic series is dominated by lava flows, the TA-54 area overlies a site of considerable variety in Tb 4 components including lavas, flow breccias, scoria and phreatomagmatic deposits, and interflow sediments. The Tb 4 cuttings collected from boreholes at TA-54 and exposed cinder vents nearby indicate that a number of volcanic centers occur in the vicinity. Information collected from deep borehole R-22 at the eastern end of MDA G points to intersection of a possible basaltic conduit at this spot that fed upper-level lava flows.

Beneath the Cerros del Rio volcanic series at TA-54 are sediments of the Puye Formation (Tpf), transitioning from fanglomerates beneath the western part of TA-54 to axial river gravels of the Totavi Lentil to the east. These two facies interfinger and the transition between the two is both lithologically varied and discontinuous, but the transition to river gravels is largely complete just east of MDA G. Older, pumice-rich fanglomerates (Tjfp) lie beneath the Puye Formation in the western part of TA-54. These pumiceous deposits appear to pinch out eastward, in the vicinity of MDA L; east of MDA L the Puye Formation deposits, whether fanglomerate or river gravel, are underlain by sands and silty sands of the Chamita Formation (Tcar) of the Santa Fe Group. Sediments beneath the Cerros del Rio volcanic series at TA-54 are thus highly varied, including coarse fanglomerates derived from volcanic centers to the west, coarse gravel to sand in river-channel deposits derived from sources to the north, and relatively fine and variably calcite-cemented Santa Fe Group sediments from the northeast.

2.3.3 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 the "TA-54 Storm Water Pollution Prevention Plan" (LANL 2009, 109438) prepared for the Laboratory's National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit. 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.

2.3.4 Vadose Zone Hydrology

The vadose zone is the zone between the land surface and the regional water table within which the hydraulic pressure is less than atmospheric barometric pressure. Beneath MDA G, the pores within the vadose zone are unsaturated (i.e., they contain both air and water). Mesita del Buey is one of the drier mesas at the Laboratory and on the Pajarito Plateau. Infiltration occurs into the shallow subsurface mostly during snowmelt or following intense summer thunderstorms. Moisture from the shallow subsurface of the mesa is removed by evapotranspiration (ET). Figure 2.3-2 presents data showing that average potential ET rates exceed precipitation rates throughout the year at TA-54. That is, little to no water is available for infiltration below the root zone at the site. Percolation into the deeper subsurface of the mesa appears to be very low. Newman et al. (2005, 099163) estimated percolation rates and vadose zone travel times in undisturbed, disturbed, and paved areas across TA-54 using moisture, chloride, and stable isotope data from shallow (1- to 2-m deep) cores. The study looked at vegetated and unvegetated areas. Under undisturbed and vegetated conditions, percolation rates on Mesita del Buey are estimated to be approximately 0.2 mm/yr; under disturbed conditions and beneath pavement, less ET occurs and percolation rates can range up to 10 mm/yr (Newman et al. 2005, 099163). Similar average percolation rates are confirmed by several independent studies (Birdsell et al. 2005, 092048; Kwicklis et al. 2005, 090069). If these conditions are maintained over long time frames, average travel times for conservative waterborne contaminants (those that do not adsorb or precipitate) from the surface to the regional aquifer of several hundred years to several thousand years are predicted under disturbed and undisturbed conditions, respectively (Stauffer et al. 2005, 097432). Adsorbing waterborne constituents will migrate more slowly. Vapor-phase contaminants may migrate more quickly than waterborne contaminants, as described above. The CSM for contaminant migration through the unsaturated zone at TA-54 is presented in detail in Appendix E of the revised MDA G CME plan (LANL 2007, 098608) and summarized in section 4 of this report.

Krier et al. (1997, 056834) present moisture data from core samples collected at three boreholes adjacent to disposal units near the center and south-central portions of MDA G. The data indicate average volumetric moisture contents within the Tshirege units ranging from 1.5% to 10% and within the Otowi member of 11.5 %. Similar moisture content ranges were reported in the MDA G Investigation Report (IR) for boreholes extending down to 700 ft below ground surface (bgs) (LANL 2005, 090513), as described in Appendix B of this report. These moisture content values are low, given that the porosity of the tuffs are in the 40% to 50% range, and for fully saturated conditions, the volumetric moisture content is equivalent to the porosity. At these moisture contents, the fractures beneath MDA G are expected to be predominantly dry, and pore water is expected to reside within the tuff matrix. During infiltration events, limited flow may occur temporarily along the fractures (Soll and Birdsell 1998, 070011). Higher volumetric moisture contents and percolation rates are expected under paved areas because of a lack of evapotranspiration (Newman et al. 2005, 099163). The paved areas are thought to be permeable enough to allow water infiltration sufficient to sustain the observed percolation rates. A comparison of moisture profiles measured with neutron probes within and adjacent to an open pit found significantly wetter conditions within the disposal pit. For example, volumetric moisture contents in the pit ranged from 8% to 12% compared with 1% to 6% in the adjacent area (LANL 1997, 056384). Enhanced ET and declining subsurface moisture will likely occur following asphalt removal and revegetation, as was observed at TA-49 following installation of an ET cover (Levitt et al. 2005, 107562).

No significant perched-intermediate groundwater occurs beneath MDA G. Borehole 54-25105, the deepest borehole to date at MDA G, was drilled to a depth of 700 ft bgs and did not encounter perched groundwater (LANL 2005, 090513). Regional wells drilled in areas next to MDA G (R-21, R-22, R-32, R-39, R-41, R-49, and R-57) also did not encounter perched-intermediate groundwater. Perched-intermediate groundwater occurs in wells R-55 and R-23/R-23i, located 2500 and 3600 ft (0.75 and 1.1 km) east and southeast of MDA G, respectively (LANL 2003, 079601; Kleinfelder 2006, 092495). Perched-intermediate groundwater also occurs in wells R-40/40i and R-37, both located approximately 5900 ft (1.8 km), northwest of MDA G (LANL 2009, 106432). This water is thought to be localized beneath the canyon floor and to result from infiltration along the adjacent canyon, which has a large drainage area.

2.3.5 Regional Aquifer Hydrology

The regional aquifer beneath the Pajarito Plateau occurs at depths between 1200 ft (366 m) along the western edge of the Pajarito Plateau and about 600 ft (183 m) along the eastern edge. Beneath MDA G, the regional water-table elevation is approximately 5810 ft amsl or approximately 900 ft (300 m) below the ground surface. The regional water table is observed within the Cerros del Rio lavas at MDA G and in the underlying sediments to the east of MDA G (Figures E-1.1-4 and E-1.1-8, Appendix E). The regional water table map, based on new data collected at the recently installed regional wells in the vicinity of MDA G, is shown in Figure E-2.2-1 of Appendix E.

Groundwater flow in the upper part of the regional aquifer beneath MDA G appears to be substantially impacted by the Cerros del Rio lavas (Figures E-1.1-2, E-1.1-3, and E-1.1-4, Appendix E). These lavas are more than 150 ft thick beneath the regional water table (Figure E-1.1-8; Appendix E). The regional structure of the groundwater flow in the aquifer in the area near MDA G may also be impacted by (1) water-supply pumping, (2) the local-scale infiltration recharge along Pajarito Canyon, (3) the lateral propagation of large-scale mountain-front aquifer recharge occurring to the west of MDA G, and (4) the discharge of the regional aquifer to the southwest from MDA G toward the White Rock Canyon springs and the Rio Grande. Additional discussion of the water table at TA-54 is presented in Appendix E, section E-2.

The phreatic-zone thickness is predominantly constrained by hydrogeological properties and thickness of Cerros del Rio lavas below the regional water table (Figure E-1.1-8, Appendix E). The effective saturated hydraulic permeability of the Cerros del Rio lavas depends on the permeabilities of (1) the intact lava matrix, (2) fractures separating lava blocks and their fracture-lining minerals, and (3) interbedded sediments between lava flows. Permeabilities of these lavas are also a function of the spatial distribution and interconnection of the fractures and interbedded sediments. The permeability of the intact lava matrix is expected to be quite low. However, high permeability fractures and interbedded sediments can lead to relatively high local groundwater flow velocities and preferential flows though the phreatic zone. Depending on the hydrogeological properties and spatial connection between the fractures and interbedded sediments, the groundwater volume flowing through the fractures is expected to be relatively low. As a result, the effective saturated hydraulic permeability of the Cerros del Rio lavas is also expected to be relatively low. Although total groundwater flux through the phreatic system may be lower than to other parts of the Pajarito Plateau, focusing flow into fractures or interbedded sediments may lead to higher groundwater transport velocities than would be encountered where the phreatic system is found in sediments (such as the Puye Formation). The low effective permeability of the Cerros del Rio lavas is supported by the observed steep gradients in the areas where these rocks occur at the top of the regional aquifer (Figure E-2.2-1, Appendix E) The hydraulic gradient along the regional water table beneath MDA G is 0.02 m/m; it is among the highest hydraulic gradients observed beneath the Laboratory.

The groundwater flow in the regional aquifer beneath MDA G is predominantly from northwest to southeast. The direction of the potential contaminant transport in the regional aquifer is expected to follow the hydraulic gradients along the regional water table, although fractures or interbedded sediments may cause permeability anisotropy that could lead to deviations from the predominant flow direction. In the area downgradient from MDA G, the direction of the regional aquifer flow is believed to be dominantly towards the southeast based on regional water table maps. However, there is some uncertainty about the flow regime where regional groundwater exits the lavas and merges with the groundwater flow in the more permeable sediments of the Totavi Lentil to the east and north. This transition between lavas and Totavi sediments at the regional water table occurs near the eastern boundary of MDA G (Figure E-1.1-8, Appendix E). The transitional nature of the water table at the interface between the lavas and Totavi Lentil sediments is probably reflected by the relatively low water level observed at R-41 (Figure E-2.2-1, Appendix E). The water table map (Figure E-2.2-1) suggests there may be a local component of regional groundwater flow to the northwest near the northeast corner of MDA G. The existing regional groundwater monitoring-well network downgradient of MDA G (wells R-23, R-41, R-55, R-57, R-39 and R-49) potentially cover the uncertainty range in flow directions. The hydrogeologic complexity and uncertainty in the groundwater flow directions are further discussed in Appendix E.

The deep portion of the regional aquifer beneath MDA G is predominantly within Chamita Formation sediments (Figures E-1.1-3 and E-1.1-4, Appendix E). Hydrodynamically, the deep aquifer is under confined conditions, and it is stressed by Pajarito Plateau water supply pumping. The intensive pumping causes small water-level fluctuations in the shallow phreatic (unconfined) zone. Currently, the largest seasonal fluctuations in the shallow phreatic zone near MDA G have been observed at R-20 screen 1, which varies up to 0.6 ft (0.2 m) (LANL 2009, 106939, Appendix M). Well R-20 is located 0.25 mi east-southeast of well PM-2 (Figure 2.3-3). These low-magnitude responses in the phreatic zone from municipal well pumping are in sharp contrast to the larger responses at monitoring well screens completed in deeper parts of the aquifer (e.g., R-20 screen 3; see LANL 2009, 106939, Appendix M), indicating that the hydraulic communication between the phreatic zone and deeper parts of the aquifer is poor. Regardless of the poor hydraulic communication between the deep and shallow section of the aquifer, it is plausible that the shape of regional water table is influenced by the water-supply pumping by PM-2 in the area west of MDA G (near wells R-40, R-20, and R-54) (Figure E-2.2-1, Appendix E). The poor hydraulic communication between the two zones also does not preclude the possibility that some contaminant migration may occur between the shallow and deep zones. Between the two zones, the hydraulic gradient has a downward vertical component because of water supply pumping in the deep zone, creating the possibility that downward contaminant flow may occur along “hydraulic windows,” although these flows have not been directly observed.

Based on the existing hydrogeological information, it has either already been observed or is expected that all the monitoring wells located to the west of MDA G (R-21, R-56, and R-32) respond to the water-supply pumping at PM-2 and PM-4 (Table E-2.1-1). In contrast, the monitoring wells to the east of MDA G do not appear to respond to the water-supply pumping at PM-2 and PM-4. This observation is expected, considering the lateral distance between the pumping and monitoring wells R-41, R-57, R-39, and R-49. However, it is somewhat surprising for R-22; the deep screens in this well are placed at such depths that water-supply pumping drawdowns are expected based on responses observed at other monitoring wells located at similar distances to the north of the supply wells (e.g., R-28). The lack of pumping response in the deep screens at R-22 may indicate the presence of localized heterogeneities (low permeable zones, faulting, etc.) in the regional aquifer between PM-2/PM-4 and R-22. Alternatively, there may be a general trend of north-south oriented anisotropy within the aquifer (such as north-south oriented highly permeable channels in Chamita riverine deposits) that causes water-supply pumping drawdowns to propagate predominantly to the north rather than to the east.

Hydrogeologic data from wells R-41, R-57, R-49, and R-39 suggest that the uppermost screens in the regional aquifer are tapping saturated zones that are either unconfined or partly confined (Appendix E, section E-2) and that these upper well screens and the regional water table are potentially hydraulically connected. In addition, cross-well hydraulic responses between R-57, R-49, and R-39 during pumping tests (Appendix E) demonstrate that the well screens are in good hydraulic communication with the aquifer and will be expected to provide an early detection of potential contaminants originating from MDA G.

2.3.6 Historical Preservation and Archaeology

Known archaeological sites exist in the immediate vicinity of Area G. The site has been thoroughly characterized for archaeological sites and structures that may be subject to historical preservation restrictions (LANL 1992, 007669). The exact locations of existing archaeological sites are not identified in this report to protect the cultural resources.

2.4 Summary of Previous Investigations

MDA G has been the subject of several site investigations and two soil-vapor extraction (SVE) pilot studies (LANL 2009, 105112). The first investigation was conducted in 1985, following receipt of a Compliance Order from the New Mexico Environmental Improvement Division (NMEID, now the NMED). A Phase I RCRA facility investigation (RFI) was conducted at MDA G between 1993 and 1995. A Consent Order site investigation was concluded in 2007. All three investigations are summarized in the following sections and in the approved investigation report (LANL 2005, 090513) and addendum to the investigation report (LANL 2007, 096110). These investigations composed a comprehensive approach to characterizing potential releases of hazardous wastes and hazardous constituents from all subsurface disposal units at Area G. NMED ultimately approved the investigation report (NMED 2007, 096716). Relevant data, figures, and tables from these investigations are included in Appendix B, and the key findings from these studies are summarized below.

The investigation report addendum (LANL 2007, 096110) concluded that the hazardous constituents in the subsurface of MDA G pose no potential unacceptable present-day risk or dose to human health or the environment.

2.4.1 Summary of 1985 Physical Investigations

In 1985, the Laboratory received a Compliance Order from NMEID that addressed numerous waste management issues at the Laboratory (NMEID 1985, 075885, pp. 1–9). An investigation in and around MDA G was performed and focused on six tasks outlined in the 1985 Compliance Order. The results and outcomes of these six tasks are described in a hydrogeologic assessment of Areas G and L in TA-54 (IT Corporation 1987, 076068, pp. 6-2–6-7).

2.4.2 Summary of Phase I RFI

In 1993, 1994, and 1995, ambient-air, channel-sediment, surface-flux, and subsurface-core samples were collected at MDA G during a Phase I RFI. In addition, pore-gas samples have been collected since 1985. The results of these previous investigations are summarized in the historical investigation report of the approved work plan for MDA G (LANL 2004, 087833, Appendix B, pp. B-5–B-18) and included in Appendix B, section B-2.0 of this CME report. The key findings from these studies are summarized below:

- In channel sediments, cadmium, tritium, plutonium-238, plutonium-239, and americium-241 were detected above background values (BVs). These results indicated that migration of contaminants from Area G via surface flow and sediment transport may have occurred.
- In ambient-air samples, elevated levels of tritium, plutonium-238, plutonium-239, and americium-241 were detected during routine monitoring in 2002. These results showed potential transport of contaminants via air dispersion and wind.
- Surface-flux measurements for vapors were taken at several locations across the mesa top and sides at Area G. Vapor fluxes for tritium and several volatile organic compounds (VOCs) were observed (e.g. 1,1,1-trichloroethane [TCA], trichloroethene [TCE], tetrachloroethene [PCE], and Freon). These results indicated diffusion of subsurface vapors releasing to the atmosphere.
- A total of 125 borehole soil and tuff samples were collected in 19 boreholes over depths of approximately 38.5 ft to 150 ft bgs. Forty-three constituents of potential concern (COPCs), including metals, radionuclides, PCBs, semivolatile organic compounds (SVOCs), and VOCs, were identified from these samples because either detections or detection limits exceeded BVs or the constituents were detected but had no BVs. Metals had very low frequencies of detection above BVs, suggesting limited mobility in the subsurface. Most radionuclides had very low frequencies of detection (2 or fewer), suggesting limited mobility in the subsurface. Tritium was detected above BV in most samples; Americium-241 and uranium-235 had multiple detections. Detections of PCBs, SVOCs, and VOCs were also infrequent and sporadic. The interpretation of these data indicates limited mobility by liquid-phase transport away from the disposal units.
- Pore-gas monitoring data for MDA G indicate that VOCs and tritium are present in pore gas. Trichloroethane was the dominant VOC detected. Pore-gas data indicate that VOCs and tritium had been released into the tuff beneath the disposal units (LANL 2005, 090513, p. 4).

2.4.3 Summary of Consent Order Investigations

Two investigations were conducted under the Consent Order at MDA G: a 2005 site investigation (LANL 2005, 090513) and a 2007 supplemental investigation (LANL 2007, 096110).

2.4.3.1 2005 Site Investigation

Field investigations conducted in 2005 at MDA G under the Consent Order are reported in the MDA G investigation report (LANL 2005, 090513) and summarized in Appendix B, section B-3.1 of this CME report. Under this investigation, 39 boreholes were drilled in accordance with the approved MDA G work plan (LANL 2004, 087833). These boreholes were drilled and sampled to characterize underlying stratigraphy (37 of the 39 boreholes) or to determine whether perched water was present (2 of the 39 boreholes). Core samples in and adjacent to fractures were collected and analyzed for target analytes. In addition, a risk assessment was conducted that concluded surface and subsurface contamination did not pose an unacceptable risk to human health and the environment based on current site use.

The soil and rock sample results indicated a number of inorganic and organic chemicals were detected at trace levels beneath the former disposal units and were consistent with the results obtained during the Phase I RFI. All inorganic chemicals detected above BVs during the 2005 study were generally less than five times the BV. In addition, all inorganic chemicals detected at levels greater than BVs were in samples from intervals containing clay-filled fractures and were at levels less than the soil BV, which was considered to be a more representative metric for comparison (LANL 2005, 090513). The interpretation of these results indicates little if any migration of metals and other inorganic chemicals from the disposal units.

The only organic chemicals detected in core samples were trace levels of several dioxin and furan congeners. Pore-gas sampling was also conducted under the 2005 investigation. After drilling activities concluded, pore-gas samples were collected at the depth of the nearest adjacent disposal unit and at total depth (TD). Results confirmed the presence of VOCs, consisting primarily of chlorinated VOCs, in the vadose zone beneath MDA G. The dominant subsurface vapor contaminant was TCA. Tritium was also detected in pore gas. The highest tritium concentrations were detected in samples from locations in the eastern and south-central portions of MDA G.

Naturally occurring and anthropogenic radionuclides were confirmed at levels above BVs in soil and rock samples collected beneath MDA G. The anthropogenic radionuclides detected sporadically across the site included americium-241, plutonium-238, plutonium-239, and strontium-90.

Subsurface samples collected to a depth of 700 ft (210 m) beneath the MDA G subsurface units did not identify perched water zones.

2.4.3.2 2007 Supplemental Site Investigation

Field investigations conducted in 2007 at MDA G under the Consent Order are reported in the addendum to the MDA G investigation report (LANL 2007, 096110) and summarized in Appendix B, section B-3.2 of this CME report. Four boreholes were extended to define the vertical extent of VOC pore-gas contamination. Validated analytical results collected during pore-gas monitoring of these boreholes confirm the presence of VOCs and tritium in vapor samples. The addendum concluded that the additional data supported the risk assessment presented in the 2005 investigation report that the site did not pose a potential unacceptable risk to human health or the environment. The vertical distribution of VOC and tritium concentrations indicated no current threat of groundwater contamination, but the fiscal year 2007 (FY2007) periodic monitoring report (LANL 2007, 101771) recommended future pore-gas monitoring. The pore-gas sampling data supported the adequacy of the existing subsurface vapor-monitoring network to track contaminants in pore gas (LANL 2007, 101771).

2.4.4 Summary of SVE Pilot Studies

NMED requested LANL to conduct pilot tests to determine the effectiveness of SVE to remove VOCs from the vadose zone (NMED 2007, 098446). Two active in situ SVE pilot studies have been conducted at MDA G to evaluate the effectiveness of SVE technology for remediating the subsurface VOC vapor plumes and to provide design, operational, and cost information necessary for evaluating SVE as a remedial alternative during the CME. The first study was conducted during the summer of 2008; the second study was conducted in the spring of 2010.

The 2008 SVE pilot study was conducted adjacent to the disposal shaft field located west of Building 54-0412 (Figures 2.4-1 and 2.4-2) and included a shallow active extraction test, a deep active extraction test, and a passive monitoring period. Results of the 2008 SVE pilot study determined that active SVE is a viable technology for removing vapor-phase VOCs from the subsurface at MDA G. Approximately 278 lb (126 kg) of VOCs was removed from the Tshirege Member during the 30-d active shallow-extraction phase of the pilot study, with TCA making up approximately 75% of the recovered VOC mass. Using data collected from the pilot study, the two-dimensional numerical analysis estimated the radii of influence to be approximately 150 ft (45 m) for the shallow-extraction interval and approximately 50 ft (15 m) for the deep-extraction interval.

At the direction of NMED (NMED 2009, 107044), a supplemental SVE pilot study was conducted at MDA G at the same location as the 2008 SVE pilot study (Figure 2.4-3). The objectives of the supplemental pilot study were (1) to determine the capabilities and optimal design for a full-scale active SVE system at MDA G and (2) to further demonstrate that active SVE has the potential to be an effective part of remediation of hazardous constituents at MDA G. The 2010 SVE pilot test was designed to target the permeable zones identified in the Tshirege Member of the Bandelier Tuff, the contacts between the stratigraphic units, and any permeable layers in the geologic column. It was also designed to assess the ability of major stratigraphic units, such as the Cerro Toledo unit and Otowi Member, to act as either a barrier to contaminant migration or as an effective extraction interval. Results and conclusions of the pilot study are detailed in “Report for Supplemental Soil-Vapor Extraction Pilot Test at Material Disposal Area G, Technical Area 54” (LANL 2010, 109657).

The results of the 2010 SVE pilot test further demonstrated that active SVE has the potential be an effective remedial technology for removing VOCs from the subsurface at MDA G. Discrete permeability values measured during the pilot study were within the ranges of values considered feasible for implementation of SVE. Similarly, the pressure responses measured during the step tests indicated a radius of influence (ROI) large enough for SVE to be implementable and cost effective at the MDA G site, depending on cleanup levels. The tests further show that an effective ROI can be achieved using vacuums and air-flow rates achievable with equipment typically used for SVE, although safety considerations associated with use of higher vacuums than previously tested would need to be addressed.

2.4.5 Status of Pore-Gas Monitoring

Pore-gas monitoring activities have been conducted at MDA G since 1985 to characterize VOC and tritium concentrations present in the vadose zone beneath MDA G. Quarterly pore-gas monitoring began in 1990 after EPA issued Module VIII of the Laboratory’s HWFP, which included requirements for quarterly pore-gas sampling at MDA G as an input to the RFI. The Consent Order further required pore-gas monitoring during the site investigations and submittal of a long-term pore-gas monitoring plan. Currently, pore-gas monitoring activities are implemented annually in accordance with the revised long-term vapor-monitoring plan, provided as part of the MDA G CME Plan (LANL 2007, 098608), and a subsequent table of revised pore-gas monitoring locations, approved by NMED (Shen 2008, 103907).

Pore-gas monitoring activities at MDA G currently include field screening 121 completed sampling ports in 20 pore-gas monitoring boreholes and 1 open borehole. VOC and tritium samples are collected from 41 sampling ports within each of the 20 completed boreholes and from the open borehole. Vapor-monitoring boreholes, port depths, and corresponding sampling intervals that were field screened and sampled during the most recently reported monitoring event (fourth quarter FY2009, from August 5 to September 30, 2009) are presented in Table 2.4-1. Pore-gas monitoring borehole locations are shown in Figure 2.4-4.

VOC and tritium samples are collected from sampling ports within each monitoring borehole corresponding to the greatest depth of the adjacent disposal unit, and from the TD of the borehole.

Because sampling methods and resulting data quality have changed substantially over the years, pore-gas data before 1996 were not subject to the current quality assurance / quality control (QA/QC) procedures. Data collected from 1997 to the present have been subjected to rigorous QA/QC procedures.

Results of long-term pore-gas monitoring activities at MDA G have shown that VOCs are the primary RCRA-regulated vapor-phase constituents in the subsurface at MDA G. The nature and extent of the VOCs are discussed in section 3.2.4 and Appendix C.

2.4.6 Summary of Canyons Investigations

Sediment, surface water, and groundwater data are collected as part of the canyons investigations. These data are very useful at helping determine whether SWMUs (particularly those with outfall/mesa slope aspects) have contamination or release histories that manifest in the canyon floor and whether they are at levels that represent potentially unacceptable human-health risk or adverse ecological affects. These data are presented in canyons investigation reports. For MDA G, potential releases are discussed within this and previous documents (LANL 2005, 090513) that address nature and extent from the subsurface units that constitute MDA G.

The data from adjacent canyons, specifically Pajarito Canyon and Cañada del Buey, are used to address potential impacts from Area G (as distinguished from MDA G) on shallow surface media including sediment, surface water, alluvial groundwater, and biota. The possible impact of releases from Area G on sediment in Pajarito Canyon was evaluated using data collected from sediment investigation reaches upcanyon and downcanyon from Area G (LANL 2009, 106939). These sediment data indicate no potential impacts from Area G in canyon-bottom sediments. The spatial distribution of COPCs indicates that TA-09, TA-18, and possibly TA-16 are the main sources of mobile contaminants in surface water and groundwater in Pajarito Canyon. Biota investigations for the segment of Pajarito Canyon adjacent to Area G also indicate no adverse affects.

The possible impact of releases from MDA G on sediment in Cañada del Buey was evaluated using data collected from several sediment investigation reaches upcanyon and downcanyon from MDA G (LANL 2009, 107497). Based on their spatial distribution, MDA G is a potential source for several COPCs in Cañada del Buey sediment, including low levels of radionuclides, inorganic chemicals, and PCBs. In Cañada del Buey, the activities of americium-241, plutonium-238, and plutonium-239/240, as well as the concentrations of PCBs (specifically Aroclor-1248) are highest in upcanyon reaches from MDA G. The concentrations of several inorganic chemicals, including aluminum and antimony, have their highest concentrations in downcanyon reaches of MDA G. Concentrations of COPCs associated with MDA G decrease rapidly downcanyon from the upper reaches and are either not detected or are not present at concentrations above sediment background values above NM 4 and White Rock. The absence of confirmed contaminants in the lower reaches indicates that contaminants released from MDA G have had little to no off-site impact and that MDA G is not a recognizable source of contaminants for White Rock or the Rio Grande. No alluvial groundwater is known to be present along the reaches adjacent to MDA G, and only occasional stormwater flow is present.

2.5 Status of Groundwater Monitoring

Groundwater monitoring at the Laboratory is currently conducted in accordance with the 2010 Interim Facility-Wide Groundwater Monitoring Plan (IFGMP) (LANL 2010, 109830). The monitoring at TA-54 provides the basis for accurately describing the groundwater conditions beneath TA-54, including MDA G. The monitoring well network at MDA G includes new wells drilled in 2010 that are part of the overall effort to further characterize the groundwater conditions. The groundwater monitoring network for TA-54 includes both perched-intermediate and regional wells (Figure 2.3-3).

Groundwater characterization for TA-54 is conducted with perched-intermediate well screens at R-40i, R-40 screen-1, R-23i, and R-37 screen 1, and 18 regional wells: R-20, R-21, R-22, R-23, R-32, R-37, R-38, R-39, R-40, R-41, R-49, R-51, R-52, R-53, R-54, R-55, R-56, and R-57 (Figure 2.3-3). R-22 is not currently sampled. The actively sampled wells have one or two screens, all of which are equipped with purgeable sampling systems. Table 2.5-1 shows the monitoring frequency and analyte suites specified for the active screens in these 19 wells in the 2010 IFGMP (LANL 2010, 109830). Each screen is also equipped with a dedicated pressure transducer for continuous monitoring of groundwater levels.

Data from the groundwater monitoring network around TA-54 show sporadic detections of a variety of contaminants including, most notably, several VOCs. The temporal and spatial nature of the occurrences do not, however, clearly indicate the presence of a discernable plume or a source related to MDA G or other sources at TA-54 (LANL 2009, 106939). Further evaluation of existing groundwater data in the MDA G area is included in section 3.2.5 of this report.

The regional monitoring-well network downgradient of MDA G is a system that includes redundancy and is designed to provide reliable detection of potential contaminants reaching the regional aquifer in an area of considerable hydrogeologic complexity. The wells are located both near the facility boundary and at more distal locations along the dominant regional flow direction as well as along potential local flow directions to the northeast. The locations of wells also address potential complex pathways for contaminants in the vadose zone. Because of the difficulties associated with monitoring groundwater that occurs in lavas beneath MDA G, the network is made up of two-screen wells with an upper well screen placed as close to the water table as possible to monitor the first arrival of contaminants in the aquifer and a lower screen placed in permeable aquifer sediments to monitor the primary groundwater pathways downgradient of the facility. The configuration and performance of the groundwater monitoring system downgradient of MDA G is reliable and adequate for the monitoring objectives.

3.0 SITE CONDITIONS

The following subsections summarize the current nature and extent of contamination in surface and subsurface media at MDA G.

3.1 Surface Conditions

Temporary structures to support ongoing waste management activities are present at Area G, including structures over many of the subsurface disposal units at MDA G. A very limited portion of the area is undisturbed. The surface of Area G consists of asphalt-paved roads and storage pads, graded roads, buildings, utilities, stormwater drainages, shaft caps, and vegetated pit and trench covers (Figure 3.1-1).

3.2 Subsurface Conditions

3.2.1 Subsurface Utilities

The locations of subsurface utilities are shown in Figure 3.1-1. Utilities include electricity and communication lines as well as potable water, fire water, and sewer lines.

3.2.2 Disposal Pits

The disposal pits range in depth from 8 to 65 ft and are unlined (Table 2.1-1). After a pit was filled, it was covered with approximately 3 ft of crushed tuff and a nominal 4 in. of topsoil. Native grasses were seeded in the topsoil.

3.2.3 Disposal Shafts

The disposal shafts range in diameter from 1 to 8 ft and are up to 65 ft deep (Table 2.1-3). Shafts are lined or unlined, depending on the type of waste they contain. Typically, a shaft was filled with waste to within 3 ft of the ground surface. Once it was determined that a shaft would no longer receive waste, it was backfilled with crushed tuff and plugged with approximately 3 ft of concrete, slightly rounded at the surface to form a dome.

3.2.4 Nature and Extent of Vadose Zone Contaminants

Subsurface VOC vapor plumes are present in the vadose zone at MDA G. The sources of VOC vapors at MDA G are thought to be associated with mixed wastes disposed in the pits and shafts at the site, with VOCs being a component of the waste rather than a primary waste form. The VOCS are not expected to be present in the waste disposal units as solvents in a liquid phase. The source may be ongoing because VOC vapors are emanating from mixed wastes contained in drums or other containers that limit their rate of escape.

The VOC vapor plumes differ across the site in terms of the constituents and concentrations of VOCs of which they are composed (LANL 2010, 108496). An important aspect of vapor migration is that vapors are transported predominantly by vapor-phase diffusion; in the dry environment present at MDA G, this process is faster than migration in the liquid phase.

A two-tiered-method screening evaluation was developed to identify vapor-phase VOCs that could potentially affect groundwater at concentrations exceeding applicable cleanup levels. The screening evaluation is described in Appendix C and summarized below.

- The Tier I screening method uses Henry's Law to identify the vapor-phase VOC concentration threshold that would have to be exceeded for a given VOC to potentially impact the groundwater at concentrations exceeding applicable groundwater standards. If the Tier I screening level is exceeded for a given VOC, the Tier II screen is applied. The Tier I screening method is consistent with screening performed in the pore-gas periodic monitoring reports.
- The Tier II method analysis considers the migration of the VOCs to the water table and subsequent mixing with groundwater. This analysis includes migration of VOCs through the vadose zone in both the pore water and vapor phases. The resulting groundwater concentration following mixing immediately beneath the site is calculated and compared with applicable groundwater standards. If that calculated groundwater concentration exceeds a standard, further evaluation of the soil-vapor data is required to assess the potential impact that the particular VOC may have on groundwater.

The tiered approach presented in Appendix C identified four VOC COPCs in these plumes, TCA, TCE, 1,1-dichlorethene (1,1-DCE), and PCE. Further data analysis was performed on contaminant concentration data for these four VOCs, including spatial and temporal analyses. The analysis identifies three comingled plume areas across MDA G.

- An eastern plume is present near Pits 1 through 5 that has concentrations of TCA, TCE, 1,1-DCE, and PCE that exceed Tier II screening values. This area is considered to be an ongoing source for VOC vapors, although concentrations may be declining, because concentrations remain higher than the Tier II screening values some 40 to 50 yr after disposal units in this area were closed.

- A central plume is present near Pit 6 where concentrations of TCE exceed the Tier II screening value. This area is considered to be a potentially ongoing source of limited extent for TCE vapors.
- A western plume is present near Pits 29 and 33 where concentrations of TCE exceed its Tier II screening value and near Pit 29 where TCA exceeds its screening value. This area is considered to be a potentially ongoing source of limited extent for TCE and TCA vapors.

Appendix C provides present-day mass estimates for TCA and TCE of 210 kg and 79 kg, respectively, accounting for both vapor and liquid phases. Approximately 95% of the mass of the TCA and TCE in these three plumes is within the Tshirege Member of the Bandelier Tuff, and within the 423,000 $\mu g/m^3$ and 20,000 $\mu g/m^3$ contours, respectively. These concentrations represent 10 times the screening values for these constituents, as defined in the pore-gas PMRs (e.g., LANL 2010, 109955) and the Tier I screening levels defined in Appendix C. Decreasing concentrations and masses are present in deeper units.

Inorganic chemicals, including metals, perchlorate, and nitrate, were disposed of at MDA G. These constituents migrate as waterborne constituents, and their transport is controlled by unsaturated water flow rates. As noted above, infiltration rates are low in the unsaturated zone beneath MDA G, generally less than 1 mm/yr. In addition, many metals adsorb onto mineral surfaces, causing them to migrate more slowly than the water phase. The sources of inorganic chemicals at MDA G are thought to be associated with mixed wastes disposed in the pits and shafts at the site. Inorganic chemicals were detected during the Phase I RFI work (section 2.4.2) and the 2005 site investigation (section 2.4.3.1) in core samples collected beneath and adjacent to the base of disposal pits and shafts at MDA G. The two studies showed consistent results. All inorganic chemicals detected above BVs during the 2005 study were generally less than five times the BV. In addition, all inorganic chemicals detected at levels greater than BVs were in samples from intervals containing clay-filled fractures and were at levels less than the soil BV, which was considered to be a more representative metric for comparison (LANL 2005, 090513). These results indicate little, if any, migration of metals and other inorganic chemicals from the disposal units.

3.2.5 Nature and Extent of Groundwater Contaminants

A screening protocol was implemented in Appendix D to evaluate the presence of contaminants in groundwater from wells downgradient of MDA G. Deep groundwater monitoring wells R-22, R-39, R-41, R-49, R-55, and R-57 constitute the downgradient well network specific to MDA G. For completeness, the screening protocol was also applied to wells R-23 and R-23i, which primarily monitor contaminant sources in the Pajarito watershed but are also downgradient of MDA G. The screening was conducted using a tiered approach. The first tier compared analytical data with detection status (for organics) and with groundwater background values (for naturally occurring constituents, including trace metals). The second tier compared analytical data with the lowest applicable regulatory standards or other published risk-based screening levels. The evaluation of the outcome of this screening protocol also considered factors such as frequency of detection, data for corresponding quality assurance/quality control QA/QC samples such as field duplicates and blanks, persistence, trends, and relationship to field activities at a well such as redevelopment or installation of a sampling system.

The screening protocol was applied to validated water-quality data available as of October 31, 2010. Results from at least six sampling rounds are available for most wells, with the exception of new regional wells R-55 and R-57. These two wells were completed on August 25, 2010, and June 8, 2010, respectively, and validated data are available for only one characterization event. Regional well R-22 was redeveloped between April and July 2009, and one post-redevelopment sample is available from screens 1 and 5.

The results of the screening and evaluation conducted in Appendix D indicate that there is no compelling evidence for the presence of contamination from MDA G in wells downgradient of MDA G. The majority of the organic constituents that have been detected are mostly associated with the first year of sampling following well completion or redevelopment. These organic constituents are not persistent after the first few rounds of sampling at a well, or they are detected only sporadically and near their respective detection limits.

TA-54 monitoring network wells, including those specific to MDA G, will continue to be sampled on a quarterly basis, consistent with the 2010 IFGMP (LANL 2010, 109830)) and as summarized previously in Table 2.5-1.

4.0 CONCEPTUAL SITE MODEL FOR MDA G

A conceptual site model is a representation of site conditions that conveys what is known or suspected about the sources, releases and release mechanisms, contaminant fate and transport, exposure pathways, potential receptors, and risks. Conceptual site models are developed based on analyses and interpretation of existing site knowledge, observations, and data. They describe potential contaminant sources, release mechanisms (transport pathways), exposure media that may become contaminated, and potential receptors (EPA 1989, 008021, pp. 4-10). The sources, pathways, and receptors are shown pictorially in Figure 4.0-1. A schematic diagram of the CSM that displays the release mechanisms from the sources (the disposal pits and shafts) to potential receptors and the potential risk is shown in Figure 4.0-2.

The CSM diagram describes how complete each pathway is under current site conditions and for a future scenario that includes removal of domes, utilities, and existing asphalt pads, as required by RCRA closure at the conclusion of all waste removal operations. The future scenario conservatively assumes that institutional controls are not maintained. Current and future risks are also qualitatively evaluated for the purpose of the CME.

4.1 Sources of Contamination

The primary sources of buried waste at MDA G are the disposal pits and shafts. Area G has been used as the Laboratory’s primary radioactive disposal facility since 1957. Hazardous and mixed waste was disposed of in pits and shafts at MDA G until 1990 (section 2.1). The hazardous constituents disposed of at MDA G included metals, inorganic chemicals, VOCs, SVOCs, asbestos, and PCBs. For the purposes of this CME report, the CSM is concerned with the transport and risks associated with the hazardous constituents.

4.2 Primary Release Mechanisms

Five primary release mechanisms for the waste from the pits and shafts were identified (Figure 4.0-2). These are (1) release of waste into subsurface soils by biointrusion and leaching, (2) volatilization of VOCs to become soil vapor, (3) excavation into the waste, (4) biointrusion, surface erosion, and subsidence of the waste, and (5) cliff retreat and seismic events that expose waste.

Biointrusion into the waste has the potential to spread contaminants into subsurface soils or to the surface through (1) adsorption of soluble chemicals by plant roots or (2) movement of wastes by burrowing animals. For plants common to Mesita del Buey, roots are most abundant in the upper 2 m but may extend deeper for some bushes and trees (Tierney and Foxx 1987, 006669). Burrow depths for ants and small mammals are generally less than 1 m, although a small fraction of burrows extend to 2 m

(Tierney and Foxx 1987, 006669). The crushed tuff covering the pits and shafts is subject to biointrusion, and the rooting and burrow depths cited are similar to the estimated crushed tuff thickness that currently covers the pit waste at the site. Shallow rooting plants and animal burrows are present in unpaved areas of MDA G. The site is currently mowed during the growing season, deeper-rooted plants (shrubs and trees) are removed, animal burrows are filled, and animal populations are controlled to minimize this pathway. Areas of the site that are currently covered with asphalt are less susceptible to biointrusion. Under the future conditions assumed in the CSM, which includes removal of pavement and loss of cover maintenance, deeper-rooted plant communities and larger animal populations may be established.

Leaching of waste constituents into the subsurface soils beneath and adjacent to the pits and shafts potentially began during waste disposal. During disposal, open pits collected precipitation and runoff; therefore, leaching rates were probably elevated compared with rates following pit closure. Because the shafts were routinely covered during disposal, and they have a much smaller surface area, collection of precipitation and runoff was probably minimal during disposal. Following pit/shaft closure, leaching of contaminants by water that infiltrates into the disposal units continues. Leach rates in covered units are currently expected to be controlled by infiltration rates, which are estimated to be 10 mm/yr or less in paved areas and less than 1 mm/yr in vegetated areas (section 2.2.4). Leach rates in paved areas will decrease following asphalt removal as part of RCRA closure. Investigation data indicate little if any migration of metals and other inorganic chemicals due to leaching from the disposal units (section 3.2.4. of this report and LANL 2005, 090513).

The source of VOC vapors in the subsurface at MDA G is thought to be associated with mixed wastes that have VOCs as a component of the waste rather than as a primary waste form. Volatilization of uncontainerized VOCs likely occurred predominantly into soil vapor during and soon after disposal in the pits and shafts. Volatilization from containers is believed to still occur in the pits and shafts because soil-vapor concentrations remain elevated, especially on the eastern end of MDA G (section 3.2.4). The source may still be ongoing because containers limit the rate at which vapors can escape into the surrounding fill. Volatilization of VOCs present in the waste will affect soil vapor located in fill material within the disposal units before diffusing further to subsurface soil vapor.

The third primary release mechanism is excavation, which would take place through the crushed tuff covering the pits and some shafts. However, shafts having a 3-ft concrete cover may be less susceptible to excavation. Exposure by excavation is a function of the volume and depth of waste excavated and will depend largely upon site access. Excavation into wastes is currently prohibited by site controls, but lack of these controls in the future may increase the potential for this release mechanism.

Erosion is another primary release mechanism that can expose waste. Rills and gullies sometimes form in the crushed tuff cover at the site. However, the interim cover currently has sufficient thickness to prevent waste exposure though erosion. In addition, as part of site maintenance, the interim cover is repaired if affected by erosion. Much of the site is currently covered with asphalt, which limits erosion in those areas. In the future, without site controls, erosion could degrade the cover. For the most part, surface erosion will result in a gradual thinning of the crushed tuff cover over extended periods, and eroded sediments will be transported into the adjacent canyons. However, the quantities and intensities of precipitation falling on the site will have strong impacts on the generation of surface runoff and, hence, rates and patterns of erosion (French et al. 2008, 106890).

Subsidence of the waste within the disposal units has the potential to expose wastes. Evidence of waste settling has been observed at the site and repaired as part of cover maintenance, although waste exposure due to subsidence has not occurred. In the future without site controls, subsidence will have greater potential to expose waste.

Exposure of the waste from cliff retreat is not currently observed, as the disposal units are set back from the mesa edge (Appendix E). Cliff retreat and seismic events are potential release mechanisms that may expose wastes over time (Appendix E).

4.3 Secondary Sources of Contamination

Two secondary sources, subsurface soils and soil vapor, are generated directly from primary release mechanisms (Figure 4.0-2). Direct release to surface soils is not included as a secondary source because it is assumed that solid wastes were successfully disposed of into the disposal units rather than spilled and left at the surface. However, surface soils are included as a secondary source because migration of contaminants from subsurface soils to surface soils can occur through biotic intrusion, volatilization, excavation, erosion, and subsidence.

4.4 Secondary Release Mechanisms

Several secondary release mechanisms can further spread contaminants from secondary sources toward potential receptors (Figure 4.0-2). For surface soils, these mechanisms are (1) stormwater runoff and erosion, (2) volatilization and vapor diffusion of VOCs, (3) excavation, (4) biointrusion, and (5) wind. For subsurface soils, the secondary release mechanisms are (1) leaching by percolating water, (2) volatilization and vapor diffusion of VOCs, (3) excavation, and (4) biointrusion. For soil vapor, the secondary release mechanism is diffusion. Erosion, excavation, and biointrusion affect migration for contaminants mixed with surface and subsurface soils, much like that for waste as described above, because much of the waste material is surrounded by crushed tuff.

Currently, limited contaminant transport by stormwater runoff and erosion of surface soils may occur at MDA G. For example, perimeter soil sampling results in 2006 showed heavy metals below the regional statistical reference level (RSRL) in 478 out of 483 measurements; only zinc and antimony exceeded the RSRL, each in a single sample, and their concentrations were below industrial and occupational screening limits. These pathways are more likely to be complete in unpaved areas than in paved areas because pavement prevents migration of surface soils. These pathways will become even more viable after asphalt is removed and if cover maintenance is stopped.

Volatilization and vapor diffusion of VOCs can occur from both surface soils and subsurface soils with subsequent migration in soil vapor. VOCs in waste or in pore water volatilize to form soil vapor as determined by Henry’s Law partitioning. Vapor-phase diffusion is a relatively rapid process, which, under the existing conditions (low infiltration rates), is faster than unsaturated groundwater flow and accounts for the observed migration to depth of VOCs in soil vapor within the Bandelier Tuff (Stauffer et al. 2005, 090537).

Topography plays an important role in vapor transport within Mesita del Buey. With low contaminant concentrations in the air phase along the top and sides of the mesas, the steepest concentration gradients are toward the surface, which leads to preferential VOC transport toward the external mesa boundaries and yields releases of VOCs to the atmosphere, as observed from the surface-flux survey conducted at the site (section 2.4.2). Shallow vapor-phase contaminants tend to diffuse out at the surface, while deeper vapor-phase contaminants may diffuse deeper. In paved areas, asphalt decreases this mechanism somewhat, because it blocks diffusive transport of the VOC vapors from exiting at the surface. Diffusive gradients also spread contaminants downward toward the regional aquifer. Although uniform diffusive contaminant migration is observed in the high-porosity tuff, it is uncertain whether or not diffusion through the low-porosity, fractured Cerros del Rio basalt will be uniform (Appendix C).

Vapor-phase VOCs originating from the pits and shafts are spread in soil vapor in the vadose zone; pore-gas data indicate VOC plumes from the surface to depths of approximately 200 to 250 ft (Appendix C). There appear to be three main plumes: an eastern plume near Pits 1 through 5, a central plume near Pit 6, and a western plume near Pits 29 and 33 (section 3.2.4 and Appendix C). Surface-flux measurements showed releases of contaminants to the surface across the site, with the greatest fluxes measured at the eastern side of MDA G ((Trujillo et al. 1998, 058242). Vapor-phase diffusion from the pits and shafts impacts air and may potentially impact regional groundwater in the future. Future impact is difficult to estimate because of uncertainties related to diffusive transport through the basalt.

Leaching of contaminants from the disposal units and downward migration by percolating water will continue at a slow rate because of infiltrating water at the site, as discussed in section 4.2. Travel times of nonsorbing species from the source areas to the regional aquifer in excess of several hundred years are predicted under this scenario, assuming uniform groundwater flow in the subsurface (Stauffer et al. 2005, 097432 and Appendix B of this report). When the asphalt is removed, and especially if plants reoccupy the site, leaching and percolation rates will decrease further and travel times to the aquifer will be longer. Absorbing constituents, like metals, have longer travel times than adsorbing constituents. Both vadose zone and regional groundwater data indicate that this release mechanism to groundwater is currently incomplete for both inorganic and organic chemicals.

4.5 Exposure Media

Contact with contaminated environmental media creates pathways for both human and ecological receptors (Figure 4.0-2). Seven potential exposure media are identified for the site (1) sediment, (2) surface water, (3) air, (4) soil, (5) dust, (6) groundwater, and (7) waste.

4.6 Receptors and Risk

Three potential receptors are identified (1) humans, (2) ecological receptors, and (3) groundwater. Groundwater is considered as both an exposure medium and a receptor; human and ecological receptors may be exposed to groundwater, but it is also a natural resource. Human and ecological receptors may be exposed if pathways are complete through exposure routes such as inhalation of volatile emissions in air or of dust, ingestion of contaminated media (sediment, groundwater, surface water), or dermal contact. Risks to human health and the environment may occur if elevated concentrations of contaminants are present in the exposure media. Both current and future risks are qualitatively evaluated below (Figure 4.0-2). The future risk scenario includes removal of buildings, domes, and the existing asphalt pavement that covers some of the disposal units.

Under current conditions, several transport pathways are considered to be complete or potentially complete.

- Based on field data, the sediment, surface water, and wind pathways are complete. The risk of exposure is very low because current surface and subsurface contaminant levels do not pose an unacceptable risk to human health (LANL 2005, 090513; LANL 2007, 098644).
- The air pathway is complete for VOCs. Exposure to ambient air at the site, however, does not pose an unacceptable risk to human health (LANL 2005, 090513), and VOC vapor fluxes emitted at the surface are low. Therefore, the current risk of exposure is very low.
- The completeness of the biointrusion pathway differs with depth because density of plant roots and animal burrows decreases with depth (section 4.2). It is considered to be complete for surface soils and potentially complete for subsurface soils and wastes. Site maintenance such as

mowing, removal of deeper-rooted plants, and pest control minimize biointrusion, which helps to keep the risk of exposure very low. The thickness of the interim cover helps to minimize exposure.

- The excavation pathway is considered to be potentially complete for site workers for surface soils and subsurface soils. However, excavation directly into the waste is considered to be an incomplete pathway because of current site controls. The risk of exposure is very low because of site maintenance and operational controls. For the general public, the excavation pathway is not complete.
- Erosion and subsidence directly into the waste are potentially complete pathways based on the development of erosional rills and gullies and site settling. The thickness of the interim cover and cover maintenance help to minimize exposure. Exposure risk is considered to be very low.
- All other pathways (leaching and diffusion/volatilization to groundwater and cliff retreat / seismic events) are currently considered to be incomplete.

Under future conditions, the transport processes have longer to develop and pathways may become complete. For the CSM, RCRA closure activities are assumed to be complete, and institutional controls are assumed to cease. These changes impact the following pathways and exposure scenarios. Most risks are for human health and ecological receptors unless groundwater is specified.

- Stormwater runoff and erosion of surface soils may result in complete pathways for exposure to sediment and surface water. The future risk of these pathways is considered to increase from very low to low because surface-soil concentrations may increase without site controls.
- The air pathway remains complete for VOCs. Air concentrations may increase upon removal of asphalt at the site, elevating the risk of exposure from very low (the current risk) to low.
- Wind may result in a complete pathway for exposure to dust. The future risk of this pathway is considered to increase from very low to low because surface-soil concentrations may increase without site controls.
- The potential for excavation into surface soils, subsurface soils, and waste increases in the future if people inadvertently enter the site. Exposure risks range from low/medium for surface soils to medium for subsurface soils and waste because concentrations closer to the waste are assumed to be higher. The assumed future medium exposure risk is based on uncertainty related to the inventory and concentrations of hazardous constituents in the waste.
- The completeness of the biointrusion pathway also differs with depth under future conditions because of the decreasing density of plant roots and animal burrows with depth. However, without maintenance, the surface soil will degrade and erode with time. Under the future scenario, the pathway is considered to be complete for surface soils and subsurface soils, and potentially complete for wastes. Exposure risks range from low/medium for surface soils to medium for subsurface soils and waste. The assumed future medium exposure risk is based on uncertainty related to the inventory and concentrations of hazardous constituents in the waste.
- Leaching is considered to be a potentially complete pathway. However, the period over which contaminants are predicted to reach groundwater is very long (e.g., several hundred to thousands of years), resulting in a very low risk to the groundwater resource.
- Uncertainties are associated with diffusion of vapor-phase contaminants through the basalt; therefore, there are uncertainties about the potential of vapor-phase diffusion to impact groundwater. For this reason, the future pathway is considered to be potentially complete. Vapor-phase concentrations of four VOCs (TCA, TCE, PCE, and 1,1-DCE) exceed the Laboratory-

proposed Tier II screening value (Appendix C). Because of uncertainty associated with this pathway, it is ranked as a medium risk to the groundwater resource.

- The future human health and ecological risks due to diffusion of vapor-phase contaminants to groundwater are considered to be low based on exposure to groundwater. The groundwater exposure location for receptors is not likely to occur within the bounds of Area G. Therefore, the concentrations of any contaminants reaching groundwater in the future will decrease because of dilution, dispersion, and attenuation before reaching a groundwater well.
- Erosion and subsidence may result in a potentially complete pathway to the waste. Subsurface soils or intrusion into the waste will yield higher concentrations and result in a medium risk from exposure. The assumed future medium exposure risk is based on uncertainty related to the inventory and concentrations of hazardous constituents in the waste.
- Exposure of waste from cliff retreat and seismic activities may result in a potentially complete pathway. The disposal units are located a minimum of 50 ft from the mesa edge and are not expected to be impacted by cliff retreat for more than 10,000 yr (Broxton and Eller 1995, 058207; Reneau and Raymond 1995, 054709, and Appendix E of this report), which results in a very low future risk of exposure.

4.7 Remedial Action Objectives

The CSM has identified two source types that may result in a medium future risk of exposure, the primary source (the combined pits and shafts), and the secondary source/exposure medium (soil vapor within the vadose zone). The remedial action objectives (RAOs) for these areas are as follows:

- Prevent future human health and ecological exposure to waste through excavation, biointrusion, erosion, or subsidence of the waste
- Prevent future human health and ecological exposure to contaminated surface and subsurface soils through excavation or biointrusion
- Prevent groundwater from being impacted in the future above a regulatory standard from diffusion of VOCs through soil vapor

5.0 CORRECTIVE ACTIONS AND CLOSURE REQUIREMENTS

The MDA G subsurface units are subject to a CME as outlined in the Consent Order. The LLW disposal units are subject to closure requirements under DOE Order 435.1, including long-term performance objectives for radiological protection of the public. DOE closure requirements for the LLW disposal units are addressed in Appendix F. The operating CSUs are subject to closure under the Laboratory's HWFP rather than corrective action under the Consent Order. As discussed in section 1.0 above, there are also regulated units at MDA G, which are a small subset of the MDA G SWMUs. The regulated units are subject to corrective action under the Consent Order pursuant to the alternative closure requirements in 40 CFR 264.110(c).The closure requirements for the permitted and interim-status aboveground CSUs and the regulated units are discussed below.

5.1 Permitted and Interim-Status Container Storage Units

The closure performance standards for the permitted and interim-status aboveground CSUs include minimizing the need for further maintenance, controlling any postclosure escape of hazardous waste or constituents to the extent necessary to protect human health and the environment, and complying with applicable regulatory standards.

There are eight permitted CSUs currently operating on the surface of Area G. They include six large asphalt pads (Pads, 1, 3, 5, 6, 9, and 10) with storage domes and two buildings (54-8 and 54-33). These CSUs include both permitted and interim-status units, depending upon their operational dates, although all are incorporated in the proposed HWFP (likely to be issued to the Laboratory in late 2010) and are therefore subject to the 40 CFR 264, Subpart G and I closure standards. These surface units must be closed before subsequent closure activities for the MDA G subsurface SWMUs and regulated units may be completed under the Consent Order. The proposed permit contains detailed closure plans for the surface units, including the removal of the storage structures and the asphalt pads, and sampling and analysis procedures for the underlying soil. If the remaining soil cannot be demonstrated to be decontaminated to the levels contained in the closure plans, further closure activities for these units may be coordinated with the closure activities undertaken for corrective action at MDA G by the Consent Order as described in the proposed permit.

5.2 Regulated Units and Solid Waste Management Units

Pit 29 and Shafts 124, 145, and 146 are regulated units. Pit 29 is 600 ft long and 30 ft deep and received nonliquid waste. Shaft 124 is 6 ft in diameter and 65 ft deep and was used for disposal of solid radioactive wastes but included approximately 1 ft^2 of hazardous wastes made up of organic liquids and vials. Shafts 145 and 146 are identical in construction, consisting of 6-ft-diameter shafts augured to a depth of 60 ft. The shafts served as containment systems for the containerized mixed waste stored in each shaft. As discussed in section 1.0 above, regulated units will be closed under alternative closure requirements established under the Consent Order rather than the closure requirements of 40 CFR 264 Subparts G and N. The alternative closure requirements will be established using the CME process for MDA G contained in Section VII.D of the Consent Order. Upon NMED's selection of the remedy for MDA G, the Laboratory will prepare and submit a corrective measures implementation (CMI) plan. The CMI plan will fulfill the requirements for a closure plan and postclosure plan for the regulated units, as specified in 40 CFR Part 264, Subparts G and N.

The cleanup and screening levels described in Section VIII of the Consent Order (Table 5.3-1) were followed in this CME to determine the recommended corrective measure alternative. The cleanup levels are based on the New Mexico Water Quality Control Commission's (NMWQCC's) groundwater and surface water standards and NMED's cleanup levels for protection of human health and are consistent with the EPA's National Oil and Hazardous Substance Pollution Contingency Plan, 40 CFR Section 300.430(e)(2)(i)(A)(2).

NMED selected a human health target risk level of 10^{-5} and a hazard index (HI) of 1.0 as cleanup goals for establishing site-specific cleanup levels for one or more contaminants for which toxicological data are published. NMED and the EPA have soil screening levels (SSLs) and maximum contaminant levels (MCLs), and the NMWQCC has adopted groundwater and surface-water standards that are described below.

Screening for ecological risk to determine the recommended corrective measure alternative used the ecological screening levels (LANL 2004, 087630; LANL 2005, 090032) and the information contained within the ECORISK Database, Version 2.1 (LANL 2004, 087386).

5.2.1 Soil

NMED specified SSLs that are based on a target total excess cancer risk of 10^{-5} and, for noncarcinogenic contaminants, a target HI of 1.0 for residential and industrial land use. Residential and industrial soil screening levels are from NMED's "Technical Background Document for Development of Soil Screening Levels, Revision 5.0" (NMED 2009, 108070). If an NMED SSL has not been established for a contaminant for which toxicological information is published (NMED 2009, 108070), the Laboratory uses the most recent version of the EPA Region 6 human health medium specific screening level for residential and industrial soil.

If an excavation alternative is selected, these SSLs will be used as cleanup levels as specified in the Section VIII.B.1 of the Consent Order.

5.2.2 Groundwater

The selected corrective measure alternative will be required to meet the groundwater-quality standards given in Section VIII.A of the Consent Order. These standards include the NMWQCC groundwater standards, including alternative abatement standards (20.6.2.4103 NMAC), and the drinking water MCLs adopted by EPA under the federal Safe Drinking Water Act (42 U.S. Code Sections 300f to 300j-26) or the Environmental Improvement Board (20.7.10 NMAC). If both an NMWQCC standard and a MCL have been established for an individual substance, then the lower of the two levels is considered the cleanup level for that substance.

If there is not an MCL or NMWQCC standard, the Laboratory will use the NMED tap water screening levels (NMED 2009, 106420). If there is no NMED tap water screening level, the Laboratory will use EPA regional tap water screening levels (http://www.epa.gov/region06/6pd/rcra_c/pd-n/screen.htm), adjusted to the 10^{-5} risk for carcinogens. If no NMWQCC groundwater standard or MCL has been established for a contaminant for which toxicological information is published, then the Laboratory will use a target excess cancer risk level of 10^{-5} and/or an HI of 1.0 as the basis for proposing a cleanup level for the contaminant. If the naturally occurring (background) concentration of a contaminant exceeds the standard, then the cleanup goal defaults to the background concentration for that specific contaminant.

5.2.3 Surface Water

No permanent surface water is present at MDA G, and MDA G does not have discharges of pollutants to surface water subject to a permit under Section 402 of the federal Clean Water Act. Therefore, the surface-water cleanup levels contained in Section VIII.C of the Consent Order are not applicable to corrective measures at MDA G.

5.2.4 Pore Gas

The Consent Order does not specifically address cleanup standards, screening levels, or other regulatory criteria for pore gas. The Laboratory therefore recommends a two-tiered screening approach to screen vapor-phase VOCs detected in the vadose zone. A screening method that compares vapor-phase concentrations with screening values is presented in the periodic monitoring reports for vapor-sampling activities (e.g., LANL 2010, 109955) and is discussed below as a Tier I screening evaluation. Because several VOCs exceed the screening value at MDA G, a two-tiered method was applied to identify vapor-phase VOCs and vadose zone pore-gas concentrations that could potentially affect groundwater at concentrations exceeding applicable cleanup levels (Figure C-1.0-1, Appendix C). The screening process uses all data from a select period of record and is initially inclusive of constituents with low frequency of detection or other variables that are considered later in the screening process as part of an uncertainty analysis. The screening approach is described in section 3.2.4 and demonstrated in Appendix C using the most recently reported soil-vapor monitoring data from MDA G. The Tier I methodology is extremely conservative and does not consider dilution or attenuation. If Tier I screening levels are not exceeded, VOCs would not be able to contaminate groundwater above cleanup levels, and no further screening is necessary. If Tier I screening levels are exceeded, the less conservative Tier II screening approach is applied (see Appendix C).

5.3 Toxic Substances Control Act

PCBs are managed under the TSCA. The TSCA gives the EPA the authority to develop, implement, and enforce regulations concerning the use, manufacture, cleanup, and disposal of PCBs.

5.4 Consent Order CME Evaluation Requirements

Consent Order specified evaluation criteria were used in this report to select the recommended corrective measure alternative for MDA G subsurface units. Sections VII.D.4.a and VII.D.4.b of the Consent Order provide threshold and balancing criteria for screening and evaluation of prospective corrective measures, respectively. These criteria are listed below in sections 5.4.1 and 5.4.2. Figure 5.4-1 presents a flow chart of the selection process used to determine the recommended corrective measure alternative. Corrective measure alternatives that passed both the screening and evaluation phases were evaluated with a final set of criteria described in Section XI.F.11. These criteria are listed in section 5.4.3.

5.4.1 Threshold Criteria

All technologies were screened based on the threshold criteria described in Section VII.D.4.a of the Consent Order. To be selected, the technology must

1. be protective of human health and the environment;
2. attain media cleanup standards;
3. control the source or sources of releases so as to reduce or eliminate, to the extent practicable, further releases of contaminants that may pose a threat to human health and the environment; and
4. comply with applicable standards for management of waste.

5.4.2 Balancing Criteria

Section VII.D.4.b of the Consent Order identifies five evaluation criteria against which each technology will be evaluated. The criteria are to be balanced in proposing a recommended alternative. The criteria are as follows:

1. long-term reliability and effectiveness
2. reduction of toxicity, mobility, or volume
3. short-term effectiveness

4. implementability
5. cost

5.4.3 Selection Criteria

A recommended alternative was proposed, based on evaluating the technologies and combining the highest-ranked technologies by source area (pits and shafts, vadose zone). Compliance of this alternative with a final set of criteria described in Section XI.F.11 of the Consent Order is detailed in section 9 of this report. The criteria used in the description of the final selection were as follows:

1. achieve cleanup objectives in a timely manner
2. protect human and ecological receptors
3. control or eliminate the sources of contamination
4. control migration of released contaminants
5. manage remediation waste in accordance with state and federal regulations

The justification for the recommended corrective measure alternative includes the supporting rationale for the remedy selection based on the factors listed in sections 7 and 8, a discussion of short- and long-term objectives for the site, and the benefits and possible hazards of the alternative.

6.0 IDENTIFICATION OF TREATMENT TECHNOLOGIES

Section 6.1 describes the process used to identify treatment technologies, and section 6.2 describes the screening of treatment technologies for MDA G. The technologies retained for further evaluation in the process described in section 6.2 are summarized in section 6.3 and carried forward to section 7 for screening against the threshold criteria.

6.1 Evaluation of Treatment Technologies

General types of corrective measures technologies potentially applicable to MDA G site conditions and waste types were selected from the comprehensive technology list developed by the Federal Remediation Technologies Roundtable (FRTR 2009, 104730, Table B-1), available at http://www.frtr.gov/matrix2/section1/list-of-tables.html).

For wastes disposed at MDA G, potentially appropriate technologies fall into the four general categories listed below:

- containment
- in situ treatment
- excavation/retrieval
- ex situ treatment

Within the containment category, the subcategories evaluated are vertical barriers, deep and near-surface horizontal barriers, and surface barriers. Within the treatment categories, the subcategories include biological, chemical, physical, and thermal treatment. The excavation/retrieval technology will require either on-site or off-site waste disposal.

The majority of waste disposed at MDA G was LLW. Pre-1970 TRU and MLLW were disposed at MDA G, but extensive liquid hazardous waste was not disposed at MDA G. Although there is a vapor-phase VOC plume in the subsurface of MDA G, there is not a discrete source of liquid VOCs in the pits and shafts. The screening of technologies is focused on (1) containment, in situ treatment, excavation/retrieval, or ex situ treatment of the hazardous waste component of the MLLW in the pits and shafts and (2) in situ treatment of the VOC plume in the vadose zone.

6.2 Screening of Technologies

Corrective action guidance from EPA (1994, 095975, p. 58) and DOE (1993, 073487, pp. 4-51-4-52) requires that potential corrective measures technologies be examined to eliminate those technologies that prove to be impractical to implement, that rely on technologies not likely to perform satisfactorily or reliably, or that do not achieve the corrective action objectives within a reasonable time frame. When comparable technologies provide similar benefits, cost is often also used as a screening tool.

For the MDA G CME, the screening of technologies included the following:

- review of site and characterization data and the CSM to identify conditions that may limit or promote the use of certain technologies
- identifying the waste characteristics that limit the effectiveness or feasibility of technologies
- determining the level of technology development, performance record and inherent construction, and the operations and maintenance (O&M) challenges for each technology considered

6.2.1 Containment Technologies

Containment technologies are intended to limit migration of contaminants or limit infiltration into the vadose zone. Such technologies may include surface and subsurface barriers, and various orientations and compositions of barriers may be used. The general functionality and potential applicability of each containment technology considered at MDA G are discussed below.

6.2.1.1 Vertical Barriers

Vertical barrier technologies are considered of limited benefit for MDA G applications because the absence of near-surface groundwater at the site already limits lateral migration of most contaminants. Limiting the lateral component of vapor-phase transport of a limited number of volatile contaminants at the site is one potential application for vertical barriers at MDA G. However, modeling indicates that vertical barriers may enhance downward migration of volatile contaminants and, as a result, may have a higher potential to impact groundwater.

The following vertical barrier technologies were considered when preparing the CME:

Slurry Wall/Grout Curtain

Slurry walls are formed using slurried bentonite clays or cement-grout or other barrier materials placed in narrow, deep trenches or in a series of adjacent open boreholes surrounding the perimeter or at the migrating edge of a disposal site. Slurry walls are commonly used to intercept contaminants that migrate laterally. The arid environment at MDA G is not compatible with the use of bentonite clays, which become cracked and permeable when desiccated, and the porous nature of grout materials would not significantly impede vapor-phase transport of volatile contaminants at MDA G. Additionally, downward migration of contaminants may be enhanced by this type of technology. The slurry wall/grout curtain technology was not retained.

Rock-Grout Mixing

Rock-grout barriers are formed by drilling adjacent deep shafts on the perimeter of a disposal site and then mixing the cuttings with injected grout in the shaft. Like slurry walls, rock-grout mixing is used to intercept contaminants that migrate laterally. The porous nature of grout materials would not impede vapor-phase transport of volatile contaminants of concern at MDA G. Additionally, downward migration of contaminants may be enhanced by this type of technology. The rock-grout mixing technology was not retained.

Synthetic Membrane

A synthetic membrane, such as a geosynthetic liner, can be placed in a vertical trench. The membrane forms a barrier that restricts the lateral migration of contaminants. Although this technology may be adapted to impede lateral migration of vapor-phase contaminants at MDA G, the potential to enhance downward migration of these contaminants is an issue. The synthetic membrane technology was not retained.

Reactive Barrier

A chemically active material can be placed in a vertical orientation around the waste disposal area, or the reactive materials can be incorporated into another barrier technology. The reactive chemical, such as zero-valence iron or activated carbon may be chosen for the capability to absorb or chemically degrade VOCs. However, since reactive barriers have been demonstrated only with liquid phase and not the vapor phase, their applicability to MDA G is uncertain. The reactive barrier technology was not retained.

6.2.1.2 Deep Subsurface Horizontal Barriers

The purpose of a deep subsurface horizontal barrier is to contain downward aqueous-phase contaminant transport and is generally suitable for sites with known aqueous-phase releases and/or climates with significant infiltration from the surface. Bottom barriers are horizontal subsurface barriers (i.e., underground barriers that run parallel to the surface) that prevent vertical migration by providing a floor of impermeable materials beneath the waste.

Forced Grout Injection

The installation of a grout injection barrier under the pits and shafts involves directional drilling with forced grout injection. Implementation of this technology is highly dependent on the physical properties of soil underlying the waste. Groundwater monitoring data have not demonstrated that aqueous-phase liquids are presently being released, and the pore-gas VOCs can be recovered with pore-gas extraction technologies. In addition, the heterogeneity of the subsurface strata would make it very difficult to form a solid barrier. Based upon these limitations, forced grout injection, specifically deep subsurface horizontal barriers, was not retained as a source-control technology at MDA G.

6.2.1.3 Near-Surface Horizontal Barriers

Near-surface horizontal barriers created by a soil-grout mixture or vitrification could potentially provide protection from exposure by controlling intrusion into the waste by plants, animals, or people. Additionally, these barriers could limit the transport of contaminants by reducing infiltration of water through the waste. The following horizontal barrier technologies within this category were considered:

Soil-Grout Mix

A concrete-grout mixture containing soil or crushed tuff was considered as an alternative to replace a subsurface portion of the existing cover materials over the MDA G pits and shafts. Although this barrier may be safely constructed and has the potential to decrease permeability to water and/or penetrability by plants and animals, this type of barrier does not provide water storage for evapotranspiration. Rainfall that does not infiltrate the soil-grout mix will move to the edges of the treated area where it will infiltrate, creating focused recharge and increased infiltration in that area. The soil-grout mix technology was not retained.

Vitrification

In situ vitrification is the process of using electrical resistance to heat soil or rock to temperatures high enough to melt them. Soil temperatures during this process range from 2900°F to 3650°F (1600°C to 2000°C). When the melted materials cool, a glass-like material forms. In situ vitrification produces an impermeable, impenetrable horizontal barrier and has been demonstrated to a depth of 30 ft (9.1 m) at TA-21. Current operational cover soils at MDA G are limited to 3.3 to 13 ft (1 to 4 m) thick over the disposed waste. To act as a horizontal barrier over the waste units, the technology will have to be deployed in existing operational cover soils or in materials to be added as part of a more comprehensive cover system at MDA G. The in situ vitrification horizontal barrier technology was not retained.

6.2.1.4 Surface Barriers

Barriers placed on the surface of disposal sites provide protection against the infiltration of water; provide resistance to water and wind erosion; prevent or minimize intrusion into wastes by plants or animals; act as a deterrent to inadvertent human intrusion; and, limit flux of gas-phase contaminants. The existing surface barriers at MDA G have proven effective. Enhancements to existing covers could readily allow MDA G to meet the evaluation criteria for protecting human health and the environment. Cover system design guidance has also been developed that provides requirements and considerations for implementation at the Laboratory. Enhancements would likely be drawn from the following readily available surface barrier technologies.

Asphalt Cover

Asphalt provides a substantial barrier to surface erosion processes but has been shown at another Laboratory site, MDA AB Area 2 at TA-49 (LANL 1999, 063918, p. 22), to trap moisture that will otherwise be evaporated or transpired from the subsurface. Such trapped moisture could induce transport of contaminants to the groundwater. As maintaining low moisture content is a desirable feature for MDA G, an asphalt cover is not suitable for this site. The asphalt cover technology was not retained.

Compacted Clay Cover

Compacted clay covers have successfully controlled excess infiltration at RCRA-regulated landfills located in humid environments. However, clay liners are far less effective in arid and semiarid climates because the clay tends to dry out and crack, allowing moisture to flow directly into disposal units (Mulder and Haven 1995, 071297, p. 7). Because of potential dessication, compacted clay covers are not suitable for MDA G, and the clay cover technology was not retained.

Multilayer Cover (RCRA Cover)

Multilayer covers consist of layers of different geologic and synthetic materials layered in specific order to control various potentially detrimental processes and conditions at a site (e.g., infiltration, erosion, and biointrusion). RCRA Subtitle C covers fit within this category. This technology was evaluated even though the regulated units at MDA G are being addressed under the Consent Order using alternative closure requirements. Multilayer covers can be compromised if differential settlement occurs or if any of their components is not suited for the site. At sites with the potential for differential settlement, application of conventional multilayer caps is problematic. Such sites include those where significant waste has been placed at depth without uniform compaction or sites where clay components would become desiccated and crack.

At MDA G, the variation between settlement potential of excavated disposal units and surrounding geologic structures would be dramatic, and deeper waste units might have the greatest potential to settle. Although subsidence at MDA G would potentially be a long-term occurrence, its impact on the synthetic or geosynthetic membrane component(s) of a multilayer cover would be significant and could remain unnoticed from the surface. The arid nature of the climate at Los Alamos is also considered incompatible with typical clay-component layers of the RCRA Subtitle C multilayer cover because of the cracking that occurs in clays with desiccation in a semiarid environment. Based upon concerns associated with desiccation of the clay layer in the arid environment, and potential deep-waste settling and its associated impact on geomembrane performance, this technology was not retained

Evapotranspiration Cover

Evapotranspiration (ET) covers are designed to provide infiltration protection for arid and semiarid environments, where materials such as clays and synthetic/geosynthetic membranes are less reliable. ET covers may consist of multiple layers of geologic materials suited to achieve the ET criteria. Suitable vegetation is a significant component for most ET covers to aid in the dewatering of the cover material(s). The vegetated ET cover was developed specifically for landfills located in arid and semiarid environments such as Los Alamos (Barnes et al. 1990, 070209, pp. 1201–1202). The earliest research in this area was conducted at Los Alamos at a test site within 1 mi of MDA L (Nyhan et al. 1984, 008797; Nyhan 1989, 006876; Nyhan et al. 1989, 006874).

The Los Alamos climate’s demand for water or potential ET far exceeds the actual supply of water (precipitation) (Figure 2.3-2). The ET cover provides for a deeper-rooting medium, thus providing an opportunity for native vegetation to survive lengthy periods of drought. This technology was retained for further consideration for the pits and shafts at MDA G.

Vegetative Cover

A vegetative cover consists of a soil cap supporting native vegetation. The vegetative cover is constructed over the disposal unit to protect it from erosion and to reduce the amount of water that may infiltrate from the surface. The vegetative cover typically has at least two layers of different soil types. The lower layer, directly above the impoundment, is finer grained, has higher density, and has lower permeability, than the soil above. The purpose of this layer is to inhibit surface water from seeping into the waste zone. The upper soil layer consists of coarser materials, has lower density, and has higher permeability than the soil below. The purpose of this layer is to encourage plant growth. This two-layered soil cap would be seeded with native vegetation once in place. Vegetation is often used in combination with other best management practices: protecting the soil from erosion along diversion ditches and on areas that have been regraded and/or capped. The vegetative cover technology was retained for the MDA G pits and shafts.

Biotic Barriers

Various materials have been used to control the intrusion of plants and/or animals into hazardous landfills. Installation of horizontal barriers constructed of cobble-sized rock to pea gravel inhibits deep-rooting plants and discourages burrowing animals. Chain-link fencing laid on the surface of a cover has been successfully used at a Laboratory site to discourage burrowing animals, while having no observable impact on beneficial vegetation (LANL 1999, 063919). Either of these biobarriers, i.e., rocks/gravel or chain-link fences, could be used as a standalone technology or could be incorporated into enhanced cover designs considered for MDA G. The biotic barrier technology was retained for consideration and application at the MDA G pits and shafts.

Flexible Membrane Liner

Flexible membrane liners or geomembranes are thin, flexible, impermeable liners that are combined with base soil to reduce seepage. The geomembrane is a synthetic material that offers very little structural capacity. It relies on a properly constructed subgrade and careful installation to provide optimum results which would be difficult to implement with potential for long-term settling of the site. The geomembrane is covered with a soil layer to protect the liner from physical abrasion as well as to prevent photodegradation. This technology is suitable for controlling atmospheric releases of VOCs, thereby preventing exposure to workers. However, sites with potential for long term settling pose implementation difficulty, and the impermeable membrane may enhance the downward migration of VOCs. The flexible membrane technology was not retained.

Concrete Cap

A concrete cap is a single layer of concrete placed over a disposal unit to form a surface barrier that restricts human and ecological exposure to the waste. Moisture trapped under the cap may induce transport of contaminants to the groundwater. Additionally, the size of the cap required to cover the MDA G disposal unit has a high potential for cracking, thus limiting its effectiveness. The concrete cap technology was not retained.

6.2.2 In situ Treatment Technologies

In situ waste treatment technologies are used to reduce the mobility and/or toxicity of wastes or to increase their stability without removing the wastes from their disposal location. In situ treatment generally requires longer time periods, and there is less certainty about the uniformity of treatment because of the variability in soil and aquifer characteristics and because the effectiveness of the process is more difficult to verify. The benefit derived from most in situ treatments over ex situ treatment options is the reduction in exposure potential for workers. The decision to use in situ treatment may vary from waste unit to waste unit in MDA G, based on the types and orientations of wastes, their potential to produce future risks, and the availability of other options. The different in situ methods (i.e., biological, chemical, physical, and thermal) discussed in this section may be appropriate for some, but not all, contaminants or disposal environments.

Monitored Natural Attenuation

Monitored natural attenuation (MNA) uses natural subsurface processes to reduce contaminant concentrations to acceptable levels. The natural attenuation processes include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil, soil vapor, or groundwater. These in situ processes include adsorption, biodegradation, dispersion, dilution, sorption, volatilization, radioactive decay, chemical reactions (oxidation or reduction), and chemical or biological stabilization.

Consideration of the MNA technology requires evaluation of contaminant degradation rates and products, as well as prediction of contaminant concentration at downgradient receptor points. The primary objective is to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards or risk-based levels before potential exposure pathways are completed. In addition, long-term monitoring is conducted to measure degradation rates to evaluate compliance with cleanup objectives. Commonly targeted contaminants for MNA include VOCs, SVOCs and fuel hydrocarbons. This technology may be applicable to the VOCs in the vadose zone. Based upon potential benefits, the MNA technology was retained for further consideration for application in the vadose zone.

6.2.2.1 Biological Treatment Technologies

Biological methods, using various microorganisms and vegetation, have been effective in metabolizing a variety of organic contaminants and also in changing the solubility of certain inorganic chemical and radioactive species in low concentrations during the wastewater treatment processes. These technologies are not effective in treating halogenated SVOCs, including PCBs. Potential in situ biological treatment technologies including bioventing, enhanced bioremediation, and phytoremediation are discussed below.

Bioventing

Bioventing is an in situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents (typically aromatic hydrocarbons are most amenable to this technology) adsorbed on soil particles in the vadose zone. Induced air flow into the soil, and if necessary, nutrient addition, enhances the activity of indigenous bacteria and stimulates the natural in situ biodegradation of aromatic hydrocarbons in the soil. During bioventing, oxygen may be supplied through direct air injection into residual contamination in the soil. However, uniform delivery of supplements into the contaminated soil poses significant difficulties. The dry soils present at MDA G reduce transport of necessary nutrients to the target zones. Biological treatment is also less viable for many chlorine-containing organic chemicals and/or may lead to more toxic byproducts than the original contaminant (e.g., TCE to vinyl chloride), both of which are present at MDA G. The bioventing technology was not retained.

Enhanced Bioremediation

Enhanced bioremediation is a process in which indigenous or inoculated microorganisms (e.g., fungi, bacteria, and other microbes) degrade (e.g., metabolize) organic contaminants found in soil and/or groundwater, thereby converting them to innocuous end products. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials. This technology has the same requirements and challenges as bioventing. The enhanced bioremediation technology was not retained.

Phytoremediation

Phytoremediation is a bioremediation process that uses various types of plants to remove, transfer, stabilize, and/or destroy contaminants in the soil and groundwater. Contaminants are often transferred to the plant tissue from the soil and/or groundwater. Generally, the use of phytoremediation is limited to sites with lower contaminant concentrations and contamination in shallow soils, streams, and groundwater. The success of remediation depends in establishing a selected plant community. However, introducing new plant species can have widespread ecological ramifications that should be considered beforehand. If implemented, the site should be monitored frequently to manage the introduced species and prevent it from becoming invasive. Additionally, the establishment of the plants may require several seasons of irrigation. It is possible that extra mobilization of contaminants in the soil and from the groundwater may occur during this start-up period. It is undesirable for plants to bring radionuclides to the surface. The phytoremediation technology was not retained.

6.2.2.2 Chemical Treatment Technologies

Chemical treatment uses the physical properties of the contaminants or the contaminated medium to destroy (i.e., chemically convert), separate, or contain the contamination. Two chemical treatment technologies are evaluated below.

Chemical Oxidation

Oxidation chemically converts hazardous contaminants to nonhazardous or less-toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. This technology was not considered applicable to the MDA G site because there is not a discrete source of liquid hazard waste in the pits and shafts. There are difficulties in delivering the reactive chemicals uniformly to large areas of the vadose zone where concentrations are low. Managing, storing, and delivering large quantities of hazardous oxidizing materials poses additional concerns for workers and the environment. Based upon these concerns, the chemical oxidation technology was not retained.

Soil Flushing

In situ soil flushing is the extraction of contaminants from the soil with water or other suitable aqueous solutions. Soil flushing is accomplished by passing the extraction fluid through in situ soils using an injection or infiltration process. Extraction fluids must be recovered from the underlying strata and, when possible, recycled. Adding extraction fluids to the vadose zone that would have to be removed from groundwater is contrary to the intent of this CME. The soil flushing technology was not retained.

6.2.2.3 Physical Treatment Technologies

In situ physical treatment technologies are a diverse group of technologies that include methods to remove mobile contaminants; increase the mobility of contaminants; further stabilize contaminants; and, destroy contaminants in place. The following discussion presents the in situ physical treatment technologies considered for MDA G.

Soil-Gas Venting

Soil-gas venting consists of drilling open boreholes into the contaminated matrix to allow the release of subsurface vapors and gases to the atmosphere. Soil-gas venting uses ambient meteorological conditions to extract vapor-phase contaminants. Pore gas is naturally pumped out of the vadose zone as a result of the difference between the atmospheric barometric pressure and the soil pressure in the near subsurface. No wellhead control device is used for this technology. This technology is primarily applicable to VOCs. The soil-gas venting technology was retained for further consideration for application in the vadose zone.

Soil-Vapor Extraction

This technology uses vacuum blowers to accelerate the removal of subsurface gases or vapors. The blowers create a negative pressure or vacuum in one or more boreholes. The vacuum removes the gases or vapors from boreholes by advective transport. This technology commonly requires a treatment system for the contaminated vapor that is extracted from the subsurface. At low concentrations, passive SVE may be more effective. Passive SVE is a pore-gas remediation technology that uses ambient meteorological conditions to extract vapor-phase contaminants, primarily VOCs and methane, from the vadose zone. As with soil venting, pore gas is naturally pumped out of the vadose zone as a result of the difference between the atmospheric barometric pressure and the soil pressure in the near subsurface. Passive SVE can be enhanced with a wellhead control device that restricts the inward flow of ambient air into the subsurface under high atmospheric barometric conditions, allowing only outward flow of air. The SVE pilot test conducted in the eastern plume area (west of Pits 2 and 4) in 2008 apparently caused a long-term (over a 10-mo period) reduction in the plume within the ROI of the extraction well in terms of decreasing the mass and the maximum concentration of TCA vapor locally (LANL 2010, 109657). This indicates that periodic SVE can control and even decrease plume growth by lowering overall concentrations and removing VOC mass. The two SVE pilot studies conducted at MDA G in 2008 and 2010 (LANL 2009, 105112; LANL 2010, 109657) support retaining this technology for further consideration.

Pneumatic Fracturing

Pneumatic fracturing uses the injection of a fluid under pressure to create open fractures in the area where a contaminant plume exists. Opening subsurface flow paths allows access to the contaminated media for removal or treatment. Since pneumatic fracturing has the potential to introduce large amounts of water into a formation that has optimal low moisture content, it is not desirable. Pneumatic fracturing has limited benefit and poses added risks at MDA G. Pneumatic fracturing is not an appropriate technology for use at MDA G and was not retained.

Electrokinetic Soil Treatment

Electrokinetic soil treatment is an in situ process for the continuous removal of ionic or charged species from soils, including heavy metals, radionuclides, and ionized organic chemicals. The technology is implemented by passing a direct current through the soil. Electrokinetics is most applicable in low-permeability soils. Low-permeability soils are typically saturated or partially saturated clays and silty-clay mixtures and are not readily drained. The effectiveness of this technology is dramatically reduced in low soil-moisture applications, such as at MDA G, and the use of direct current in the vicinity of the waste unit is problematic because of buried metal objects. The electrokinetic soil treatment technology was not retained.

Electroacoustic Treatment

In situ electroacoustic treatment is an emerging technology used to decontaminate soils containing organic chemicals. As with electrokinetic soil treatment, this technology is most applicable in low-permeability soils. The effectiveness of this technology is reduced in low soil-moisture applications. Given the low vapor-phase concentration of organic contaminants, the electroacoustic treatment technology was not retained.

Dynamic Compaction

Dynamic compaction is used to compact and consolidate wastes in place to reduce the potential for settling or sinking over time. The technology has been successfully demonstrated on landfills where subsidence (e.g., settling) over large areas is likely, and where waste is near the surface and of a homogeneous waste form (EPA 2002, 102739, p. 1). Dynamic compaction may adversely affect existing waste forms. Based upon the potential of a release from breached waste forms, the dynamic compaction technology was not retained for further consideration.

Jet Grouting

Jet grouting employs high-pressure injection of a cementitious grout slurry into a soil strata to hydraulically mix the in situ material with the grout. The grout slurry is injected into and/or around the waste to fill void spaces and to reduce the porosity within and between buried objects. The objective of this treatment is to stabilize the waste form, to reduce the infiltration and movement of surface water into and through the waste, and to reduce the future potential for subsidence of waste and overburden. One method involves injecting group into holes drilled through the waste while simultaneously pulverizing the waste and mixing it with the grout. This approach is applicable only for homogeneous soil-like wastes.

A second waste stabilization method involves the direct injection of grout into void spaces surrounding the waste. A pipe or auger is drilled into the subsurface and slowly rotated and pressurized. The high pressure (4000–13,000 psi) forces the grout out laterally through special ports on the sides of the pipe or auger. The slurry exits the jet port at very high velocity, penetrating the soil several inches to several feet. The rotating jets destroy soft soil formations and mix the native soil with cement. Finally, the rotating pipe/auger is drawn slowly upward at a controlled rate to create a nearly cylindrical column of treated soil.

The waste material in the pits and shafts ranges from 8 ft to 65 ft bgs. Use of high pressure at the shallower depths could be hazardous to workers and a breach of the pits and/or shafts. The jet grouting technology was not retained.

6.2.2.4 Thermal Treatment Technologies

Thermal treatment technologies have been developed and implemented to decompose heat-sensitive contaminants into less toxic or less mobile forms or to enhance the extractability of a contaminant by heating it into a vapor phase. Heat is generated or delivered using several types of radiation (e.g., microwave, radio frequency, or thermal) or using direct conductance of electricity or injection of already heated materials (e.g., steam). Some of these treatment technologies are discussed below.

Thermal Treatment

In situ heating of waste media at MDA G by steam or hot-air injection, electrical resistance, electromagnetic, fiber-optic, or radio frequency is used to increase the volatilization rate of volatiles and to facilitate extraction. Both halogenated and nonhalogenated VOCs and SVOCs respond favorably to thermal treatment. However, the source of VOCs is diffuse in the pits and shafts at MDA G. Thermal treatment is ineffective for inorganic chemicals and radionuclides . This treatment technology is also costly because of energy consumption and capital equipment requirements. Debris or large buried objects possibly present within MDA G subsurface waste units could cause the level of effectiveness of this technology to be inconsistent (EPA 1996, 102748, p. 4). The thermal treatment technology was not retained.

Vitrification

Several in situ vitrification technologies exist for solidifying waste masses in the ground. In situ vitrification uses electrical resistance to heat soil or rock (and waste materials) to melting temperatures. When the melted materials cool, a glass-like material is formed. In situ vitrification produces an impermeable mass. Competing vitrification applications achieve waste stabilization by alternative techniques. The *surface-down melt-in* method has the potential to trap volatilized gases under a molten waste/matrix and has been prone to catastrophic release in some situations. An alternative method that melts waste and matrix between two electrodes at all depths simultaneously has been shown to achieve similar results more safely. Electrodes are sequentially moved to create multiple melt planes in parallel until the necessary application coverage is achieved. This technology has been demonstrated to successfully vitrify materials only to depths of 30 ft at TA-21. The MDA G pits and shafts extend to 65 ft bgs. There are currently no systems capable of achieving vitrification to 65 ft bgs. Based upon these potential risks and limitations, vitrification technology was not retained.

6.2.3 Excavation/Retrieval Technologies

Excavation/retrieval is a viable technology applicable for some of the waste in MDA G subsurface units. The potential for excavation and retrieval of materials at MDA G varies greatly among waste units because of the following issues:

- potential long-term environmental risk from in situ waste versus increased short-term risk during excavation;
- disposal requirements at an off-site treatment, storage, and disposal (TSD) facility, including waste analysis, segregation, temporary storage, and shipping;
- the existence of a permitted facility that can accept the waste.

Various options for excavation and disposal methods are evaluated below.

6.2.3.1 Excavation/Retrieval

Excavation

Excavation is the primary option for removing waste from the MDA G subsurface units. Waste in the larger disposal areas (i.e., pits) of MDA G would require large-scale soil moving and excavating equipment (remotely operated, if necessary); remotely operated grappling devices; and containerization tools to safely remove the waste from the subsurface. The current overburden would be removed and the waste retrieved, sorted for characterization, and manually repackaged to new waste containers for waste treatment, and/or on-site or off-site disposal.

Trench excavation techniques are a viable option for removing some of the shaft waste at MDA G. The MDA G shafts would be accessed by excavating a large trench alongside shafts, thereby making removal by backhoe and crane possible. This technology has already been used at MDA G to excavate trenches to a maximum depth of 65 ft (19.8 m) in unit 2 of the Bandelier Tuff. The waste would then be retrieved, sorted for characterization, and manually repackaged to new waste containers for waste treatment and/or on-site or off-site disposal. The excavated areas would then be backfilled with fill materials that meet residential SSLs. The excavation technology was retained for further consideration.

Overcoring Retrieval (Shafts Only)

Overcoring retrieval is a technology for retrieving an entire shaft without having to dig a trench. This methodology typically involves using a crane to lift and suspend a large-diameter steel casing over the shaft. The diameter of the casing is larger than that of the shaft. The casing is driven into the ground by a vibratory driver until the casing encompasses the entire shaft. Once the casing is at the appropriate depth, the casing's open bottom is sealed shut by injecting grout into the ground within the casing to the base of the core. When the seal has cured and hardened, the entire casing is lifted to retrieve the intact shaft contained inside the casing. The excavated core is then backfilled with materials that meet residential SSLs. The overcoring retrieval technology was retained for the shafts.

Waste Container Retrieval (Shafts Only)

Although access to the MDA G disposal shafts can be gained by removing the concrete caps from the tops of the shafts, the small diameter of the shafts provides a limited space for manipulating the contents of the shafts. A remotely operated backhoe cannot remove objects located deeper than approximately 10 to 12 ft (3 to 3.6 m). Deep removal can be accomplished only by using a crane and manual rigging equipment, which cannot be done remotely. While not impossible, this type of excavation is not desirable because of potential risks to workers. Use of grappling devices or magnetic lifts is possible for certain inventory items; however, because of their size or shape, many items can be removed only by manual rigging. Additionally, the unknown conditions of the waste packaging increases the risk to workers and the environment. It is known that the older shafts were not containerized. The safety hazards of working in the narrow shafts at depths greater than 12 ft (3.6 m) eliminate vertical shaft container retrieval as a viable technology for MDA G. The waste container retrieval technology was not retained.

6.2.3.2 Waste Management and Disposal

Disposal units regulated under the Consent Order that contain MLLW, TSCA, and RCRA waste will be removed under the excavation alternative. Waste types and locations are listed in Table 2.0-1. Excavation/retrieval will require that removed waste is disposed of in a permitted facility. This could include construction of a new on-site disposal facility for LLW or RCRA waste, or transportation of waste to an off-site facility.

Disposal units (Pits 15, 38, and 39) that contain DOE-regulated low-level waste will remain in situ. Retrievably stored TRU waste will be removed and disposed of before implementation of the final remedy. Pits 1−5, 7, 8, 12, 17, and 26 contain waste that would be categorized as newly generated TRU waste; if excavated. WIPP is the only permitted location for disposal of this material. This waste volume is not currently included in the permitted capacity for WIPP.

Various waste management technologies are discussed below.

On-Site Resource Conservation and Recovery Act Landfill

This technology would require the construction of a new landfill at LANL designed to meet the RCRA Subtitle C minimum technology requirements (MTRs). A RCRA Subtitle C landfill is defined as a disposal facility or part of a facility where hazardous waste is placed. Consolidation or placement of cleanup wastes into a RCRA landfill has strict requirements such as land disposal restrictions (LDRs) and is subject to MTRs. RCRA landfill operating permits are typically limited to 10 yr and include an active monitoring program. Based upon potential applicability, on-site RCRA landfill technology was retained.

On-Site Corrective Action Management Unit

Corrective action management units (CAMUs) are used for the on-site management of cleanup wastes under RCRA. A CAMU special unit under RCRA is used for on-site treatment, storage, or disposal of hazardous wastes managed for implementing cleanup. Consolidation or placement of cleanup wastes into a CAMU is not considered land disposal and does not trigger LDRs or create a unit subject to MTRs. NMED may designate a regulated unit as a CAMU or may incorporate a regulated unit into a CAMU if the regulated unit is closed or closing and the inclusion of the regulated unit would enhance the remedy [40 CFR 264.551(b)(1)]. Additionally, CAMUs can be temporary or permanent (i.e., can be closed after removing waste or become a disposal unit). Based upon potential applicability, the on-site CAMU technology was retained.

Off- Site Disposal

The complete off-site disposal technology considers that all MLLW will be shipped off-site to permitted facilities. Transportation of wastes in approved trucking containers will occur on public highways. Facilities considered for this option include the Nevada Test Site and Clive, Utah. Off-site disposal in approved containers will be required for all disposal options based upon waste materials. For costing purposes only, it was assumed that TRU waste would be disposed at Clive, Utah. TSCA waste must be disposed of in the approved facility in Utah. This technology was not evaluated separately from the excavation technologies because it is an integral part of the excavation technologies. The off-site disposal technology was retained.

6.2.4 Ex situ Treatment Technologies

If excavated, MDA G waste materials and/or contaminated media will require characterization to determine whether the waste materials meet the waste acceptance criteria (WAC) of the on-site and/or off-site facilities. Additionally, some of the waste may require treatment before it is reused as backfill or emplaced in an approved facility. Any potential ex situ treatment technology may require a permit modification to the LANL HWFP.

The following is an evaluation of these ex situ treatment technologies:

6.2.4.1 Biological Treatment Technologies

Biological treatment technologies are destruction or transformation techniques directed toward stimulating microorganisms to grow and use the contaminants as a food and energy source by creating a favorable environment for the microorganisms. Generally, a favorable environment means providing some combination of oxygen, nutrients, and moisture and controlling temperature and pH. Sometimes, microorganisms adapted for degradation of the specific contaminants are applied to enhance the process. Four technologies are evaluated below:

Biopiles

Biopile treatment is a technology in which excavated soils are mixed with soil amendments and placed on a treatment area that includes leachate collection systems and some form of aeration. This technology is often used to reduce concentrations of petroleum constituents in excavated soils. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation. The treatment area will generally be covered or contained with an impermeable liner to minimize the risk of contaminants leaching into uncontaminated soil.

Biopile treatment has been applied to treatment of nonhalogenated VOCs and fuel hydrocarbons. Because the majority of organic contaminants at MDA G are halogenated, the applicability may be limited. Application would require creating open biopiles, which may cause uncontrolled release of radionuclides. The biopile technology was not retained.

Composting

Composting is a controlled biological process by which organic contaminants (e.g., polycyclic aromatic hydrocarbons) are converted by microorganisms (under aerobic and anaerobic conditions) to innocuous, stabilized byproducts. Soils are excavated and mixed with bulking agents and organic amendments, such as wood chips and animal and vegetable wastes. Maximum degradation efficiency is achieved through maintaining oxygenation (e.g., daily windrow turning) and moisture content as necessary. Frequent monitoring of moisture content and temperature is necessary for effective treatment.

Composting has limited application at MDA G because the majority of the organic contaminants are dispersed in low concentrations in the vadose zone. Also, excavated soils would require substantial space for composting. And excavation of contaminated soils may cause the uncontrolled release of radionuclides and VOCs. The composting technology was not retained.

Land Farming

Land farming is a full-scale bioremediation technology that requires excavation and placement of contaminated soils, sediments, or sludges onto liners to control leaching of contaminants. Contaminated media are applied into lined beds and periodically turned over or tilled to aerate the waste. Land farming has proven most successful in treating petroleum hydrocarbons and may be a suitable technology for stabilizing part of the wastes that might be excavated at MDA G to meet the WAC before disposal.

However, landfarming has limited application at MDA G, first because of the potential for uncontrolled release of radionuclides and secondly because it is most effectively applied to petroleum contamination, which is not an issue at MDA G. The land farming technology was not retained.

Slurry Phase

Slurry-phase biological treatment involves the controlled treatment of excavated soil in a bioreactor. An aqueous slurry is created by combining soil, sediment, or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of. Slurry-phase bioreactors are used primarily to treat nonhalogenated SVOCs and VOCs in excavated soils or dredged sediments.

Slurry-phase biological treatment has limited application at MDA G because the majority of the VOCs are in low concentrations in the vadose zone and this technology is used to remove higher concentrations of contaminants. In addition, sizing of materials before they are placed into the reactor can be difficult because of dewatering soil fines and the need for an acceptable method for disposing of nonrecycled wastewaters. Since this technology applies to a different category of contaminants than expected at MDA G, the slurry phase technology was not retained.

6.2.4.2 Physical/Chemical Treatment

Soil Washing

Contaminants sorbed onto fine soil particles are separated from soil in an aqueous system based on particle size. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to facilitate removal of organic compounds and heavy metals. Similar to slurry-phase treatment, this technology requires an acceptable method for disposal of nonrecycled wastewaters. Since this technology also has limited application, the soil washing technology was not retained.

6.2.4.3 Chemical Treatment Technologies

Chemical Extraction

Waste contaminated with organic compounds, metals, and radionuclides is mixed with an extractant in an extractor to dissolve and remove the contaminants. The extracted solution can then be placed in a separator, where the contaminants and extractant are separated for treatment and further use. Acid or solvent extraction technologies permit the separation of specific constituents from the remaining waste mass. Treatment is normally performed in batches so specific waste parameters can be controlled to achieve the treatment goals. Extracted material can sometimes be recycled and reused. However, this technology generally generates a secondary, aqueous waste stream requiring further treatment and/or disposal. The chemical extraction technology was not retained.

Wastewater Treatment

None of the technologies retained for ex situ waste treatment would generate waste streams as part of the remediation. Therefore, wastewater treatment technologies were not retained.

6.2.4.4 Physical Treatment Technologies

Much of the waste that would be generated from excavation of MDA G disposal units meets the RCRA definition of debris. The alternative treatment standards for hazardous debris are specified in 20.4.1.800 NMAC, which incorporates 40 CFR Section 268.45. A variety of debris treatment technologies could be suitable for MDA G wastes for stabilizing part of the wastes to meet the WAC before disposal. These physical treatment technologies are discussed below:

Cement Stabilization

Some materials may require stabilization in Portland or other cement matrixes before they are disposed of as hazardous waste or MLLW. This technology is well demonstrated throughout the waste management industry, and may be suitable for stabilizing part of the wastes that might be excavated at MDA G to meet the WAC prior to disposal. The cement stabilization technology was retained.

Alternative Stabilization/Encapsulation Technologies

Ex situ stabilization technologies generally address the need to create a waste form that will not allow target contaminants to leach from the waste matrix to potentially impact disposal site groundwater. Leachable metals and RCRA constituents generally drive this form of treatment. Stabilization and encapsulation technologies beyond cement-based techniques have been developed to reduce overall waste volume, address contaminants not well stabilized by cement chemistry, or achieve greater waste-loading potentials. Macroencapsulation is one such technology. Alternative stabilization/encapsulation technologies, specifically macroencapsuation, were retained because macroencapsuation may be a suitable technology for stabilizing part of the wastes, including debris, to meet the WAC before disposal.

6.2.4.5 Thermal Treatment Technologies

Ex situ thermal treatment technologies generally include techniques to mobilize contaminants for removal from contaminated media or to destroy contaminants. A wide variety of ex situ thermal treatments exist, including thermal desorption, steam extraction, incineration, catalytic destruction, and vitrification (which is both a thermal and physical treatment). Heat is supplied using microwave, radio frequency, or thermal radiation energy delivered to the contaminant by various means or through direct conduction of electricity.

Thermal Desorption

Thermal desorption is a physical separation process and is not designed to destroy organic compounds. Wastes are heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas-treatment system. The temperatures and residence times of these gas-treatment systems will volatilize selected contaminants but will typically not oxidize them. It is possible for VOCs in overburden and wastes at MDA G to be separated from the wastes using thermal desorption techniques. The thermal desorption technology was retained.

Thermal Destruction

High temperatures (870°C to 1200°C [1400°F to 2200°F]) are used to volatilize and combust (in the presence of oxygen) halogenated and other refractory organic compounds in hazardous wastes. Pyrolysis and incineration are the two primary technologies that provide thermal destruction of organic compounds. Pyrolysis is primarily an anaerobic process, whereas incineration is the controlled combustion of materials through an aerobic process. Pyrolysis may be performed in a refractory-lined rotary kiln, in a fluidized bed, or in a molten salt bed. Combustible gases produced during pyrolysis must generally be burned off as part of the treatment. Incineration may also be performed in a rotary kiln or a fluidized bed or in other equipment arrangements. Controlling emissions when burning radionuclides at high temperatures would create a significant permitting issue. The thermal destruction technology was not retained because it has no additional benefit over thermal desorption.

Vitrification

Ex situ vitrification generally includes the mixing of waste with materials that produce glass-like substances when heated sufficiently, especially if the waste matrix does not readily form a glass. Vitrification can often result in a waste volume reduction, especially when compared with cement-stabilization. Vitrification is particularly suited to large homogeneous waste streams because development costs for waste-specific applications generally far exceed waste minimization paybacks for smaller waste streams. Vitrification was retained.

6.3 Summary of Technologies Retained for Further Evaluation at MDA G

Candidate corrective measure technologies were evaluated in section 6.2 based on site conditions, waste characteristics, and technology limitations. The technologies considered applicable for MDA G and retained for further consideration in developing corrective measure alternatives in section 7 are summarized below. Table 6.3-1 organizes the screened technologies into two source areas: (1) pits and shafts and (2) the vadose zone.

6.3.1 Containment Technologies

The following technologies are suitable to contain the waste in the pits and shafts at MDA G:

- Surface Barriers—Vegetative cover
- Surface Barriers—ET cover
- Surface Barriers—Biotic barriers

6.3.2 In situ Treatment Technologies

The following technologies are suitable for managing and treating the environmental media at MDA G:

- Monitored Natural Attenuation
- Physical Treatment—Soil-gas venting
- Physical Treatment—Soil-vapor extraction

6.3.3 Excavation and Disposal Technologies

Any excavation/retrieval (i.e., removal) technology will require a large-area containment structure and an on-site waste analysis, segregation, and treatment facility. The following technologies are suitable for removal and disposal of waste in the pits and shafts at MDA G:

- Excavation for pits and shafts
- Overcoring retrieval for shafts
- Disposal —On-site disposal in RCRA landfill or CAMU facility
- Disposal —Off-site disposal

6.3.4 Ex situ Treatment Technologies

The following technologies are suitable for treatment of the waste after removal from the pits and shafts at MDA G. Analysis of the waste and comparison with the WAC of the permitted disposal facility will determine the requirement for pretreatment of the waste.

- Physical Treatment—Cement stabilization
- Physical Treatment—Alternative stabilization/encapsulation
- Thermal Treatment—Thermal desorption
- Thermal Treatment—Vitrification

7.0 IDENTIFICATION AND SCREENING OF CORRECTIVE MEASURES ALTERNATIVES

For purposes of evaluating corrective measures technologies, the site has been divided into two source areas: disposal pits and shafts (PS) and the vadose zone (VZ) beneath and next to these waste disposal units. Table 7.0-1 presents a matrix of the potential corrective measures technologies that were carried forward from section 6. Table 7.0-1 also presents the numbering system used to identify the technologies evaluated in this section and in section 8.

The use of institutional controls is also evaluated as part of the identification and screening of corrective measures alternatives. Section III.W.3b of the Consent Order anticipates that institutional controls, such as deed restrictions, may be a component of the chosen corrective measure.

Section 7.1 identifies activities that will be undertaken before corrective measures begin. Section 7.2 presents the threshold screening criteria that are listed in Section VII.D.4.a of the Consent Order (Figure 5.4-1). Section 7.3 presents the screening of technologies against the threshold criteria for the pits and shafts; section 7.4 presents the screening of the technologies against the threshold criteria for the vadose zone. Those technologies that satisfy all four of the threshold criteria are carried forward into section 8.0, where the technologies and the alternatives they form are evaluated against the remedial alternative evaluation criteria (also referred to as balancing criteria) defined in Section VII.D.4.b of the Consent Order (Figure 5.4-1).

7.1 Activities Undertaken before Implementation of Corrective Measures

The Laboratory's TRU Waste Disposition Project will retrieve, characterize, package, and ship both the aboveground TRU and the retrievable belowground TRU waste. The aboveground TRU includes the waste in drums and fiberglass-reinforced plywood boxes that are currently stored throughout Area G in domes. The retrievable belowground TRU waste is located in: Pit 29 (corrugated metal pipes); Pit 9; Trenches A-D; Shafts 200−232 (33 shafts); Shafts 262−266 (tritium torpedoes); and Shafts 302−306 (hot cell liners). All waste operations are required to be completed before implementing the final remedy for MDA G.

Before implementing the final remedy, seven outdoor hazardous waste CSUs and two indoor CSUs must undergo closure per the LANL HWFP. The closure plan for each CSU is documented in the HWFP. The closure requirements include the removal of all hazardous waste residues and constituents, including the removal and disposition of CSU structures; review of the operating history and potential contamination assessments for all underlying storage pads; removal of the storage pads, plus 6 in. of the underlying soil/base course; and completion of the sampling and analysis plan developed for the closure. Decontamination and decommissioning (D&D) may be performed for individual structures as necessary to support waste management consolidation or corrective action activities before initiating the final closure of a CSU. These D&D activities require a Class 1 permit modification with prior approval from NMED for structure removal.

Pad 1 is an irregularly shaped asphalt pad that is approximately 358 ft long and 213 ft wide (approximately 76,000 ft^2). The pad currently has two existing structures associated with it: building 412, which is the Decontamination and Volume Reduction System (DVRS) facility, and the Mobile Visual Examination and Repackaging (MOVER) transportainer with support trailer. The DVRS is 60 ft × 220 ft (13,200 ft^2) and is used for storage and volume reduction of bulky mixed waste. The MOVER is a 10 × 40 ft transportainer unit that contains a glovebox used to visually examine and repackage the contents of high-activity TRU waste drums. Dome 226 was previously located on this pad but underwent D&D in October 2009. Building 412 and the MOVER will undergo D&D, and Pad 1 will undergo closure before the implementation of the final remedy for MDA G.

Pad 3 is an asphalt pad that measures 339 ft long × 50 ft wide (approximately 17,000 ft^2). The pad currently has one structure associated with it: Dome 48, which is 50 ft × 285 ft (14,300 ft^2) and used for storage of hazardous waste in solid and liquid form. Dome 48 will undergo D&D, and Pad 3 will undergo closure before the implementation of the final remedy for MDA G.

Pad 5 is a consolidated CSU. This CSU includes asphalt Pad 5, which measures 850 ft long × 224 ft wide (approximately 190,000 ft^2); Pad 7, measuring 200 ft long × 64 ft wide; and Pad 8 measuring 150 ft long × 95 ft wide. There are 10 structures associated with the permitted unit: 2 domes and 8 sheds. Storage Domes 49 and 224 and the sheds are used for the storage of hazardous waste. Dome 49 is 60 ft × 440 ft (26,400 ft^2), and Dome 224 is 60 ft × 110 ft (6,600 ft^2). Storage sheds 144, 145, 146, and 177 are 30 ft^2, and storage sheds 1027, 1028, 1029, and 1041 are 207 ft^2, each a prefabricated steel structure. All structures will undergo D&D, and Pad 5 will undergo closure before the implementation of the final remedy for MDA G.

Pad 6 is an asphalt pad that measures 633 ft long × 99 ft wide (approximately 62,700 ft^2). The two structures associated with the permitted unit, Domes 153 and 283, are each used for the storage of hazardous waste in both liquid and solid form. Dome 153 is 60 ft × 326 ft (19,600 ft^2), and Dome 283 is 60 ft by 260 ft (15,600 ft^2). All structures will undergo D&D, and Pad 6 will undergo closure before the implementation of the final remedy for MDA G.

Pad 9 is an asphalt pad that measures 570 ft long × 275 ft wide (approximately 158,000 ft^2). There are four dome structures associated with the permitted unit used for the storage of hazardous waste in both liquid and solid form. Domes 229, 230, 231, and 232 are each 89 ft × 246 ft (22,000 ft^2). The domes will undergo D&D, and Pad 9 will undergo closure before the implementation of the final remedy for MDA G.

Pad 10 is an asphalt pad that measures 350 ft long × 250 ft wide (approximately 89,600 ft^2). Transuranic waste characterization trailers are situated on the permitted unit, and hazardous waste containers are stored near or in the trailers for staging associated with the waste characterization. The hazardous waste storage activities involve the following structures: trailers 54-0438 and 54-0457 (which house the super high efficiency neutron coincidence counter); trailer 54-0497 (which houses the real-time radiography system #2); trailers 54-0498 and 54-0506 (which house two high-efficiency neutron counters); trailers 54-0545, 54-0546, 54-0483, and 54-1059; trailer 54-0365 (office); and shed 54-XXX1 (the X's are part of the shed identifier). Trailers 54-0365, 54-0483, 54-1059, and shed 54-XXX1 have never stored hazardous waste. All structures will undergo D&D, and Pad 10 will undergo closure before the implementation of the final remedy for MDA G.

Pad 11 is an asphalt pad that is approximately 478 ft long × 137 ft wide (approximately 65,500 ft^2). The pad currently has one structure associated with it, Dome 375, which is 100 ft × 300 ft (30,000 ft^2) and is used for storage of hazardous waste both in liquid and solid form. Dome 375 will undergo D&D, and Pad 11 will undergo closure before the implementation of the final remedy for MDA G.

Storage shed 8 is an indoor hazardous waste container storage unit. The permitted unit is a steel-framed building with a concrete floor, which sits on a concrete supporting pad. The building is 40 ft × 16 ft (64 ft^2). Storage shed 8 will undergo closure (including D&D) before the implementation of the final remedy for MDA G.

Building 33 is an indoor hazardous waste container storage unit. The permitted unit is a storage dome with an attached concrete-block building, both of which sit on a concrete pad. The dome is 50 ft × 157 ft (7,850 ft^2). The concrete block building is 40 ft × 34 ft (1,360 ft^2). Building 33 will undergo closure

If the sampling and analysis required by the closure plans reveal that residual hazardous waste constituents are present above decontamination verification levels in the soil beneath the pads, further closure activities will be implemented in coordination with the corrective action activities at Area G through alternative closure requirements contained in the HWFP. Other on-site structures not included in the permit, including transportainers and sheds, will undergo D&D before the final action for MDA G.

7.2 Corrective Measures Threshold Screening Criteria

Section VII.D.4.a of the Consent Order states that to be selected, the remedy alternative must

1. be protective of human health and the environment.

   Protection of human health and the environment should be evaluated based on reasonably anticipated land use, both now and in the future. It should take into consideration the potential exposure pathways identified in the CSM.

2. attain media cleanup standards.

   The applicable cleanup standards developed in accordance with Section VIII of the Consent Order are presented in section 5.1. EPA guidance (61 Federal Register 19432, May 1, 1996) states, “media cleanup standards should reflect the potential risks of the facility and media in question by considering the toxicity of the constituents of concern, exposure pathways, and fate and transport characteristics.” EPA guidance further explains, “attaining media cleanup standards does not necessarily entail removal or treatment of all contaminated material above specific constituent concentrations. Depending on the site-specific circumstances, remedies may attain media cleanup standards through various combinations of removal, treatment, engineering and institutional controls.”

3. control the source or sources of releases so as to reduce or eliminate, to the extent practicable, further releases of contaminants that may pose a threat to human health and the environment.

   Source control measures evaluated may include a combination of treatment, containment, removal, and institutional controls.

4. comply with applicable standards for management of wastes.

   A remedy must be able to comply with all applicable regulatory requirements for management of any wastes removed or generated during corrective action, as well as closure requirements for any waste or contamination following implementation of the remedial alternative.

7.3 Description and Screening of Technologies Retained for the Pits and Shafts

This section describes the potential corrective measure technologies for the pits and shafts (Technologies PS-1 through PS-5) and presents a qualitative evaluation of these technologies against the threshold criteria contained in Section VII.D.4.a of the Consent Order. Table 7.3-1 summarizes the evaluation performed in section 7.3.

7.3.1 Technology PS-1: No Action

Technology PS-1 represents a true no-action technology for the pits and shafts. Under this technology, no action will be taken. The site will not be regraded and revegetated. Institutional controls will not be maintained. No maintenance of the surface soil will be performed. In summary, this technology includes

- no maintenance or monitoring, and
- no institutional controls.

7.3.1.1 Protection of Human Health and the Environment

The surface soil will be eroded by wind and water and will increase the potential for exposure to waste and contaminated surface and subsurface soils The no-action technology does not prevent direct contact, erosion, or biointrusion. There is also no protection from direct human contact with the waste or contaminated soils. This technology is not protective of human health and the environment.

7.3.1.2 Attainment of Media Cleanup Standards

Under this technology, the existing waste inventory, which includes wastes subject to regulation as hazardous wastes under RCRA, will not be removed or treated. This technology does not comply with the EPA guidance for attaining media cleanup standards when waste is left in place. This technology does not meet the closure performance standards of 40 CFR 264.111(a) and (b).

7.3.1.3 Control of Source and Releases

The technology will not control potential releases of buried waste due to erosion, direct contact, or biointrusion that have the potential to occur under the no-action scenario. This technology will not adequately control sources and releases.

7.3.1.4 Compliance with Applicable Waste Management Standards

No wastes will be generated under the no-action technology; therefore, this technology complies with applicable state and federal waste management standards

7.3.1.5 Summary

Although the no-action technology does not meet any of the threshold criteria, it is carried forward for comparison purposes in evaluating the other technologies.

7.3.2 Technology PS-2: Maintenance and Monitoring of Existing Disposal Units

This technology represents implementation of institutional controls and monitoring and maintenance of the surface for managing hazardous waste constituents in the pits and shafts. The technology involves

- regrading and revegetating the soil surface, leaving existing covers on pits and shafts;
- actively monitoring and maintaining the existing soil surface and existing covers on pits and shafts for 30 yr; and
- maintaining institutional controls for 100 yr.

This technology includes regrading the existing soil surface and revegetating with native species to minimize erosion. No additional soil will be added to the existing soil surface. The soil surface will be maintained to correct damage from erosion and to limit biointrusion.

To limit the potential for biotic intrusion into buried waste, contaminated surface soils, and contaminated subsurface soils, active monitoring and maintenance of the soil surface will be performed for 30 yr. This monitoring and maintenance will address erosion and animal burrowing and also manage vegetation (e.g., removing trees and invasive species). Additional active institutional controls, such as fencing, control of site access, deed restrictions, and other Laboratory administrative controls, are assumed to remain in place for 100 yr. DOE requirements for monitoring, maintenance, and institutional controls are not addressed in this CME.

7.3.2.1 Protection of Human Health and the Environment

Soil surface maintenance and institutional controls will limit human and ecological exposure to waste and contaminated surface and subsurface soils by limiting erosion, direct contact, and biointrusion. This technology is protective of human health and the environment.

7.3.2.2 Attainment of Media Cleanup Standards

Under this technology, the existing waste inventory would not be removed or treated. Maintaining and monitoring the existing surface soil does not meet the closure performance standards of 40 CFR 264.111(a) and (b), or attain the human health and ecological risk cleanup levels in the Consent Order.

7.3.2.3 Control of Source and Releases

Surface soil maintenance and institutional controls will limit human and ecological exposure to waste and contaminated surface and subsurface soils by minimizing erosion, direct contact, and biointrusion. This technology will adequately control sources and releases.

7.3.2.4 Compliance with Applicable Waste Management Standards

No wastes will be generated under the maintenance and monitoring technology; therefore, it complies with applicable state and federal waste management standards.

7.3.2.5 Summary

Institutional controls can provide a level of protectiveness for human health and the environment and may provide limited control of sources and releases. However, the maintenance and monitoring technology does not meet the closure performance standards of 40 CFR 264.111(a) and (b), or attain the human health and ecological risk cleanup levels in the Consent Order. Therefore, this technology is not retained for further consideration.

7.3.3 Technology PS-3a: Vegetative Cover

Under this technology, the site will be regraded and a vegetative cover will be installed over approximately 51 acres of the mesa top at the site. In addition to the institutional controls, this technology involves

- regrading the existing soil surface;
- constructing a vegetative cover consisting of 1 ft of soil-gravel fill and 6 in. of topsoil, native vegetation; riprap-armored slopes, and a moisture monitoring system;
- actively monitoring and maintaining the cover for 30 yr; and
- maintaining institutional controls for 100 yr.

The cover will be designed to meet the requirements for an alternative cover for a hazardous waste landfill as specified in 40 CFR Part 264, Subpart G─Closure and Post-Closure. Moisture monitoring probes will be installed in the cover, and moisture monitoring data will be reported to NMED in an annual report during the 30-yr active monitoring and maintenance period. The vegetative cover supports the semiarid site conditions by evaporating and transpiring water from the cover. The cover will be designed with slopes sufficient to encourage precipitation runoff while reducing erosion potential. A preliminary design concept includes a 1-ft soil-gravel admixture as fill and a 6-in. vegetated topsoil at the surface. A soil-gravel admixture placed on the surface weathers to create desert paving and protects the cover from high-intensity rainfall, reducing erosion potential. The steep slopes at the edge of the vegetative cover will be armored with riprap to provide further erosion protection. Proposed design features are presented in Figure 7.3-1.

To limit the potential for biotic intrusion into buried waste, active monitoring and maintenance of the cover will be performed for 30 yr. This monitoring and maintenance will control erosion and animal burrowing and also manage vegetation (e.g., removing trees and invasive species). Monitoring of moisture levels will confirm that moisture is not migrating towards buried waste. Additional active institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.3.3.1 Protection of Human Health and the Environment

A vegetative cover (Figure 7.3-1) will provide protection against erosion, direct contact, and biointrusion. Maintenance of the cover will limit direct human and ecological exposure to waste and contaminated surface subsurface soils by reducing erosion, direct contact, and biointrusion. This technology is protective of human health and the environment.

7.3.3.2 Attainment of Media Cleanup Standards

The designed vegetative cover attains media cleanup standards when waste is left in place by breaking the exposure pathway and reducing risk for human and ecological receptors. A vegetative cover will minimize or eliminate infiltration of precipitation that could otherwise mobilize subsurface contaminants, potentially completing exposure pathways.

7.3.3.3 Control of Source and Releases

A vegetative cover will minimize infiltration of precipitation that could otherwise mobilize subsurface contaminants, resulting in contaminant release. A vegetative cover will also limit exposure to waste and contaminated surface and subsurface soils and will provide protection against erosion, direct contact, and biointrusion. In addition, institutional controls will be implemented to restrict access, thereby restricting direct human contact. This technology provides control of sources and reduces potential for releases.

7.3.3.4 Compliance with Applicable Waste Management Standards

Any waste generated under this technology will comply with all applicable regulatory requirements.

7.3.3.5 Summary

The vegetative cover meets the threshold screening criteria and is retained for further evaluation.

7.3.4 Technology PS-3b: Evapotranspiration Cover

Under this technology, the site will be regraded and an ET cover will be installed over approximately 51 acres of the active disposal area at Area G. In addition to the institutional controls, this technology involves

- regrading the existing soil surface;
- constructing an ET cover consisting of 3.5 ft of infiltration layer, 1.5 ft of gravel admixture and vegetated topsoil, and moisture monitoring equipment;
- actively monitoring and maintaining the cover for 30 yr; and
- maintaining institutional controls for 100 yr.

The ET cover takes advantage of the semiarid site conditions by evaporating and transpiring water from the cover. Engineered ET covers have demonstrated effectiveness in reducing infiltration in semiarid regions (Davenport et al. 1998, 069674, p. 1; Dwyer et al. 2000, 069673, pp. 23–26). ET covers can be adapted to enhance desired properties for given applications such as the following:

- increasing erosion resistance by adding gravel surface amendments;
- enhancing or limiting types of plants and plant growth for transpiration by varying depths of enriched soil;
- modifying the size of the ET reservoir layer above the waste layer by varying the depths of the primary crushed-tuff ET layer; and
- preventing biointrusion by using barriers such as cobble, chain-link fencing, or pea-size gravel.

The ET cover will be designed to meet the requirements for an alternative cover for a hazardous waste landfill as specified in 40 CFR Part 264, Subpart G—Closure and Post-Closure. Moisture monitoring equipment will be installed in the cover, and moisture monitoring data will be reported to NMED in an annual report during the 30-yr active maintenance and monitoring period. A conceptual design (Dwyer 2007, 098276) includes a 1.5-ft vegetated topsoil-gravel admixture at the surface and a lower, 3.5-ft infiltration layer composed of crushed tuff mixed with soil and amendments to provide water storage and minimize infiltration. The cover will be designed with slopes sufficient to encourage precipitation runoff while limiting erosion potential. The soil-gravel admixture placed on the surface weathers to create desert paving and protects the cover from high-intensity rainfall, reducing erosion potential. The steep slopes at the edge of the cover will be armored with riprap to provide further erosion protection.

To limit the potential for biotic intrusion into buried waste, active monitoring and maintenance of the ET cover will be performed for 30 yr. This monitoring and maintenance will control erosion and also manage vegetation (e.g., removing trees and invasive species). Monitoring of moisture levels will confirm that moisture is not migrating towards buried waste. Additional active institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.3.4.1 Protection of Human Health and the Environment

A properly constructed and maintained ET cover will provide protection against erosion, direct contact, and biointrusion. Maintenance and monitoring of the surface will limit human and ecological exposure to waste and contaminated surface and subsurface soils. Institutional controls will be implemented to restrict access, thereby limiting human exposure. This technology is protective of human health and the environment.

7.3.4.2 Attainment of Media Cleanup Standards

A properly designed ET cover attains media cleanup standards when waste is left in place by breaking the exposure pathway and reducing risk for human and ecological receptors. An ET cover will also minimize or eliminate infiltration of precipitation that could otherwise mobilize subsurface contaminants.

7.3.4.3 Control of Source and Releases

An ET cover will minimize or eliminate infiltration of precipitation that could otherwise mobilize subsurface contaminants. An ET cover will also limit exposure to waste and contaminated surface and subsurface soils. The ET cover will provide protection against erosion, direct contact, and biointrusion. In addition, institutional controls will be implemented to restrict access, thereby limiting human exposure. This technology will adequately control sources and releases.

7.3.4.4 Compliance with Applicable Waste Management Standards

Any waste generated under this technology will comply with all applicable regulatory requirements.

7.3.4.5 Summary

The ET cover meets the threshold screening criteria and is retained for further evaluation.

7.3.5 Technology PS-3c: Biotic Barrier

Under this technology, a biotic barrier will be constructed over the pits and shafts. This technology involves:

- regrading the existing soil surface;
- constructing a biotic barrier consisting of a 1-ft layer of cobbles with a minimum diameter of 6 in.;
- actively monitoring and maintaining the barrier for 30 yr; and
- maintaining institutional controls for 100 yr.

This technology involves constructing a biotic barrier over the pits and shafts. The biotic barrier is intended to function as a restrictive barrier for preventing animals from burrowing into contaminated surface and subsurface soils and waste within the pits and shafts. A preliminary design includes a 1-ft layer of cobbles with a minimum diameter of 6 in.

To limit the potential for biotic intrusion into buried waste, contaminated surface soils, and contaminated subsurface soils, active monitoring and maintenance of the barrier will be performed for 30 yr. This monitoring and maintenance will control erosion and also manage vegetation (e.g., removing trees and invasive species). Additional active institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.3.5.1 Protection of Human Health and the Environment

A properly designed biotic barrier will provide protection against erosion, direct contact, and biointrusion. The barrier will minimize burrowing by animals, as well as the intrusion of woody roots from plants such as shrubs, piñon, and juniper. Maintenance and monitoring of the surface will limit human and ecological exposure to waste and contaminated surface and subsurface soils. Institutional controls will be implemented to restrict access, thereby limiting human exposure. This technology is protective of human health and the environment.

7.3.5.2 Attainment of Media Cleanup Standards

A biotic barrier partially meets media cleanup standards when waste is left in place by breaking the exposure pathway and reducing risk for human and ecological receptors. However, a biotic barrier will not minimize or eliminate infiltration of precipitation that could otherwise mobilize subsurface contaminants.

7.3.5.3 Control of Source and Releases

Maintenance of the biotic barrier will limit exposure to waste and contaminated surface and subsurface soils. In addition, institutional controls will be implemented to restrict access, thereby limiting human exposure. However, a biotic barrier will not minimize or eliminate infiltration of precipitation that could otherwise mobilize subsurface contaminants. This technology does not control sources and releases.

7.3.5.4 Compliance with Applicable Waste Management Standards

Any waste generated under this technology will comply with all applicable regulatory requirements.

7.3.5.5 Summary

The biotic barrier does not attain media cleanup standards (i.e., does not minimize or eliminate infiltration), and thus does not meet the threshold screening criteria. It is therefore not retained for further evaluation

7.3.6 Technology PS-4a: Excavation of Pits and Shafts with On-Site Disposal in a CAMU or RCRA Landfill

This technology involves

- constructing excavation enclosures;
- constructing on-site waste analysis and segregation facilities;

- constructing an on-site disposal unit (either a RCRA Subtitle C landfill or a CAMU) in the vicinity of MDA G;
- excavating waste in the pits and shafts;
- backfilling the original excavation to grade with environmental media meeting the target cleanup standards;
- disposing of wastes that already meet the LDR treatment standards into the on-site disposal unit;
- shipping wastes off-site that cannot be treated on-site to meet the LDR treatment standards;
- closing the on-site disposal unit and constructing a vegetated soil or ET cover over the disposal unit;
- actively monitoring and maintaining the site and cover for 30 yr; and
- maintaining institutional controls for 100 yr.

Excavation of the pits and shafts will be accomplished using standard excavation methods. The original units were excavated with nearly vertical side walls with an entry ramp on both sides. The remediation activities may employ the same manner of excavation, with nearly vertical slopes (1-ft horizontal to 6-ft vertical). Portions of these excavations may be used to access the shaft excavations or as a staging area. The estimated volume of excavated materials is provided in Appendix G (Tables G-3.4-1 through G-3.4-2) Confirmatory sampling will be conducted to ensure that all contaminated material has been removed from the excavations.

Excavated waste that does not meet LDR treatment standards will be treated on-site using the technologies described in Technology PS-5 (section 7.3.10) and disposed of in a permitted on-site disposal unit (either a RCRA Subtitle C landfill or a CAMU) constructed within the footprint of Area G. Waste that cannot be treated on-site to meet the LDR treatment standards (e.g., PCBs) will be shipped off-site for treatment and disposal at an appropriately permitted facility. At the end of the project, the disposal unit will be closed in accordance with HWFP requirements, and a vegetated or ET cover will be constructed over the site as described in sections 7.3.3 and 7.3.4.

Some waste may be classified as newly generated TRU waste (Appendix G, Tables G-3.4-1 through G-3.4-2). This waste was not included in the original permit of the WIPP facility, and a permit modification may be required for disposal at WIPP.

Active monitoring and maintenance of CAMU/RCRA cover will be performed according to permit requirements. Additional active institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.3.6.1 Protection of Human Health and the Environment

Excavation and disposal in a permitted on-site RCRA landfill or CAMU disposal unit will eliminate the source of contamination and provide protection to human health and the environment.

7.3.6.2 Attainment of Media Cleanup Standards

Wastes will be excavated and treated as necessary to meet target cleanup standards. Environmental media below target cleanup standards may be returned to the disposal unit. This technology will comply with EPA standards to attain media cleanup standards.

7.3.6.3 Control of Source and Releases

Complete waste removal will control sources and releases.

7.3.6.4 Compliance with Applicable Waste Management Standards

Waste exceeding target cleanup standards will be treated for on-site disposal in a RCRA landfill or CAMU or shipped off-site for treatment and disposal if it cannot be treated to meet the LDR requirements or WAC (e.g., PCBs). Some waste excavated from several pits is expected to be classified as newly generated TRU waste. This waste was not included in the original WIPP permit. A permit modification may be required for disposal at WIPP. This technology will be conducted in accordance with applicable waste management standards.

7.3.6.5 Summary

Waste excavation with on-site disposal in a permitted CAMU or RCRA onsite landfill meets the threshold screening criteria and is retained for further evaluation.

7.3.7 Technology PS-4b: Excavation of Pits and Shafts with Off-Site Disposal

This technology involves:

- constructing excavation enclosures;
- constructing on-site waste analysis and segregation facilities;
- excavating the waste in the pits and shafts;
- analyzing and segregating the waste for off-site shipment and treatment and disposal based on the WAC of the receiving facility;
- backfilling the original excavation to grade with environmental media meeting the target cleanup standards;
- shipping and disposing of the wastes off-site that do not meet target cleanup standards; and
- maintaining institutional controls for 100 yr.

Waste excavation and analysis will be performed as described in Technology PS-4a. However, Technology PS-4b wastes will be segregated from clean overburden and shipped off-site for treatment and disposal at an appropriately permitted facility. Excavations will be backfilled to grade with overburden or fill material that meets target cleanup standards.

Some waste excavated from several pits is expected to be classified as newly generated TRU waste (Appendix G, Tables G-3.4-1 through G-3.4-2). This waste was not included in the original WIPP facility permit. A permit modification may be required for disposal at WIPP.

Institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.3.7.1 Protection of Human Health and the Environment

Complete removal of the waste will eliminate the source of contamination and provide protection to human health and the environment.

7.3.7.2 Attainment of Media Cleanup Standards

Wastes will be removed to a level that meets the target cleanup goals. Environmental media below target cleanup goals may remain at the site. This technology will comply with EPA standards to attain media cleanup standards.

7.3.7.3 Control of Source and Releases

Complete waste removal will control sources and releases.

7.3.7.4 Compliance with Applicable Waste Management Standards

Waste shipped off-site for treatment and disposal will meet Department of Transportation (DOT) shipping requirements and TSD facility-specific WAC and permit conditions before the waste is shipped and disposed of. Some waste excavated from several pits is expected to be classified as newly generated TRU waste. This waste was not included in the original WIPP permit. A permit modification may be required for disposal at WIPP. This technology will be conducted in accordance with applicable waste management standards.

7.3.7.5 Summary

Waste excavation and off-site disposal meets the threshold screening criteria and is retained for further evaluation.

7.3.8 Technology PS-4c: Excavation of Pits and Overcoring Retrieval of Shafts with On-Site Disposal in a CAMU or RCRA Landfill

This technology involves:

- constructing excavation enclosures;
- constructing on-site waste analysis and segregation facilities;
- constructing a permitted on-site disposal unit (either a RCRA Subtitle C landfill or a CAMU) in the vicinity of MDA G;
- excavating the waste in the pits;
- removing the waste in the shafts by overcoring retrieval;
- backfilling the original excavation to grade with environmental media meeting the target cleanup standards;
- disposing of wastes that already meet the LDR treatment standards into the on-site disposal unit;

- off-site shipping for wastes that cannot be treated on-site to meet the LDR treatment standards;
- closing the on-site disposal unit and constructing a vegetated soil or ET cover over the disposal unit;
- actively monitoring and maintaining the CAMU/RCRA cover in accordance with permit requirements; and
- maintaining institutional controls for 100 yr.

Under this technology, the pits will be excavated as described in Technology PS-4a. However, waste in the shafts will be removed using overcoring retrieval technology, which is anticipated to generate significantly less overburden materials than excavation alone. The shafts will be overcored by driving a casing larger than the outside diameter of the existing shaft and plugging the bottom with grout. After the casing has set, the entire shaft will be removed with a crane. The estimated volume of excavated materials and retrieved waste is provided in Appendix G (Tables G-3.4-1 through G-3.4-2). Confirmatory sampling will be conducted to ensure that all contaminated material has been removed from the pit excavations and shafts.

All excavated and retrieved waste that does not meet LDR treatment standards will be treated on-site using the technologies described for Technology PS-5 (section 7.3.10) and disposed of in an on-site disposal unit (either a RCRA Subtitle C landfill or a CAMU), constructed within the footprint of Area G, as described for Technology PS-4a.

At the end of the project, the disposal unit will be closed and a vegetated or ET cover constructed over the site as described in sections 7.3.3 and 7.3.4.

Some waste may be classified as newly generated TRU waste (Appendix G, Tables G-3.4-1 through G-3.4-2). This waste was not included in the original permit for the WIPP facility. A permit modification may be required for disposal at WIPP.

Active monitoring and maintenance of CAMU/RCRA cover will be performed according to HWFP requirements. Additional active institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.3.8.1 Protection of Human Health and the Environment

Excavation and retrieval of the waste will eliminate the source of contamination and provide protection to human health and the environment.

7.3.8.2 Attainment of Media Cleanup Standards

Wastes will be excavated/retrieved and treated to a level that meets target cleanup standards. Environmental media below target cleanup standards may be returned to the original disposal unit. This technology will comply with EPA standards to attain media cleanup standards.

7.3.8.3 Control of Source and Releases

Complete waste removal will control sources and releases.

7.3.8.4 Compliance with Applicable Waste Management Standards

Waste exceeding target cleanup standards will be treated for on-site disposal in a permitted RCRA landfill or CAMU or shipped off-site for treatment and disposal if they cannot be treated to meet the LDR requirements or waste acceptance criteria (WAC) (e.g., PCBs). Some waste excavated from several pits is expected to be classified as newly generated TRU waste. This waste was not included in the original WIPP permit. A permit modification may be required for disposal at WIPP. This technology will be conducted in accordance with applicable waste management standards.

7.3.8.5 Summary

Waste excavation and retrieval with disposal in a permitted on-site CAMU or RCRA landfill meets the threshold screening criteria and is retained for further evaluation.

7.3.9 Technology PS-4d: Excavation of Pits and Overcoring Retrieval of Shafts with Off-Site Disposal

This technology involves

- constructing excavation enclosures;
- constructing on-site waste analysis and segregation facilities;
- excavating the waste in the pits;
- removing the waste in the shafts by overcoring retrieval;
- analyzing and segregating the waste for off-site shipment and treatment and disposal based on the WAC of the receiving facility;
- backfilling the original excavation to grade with environmental media meeting the target cleanup standards;
- off-site shipping and disposal for wastes that do not meet target cleanup standards; and
- maintaining institutional controls for 100 yr.

Waste excavation/retrieval will be performed as described for Technology PS-4c. Wastes will be segregated and sent off-site for treatment and disposal as discussed for Technology PS-4b.

Some waste may be classified as newly generated TRU waste (Appendix G, Tables G-3.4-1 through G-3.4-2). This waste was not included in the original permit of the WIPP facility. A permit modification may be required for disposal at WIPP.

Institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.3.9.1 Protection of Human Health and the Environment

Complete removal of the waste will eliminate the source of contamination and provide protection to human health and the environment.

7.3.9.2 Attainment of Media Cleanup Standards

Wastes will be removed to a level that meets target cleanup standards. Environmental media below target cleanup standards will remain at the site. This technology will comply with EPA standards to attain media cleanup standards.

7.3.9.3 Control of Source and Releases

Complete waste removal and off-site disposal of waste will control sources and releases.

7.3.9.4 Compliance with Applicable Waste Management Standards

Waste shipped off-site for treatment and disposal will meet DOT shipping requirements and TSD facility-specific WAC and permit conditions before the waste is shipped and disposed of. Some waste excavated from several pits is expected to be classified as newly generated TRU waste. This waste was not included in the original WIPP permit. A permit modification may be required for disposal at WIPP. This technology will be conducted in accordance with applicable waste management standards.

7.3.9.5 Summary

Waste excavation and retrieval and off-site disposal meets the threshold screening criteria and is retained for further evaluation.

7.3.10 Technology PS-5: Ex situ Treatment

This section describes ex situ treatment technologies for the waste removed from the waste disposal units and the soil surrounding the waste disposal units that has to be excavated to access the waste disposal units. Waste and soil will be analyzed to determine if they meet target cleanup goals. If cleanup goals are met, the material will be reburied on-site. If cleanup goals are not met, the material will be treated on-site to meet the appropriate standard for on-site reburial.

Before any excavated waste can be treated, the following actions are required:

- An on-site treatment facility must be permitted.
- On-site waste analysis, segregation, and treatment facilities must be constructed.
- Waste must be analyzed and segregated.

Because most waste excavated/retrieved from MDA G disposal units is likely to be MLLW, containing organic, inorganic, and radiological contaminants, a treatment-train process will be used that incorporates multiple ex situ treatment technologies in series or in parallel.

Potential ex situ waste treatment technologies, as described in section 6, include the following:

- Cement stabilization
- Alternative stabilization/macroencapsulation
- Thermal desorption
- Vitrification

7.3.10.1 Protection of Human Health and the Environment

Excavation/retrieval of the waste followed by ex situ treatment will remove the source of contamination and provide protection to human health and the environment.

7.3.10.2 Attainment of Media Cleanup Standards

Cement stabilization, vitrification, and macroencapsulation stabilize most wastes to enable the attainment of media cleanup standards. Thermal desorption is a physical separation process for removing VOCs. Thermal desorption will be used in conjunction with one or more of the three stabilization technologies considered to attain media cleanup standards for organic, inorganic, and radiological constituents. When used in combination, these technologies will be able to treat waste to a level to meet WAC standards.

7.3.10.3 Control of Source and Releases

Waste excavation/retrieval and treatment will remove the source material and control future releases.

7.3.10.4 Compliance with Applicable Waste Management Standards

Cement stabilization, vitrification, and macroencapsulation stabilize the waste to meet WAC requirements before disposal. Vitrification can often result in a waste volume reduction; however, the majority of the waste stream at MDA G is not conducive to vitrification. In addition, on-site vitrification would not likely meet the production rate necessary for treating the waste volume that will be generated from the MDA G disposal units. Macroencapsulation can reduce overall waste volume, address contaminants not well stabilized by cement chemistry, and achieve greater waste-loading potentials. Thermal desorption will segregate VOCs to meet WACs before disposal. When used in combination, these technologies will treat waste so that it complies with the WAC for on-site or off-site disposal.

7.3.10.5 Summary

When used in combination, the ex situ treatment technologies of thermal desorption and macroencapsulation are the preferred technologies. They meet the threshold screening criteria and are retained for further evaluation.

7.4 Description and Screening of Technologies Retained for the Vadose Zone

This section describes the potential corrective measure technologies for the vadose zone (Technology VZ) contamination and presents a qualitative evaluation of these technologies against the threshold criteria contained in section VII.D.4.a of the Consent Order. The evaluation performed in section 7.4 is summarized in Table 7.4-1.

7.4.1 Technology VZ-1: No Action

Technology VZ-1 presents a true no-action technology for the vadose zone. Under this technology, no action will be taken. Institutional controls will not be maintained, and pore-gas monitoring will not be performed.

7.4.1.1 Protection of Human Health and the Environment

Under the no-action technology, the potential exists for exposure through diffusion of VOCs to groundwater. The no-action technology will allow diffusion of VOCs present in the subsurface, which may impact groundwater resources. Therefore, this technology is not protective of human health and the environment.

7.4.1.2 Attainment of Media Cleanup Standards

VOC contamination in the vadose zone has the potential to migrate to groundwater and exceed groundwater standards in the future. This technology does not attain media cleanup standards.

7.4.1.3 Control of Source and Releases

The no-action technology does not control releases associated with diffusion of VOCs to groundwater.

7.4.1.4 Compliance with Applicable Waste Management Standards

No waste will be generated under the no-action technology.

7.4.1.5 Summary

Although the no-action technology does not meet any of the threshold criteria, it is carried forward for comparison in evaluating the other technologies.

7.4.2 Technology VZ-2a: Monitored Natural Attenuation

This technology involves

- active monitoring of pore gas for 30 yr, and
- maintaining institutional controls for 100 yr.

MNA uses natural subsurface processes to reduce contaminant concentrations to acceptable levels. Modeling will be performed to establish a performance standard for contaminant concentrations in the vadose zone. Pore-gas monitoring results will be compared with modeling to evaluate attenuation of VOC concentrations.

Pore gas will be monitored for 30 yr. Pore-gas monitoring will be used to detect further releases as well as to determine if the concentrations of VOC contamination in the pore gas are changing with time. Institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.4.2.1 Protection of Human Health and the Environment

MNA will decrease concentrations of VOCs in the soil pore spaces over time through natural subsurface processes and diffusion out of the mesa at the land surface and through dispersion. As concentrations are reduced, the potential to impact groundwater is reduced, thereby providing protection of human health and the environment.

7.4.2.2 Attainment of Media Cleanup Standards

MNA will decrease concentrations of VOCs in the soil pore spaces over time through natural subsurface processes and diffusion out of the mesa at the land surface and through dispersion, thereby attaining media cleanup standards.

7.4.2.3 Control of Source and Releases

MNA will measure diffusion of VOCs within soil pore gas. This technology will provide minimal control of source area and releases from the vadose zone and will provide monitoring data with which to evaluate contaminant presence within the vadose zone.

7.4.2.4 Compliance with Applicable Waste Management Standards

No waste will be generated during implementation of MNA technology.

7.4.2.5 Summary

MNA meets the threshold criteria and is retained for further consideration.

7.4.3 Technology VZ-2b: Soil-Gas Venting

Soil-gas venting consists of open boreholes drilled into the contaminated matrix that allow the release of subsurface vapors and gases to the atmosphere. This technology involves

- installing boreholes for soil-gas venting;
- using soil-gas venting to remove VOCs;
- active monitoring of pore gas for 30 yr; and
- maintaining institutional controls for 100 yr.

This technology will reduce VOC concentrations in pore gas located within the limited ROI of the open borehole. VOC concentrations within subsurface soil will be reduced.

This technology includes pore-gas monitoring for 30 yr. Pore-gas monitoring will be used to detect further releases as well as to determine if the concentrations of VOC contamination in the pore gas are changing with time. Institutional controls, such as fencing, control of site access, and Laboratory administrative controls, are assumed to remain in place for 100 yr.

7.4.3.1 Protection of Human Health and the Environment

Soil-gas venting will remove VOCs from the soil pore spaces eliminating the pathway for VOCs to impact the groundwater, thereby providing protection of human health and the environment.

7.4.3.2 Attainment of Media Cleanup Standards

Soil-gas venting will remove VOCs until media cleanup standards are met.

7.4.3.3 Control of Source and Releases

Soil-gas venting will control releases in the vadose zone by providing a path for subsurface VOC vapors to be released to the atmosphere.

7.4.3.4 Compliance with Applicable Waste Management Standards

Any waste generated under this technology will comply with all applicable regulatory requirements.

7.4.3.5 Summary

In situ treatment of pore gas by soil-gas venting meets the threshold criteria and is retained for further consideration.

7.4.4 Technology VZ-2c: Soil-Vapor Extraction

This technology provides for the removal of contamination through the use of SVE. This technology involves

- installing extraction boreholes for active SVE,
- active SVE to remove VOCs from the vadose zone,
- active monitoring of pore gas for 30 yr, and
- maintaining institutional controls for 100 yr.

This technology will reduce VOC concentrations in pore gas located within the ROI of the extraction boreholes. A conceptual SVE design was developed as part the 2010 supplemental SVE pilot study and is described in more detail in the supplemental SVE pilot test report (LANL 2010, 109657). The conceptual SVE design includes the following principal assumptions and components:

- Twenty extraction boreholes will be installed, each to a depth of approximately 150 ft bgs and terminated within the Qbt 1g geologic unit. The extraction boreholes will be located across MDA G to provide extraction of the highest concentrations of VOC vapors (approximately 10 times the screening values for TCA and TCE [see section 3.2.4 and Appendix C]).
- Extraction borehole locations will be conservatively based on a 150-ft ROI with a 20% overlap, based upon the results of the 2010 supplemental SVE pilot study (LANL 2010, 109657).
- Skid-mounted SVE units will be used, scaled to meet the 2010 Supplemental SVE pilot test operational parameters for the VOC vapor plume treatment areas.
- Off-gas treatment will be employed using granulated activated carbon.

Active vapor extraction will be conducted at each extraction borehole for up to 180 d. To allow for continuous extraction, if necessary, all extraction boreholes in each plume area will be manifolded to a central SVE unit for that plume area. Following 180 d of active extraction, VOC concentrations will be monitored at pore-gas monitoring boreholes according to the method and schedule described in Appendix H. Pre- and postmonitoring will document the effectiveness of the removal and the rebound behavior of the VOC vapor plumes. The active extraction cycles will be applied for 3 yr to remediate the vadose zone. Following the 3-yr active SVE time frame, VOC concentrations will be evaluated to determine if additional active SVE is warranted to achieve target cleanup goals.

Because active SVE can be operated periodically as necessary following the initial 3-yr active extraction time frame, active SVE will provide effective long-term removal of vapor-phase VOCs. Passive SVE following active SVE is therefore not proposed.

This technology includes pore-gas monitoring for 30 yr Pore-gas monitoring will be used to detect further releases as well as to determine if the concentrations of VOC contamination in the pore gas are changing with time. Additional active institutional controls, such as fencing, control of site access, and Laboratory administrative controls, will be assumed to remain in place for 100 yr.

7.4.4.1 Protection of Human Health and the Environment

Removal of vapor-phase VOCs within pore gas will be protective of human health and the environment by eliminating the pathway for VOCs to impact groundwater.

7.4.4.2 Attainment of Media Cleanup Standards

Active SVE will attain media cleanup standards by removing VOCs from the subsurface.

7.4.4.3 Control of Source and Releases

Active SVE will remove vapor-phase VOCs within pore gas and will control the migration from the source.

7.4.4.4 Compliance with Applicable Waste Management Standards

Any waste generated under this technology, which may include tritium-contaminated waste, will comply with all applicable regulatory requirements.

7.4.4.5 Summary

In situ treatment of pore gas using active SVE meets the threshold criteria and is retained for further consideration.

7.5 Technologies Meeting Threshold Criteria and Retained for Further Evaluation

Table 7.5-1 presents a summary of the technologies that meet the threshold criteria. These technologies are retained and brought forward to section 8 for evaluation against the remedial alternative evaluation criteria described in section VII.D.4.b of the Consent Order.

8.0 EVALUATION OF ALTERNATIVES AGAINST REMEDIAL ALTERNATIVE EVALUATION CRITERIA

Corrective measures technologies identified in section 6 as appropriate for MDA G were screened against the Consent Order threshold criteria discussed in section 7. Corrective measures technologies determined to meet the Consent Order threshold criteria for the two source areas were brought forward for further evaluation along with the no-action technology. These technologies were evaluated against the remedial alternative evaluation criteria (also known as the balancing criteria) from Section VII.D.4.b of the Consent Order. The highest-ranking technologies were then combined into alternatives for each of the two source areas, and the alternatives were evaluated against the balancing criteria. The balancing criteria are discussed below.

8.1 Remedial Alternative Evaluation Criteria (Consent Order Section VII.D.4.b)

Section VII.D.4.b of the Consent Order requires that each remedial alternative be evaluated against the balancing criteria before proposing a recommended alternative.

8.1.1 Long-Term Reliability and Effectiveness (Consent Order Section VII.D.4.b.i)

This factor includes consideration of the magnitude of risks that will remain after implementation of the remedy, the extent of long-term monitoring or other management that will be required after implementation of the remedy, the uncertainties associated with leaving contaminants in place, and the potential for failure of the remedy. Preference is given to a remedy that reduces risks with little long-term management and that has proved effective under similar conditions.

8.1.2 Reduction of Toxicity, Mobility, or Volume (Consent Order Section VII.D.4.b.ii)

This factor includes consideration of the reduction in the toxicity, mobility, and volume of contaminants. Preference is given to a remedy that uses treatment to more completely and permanently reduce the toxicity, mobility, and volume of contaminant.

8.1.3 Short-Term Effectiveness (Consent Order Section VII.D.4.b.iii)

This factor includes consideration of the short-term reduction in existing risks that the remedy would achieve; the time needed to achieve that reduction; and the short-term risks that might be posed to the community, workers, and the environment during implementation of the remedy. Preference is given to a remedy that quickly reduces short-term risks without creating significant additional risks.

8.1.4 Implementability (Consent Order Section VII.D.4.b.iv)

This factor includes consideration of installation and construction difficulties; O&M difficulties; difficulties with cleanup technology; permitting and approvals; and the availability of necessary equipment, services, expertise, and storage and disposal capacity. Preference is given to a remedy that can be implemented quickly and easily and also poses fewer difficulties.

8.1.5 Cost (Consent Order Section VII.D.4.b.v)

This factor includes a consideration of both capital costs and O&M costs. Capital costs shall include, without limitation, construction and installation costs; equipment costs; land development costs; and indirect costs, including engineering costs, legal fees, permitting fees, start-up and shakedown costs, and contingency allowances. O&M costs shall include, without limitation, operating labor and materials costs; maintenance labor and materials costs; replacement costs; utilities; monitoring and reporting costs; administrative costs; indirect costs; and contingency allowances. All costs shall be calculated based on their net present value. Preference is given to a remedy that is less costly but does not sacrifice protection of health and the environment.

8.2 Criteria for Evaluation of Corrective Measures Options (Consent Order Section XI.F.10)

In addition to these five remedial alternative evaluation criteria, Section XI.F.10 of the Consent Order identifies six criteria that must be included in the evaluation of the corrective measures options. These include applicability, technical practicability, effectiveness, implementability, human health and ecological protectiveness, and cost. These six additional criteria are evaluated as follows:

8.2.1 Applicability (Consent Order Section XI.F.10.a)

Applicability addresses the overall suitability for the corrective action option for containment or remediation of the contaminants in the subject medium for protection of human health and the environment. Potential remedial action technologies were evaluated for their applicability for addressing the specific contaminants and media for protection of human health and the environment. Furthermore, the threshold screening process in section 7 specifically evaluated each technology for its ability to protect human health and the environment. Therefore, only technologies that are protective of human health and the environment were carried forward for evaluation in section 8.

8.2.2 Technical Practicability (Consent Order Section XI.F.10.b)

Technical practicability describes the uncertainty in designing, constructing, and operating a specific remedial alternative. The description includes an evaluation of historical applications of the remedial alternative including performance, reliability, and minimization of hazards. The elements of technical practicability are all included within the definition of implementability provided in Section VII.D.4.b.iv of the Consent Order. Each of the technologies is evaluated for implementability in this section.

8.2.3 Effectiveness (Consent Order Section XI.F.10.c)

Effectiveness assesses the ability of the corrective measure to mitigate the measured or potential impact of contamination in a medium under the current and projected site conditions. The assessment also includes the anticipated duration for the technology to attain regulatory compliance. In general, all corrective measures described above will have the ability to mitigate the impacts of contamination at the site, but not all remedial options will be equally effective at achieving the desired cleanup goals to the degree and within the same time frame as other options. Each remedy will be evaluated for both short-term and long-term effectiveness.

Both long-term reliability and effectiveness and short-term reliability and effectiveness are included in the remedial alternative evaluation criteria used to evaluate each technology in this section.

8.2.4 Implementability (Consent Order Section XI.F.10.d)

Implementability characterizes the degree of difficulty during the installation, construction, and operation of the corrective measure. Operation and maintenance of the alternative shall be addressed in this section. Implementability is also one of the remedial alternative evaluation criteria in Section VII.D.4.b of the Consent Order. Each technology is evaluated for its implementability in this section.

8.2.5 Human Health and Ecological Protectiveness (Consent Order Section XI.F.10.e)

This category evaluates the short-term (remedy installation-related) and long-term (remedy operation-related) hazards to human health and the environment of implementing the corrective measure. The assessment shall include an analysis of whether the technology will create a hazard or increase existing hazards and the possible methods of hazard reduction.

Protection of human health and the environment is one of the threshold criteria used to screen potential technologies in section 7. Only technologies determined to be protective of human health and the environment were carried forward from section 7 into section 8. To weigh the relative effectiveness of each technology for protecting human health and the environment, these factors are addressed further in this section. Long-term human health and ecological protection are included in the evaluation of long-term reliability and effectiveness for each technology. Likewise, short-term human health and ecological protection are included in the evaluation of short-term reliability and effectiveness for each technology.

8.2.6 Cost (Consent Order Section XI.F.10.f)

This section shall discuss the anticipated cost of implementing the corrective measures. The costs are divided into (1) capital costs associated with construction, installation, pilot testing, evaluation, permitting, and reporting of the effectiveness of the alternative; and (2) continuing costs associated with operating, maintaining, monitoring, testing, and reporting on the use and effectiveness of the technology. Cost is also one of the remedial alternative evaluation criteria addressed in this section.

The technologies that were carried forward from section 7 are listed in Table 8.2-1. These technologies are evaluated against the five balancing criteria listed above and the relative ranking described in Table 8.2-2. The cost estimates for the technologies are presented in Table 8.2-3.

8.3 Screening of Technologies for Pits and Shafts

8.3.1 Technology PS-1: No Action

This technology has been described in section 7.3.1.

8.3.1.1 Long-Term Reliability and Effectiveness

An increase in risk is associated with implementation of the no-action technology because it removes institutional controls. No long-term monitoring or other management will be conducted because no remedy is implemented. Uncertainty is associated with future exposure to waste remaining in place because of the lack of institutional controls. The no-action technology does not provide long term reliability and effectiveness.

8.3.1.2 Reduction of Toxicity, Mobility, or Volume

Because no action is taken, there is no reduction in toxicity, mobility, or volume.

8.3.1.3 Short-Term Effectiveness

No short-term risk is associated with implementation of the no action technology because no action is taken.

8.3.1.4 Implementability

No remedy is implemented; therefore, this criterion is not applicable.

8.3.1.5 Cost

No costs are associated with the no-action technology.

8.3.2 Technology PS-3a: Vegetative Cover

This technology has been described in section 7.3.3. Assumptions for this technology are documented in Appendix G.

8.3.2.1 Long-Term Reliability and Effectiveness

Installation of a vegetative cover will reduce erosion, biointrusion, and infiltration and will also reduce the potential for exposure. The vegetative cover is reliable over the long term if constructed to the proper depth. Some uncertainty and long-term risk will be associated with waste that remains in place. The uncertainty with performance is managed through institutional controls, including maintenance and monitoring. Long-term maintenance requirements for vegetative covers include visual inspection, removal of debris and large woody plants, erosion control, periodic fertilization, and mowing.

8.3.2.2 Reduction of Toxicity, Mobility, or Volume

The vegetative cover technology will reduce mobility of waste by controlling erosion and infiltration but will have no impact on reduction of toxicity or volume. The vegetative cover technology will not reduce mobility associated with vapor transport.

8.3.2.3 Short-Term Effectiveness

A vegetative cover can be constructed in a short time frame. The vegetative cover poses relatively low risk to community, workers, and the environment during construction because it does not involve any waste excavation or management. The vegetative cover technology can be implemented quickly without creating significant additional risk.

The greatest impacts to human health from installing the cover are associated with the physical hazards of construction activities and traffic risks associated with the transportation of raw materials to the site for the construction of the cover. Workers will not be exposed to buried waste during cover construction activities, because excavation into the waste disposal sites is not required for installing the cover.

The risk of traffic accidents associated with the remedy is generally considered a function of total miles of travel for the project vehicles. Based on an average accident rate for large trucks of 2.3 fatal accidents per 100 million mi (DOT 2002, 097082, p. 2), or 2.3×10^{-8} fatal accidents per mi, and approximately 500,000 truck transport mi on public roads for delivery of project resources, the overall incident rate for fatal traffic accidents for the project would be less than 1.

8.3.2.4 Implementability

The vegetative cover is installed using standard construction techniques and presents minimal installation and construction difficulties. Following installation, low to moderate maintenance is required.

No permits or permit modifications are anticipated.

8.3.2.5 Cost

Total capital costs are estimated to be $88,063,000. The O&M costs are estimated to be $2,398,000. The present value cost is estimated to be $90,461,000. These costs are presented in Table 8.2-3.

8.3.3 Technology PS-3b: ET Cover

The ET cover technology has been described in section 7.3.4. Assumptions for this technology are documented in Appendix G.

8.3.3.1 Long-Term Reliability and Effectiveness

Installation of an ET cover will reduce erosion, biointrusion, and infiltration and will reduce the potential for future exposure. The ET cover is reliable over the long term because it does not have problems resulting from desiccation that are associated with standard RCRA caps. Some uncertainty and long-term risk will be associated with waste that remains in place. The uncertainty with performance is managed through institutional controls, including maintenance and monitoring. Long-term maintenance requirements for ET covers include visual inspection, removal of debris and large woody plants, erosion control, periodic fertilization, and mowing. ET covers have been proven effective in the arid and semiarid environments of the southwestern United States, (Dwyer et al. 2000, 069673, p. 24; LANL 2005, 089332, p. 25).

8.3.3.2 Reduction of Toxicity, Mobility, or Volume

The ET cover will reduce mobility of waste by controlling erosion and infiltration but will have no impact on reduction of toxicity or volume. The ET cover will also not reduce mobility associated with vapor transport.

8.3.3.3 Short-Term Effectiveness

An ET cover can be constructed in a short time frame (i.e., approximately 2 yr). The ET cover poses relatively low risk to community, workers, and the environment during construction because it does not involve any waste excavation or management. The ET technology can be quickly implemented without creating any significant additional risk.

The greatest impacts to human health from installing the cover are associated with the physical hazards of construction activities and traffic risks associated with the transportation of raw materials to the site for the construction of the ET cover. Workers will not be exposed to buried waste during ET cover construction activities, because excavation into the waste disposal sites is not required for installing the cover.

The risk of vehicle traffic accidents associated with implementation of the remedy is generally considered a function of total miles of travel for the project vehicles. Based on an average fatal accident rate per vehicle miles for large trucks of 2.3 fatal accidents per 100 million mi (DOT 2002, 097082, p. 2), and approximately 1.3 million truck transport mi on public roads for delivery of project resources, an overall incident rate for fatal traffic accidents for the project would be less than 1.

8.3.3.4 Implementability

The ET cover is installed using standard construction techniques and presents minimal installation and construction difficulties. Following installation, low to moderate maintenance is required. No permits or permit modifications are anticipated.

8.3.3.5 Cost

Total capital costs are estimated to be $190,225,000. The O&M costs are estimated to be $2,398,000. The present value cost is estimated to be $192,623,000. These costs are presented in Table 8.2-3.

8.3.4 Technology PS-4a: Excavation of Pits and Shafts with On-Site Disposal in a CAMU or RCRA Landfill

This technology has been described in section 7.3.6. Technology PS-4a uses excavation for the pits and shafts.

Assumptions for this technology are documented in Appendix G. Waste volumes were estimated using the pit and shaft volumes presented in Tables 2.1-1 and 2.1-3.

8.3.4.1 Long-Term Reliability and Effectiveness

Removal of the waste in the pits and shafts will eliminate the source and the potential for future exposure. Uncertainties will be managed by collecting confirmatory samples at the base of the pit or shaft to determine whether additional contamination exists and additional excavation is required. After the waste has been removed, the excavation will be backfilled with clean fill and the area will be regraded and reseeded with native vegetation. Site surveillance, monitoring, and maintenance activities will be conducted to establish the vegetation. This technology transfers the potential impact of the waste to the on-site disposal facility and the roads on which the waste is transported.

Complete removal of the waste would significantly reduce long-term risks and doses to human health following implementation of the remedy. The removal of wastes would greatly reduce potential impacts to groundwater quality, although some slight risk may remain from any residual contamination.

8.3.4.2 Reduction of Toxicity, Mobility, or Volume

The removal of waste in the pits and shafts will reduce toxicity and mobility of contaminants from the current site. However, the sorting and segregation of the excavated materials will increase the volume of waste to be disposed of by increasing the amount of packaging materials necessary for transport and disposal at various locations, depending on the waste type.

8.3.4.3 Short-Term Effectiveness

Excavation, sorting, segregation, analysis, waste determination, and transport and disposal of the waste would be conducted over a 30-yr period. The on-site CAMU or RCRA landfill would be constructed concurrently. Before the excavation activities begin, a waste sorting and segregation facility would be built. Removal activities have the high potential for injuries and accidents. Disturbance and excavation of the units increase the possibility of accidental release of hazardous materials. The possibility of release upon disturbance of the units containing unknown chemical waste increases the short-term risk of contaminant dispersal.

Potential accidents resulting from excavation and associated waste handling include industrial hazards/accidents, fires with release of hazardous materials, spills of hazardous materials, and transportation accidents.

The risk to the public from all activities, except potential fire and explosions and on-site / off-site transportation, is negligible. The risk of vehicle traffic accidents associated with implementation of the remedy is generally considered a function of total miles of travel for the project vehicles. Based on an average fatal accident rate per vehicle miles for large trucks of 2.3 fatal accidents per 100 million mi (DOT 2002, 097082, p. 2), and approximately 8.7 million truck transport mi on public roads, an overall incident rate for fatal traffic accidents for the project would be less than 1.

8.3.4.4 Implementability

The pits and shafts will be excavated using a tiered approach based on hazard level and assessment of specific inventory. Excavation will be accomplished using standard excavation methods, unless potential or real hazards dictate remote handling. Following excavation of waste, no maintenance is required.

Construction and operation of a CAMU or RCRA landfill would require operation under the provisions of the Laboratory’s HWFP issued by NMED. The establishment of either a CAMU or RCRA landfill would be considered a Class 3 Permit modification, which is the most rigorous, requiring substantial detailed engineering and operational effort, expert regulatory support, and major public involvement. The time required to permit a CAMU or RCRA landfill at the Laboratory could take from 5 to 10 yr, depending on regulatory requirements and public involvement.

Implementation of this technology includes the requirements associated with the siting, design, permitting, construction, and operation of an on-site RCRA-permitted treatment unit and a CAMU or a RCRA landfill. The RCRA seismic standard contained in 40 CFR 264.18 may limit the available locations within the Laboratory for siting the treatment and disposal units.

Although a CAMU does not technically require a permit, it can be designated only by the NMED Secretary through a process similar to a streamlined RCRA-permitting process. The CAMU technology would require a RCRA permit modification for the CAMU land disposal unit and the waste treatment facility. A RCRA permit would be required for the Subtitle C RCRA landfill.

8.3.4.5 Cost

Total capital costs for Technologies PS-4a are estimated to be $17,132,304,000. The O&M costs are estimated to be $596,596,000. The present value cost is estimated to be $17,728,900,000. These costs are presented in Table 8.2-3.

8.3.5 Technology PS-4b: Excavation of Pits and Shafts with Off-Site Disposal

This technology has been described in section 7.3.7. Technology PS-4b uses excavation for the pits and shafts.

Assumptions for this technology are documented in Appendix G. Waste volumes were estimated using the pit and shaft volumes presented in Tables 2.1-1 and 2.1-3.

8.3.5.1 Long-Term Reliability and Effectiveness

Removal of the waste in the pits and shafts will eliminate the source and the potential for future exposure. Uncertainties will be managed by collecting confirmatory samples at the base of the pits to determine whether additional contamination exists and additional excavation is required. After the waste has been removed, the excavation will be backfilled and the area will be regraded, revegetated, and maintained to establish the vegetation. This technology transfers the potential impact of the waste to the off-site disposal facility and the roads on which the waste is transported.

Complete removal of the waste would significantly reduce long-term risks and doses to human health following implementation of the remedy. The removal of wastes would greatly reduce potential impacts to groundwater quality, although some slight risk may remain from any residual contamination.

8.3.5.2 Reduction of Toxicity, Mobility, or Volume

The removal of waste in the pits and shafts will reduce toxicity and mobility of contaminants from the current site. However, the sorting and segregation of the excavated materials will increase the volume of waste to be disposed of by increasing the amount of packaging materials necessary for transport and disposal at various locations depending on the waste type.

8.3.5.3 Short-Term Effectiveness

Excavation, sorting, segregation, analysis, waste determination and transport and disposal of the waste would be conducted over a 30-yr period. Before the excavation activities begin, a waste sorting and segregation facility would be built. Removal activities have the high potential for injuries and accidents. Disturbance and excavation of the units increase the possibility of accidental release of hazardous materials. The possibility of release upon disturbance of the units containing unknown chemical waste increases the short-term risk of contaminant dispersal.

Because of the extensive excavation and waste handling required at the site, Technology PS-4b poses the highest exposure to workers and the public from transportation of waste on public roads. Potential accidents resulting from extensive excavation and associated waste handling include industrial hazards/accidents, fires with release of radioactive/hazardous materials, explosions and associated releases of radioactive materials, spills of hazardous and radioactive materials, inadvertent exposures to penetrating radiation, and transportation accidents.

The risk to the public from all activities, except potential fire and explosions and on-site / off-site transportation, is negligible. The risk of vehicle traffic accidents associated with implementation of the remedy is generally considered a function of total miles of travel for the project vehicles. Based on an average fatal accident rate per vehicle miles for large trucks of 2.3 fatal accidents per 100 million mi, (DOT 2002, 097082, p. 2), and approximately 88.7 million truck transport mi on public roads, an overall incident rate for fatal traffic accidents for the project would be approximately 2 fatalities. Under Technology PS-4b, members of the public would be exposed to the risk of transporting the waste across the nation's highways.

8.3.5.4 Implementability

The pits and shafts will be excavated using a tiered approach based on hazard level and assessment of specific inventory. Excavation will be accomplished using standard excavation methods, unless potential or real hazards dictate remote handling. Following excavation of waste, no maintenance is required.

The WAC for the facility where the waste will be disposed may require on-site treatment before the waste is shipped off-site.

No permit requirements are anticipated.

One significant challenge of this technology may be finding suitable off-site locations to receive all the various waste streams.

8.3.5.5 Cost

Total capital costs for Technology PS-4b are estimated to be $32,339,684,000. The O&M costs are estimated to be $826,000. The present value cost is estimated to be $32,340,510,000. These costs are presented in Table 8.2-3.

8.3.6 Technology PS-4c: Excavation of Pits and Overcoring Retrieval of Shafts with On-Site Disposal in a CAMU or RCRA Landfill

This technology has been described in section 7.3.8. Technology PS-4c uses excavation for the pits and overcoring for the shafts.

Assumptions for this technology are documented in Appendix G. Waste volumes were estimated using the pit and shaft volumes presented in Tables 2.1-1 and 2.1-3.

8.3.6.1 Long-Term Reliability and Effectiveness

Removal of the waste in the pits and shafts will eliminate the source and the potential for future exposure. Uncertainties will be managed by collecting confirmatory samples at the base of the pit or shaft to determine whether additional contamination exists and additional excavation is required. After the waste has been removed, the excavation will be backfilled with clean fill and the area will be regraded and reseeded with native vegetation. Site surveillance, monitoring, and maintenance activities will be conducted to establish the vegetation. Excavation, treatment, and on-site disposal transfers the potential impact of the waste to the on-site disposal facility and the roads on which the waste is transported.

Complete removal of the waste would significantly reduce long-term risks and doses to human health following implementation of the remedy. The removal of wastes would greatly reduce potential impacts to groundwater quality, although some slight risk may remain from any residual contamination.

8.3.6.2 Reduction of Toxicity, Mobility, or Volume

The removal of waste in the pits and shafts will reduce toxicity and mobility of contaminants from the current site. However, the sorting and segregation of the excavated materials will increase the volume of waste to be disposed of by increasing the amount of packaging materials necessary for transport and disposal at various locations, depending on the waste type.

8.3.6.3 Short-Term Effectiveness

Excavation, sorting, segregation, analysis, waste determination, and transport and disposal of the waste would be conducted over a 30-yr period. The on-site CAMU or RCRA landfill would be constructed concurrently. Before the excavation activities begin, a waste sorting and segregation facility would be built. Removal activities have the high potential for injuries and accidents. Disturbance and excavation of the units increase the possibility of accidental release of hazardous materials. The possibility of release upon disturbance of the units containing unknown chemical waste increases the short-term risk of contaminant dispersal.

Potential accidents resulting from excavation and associated waste handling include industrial hazards/accidents, fires with release of hazardous materials, spills of hazardous materials, and transportation accidents.

Because of the extensive excavation and waste handling required at the site, this technology poses the highest exposure risk to workers and exposure to the public from transportation of waste on public roads.

Potential accidents resulting from extensive excavation and associated waste handling include industrial hazards/accidents, fires with release of radioactive/hazardous materials, explosions and associated releases of radioactive materials, spills of hazardous and radioactive materials, inadvertent exposures to penetrating radiation, and transportation accidents.

The risk to the public from all activities, except potential fire and explosions and on-site / off-site transportation, is negligible. The risk of vehicle traffic accidents associated with implementation of the remedy is generally considered a function of total miles of travel for the project vehicles. Based on an average fatal accident rate per vehicle miles for large trucks of 2.3 fatal accidents per 100 million mi (DOT 2002, 097082, p. 2), and approximately 8.7 million truck transport mi on public roads, an overall incident rate for fatal traffic accidents for the project would be less than 1.

8.3.6.4 Implementability

Excavation of the pits can be accomplished using standard excavation methods. The overcoring technology has recently been implemented at the DOE facility in Hanford, Washington. Following excavation of waste, no maintenance is required.

Construction and operation of a CAMU or RCRA landfill would require operation under the provisions of the Laboratory’s HWFP issued by NMED. The establishment of either a CAMU or RCRA landfill would be considered a major permit modification and as such would be a Class 3 modification, which is the most rigorous, requiring substantial detailed engineering and operational effort, expert regulatory support, and major public involvement. The time required to permit a CAMU or RCRA landfill at the Laboratory could take from 5 to 10 yr, depending on regulatory requirements and public involvement.

Implementation of this technology includes the requirements associated with the siting, design, permitting, construction, and operation of an on-site RCRA-permitted treatment unit and a CAMU or a RCRA landfill. The RCRA seismic standard contained in 40 CFR 264.18 may limit the available locations within the Laboratory for siting the treatment and disposal units. Excavated material will need to be sorted, staged, and tested to determine which material would be required to be treated to meet CAMU standards or LDRs before disposal.

Although a CAMU does not technically require a permit, it can be designated only by the NMED Secretary through a process similar to a streamlined RCRA-permitting process. The CAMU technology would require a RCRA permit modification for the CAMU land disposal unit and the waste treatment facility. A RCRA permit would be required for the Subtitle C RCRA landfill.

8.3.6.5 Cost

Total capital costs for Technology PS-4c are estimated to be $17,119,491,000. The O&M costs are estimated to be $576,701,000. The present value cost is estimated to be $17,696,192,000. These costs are presented in Table 8.2-3.

8.3.7 Technology PS-4d: Excavation of Pits and Overcoring Retrieval of Shafts with Off-Site Disposal

This technology has been described in section 7.3.9. Technology PS-4d uses excavation for the pits and overcoring for the shafts.

Assumptions for this technology are documented in Appendix G. Waste volumes were estimated using the pit and shaft volumes presented in Tables 2.1-1 and 2.1-3.

8.3.7.1 Long-Term Reliability and Effectiveness

Removal of the waste in the pits and shafts will eliminate the source and the potential for future exposure. Uncertainties will be managed by collecting confirmatory samples at the base of the pits and shafts to determine whether additional contamination exists and additional excavation is required. After the waste has been removed, the excavation will be backfilled and the area regraded, revegetated, and maintained to establish the vegetation. This technology transfers the potential impact of the waste to the off-site disposal facility and the roads on which the waste is transported.

Complete removal of the waste would significantly reduce long-term risks and doses to human health following implementation of the remedy. The removal of wastes would greatly reduce potential impacts to groundwater quality, although some slight risk may remain from any residual contamination.

8.3.7.2 Reduction of Toxicity, Mobility, or Volume

The removal of waste in the pits and shafts will reduce toxicity and mobility of contaminants from the current site. However, the sorting and segregation of the excavated materials will increase the volume of waste to be disposed of by increasing the amount of packaging materials necessary for transport and disposal at various locations, depending on the waste type.

8.3.7.3 Short-Term Effectiveness

Excavation, sorting, segregation, analysis, waste determination, and transport and disposal of the waste would be conducted over a 30-yr period. Before the excavation activities begin, a waste sorting and segregation facility would be built. Removal activities have the high potential for injuries and accidents. Disturbance and excavation of the units increase the possibility of accidental release of hazardous materials. The possibility of release upon disturbance of the units containing unknown chemical waste increases the short-term risk of contaminant dispersal.

Because of the extensive excavation and waste handling required at the site, this technology poses the highest risk exposure to workers and the public from transportation of waste on public roads.

Potential accidents resulting from extensive excavation and associated waste handling include industrial hazards/accidents, fires with release of radioactive/hazardous materials, explosions and associated releases of radioactive materials, spills of hazardous and radioactive materials, inadvertent exposures to penetrating radiation, and transportation accidents.

The risk to the public from all activities, except potential fire and explosions and on-site/off-site transportation, is negligible. The risk of vehicle traffic accidents associated with implementation of the remedy is generally considered a function of total miles of travel for the project vehicles. Based on an average fatal accident rate per vehicle miles for large trucks of 2.3 fatal accidents per 100 million mi (DOT 2002, 097082, p. 2), and approximately 88.7 million truck transport mi on public roads, an overall incident rate for fatal traffic accidents for the project would be approximately 2 fatalities. Under Technology PS-4d, members of the public would be exposed to the risk of transporting the waste across the nation's highways.

8.3.7.4 Implementability

Excavation of the pits can be accomplished using standard excavation methods, unless potential or real hazards dictate remote handling. The overcoring technology has recently been implemented at the DOE facility in Hanford, Washington. Following excavation of waste, no maintenance is required.

The WAC for the facility where the waste will be disposed may require on-site treatment before the waste is shipped off-site.

No permit requirements are anticipated.

8.3.7.5 Cost

Total capital costs for Technology PS-4d are estimated to be $32,400,750,000. The O&M costs are estimated to be $826,000. The present value cost is estimated to be $32,401,576,000. These costs are presented in Table 8.2-3.

8.3.8 Technology PS-5: Ex situ Treatment

This technology is described in section 7.3.10. Assumptions for this technology are documented in Appendix G.

8.3.8.1 Long-Term Reliability and Effectiveness

Treatment of the excavated waste will immobilize or chemically alter the waste form to meet standards for LDRs so the waste can be disposed in an on-site CAMU or RCRA landfill. Uncertainty with treatment requirements will be managed by waste analysis, which will determine whether the waste is low-level, MLLW, hazardous waste, or material that meets LDRs and can be reburied on-site. No long-term maintenance is required after treatment of the waste.

8.3.8.2 Reduction of Toxicity, Mobility, or Volume

Treatment of the excavated waste would significantly reduce the toxicity and mobility of the waste, but some treatment technologies would increase the volume of the treated waste.

8.3.8.3 Short-Term Effectiveness

Waste would be treated over a 30-yr period in conjunction with waste removal. Waste treatment poses potential risk to workers for injuries and accidents during the treatment process. Potential accidents resulting from waste treatment and associated waste handling include industrial hazards/accidents, fires with release of hazardous materials, spills of hazardous materials, and transportation accidents.

8.3.8.4 Implementability

Waste treatment equipment would have to be purchased. Analysis of the waste forms would be necessary to determine the pretreatment requirements for the waste to meet WAC. Following treatment of the waste, no maintenance is required. Permit requirements are anticipated.

8.3.8.5 Cost

Total capital costs for Technology PS-5 are estimated to be $18,217,072,000. The O&M costs are estimated to be $396,930,000. The present value cost is estimated to be $18,614,002,000. These costs are presented in Table 8.2-3

8.3.9 Screening Summary for Pits and Shafts

The screening criteria for the pits and shafts are summarized in Table 8.3-1.

8.4 Evaluation of Technologies for the Vadose Zone

8.4.1 Technology VZ-1: No Action

This technology is described in section 7.4.1.

8.4.1.1 Long-Term Reliability and Effectiveness

This technology does not involve implementation of any action; therefore, there is no risk associated with implementation, no monitoring or management requirements associated with implementation, and no potential for remedy failure. This technology does not provide long-term reliability and effectiveness.

8.4.1.2 Reduction of Toxicity, Mobility, or Volume

This technology does not involve implementation of any action; therefore, there is no reduction in toxicity, mobility, or volume.

8.4.1.3 Short-Term Effectiveness

No short-term risk is associated with implementation of this technology because no action is taken.

8.4.1.4 Implementability

Under the no-action technology, no remedy is implemented; therefore, this criterion is not applicable.

8.4.1.5 Cost

No cost is associated with the no-action technology.

8.4.2 Technology VZ-2a: Monitored Natural Attenuation

This technology is described in section 7.4.2. Assumptions for this technology are documented in Appendix G.

8.4.2.1 Long-Term Reliability and Effectiveness

MNA will effectively remove the VOCs from the vadose zone, thereby removing the potential for future migration to groundwater. Some uncertainty and long-term risk are associated with the unknown volume of VOCs in the vadose zone. The uncertainty with performance is managed through modeling and monitoring.

8.4.2.2 Reduction of Toxicity, Mobility, or Volume

MNA will be effective in permanently reducing the mobility and volume of VOC contamination; however, it will require a long time to achieve the desired level of reduction.

8.4.2.3 Short-Term Effectiveness

MNA can be implemented quickly and poses minimal risk to community, workers, and the environment during implementation.

8.4.2.4 Implementability

MNA is easy to implement. Standard construction techniques and materials are required to install pore-gas monitoring locations. Modeling can be performed to predict pore-gas concentration behavior.

8.4.2.5 Cost

Total capital costs for Technology VZ-2a are estimated to be $15,153,000. The O&M costs are estimated to be $3,811,000. The present value cost is estimated to be $18,964,000. These costs are presented in Table 8.2-3.

8.4.3 Technology VZ-2b: Soil-Gas Venting

This technology is described in section 7.4.3. Assumptions for this technology are documented in Appendix G.

8.4.3.1 Long-Term Reliability and Effectiveness

Soil-gas venting will effectively remove the VOCs from the vadose zone, thereby removing the potential for future migration to groundwater. Some uncertainty and long-term risk are associated with the unknown volume of VOCs in the vadose zone. The uncertainty with performance is managed through modeling and monitoring. Long-term maintenance requirements for the soil-gas venting system include regular inspections of the system.

8.4.3.2 Reduction of Toxicity, Mobility, or Volume

Soil-gas venting will be effective in permanently reducing the mobility and volume of VOC contamination and will have an immediate impact on the VOC concentrations; however, it will require a long period of operation to achieve the desired level of reduction.

8.4.3.3 Short-Term Effectiveness

Soil-gas venting can be implemented quickly by using existing monitoring boreholes or constructing new boreholes and poses minimal risk to community, workers, and the environment during implementation.

8.4.3.4 Implementability

Soil-gas venting is easy to implement. Standard construction techniques and materials are required to install pore-gas monitoring locations. Modeling can be performed to predict pore-gas concentration behavior.

8.4.3.5 Cost

Total capital costs for Technology VZ-2b are estimated to be $85,921,000. The O&M costs are estimated to be $33,524,000. The present value cost is estimated to be $119,445,000. These costs are presented in Table 8.2-3.

8.4.4 Technology VZ-2c: Soil-Vapor Extraction

This technology is described in section 7.4.4. Assumptions for this technology are documented in Appendix G.

8.4.4.1 Long-Term Reliability and Effectiveness

Active SVE will effectively remove VOCs from the source area as well as from the vadose zone, thereby removing the potential for future migration to groundwater. Some uncertainty and long-term risk are associated with the unknown volume of VOCs in the vadose zone. The uncertainty with performance is managed through monitoring, which will be used to evaluate the effectiveness of SVE. Long-term maintenance requirements for the SVE system or systems include regular inspections of the system(s).

8.4.4.2 Reduction of Toxicity, Mobility, or Volume

SVE will be effective in permanently reducing the mobility and volume of VOC contamination and will have an immediate impact on the VOC concentrations.

8.4.4.3 Short-Term Effectiveness

SVE equipment is commercially available and extraction boreholes can be constructed within a 3-mo time frame. SVE systems pose relatively low risk to community, workers, and the environment during construction as demonstrated by the SVE pilot studies. This technology can be implemented quickly without creating significant additional risk.

8.4.4.4 Implementability

SVE is easy to install and operate, and the necessary equipment is readily available. Operation of an SVE system or systems will require a modification to the Laboratory’s air permit.

8.4.4.5 Cost

Total capital costs for Technology VZ-2c are estimated to be $78,381,000. The O&M costs are estimated to be $14,341,000. The present value cost is estimated to be $92,722,000. These costs are presented in Table 8.2-3.

8.4.4.6 Summary of Vadose Zone Screening

The screening criteria for the vadose zone are summarized in Table 8.4-1.

8.5 Development and Evaluation of Alternatives

MDA G contains both intact buried wastes and contaminants that have migrated from waste disposal zones into adjacent environmental media. The identified corrective measure alternatives were developed to contain, remediate, and/or control the buried waste source materials and adjacent contaminated environmental media and to address the RAOs.

In order to address the complex issues associated with MDA G, the highest-ranking technologies were assembled into a number of alternatives to determine the most effective alternative for closing the site. These alternatives are presented below. Table 8.5-1 provides the ranking of each alternative against the balancing criteria.

- Alternative 1: Technologies PS-1 and VZ-1: No action
- Alternative 2: Technologies PS-3b and VZ-2c:
    - ❖ Construction of an ET cover (PS-3b) eliminates the human and ecological exposure through excavation, biointrusion, and erosion to the waste. Construction of an ET cover provides the additional benefit of long-term reliability and effectiveness over Technology PS-3a (vegetative cover).
    - ❖ Operation of SVE systems (VZ-2c) would have an immediate effect in reducing the volume of VOCs in the vadose zone, an advantage over Technologies VZ-2a (MNA) or VZ-2b (soil-gas venting).
- Alternative 3: Technologies PS-4b (or PS-4d) and VZ-2c:
    - ❖ Waste excavation with off-site disposal (PS-4b or PS-4d) eliminates future risk from failure of liner and leachate collection systems for a CAMU or RCRA landfill (PS-4a or PS-4c). However, off-site disposal increases the risk of accidents because of significantly increased transportation mileage.
    - ❖ Operation of SVE systems (VZ-2c) would have an immediate effect in reducing the volume of VOCs in the vadose zone, an advantage over Technologies VZ-2a (MNA) or VZ-2b (Soil-gas venting).

9.0 SELECTION OF THE RECOMMENDED CORRECTIVE MEASURES ALTERNATIVE

Selection of the recommended alternative is based on the criteria listed in Table 8.5-1. This table provides summaries of the corrective measure alternatives based on selection criteria defined in Section VII.D.4 of the Consent Order and discussed in section 8.1 of this report. The highest-ranking alternative for the pits and shafts, and for the vadose zone, is Alternative 2.

- Pits and shafts—ET cover
- Vadose zone—SVE

9.1 Selection of Recommended Corrective Measure

As shown in Table 8.5-1, Alternative 2 is superior to Alternative 3 in terms of the following balancing criteria: Short-Term Effectiveness, Implementability, and Cost. Alternative 3 presents significantly higher transportation risks, with the potential for fatalities from transport of waste to off-site disposal units. In terms of implementability, Alternative 2 is essentially completed in 3 yr versus 30 yr for Alternative 3’s complete excavation and off-site disposal. The implementation for Alternative 3 has significantly higher long-term costs compared with Alternative 2.

The selected alternative meets the RAOs developed for the CSM for the two source areas. The RAOs include the following:

- Prevent future human health and ecological exposure to waste through excavation, biointrusion, erosion, or subsidence of the waste;
- Prevent future human health and ecological exposure to contaminated surface and subsurface soils through excavation or biointrusion;
- Prevent groundwater from being impacted in the future above a regulatory standard from diffusion of VOCs through soil vapor.

The ET cover would be placed over the pits and shafts, as shown in Figure 7.3-1. Twenty SVE boreholes will then be installed to facilitate active extraction of vapor-phase VOCs from the vadose zone. The ROI for each extraction borehole conservatively assumes 150 ft from the point of extraction. The 20 boreholes will be spaced laterally to provide coverage of the highest concentrations (approximately 10 times the screening values for TCA and TCE—see section 3.2.4 and Appendix C) of overlapping VOC plumes shown in Figure 2.4-2 and Figures C-3.1-1 through C-3.1-5 (Appendix C). The 20 extraction boreholes will be manifolded to one of four SVE systems located in the four VOC plume areas. Each SVE system will operate for a 180-d continuous period. Active SVE will be performed in this manner for 3 yr. Following the 3-yr active SVE time frame, pore-gas monitoring will continue for 27 yr to evaluate VOC concentrations and whether additional active SVE is warranted to achieve target cleanup goals. If acceptable reductions in VOC concentrations have not been achieved, additional active SVE will be performed. Institutional controls will be implemented to include the following actions: (1) access control to prevent human intrusion and (2) maintenance of the cover to ensure the cover does not erode and that biointrusion is prevented.

The recommended alternative is evaluated against the selection criteria in the following sections.

9.1.1 Long-Term Reliability and Effectiveness

Installation of an ET cover will reduce erosion, biointrusion, and infiltration and will reduce the potential for future exposure. The ET cover is reliable over the long term if it is constructed to the proper depth. Some uncertainty and long-term risk will be associated with waste that remains in place. The uncertainty with performance and potential for failure is managed through institutional controls, including maintenance and monitoring. Long-term maintenance requirements for ET covers include annual inspection and repair for erosion and subsidence, removal of debris and large woody plants, and fertilization and mowing as needed to maintain the ET cover.

Some uncertainty and long-term risk are associated with the unknown volume of VOCs in the vadose zone; however, the operation of a SVE system will remove the VOCs from the vadose zone, thereby reducing any potential future risk. The uncertainty with performance is managed through pore-gas monitoring, which will be used to evaluate the effectiveness of the SVE system and whether additional active SVE is warranted. Long-term maintenance requirements for the SVE system include regular inspections of the system.

9.1.2 Reduction of Toxicity, Mobility, or Volume

The ET cover will reduce mobility of waste by controlling erosion and infiltration but will have no impact on the reduction of toxicity or volume. The ET cover will not reduce mobility associated with vapor transport.

SVE will be effective in permanently reducing the mobility and volume of VOC contamination in the vadose zone. SVE will have an immediate impact on the VOC concentrations; however, it will require a long period of operation to achieve the desired level of reduction.

The ET cover does not meet the preference for a remedy that uses treatment. SVE meets the preference for a remedy that uses treatment.

9.1.3 Short-Term Effectiveness

An ET cover can be constructed in a short time frame (i.e., approximately 2 yr). This cover poses relatively low risk to the community, workers, and the environment during construction because it does not involve any waste excavation or management. This alternative can be quickly implemented without creating significant additional risk.

SVE equipment is commercially available, and extraction boreholes can be constructed within a 3-mo time frame. The SVE system poses relatively low risk to the community, workers, and the environment during construction as demonstrated by the SVE pilot study. This alternative can be implemented quickly without creating significant additional risk.

9.1.4 Implementability

The ET cover is installed using standard construction techniques and presents minimal installation and construction difficulties. Following installation, low to moderate maintenance is required. Minimal permitting and approvals are required to install the ET cover.

SVE is easy to install and operate and the necessary equipment is readily available. Operation of the SVE system may require a modification to the Laboratory’s air permit. Moderate permitting and approvals are required to install the SVE system.

9.1.5 Cost

Total capital costs for the ET cover and SVE system are estimated to be $268,606,000. The O&M costs are estimated to be $16,740,000. The present value cost is estimated to be $285,346,000 (Table 9.1-1).

9.1.6 Summary of Selection Criteria Evaluation

The recommended alternative meets the RAOs and the five selection criteria. The remedy selected was based on the ability of the recommended alternative to (1) achieve cleanup objectives in a timely manner; (2) protect human and ecological receptors; (3) control or eliminate the sources of contaminants; (4) control migration of released contaminants; and (5) manage remediation waste in accordance with state and federal regulations.

The CSM has been refined to illustrate the impact of the recommended alternative on the release mechanisms and the reduction in exposure potential (incomplete pathways) and future risk reduction. The refined CSM is shown in Figure 9.1-1.

10.0 DESIGN CRITERIA TO MEET CLEANUP OBJECTIVES

As required in Section XI.F.12 of the Consent Order, this section presents a preliminary plan and key specifications for design of the ET cover and SVE system and its anticipated implementation.

10.1 Design Approach

Selection of the recommended corrective action alternative requires designing an ET cover and finalizing the design of a SVE system during the CMI phase for MDA G. The design does not include the requirements for closing the LLW units as defined by DOE Order 435.1, which are described in Appendix F.

The design process will include the following.

ET Cover

- Identify critical infiltration events, including the design precipitation event (maximum precipitation event that the design can endure, including snowfall), or series of events.
- Determine the minimum required thickness and the contours required to ensure the cover has adequate thickness and slopes to control erosion and infiltration over the 30-yr maintenance period based on precipitation events identified above. Also, determine the minimum soil thickness required to establish and maintain vegetation. The surface area of the cover is a total of approximately 51 acres. The preliminary cover design includes 3.5 ft of fill and 1.5 ft of a topsoil/soil-gravel admixture.
- Determine the minimum required water-storage capacity of MDA G soil based on design infiltration events identified above.
- Identify the seed mixture to be used, the surface treatment to be employed before seeding, and the frequency of watering necessary to establish vegetation on the cover; meet with representatives of San Ildefonso Pueblo to review the seed mixture to ensure the mixture has no adverse effect on adjacent Pueblo lands.
- Plan for long-term maintenance requirements for the ET cover, which include annual inspection and repair for erosion and subsidence, removal of debris and large woody plants, removal of burrowing animals, and fertilization and mowing as needed to maintain the ET cover.

SVE

The results and conclusions of the SVE pilot tests conducted at MDA G in 2008 and 2010 (LANL 2009, 105112; LANL 2010, 109657) determined that SVE is a viable technology for removing VOCs from the subsurface at MDA G. They also determined that the effective extraction ROI was approximately 150 ft at the vapor-extraction vacuums and flow rates at which the SVE systems were operated. Based on these findings, a preliminary conceptual SVE design was provided in the 2010 supplemental SVE pilot test report (LANL 2010, 109657), which includes the following principal assumptions and components:

- An O&M manual will be developed based on design and monitoring requirements that will be reviewed during final design meetings and submitted to NMED for approval.
- Twenty SVE extraction boreholes will be installed, each to a depth of approximately 150 ft bgs within unit Qbt 1g. The 20 extraction boreholes will be spaced across the four MDA G VOC vapor plumes to provide effective extraction of VOC vapors (see section 3.2.4 and Appendix C) exceeding approximately 10 times the screening values for TCA and TCE. Extraction borehole spacing will be conservatively based on a 150-ft ROI with a 20% overlap, covering approximately 26.8 acres. The number of extraction boreholes corresponding to each vapor plume area will be as follows:
    - ❖ Western TCE/TCA plume area – 12.6 acres, 9 extraction boreholes
    - ❖ Eastern/central TCE plume area – 9.1 acres, 7 extraction boreholes

- Eastern/central TCA plume area – 4.2 acres, 3 extraction boreholes
- Southeastern TCE plume area – 0.9 acres, 1 extraction borehole

- Four mobile skid-mounted SVE extraction systems will be operated. Extraction boreholes in each plume area will be manifolded to one of the four SVE systems. Each system will be capable of maintaining a minimum extraction vacuum of 70 in. water. Each system will consist of a control panel, condensate knockout tank, vacuum pump blower and motor, silencer, and air dryer. Extracted pore gas will be treated using granular activated carbon. Spent carbon will be regenerated/disposed off-site.
- Active vapor extraction will be conducted at each of the four VOC vapor plume areas for 180 d. Following 180 d of active extraction, VOC concentrations will be monitored at pore-gas monitoring boreholes according to the methodology and schedule described in Appendix H. Pre- and post-pore-gas monitoring will provide important information on removal effectiveness and VOC plume rebound behavior.
- After the first 3 yr of operation of the active SVE system the long-term monitoring plan for VOCs will be reviewed (Appendix H of this report), which includes a review of data by NMED and DOE. This proposed review will result in a determination of whether the active SVE system operation has sufficiently reduced VOC contamination to the point that active SVE is no longer necessary.

10.2 Preliminary Design Criteria and Rationale

Preparation of the CMI plan includes a schedule for design, including development of design considerations and documentation that will be submitted to NMED according to the CMI schedule. Design considerations will include, but will not be limited to, the following:

- The cover will have sufficient thickness and will be contoured to control erosion resulting from the 100-yr precipitation event.
- The cover will have sufficient capacity to store the “maximum” infiltration quantity resulting from the 100-yr precipitation event until it can be removed through ET.
- The proposed seed mixture used to stabilize the cover with vegetation will closely emulate the local plant community, will ensure the vegetative cover remains viable, and will have no detrimental effect on neighboring Pueblo lands.
- The surface treatment method will encourage native vegetation establishment and growth and reduce erosion.
- The proposed SVE system will effectively limit VOC migration.
- Preliminary specifications, sufficient for evaluating the approximate cost of the alternative, are included for
    - cover vegetation;
    - surface treatment (gravel admixture, typical soil-gravel admixture, gravel size); and
    - cover soil (water-storage medium thickness, unsaturated hydraulic conductivity, erodibility).

10.2.1 Surface Treatment

Surface treatments, such as soil nutrients, a gravel layer, or a soil-gravel admixture, may be warranted in the semiarid climate at the Laboratory to help establish native vegetation and reduce erosion. During the CMI design phase, a seed mix will be specified to stabilize the cover with vegetation consisting of plant communities that closely resemble the undisturbed and well-established plant communities inhabiting Mesita del Buey.

The addition of a layer of gravel-soil admixture on the surface of the cover provides erosion protection for the design storm event and promotes ET from nonclimax vegetation composed mostly of native species of grasses. Erosion and water-balance studies at the Laboratory indicate moderate amounts of gravel mixed into the cover topsoil will control both water and wind erosion with little effect on the vegetation or the soil-water balance. As wind and water flow over the cover surface, some winnowing of fines from the admixture is expected, creating a vegetated, erosion-resistant surface.

The design of a soil-gravel admixture layer is based primarily on the need to protect the soil cover from erosion. A soil-gravel admixture protects a cover from long-term wind erosion. The protection from water erosion depends on the depth, velocity, and duration of stormwater flowing across the MDA G cover. Flow values can be established from the physical properties of the cover (slope, convex or concave grading, slope uniformity, and length of flow paths) and the intensity of the precipitation (precipitation rates, infiltration versus runoff relationships, snowmelt, and off-site flows).

An ET cover is intended to function under unsaturated conditions; consequently, obtaining very low saturated hydraulic conductivity is not essential to a successful cover. The cover soil moisture characteristics and cover compaction density are crucial parameters. Compaction density requirements will be based on the design criteria used but generally will achieve a density in the upper soil layer that approximates that of the surrounding undisturbed soil. Uniformity of compaction is critical to avoid creating preferential infiltration pathways.

The recommendation on surface treatment is based on review of site-specific conditions at MDA G and Laboratory data from cover experiments at TA-51 (Nyhan et al. 1996, 063111). The best surface layer will be chosen during the CMI design phase.

10.2.2 Cover Soil

The performance of the ET cover relies on its thickness, materials, and placement. The ET cover for MDA G will be of sufficient thickness to prevent erosion resulting from the design precipitation event.

10.3 General Operation and Maintenance Requirements

Irrigation is needed during the 2 yr following construction to aid in the germination and establishment of the vegetative cover. Vegetation establishment will be offset by keeping infiltration below the storage capacity of the cover.

The Laboratory will inspect the cover on a regular basis and after significant precipitation events to identify erosion indicators on the cover. Any eroded areas will be repaired. After the cover is established, it will be inspected annually in the fall after the monsoon season has ended, and any cover erosion will be repaired.

The SVE system will be operated as described in Appendix H.

10.3.1 Long-Term Monitoring Requirements

After implementation of the selected alternative, groundwater monitoring of the regional aquifer beneath MDA G will be conducted in accordance with requirements in the Laboratory's HWFP and Section III.W.1 of the Consent Order.

VOCs will be monitored for 30 yr in the selected boreholes on-site

10.4 Additional Engineering Data Required

Before the CMI design is completed, additional data is required, including

- verifying the existing depths to the top of waste in the pits and shafts using ground-penetrating radar to properly determine the operational cover thickness and
- testing the geotechnical properties of all materials used for the soil-gravel admixture.

10.5 Additional Requirements

10.5.1 Permits and Regulatory Requirements

NMED will select a final remedy, issue a Statement of Basis for the selected remedy, and designate a period for public comment (section 11). The emission source from the SVE system will be evaluated to determine if a permit is required to operate the SVE system.

10.5.2 Access, Easements, Right-of-Way Agreements

Access, easements, and right-of-way agreements are internal to the Laboratory and will be developed as required once the corrective measure is selected.

10.5.3 Health and Safety Requirements

A site-specific health and safety plan will be prepared to describe the health and safety requirements to be followed during construction of the MDA G cover, construction of the SVE-monitoring system, O&M activities, and monitoring activities.

10.5.4 Community-Relations Activities

A community-relations program will be developed in accordance with Section VII.E.4 to keep Northern New Mexico stakeholders and other interested parties involved in project activities and progress.

11.0 SCHEDULE FOR COMPLETION OF ACTIVITIES

The Consent Order requires that a schedule for completion of activities be submitted in the CME report. Activities leading to completion of the remedy includes planning, design, and construction of the ET cover; operation of the SVE system and installation and testing of monitoring systems. Several milestones for completion of the corrective measure at MDA G are presented in the Consent Order, along with schedule updates. In addition to these milestones, the Consent Order requires the CME report to include a proposed schedule for implementation of the preferred remedy. The schedule identifies the duration of corrective action operations, the frequency of monitoring and sampling activities, the dates for submitting inspection and monitoring reports to the NMED, including all status reports and preliminary data.

Proposed milestones include the following.

- NMED shall prepare a Statement of Basis for remedy selection and issue the statement for public comment.
- NMED shall receive public comments on the Statement of Basis for at least 60 d following public notice. NMED shall provide an opportunity for a public hearing that may extend the public comment period.
- Based upon the Laboratory's preferred remedy in the CME, the Laboratory requests to submit a CMI plan within 18 m after NMED selects a final remedy. The plan will contain detailed engineering design drawings and system specifications for all elements of the remedy and a schedule for implementation of the corrective action.
- A Class 1 Permit Modification will be submitted as necessary to NMED to perform D&D of existing structures for the aboveground CSUs.
- The aboveground CSUs will be closed, and retrievably stored TRU will be removed before the CMI plan is implemented.
- The corrective measure will be implemented and a remedy completion report submitted according to the schedule in the CMI plan. Following approval of the CMI plan, construction of the Laboratory's preferred remedy is expected to take 2 yr.
- Active SVE and pore-gas monitoring will occur as discussed in Appendix H and presented in Table 11.0-1.
- Monitoring and maintenance, including reporting requirements, will be completed according to the CMI plan.
- Following completion of the remedy, groundwater monitoring will be conducted and reported as required by the Laboratory's HWFP.

12.0 REFERENCES AND MAP DATA SOURCES

12.1 References

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Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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12.2 Map Data Sources

Hypsography, 20- and 100-ft Contour Intervals; Los Alamos National Laboratory, ENV-Environmental Remediation and Surveillance Program; 1991

LANL DOE Boundary; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; Development Edition of 05 January 2005

LANL Technical Areas; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; Development Edition of 05 January 2005

Materials Disposal Areas; Los Alamos National Laboratory, ENV-Environmental Remediation and Surveillance Program; ER2004-0221; 1:2,500 Scale Data; 23 April 2004

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; Development Edition of 17 January 2006

Waste Storage Features; Los Alamos National Laboratory, ENV-Environmental Remediation and Surveillance Program, ER2005-0748; 1:2,500 Scale Data; 06 October 2005

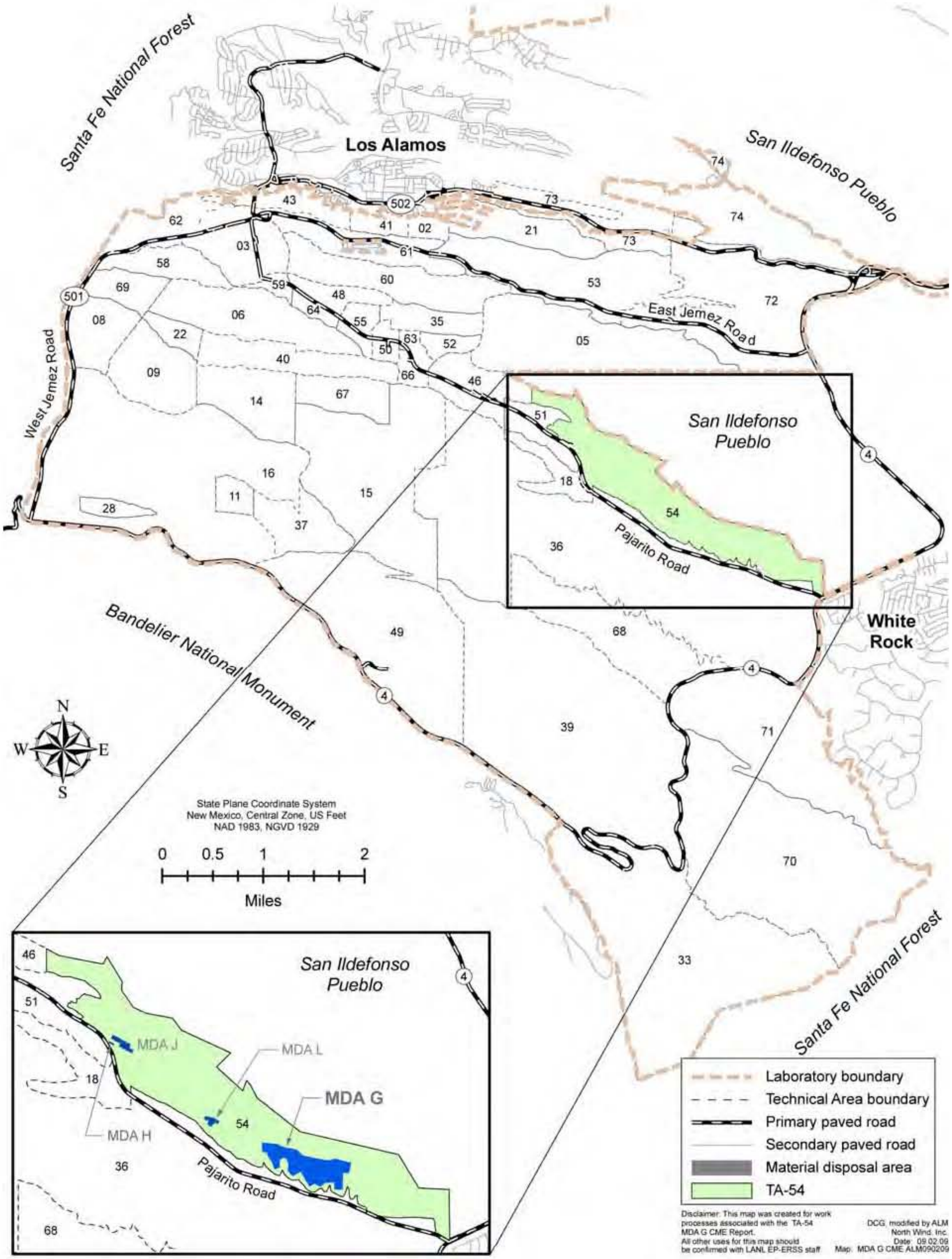


Figure 1.0-1 Location of Area G in TA-54 with respect to Laboratory TAs and surrounding land holdings

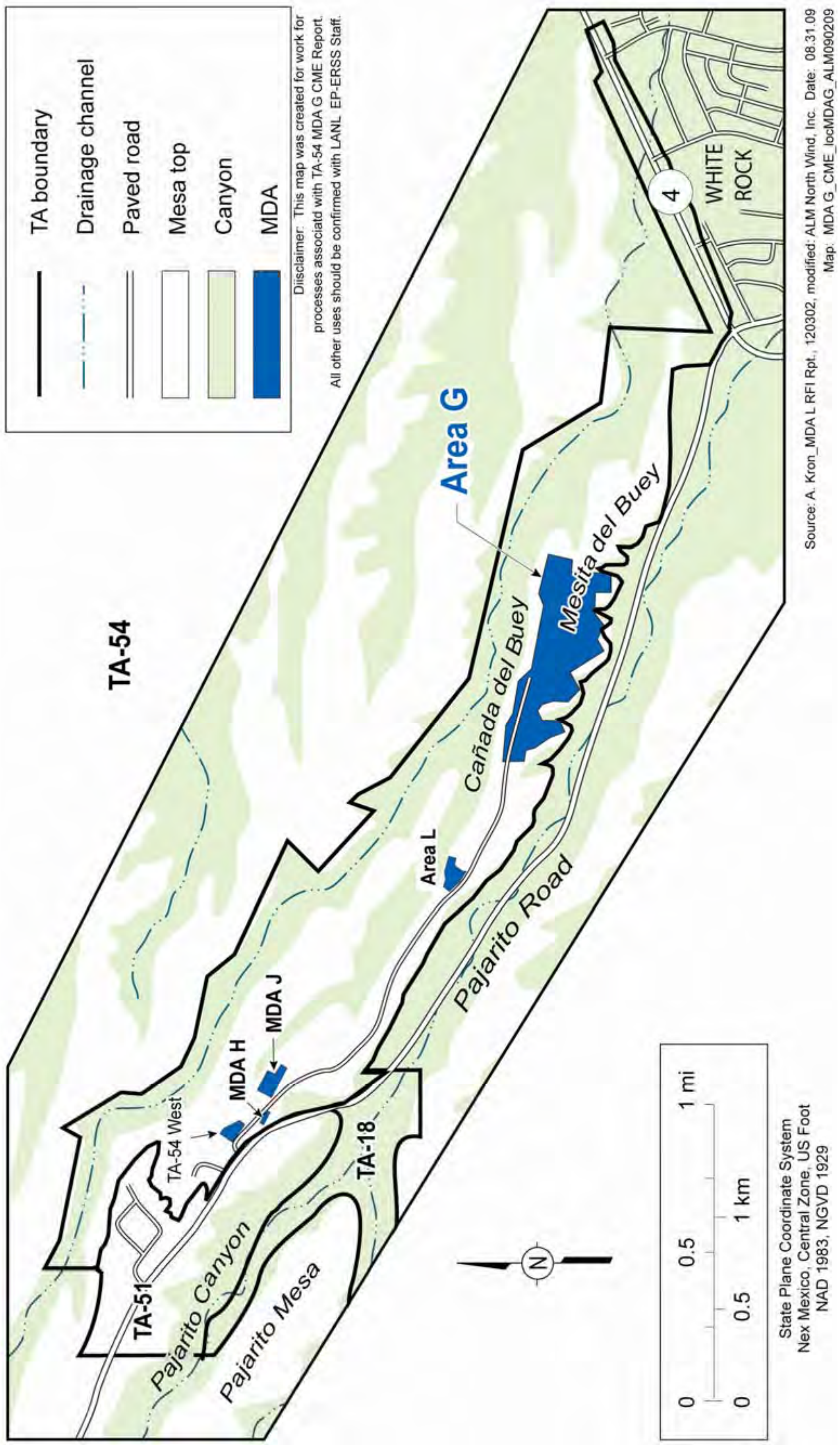


Figure 1.0-2 Location of Area G in TA-54

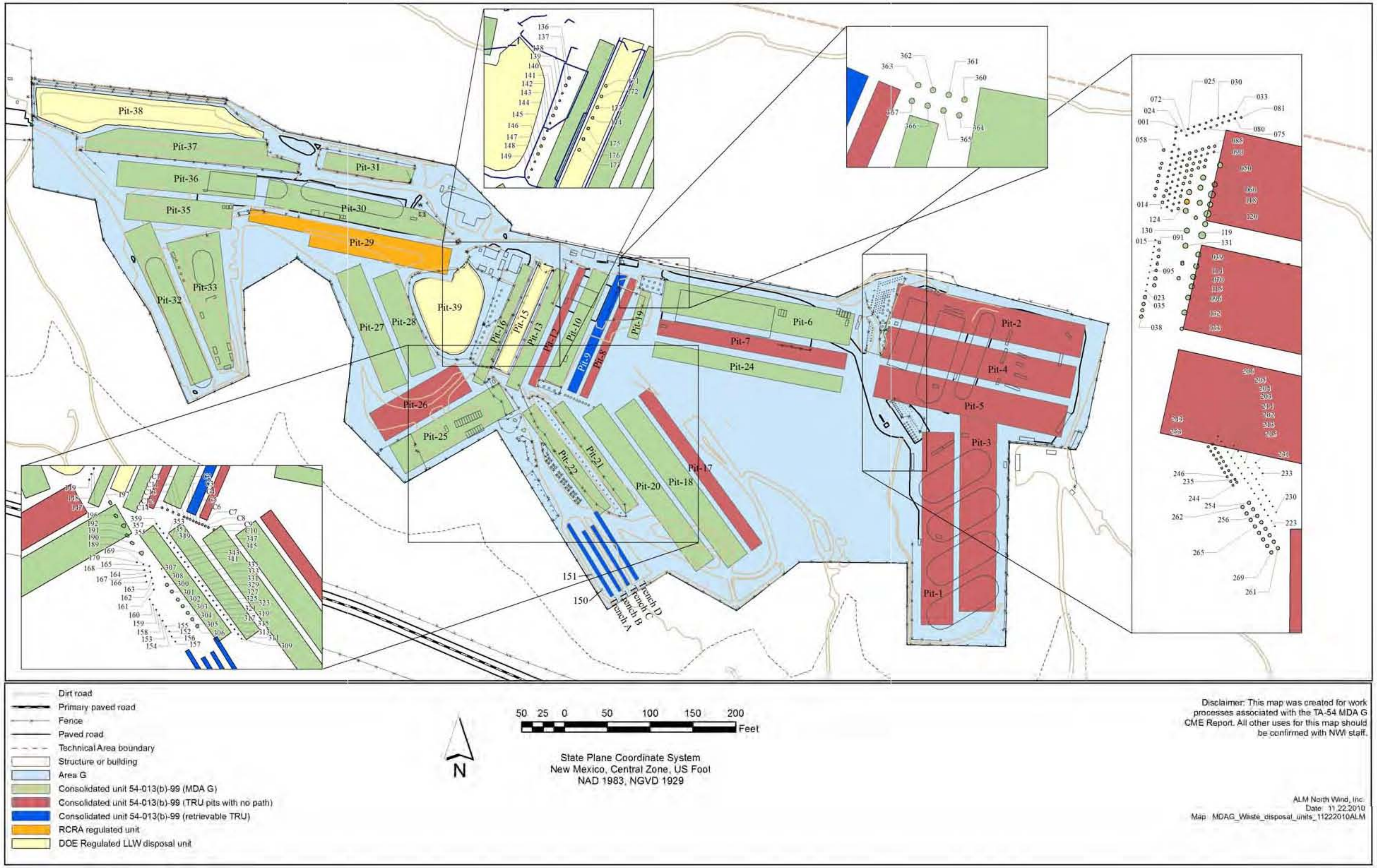


Figure 1.0-3 Area G waste disposal units

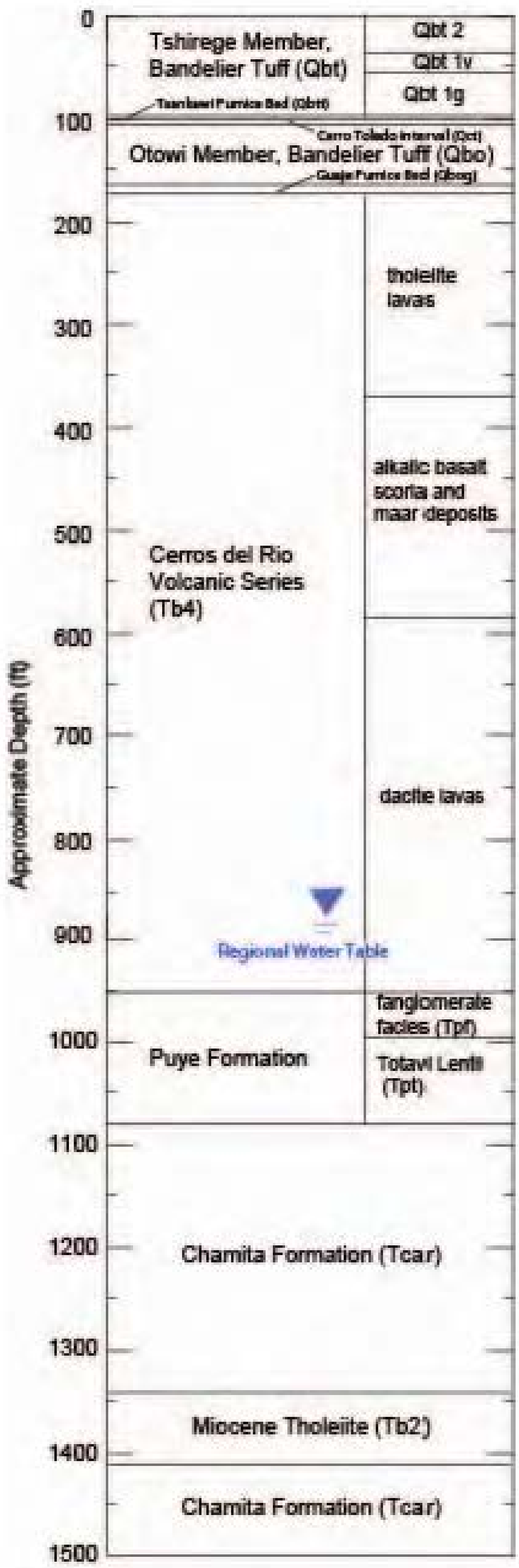


Figure 2.3-1 Generalized stratigraphic column for MDA G. Approximate depths to geologic contacts are shown for the east end of MDA G.

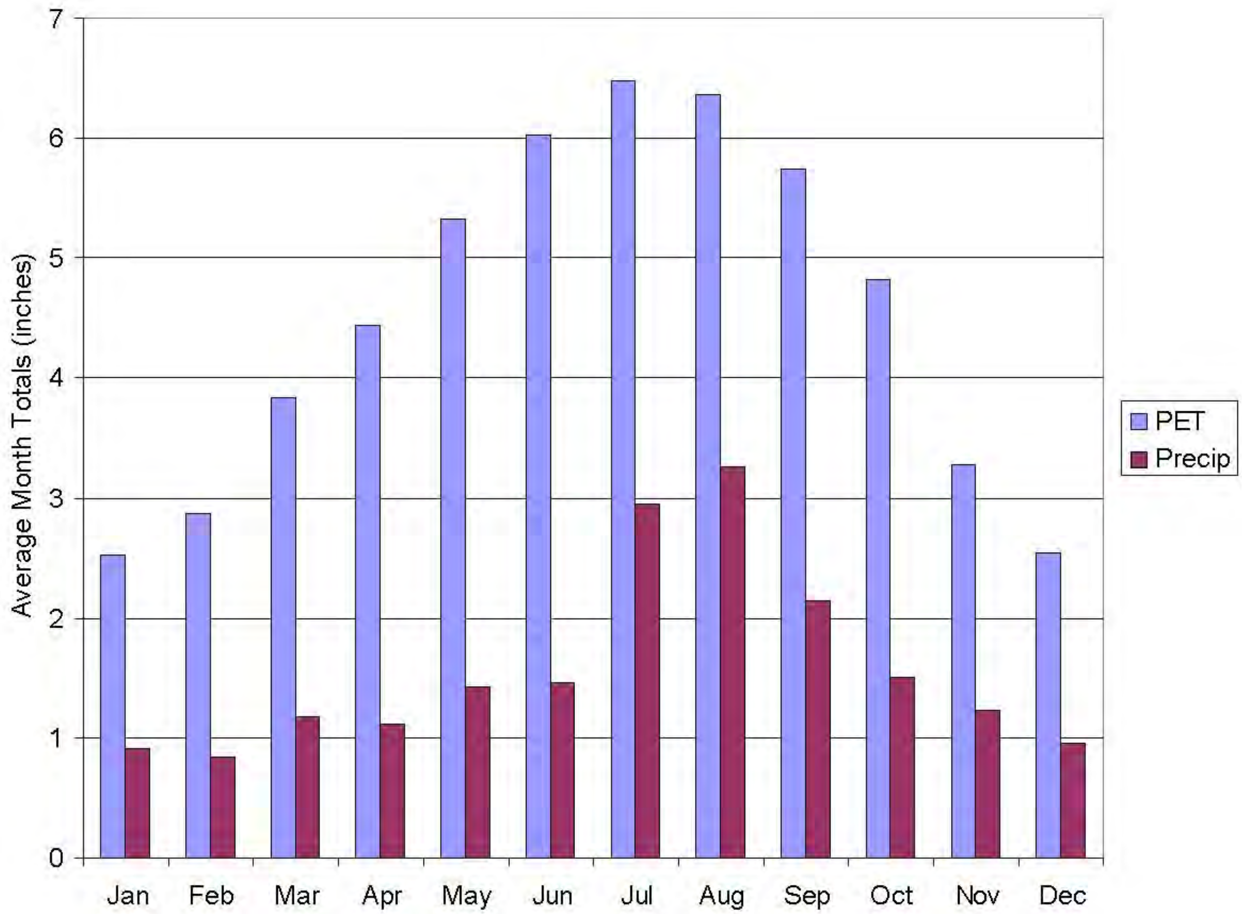


Figure 2.3-2 Climate's demand for water (potential ET) versus supply of water (precipitation) for Los Alamos, New Mexico

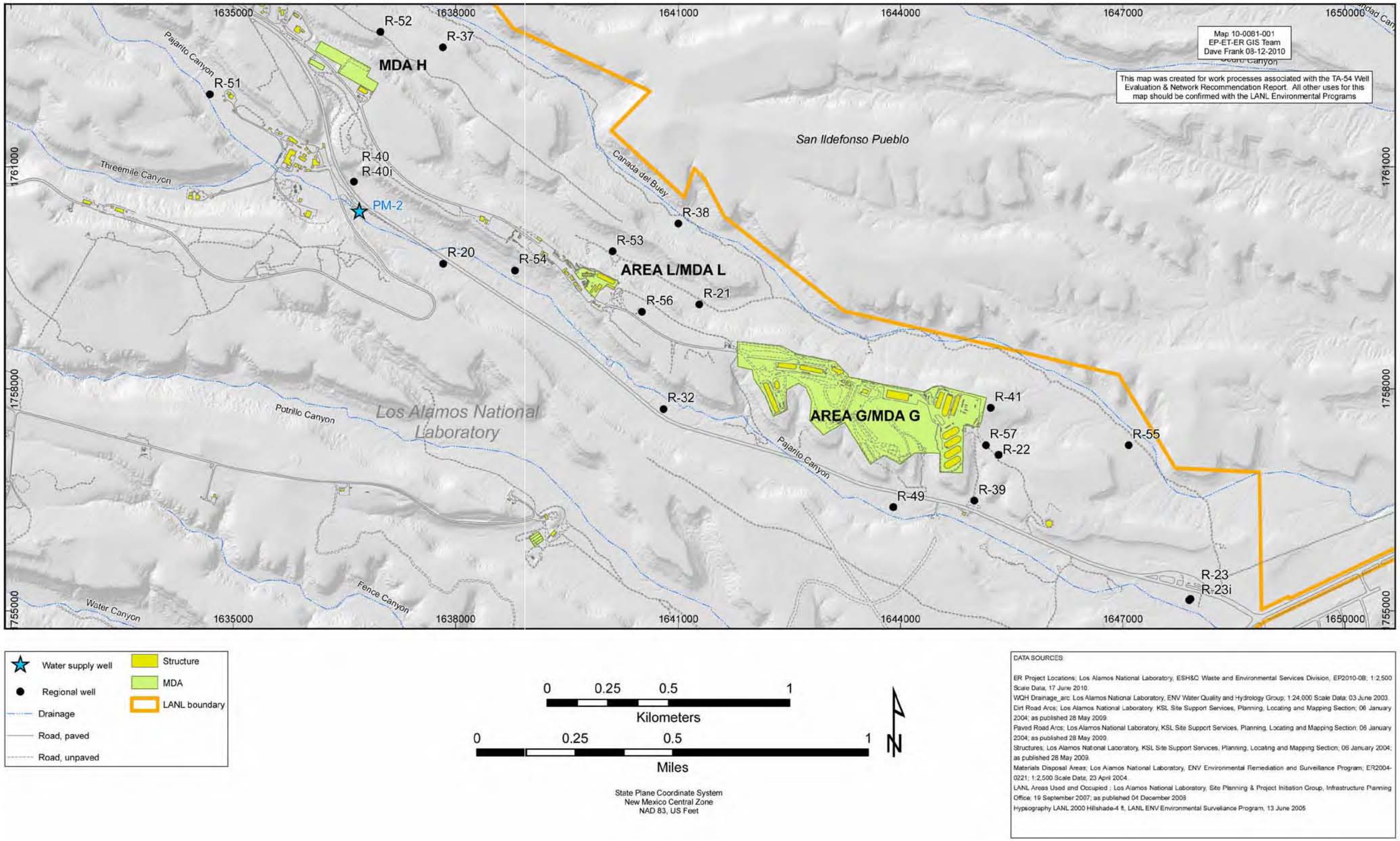


Figure 2.3-3 TA-54 groundwater-monitoring network

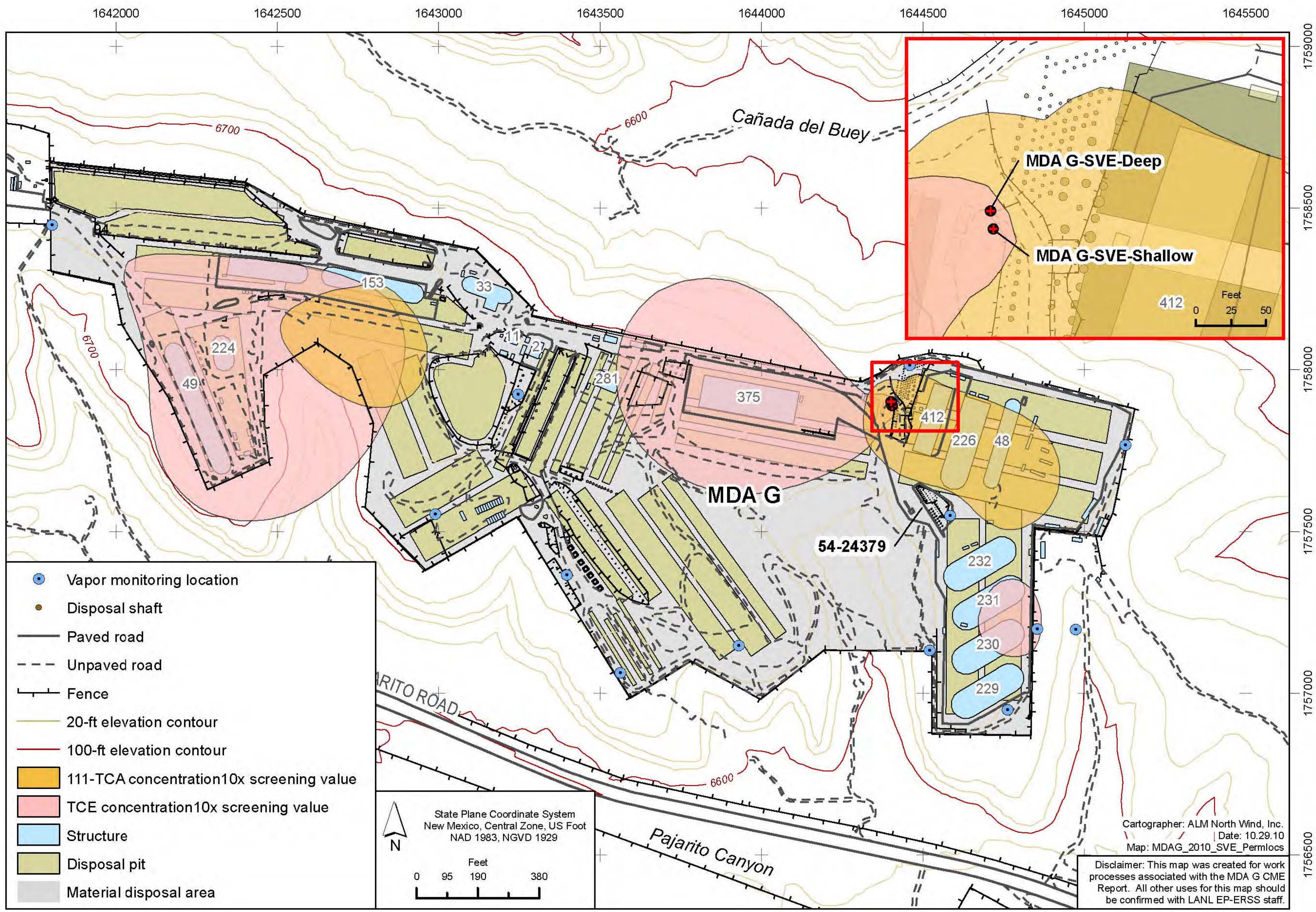


Figure 2.4-1 2008 MDA G SVE pilot test location

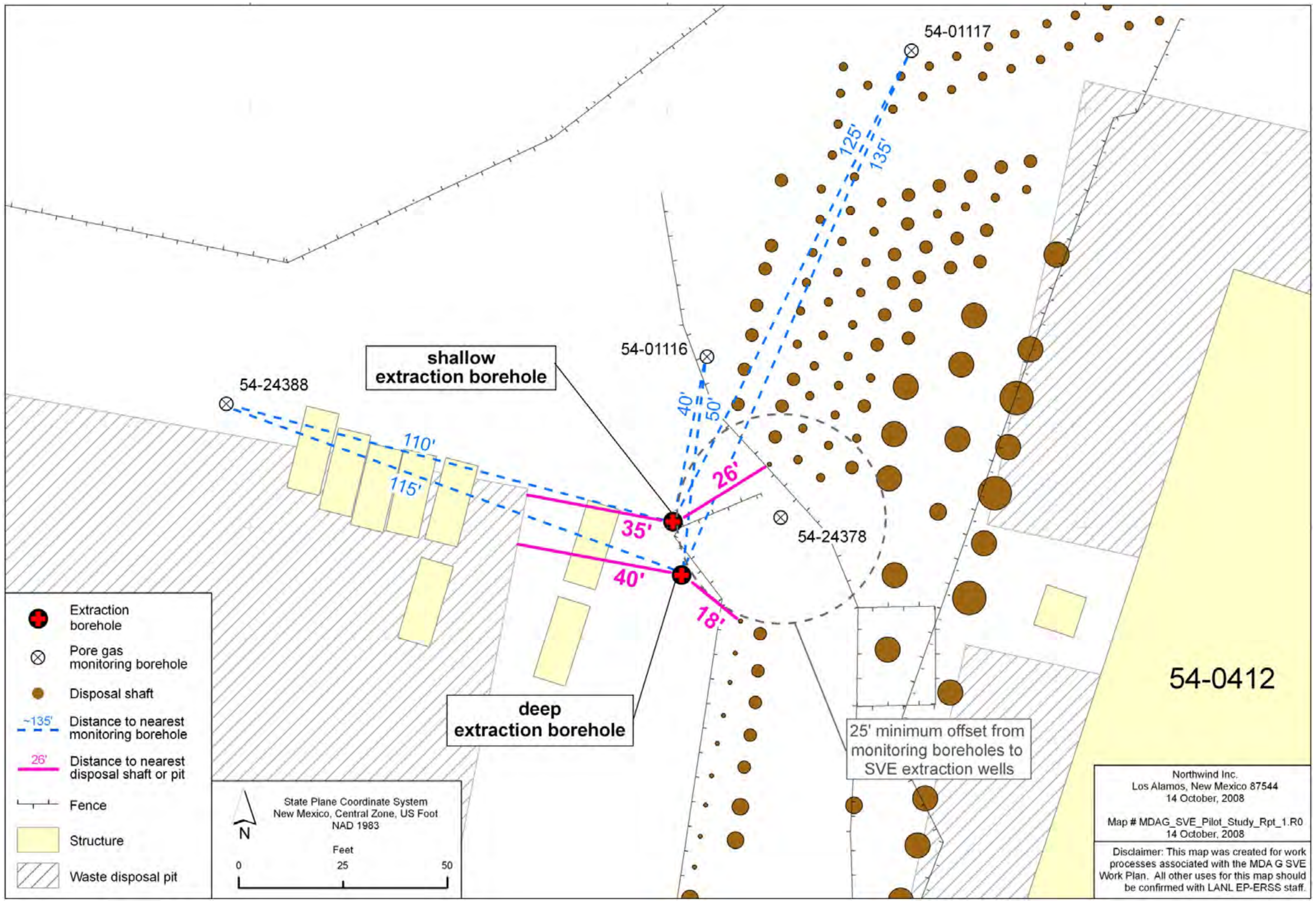


Figure 2.4-2 2008 MDA G SVE pilot test extraction and monitoring borehole locations

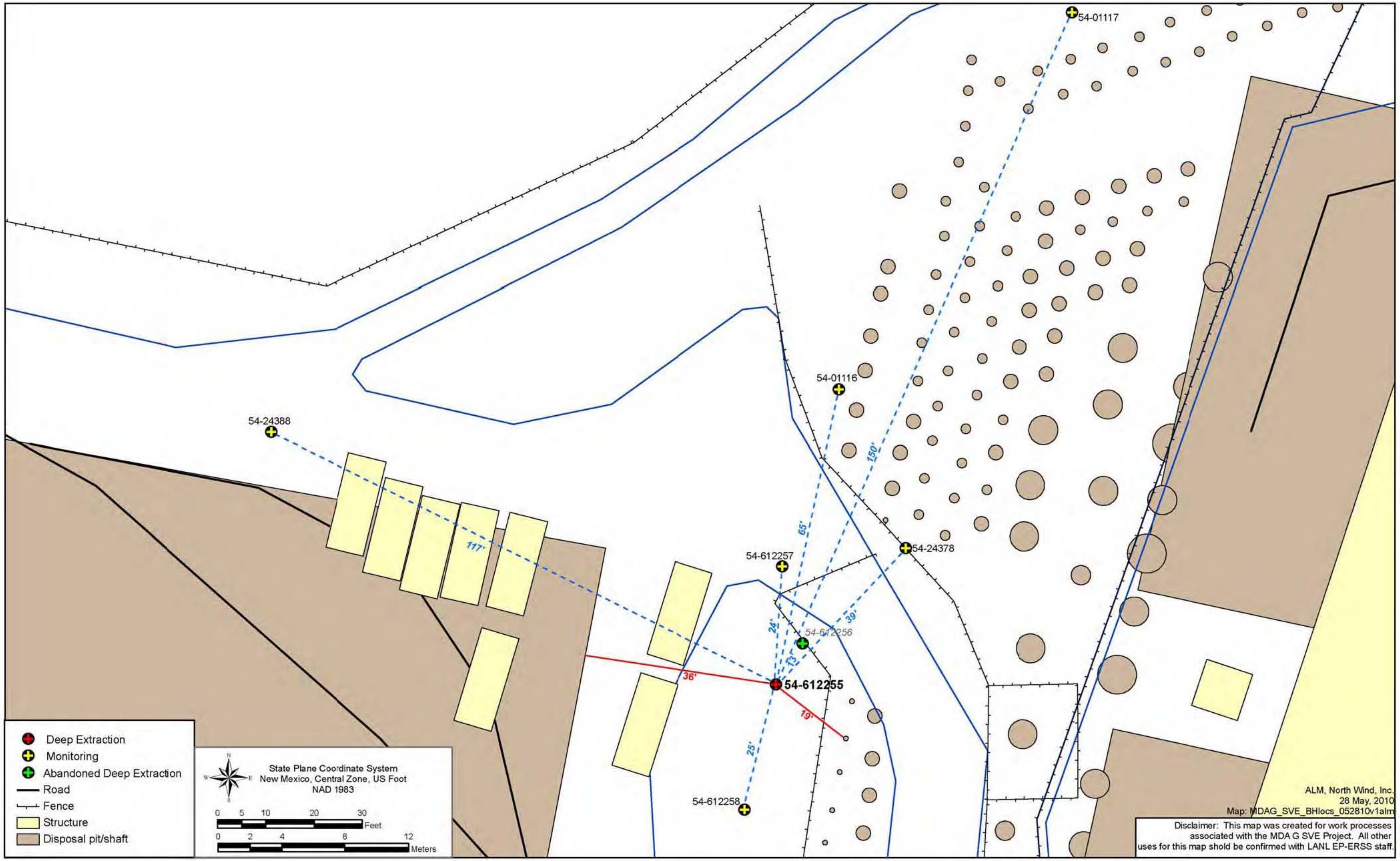


Figure 2.4-3 2010 MDA G SVE pilot test extraction and monitoring borehole locations

Figure 2.4-4 MDA G pore-gas monitoring borehole locations

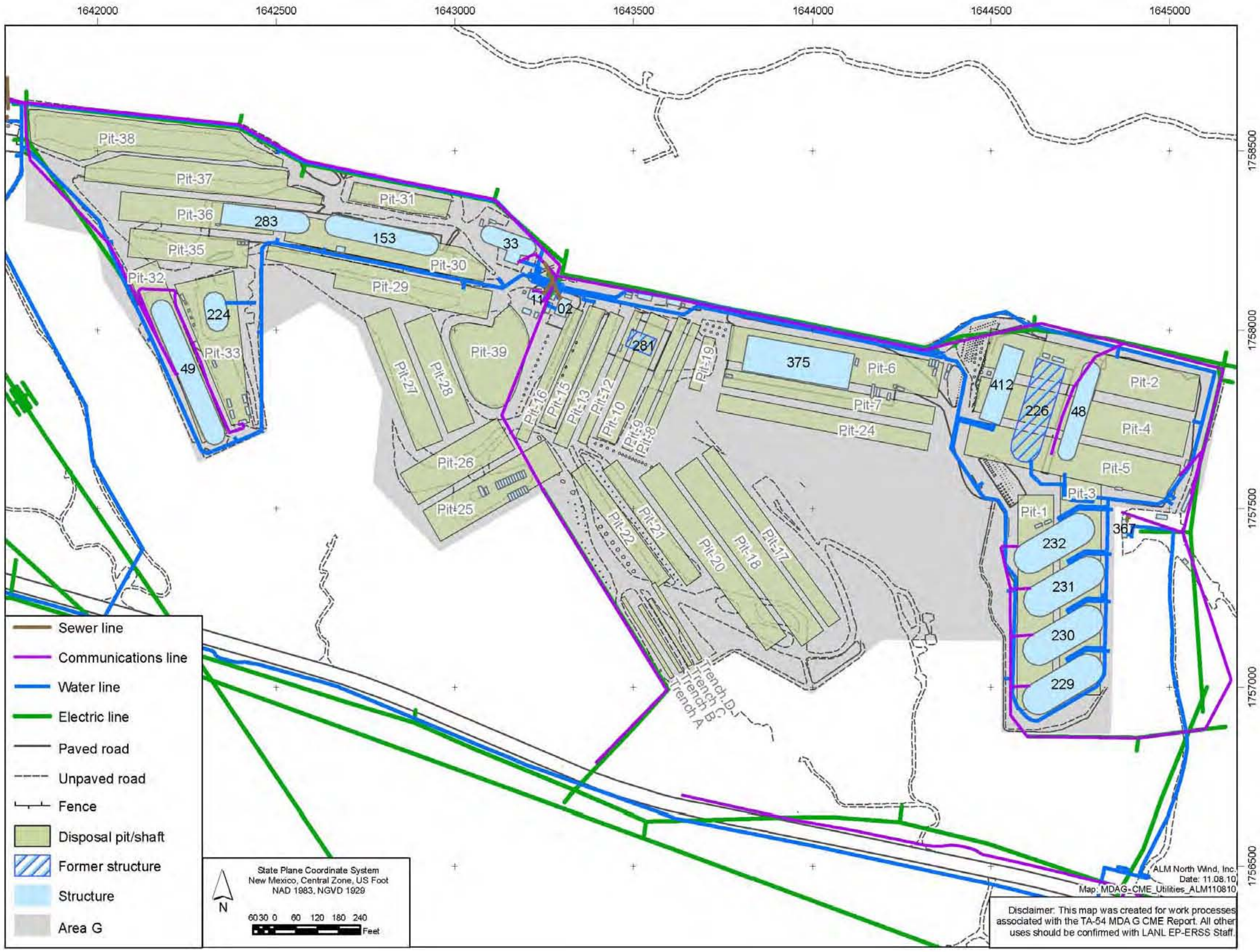


Figure 3.1-1 Surface structures and subsurface utilities at Area G

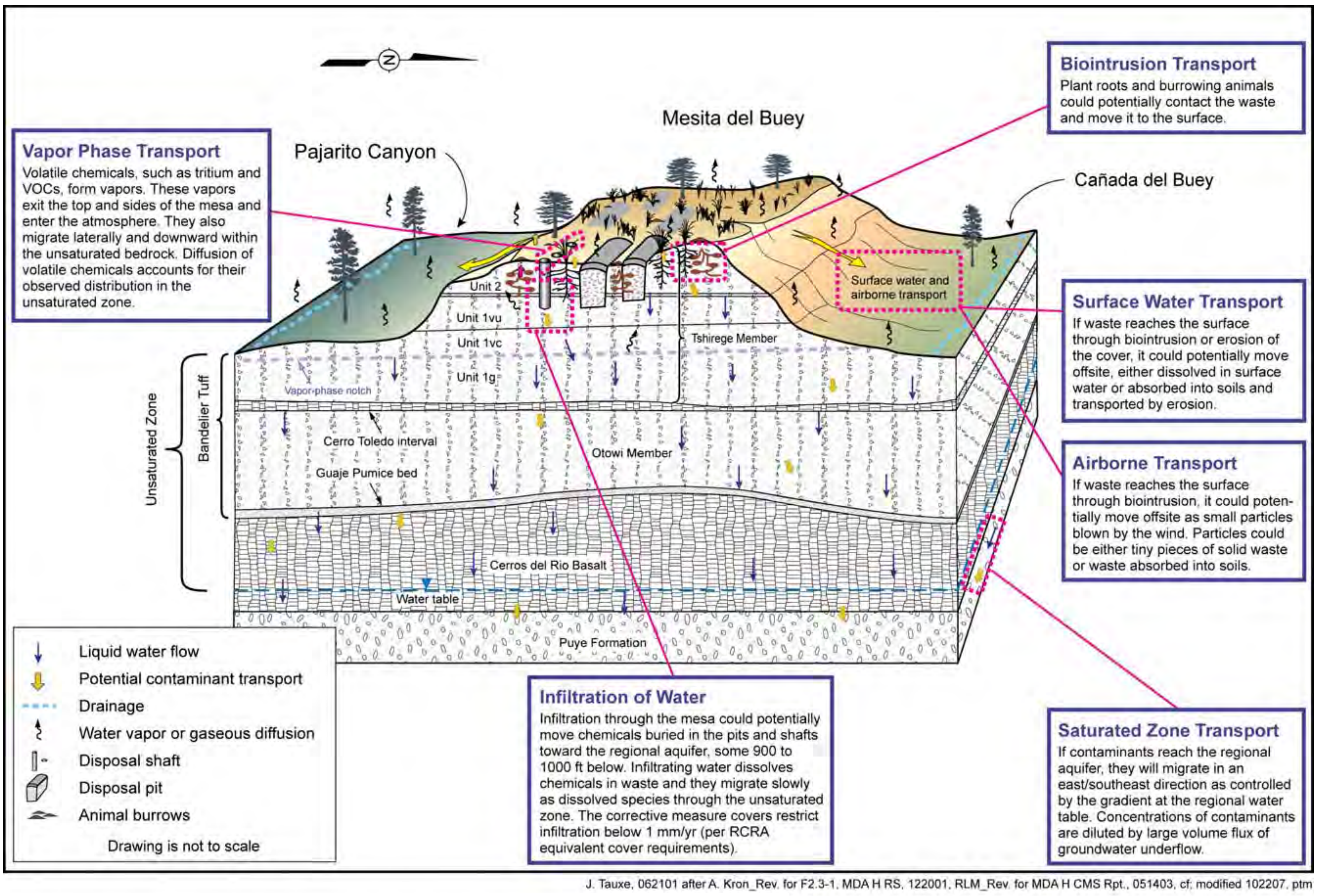


Figure 4.0-1 Hydrogeologic conceptual site model for Area G

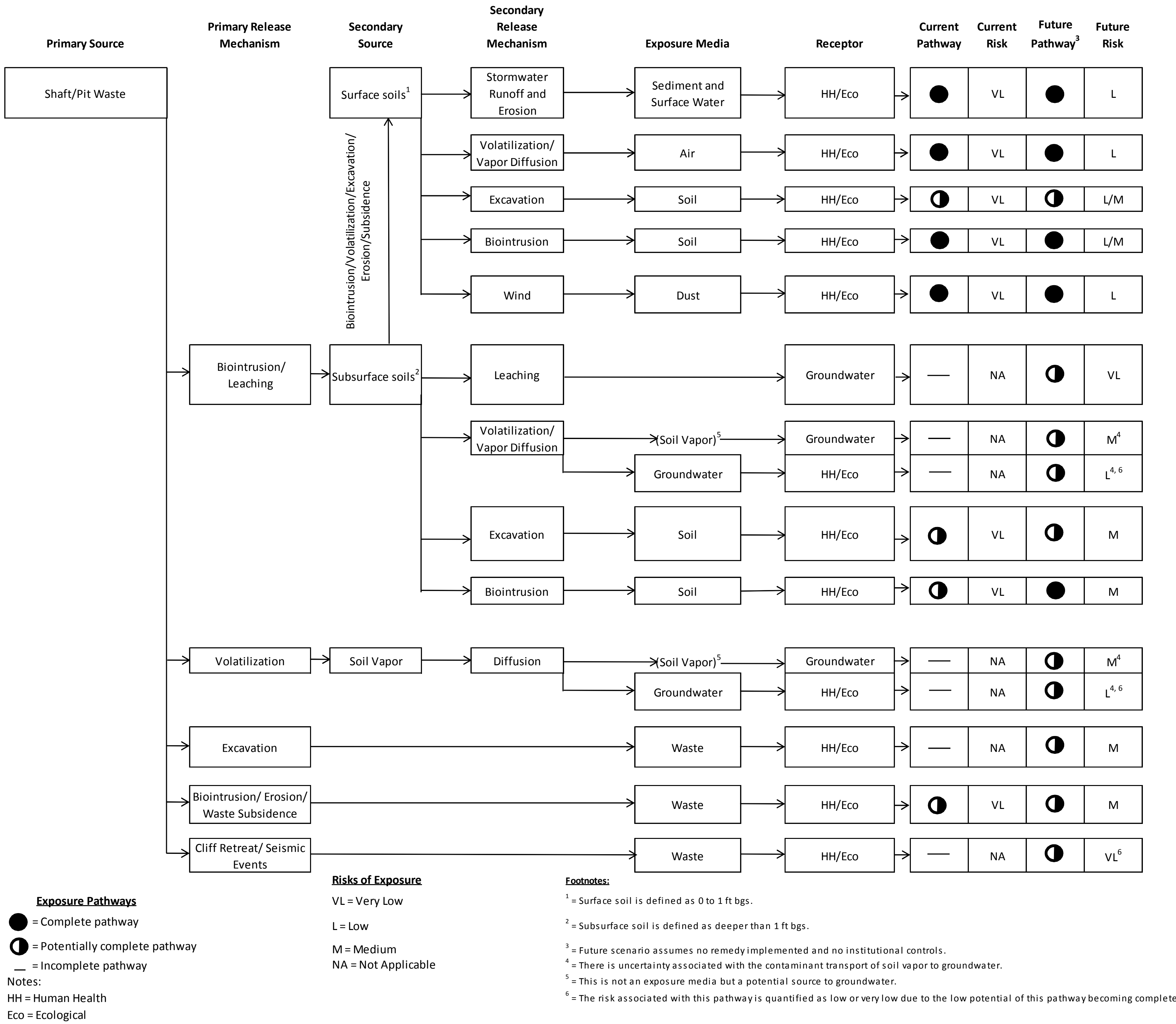


Figure 4.0-2 Conceptual site model for pit and shaft waste at MDA G

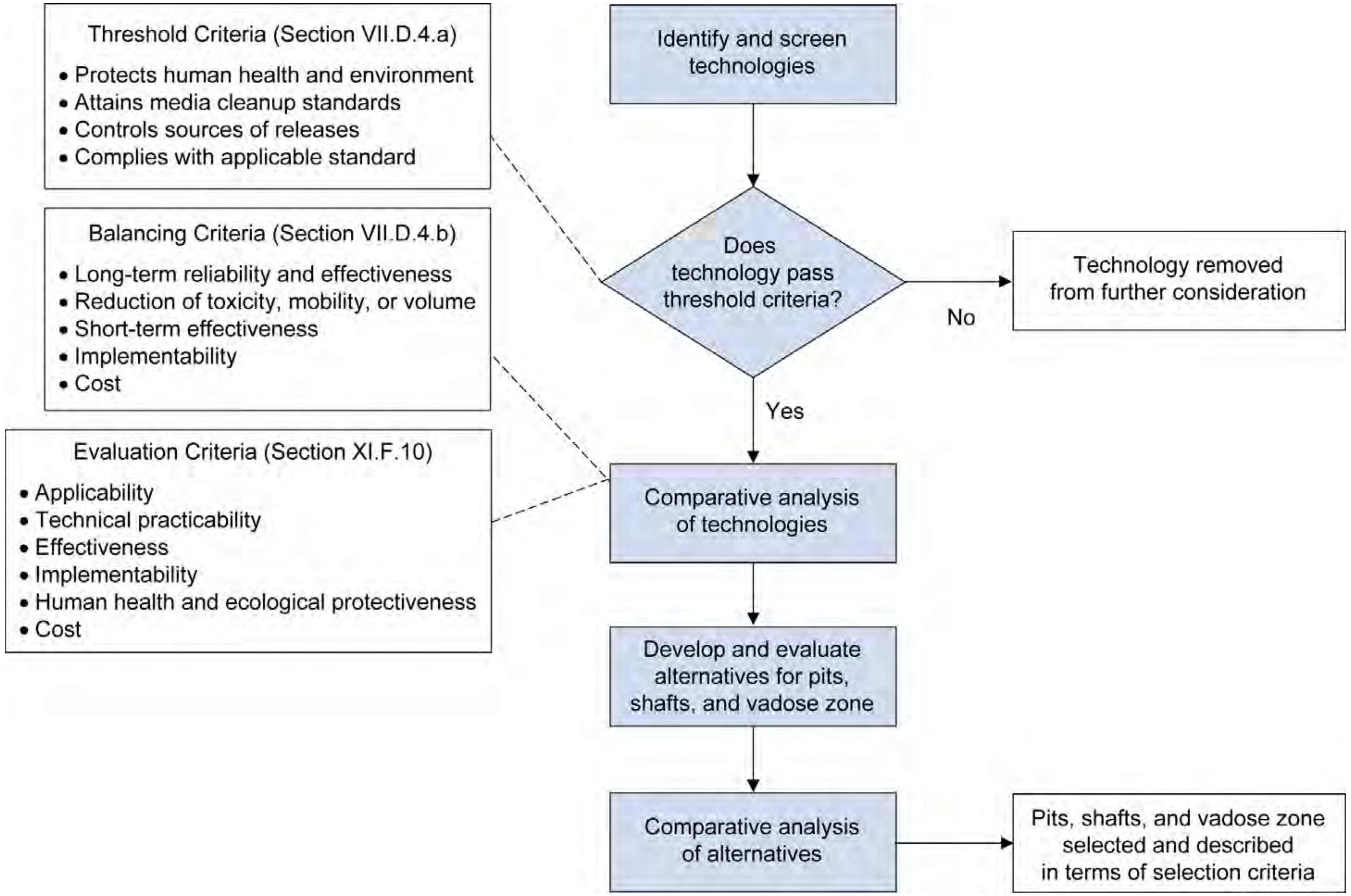


Figure 5.4-1 The selection process for the preferred corrective measures alternative

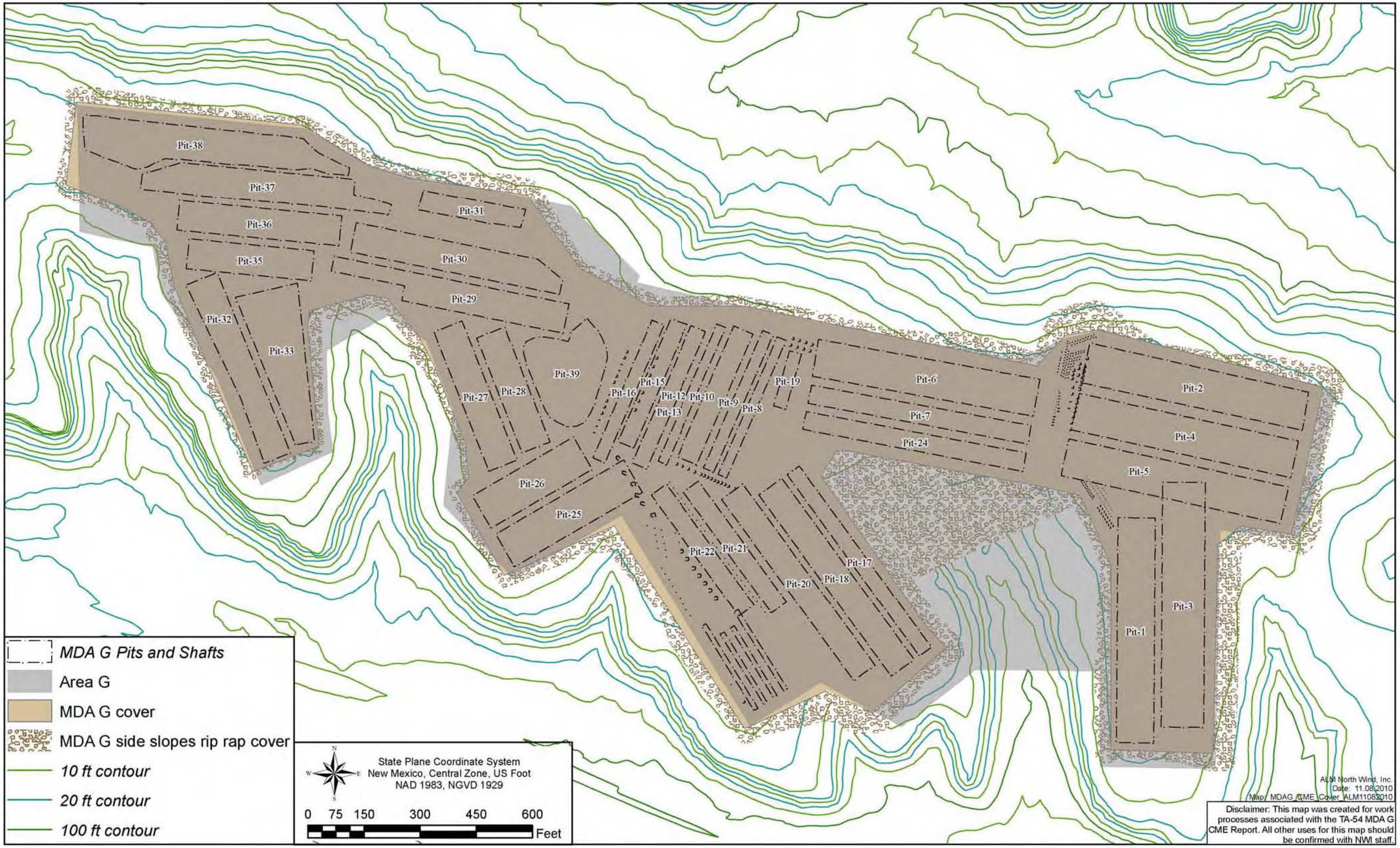
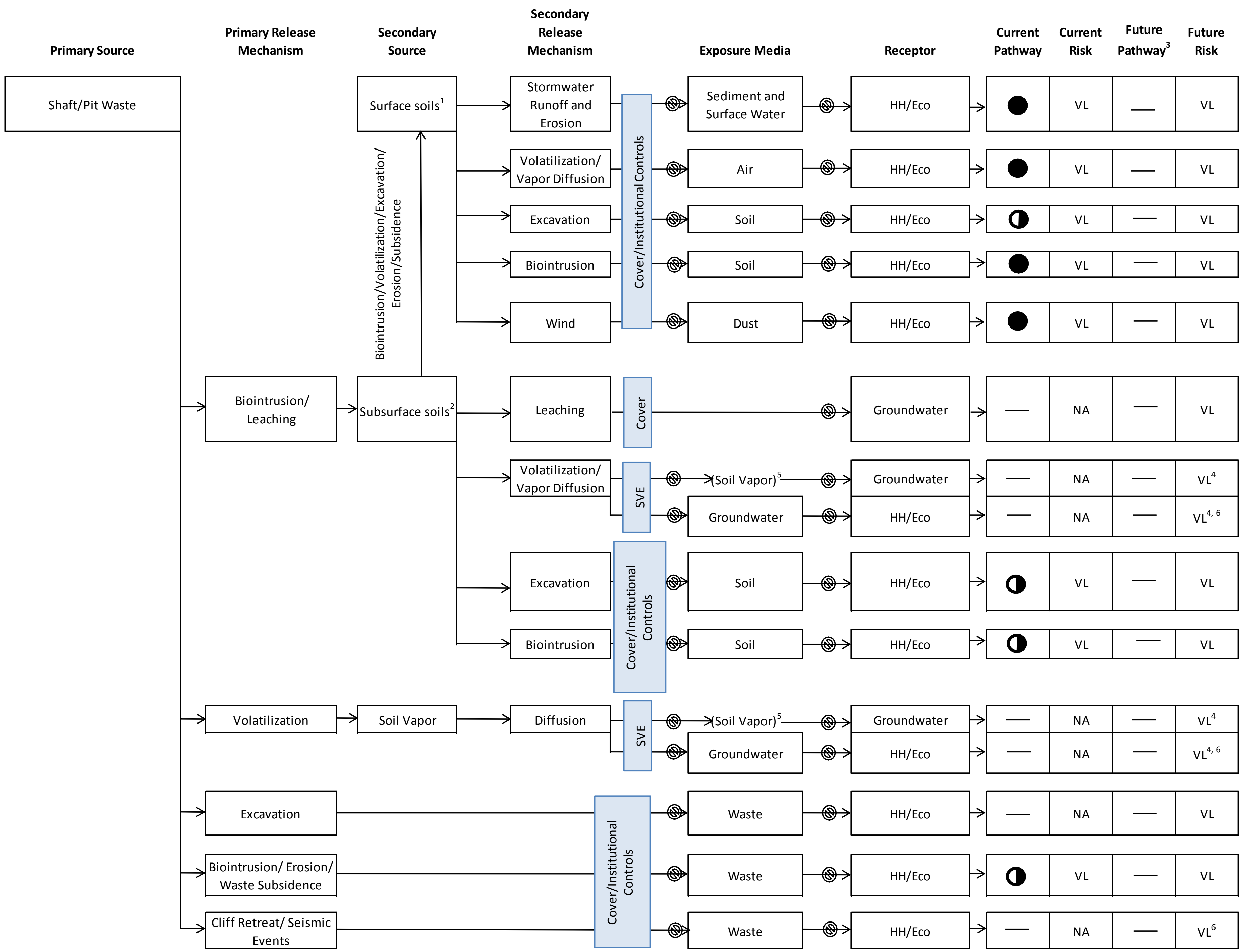


Figure 7.3-1 Cover site map



Exposure Pathways

● = Complete pathway

◐ = Potentially complete pathway

— = Incomplete pathway

⊘ = Pathway broken by corrective measure remedy

Risks of Exposure

VL = Very Low

L = Low

M = Medium

NA = Not Applicable

Notes:

HH = Human Health

Eco = Ecological

Footnotes:

1 = Surface soil is defined as 0 to 1 ft bgs.

2 = Subsurface soil is defined as deeper than 1 ft bgs.

3 = Future scenario assumes no remedy implemented and no institutional controls.

4 = There is uncertainty associated with the contaminant transport to groundwater. This uncertainty will be managed by the final action.

5 = This is not an exposure media but a potential source to groundwater.

6 = The risk associated with this pathway is quantified as very low due to the low potential of this pathway becoming complete.

Figure 9.1-1 Refined conceptual site model for pit and shaft wastes

Table 1.0-1
Crosswalk with Consent Order Requirements

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
1	The Respondents shall follow the Corrective Measures Evaluation Report format outlined in Section XI.F of this Consent Order.	VII.D.2	Table of Contents
2	The corrective measures evaluation shall evaluate potential remedial alternatives and shall recommend a preferred remedy that will be protective of human health and the environment and attain the appropriate cleanup goals.	VII.D.2	Sections 5 through 9
3	1. A description of the location, status, and current use of the site.	VII.D.2	Sections1 and 2
4	2. A description of the history of site operations and the history of releases of contaminants.	VII.D.2	Section 2
5	3. A description of site surface conditions.	VII.D.2	Sections 2. and 3
6	4. A description of site subsurface conditions.	VII.D.2	Sections 2 and 3
7	5. A description of on- and off-site contamination in all affected media.	VII.D.2	Section 2 and Appendix B
8	6. An identification and description of all sources of contaminants.	VII.D.2	Section 2 and Appendix B
9	7. An identification and description of contaminant migration pathways.	VII.D.2	Section 4
10	8. An identification and description of potential receptors.	VII.D.2	Section 4
11	9. A description of cleanup standards or other applicable regulatory criteria.	VII.D.2	Section 5
12	10. An identification and description of a range of remedy alternatives.	VII.D.2	Section 7
13	11. Remedial alternative pilot or bench scale testing results.	VII.D.2	Section 2 and Appendix B
14	12. A detailed evaluation and rating of each of the remedy alternatives, applying the criteria set forth in Section VII.D.4.	VII.D.2	Sections 8 and 9
15	13. An identification of a proposed preferred remedy or remedies.	VII.D.2	Section 9
16	14. Design criteria of the selected remedy or remedies.	VII.D.2	Section10
17	15. A proposed schedule for implementation of the preferred remedy.	VII.D.2	Section 11.0
18	The Respondents shall select corrective measures that are capable of achieving the cleanup standards and goals outlined in Section VIII of this Consent Order including, as applicable, approved alternate cleanup goals established by a risk assessment.	VII.D.3	Sections 8 and 9

Table 1.0-1 (continued)

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
19	The Respondents shall evaluate each of the remedy alternatives for the following threshold criteria. To be selected, the remedy alternative must: 1. Be protective of human health and the environment. 2. Attain media cleanup standards. 3. Control the source or sources of releases so as to reduce or eliminate, to the extent practicable, further releases of contaminants that may pose a threat to human health and the environment. 4. Comply with applicable standards for management of wastes.	VII.D.4.a	Section 7
20	The remedy shall be evaluated for long-term reliability and effectiveness. This factor includes consideration of the magnitude of risks that will remain after implementation of the remedy; the extent of long-term monitoring, or other management that will be required after implementation of the remedy; the uncertainties associated with leaving contaminants in place; and the potential for failure of the remedy. Respondents shall give preference to a remedy that reduces risks with little long-term management, and that has proven effective under similar conditions.	VII.D.4.b.i	Section 8
21	The remedy shall be evaluated for its reduction in the toxicity, mobility, and volume of contaminants. Respondents shall give preference to remedy that uses treatment to more completely and permanently reduce the toxicity, mobility, and volume of contaminants.	VII.D.4.b.ii	Section 8
22	The remedy shall be evaluated for its short-term effectiveness. This factor includes consideration of the short-term reduction in existing risks that the remedy would achieve; the time needed to achieve that reduction; and the short-term risks that might be posed to the community, workers, and the environment during implementation of the remedy. Respondents shall give preference to a remedy that quickly reduces short-term risks, without creating significant additional risks.	VII.D.4.b.iii	Section 8
23	The remedy shall be evaluated for its implementability or the difficulty of implementing the remedy. This factor includes consideration of installation and construction difficulties; operation and maintenance difficulties; difficulties with cleanup technology; permitting and approvals; and the availability of necessary equipment, services, expertise, and storage and disposal capacity. Respondents shall give preference to a remedy that can be implemented quickly and easily, and poses fewer and lesser difficulties.	VII.D.4.b.iv	Section 8

Table 1.0-1 (continued)

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
24	The remedy shall be evaluated for its cost. This factor includes a consideration of both capital costs, and operation and maintenance costs. Capital costs shall include, without limitation, construction and installation costs; equipment costs; land development costs; and indirect costs including engineering costs, legal fees, permitting fees, startup and shakedown costs, and contingency allowances. Operation and maintenance costs shall include, without limitation, operating labor and materials costs; maintenance labor and materials costs; replacement costs; utilities; monitoring and reporting costs; administrative costs; indirect costs; and contingency allowances. All costs shall be calculated based on their net PV. Respondents shall give preference to a remedy that is less costly, but does not sacrifice protection of health and the environment.	VII.D.4.b.v	Section 8
25	All investigation summaries, site condition descriptions, corrective action goals, corrective action options, remedial options selection criteria, and schedules shall be included in the corrective measures evaluations.	XI.F	Sections 4, 8, and 9
26	In general, interpretation of historical investigation data and discussions of prior interim activities shall be presented only in the background sections of the corrective measures evaluations.	XI.F	Section 2. and Appendix B
27	At a minimum, detections of contaminants encountered during previous site investigations shall be presented in the corrective measures evaluations in table format with an accompanying site plan showing sample locations.	XI.F	Section 2 and Appendix B
28	The other text sections of the corrective measures evaluations shall be reserved for presentation of corrective action-related information regarding anticipated or potential site-specific corrective action options and methods relevant to the project.	XI.F	Section 8
29	The title page shall include the type of document; Facility name; TA designation; SWMU or AOC name, site, and any other unit name; and the submittal date. A signature block providing spaces for the name and title of the responsible DOE and University of California (or co-operator) representative shall be provided on the title page in accordance with 20.4.1.900 NMAC incorporating 40 C.F.R. 270.11(d)(1).	XI.F.1	Title Page Signature Block Page
30	This executive summary or abstract shall provide a brief summary of the purpose and scope of the corrective measures evaluation to be conducted at the subject site. The executive summary or abstract shall also briefly summarize the conclusions of the evaluation. The SWMU, AOC, and site names, location, and TA designation shall be included in the executive summary.	XI.F.2	Executive Summary
31	The table of contents shall list all text sections, subsections, tables, figures, and appendices or attachments included in the corrective measures evaluation. The corresponding page numbers for the titles of each section of the report shall be included in the table of contents.	XI.F.3	Table of Contents

Table 1.0-1 (continued)

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
32	The Introduction section shall include the Facility name, TA designation, site location, and site status (e.g. closed, corrective action). General information on the current site usage and status shall be included in this section. A brief description of the purpose of the corrective measures evaluation and the corrective action objectives for the project also shall be provided in this section.	XI.F.4	Section 1
33	The Background section shall describe the relevant background information. This section shall briefly summarize historical site uses by the U.S. Government and any other entity since the 1940s, including the locations of current and former site structures and features. A labeled figure shall be included in the document showing the locations of current and former site structures and features. The locations of any subsurface features such as pipelines, underground tanks, utility lines, and other subsurface structures shall be included in this section and labeled on the site plan, as appropriate.	XI.F.5	Section 2 and associated figures
34	This section shall include contaminant and waste characteristics, a brief summary of the history of contaminant releases, known and possible sources of contamination, and the vertical and lateral extent of contamination present in each medium. This section shall include brief summaries of results of previous investigations, including references to pertinent figures, data summary tables, and text in previous reports. References to previous reports shall include page, table, and figure numbers for referenced information. Summary tables and site plans showing relevant investigation locations shall be referenced and included in the Tables and Figures sections of the document, respectively.	XI.F.5	Section 2 and Appendix B
35	A section on surface conditions shall describe current and historic site topography, features, and structures, including a description of topographic drainages, man-made drainages, vegetation, and erosional features. It shall also include a description of current uses of the site and any current operations at the site. This section shall also include a description of those features that could potentially influence corrective action option selection or implementation such as archeological sites, wetlands, or other features that may affect remedial activities. In addition, descriptions of features located in surrounding sites that may have an effect on the subject site regarding sediment transport, surface water runoff or contaminant transport shall be included in this section. A site plan displaying the locations of all pertinent surface features and structures shall be included in the Figures section of the corrective measures evaluation.	XI.F.6a	Sections 2 and 3 and associated figure

Table 1.0-1 (continued)

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
36	A section on subsurface conditions shall describe the site conditions observed during previous subsurface investigations. It shall include relevant soil horizon and stratigraphic information, groundwater conditions, fracture data, and subsurface vapor information. A site plan displaying the locations of all borings and excavations advanced during previous investigations shall be included in the Figures section of the corrective measures evaluation. A brief description of the stratigraphic units anticipated to be present beneath the site may be included in this section if stratigraphic information is not available from previous investigations conducted at the site.	XI.F.6b	Sections 2 and 3 and associated figures
37	A section shall provide a list of all sources of contamination at the subject site where corrective measures are to be considered or required. Sources that are no longer considered to be releasing contaminants at the site, but may be the point of origination for contaminants transported to other locations, shall be included in this section.	XI.F.7a	Section 4
38	A section shall describe potential migration pathways that could result in either acute or chronic exposures to contaminants. It shall include such pathways as utility trenches, paleochannels, surface exposures, surface drainages, stratigraphic units, fractures, structures, and other features. The migration pathways for each contaminant and each relevant medium should be tied to the potential receptors for each pathway. A discussion of contaminant characteristics relating to fate and transport of contaminants through each pathway shall also be included in this section.	XI.F.7b	Section 4
39	A section shall provide a listing and description of all anticipated potential receptors that could possibly be affected by the contamination present at the site. Potential receptors shall include human and ecological receptors, groundwater, and other features such as pathways that could divert or accelerate the transport of contamination to human receptors, ecological receptors, and groundwater.	XI.F.7c	Section 4
40	A section shall set forth the applicable cleanup standards, risk-based screening levels, and risk-based cleanup goals for each pertinent medium at the subject site. The appropriate cleanup levels for each site shall be included, if site-specific levels have been established at separate sites or units. A table summarizing the applicable cleanup standards or levels, or inclusion of applicable cleanup standards or levels in the summary data tables shall be included in the Tables section of the document. The risk assessment shall be presented in a separate document or in an appendix to this report. If cleanup or screening levels calculated in a risk evaluation are employed, the risk evaluation document shall be referenced including pertinent page numbers for referenced information.	XI.F.8	Section 5 and associated tables; Risk assessment in Appendix G of the MDA G investigation report (LANL 2005, 090513)

Table 1.0-1 (continued)

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
41	A section shall identify and describe potential corrective measures for source, pathway, and receptor controls. Corrective measures options shall include the range of available options including, but not limited to, a no action alternative, institutional controls, engineering controls, in-situ and on-site remediation alternatives, complete removal, and any combination of alternatives that would potentially achieve cleanup goals.	XI.F.9	Sections 7 and 8
42	A section shall provide an evaluation of the corrective measures options identified in Section XI.F.9 above. The evaluation shall be based on the applicability, technical feasibility, effectiveness, implementability, impacts to human health and the environment, and cost of each option. A table summarizing the corrective measures alternatives and the criteria listed below shall be included in the Tables section of this document.	XI.F.10	Section 8 and associated tables
43	The assessment also shall include the anticipated duration for the technology to attain regulatory compliance. In general, all corrective measures described above will have the ability to mitigate the impacts of contamination at the site, but not all remedial options will be equally effective at achieving the desired cleanup goals to the degree and within the same time frame as other options. Each remedy shall be evaluated for both short-term and long-term effectiveness.	XI.F.10.c	Section 8
44	Implementability characterizes the degree of difficulty involved during the installation, construction, and operation of the corrective measure. Operation and maintenance of the alternative shall be addressed in this section.	XI.F.10.d	Section 8
45	This category evaluates the short-term (remedy installation-related) and long-term (remedy operation-related) hazards to human health and the environment of implementing the corrective measure. The assessment shall include whether the technology will create a hazard or increase existing hazards and the possible methods of hazard reduction.	XI.F.10.e	Section 8
46	This section shall discuss the anticipated cost of implementing the corrective measure. The costs shall be divided into: 1) capital costs associated with construction, installation, pilot testing, evaluation, permitting, and reporting of the effectiveness of the alternative; and 2) continuing costs associated with operating, maintaining, monitoring, testing, and reporting on the use and effectiveness of the technology.	XI.F.10.f	Section 8

Table 1.0-1 (continued)

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
47	The Respondents shall propose the preferred corrective measure(s) at the site and provide a justification for the selection in this section. The proposal shall be based upon the ability of the remedial alternative to: 1) achieve cleanup objectives in a timely manner; 2) protect human and ecological receptors; 3) control or eliminate the sources of contamination; 4) control migration of released contaminants; and 5) manage remediation waste in accordance with State and Federal regulations. The justification shall include the supporting rationale for the remedy selection, based on the factors listed in Section XI.F.10 and a discussion of short- and long-term objectives for the site. The benefits and possible hazards of each potential corrective measure alternative shall be included in this section.	XI.F.11	Section 9
48	The Respondents shall present descriptions of the preliminary design for the selected corrective measures in this section. The description shall include appropriate preliminary plans and specifications to effectively illustrate the technology and the anticipated implementation of the remedial option at the subject area. The preliminary design shall include a discussion of the design life of the alternative and provide engineering calculations for proposed remediation systems.	XI.F.12	Section 10
49	A section shall set forth a proposed schedule for completion of remedy-related activities such as bench tests, pilot tests, construction, installation, remedial excavation, cap construction, installation of monitoring points, and other remedial actions. The anticipated duration of corrective action operations and the schedule for conducting monitoring and sampling activities shall also be presented. In addition, this section shall provide a schedule for submittal of reports and data to the Department, including a schedule for submitting all status reports and preliminary data.	XI.F.13	Section 11
50	1. A table summarizing regulatory criteria, background, and/or the applicable cleanup standards.	XI.F.14	Table 5.3-1
51	2. A table summarizing historical field survey location data.	XI.F.14	Section 2.4, Appendix B, and associated figures and tables
52	3. Tables summarizing historical field screening and field parameter measurements of soil, rock, sediments, groundwater, surface water, and air quality data.	XI.F.14	Appendix B of the MDA G investigation report (LANL 2005, 090513); Appendix C of the MDA G addendum to the investigation report (LANL 2007, 096110)
53	4. Tables summarizing historical soil, rock, or sediment laboratory analytical data. The summary tables shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.	XI.F.14	Section 2, Appendix B, and associated figures and tables

Table 1.0-1 (continued)

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
54	5. A table summarizing historical groundwater elevation and depth to groundwater data. The table shall include the monitoring well depths and the screened intervals in each well.	XI.F.14	Sections 2 and 3 and Appendix D
55	6. Tables summarizing historical groundwater laboratory analytical data. The analytical data tables shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.	XI.F.14	Section 3.2.5 and Appendix D
56	7. Tables summarizing historical surface water laboratory analytical data. The analytical data tables shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.	XI.F.14	Not applicable; no surface water at site
57	8. Tables summarizing historical air sample screening and analytical data. The data tables shall include the screening instruments used, laboratory analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.	XI.F.14	Section 2 and Appendix B
58	9. Tables summarizing historical pilot or other test data, if applicable, including units of measurement and types of instruments used to obtain measurements.	XI.F.14	Section 2 and Appendix B
59	10. A table summarizing the corrective measures alternatives and evaluation criteria.	XI.F.14	Sections 8 and 9 and associated tables
60	11. A table presenting the schedule for installation, construction, implementation, and reporting of selected corrective measures.	XI.F.14	Section 11
61	A section shall present the following figures for each site, as appropriate. All figures must include an accurate bar scale and a north arrow. An explanation shall be provided on each figure for all abbreviations, symbols, acronyms, and qualifiers. All figures shall have a date.	XI.F.15	See below
62	1. A vicinity map showing topography and the general location of the subject site relative to surrounding features or properties.	XI.F.15	Figures 1.0-1 and 1.0-2
63	2. A unit site plan that presents pertinent site features and structures, underground utilities, well locations, and remediation system locations and details. Off-site well locations and other relevant features shall be included on the site plan if practical. Additional site plans may be required to present the locations of relevant off-site well locations, structures, and features.	XI.F.15	Figure 3.1-1
64	3. Figures showing historical soil boring or excavation locations and sampling locations.	XI.F.15	Appendix B
65	4. Figures presenting historical soil sample field screening and laboratory analytical data, if appropriate.	XI.F.15	Appendix B; Appendix B of the MDA G investigation report (LANL 2005, 090513); Appendix C of the MDA G addendum to the investigation report (LANL 2007, 096110)

Table 1.0-1 (continued)

No.	Consent Order Requirement	Consent Order Section Reference	CME Report Section or Other Source
66	5. Figures showing all existing wells including vapor monitoring wells and piezometers. The figures shall present historical groundwater elevation data and indicate groundwater flow directions.	XI.F.15	Section 2, Figure 2.3-3, and Appendixes D and E
67	6. Figures presenting historical groundwater laboratory analytical data including past data, if applicable. The analytical data corresponding to each sampling location may be presented as individual concentrations, in table form on the figure or as an isoconcentration map.	XI.F.15	Appendix D
68	7. Figures presenting historical surface water sample locations and analytical data including past data, if applicable. The laboratory analytical data corresponding to each sampling location may be presented as individual concentrations or in table form on the figure.	XI.F.15	Not applicable; no surface water exists at site
69	8. Figures presenting historical air sampling locations and presenting air quality data. The field screening or laboratory analytical data corresponding to each sampling location may be presented as individual concentrations, in table form on the figure or as an isoconcentration map.	XI.F.15	Section 2, Appendix B, and associated figures
70	9. Figures presenting historical pilot or other test locations and data, where applicable, including site plans or graphic data presentation.	XI.F.15	Appendix B
71	10. Figures presenting geologic cross-sections based on outcrop and borehole data, if applicable.	XI.F.15	Appendix E
72	11. Figures presenting the locations of existing and proposed remediation systems.	XI.F.15	Figures 2.4-1 through 2.4-3, Appendixes B and H
73	12. Figures presenting existing remedial system design and construction details.	XI.F.15	Not applicable
74	13. Figures presenting preliminary design and construction details for preferred corrective measures.	XI.F.15	Figure 7.3-1, Section 10.1 and LANL 2010,109657
75	Each corrective measures evaluation shall include, as appropriate, as an appendix, the management plan for waste, including investigation derived waste, generated as a result of construction, installation, or operation of remedial systems or activities conducted.	XI.F.16	To be developed as part of CMI plan
76	Each corrective measures evaluation shall include additional appendices presenting relevant additional data, such as pilot or other test or investigation data, remediation system design specifications, system performance data, or cost analyses as necessary.	XI.F.16	Appendixes F through H

Table 2.0-1
Area G Waste Unit Categories

	MDA G, Consolidated Unit 54-013(b)-99, Closure Requirements Defined under Corrective Action		Area G Waste Disposal Units		Closure Requirements Defined by Operating Permit[a]
	Corrective Action Disposal Units	Retrievable TRU Waste[b]	LLW Disposal Units[b]	LLW/Retrievable TRU Waste Storage Units	Surface Container Storage Unit(s) (CSU[s])
Unit	Pits 1–8, 10, 12, 13, 16–22, 24–28, 30–33, and 35–37 Shafts C1–C10, C12, C13, 1–20, 22, 24–96, 99–112, 114, 115, 118–123, 125–136, 138–140, 150–160, 189–192, and 196 **Total Pits = 30** **Total Shafts =159** Regulated Units Pit 29 Shaft 124 RCRA CSUs: Shafts 145 and 146 **Total Pits = 1** **Total Shafts = 3**	TRU waste in corrugated metal pipes stored atop Pit 29 Pit 9 Trenches A–D Shafts 200–233 **Total Pits = 1** **Total Shafts = 34** **Total Trenches = 4**	Pit 15 Pits 38 and 39 Shafts 21, 23, 97, 137, 141–144, 147–149, 161–177, 197, 300, 301, 307, 308, 360–367, 369, and 370 Shafts C11, C14, 321, 323, 325, 327, 329, 331, 333, 335, 339, 341, 343, 345, 347, 349, 351, 355, and 357 Shafts 309, 311, 313, 315, 317, 319, 337, 353, and 359 **Total Pits = 3** **Total Shafts =71**	Shafts 235, 236–243[c], 246–253[c], 262–266, and 302–306 **Total shafts = 27**	Surface CSUs Pad 1 (54-226 and 54-412) Pad 3 (54-48) Pads 5, 7, and 8 (54-49, 54-224, 54-144, 54-145, 54-146, 54-177, 54-1027, 54-1028, 54-1030, and 54-1041) Pad 6 (54-153 and 54-283) Pad 9 (54-229, 54-230, 54-231, and 54-232) Pad 10 (formerly Pads 2 and 4) Pad 11 (54-375)[d] 54-8 54-33

Note: Shaded area indicates units addressed in this CME report.

[a] Associated buildings in parentheses with exception of Pad 10.

[b] Regulated by DOE under the AEA.

[c] Removed in 2009.

[d] Included in RCRA permit application renewal.

Table 2.0-2
Consolidated Unit 54-013(b)-99 SWMUs

SWMU	Description
SWMU 54-013(b)	SWMU 54-013(b) was a vehicle monitoring/decontamination area located in the central portion of Area G on the surface of Pit 19. The area was used to decontaminate trucks and TRU waste drums but is no longer in use.
SWMU 54-014(b)	SWMU 54-014(b) consists of Pit 9, an inactive disposal pit measuring 30 ft wide × 400 ft long × 20 ft deep. From 1974 to 1978, Pit 9 received retrievable TRU. When filled, the pit was covered with 3.3 ft of consolidated crushed tuff and 4 in. of topsoil and reseeded with native grasses. The TRU wastes in Pit 9 will be retrieved and processed for disposal at WIPP.
SWMU 54-014(c)	SWMU 54-014(c) consists of retrievable TRU waste storage shafts 200 through 233, located in the northeastern quadrant of Area G, TA-54. The shafts each measure 1 ft in diameter and 18 ft deep and are lined with concrete. Some of the shafts began receiving TRU waste in 1978 and were closed between 1979 and 1987. The shafts were used for wastes that required special packaging (primarily tritium), special handling (e.g., highly active metals), or segregation. When filled, the shafts typically were filled with waste to within 3 ft of the ground surface, backfilled with crushed tuff, and covered with a concrete dome. The TRU wastes in these shafts will be retrieved and processed for disposal at WIPP.
SWMU 54-014(d)	SWMU 54-014(d) consists of retrievable TRU waste storage trenches A, B, C, and D, which are located in the south-central portion of TRA-54's Area G. These trenches began receiving TRU in 1974. Trenches A, B, and C vary in size from 219 ft to 262.5 ft long × 13 ft wide × 6 ft to 8 ft deep. Trench D is 60 ft long × 13 ft wide × 6 ft deep. The TRU waste placed in these trenches was packaged in 30-gal. containers inside concrete casks. When filled, the trenches were backfilled with 3.3 ft of crushed tuff followed by 4 in. of topsoil. The surface was reseeded with native grasses. The TRU wastes in these trenches will be retrieved and processed for disposal at WIPP.
SWMU 54-015(k)	SWMU 54-015(k) consists of a layer of retrievable TRU waste in cement-filled sections of corrugated pipe located inside a mound of fill material that was placed on top of inactive Pit 29 in the northeast quadrant of TA-54's Area G. These TRU wastes will be retrieved and processed for disposal at WIPP.
SWMU 54-017	SWMU 54-017 consists of inactive disposal pits 1 through 8, 10, 12, 13, 16 through 22, and 24. Pits 1 through 8, 10, 12, 13, 16 through 22, and 24 were operational between 1959 and 1980 and received radioactive, mixed, and nonretrievable TRU wastes in the form of wing tanks, dry boxes, building debris, sludge drums, lab waste, contaminated soil, D&D waste, filter plenums, and uranium. Pits 1 through 8, 10, 12, 13, 16 through 22, and 24 are located in the eastern portion of Area G with volumes ranging from 1371 to 56,759 yd^3. When filled, the pits were covered with 3.3 ft of consolidated crushed tuff and 4 in. of topsoil, and reseeded with native grasses.
SWMU 54-018	SWMU 54-018 consists of disposal pits 25 through 33 and 35 through 37. Only Pit 29 (although no longer in use) is considered a regulated unit until RCRA closure is certified and approved by NMED. Pits 25 through 28 and 30 through 36 were operational between 1979 and 1980 and received radioactive, mixed, and TRU-contaminated waste in the form of reactor control rods, D&D waste, contaminated soil, transformers, glove boxes, asbestos, and lab waste and range in volume from 20,957 to 59,930 yd^3. Pit 29 operated until 1986. Pit 37 operated from 1990 to 1997 and primarily received circuit boards and contaminated soil. When filled, the pits were covered with 3.3 ft of consolidated crushed tuff and 4 in. of topsoil, and reseeded with native grasses.

Table 2.0-2 (continued)

SWMU	Description
SWMU 54-019	SWMU 54-019 consists of disposal shafts 1 through 20, 24 through 34, 38 through 92, 96, 109 through 112, and 150. These shafts, which were operational between 1966 and 1980, received LLW and hazardous and mixed waste. The shafts range in size from 1 ft to 6 ft in diameter and 25 ft to 60 ft deep and are located primarily in the northeast quadrant of Area G. Disposal shafts typically were filled with waste to within 3 ft of the ground surface, backfilled with crushed tuff, and covered with a concrete dome.
SWMU 54-020	SWMU 54-020 consists of disposal shafts C1 through C10, C12, C13, 22, 35 through 37, 93 through 95, 99 through 108, 114, 115, 118 through 136, 138 through 140, 151 through 160, 189 through 192, and 196. These shafts were operational between 1970 and the early 1990s. Only Shaft 124 (although no longer in use) is considered active until RCRA closure is certified and approved by NMED. The shafts contain one or a combination of the following waste types: PCB residues, LLW, hazardous, and mixed waste. The shafts range in size from 1 ft to 8 ft in diameter and 25 ft to 65 ft deep, and are located throughout the eastern portion of Area G. Disposal shafts were typically filled with waste to within 3 ft of the ground surface, backfilled with crushed tuff, and covered with a concrete dome.

Table 2.1-1
MDA G Subsurface Disposal Unit Information for Pits

Pit No.[a]	Operational Period	Dimensions (length × width × depth)	Rectangular Vol. of Pit (yd^3)	Field Meas. Pit Vol. (yd^3)	Vol. of Waste in Pit (yd^3)	Waste Description
1	Jan 1959–Apr 1961	616 ft × 113 ft × 20 ft	51,561	37,080	5529	Wing tanks from Kirtland Air Force Base, dry boxes, “normal trash.” Pit used to burn combustibles
2	Apr 1961–Jul 1963	618 ft × 104 ft × 26 ft	61,892	42,911	6407	Classified Bendix waste, 55-gal. drums, property numbers, D-38, hot dirt
3	Jun 1963–Mar 1966	655 ft × 115 ft × 33 ft	92,064	56,759	9473	Misc. material, lumber, pipe, 55-gal. drums, D&D, D-38, Bendix classified waste, soil from TA-10 - Bayo Canyon
4	Jan 1966–Dec 1967	600 ft × 110 ft × 34 ft	83,111	44,950	8212	D&D, graphite, wooden boxes, D-38, 55-gal. drums, classified Bendix waste, property numbers. Burning trench along south wall of pit
5	Jan 1967–Mar 1974	600 ft × 100 ft × 29 ft	64,444	41,258	6624	Scrap material, D&D, graphite hoppers, sludge drums (possibly aqueous solution from TA-50), property numbers
6	Jan 1970–Aug 1972	600 ft × 113 ft × 26 ft	65,289	43,933	6696	Misc. scrap, wood, D&D. Covered with topsoil from TA-1 with up to 20 pCi/g Pu contamination

Table 2.1-1 (continued)

Pit No.[a]	Operational Period	Dimensions (length × width × depth)	Rectangular Vol. of Pit (yd³)	Field Meas. Pit Vol. (yd³)	Vol. of Waste in Pit (yd³)	Waste Description
7	Mar 1974–Oct 1975	600 ft × 50 ft × 30 ft	33,333	17,101	4343	Low-level TRU-contaminated waste. Replaced Pit 17 for low-level TRU-contaminated waste in 1974. Covered with topsoil from TA-1 with up to 20 pCi/g Pu contamination
8	Sep 1971–May 1974	400 ft × 25 ft × 25 ft	9259	6528	2311	55 gal. drums of sludge from H-7 and nonretrievable TRU waste also drums from TA-50 (aqueous and nonretrievable TRU)
9	Nov 1974–Nov 1979	400 ft × 30 ft × 20 ft	8889	9027	na[b]	Drums and fiberglass crates containing retrievable TRU wastes (>10 nCi/g Pu-239 or U-233 or >100 nCi/g Pu-238) bottom of pit is paved
10	May 1979–Mar 1980	380 ft × 57 ft × 27 ft	21,660	15,549	4016	Building debris, lab wastes, sludge drums (from TA-50 dewatering, possibly aqueous)
12	Sep 1971–Dec 1975	400 ft × 25 ft × 25 ft	9259	7303	2363	Nonretrievable TRU waste. Originally contained retrievable TRU, but was transferred to Pit 9 (30 55-gal. drums)
13	Nov 1976–Sep 1977	400 ft × 42 ft × 28 ft	17,422	12,107	1931	Uranium, mixed fission products, mixed activation products. Uranium fission products and induced activity wastes
16	Sep 1971–Aug 1975	400 ft × 25 ft × 25 ft	9259	8081	2235	Crates and drums containing uranium contaminated wastes
17	Aug 1972–Mar 1974	600 ft × 46 ft × 24 ft	24,533	17,399	4962	Low-level Pu TRU <10 nCi/g. Misc. scrap wastes, crates, filter plenums
18	Feb 1978–Aug 1979	600 ft × 75 ft × 40 ft	66,667	46,685	12,358	Contaminated dirt, lab wastes, noncompactible waste, D&D, drums
19	Nov 1975–Aug 1979	153 ft × 30 ft × 18 ft	3060	1371	na	Asbestos and carcinogens, plastic layer placed in bottom
20	Nov 1975–Oct 1977	600 ft × 71 ft × 36 ft	56,800	37,454	14,899	Lab waste, oil, sludge drums, trash, contaminated dirt
21	Aug 1972–Dec 1974	402 ft × 56 ft × 26 ft	21,678	13,328	3607	U, classified material, boxes, drums, scrap metal
22	Sep 1976–Mar 1978	413 ft × 56 ft × 33 ft	28,268	17,690	3744	Filter plenum, sludge drums (possibly aqueous from TA-50), lab waste, graphite fuel rods, contaminated dirt
24	Jul 1975–Nov 1976	600 ft × 58 ft × 30 ft	38,667	23,388	7327	Graphite, lab wastes, 22 truck loads of soil. Uranium, tritium, mixed fission products, and mixed activation products

Table 2.1-1 (continued)

Pit No.[a]	Operational Period	Dimensions (length × width × depth)	Rectangular Vol. of Pit (yd³)	Field Meas. Pit Vol. (yd³)	Vol. of Waste in Pit (yd³)	Waste Description
25	Jan 1980–May 1981	395 ft × 103 ft × 39 ft	58,767	47,000	6530	Reactor control rods, D&D, scrap Drums, lab wastes, test drums, PCB-contaminated waste forms
26	Feb 1984–Feb 1985	310 ft × 100 ft × 36 ft	41,333	22,209	4312	Building debris, TRU culverts, asbestos, alpha box soil, lumber, PCBs
27	May 1981–Jul 1982	400 ft × 80 ft × 46 ft	54,519	26,946	7441	Laboratory waste, contaminated soil and pipe, D&D, PCBs, and unknown chemical waste
28	Dec 1981–Apr 1983	330 ft × 83 ft × 40 ft	40,578	21,381	4422	Ba nitrate, PCB soil, lab waste, property numbers, transformers, clay pipes, building debris, uranium graphite
29	Oct 1984–Oct 1986	658 ft × 80 ft × 50 ft	97,481	45,795	9784	TRU cement paste (recoverable), D&D soil, glove boxes, plywood boxes (4 ft × 4 ft × 8 ft), asbestos, PCBs, and unknown chemical waste
30	Oct 1988–Jun 1990	568 ft × 39 ft × 35 ft	28,716	42,843	13,464	Asbestos, PCBs, and unknown chemical waste
31	Jun 1990–Mar 2003	280 ft × 52 ft × 25 ft	13,481	na	2702	Asbestos, mixed fission products, and mixed activation products.
32	Nov 1985–Aug 1987	518 ft × 74 ft × 51 ft	72,405	36,364	5367	PCB asphalt, transformers, contaminated soil, glove boxes, 4 ft × 4 ft × 8 ft plywood boxes, capacitors, building debris
33	Nov 1982–Jul 1984	425 ft × 115 ft × 40 ft	72,407	59,930	7776	Be in stainless steel, lab waste, building debris, asbestos, noncompactible trash, PCBs, and unknown chemical waste
35	Jun 1987–Feb 1988	363 ft × 83 ft × 40 ft	44,636	20,957	3361	Trash, 4 ft × 4 ft × 8 ft plywood boxes, asbestos, lab waste, PCBs, and unknown chemical waste
36	Jan 1988–Dec 1988	435 ft × 83 ft × 43 ft	57,501	28,057	4491	4 ft × 4 ft × 8 ft plywood boxes, compactable nonnuclear. trash, rubble, building waste, beryllium, and PCB soil (<200 ppm)
37	Apr 1990–Apr 1997	731 ft × 83 ft × 61 ft	137,076	57,213	24,299	Ultra-High-Temperature Reactor Experiment reactor vessel and stack, asbestos, PCBs, and unknown chemical waste

[a] Does not include LLW pits 15, 38, and 39.

[b] na = Not available.

Table 2.1-2
MDA G Subsurface Disposal Unit Information for Trenches

Trench No.	Operational Period	Dimensions (length × width × depth)	Waste Description
A	1974	262.5 ft × 12.75 ft × 8 ft	Heat source Pu-238 (80% Pu-238, 16% Pu-239, 3% Pu-239, 1% other) in casks from (1) radiolytic heating, (2) radiolytic gas formation, and (3) radiation emitting from waste. Average of 18 g Pu-238 per cask, with max 40 g Pu-238.
B	1974–1977	218.75 ft × 12.75 ft × 8 ft	
C	1977–1981	218.75 ft × 12.75 ft × 10 ft (est.)	
D	1981–1985	250 ft × 12.75 ft × 10 ft (est.)	

Table 2.1-3
MDA G Subsurface Disposal Unit Information for Shafts

Shaft No.	Operational Period	Diameter/ Depth (ft)	Lining	Shaft Volume (ft^3)	Waste Volume (ft^3)	Waste Description
1	1966–1967	2/25	N[a]	78.4	63	Cell trash, irradiated metal, animal tissue
2	1966–1967	2/25	N	78.4	42	DU[b] chips, animal tissue, irradiated Pu cell waste
3	1966–1967	2/25	N	78.4	35	Pu-contaminated Na and metal, neutron generators
4	1967–1968	2/25	N	78.4	44	U-contaminated metal, U-238 samples, DU
5	1967–1968	2/25	N	78.4	29	DU, tritium-contaminated materials, U-238-contaminated metal
6	1967–1968	2/25	N	78.4	21	Tritium-contaminated materials, U-235
7	1967–1968	2/25	N	78.4	52	Animal tissue, PTC waste, tritium DU
8	1968–1969	2/25	N	78.4	na[c]	Pu cell waste, animal tissue, end boxes
9	1968–1969	2/25	N	78.4	70	Hot cell waste, Pu cell waste, Experimental Breeder Reactor (EBR) II waste, fuel elements
10	1969	2/25	N	78.4	54	Animal tissue, Pu-239 waste, U-contaminated chemicals
11	1967–1969	3/25	N	176.5	72	PeeWee waste and trash, U-235 cell waste, graphite
12	1966–1970	3/25	N	176.5	83	Cell waste, Rover waste, tritium
13	1966–1970	3/25	N	176.5	122	Animal tissue, EBR hardware, reactor parts
14	1966–1969	1/25	CMP[d]	19.7	na	U-235 vermiculite, neutralized solution HCL + U-235
15	1969–1970	1/25	CMP	19.7	8	Tritium in H_3PO_4, hot cell waste
16	1969	1/25	CMP	19.7	4	Tritium
17	1970–1974	1/25	CMP	19.7	1	Tritium pump, U-235 in Na
18	1970–1973	1/25	CMP	19.7	13	Neutralized Na, Cs-137 + Ba-140
19	1971–1974	1/25	CMP	19.7	3	Pu-239 solution, reacted Pu-239
20	1974–1975	1/25	CMP	19.7	8	Sorbed Pu-239 solution
22	1980–1993	1/25	CMP	19.7	7	Radioactive sources
24	1969–1970	2/25	N	78.4	44	Animal tissue, DU, unloaded fuel elements

Table 2.1-3 (continued)

Shaft No.	Operational Period	Diameter/ Depth (ft)	Lining	Shaft Volume (ft^3)	Waste Volume (ft^3)	Waste Description
25	1969–1971	2/25	N	78.4	45	DU, U-238 residue, U-238 contaminated metal
26	1969–1970	2/25	N	78.4	56	Hot cell trash, fuel elements, DU-contaminated metal
27	1970	2/25	N	78.4	13	Irradiated material, DU-contaminated material
28	1970	2/25	N	78.4	14	LA notebooks, U-235 residues
29	1970–1971	2/25	N	78.4	24	Thermocouple waste, U-235 residue
30	1970–1971	2/25	N	78.4	11	Animal tissue, Pu-239 hot cell waste
31	1970–1971	2/25	N	78.4	47	DU
32	1970–1971	2/25	N	78.4	33	Los Alamos Molten Plutonium Reactor Experiment II (LAMPRE-II) lines and valves, animal tissue, irradiated stainless steel
33	1970–1971	2/25	N	78.4	15	Pu-239 hot cell waste
34	1970–1972	6/60	N	1709.2	932	U-contaminated oil
35	1971–1985	3/40	N	282.9	125	Hot cell wastes, animal tissues, herbicide containers, fission products
36	1970–1985	3/40	N	282.9	198	Hot cell wastes, spallation products
37	1970–1985	3/40	N	282.9	198	Animal and chemical wastes
38	1970–1974	3/40	N	282.9	69	Rover reactor parts, LAMPRE-II tank
39	1970–1973	6/60	N	1709.2	537	Tritium-contaminated equipment
40	1971	2/25	N	78.4	28	Animal tissue
41	1971–1972	2/25	N	78.4	71	Animal tissue, graphite
42	1972	2/25	N	78.4	56	Animal tissue, U-contaminated metal
43	1971–1972	2/25	N	78.4	43	U-contaminated metal, DU
44	1971–1972	2/25	N	78.4	61	Animal tissue, Pu-239-contaminated vermiculite, DU with graphite
45	1971–1972	2/25	N	78.4	70	Pu-contaminated steel, U-235 residues
46	1972	2/25	N	78.4	38	Animal tissue, Pu-239-contaminated steel
47	1972	2/25	N	78.4	32	Animal tissue, contaminated metal, fuel waste (no vol.)
48	1972	2/25	N	78.4	19	Hot cell trash, fuel waste (no vol.)
49	1972	2/25	N	78.4	21	Animal tissue
50	1974–1976	6/60	N	1709.2	581	Tritium (1110 Ci)
51	1975	2/25	N	78.4	52	Hot cell waste
52	1975–1976	2/25	N	78.4	6	Pu, U, mixed fission products, mixed activation products, hot cell wastes
53	1975–1976	2/25	N	78.4	3	Mixed fission products, cell wastes, Pu-239, U-235
54	1976	2/25	N	78.4	6	Mixed fission products, cell trash
55	1976–1977	2/25	N	78.4	20	Hot cell trash

Table 2.1-3 (continued)

Shaft No.	Operational Period	Diameter/ Depth (ft)	Lining	Shaft Volume (ft^3)	Waste Volume (ft^3)	Waste Description
56	1977	2/25	N	78.4	11	Cell waste, contaminated parts from Size Reduction Lab
57	1977	2/25	N	78.4	8	Hot cell waste
58	1972–1973	3/25	N	176.5	88	Hot cell waste, DU
59	1973–1974	6/60	N	1709.2	120	Tritium-contaminated steel, tools, and waste
60	1972–1974	3/25	N	176.5	128	Oil contaminated with U-235, Pu-239
61	1973–1974	3/25	N	176.5	143	Be waste, U-238-contaminated metal, animal tissue
62	1976	3/25	N	176.5	141	Animal tissue, Pu-238, P-32
63	1976	3/25	N	176.5	28	DU, residues
64	1976–1977	3/25	N	176.5	32	Animal wastes, U-235
65	1976–1977	3/25	N	176.5	123	Classified U wastes, targets, animal tissue
66	1976–1979	3/25	N	176.5	25	Animal tissue
67	1977	2/25	N	78.4	48	Targets, cell trash
68	1977	2/25	N	78.4	23	Cell trash, classified notebooks
69	1977	2/25	N	78.4	20	Air conditioning parts from recovery
70	1975–1976	6/60	N	1709.2	917	Contaminated oil
71	1978	2/25	N	78.4	31	No description
72	1972–1973	2/25	N	78.4	61	Irradiated stainless steel, hot cell waste trash
73	1973	2/25	N	78.4	43	Hot cell trash
74	1973	2/25	N	78.4	69	Pu-239 waste
75	1973	2/25	N	78.4	61	Pu-238 waste, cell trash
76	1973–1974	2/25	N	78.4	75	Hot cell trash
77	1973–1974	2/25	N	78.4	33	Hot cell trash, Pu-239 hot cell trash
78	1974–1975	2/25	N	78.4	46	Cell wastes, reactor wastes, irradiated box ends
79	1974–1975	2/25	N	78.4	46	Hot cell waste, irradiated metal
80	1975–1976	2/25	N	78.4	25	Sodalime, Ta-182 chips, animal tissue
81	1976	2/25	N	78.4	na	Animal tissue (12 boxes)
82	1978	3/25	N	176.5	1	Trash, chemical wastes
83	1978	3/25	N	176.5	44	Animal tissue, DU
84	1978	3/25	N	176.5	17.3	Trash from Size Reduction Lab, cell trash
85	1978	3/25	N	176.5	12	Neutralized Na Dowanol, cell trash
86	1977	3/25	N	176.5	22	Spalation products, classified materials
87	1977	2/25	N	78.4	23	Cell wastes
88	1977	2/25	N	78.4	18	Cell wastes
89	1977–1978	2/25	N	78.4	12	Animal tissue (5 boxes), cell waste
90	1978	2/25	N	78.4	25	DU, hot cell trash

Table 2.1-3 (continued)

Shaft No.	Operational Period	Diameter/ Depth (ft)	Lining	Shaft Volume (ft^3)	Waste Volume (ft^3)	Waste Description
91	1977–1978	3/50	N	353.4	54	Spalation products, animal waste, cell trash, trash cans
92	1977–1978	3/50	N	353.4	60	Spalation products, uranyl-nitrate in HNO3
93	1978–1984	3/50	N	353.4	139	Spalation products, fuel elements, cell waste, animal tissues
94	1978–1984	3/50	N	353.4	29	Hot cell waste, DU, control rods
95	1984	3/50	N	353.4	142	Cell wastes, animal tissues
96	1977–1979	6/50	N	1413.6	438	U-contaminated oil, niobium, zirconium, chlorides, aluminum shell
99	1983–1984	3/60	N	424.1	189	Hot cell wastes, animal tissue, machine parts
100	1983	3/60	N	424.1	3	Hot cell waste, target and stinger
101	1980–1981	3/60	N	424.1	75	Spalation products, hot cell waste
102	1982–1983	3/60	N	424.1	184	No description
103	1981–1982	3/60	N	424.1	118	Hot cell waste, spent fuel elements
104	1982	3/60	N	424.1	10	U chips, scrap metal
105	1982–1983	3/60	N	424.1	2	Animal tissue
106	1980–1981	3/60	N	424.1	69	Spalation products, hot cell waste
107	1978–1981	3/60	N	424.1	27	Hot trash, animal tissue, chemical waste
108	1980–1982	3/60	N	424.1	230	Spalation products, solvent, animal tissue
109	1980	2/60	N	188.5	83	Spalation products, trash cans
110	1979	3/60	N	424.1	128	Spalation products, animal tissue, mixed combustible trash
111	1979–1980	2/60	N	188.5	134	Cell waste, spallation products, niobium and tantalum perchloride
112	1978–1979	3/60	N	424.1	149	Classified pieces, animal waste, cell waste, spallation products
114	1979–1982	6/60	N	1696.5	981	Shielding blocks, graphite design assembly
115	1979–1982	6/60	N	1696.5	539	Hot trash, tritium scrap
118	1983–1984	8/62	N	3267.3	461	Vials
119	1983	8/62	N	3116.5	549	DU chips, hydrocarbons, HF leach solids
120	1983–1984	8/63	N	3116.6	531	Shielding blocks, graphite design assembly
121	1984–1985	4/60	N	753.9	245	Animal tissue, cell trash
122	1984–1985	4/60	N	753.9	258	Hot cell waste, waste cans
123	1984	6/60	N	1696.5	516	DU chips and turnings, firing residue
124	1984–1991	6/65	N	1837.7	491	Vials, organics
125	1984	6/65	N	1837.7	597	DU chips and turnings
126	1985–1987	6/65	N	1837.7	781	Meson and hot cell waste
127	1985	6/65	N	1837.7	484	DU chips and turnings, U3 08 oil and wax
128	1985–1986	6/65	N	1837.7	417	Animal tissue, mustargen

Table 2.1-3 (continued)

Shaft No.	Operational Period	Diameter/ Depth (ft)	Lining	Shaft Volume (ft^3)	Waste Volume (ft^3)	Waste Description
129	1986	3/65	N	459.4	136	Mixed spallation products
130	1986–1987	6/65	N	1837.7	1110	DU chips, metal trash
131	1987–1995	6/65	N	1837.7	438	Activated shielding
132	1987–1993	6/65	N	1837.7	634	Classified material
133	1986–1987	4/65	N	816.8	96	Spalation products, hot cell waste
134	1986	3/65	N	459.4	239	Animal tissue
135	1986–1987	3/65	N	459.4	219	Animal tissue
136	1986–1995	6/65	N	1837.7	50	Low-level tritium
138	1987–1989	4/60	N	753.9	191	Animal tissue
139	1987–1988	4/60	N	753.9	308	Hot cell waste
140	1987–1991	6/61	N	1724.7	869	Animal tissue
150	1976–1979	6/60	CMPAC[e]	1696.5	86	Low-level tritium
151	1979–1986	3/60	CMPAC	424.1	131	Low-level tritium
152	1980–1983	3/60	CMPAC	424.1	147	Tritium scrap, tubing, hardware
153	1983–1984	3/60	CMPAC	424.1	12	Contaminated pump, property numbers
154	1984–1986	3/65	CMPAC	459.4	135	High-level tritium, molecular sieves
155	1988–1989	3/65	CMPAC	459.4	137	High-level tritium
156	1986–1987	3/45	CMPAC	318.2	59	Dry box trash, molecular sieves
157	1987–1988	3/45	CMPAC	318.2	88	Tritium
158	1989–1998	2/45	CMPAC	141.2	78	High-level tritium
159	1989	2/45	CMPAC	141.2	12	High-level tritium
160	1990–1993	2/45	CMPAC	141.2	89	High-level tritium
189	1987–1988	8/65	N	3267.3	1743	Los Alamos Meson Physics Facility (LAMPF) activated shielding (triple shaft)
190	1983–1984	8/65	N	3267.3	1077	Scrap metal
191	1984–1986	8/65	N	3267.3	1470	LAMPF scrap metal, graphite target (double shaft)
192	1987–1989	8/65	N	3267.3	1537	LAMPF scrap metal (triple shaft)
196	1989–1993	6/53	N	2997.5	2050	LAMPF inerts
200	1980–1981	1/18	SPI[f]	56.5	44	Hot cell wastes
201	1978–1979	1/18	SPI	56.5	39	Hot cell wastes
202	1980	1/18	SPI	56.5	43	Hot cell wastes
203	1980	1/18	SPI	56.5	43	Hot cell wastes
204	1978–1979	1/18	SPI	56.5	38	Hot cell wastes, fuel cans
205	1980	1/18	SPI	56.5	45	Hot cell wastes, trash, fuel cans
206	1980–1981	1/18	SPI	56.5	67	Cell trash and fuel sample
207	1981	1/18	SPI	56.5	48	Cell trash, fuel cells
208	1981	1/18	SPI	56.5	48	Hot cell trash, waste

Table 2.1-3 (continued)

Shaft No.	Operational Period	Diameter/ Depth (ft)	Lining	Shaft Volume (ft^3)	Waste Volume (ft^3)	Waste Description
209	1981	1/18	SPI	56.5	48	Hot cell paint, trash
210	1981	1/18	SPI	56.5	48	Hot cell trash
211	1981	1/18	SPI	56.5	48	Hot cell trash
212	1980	1/18	SPI	56.5	75	LAMPF fuel vessel
213	1981	1/18	SPI	56.5	30	Hot cell wastes, trash
214	1982	1/18	SPI	56.5	30	Hot cell wastes
215	1982	1/18	SPI	56.5	30	Hot cell trash
216	1982	1/18	SPI	56.5	30	Hot cell wastes
217	1982	1/18	SPI	56.5	30	Hot cell wastes
218	1982	1/18	SPI	56.5	30	Hot cell wastes
219	1983	1/18	SPI	56.5	30	Hot cell wastes
220	1983	1/18	SPI	56.5	30	Hot cell wastes
221	1983	1/18	SPI	56.5	30	Hot cell wastes
222	1983	1/18	SPI	56.5	30	Hot cell wastes
223	1983	1/18	SPI	56.5	30	Hot cell wastes
224	1985	1/18	SPI	56.5	4	Hot cell wastes
225	1984	1/18	SPI	56.5	4	Hot cell wastes
226	1984	1/18	SPI	56.5	4	Hot cell wastes
227	1984	1/18	SPI	56.5	4	Hot cell wastes
228	1987	1/18	SPI	56.5	1	Hot cell wastes
229	1984	1/18	SPI	56.5	5	Hot cell wastes
230	1984	1/18	SPI	56.5	4	Hot cell wastes
231	1985	1/18	SPI	56.5	4	Hot cell wastes
232	1987	1/18	SPI	56.5	1	Hot cell wastes
233	na	1/18	SPI	56.5	na	Hot cell wastes
C1	na	6/60	N	1696.5	221	PCBs (no liquids)
C2	na	6/60	N	1696.5	357	PCBs (no liquids)
C3	na	6/60	N	1696.5	339	PCBs (no liquids)
C4	na	6/60	N	1696.5	385	PCBs (no liquids)
C5	na	6/60	N	1696.5	258	PCBs (no liquids)
C6	na	6/60	N	1696.5	449	PCBs (no liquids)
C7	na	6/60	N	1696.5	512	PCBs (no liquids)
C8	na	6/60	N	1696.5	498	PCBs (no liquids)

Table 2.1-3 (continued)

Shaft No.	Operational Period	Diameter/ Depth (ft)	Lining	Shaft Volume (ft^3)	Waste Volume (ft^3)	Waste Description
C9	na	6/60	N	1696.5	406	PCBs (no liquids)
C10	1984–1985	6/60	N	1696.5	534	PCBs (no liquids)
C12	1986–1990	6/65	N	1696.5	588	PCBs (no liquids)
C13	1987–1995	6/65	N	1696.5	1060	PCBs (no liquids)

Note: Does not include LLW shafts.
[a] N = No.
[b] DU = Depleted uranium.
[c] na = Not available.
[d] CMP = Corrugated metal pipe.
[e] CMPAC = Corrugated metal pipe asphalt coated.
[f] SPI = Steel pipe insert.

Table 2.4-1
MDA G Subsurface Pore-Gas Monitoring Locations

Borehole ID	VOC and Tritium Sampling Port Depth Intervals (ft bgs)
54-01107	20 (19–21), 44.5 (43.5–45.5), **56.5 (55.5–57.5)**, 74 (73–75), 91 (90–92), **100 (99–101)**
54-01110	20 (19–20), 48 (47–49), **60 (59–61)**, 70 (69–71), 85 (84–86), **90 (89–91)**
54-01111	**20 (19–21)**, 39.5 (38.5–40.5), 50 (49–51), 70 (69–71), 78 (77–79), 100 (99–101), **139 (138–140)**
54-01115[a]	7 (6–8), 26 (25–27), **40 (39–41)**, 53 (52–54), 63 (62–64), **68 (67–69)**
54-01116	**22.5 (20–25)**, 42.5 (40–45), 67.5 (65–70), 82.5 (80–85), 97.5 (95–100), 132.5 (130–135), 151.5 (149–154), 165 (162.5–167.5), **187.8 (185.3–190.3)**
54-01117[b]	**20 (20),** 31.5 (31.5), 55 (55), 73 (73), 82 (82), **85 (85)**
54-01117[c]	**20 (18.5–22.5)**, 42.5 (40–45), 67.5 (65–70), 82.5 (80–85), 97.5 (95–100), 132.5 (130–135), 150 (147.5–152.5), 159.5 (157–162), **179.8 (177.3–182.3)**
54-01121	**20 (19–21)**, 26 (25–27), 61.5 (60.5–62.5), 70 (69–71), 76 (75–77), 98 (97–99), **121 (120–122)**
54-01126[a]	7 (6–8), 17 (16–18), 28 (27–29), **35 (34–36)**, 42 (41–43), **49 (48–50)**
54-01128[a]	7.5 (6.5–8.5), 15(14–16), **20 (19–21)**, 30 (29–31), **39 (38–40)**
54-02009	**37 (34.5–39.5)**, 62 (59.5–64.5), 79 (76.5–81.5) **92 (89.5–94.5)**
54-02010	**30 (27.5–32.5)**, 53 (51.5–55.5), **95 (92.5–97.5)**
54-02032	**20 (20)**, 60 (60), 100 (100), 130 (130), **156 (156)**
54-02033	20 (20), **60 (60)**, 100 (100), 160 (160), 200 (200), 220 (220), 260 (260), **277 (277)**
54-22116[d]	28 (27–29), 46 (45–47), 64 (63–65), 82 (81–83), 100 (99–101), 118 (117–119), 136 (135–137), 154 (153–155), **172 (171–173), 190 (189–191),** 208 (207-209), 226 (225–227), 244 (243–245), 262 (261–263), **280 (279–281)**
54-24370	**40 (35–45)**, 72.5 (67.5–77.5), 120 (115–125), 174.7 (169.7–179.7), 200 (195–205), **243.7 (238.7–248.7)**
54-24386	**40 (37.5–42.5)**, 83 (80.5–85.5), 117 (114.5–119.5), 135 (132.5–137.5), **195 (192.5–197.5)**
54-24394	**50 (45–55)**, 100 (95–105), 150 (145–155), 192.5 (187.5–197.5), 245.25 (240.25–250.25), **300.5 (295.5–305.5)**
54-24397	**50 (45–55)**, 90 (85–95), 130 (125–135), 165 (160–170), 188 (183–193), **239.75 (234.75–244.3)**
54-25105[e]	**485 (485–701)**
54-27436	**45 (40–50)**, 70 (65–75), 115 (110–120), 163 (158–168), **185 (180–190)**

Note: Depths highlighted in bold denote intervals where VOC and tritium samples are to be collected.

[a] Borehole location is an angled borehole. Port depth and interval is depth below ground surface.

[b] Borehole depth represents old port intervals prior to redrill and installation of new depths.

[c] Borehole location redrilled during the reporting time frame (May and June of 2008).

[d] Borehole location is horizontal borehole. Port depths and intervals are length from borehole head.

[e] Open Borehole.

Table 2.5-1
Interim Monitoring Plan for Wells in the TA-54 Monitoring Group, MDAs G, H, and L

Well	Rationale	No. of VOC sampling rounds through Oct 2010	TAL Metals[a]	VOC + TICs[b]	SVOC + TICs[b]	Pesticides	PCB[c]	HEXP[d]	Dioxins/Furans	RAD[e]	Low-Level Tritium[f]	Gen. Inorganics[g]	Perchlorate	Stable Isotopes[h]	Field Parameters[i]
Wells downgradient of MDA G															
R-22 screen 1	Monitors TA-54 and potential sources in Pajarito watershed. Rehabilitated Westbay well; final configuration to be determined.	1 (PR[j])	TBD[k]	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
R-22 screens 2 through 5	Monitors TA-54 and potential sources in Pajarito watershed. Rehabilitated Westbay well; final configuration to be determined.	0	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
R-23i[l] piezometer (port 1)	Downgradient monitoring location for TA-54. Monitors potential sources in Pajarito watershed and potential sources in canyons to the north.	12	Q	Q	S	–[m]	–	S	–	A	S	Q	S	A	Q
R-23i[l] screen 1 (port 2)	Downgradient monitoring location for TA-54. Also monitors potential sources in Pajarito watershed and potential sources in canyons to the north.	17	Q	Q	S	–	–	S	–	A	S	Q	S	A	Q
R-23i[l] screen 2 (port 3)	Downgradient monitoring location for TA-54. Monitors potential sources in Pajarito watershed and potential sources in canyons to the north.	15	Q	Q	S	–	–	S	–	A	S	Q	S	A	Q
R-23[l]	Downgradient monitoring location for TA-54. Also monitors potential sources in Pajarito watershed and possible sources from canyons to the north.	24	Q	Q	Q	A	A	A	A	A	Q	Q	Q	A	Q
R-39	Monitors TA-54 and potential sources in Pajarito watershed.	9	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q

Table 2.5-1 (continued)

Well	Rationale	No. of VOC sampling rounds through Oct 2010	TAL Metals[a]	VOC + TICs[b]	SVOC + TICs[b]	Pesticides	PCB[c]	HEXP[d]	Dioxins/Furans	RAD[e]	Low-Level Tritium[f]	Gen. Inorganics[g]	Perchlorate	Stable Isotopes[h]	Field Parameters[i]
R-41 screen 1	Monitors perched intermediate groundwater near northeast corner of MDA G. Screen has been dry since installation.	0	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-41 screen 2	Monitors groundwater near northeast corner of MDA G.	7	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-49 screen 1	Monitors groundwater south of Area G in Pajarito Canyon.	7	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-49 screen 2	Monitors groundwater south of Area G in Pajarito Canyon.	7	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-55 screen 1	New well downgradient of MDA G to monitor for potential contaminant releases from MDA G and other sources in Pajarito Canyon. Completed on August 25, 2010.[n]	1	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-55 screen 2	New well downgradient of MDA G to monitor for potential contaminant releases from MDA G and other sources in Pajarito Canyon. Completed on August 25, 2010.[l]	1	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-57 screen 1	New well downgradient of MDA G at eastern end of TA-54; monitors for potential releases from MDA G. Completed on June 8, 2010.[n]	1	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-57 screen 2	New well downgradient of MDA G at eastern end of TA-54; monitors for potential releases from MDA G. Completed on June 8, 2010.[n]	1	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
Wells downgradient of MDA H															
R-20 screen 1[o]	Monitors TA-54 and potential sources in Pajarito watershed.	11 (PR[o])	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-20 screen 2[o]	Monitors TA-54 and potential sources in Pajarito watershed.	11 (PR[o])	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q

Table 2.5-1 (continued)

Well	Rationale	No. of VOC sampling rounds through Oct 2010	TAL Metals[a]	VOC + TICs[b]	SVOC + TICs[b]	Pesticides	PCB[c]	HEXP[d]	Dioxins/Furans	RAD[e]	Low-Level Tritium[f]	Gen. Inorganics[g]	Perchlorate	Stable Isotopes[h]	Field Parameters[i]
R-37 screen 1	Monitors perched-intermediate groundwater downgradient of MDA H.	8	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-37 screen 2	Monitors regional groundwater downgradient of MDA H.	7	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-40i[p]	Monitors TA-54 and potential sources in Pajarito watershed. Screen impacted by drilling fluids.	8	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-40 screen 1[p]	Monitors TA-54 and potential sources in Pajarito watershed.	7	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-40 screen 2[o]	Monitors TA-54 and potential sources in Pajarito watershed.	7	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-52 screen 1	New well north-northeast of MDAs H and J, on mesa south of Cañada del Buey. Monitors for potential releases of contaminants from MDAs H and J. Completed on April 5, 2010.[n]	3	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-52 screen 2	New well north-northeast of MDAs H and J, on mesa south of Cañada del Buey. Monitors for potential releases of contaminants from MDAs H and J. Completed on April 5, 2010.[n]	3	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q

Table 2.5-1 (continued)

Well	Rationale	No. of VOC sampling rounds through Oct 2010	TAL Metals[a]	VOC + TICs[b]	SVOC + TICs[b]	Pesticides	PCB[c]	HEXP[d]	Dioxins/Furans	RAD[e]	Low-Level Tritium[f]	Gen. Inorganics[g]	Perchlorate	Stable Isotopes[h]	Field Parameters[i]
Wells downgradient of MDA L															
R-21	Monitors regional groundwater in Mortandad Canyon.	20	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-32	Monitors TA-54 and potential sources in Pajarito watershed.	13 (PR)	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-38	Monitors groundwater downgradient of MDA L in the north fork of Cañada del Buey, in the Mortandad watershed.	8	Q	Q	Q	A	A	A	A	A	Q	Q	Q	S	Q
R-53 screen 1	New well located north of MDA L in Cañada del Buey; monitors for potential releases from MDA L. Completed March 29, 2010.[l]	3	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-53 screen 2	New well located north of MDA L in Cañada del Buey; monitors for potential releases from MDA L. Completed March 29, 2010.[l]	3	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-54 screen 1[o]	New well located immediately west of MDA L in Pajarito Canyon; monitors for potential releases from MDA L. Completed on January 29, 2010.[n]	4	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-54 screen 2[o]	New well located immediately west of MDA L in Pajarito Canyon; monitors for potential releases from MDA L. Completed on January 29, 2010.[n]	4	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-56 screen 1	Located on Mesita del Buey between MDA G and MDA L. Monitors for potential contaminant releases from MDAs G and L, and other sources in Pajarito Canyon. Completed on July 19, 2010.[n]	1	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q

Table 2.5-1 (continued)

Well	Rationale	No. of VOC sampling rounds through Oct 2010	TAL Metals[a]	VOC + TICs[b]	SVOC + TICs[b]	Pesticides	PCB[c]	HEXP[d]	Dioxins/Furans	RAD[e]	Low-Level Tritium[f]	Gen. Inorganics[g]	Perchlorate	Stable Isotopes[h]	Field Parameters[i]
R-56 screen 2	Located on Mesita del Buey between MDA G and MDA L. Monitors for potential contaminant releases from MDAs G and L, and other sources in Pajarito Canyon. Completed on July 19, 2010.[n]	1	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
Wells upgradient of MDAs G, H, and L															
R-51 screen 1	New well west of MDAs H and J, and northwest of TA-18. Monitors other potential contaminant sources in Pajarito Canyon. Completed February 8, 2010.[n]	4	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q
R-51 screen 2	New well west of MDAs H and J, and northwest of TA-18. Monitors other potential contaminant sources in Pajarito Canyon. Completed February 8, 2010.[n]	4	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	S	Q

Table 2.5-1 (continued)

Source: Table 5.4-1 of the 2010 IFGMP (LANL 2010, 109830)

Notes: Sampling suites and frequencies: Q = quarterly (4 times/yr); S = semiannual (2 times/yr); A = annual (1 time/yr); Nonfiltered and filtered samples will be collected for general inorganics (excluding anions) and metals. Anions and perchlorate samples will be filtered. Samples collected for radionuclide analysis will be nonfiltered only for all water media. Organic and HEXP constituents are nonfiltered for all water media. Stable isotope samples for nitrogen isotopes are filtered; stable isotope samples for deuterium and oxygen isotopes are not filtered.

[a] Metals analysis includes the 23 target analyte list (TAL) metals, plus boron, molybdenum, silicon dioxide, strontium, tin, and uranium.

[b] VOC = Volatile organic compounds; SVOC = semivolatile organic compounds; TICs = tentatively identified compounds.

[c] PCB = Polychlorinated biphenyl (compound).

[d] HEXP = High explosive (compounds). The HEXP analytical suite includes the Consent Order list of the normal SW-846:8330 analytes plus pentaerythritol tetranitrate (PETN); triaminotrinitrobenzene (TATB); 3,5-dinitroaniline, tri(o-cresyl)phosphate (TOCP); 2,4-diamino-6-nitrotoluene; and 2,6-diamino-4-nitrotoluene. These additional analytes are analyzed by SW-846:8321A.

[e] The radionuclide (RAD) suite includes gross alpha, gross beta, alpha spectroscopy, gamma spectroscopy, and strontium-90.

[f] Low-level tritium is analyzed using electrolytic enrichment or direct counting.

[g] General inorganic analysis includes major anions (bromide, chloride, fluoride, sulfate); major cations (calcium, magnesium, sodium, potassium); nitrate plus nitrite (as N); total Kjeldahl nitrogen (TKN); ammonia; total phosphorus, total organic carbon (TOC); total dissolved solids (TDS); alkalinity; specific conductivity; pH; and hardness.

[h] Analysis for stable nitrogen, deuterium, and oxygen isotopes.

[i] Field parameters include pH, turbidity, specific conductance, dissolved oxygen, and temperature at all locations. Oxidation-reduction potential (ORP) will be measured if a flow-through cell is used. Alkalinity (ALK) will be measured for all samples either in the field or at the on-site Earth and Environmental Sciences (EES-14) laboratory.

[j] PR = post-rehabilitation sampling events

[k] TBD = to be determined.

[l] In the 2010 IFGMP (LANL 2010, 109830, Table 5.4-1), wells R-23 and R-23i are assigned to "General Surveillance Monitoring Locations." These wells are included in Table 2.5-1 above because they are relevant downgradient wells.

[m] — = This analytical suite is not scheduled to be collected at this location.

[n] Characterization suites and frequencies apply to new intermediate perched or regional groundwater wells. “New” wells are defined as those which are completed, rehabilitated, or converted after July 1, 2009. After completion of four rounds of characterization sampling, a new well is reassigned automatically to the routine analytical suites and frequencies of the appropriate area-specific monitoring group or general surveillance monitoring plan unless specified otherwise.

[o] Wells R-20 and R-54 are generally upgradient of MDA L. However, these wells potentially could be downgradient of MDA L if pumping at water-supply well PM-2 affects the local gradient. Similarly, well R-40 screen 2 is generally upgradient of MDA H but could potentially be downgradient of this MDA if pumping at PM-2 affects the local gradient.

[p] The gradient in the perched intermediate zone is not known with sufficient accuracy to determine whether or not wells R-40i and R-40 screen 1 are downgradient of MDA H.

Table 3.3-1
Statistical Summary of Analytes Detected Above Screening Levels in Groundwater Samples from MDA G Monitoring Network Wells through October 2010

Analyte	Well	Port Depth (ft bgs)*	Comments
SVOCs			
Bis(2-ethylhexyl)phthalate	R-23	816	Detected above screening level of 6 µg/L in one sample (7.6 µg/L); below screening level in subsequent samples. Note that the practical quantitation limit for this analyte is 10 µg/L (LANL 2010, 109830, section C-4.1).
General Inorganics (filtered)			
Total dissolved solids (TDS)	R-23	816	Detected above screening level of 1000 mg/L in field duplicate (Jul-05); below screening level in corresponding routine sample and in all subsequent samples.
Metals (filtered)			
Manganese	R-23	816	First characterization sample (Dec-03) exceeds screening level of 200 µg/L. Corresponding unfiltered sample is below screening level. Concentrations in subsequent filtered samples are below the regional background level (36 µg/L, LANL 2010, 110535, Table 4.2-2).
Metals (unfiltered)			
Lead	R-23i	524	Detected only in first sample (Oct-06). All other filtered and unfiltered samples collected at this location have been below detection.
Zinc	R-23i	524	Detected above screening level only in first sample (Oct-06). All other filtered and unfiltered samples collected at this location have been below the practical quantitation limit (10 µg/L) (LANL 2010, 109830, section C-4.1).

Source: Appendix D.

* Note:: bgs = Below ground surface.

Table 5.3-1
Summary of Regulatory Criteria and Cleanup Levels

Media	Hazardous Constituents
Groundwater	– Water Quality Control Commission standards – Safe Drinking Water Act standards
Soil	– NMED's "Technical Background Document for Development of Soil Screening Levels" – EPA Region VI Human Health Medium Specific Screening Levels

Table 6.3-1
Summary of Technologies Retained for Further Evaluation at MDA G

Retained Technologies	Pits and Shafts	Vadose Zone
Containment Technologies		
Surface Barriers – Vegetative Cover	●[a]	–[b]
Surface Barriers – ET Cover	●	–
Surface Barriers – Biotic Barriers	●	–
In Situ Treatment Technologies		
Monitored Natural Attenuation	–	●
Physical Treatment – Soil-Gas Venting	–	●
Physical Treatment –Soil-Vapor Extraction	–	●
Excavation/Retrieval Technologies		
Excavation	●	–
Overcoring Retrieval	x[c]	–
Ex Situ Waste Treatment Technologies		
Physical Treatment – Cement Stabilization	●	–
Physical Treatment – Alternative Stabilization/Encapsulation	●	–
Thermal Treatment – Thermal Desorption	●	–
Thermal Treatment – Vitrification	●	–

[a] ● = Applicable.

[b] – = Not applicable.

[c] Applies only to shafts.

Table 7.0-1
Summary of Potential Remedial Action Technologies

Area	No Action	Maintenance and Monitoring Only	Containment	In Situ Treatment	Excavation/Retrieval	Ex Situ Treatment
Pits and Shafts Exposure pathways of concern include • direct exposure to waste via erosion, biointrusion, waste subsidence, or excavation • exposure to contaminated subsurface soils via excavation or biointrusion • exposure to contaminated surface soils via excavation, biointrusion, or wind.	PS-1 No action	PS-2 Maintenance and monitoring of existing disposal units	PS-3a – Vegetative cover PS-3b – ET cover PS-3c – Biotic barrier	n/a[a]	PS-4a –excavation of pits and shafts with on-site disposal in a CAMU/ RCRA landfill PS-4b – excavation of pits and shafts with off-site disposal PS-4c – excavation of pits and over-coring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill PS-4d –excavation of pits and over-coring retrieval of shafts with off-site disposal	PS-5 – Ex situ treatment, including • Cement stabilization • Alternative stabilization/ encapsulation • Thermal desorption • Vitrification
Vadose Zone [b] • Exposure pathways include • volatilization of VOCs from waste or contaminated subsurface soils with diffusion through pore gas to groundwater.	VZ-1 No action	n/a	n/a	VZ-2a Monitored natural attenuation VZ-2b – Soil-gas venting VZ-2c – Soil-vapor extraction	n/a	n/a

[a] n/a = Not applicable.

[b] Pore-gas monitoring is included in all VZ options (VZ-2a, VZ-2b, and VZ-2c) other than no action (VZ-1).

Table 7.3-1
Screening of Technologies for Pits and Shafts against the Threshold Screening Criteria

Technology	Description	Threshold Screening Criteria				Retained
		Protective of HH&E[a]	Attains Media Cleanup Standards	Controls Source and Releases	Complies with Waste Management Standards	
Technology PS-1 No action	This technology includes no monitoring, maintenance, or institutional controls.	**No** Potential remains for exposure through erosion, direct contact, and biointrusion.	**No** Does not comply with the EPA guidance for attaining media cleanup standards when waste is left in place.	**No** Will not control releases of buried waste exposed because of erosion, direct contact, and biointrusion.	**Yes** n/a[b]. No waste will be generated.	**Yes** For comparison purposes only
Technology PS-2 Maintenance and monitoring of existing disposal units	Existing disposal units will be monitored for signs of erosion and maintained as needed for 30 yr. Institutional controls will be implemented for 100 yr.	**Yes** Provides protection against erosion, direct contact, and biointrusion.	**No** Does not comply with the EPA guidance for attaining media cleanup standards when waste is left in place.	**Yes** Provides protection against erosion, direct contact, and biointrusion.	**Yes** n/a. No waste will be generated.	**No**
Technology PS-3a Vegetative cover	The existing surface soil will be regraded and a vegetative cover will be constructed and maintained for 30 yr. Institutional controls will be implemented for 100 yr.	**Yes** Provides protection against erosion, direct contact, and biointrusion.	**Yes** Complies with the EPA guidance for attaining media cleanup standards when waste is left in place.	**Yes** Provides protection against erosion, direct contact, and biointrusion.	**Yes** Any waste generated under this technology will comply with all applicable regulatory requirements.	**Yes**

Table 7.3-1 (continued)

Technology	Description	Threshold Screening Criteria				Retained
		Protective of HH&E[a]	Attains Media Cleanup Standards	Controls Source and Releases	Complies with Waste Management Standards	
Technology PS-3b ET cover	The existing surface soil will be regarded, and an ET cover will be constructed and maintained for 30 yr. Institutional controls will be implemented for 100 yr.	**Yes** Provides protection against erosion, direct contact, and biointrusion.	**Yes** Complies with the EPA guidance for attaining media cleanup standards when waste is left in place.	**Yes** Provides protection against erosion, direct contact, and biointrusion.	**Yes** Any waste generated under this technology will comply with all applicable regulatory requirements.	**Yes**
Technology PS-3c Biotic barrier	The existing surface soil will be regarded, and a biotic barrier will be constructed and maintained for 30 yr. Institutional controls will be implemented for 100 yr.	**Yes** Provides protection against erosion, direct contact, and biointrusion.	**No** Does not comply with the EPA guidance for attaining media cleanup standards when waste is left in place.	**Yes** Provides protection against erosion, direct contact, and biointrusion.	**Yes** Any waste generated under this technology will comply with all applicable regulatory requirements.	No
Technology PS-4a Excavation of pits and shafts with on-site disposal in a CAMU/ RCRA landfill	Waste from the pits and shafts will be excavated and disposed on-site in a CAMU or RCRA Subtitle C landfill. The excavated areas will be backfilled with clean fill material. Some waste will require ex situ treatment before disposal in the CAMU/RCRA landfill. Some materials may be returned to the excavated area if it meets target cleanup goals. Some waste will be shipped off-site for disposal. Institutional controls will be implemented for 100 yr.	**Yes** Removal of the waste before re-disposal in an engineered on-site CAMU/ RCRA landfill will be protective of HH&E.	**Yes** Waste will be excavated to a level that meets target cleanup goals.	**Yes** Excavation will remove the source material and prevent future releases.	**Yes** Excavation and subsequent waste mgmt. activities will comply with WAC for onsite disposal.	**Yes**

Table 7.3-1 (continued)

Technology	Description	Threshold Screening Criteria				Retained
		Protective of HH&E[a]	Attains Media Cleanup Standards	Controls Source and Releases	Complies with Waste Management Standards	
Technology PS-4b Excavation of pits and shafts with off-site disposal	Waste from the pits and shafts will be excavated and shipped off-site for disposal. The excavated areas will be backfilled with clean fill material. Some materials may be returned to the excavated area if it meets target cleanup goals. Institutional controls will be implemented for 100 yr.	**Yes** Removal of the waste before re-disposal at an off-site location will be protective of HH&E.	**Yes** Waste will be excavated to a level that meets target cleanup goals.	**Yes** Excavation will remove the source material and prevent future releases.	**Yes** Excavation and subsequent waste mgmt. activities will comply with WAC for off-site disposal.	**Yes**
Technology PS-4c Excavation of pits and overcoring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill	Waste from the pits will be excavated and waste from shafts will be retrieved using overcoring technology and disposed on-site in a CAMU or RCRA Subtitle C landfill. The excavated areas will be backfilled with clean fill material. Some waste will require ex situ treatment before disposal in the CAMU/RCRA landfill. Some materials may be returned to the excavated area if it meets target cleanup goals. Some waste will be shipped off-site for disposal. Institutional controls will be implemented for 100 yr.	**Yes** Removal of the waste before re-disposal in an engineered on-site CAMU/ RCRA landfill will be protective of HH&E.	**Yes** Waste will be excavated to a level that meets target cleanup goals.	**Yes** Excavation will remove the source material and prevent future releases.	**Yes** Excavation and subsequent waste mgmt. activities will comply with WAC for on-site disposal.	**Yes**
Technology PS-4d Excavation of pits and overcoring retrieval of shafts with off-site disposal	Waste from the pits will be excavated, and waste from shafts will be retrieved using overcoring technology and shipped off-site for disposal. The excavated areas will be backfilled with clean fill material. Some materials may be returned to the excavated area if it meets target cleanup goals. Institutional controls will be implemented for 100 yr.	**Yes** Removal of the waste before re-disposal at an off-site location will be protective of HH&E.	**Yes** Waste will be excavated to a level that meets target cleanup goals.	**Yes** Excavation will remove the source material and prevent future releases.	**Yes** Excavation and subsequent waste mgmt. activities will comply with WAC for off-site disposal.	**Yes**

Table 7.3-1 (continued)

Technology	Description	Threshold Screening Criteria				Retained
		Protective of HH&E[a]	Attains Media Cleanup Standards	Controls Source and Releases	Complies with Waste Management Standards	
Technology PS-5 Ex situ treatment	Excavated/retrieved waste that does not meet target cleanup goals will be treated using one or a combination of the following treatment technologies: • Cement stabilization • Alternative stabilization/encapsulation • Thermal desorption • Vitrification Waste that meets the target cleanup goals may be returned to the on-site disposal unit; waste that meets on-site target cleanup goals will be disposed of on-site. Some waste may require off-site disposal.	**Yes** Treatment before disposal will be protective of HH&E.	**Yes** Waste will be treated to a level that meets the WAC.	**Yes** Excavation and treatment will remove the source material and prevent future releases.	**Yes** Will comply with WAC for on-site or off-site disposal.	**Yes**

[a] Human health and the environment.

[b] na = Not applicable.

Table 7.4-1
Screening of Technologies for Vadose Zone against the Threshold Screening Criteria

Technology	Description	Threshold Screening Criteria				Retained
		Protective of HH&E[a]	Attains Media Cleanup Standards	Controls Source and Releases	Complies with Waste Management Standards	
Technology VZ-1 No action	This technology includes no pore-gas monitoring, maintenance, or institutional controls.	**No** Potential for exposure through diffusion to groundwater.	**No** Groundwater standards may be exceeded.	**No** Will provide no control of source area and releases.	**Yes** n/a[b]. No waste will be generated.	**Yes** For comparison purposes only
Technology VZ-2a Monitored natural attenuation	Pore-gas monitoring and modeling will be performed to establish a performance standard to measure attenuation of VOC concentrations. Pore-gas monitoring and institutional controls will be implemented.	**Yes** Will decrease pore-gas VOC concentrations .	**Yes** Will decrease VOC concentrations until target cleanup goals are met.	**Yes** Will provide minimal control of source area and releases.	**Yes** n/a. No waste will be generated.	**Yes**
Technology VZ-2b Soil-gas venting	Soil-gas venting through open boreholes will be used to remove VOCs from the pore-gas plumes. Pore-gas monitoring and institutional controls will be implemented.	**Yes** Will remove VOC mass from pore gas .	**Yes** Will remove VOC mass from pore-gas until target cleanup goals are met.	**Yes** Will provide control of source area and releases.	**Yes** Waste generated through soil-gas venting will be managed in accordance with applicable waste management standards.	**Yes**

Table 7.4-1 (continued)

Technology	Description	Threshold Screening Criteria				Retained
		Protective of HH&E[a]	Attains Media Cleanup Standards	Controls Source and Releases	Complies with Waste Management Standards	
Technology VZ-2c Soil Vapor Extraction	Soil vapor extraction systems will be installed and operated to remediate the VOC pore-gas plumes. Pore-gas monitoring and institutional controls will be implemented.	**Yes** Will remove VOC mass from pore gas.	**Yes** SVE system will be operated to remove VOC mass from pore-gas until target cleanup goals are met.	**Yes** Will provide control of source area and releases.	**Yes** Waste generated through SVE system operation will be managed in accordance with applicable waste management standards.	**Yes**

[a] Human health and environment.

[b] n/a = Not applicable.

Table 7.5-1
Technologies that Meet the Threshold Criteria and are Retained for Further Evaluation

Technologies Retained for the Pits and Shafts	Technologies Retained for the Vadose Zone
Technology PS-1 No action	**Technology VZ-1** No action
Technology PS-3a Vegetative cover	**Technology VZ-2a** Monitored natural attenuation
Technology PS-3b ET cover	**Technology VZ-2b** Soil-gas venting
Technology PS-4a Excavation of pits and shafts with on-site disposal in a CAMU/ RCRA landfill	**Technology VZ-2c** Soil-vapor extraction
Technology PS-4b Excavation of pits and shafts with off-site disposal	
Technology PS-4c Excavation of pits and overcoring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill	
Technology PS-4d Excavation of pits and overcoring retrieval of shafts with off-site disposal	
Technology PS-5 Ex situ treatment	

Table 8.2-1
Comparison of Retained Corrective Measure Technologies by Area

Technology	Description	SVE Duration (yr)	Monitoring and Maintenance Period (yr)	DOE Active Institutional Control Period (yr)
Pits and Shafts				
PS-1	No action	n/a[a]	n/a	n/a
PS-3a	Vegetative cover	n/a	30[b]	100
PS-3b	ET cover	n/a	30[b]	100
PS-4a	Excavation of pits and shafts with on-site disposal in a CAMU/ RCRA landfill	n/a	30[b]	100
PS-4b	Excavation of pits and shafts with off-site disposal	n/a	30[b]	100
PS-4c	Excavation of pits and over-coring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill	n/a	30[b]	100

Table 8.2-1 (continued)

Technology	Description	SVE Duration (yr)	Monitoring and Maintenance Period (yr)	DOE Active Institutional Control Period (yr)
Pits and Shafts				
PS-4d	Excavation of pits and over-coring retrieval of shafts with off-site disposal	n/a	30[b]	100
PS-5	Ex situ treatment	n/a	30[b]	100
Vadose Zone				
VZ-1	No action	0	n/a	n/a
VZ-2a	Monitored natural attenuation	30	30[b]	100
VZ-2b	Soil-gas venting	30[b]	30[b]	100
VZ-2c	Soil-vapor extraction	3[c]/27[d]	30[b]	100

[a] n/a = Not applicable.

[b] Based on the RCRA post-closure care period.

[c] Active extraction time frame.

[d] Pore-gas monitoring and active extraction as necessary (if required).

Table 8.2-2
Explanation of Ranking System Used for Evaluating Remedial Technology Evaluation Criteria

Relative Rating	Remedial Technology Balancing Criteria				
	Long-Term Reliability and Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Cost
1 Very low benefit	Low long-term reliability and effectiveness, high long-term risk, and high uncertainty associated with leaving waste in place	Little or no reduction in toxicity, mobility, or volume of contaminants	Long time to achieve risk reduction and adds short-term risk (potential for fatalities)	Difficult to obtain permits or materials needed for construction and technically difficult to construct and operate	High cost to implement, operate, and maintain
2 Low benefit	Low to medium long-term reliability and effectiveness, and high to medium long-term risk and uncertainty in leaving waste in place	Reduction in volume, but little or no reduction in toxicity and mobility	Moderate to long time to achieve risk reduction with moderate short-term risk	Remedy difficult to permit or difficult to construct and operate	Moderate cost to implement, higher cost to operate and maintain
3 Medium benefit	Medium long-term reliability, effectiveness, risk, and uncertainty in leaving waste in place	Reduction in toxicity or mobility with little or no reduction in volume	Moderate time to achieve risk reduction with moderate short-term risk	Moderately difficult to permit, implement, and operate	Moderate cost to implement, operate, and maintain
4 High benefit	Medium to high long-term reliability and effectiveness, medium to low long-term risk, and low uncertainty associated with leaving waste in place	Reduction in toxicity and mobility, with some reduction in volume	Moderate to short time to achieve risk reduction with limited short-term risk	Difficult to permit but easy to construct and operate once permitted	Lower cost to implement, moderate cost to operate and maintain
5 Very high benefit	High long-term reliability and effectiveness, low long-term risk, and low uncertainty associated with leaving waste in place	Toxicity, mobility, and volume of contaminants are reduced.	Short time to achieve risk reduction with little to no short-term risk	Easy to obtain permits and materials and easy to construct and operate	Low cost to implement, operate, and maintain

Table 8.2-3
Cost Estimates

WBS9 Code	Item Description	Labor Hours	Labor Total–Gross	Mat Total–Gross	Subs Total–Gross	Equipment Total–Gross	Other Total–Gross	Gross Total Costs
1	Project WBS: 1 - MDA G CME							
1.PS3a.1	Vegetative Cover - Direct Costs Total	246,984.70	17,516,025.14	7,312,311.53	1,699,912.85	6,005,663.14	3,567.31	32,537,480
1.PS3a.2	Project WBS: 1.PS3a.2 - Vegetative Cover - Indirect Costs							
1.PS3a.2	Vegetative Cover - Indirect Costs Total	84,940.20	18,646,620.52		7,524,487.47		29,354,294.00	55,525,402
1.PS3a.3	Project WBS: 1.PS3a.3 - Vegetative Cover - Direct Operations & Maintenance							
1.PS3a.3	Vegetative Cover - Direct Operations & Maintenance Total	11,541.70	1,273,549.25	66,775.67		8,337.25		1,348,662
1.PS3a.4	Project WBS: 1.PS3a.4 - Vegetative Cover - Indirect Operations & Maintenance							
1.PS3a.4	Vegetative Cover - Indirect Operations & Maintenance Total	1,142.60	250,180.83				799,421.50	1,049,602
1.PS3a	Vegetative Cover Total	344,609.10	37,686,375.75	7,379,087.20	9,224,400.32	6,014,000.40	30,157,282.81	90,461,146
1.PS3b.1	ET Cover - Direct Cost Total	403,903.80	28,287,655.48	22,049,928.84	3,348,385.35	16,594,784.95	3,567.31	70,284,322
1.PS3b.2	Project WBS: 1.PS3b.2 - ET Cover - Indirect Cost							
1.PS3b.2	ET Cover - Indirect Cost Total	183,476.10	40,278,630.58		16,253,671.86		63,408,313.50	119,940,616
1.PS3b.3	Project WBS: 1.PS3b.3 - ET Cover - Direct Operations & Maintenance							
1.PS3b.3	ET Cover - Direct Operations & Maintenance Total	11,541.70	1,273,549.25	66,775.67		8,337.25		1,348,662
1.PS3b.4	Project WBS: 1.PS3b.4 - ET Cover - Indirect Operations & Maintenance							
1.PS3b.4	ET Cover - Indirect Operations & Maintenance Total	1,142.60	250,180.83				799,421.50	1,049,602
1.PS3b	ET Cover Total	600,064.20	70,090,016.14	22,116,704.51	19,602,057.22	16,603,122.20	64,211,302.31	192,623,202
1.PS4a.1	Excavation, Treatment, Onsite - Direct Cost Total	39,371,333.50	2,866,615,234.52	744,635,024.70	2,494,250,126.22	237,078,637.09	1,408,144.99	6,343,987,168
1.PS4a.2	Project WBS: 1.PS4a.2 - Excavation, Treatment, Onsite - Indirect Cost							
1.PS4a.2	Excavation, Treatment, Onsite - Indirect Cost Total	16,478,967.30	3,617,696,440.51		1,459,852,283.68		5,710,767,946.50	10,788,316,671
1.PS4a.3	Project WBS: 1.PS4a.3 - Excavation, Treatment, Onsite - Direct Operations & Maintenance							
1.PS4a.3	Excavation, Treatment, Onsite - Direct Operations & Maintenance Total	2,319,963.00	333,586,642.10	66,775.67		8,337.25		333,661,755
1.PS4a.4	Project WBS: 1.PS4a.4 - Excavation, Treatment, Onsite - Indirect Operations & Maintenance							
1.PS4a.4	Excavation, Treatment, Onsite - Indirect Operations & Maintenance Total	291,837.70	64,067,702.69				198,866,728.60	262,934,431
1.PS4a	Excavation of pits and shafts with on-site disposal in a CAMU/RCRA landfill Total	58,462,101.60	6,881,966,019.82	744,701,800.37	3,954,102,409.91	237,086,974.35	5,911,042,820.09	17,728,900,025
1.PS4b.1	Bulk Excavation with Offsite Disposal - Direct Cost Total	83,555,037.90	5,996,062,384.46	1,676,949,896.30	3,845,150,390.26	429,301,384.12	1,404,577.68	11,948,868,633
1.PS4b.2	Project WBS: 1.PS4b.2 - Excavation, Offsite - Indirect Cost							
1.PS4b.2	Excavation, Offsite - Indirect Cost Total	31,191,828.70	6,847,672,871.01		2,763,247,564.59		10,779,894,534.50	20,390,814,970
1.PS4b.3	Project WBS: 1.PS4b.3 - Excavation, Offsite - Direct Operations & Maintenance							
1.PS4b.3	Excavation, Offsite - Direct Operations & Maintenance Total	4,145.70	469,174.90					469,175
1.PS4b.4	Project WBS: 1.PS4b.4 - Excavation, Offsite - Indirect Operations & Maintenance							
1.PS4b.4	Excavation, Offsite - Indirect Operations & Maintenance Total	375.6	81,794.13				275,484.50	357,279
1.PS4b	Excavation of pits and shafts with off-site disposal Total	114,751,388.00	12,844,286,224.50	1,676,949,896.30	6,608,397,954.85	429,301,384.12	10,781,574,596.68	32,340,510,056

Table 8.2-3 (continued)

WBS9 Code	Item Description	Labor Hours	Labor Total–Gross	Mat Total–Gross	Subs Total–Gross	Equipment Total–Gross	Other Total–Gross	Gross Total Costs
1.PS4c	Project WBS: 1.PS4c - Excavation of pits and overcoring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill							
1.PS4c.1	Project WBS: 1.PS4c.1 - Excavation & Overcore, Treatment, Onsite - Direct Cost							
1.PS4c.1	Excavation & Overcore, Treatment, Onsite - Direct Cost Total	39,156,423.90	2,776,902,697.98	745,063,729.89	2,566,953,195.31	234,982,971.27	1,408,144.99	6,325,310,739
1.PS4c.2	Project WBS: 1.PS4c.2 - Excavation & Overcore, Treatment, Onsite - Indirect Cost							
1.PS4c.2	Excavation & Overcore, Treatment, Onsite - Indirect Cost Total	16,511,858.30	3,624,917,143.03		1,462,766,060.26		5,706,496,970.40	10,794,180,174
1.PS4c.3	Project WBS: 1.PS4c.3 - Excavation & Overcore, Treatment, Onsite - Direct Operations & Maintenance							
1.PS4c.3	Excavation & Overcore, Treatment, Onsite - Direct Operations & Maintenance Total	2,319,963.00	333,586,642.10	66,775.67		8,337.25		333,661,755
1.PS4c.4	Project WBS: 1.PS4c.4 - Excavation & Overcore, Treatment, Onsite - Indirect Operations & Maintenance							
1.PS4c.4	Excavation & Overcore, Treatment, Onsite - Indirect Operations & Maintenance Total	292,163.60	64,139,236.46				178,900,495.50	243,039,732
1.PS4c	Excavation of pits and overcoring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill Total	58,280,408.80	6,799,545,719.57	745,130,505.56	4,029,719,255.57	234,991,308.53	5,886,805,610.89	17,696,192,400
1.PS4d.1	Excavation & Overcore, Offsite - Direct Cost Total	83,449,137.50	5,988,614,496.76	1,678,747,707.21	3,875,328,188.81	427,333,061.27	1,408,144.99	11,971,431,599
1.PS4d.2	Project WBS: 1.PS4d.2 - Excavation & Overcore, Offsite - Indirect Cost							
1.PS4d.2	Excavation & Overcore, Offsite - Indirect Cost Total	31,250,728.10	6,860,603,284.33		2,768,465,385.86		10,800,250,134.50	20,429,318,805
1.PS4d.3	Project WBS: 1.PS4d.3 - Excavation & Overcore, Offsite - Direct Operations & Maintenance							
1.PS4d.3	Excavation & Overcore, Offsite - Direct Operations & Maintenance Total	4,145.70	469,174.90					469,175
1.PS4d.4	Project WBS: 1.PS4d.4 - Excavation & Overcore, Offsite - Indirect Operations & Maintenance							
1.PS4d.4	Excavation & Overcore, Offsite - Indirect Operations & Maintenance Total	375.6	81,794.13				275,484.50	357,279
1.PS4d	Excavation of pits and overcoring retrieval of shafts with off-site disposal Total	114,704,386.80	12,849,768,750.12	1,678,747,707.21	6,643,793,574.67	427,333,061.27	10,801,933,763.99	32,401,576,857
1.PS5a.1	Ex situ Treatment, Onsite - Direct Cost Total	26,956,743.00	2,186,279,885.88	821,723,337.63	3,464,021,230.78	255,234,216.49	3,586,269.07	6,730,844,940
1.PS5a.2	Project WBS: 1.PS5a.2 – Ex situ Treatment - Indirect Cost							
1.PS5a.2	Ex situ Treatment - Indirect Cost Total	17,570,481.80	3,857,321,199.16		1,556,548,277.44		6,072,357,208.50	11,486,226,685
1.PS5a.3	Project WBS: 1.PS5a.3 – Ex situ Treatment - Direct Operations & Maintenance							
1.PS5a.3	Ex situ Treatment - Direct Operations & Maintenance Total	1,543,093.30	222,011,235.81					222,011,236
1.PS5a.4	Project WBS: 1.PS5a.4 – Ex situ Treatment - Indirect Operations & Maintenance							
1.PS5a.4	Ex situ Treatment - Indirect Operations & Maintenance Total	194,091.40	42,609,035.83				132,310,136.00	174,919,172
1.PS5a	Ex situ Treatment Total	46,264,409.40	6,308,221,356.68	821,723,337.63	5,020,569,508.23	255,234,216.49	6,208,253,613.57	18,614,002,033
1.VZ2a.1	Monitoring Natural Attenuation - Direct Cost Total	45,449.80	4,352,490.53	961,214.51	219,169.26	62,415.29	3,567.31	5,598,857
1.VZ2a.2	Project WBS: 1.VZ2a.2 - Monitoring Natural Attenuation - Indirect Cost							
1.VZ2a.2	Monitoring Natural Attenuation - Indirect Cost Total	14,618.50	3,208,600.11		1,294,769.27		5,051,113.00	9,554,482
1.VZ2a.3	Project WBS: 1.VZ2a.3 - Monitoring Natural Attenuation - Direct Operations & Maintenance							
1.VZ2a.3	Monitoring Natural Attenuation - Direct Operations & Maintenance Total	5,923.00	625,870.25		1,263,892.51			1,889,763
1.VZ2a.4	Project WBS: 1.VZ2a.4 - Monitoring Natural Attenuation - Indirect Operations & Maintenance							
1.VZ2a.4	Monitoring Natural Attenuation - Indirect Operations & Maintenance Total	2,967.60	650,826.36				1,270,294.50	1,921,121
1.VZ2a	Monitoring Natural Attenuation Total	68,958.90	8,837,787.25	961,214.51	2,777,831.04	62,415.29	6,324,974.81	18,964,223
1.VZ2b	Project WBS: 1.VZ2b – Soil-Gas Venting							

Table 8.2-3 (continued)

WBS9 Code	Item Description	Labor Hours	Labor Total–Gross	Mat Total–Gross	Subs Total–Gross	Equipment Total–Gross	Other Total–Gross	Gross Total Costs
1.VZ2b.1	Project WBS: 1.VZ2b.1 – Soil-Gas Venting - Direct Cost							
1.VZ2b.1	Soil-Gas Venting - Direct Cost Total	348,194.30	34,683,398.18	4,908,058.16	4,791,269.93	1,553,736.66	3,567.31	45,940,030
1.VZ2b.2	Project WBS: 1.VZ2b.2 – Soil-Gas Venting - Indirect Cost							
1.VZ2b.2	Soil-Gas Venting - Indirect Cost Total	14,670.00	3,219,910.04		8,120,833.39		28,640,386.50	39,981,130
1.VZ2b.3	Project WBS: 1.VZ2b.3 – Soil-Gas Venting - Direct Operations & Maintenance							
1.VZ2b.3	Soil-Gas Venting - Direct Operations & Maintenance Total	21,677.60	2,014,900.20		12,467,700.56			14,482,601
1.VZ2b.4	Project WBS: 1.VZ2b.4 – Soil-Gas Venting - Indirect Operations & Maintenance							
1.VZ2b.4	Soil-Gas Venting - Indirect Operations & Maintenance Total	35,835.50	7,866,450.82				11,174,526.00	19,040,977
1.VZ2b	Soil-Gas Venting Total	420,377.40	47,784,659.24	4,908,058.16	25,379,803.88	1,553,736.66	39,818,479.81	119,444,738
1.VZ2c.1	Soil-Vapor Extraction Direct Cost Total	826,920.50	32,919,994.17	3,023,652.03	1,530,612.84	915,904.43	3,567.31	38,393,731
1.VZ2c.2	Project WBS: 1.VZ2c.2 – Soil-Vapor Extraction Indirect Cost							
1.VZ2c.2	Soil-Vapor Extraction Indirect Cost Total	40,295.90	8,845,667.65		5,014,850.19		26,127,124.50	39,987,642
1.VZ2c.3	Project WBS: 1.VZ2c.3 – Soil-Vapor Extraction - Direct Operations & Maintenance							
1.VZ2c.3	Soil-Vapor Extraction - Direct Operations & Maintenance Total	57,967.90	6,515,834.52		1,263,892.51			7,779,727
1.VZ2c.4	Project WBS: 1.VZ2c.4 – Soil-Vapor Extraction Indirect Operations & Maintenance							
1.VZ2c.4	Soil-Vapor Extraction Indirect Operations & Maintenance Total	8,116.70	1,781,244.61				4,780,486.00	6,561,731
1.VZ2c	Soil-Vapor Extraction Total	933,301.00	50,062,740.95	3,023,652.03	7,809,355.53	915,904.43	30,911,177.81	92,722,831
1	MDA G CME Total	394,830,005.10	45,898,249,650.01	5,705,641,963.47	26,321,376,151.23	1,609,096,123.72	39,761,033,622.78	119,295,397,511
	Grand Total	394,830,005.10	45,898,249,650.01	5,705,641,963.47	26,321,376,151.23	1,609,096,123.72	39,761,033,622.78	119,295,397,511

Note: Blank cells indicate no quantities and no costs.

Table 8.3-1
Screening of Technologies for Pits and Shafts against the Balancing Criteria

Technology	Description	Balancing Criteria					Score
		Long-Term Reliability and Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Cost	
Technology PS-1 No action	No action is taken. This technology includes no monitoring, maintenance, or institutional controls.	1	1	2	5	5	14
Technology PS-3a Vegetative cover	The existing surface soil will be regarded, and a vegetative cover will be constructed and maintained for 30 yr. Institutional controls will be implemented for 100 yr.	2	3	5	4	4	18
Technology PS-3b ET cover	The existing surface soil will be regarded, and a vegetative cover will be constructed and maintained for 30 yr. Institutional controls will be implemented for 100 yr.	3	3	5	4	4	19
Technology PS-4a Excavation of pits and shafts with on-site disposal in a CAMU/ RCRA landfill	Waste from the pits and shafts will be excavated and disposed on-site in a CAMU or RCRA Subtitle C landfill. The excavated areas will be backfilled with clean fill material. Some waste will require ex situ treatment before disposal in the CAMU/RCRA landfill. Some materials may be returned to the excavated area if it meets target cleanup goals. Some waste will be shipped off-site for disposal. Institutional controls will be implemented for 100 yr.	5	5	2	1	1	14
Technology PS-4b Excavation of pits and shafts with off-site disposal	Waste from the pits and shafts will be excavated and shipped off-site for disposal. The excavated areas will be backfilled with clean fill material. Some materials may be returned to the excavated area if it meets target cleanup goals. Institutional controls will be implemented for 100 yr.	5	5	1	2	2	15

Table 8.3-1 (continued)

Technology	Description	Long-Term Reliability and Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Cost	Score
Technology PS-4c Excavation of pits and overcoring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill	Waste from the pits will be excavated and waste from shafts will be retrieved using overcoring technology and disposed on-site in a CAMU or RCRA Subtitle C landfill. The excavated areas will be backfilled with clean fill material. Some waste will require ex situ treatment before disposal in the CAMU/RCRA landfill. Some materials may be returned to the excavated area if it meets target cleanup goals. Some waste will be shipped off-site for disposal. Institutional controls will be implemented for 100 yr.	5	5	2	1	1	14
Technology PS-4d Excavation of pits and overcoring retrieval of shafts with off-site disposal	Waste from the pits will be excavated and waste from shafts will be retrieved using overcoring technology and shipped off-site for disposal. The excavated areas will be backfilled with clean fill material. Some materials may be returned to the excavated area if it meets target cleanup goals. Institutional controls will be implemented for 100 yr.	5	5	1	2	2	15
Technology PS-5 Ex situ treatment	Excavated/retrieved waste that does not meet target cleanup goals will be treated using a combination of the following treatment technologies: thermal desorption alternative stabilization/encapsulation Waste that meets the target cleanup goals may be returned to the on-site disposal unit; waste that meets on-site target cleanup goals will be disposed off-site. Some waste may require off-site disposal. Institutional controls will be implemented for 100 yr.	5	5	1	1	1	13

Table 8.4-1
Screening of Technologies for Vadose Zone Contamination against the Balancing Criteria

Technology	Description	Balancing Criteria					
		Long-Term Reliability and Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Cost	Score
Technology VZ-1 No action	No action is taken once the surface CSUs have been removed as part of the RCRA closure. This technology does not include pore-gas monitoring, maintenance, or institutional controls.	1	1	2	5	5	14
Technology VZ-2a Monitored natural attenuation	Pore-gas monitoring and modeling will be performed to establish a performance standard to measure attenuation of VOC concentrations. Pore-gas monitoring and institutional controls will be implemented.	3	3	3	4	4	17
Technology VZ-2b Soil-gas venting	Soil-gas venting through open boreholes will be used to remove VOCs from the pore-gas plumes. Pore-gas monitoring and institutional controls will be implemented.	3	3	2	3	4	15
Technology VZ-2c Soil-vapor Extraction	Soil-vapor extraction systems will be installed and operated to remediate the VOC pore-gas plumes. Pore-gas monitoring and institutional controls will be implemented.	5	5	5	4	3	22

Table 8.5-1
Screening of Alternatives against the Balancing Criteria

Alternative	Description	Balancing Criteria					Score
		Long-Term Reliability and Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Cost	
Alternative 1: Technology PS-1 No action	No action is taken once the surface CSUs have been removed as part of the RCRA closure. This alternative includes no monitoring, maintenance, or institutional controls.	1	1	2	5	5	14
Alternative 2: Technologies PS-3b and VZ-2c ET cover and Soil-vapor extraction	Following removal of the surface CSUs, the existing surface soil will be regarded, and an ET cover will be constructed and maintained for 30 yr. Soil-vapor extraction systems will be installed and operated to remediate the VOC pore-gas plumes. Pore-gas monitoring and institutional controls will be implemented.	5	4	5	4	3	21
Alternative 3: Technologies PS-4b/PS-4d, and VZ-2c Excavation of pits and shafts with off-site disposal and Soil-vapor extraction	Waste from the pits and shafts will be excavated and shipped off-site for disposal. The excavated areas will be backfilled with clean fill material. Some materials may be returned to the excavated area if it meets target cleanup goals. Soil-vapor extraction systems will be installed and operated to remediate the VOC pore-gas plumes. Pore-gas monitoring and institutional controls will be implemented.	5	5	1	1	1	13

Table 9.1-1
Summary of Capital and Recurring Cost Estimates for the Preferred Alternative

WBS9 Code	Item Description	Labor Hours	Labor Total–Gross	Mat Total–Gross	Subs Total–Gross	Equipment Total–Gross	Other Total–Gross	Gross Total Costs
1.PS3b.1	ET Cover - Direct Cost Total	403,903.80	28,287,655.48	22,049,928.84	3,348,385.35	16,594,784.95	3,567.31	70,284,322
1.PS3b.2	Project WBS: 1.PS3b.2 - ET Cover - Indirect Cost							
1.PS3b.2	ET Cover - Indirect Cost Total	183,476.10	40,278,630.58		16,253,671.86		63,408,313.50	119,940,616
1.PS3b.3	Project WBS: 1.PS3b.3 - ET Cover - Direct Operations & Maintenance							
1.PS3b.3	ET Cover - Direct Operations & Maintenance Total	11,541.70	1,273,549.25	66,775.67		8,337.25		1,348,662
1.PS3b.4	Project WBS: 1.PS3b.4 - ET Cover - Indirect Operations & Maintenance							
1.PS3b.4	ET Cover - Indirect Operations & Maintenance Total	1,142.60	250,180.83				799,421.50	1,049,602
1.PS3b	ET Cover Total	600,064.20	70,090,016.14	22,116,704.51	19,602,057.22	16,603,122.20	64,211,302.31	192,623,202
1.VZ2c.1	Soil-Vapor Extraction Direct Cost Total	826,920.50	32,919,994.17	3,023,652.03	1,530,612.84	915,904.43	3,567.31	38,393,731
1.VZ2c.2	Project WBS: 1.VZ2c.2 – Soil-Vapor Extraction Indirect Cost							
1.VZ2c.2	Soil-Vapor Extraction Indirect Cost Total	40,295.90	8,845,667.65		5,014,850.19		26,127,124.50	39,987,642
1.VZ2c.3	Project WBS: 1.VZ2c.3 – Soil-Vapor Extraction - Direct Operations & Maintenance							
1.VZ2c.3	Soil-Vapor Extraction - Direct Operations & Maintenance Total	57,967.90	6,515,834.52		1,263,892.51			7,779,727
1.VZ2c.4	Project WBS: 1.VZ2c.4 – Soil-Vapor Extraction Indirect Operations & Maintenance							
1.VZ2c.4	Soil-Vapor Extraction Indirect Operations & Maintenance Total	8,116.70	1,781,244.61				4,780,486.00	6,561,731
1.VZ2c	Soil-Vapor Extraction Total	933,301.00	50,062,740.95	3,023,652.03	7,809,355.53	915,904.43	30,911,177.81	92,722,831

Note: Blank cells indicate no quantities and no costs.

Table 11.0-1
Long-Term Pore-Gas Monitoring Schedule

Borehole Type	Active SVE Years 1–3	Monitoring Years 4–30
Extraction	2 per yr	1 per yr
Monitoring (source area)	2 per yr	1 per yr
Monitoring (outside source area)	1 per yr	1 per 2 yr

Appendix A

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

A-1.0 ACRONYMS AND ABBREVIATIONS

aCi	attocuries
ACZ	acceptable compaction zone
A/E	architect/engineer
AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
amsl	above mean sea level
AMWTP	Advanced Mixed Waste Treatment Project
AOC	area of concern
APV	access port valve
B&K	Brüel and Kjaer
bgs	below ground surface
BH	borehole
BV	background value
CAMU	corrective action management unit
CFR	Code of Federal Regulations
CM	construction manager
CME	corrective measures evaluation
CMI	corrective measures implementation
Consent Order	Compliance Order on Consent
COPC	chemical of potential concern
CSM	conceptual site model
CSU	container storage unit
CY	calendar year
DCA	dichloroethane
DCE	dichloroethene
D&D	decontamination and decommissioning
DOE	Department of Energy (U.S.)
DOT	Department of Transportation
DVRS	Decontamination and Volume Reduction System
EO	Executive Order
EPA	Environmental Protection Agency (U.S.)
ERDF	Environmental Restoration Disposal Facility
ES&H	environment, safety, and health

ESL	ecological screening level
ET	evapotranspiration
FD	field duplicate
FLUTe	Flexible Liner Underground Technology
FRTR	Federal Remediation Technologies Roundtable
FY	fiscal year
GBIR	Groundwater Background Investigation Report
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEM	Hillslope Erosion Model
HEPA	high-efficiency particulate air (filter)
HI	hazard index
HHMSSL	human health medium-specific screening level
hp	horse power
HSA	hollow-stem auger
HWA	Hazardous Waste Act (New Mexico)
HWFP	Hazardous Waste Facility Permit
IFGMP	Interim Facility-Wide Groundwater Monitoring Plan
INL	Idaho National Laboratory
kPa	kilopascal
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
LDR	land disposal restriction
LLW	low-level waste
MCL	maximum contaminant level
MDA	material disposal area
MDD	maximum dry density
MDL	method detection limit
MEI	maximally exposed individual
MLLW	mixed low-level waste
MNA	monitored natural attenuation
MOVER	Mobile Visual Examination and Repackaging
MTR	minimum technology requirement (RCRA)
N	number
NEPA	National Environmental Policy Act

NMAC	New Mexico Administrative Code
NMED	New Mexico Environmental Department
NMEID	New Mexico Environmental Improvement Division (New Mexico Environment Department before 1991)
NMHWA	New Mexico Hazardous Waste Act
NMWQCC	New Mexico Water Quality Control Commission
NNMCAB	Northern New Mexico Citizens Advisory Board
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
NWS	National Weather Service
OB	open burn
OD	open detonation
O&M	operations and maintenance
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
PA	performance assessment
PAH	polycyclic aromatic hydrocarbon [interchangeable with polynuclear aromatic hydrocarbon]
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PE	professional engineer
PET	potential evapotranspiration
PETN	pentaerythritol tetranitrate
PL	Public Law
PLS	pure live seed
PPE	personal protective equipment
ppmv	parts per million by volume
PQL	practical quantitation limit
PS	pits and shafts (disposal)
PV	present value
QA	quality assurance
QC	quality control
RA	remedial action
RAO	remedial action objective
RACER	Remedial Action Cost Engineering and Requirements

RCRA	Resource Conservation and Recovery Act
RD	remedial design
RH	remote handling
RLD	root length density
RFI	RCRA facility investigation
ROI	radius of influence
RSL	regional screening level (EPA)
RSRL	regional statistical reference level
RUSLE	Revised Universal Soil Loss Equation
SL	screening level
SME	subject matter expert
SSL	soil screening level
SV	screening value
SVE	soil-vapor extraction
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWPPP	stormwater pollution prevention plan
TA	technical area
TAL	target analyte list (EPA)
TATB	triaminotrinitrobenzene
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TD	total depth
TDR	time-domain reflectometry
TEDE	total effective dose equivalent
TIC	tentatively identified compound
TOCP	tri-ortho-cresyl-phosphate
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal (facilities)
USC	United States Code
UTL	upper tolerance lomit
VA	value assessment
VOC	volatile organic compound

VZ	vadose zone
WAC	waste acceptance criteria
WBS	work breakdown structure
WIPP	Waste Isolation Pilot Plant
WM	Waste Management (Committee)

A-2.0 METRIC CONVERSION TABLE

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

A-3.0 DATA QUALIFIER DEFINITIONS

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

Appendix B

Historical Investigations

B-1.0 INTRODUCTION

This appendix provides additional information for Phase I Resource Conservation and Recovery Act facility investigation (RFI) activities and investigations under the Compliance Order on Consent (the Consent Order) conducted for Material Disposal Area (MDA) G. It also summarizes site-specific studies of typical Los Alamos National Laboratory (the Laboratory or LANL) rooting depths (i.e., biointrusion), predicted contaminant breakthrough times to groundwater, and near-surface hydrologic behavior at MDA G.

B-2.0 PHASE I RFI ACTIVITIES

In 1993, 1994, and 1995, samples were collected at MDA G during the Phase I RFI. In addition, pore-gas samples have been collected since 1985. The results of these previous investigations are summarized in the historical investigation report of the approved investigation work plan for MDA G (LANL 2004, 087833, Appendix B, pp. B-5–B-18).

During the Phase I RFI, the following samples were collected and analyzed:

- 59 surface channel sediment samples in surrounding canyons
- 156 core samples from 10 vertical boreholes and 10 angled boreholes in the mesa
- 142 tritium surface-flux samples
- 281 (including field duplicates) volatile organic compound (VOC) surface-flux samples consisting of 227 ambient-air samples for tritium and 16 ambient-air samples for VOCs
- 48 subsurface pore-gas samples for VOCs
- 13 subsurface pore-gas samples for tritium

In the channel sediments, six metals, including beryllium, cadmium, cobalt, mercury, selenium, and silver, were retained as contaminants of potential concern (COPCs) because of either elevated concentrations or detection limits above background values (BVs). Five radionuclides, including tritium, cobalt-60, plutonium-238, plutonium-239, and americium-241, were detected in channel sediment samples: all were above BVs, except cobalt-60, for which a BV has not been established (LANL 1998, 059730, pp. 44–45). Therefore, these radionuclides were also identified as COPCs (Figure B-2.0-1). Methoxychlor(4, 4’-) was the only organic chemical detected in sediment and was also identified as a COPC. The channel sediment sampling data are shown in Figure B-2.0-2.

In the ambient-air samples, slightly elevated to elevated levels of radionuclides (i.e., tritium, plutonium-238, plutonium-239, americium-241 and various uranium isotopes) as well as two VOCs (i.e., acetone, and methanol) were detected (Tables B-2.0-1 and B-2.0-2). Locations of the ambient-air sampling stations are shown in Figure B-2.0-3.

Tritium and four VOCs, specifically, methylene chloride; 1,1,1-trichloroethane (TCA); tetrachloroethene (PCE); and 1,1,2-trichlorotrifluoroethane (Freon-113) were detected in surface flux-gas samples (Eklund 1995, 056033, pp. 3-9, 3-18, 4-2–4-9, and 4-12). Locations of tritium high-flux areas are shown in Figure B-2.0-4, and tritium and VOC surface flux chamber sampling locations are shown in Figure B-2.0-5.

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 (Figure B-2.0-6). Details of the surface flux chamber investigations are reported in Eklund (1995, 056033, pp. iv–7-1).

Details of the EMFLUX surface adsorbent cartridges investigations are presented in reports prepared by Quadrel Services (1993, 063868, pp. 9–11; 1994, 063869, pp. 3-21) and Trujillo et al. (1998, 058242, pp. 18–21). During the summers of 1993 and 1994, tritium flux was measured at 142 locations on and near the surface of Area G (Eklund 1995, 056033, pp. 3-11–3-17) (Figure B-2.0-6). Sixteen VOCs were detected in 1993 mesa-top surface flux studies: acetone, benzene, carbon disulfide, carbon tetrachloride, chloroform, chloromethane, 1,1-dichloroethane (DCA), 1,1-dichloroethene (DCE), methylene chloride, PCE, toluene, TCA, trichloroethene (TCE), trichlorofluoromethane (Freon-11), Freon-113, and xylenes. Slightly fewer (i.e., 10) VOCs were detected in the 1994 samples: acetone, DCA, DCE, methylene chloride, PCE, toluene, TCA, TCE, Freon-113, and xylenes.

Additionally, in 1994, 16 ambient-air samples were collected for 8 d at two sampling locations along the northern perimeter of Area G. Surface flux and ambient-air sampling results indicated that VOCs and tritium were being released into the atmosphere from the subsurface (LANL 2005, 090513, p. 4).

Borehole soil and tuff core samples identified 43 COPCs, including one anion (cyanide); eight metals (antimony, cadmium, mercury, molybdenum, selenium, silver, thallium, and vanadium); 12 radionuclides (i.e., ,tritium, cobalt-60, strontium-90, cesium-137, europium-152, thorium-230, uranium-234, uranium-235, uranium-238, plutonium-238, plutonium-239, and americium-241); and 22 organic compounds (acetone, aldrin, Aroclor-1254, benzene, benzo(a)pyrene, benzo(g,h,i)perylene, bis(2 ethylhexyl)phthalate, 2-butanone, butylbenzylphthalate, gamma-chlordane, di-n-butylphthalate, di-n-octylphthalate, ethylbenzene, heptachlor epoxide, methylene chloride, 2-methylnaphthalene, naphthalene, pyrene, PCE, toluene, 1,2,4-trimethylbenzene, and total xylenes). Figures B-2.0-7, B-2.0-8, and B-2.0-9 show the locations and data for the above-listed COPCs.

The pore-gas monitoring data for MDA G indicate VOCs are COPCs in pore gas. TCA is the dominant VOC detected. The highest TCA concentration measured was 167 ppmv. Table B-2.0-3 presents the detected VOCs in pore-gas samples from MDA G subsurface units between 1999 and 2002, with borehole sampling locations shown in Figure B-2.0-10.

In 2003, 13 subsurface pore-gas samples were collected and analyzed for tritium from two boreholes, 54-01110 and 54-01111, located next to the tritium disposal shafts. A review and analysis of the data indicate that tritium has been released into the tuff beneath the disposal units (LANL 2005, 090513, p. 4). Table B-2.0-4 summarizes the pore-gas tritium results for these two boreholes (LANL 2004, 087833, Appendix B, p. B-75).

B-3.0 CONSENT ORDER INVESTIGATION ACTIVITIES

B-3.1 2005 Activities

Field investigations conducted in 2005 at MDA G under the Consent Order are reported in the MDA G investigation report (LANL 2005, 090513). During this investigation, 39 boreholes (Figure B-3.1-1) were drilled in accordance with the approved MDA G work plan (LANL 2004, 087833). In 2005, the Consent Order required pore-gas monitoring during the site investigations for all MDAs and a long-term pore-gas monitoring plan for each MDA. The Consent Order required that drilling continue a minimum of 25 ft (8 m) below the deepest detected VOC contamination zone, based on head-space field screening. Thirty-seven shallow boreholes were drilled using a hollow-stem auger rig either to refusal or to the target depth specified in the work plan. Per the Consent Order, another deep borehole was drilled with an air-rotary rig to determine whether perched water was present. This borehole was abandoned at 556 ft (169 m) when drilling problems prevented further advancement the target depth of 700 ft (213 m). A replacement borehole was drilled next to the target depth.

Continuous cores were collected from the 37 shallow boreholes to characterize the stratigraphy beneath the site. Core samples were analyzed for target analyte list (TAL) metals, cyanide, nitrates, explosive compounds, dioxins, furans, perchlorate, VOCs, and radionuclides. The sampling, which focused on fracture characterization, included the collection of fracture fill material and surrounding intact tuff (Table B-3.1-1). Geotechnical and geochemical samples were collected from the deep boreholes to measure chloride-ion concentration, matric potential, and moisture content. Pore-gas samples for tritium and VOCs were collected to evaluate the nature and extent of vapor-phase VOCs and tritium in pore gas beneath MDA G.

The soil and tuff sampling results indicated a number of inorganic and organic chemicals (Plates 2 and 3, respectively) were detected at trace levels beneath the former disposal units and were consistent with the results obtained during the Phase I RFI. The only organic compounds detected in core samples were trace levels of several dioxin and furan congeners. The inorganic chemicals detected above BVs did not show any discernable patterns or trends and did not indicate a release from the historical subsurface waste units at MDA G.

Naturally occurring and anthropogenic radionuclides were confirmed at levels above BVs in soil and rock samples collected beneath MDA G. The anthropogenic radionuclides detected sporadically across the site included americium-241, plutonium-238, plutonium-239, and strontium-90. Naturally occurring radionuclides detected above BVs included thorium isotopes, uranium-234, uranium-235, and uranium-238. Naturally occurring radionuclides were detected at concentrations within the natural variability in the subsurface tuff (Plate 3).

Pore-gas samples were collected in the boreholes at the depth nearest to the disposal unit and at the total depth of the borehole. The pore-gas sample results confirmed the presence of VOCs, consisting primarily of chlorinated VOCs, in the vadose zone beneath MDA G. Data collected during the Phase I RFI, quarterly monitoring events, and the 2005 investigation indicate the highest VOC concentrations are beneath the eastern and south-central portions of MDA G and are limited at depth by the Cerros del Rio basalt at approximately 630 ft (192 m). The dominant subsurface vapor contaminant is TCA. Tritium was also detected in pore gas. The highest tritium concentrations were detected in samples from locations in the eastern and south-central portions of MDA G, coinciding with the highest vapor concentrations of VOCs (Tables B-3.1-2 and B-3.1-3).

Subsurface samples collected to a depth of 700 ft (210 m) beneath the MDA G subsurface units did not identify perched water zones. Gravimetric moisture analyses showed moisture levels ranging from 0.2% to 27.2% by weight (Table B-3.1-4). Laboratory matric potential readings confirmed all samples collected beneath MDA G contained moisture levels below saturation. Perched groundwater was not detected in the 39 boreholes, including the deep borehole completed to 700 ft (210 m). Perched groundwater is unconfined and separated from an underlying main body of groundwater by an unsaturated zone. Not finding perched groundwater, however, does not preclude the possibility of concentrated preferential flow, including lateral flow.

B-3.2 2007 Supplemental Site Investigation

A supplemental investigation was conducted in 2007 at MDA G that focused primarily on additional pore-gas sampling (LANL 2007, 101771). The Laboratory extended four existing boreholes ([BH] 2 [location 54-24361], BH-10 [location 54-24370], BH-26 [location 54-24386], and BH-34 [location 54-24394], shown in Figure B-3.1-1), to define the vertical extent of VOC pore-gas contamination (LANL 2007, 096110, p. v). Table B-3.2-1 summarizes a typical sampling port construction. Also, during this investigation, an existing borehole, BH-37 (location 54-24397), was extended to determine the vertical profile of tritium concentrations in the vapor phase at this location.

The 2007 pore-gas sampling confirmed the results of the Phase I RFI, previous quarterly monitoring, and the 2005 investigation: the highest VOC concentrations are beneath the eastern portions of MDA G. VOC concentrations are highest in the Tshirege Member of the Bandelier Tuff and decrease markedly in the underlying stratigraphic units. The lowest VOC concentrations are found in the deepest unit sampled, the Cerros del Rio basalt. TCA is the dominant subsurface VOC vapor contaminant in the eastern and central portions of MDA G, while TCE is dominant VOC in the western portions of MDA G (Table B-3.2-2). Tritium is only detected in BH-37, with concentrations peaking at 50 ft (15 m) below ground surface (bgs) near the base of the nearby tritium shafts, and decreases to total depth of 239.75 ft (73 m) bgs (Table B-3.2-3).

Validated analytical results of samples collected during pore-gas monitoring in fiscal year (FY) 2007 confirm the presence of VOCs and tritium in the subsurface. Analyses of samples collected periodically since 1997 from four pore-gas locations show stable or decreasing VOC concentrations. The vertical distribution of VOC and tritium concentrations indicated that there is no current threat of groundwater contamination, but the FY2007 periodic monitoring report (LANL 2007, 101771) recommended future pore-gas monitoring. The pore-gas sampling data supported the adequacy of the existing subsurface vapor-monitoring network to track contaminants in pore gas (LANL 2007, 101771).

B-4.0 MDA G SITE-SPECIFIC STUDIES

B-4.1 Rooting Depth Study

Deep rooted plants may provide a pathway for the release of waste from an area like MDA G into the environment. A field study was completed to determine rooting depths of plants collected from four canyon areas within the Laboratory: Pajarito, Potrillo, Mesita del Buey, and Mortandad Canyons (Tierney and Foxx 1987, 006669). The study was performed to obtain data on the root structures of native species common to the Laboratory. Root samples were collected from 22 different plant specimens. The majority of the plants had been found on low-level waste sites in the past. In general, the greatest observed biomass of the roots of all trees, shrubs, and forbs was located in the upper 6 ft of soil (Tierney and Fox 1987, 006669, p. 14). Roots of immature specimens were also found within 6 ft of the surface (Tierney and Fox 1987, 006669, p. 14). Of the three tree species examined, roots for piñon pine and one-seed juniper were found to extend to depths greater than 18 ft in fractured tuff (Tierney and Fox 1987, 006669, p. 15).

B-4.2 Near-Surface Hydrologic Properties at MDA G Study

For this study, 26 shallow cores were collected from various areas within MDA G: in the pits, next to the pits, in non-pit areas, under asphalt, under unpaved areas, and within vegetated areas (Newman et al. (2005, 099163). The samples were then analyzed for near-surface (3.3 to 6.6 ft bgs) hydrogeologic conditions.

Results of the study indicate substantial evaporation occurs in unpaved locations at MDA G, and little evaporation occurs in paved locations. The measured average gravimetric water content percentage in the top 1 m under the paved areas was 11% versus 5% in the unpaved areas. The total estimated flux was 0.46 cm/yr under the paved areas versus 0.073 cm/yr under the unpaved areas. No significant differences were found in the hydrogeologic variables examined for the covered pit areas and adjacent areas. Downward flux estimates show significant differences between the unpaved active disposal areas and the undisturbed vegetated areas west of MDA G. The total flux was estimated to be 0.14 cm/yr in active, unpaved areas and 0.072 cm/yr in the undisturbed vegetated area.

B-4.3 Groundwater Breakthrough Modeling Study for MDA G Performance Assessment

A numerical model was formulated to estimate the travel time of contaminant transport to the groundwater beneath MDA G (Stauffer et al. 2005, 097432). This groundwater pathway model assumes that the infiltration rate through the future cover will be similar to that observed on the undisturbed mesa top. Infiltration rates greater than 10 mm/yr (0.39 in./yr) are typically assumed to be an upper bound associated with disturbed sites; therefore, the groundwater transport model considers this infiltration rate and lower infiltration rates as determined by Newman et al. (2005, 099163), and described in section B-3.2. Infiltration rates of 2 to 10 mm/yr (0.079 to 0.39 in./yr) increase the possibility for breakthrough at the regional aquifer within 1000 yr. However, these infiltration rates are considered to be high for the site that will be under a cover (e.g., evapotranspiration or vegetative) in the future.

For the highest infiltration rate modeled (i.e., 10 mm/yr [0.39 in./yr]), near the eastern disposal shafts, the predicted contaminant breakthrough for nonsorbing species starts at 500 yr and peaks around 750 yr (Stauffer et al. 2005, 097432). This is the shortest resulting breakthrough time modeled. Other modeled infiltration rates result in breakthrough starting thousands of years later. Because the thickness of the Bandelier Tuff increases at the site from east to west and the differences in the disposal units' depths, breakthrough occurs more quickly on the eastern end of the site than on the western end.

B-4.0 REFERENCES

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

Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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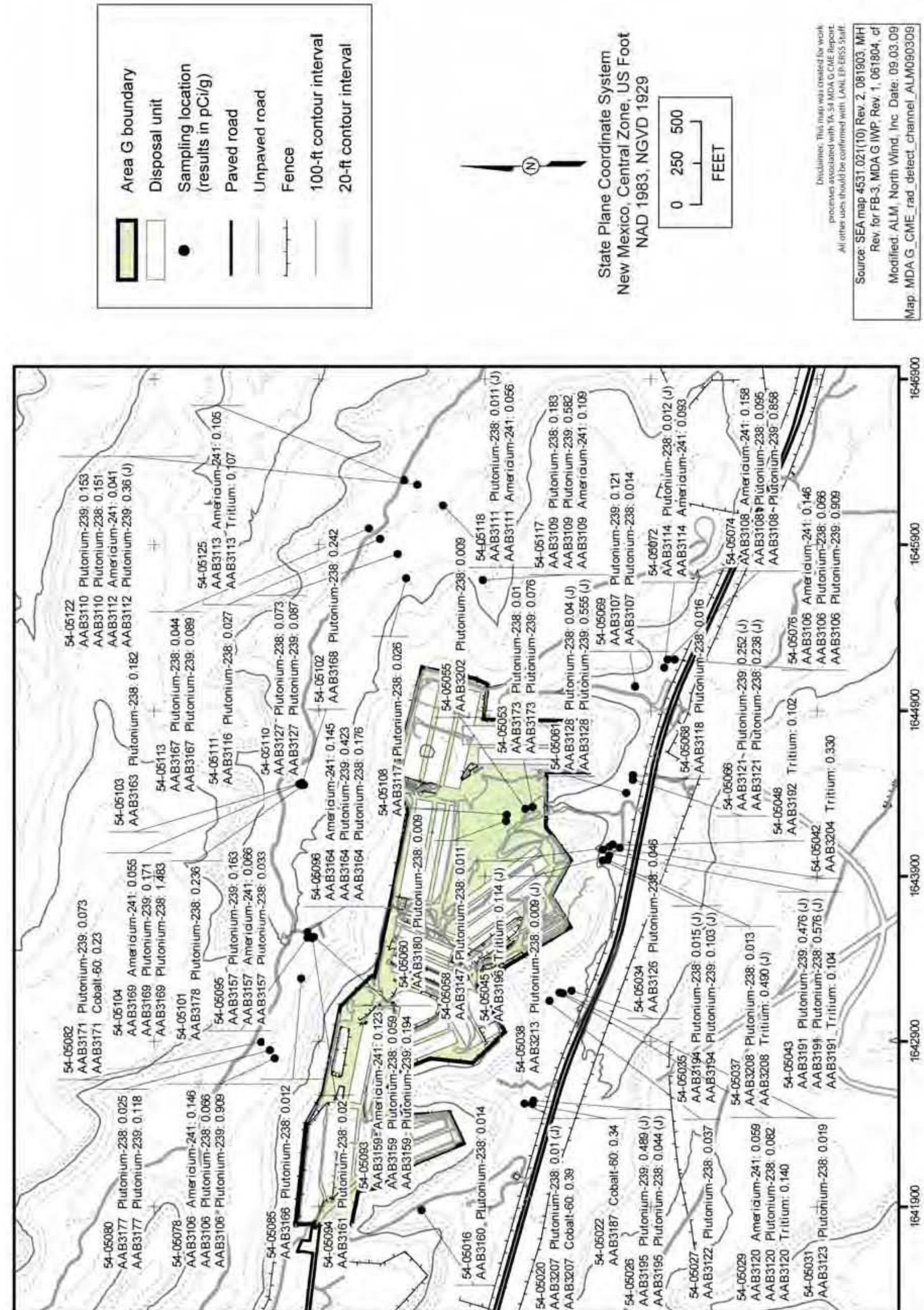

Figure B-2.0-1 Radionuclides detected above BVs in Area G channel sediments during Phase I RFI sampling

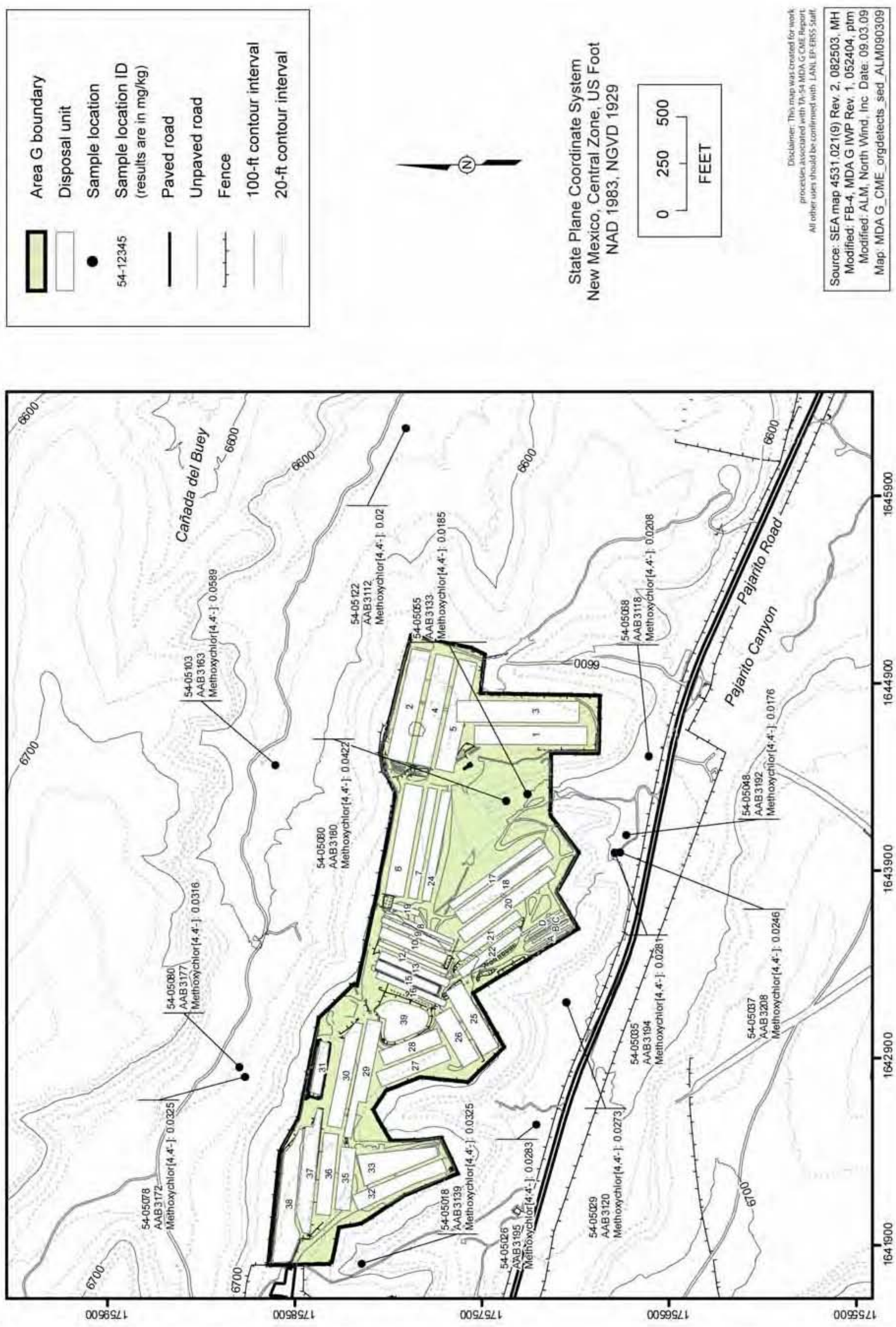

Figure B-2.0-2 Organic chemicals detected in channel sediments at Area G during Phase I RFI sampling

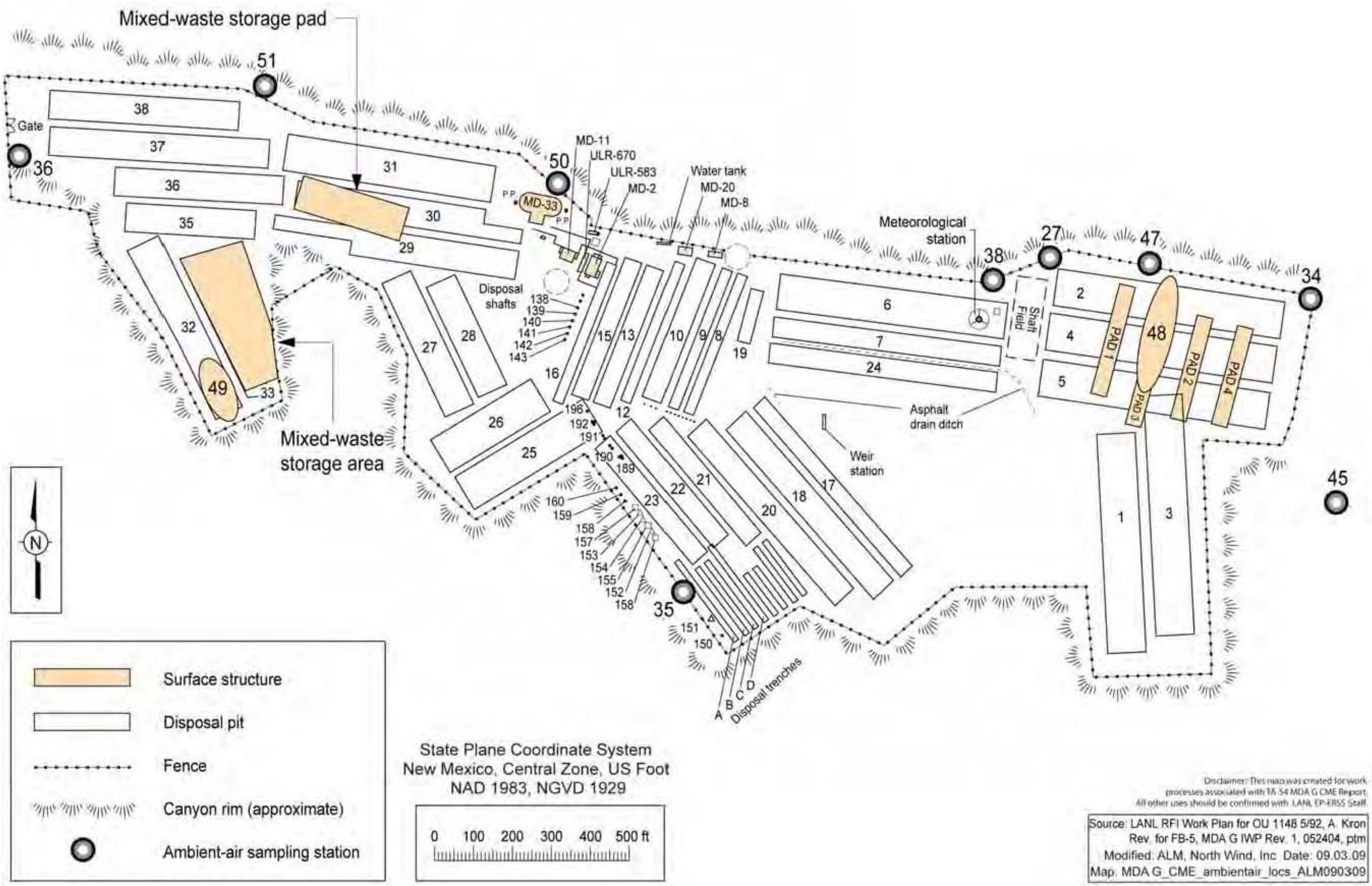

Figure B-2.0-3 Locations of ambient-air sampling stations at Area G

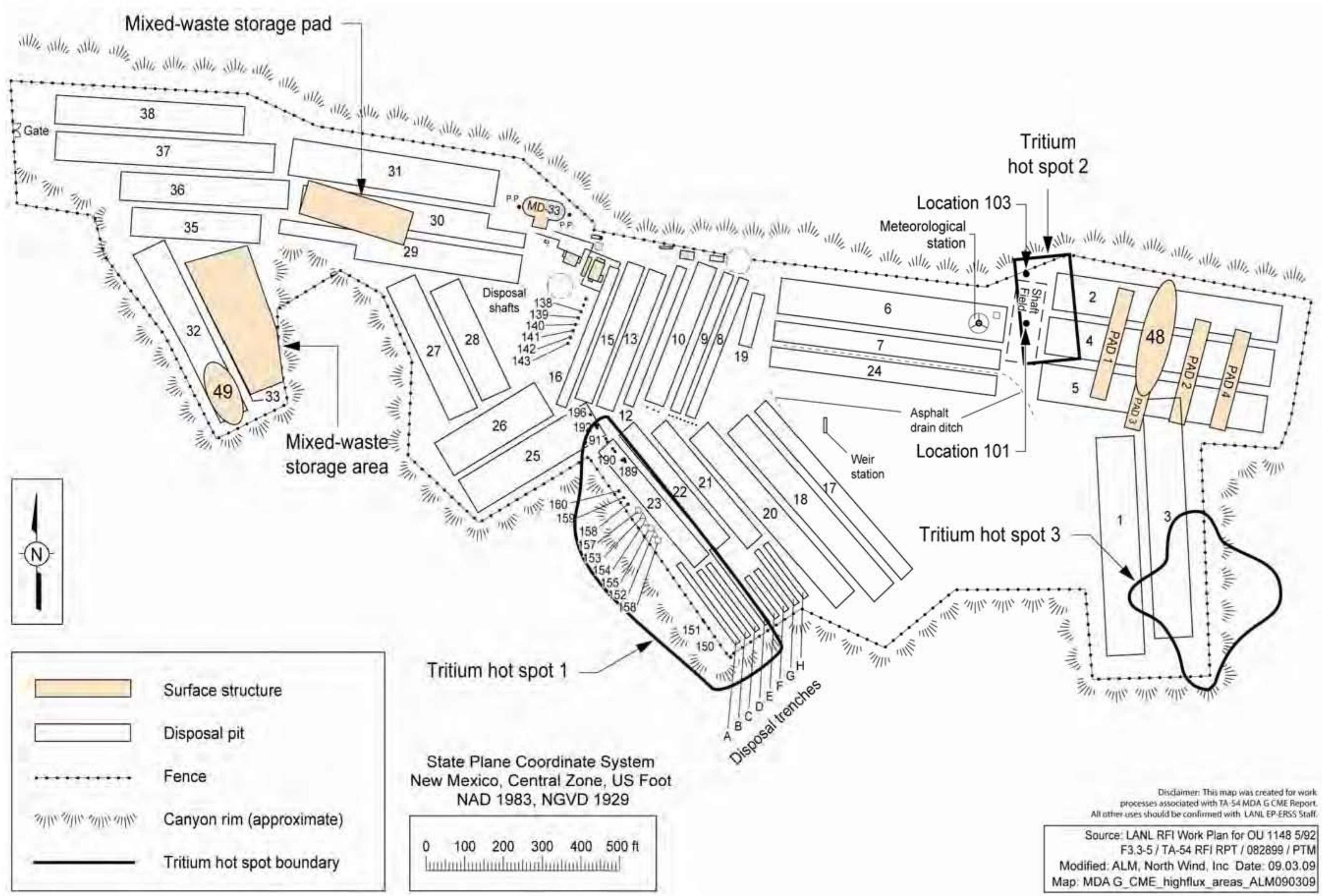

Figure B-2.0-4 Locations of high tritium surface-flux areas at Area G during 1993–1994 survey

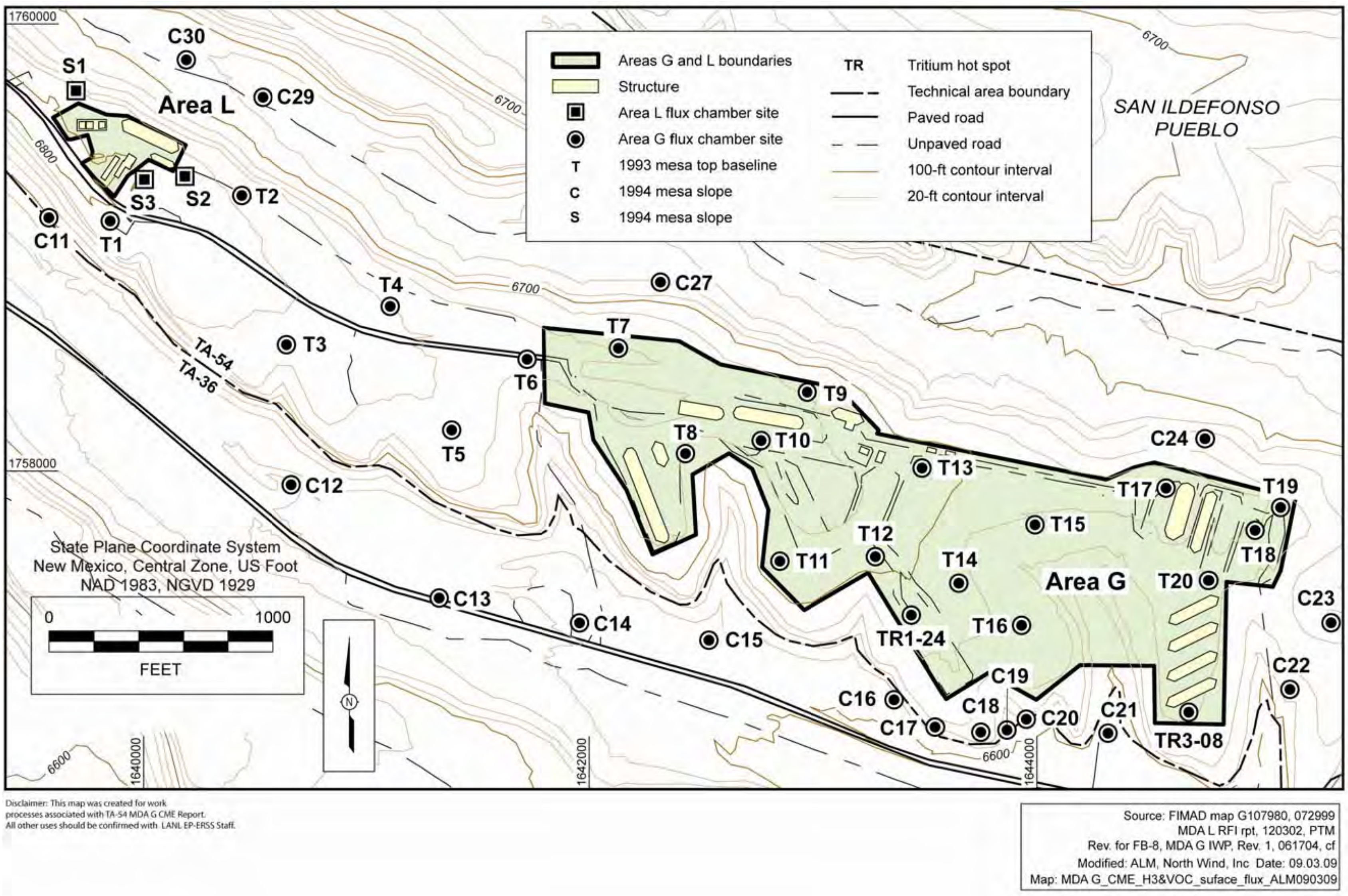

Figure B-2.0-5 Tritium and VOC surface flux chamber sampling locations at Areas G and L

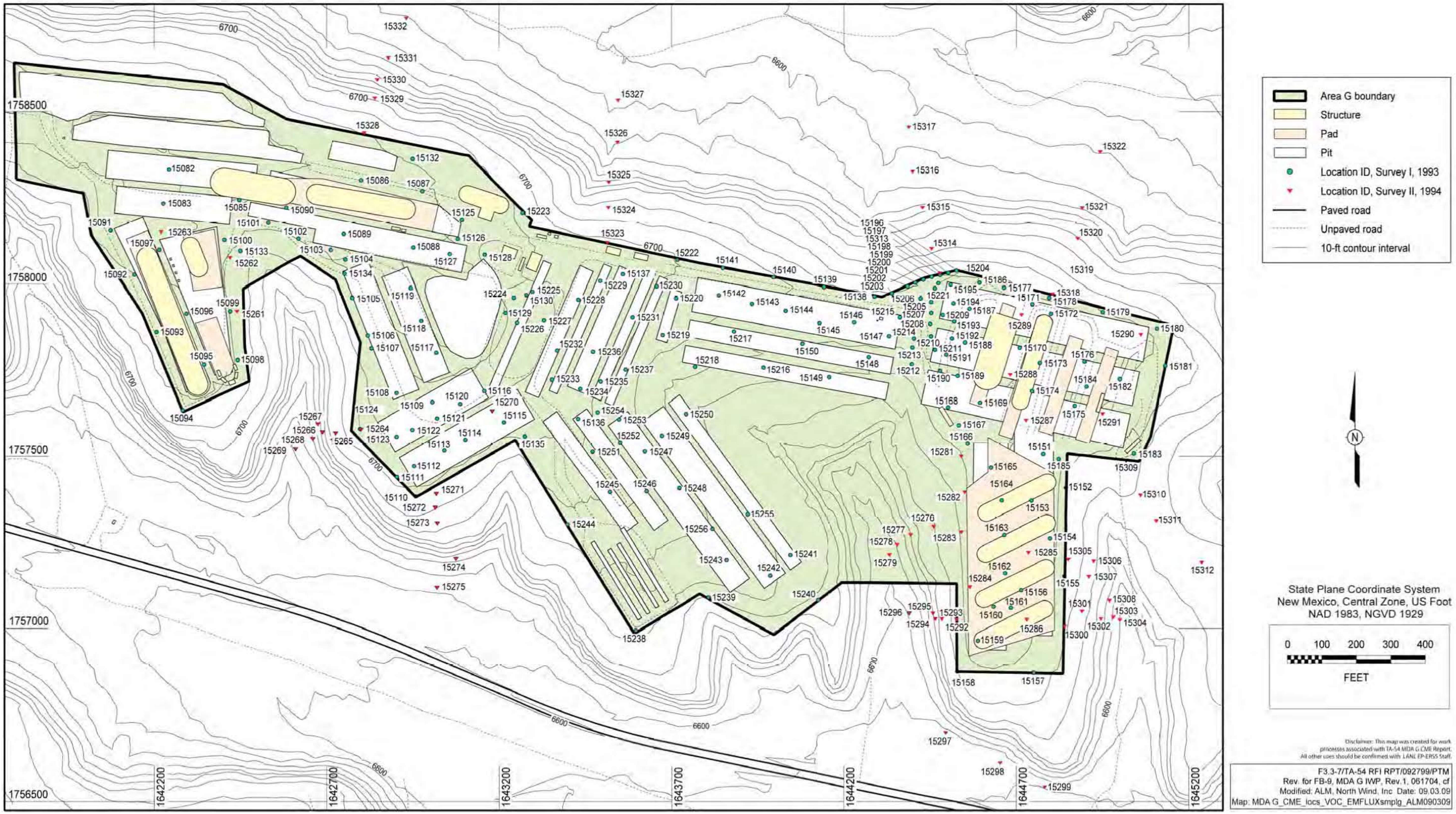

Figure B-2.0-6 VOC EMFLUX surface flux sampling locations at Area G for 1993–1994 survey

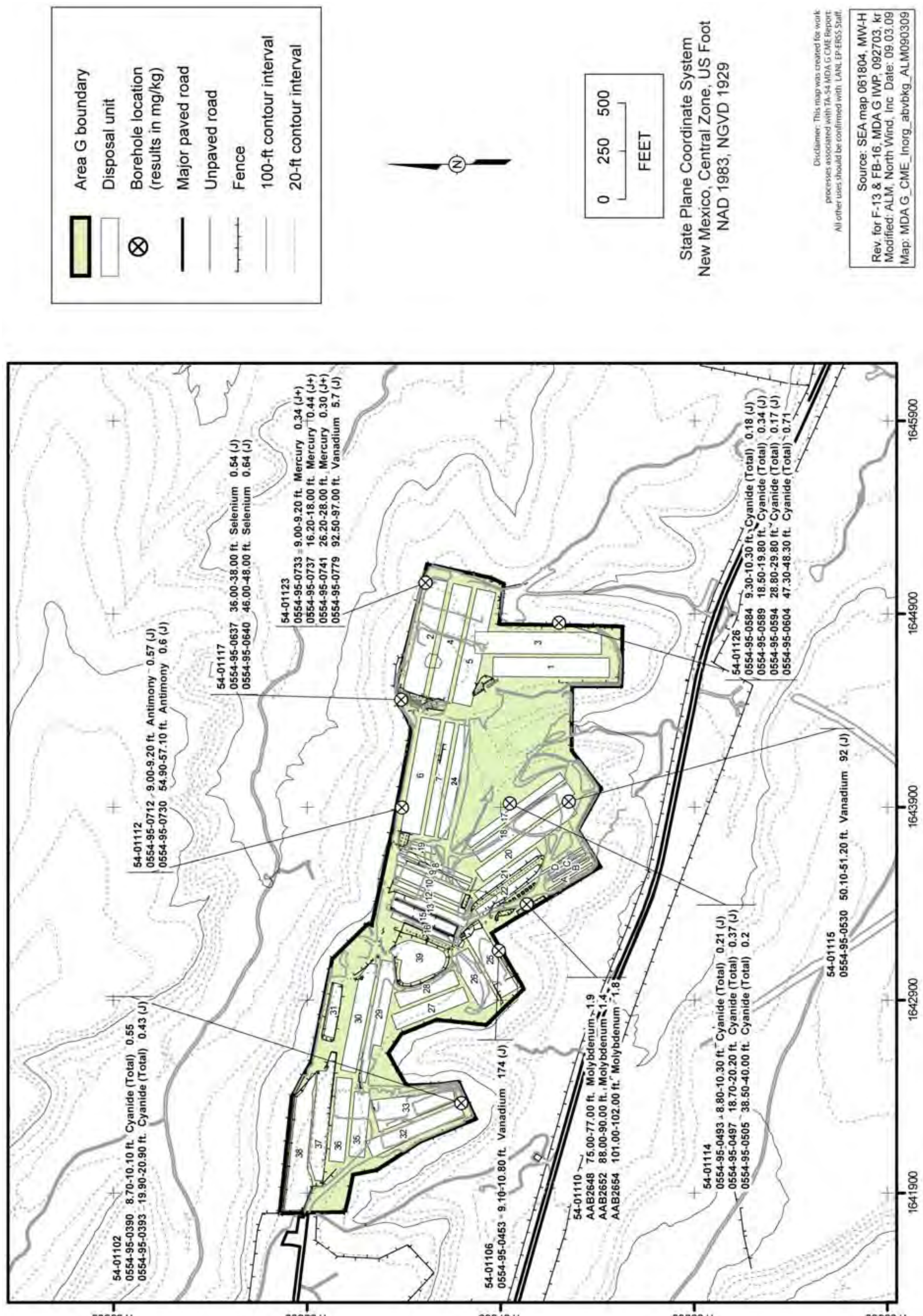

Figure B-2.0-7 Inorganic chemicals detected above BVs in subsurface tuff at MDA G during Phase I RFI sampling

Figure B-2.0-8 Radionuclides detected above BVs in subsurface tuff at MDA G during Phase I RFI sampling

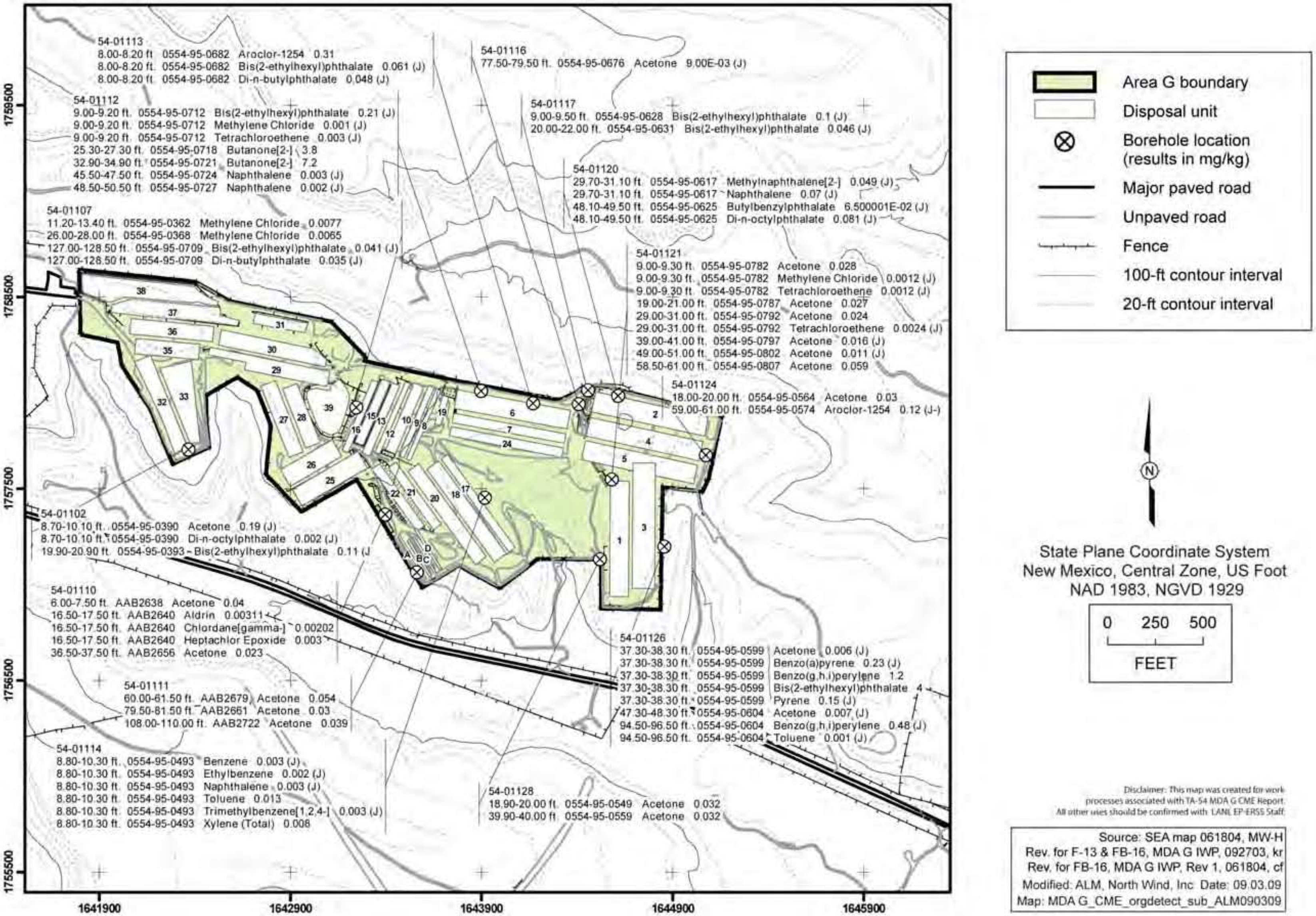

Figure B-2.0-9 Organic chemicals detected in subsurface tuff at MDA G during Phase I RFI sampling

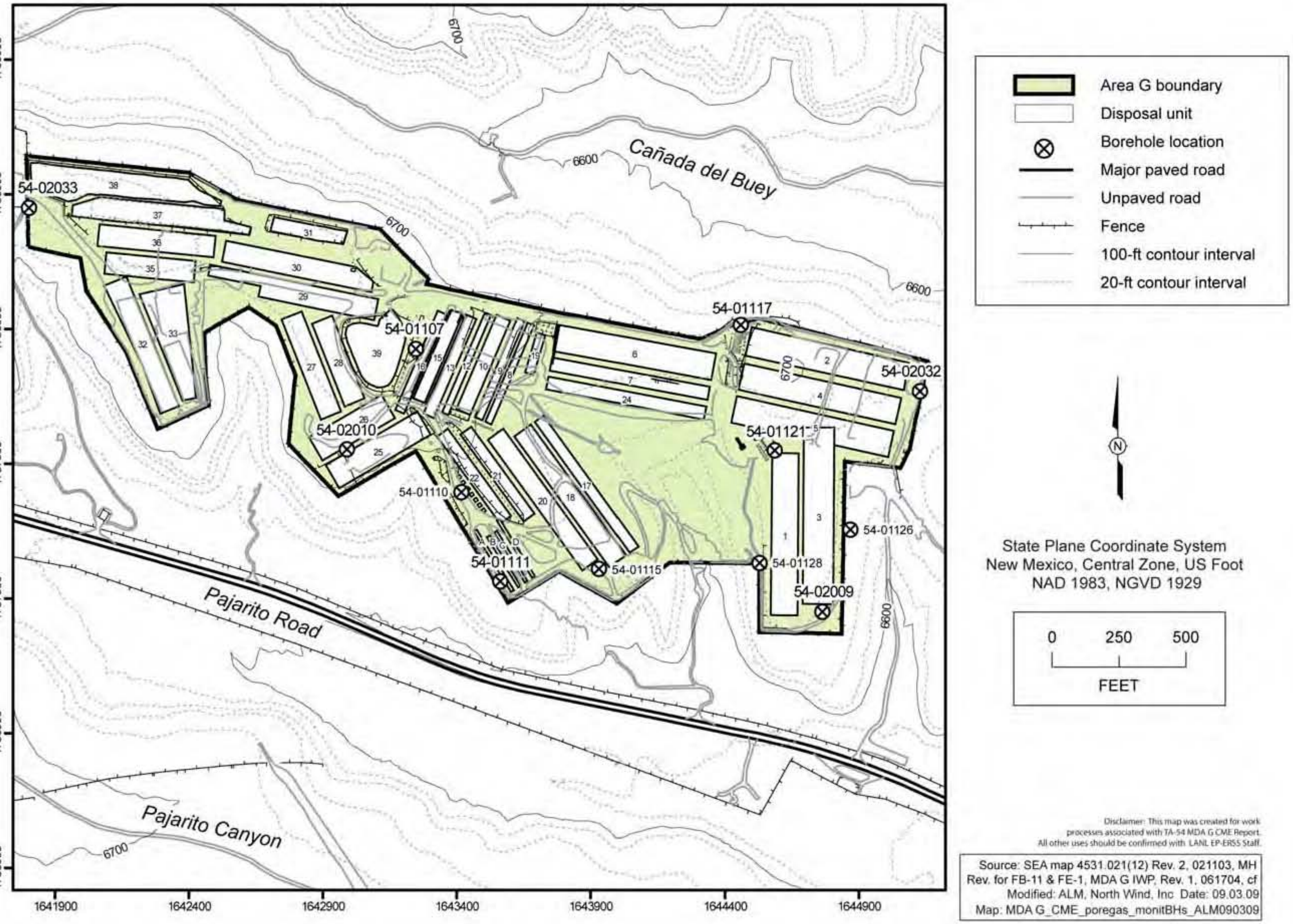

Figure B-2.0-10 MDA G pore-gas monitoring borehole locations (through 2002)

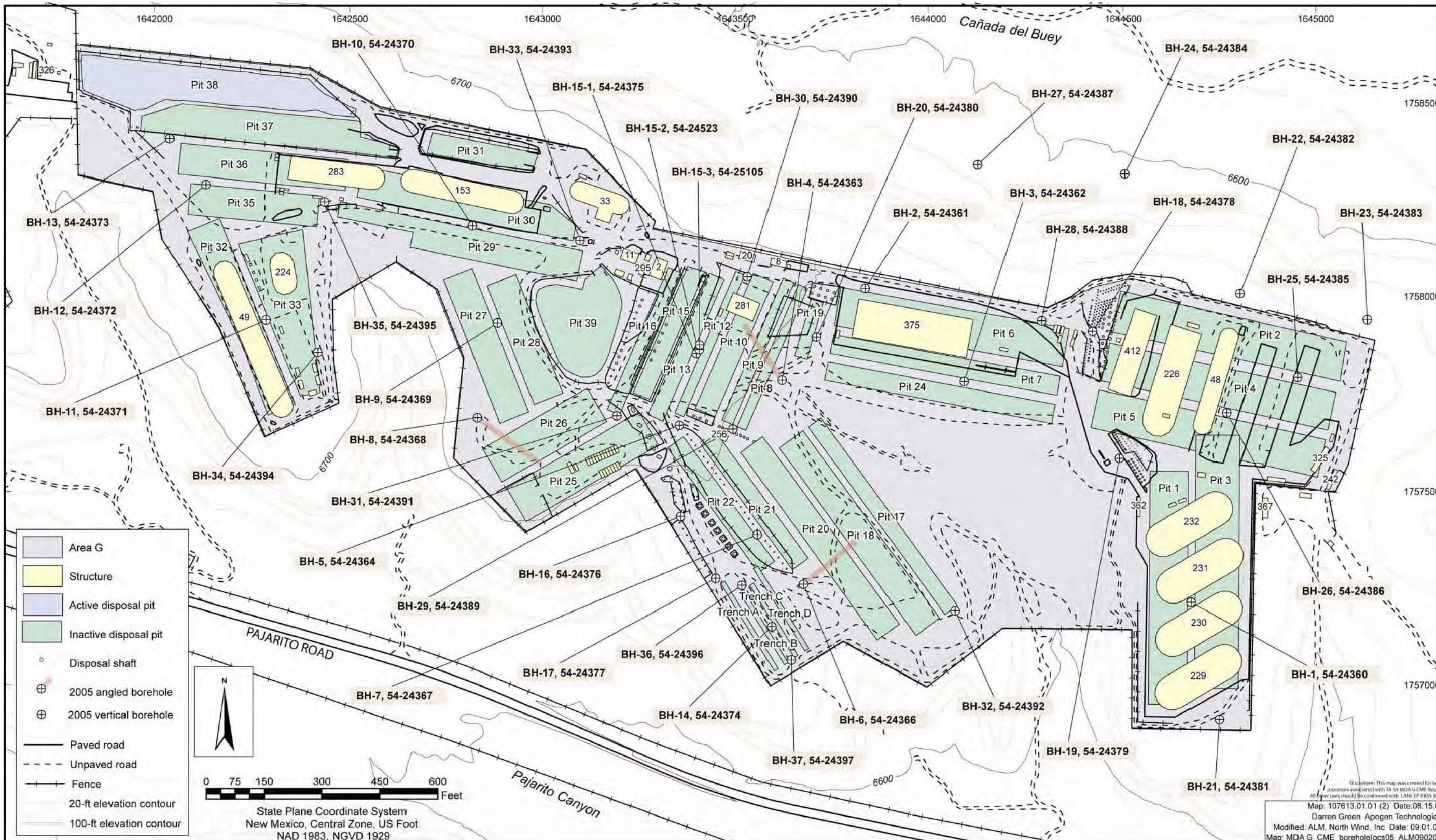

Figure B-3.1-1 Boreholes drilled during the 2005 MDA G investigation

Table B-2.0-1
Average Concentrations of VOCs in Ambient Air from SUMMA Canisters Collected at Area G during Phase I RFI

Analyte	Area G Location 1 Average Concentration		Area G Location 2 Average Concentration	
	ppb	mg/m^3	ppb	mg/m^3
Acetone	0.75	0.0018	0.56	0.0013
Benzaldehyde	—*	—	0.045	0.00020
Benzene	0.079	0.00025	0.12	0.00038
Carbon tetrachloride	0.019	0.00012	0.017	0.00011
Chlorodifluoromethane	0.20	0.00072	—	—
Chloromethane	0.13	0.00028	0.11	0.00024
Dichlorodifluoromethane	0.12	0.00058	0.085	0.00042
Freon 113	0.024	0.00018	0.017	0.00013
Methanol	8.1	0.011	0.48	0.00063
Toluene	0.19	0.00071	0.20	0.00076
TCA	0.20	0.0011	0.029	0.00016
Trichlorofluoromethane	0.084	0.00047	0.04	0.00023
Xylene	0.075	0.00033	0.13	0.00055

Note: Data were corrected for seasonal variability.
* — = The VOC was detected in less than four samples.

Table B-2.0-2
Range of 2001 Ambient-Air Concentrations Measured at Area G and at Regional Air Stations

Analyte	Area G Air Stations		Regional Air Stations	
	Lowest Annual Average (Station Number)	Highest Annual Average (Station Number)	Lowest Annual Average	Highest Annual Average
Plutonium-238	0.0 aCi/m^3* (35)	3.2 aCi/m^3 (34)	0.0 aCi/m^3	0.1 aCi/m^3
Plutonium-239	0.1 aCi/m^3 (36)	25.1 aCi/m^3 (34)	0.0 aCi/m^3	0.6 aCi/m^3
Americium-241	0.0 aCi/m^3 (35,36)	66.6 aCi/m^3 (34)	0.0 aCi/m^3	0.1 aCi/m^3
Uranium-234	10.6 aCi/m^3 (36)	48.0 aCi/m^3 (45)	10.0 aCi/m^3	31.8 aCi/m^3
Uranium-235	0.2 aCi/m^3 (36)	3.1 aCi/m^3 (45)	0.1 aCi/m^3	2.9 aCi/m^3
Uranium-238	16.4 aCi/m^3 (36)	50.7 aCi/m^3 (45)	7.4 aCi/m^3	31.2 aCi/m^3

* aCi indicates attocuries (10–8 curie).

Table B-2.0-3
Frequency of Detected Organic Chemicals in MDA G Pore-Gas Samples from 1999 to 2002

Analyte	Number of Analyses	Number of Detects	Concentration Range* (ppbv)	Frequency of Detects
Acetone	46	7	[1]–[57000]	7/46
Acetonitrile	32	1	0.6–[11000]	1/32
Acetophenone	13	0	[50]–[500]	0/13
Acrolein	32	1	[1.2]–[5700]	1/32
Acrylonitrile	32	0	[1.2]–[5700]	0/32
Benzene	48	6	[0.48]–[2300]	6/48
Benzonitrile	13	0	[50]–[500]	0/13
Benzyl Chloride	39	0	[0.48]–[2300]	0/39
Bromodichloromethane	46	1	[0.48]–[2300]	1/46
Bromoform	46	0	[0.48]–[2300]	0/46
Bromomethane	48	0	[0.48]–[2300]	0/48
Butadiene[1,3-]	46	0	[0.48]–[2300]	0/46
Butane[n-]	32	10	[0.49]–[2300]	10/32
Butanol[1-]	46	2	[1]–[5700]	2/46
Butanone[2-]	46	3	[1.2]–[5700]	3/46
Butene[1-]	13	2	[3.7]–[102]	2/13
Butene[cis-2-]	13	6	0.8–[50]	6/13
Butene[trans-2-]	13	3	4.4–[50]	3/13
Carbon Disulfide	46	1	[0.48]–[2300]	1/46
Carbon Tetrachloride	48	6	[0.48]–[2300]	6/48
Chloro-1,3-butadiene[2-]	13	0	[5]–[50]	0/13
Chloro-1-propene[3-]	32	0	[0.48]–[2300]	0/32
Chlorobenzene	48	0	[0.48]–[2300]	0/48
Chlorodibromomethane	46	1	[0.48]–[2300]	1/46
Chlorodifluoromethane	41	8	[0.4]–[2300]	8/41
Chloroethane	48	6	[0.48]–[2300]	6/48
Chloroform	48	13	[0.5]–[2300]	13/48
Chloromethane	48	1	[0.84]–[5700]	1/48
Cyclohexane	46	6	[0.5]–[5700]	6/46
Cyclohexanone	13	0	[50]–[500]	0/13
Cyclopentane	13	1	1.4–[50]	1/13
Cyclopentene	12	0	[5]–[50]	0/12
Decane[n-]	19	0	[0.48]–[2300]	0/19
Dibromoethane[1,2-]	39	1	[0.48]–[2300]	1/39
Dibromomethane	19	1	[0.48]–[2300]	1/19
Dichloro-1,1,2,2-tetrafluoroethane[1,2-]	39	2	[0.48]–[2300]	2/39
Dichlorobenzene[1,2-]	48	0	[0.48]–[2300]	0/48

Table B-2.0-3 (continued)

Analyte	Number of Analyses	Number of Detects	Concentration Range* (ppbv)	Frequency of Detects
Dichlorobenzene[1,3-]	48	0	[0.48]–[2300]	0/48
Dichlorobenzene[1,4-]	48	0	[0.4]–[2300]	0/48
Dichlorodifluoromethane	39	28	6–[2300]	28/39
Dichloroethane[1,1-]	48	44	0.26–6100	44/48
Dichloroethane[1,2-]	48	7	[0.48]–[2300]	7/48
Dichloroethene[1,1-]	48	43	[0.49]–14000	43/48
Dichloroethene[cis-1,2-]	48	8	0.4–[2300]	8/48
Dichloroethene[trans-1,2-]	46	2	[0.48]–[2300]	2/46
Dichloropropane[1,2-]	48	2	[0.48]–[2300]	2/48
Dichloropropane[1,3-]	1	0	[10]–[10]	0/1
Dichloropropene[cis-1,3-]	48	0	[0.48]–[2300]	0/48
Dichloropropene[trans-1,3-]	48	0	[0.48]–[2300]	0/48
Diethyl Ether	32	0	[1.2]–[5700]	0/32
Dimethylbutane[2,2-]	13	4	1.8–[50]	4/13
Dimethylbutane[2,3-]	13	0	[5]–[50]	0/13
Dimethylpentane[2,3-]	13	2	0.2–[50]	2/13
Dioxane[1,4-]	27	0	[3.4]–[1400]	0/27
Dodecane[n-]	19	0	[0.48]–[2300]	0/19
Ethanol	27	5	[3.4]–18000	5/27
Ethyl Acrylate	13	0	[50]–[500]	0/13
Ethyl Tert-Butyl Ether	13	0	[50]–[500]	0/13
Ethylbenzene	48	0	[0.48]–[2300]	0/48
Ethyltoluene[4-]	5	0	[29]–[1300]	0/5
Hexachlorobutadiene	48	4	[0.48]–[2300]	4/48
Hexane	46	4	0.4–[2300]	4/46
Hexanone[2-]	46	0	[1.2]–[5700]	0/46
Hexene[cis-3-]	13	0	[5]–[50]	0/13
Hexene[trans-2-]	13	0	[5]–[50]	0/13
Isobutane	13	7	2.4–297	7/13
Isooctane	13	1	0.2–[50]	1/13
Isopentane	13	8	[5]–[50]	8/13
Isoprene	13	0	[5]–[50]	0/13
Isopropylbenzene	32	0	[0.48]–[2300]	0/32
Methacrylonitrile	13	0	[50]–[500]	0/13
Methanol	46	6	[6.3]–[110000]	6/46
Methyl Methacrylate	13	0	[50]–[500]	0/13
Methyl Tert-Butyl Ether	46	0	[1.2]–[5700]	0/46
Methyl-1-butene[3-]	13	1	0.4–[50]	1/13

Table B-2.0-3 (continued)

Analyte	Number of Analyses	Number of Detects	Concentration Range* (ppbv)	Frequency of Detects
Methyl-1-pentene[2-]	13	0	[5]–[50]	0/13
Methyl-1-pentene[4-]	13	0	[5]–[50]	0/13
Methyl-2-butene[2-]	13	2	[0.6]–[50]	2/13
Methyl-2-pentanone[4-]	46	0	[1.2]–[5700]	0/46
Methylcyclohexane	13	4	0.9–[50]	4/13
Methylcyclopentane	13	7	1.4–[50]	7/13
Methylene Chloride	48	20	[0.49]–48000	20/48
Methylheptane[2-]	13	0	[5]–[50]	0/13
Methylheptane[3-]	13	0	[5]–[50]	0/13
Methylhexane[2-]	13	0	[5]–[50]	0/13
Methylhexane[3-]	13	0	[0.4]–[50]	0/13
Methylpentane[2-]	13	5	0.5–[50]	5/13
Methylpentane[3-]	13	5	1.9–[50]	5/13
Methylstyrene[alpha-]	32	0	[0.48]–[2300]	0/32
Naphthalene	19	1	[0.48]–2700	1/19
n-Heptane	46	1	[0.48]–[2300]	1/46
Nitrobenzene	13	0	[50]–[500]	0/13
Nitropropane[2-]	13	1	0.5–[500]	1/13
Nonane[1-]	32	0	[0.48]–[2300]	0/32
Octane[n-]	32	0	[0.48]–[2300]	0/32
Pentane	32	7	[0.1]–[5700]	7/32
Pentene[1-]	13	0	[1]–[50]	0/13
Pentene[cis-2-]	13	0	[5]–[50]	0/13
Pentene[trans-2-]	13	0	[5]–[50]	0/13
Pinene[alpha-]	13	0	[5]–[50]	0/13
Pinene[beta-]	13	1	[5]–120	1/13
Propanol[2-]	27	4	0.4–4500	4/27
Propionitrile	13	0	[50]–[500]	0/13
Propylbenzene[1-]	32	0	[0.48]–[2300]	0/32
Propylene	27	6	[3.4]–[1400]	6/27
Styrene	48	2	[0.48]–[2300]	2/48
Tetrachloroethane[1,1,2,2-]	48	0	[0.48]–[2300]	0/48
Tetrachloroethene	48	43	0.41–[2300]	43/48
Tetrahydrofuran	27	0	[3.4]–[1400]	0/27
Toluene	48	10	0.1–[2300]	10/48
Trichloro-1,2,2-trifluoroethane[1,1,2-]	48	33	2.1–15000	33/48
Trichlorobenzene[1,2,4-]	48	3	[0.48]–[2300]	3/48
Trichloroethane[1,1,1-]	48	48	7.5–167000	48/48

Table B-2.0-3 (continued)

Analyte	Number of Analyses	Number of Detects	Concentration Range* (ppbv)	Frequency of Detects
Trichloroethane[1,1,2-]	48	5	[0.48]–[2300]	5/48
Trichloroethene	48	39	0.37–3600	39/48
Trichlorofluoromethane	39	25	11–[2300]	25/39
Trimethylbenzene[1,2,4-]	48	0	[0.1]–[2300]	0/48
Trimethylbenzene[1,3,5-]	48	0	[0.48]–[2300]	0/48
Trimethylpentane[2,3,4-]	13	0	[5]–[50]	0/13
Undecane[n-]	19	0	[0.48]–[2300]	0/19
Vinyl acetate	46	1	0.81–[5700]	1/46
Vinyl Chloride	48	0	[0.48]–[2300]	0/48
Xylene (Total)	21	0	[0.48]–[2000]	0/21
Xylene[1,2-]	48	1	[0.48]–[2300]	1/48
Xylene[1,3-]	13	0	[5]–[50]	0/13
Xylene[1,3-]+Xylene[1,4-]	14	0	[0.49]–[2300]	0/14

* Square brackets indicate method detection limits.

Table B-2.0-4
2003 Pore-Gas Tritium Results for
MDA G Borehole Locations 54-01110 and 54-01111

Borehole	Sample ID	Depth (ft bgs)	Tritium (pCi/L)*	Qualifier
54-01110	MD54-03-50390	20	1.80E+07	J+
54-01110	MD54-03-50391	48	2.10E+07	J+
54-01110	MD54-03-50392	60	5.00E+05	J+
54-01110	MD54-03-50393	70	8.20E+05	J+
54-01110	MD54-03-50394	85	1.04E+08	J+
54-01110	MD54-03-50395	90	1.62E+08	J+
54-01111	MD54-03-50396	20	2.71E+08	J+
54-01111	MD54-03-50397	39.5	3.81E+07	J+
54-01111	MD54-03-50398	50	9.24E+07	J+
54-01111	MD54-03-50399	70	4.60E+09	J+
54-01111	MD54-03-50403	70	4.39E+08	J+
54-01111	MD54-03-50400	78	1.18E+10	J+
54-01111	MD54-03-50402	100	5.06E+09	J+
54-01111	MD54-03-50401	139	4.85E+08	J+

* Tritium pore-vapor concentrations have been corrected for silica gel bound water (Marczak 2009, 106500).

Table B-3.1-1
Fracture Sample Summary for Boreholes at MDA G

Borehole ID	Borehole Location	Sample ID	Media Code	Begin Depth (ft)	End Depth (ft)	Sample Description	Notes
BH 3	54-24362	MD54-05-57887	Qbt 2	35	40	Fracture (38–40 ft) filled with clay	Sample represents base of closest disposal unit
		MD54-05-57894					Duplicate of MD54-05-57887
BH 4	54-24363	MD54-05-57896	Qbt 2	42.8	45.2	Clay-filled fracture	Did not collect a paired sample above fracture because a sample was collected at 31.8–35.4 ft
BH 9	54-24369	MD54-05-57960	Qbt 2	65	70	2–3-mm-thick clay-filled fracture	Sample represents base of closest disposal unit
		MD54-05-57967					Duplicate of MD54-05-57967
BH 15	54-24375	MD54-05-58014	Qbt 2	62	64	Tuff sample collected above fracture	Paired fracture sample
		MD54-05-58015		64	65	1–2-mm-thick mud-filled fracture	
BH 25	54-24385	MD54-05-58103	Qbt 2	30	35	Fracture (31.8–32.0 ft) filled with 0.1 mm clay coating	Sample represents base of closest disposal unit
		MD54-05-58110					Duplicate of MD54-05-58103
BH 26	54-24386	MD54-05-58117	Qbt 2	56	58	Tuff sample collected above fracture	Paired fracture sample
		MD54-05-58118		58	59	2-mm-thick silt-filled fracture	
BH 30	54-24390	MD54-05-58149	Qbt 2	56	57	Fracture from 56–57 ft	Not enough material in core barrel to collect sample above the fracture
		MD54-05-58150	Qbt 1v	93	94	Tuff sample collected above fracture	Paired fracture sample
		MD54-05-58151		94	95	1–2-mm-thick clay-filled fracture	
BH 34	54-24394	MD54-05-58186	Qbt 2	50	55	Fracture (50–55 ft) filled with 3-mm-thick clay and organic material	Did not collect sample above fracture because a sample was collected at 40–45 ft
		MD54-05-58187	Qbt 1v	100	102	Tuff sample collected above fracture	Paired fracture sample

Table B-3.1-2
VOCs Detected in 2005 Pore-Gas Samples Collected from MDA G Subsurface Units

Borehole Location	Depth (ft)	Sample ID	Analyte	Result ($\mu g/m^3$)
54-24361	30–32	MD54-05-60283	Chloroform	234
			Dichloroethane[1,1-]	688
			Dichloroethene[1,1-]	436
			Tetrachloroethene	9490
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	3140 (J)*
			Trichloroethane[1,1,1-]	14700
			Trichloroethene	53700
	138–140	MD54-05-60282	Chloroform	381
			Dichloroethane[1,1-]	1130
			Dichloroethene[1,1-]	832
			Tetrachloroethene	3320
			Toluene	267
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1460 (J)*
			Trichloroethane[1,1,1-]	13600
			Trichloroethene	29000
54-24362	35–37	MD54-05-60285	Carbon Tetrachloride	32.0
			Chloroform	100
			Dichlorodifluoromethane	2400
			Dichloroethane[1,1-]	260
			Dichloroethene[1,1-]	330
			Styrene	45.0
			Tetrachloroethene	1100
			Toluene	400
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1200
			Trichloroethane[1,1,1-]	8200
			Trichloroethene	6500
			Trichlorofluoromethane	130
	135–137	MD54-05-60284	Acetone	64.1 (J)*
			Chloroform	151
			Dichloroethane[1,1-]	526
			Dichloroethene[1,1-]	753
			Methylene Chloride	55.5
			Styrene	51.1
			Tetrachloroethene	1150
			Toluene	324
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	3060 (J+)*

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24362 (continued)	135–137	MD54-05-60284	Trichloroethane[1,1,1-]	10900
			Trichloroethene	5260
			Trichlorofluoromethane	286
54-24363	12–250	MD54-05-60286	Toluene	240
			Carbon Disulfide	2.9
			Chloroform	5.2
			Dichlorodifluoromethane	13
			Dichloroethane[1,1-]	11
			Dichloroethene[1,1-]	46
			Styrene	10
			Butanone[2-]	5
			Tetrachloroethene	96
			Acetone	70
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	120
			Trichloroethane[1,1,1-]	900
			Trichloroethene	45
			Trichlorofluoromethane	6.6
			Xylene[1,3-]+Xylene[1,4-]	8.4
54-24364	65–67	MD54-05-60289	Dichloroethane[1,1-]	129
			Dichloroethene[1,1-]	384
			Dichloropropane[1,2-]	25.9
			Methylene Chloride	29.9
			Tetrachloroethene	1760
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1840 (J)*
			Trichloroethane[1,1,1-]	5340
			Trichloroethene	2850
			Trichlorofluoromethane	225
	130–132	MD54-05-60288	Acetone	102
			Dichloroethane[1,1-]	105
			Dichloroethene[1,1-]	384
			Dichloropropane[1,2-]	42.0
			Methylene Chloride	45.1
			Tetrachloroethene	1290
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1300 (J)*
			Trichloroethane[1,1,1-]	4040
			Trichloroethene	1830
			Trichlorofluoromethane	180

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24366	12–250	MD54-05-60290	Trichloroethane[1,1,1-]	29
			Acetone	17
			Toluene	20
54-24367	30–32	MD54-05-60293	Dichloroethane[1,1-]	259
			Dichloroethene[1,1-]	396
			Styrene	63.9
			Tetrachloroethene	481
			Toluene	527
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	2070 (J+)*
			Trichloroethane[1,1,1-]	13100
			Trichloroethene	1290
			Trichlorofluoromethane	399
	153–155	MD54-05-60292	Dichloroethane[1,1-]	809
			Dichloroethene[1,1-]	2540
			Styrene	111
			Tetrachloroethene	881
			Toluene	1170
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	6360 (J+)*
			Trichloroethane[1,1,1-]	31600
			Trichloroethene	2420
			Trichlorofluoromethane	483
54-24368	95–97	MD54-05-60295	Dichlorodifluoromethane	310
			Dichloroethane[1,1-]	660
			Dichloroethene[1,1-]	1900
			Styrene	160
			Tetrachloroethene	290
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	7100
			Trichloroethane[1,1,1-]	42000
			Trichloroethene	480
			Trichlorofluoromethane	770
	192–194	MD54-05-60294	Dichlorodifluoromethane	390
			Dichloroethane[1,1-]	430
			Dichloroethene[1,1-]	1600
			Propanol[2-]	210
			Styrene	500
			Tetrachloroethene	280
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	4000
			Trichloroethane[1,1,1-]	22000

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24368 (continued)	192–194	MD54-05-60294	Trichloroethene	470
			Trichlorofluoromethane	820
54-24369	65–67	MD54-05-61743	Dichlorodifluoromethane	2800
			Dichloroethane[1,1-]	2800
			Dichloroethene[1,1-]	4800
			Tetrachloroethene	3600
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	18000
			Trichloroethane[1,1,1-]	120000
			Trichloroethene	3200
			Trichlorofluoromethane	2500
	184–186	MD54-05-61742	Dichlorodifluoromethane	1000
			Dichloroethane[1,1-]	490
			Dichloroethene[1,1-]	1100
			Tetrachloroethene	500
			Toluene	140
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	3800
			Trichloroethane[1,1,1-]	20000
			Trichloroethene	500
			Trichlorofluoromethane	780
54-24370	37–39	MD54-05-60299	Dichlorodifluoromethane	10400
			Dichloroethene[1,1-]	2730
			Dichloroethene[cis-1,2-]	388
			Tetrachloroethene	1020
			Toluene	791
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	48300 (J+)*
			Trichloroethane[1,1,1-]	92700
			Trichloroethene	12400
			Trichlorofluoromethane	10100
	148–150	MD54-05-60298	Dichlorodifluoromethane	12400
			Dichloroethane[1,1-]	6880
			Dichloroethene[1,1-]	3290
			Dichloroethene[cis-1,2-]	396
			Methylene Chloride	312
			Styrene	179
			Tetrachloroethene	624
			Toluene	1130
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	33700 (J+)*
			Trichloroethane[1,1,1-]	65400

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24370 (continued)	148–150	MD54-05-60298	Trichloroethene	6980
			Trichlorofluoromethane	7300
54-24371	40–42	MD54-05-61745	Butanone[2-]	72.0
			Chloroform	100
			Dichlorodifluoromethane	730
			Dichloroethane[1,1-]	760
			Dichloroethene[1,1-]	290
			Methyl-2-pentanone[4-]	29.0
			Styrene	120
			Tetrachloroethene	460
			Toluene	4400
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	12000
			Trichloroethane[1,1,1-]	9100
			Trichloroethene	2400
			Trichlorofluoromethane	1300
	141–143	MD54-05-61744	Acetone	46.0
			Butanone[2-]	84.0
			Chloroform	92.0
			Dichlorodifluoromethane	690
			Dichloroethane[1,1-]	720
			Dichloroethene[1,1-]	330
			Methyl-2-pentanone[4-]	28.0
			Methylene Chloride	17.0
			Styrene	100
			Tetrachloroethene	410
			Toluene	4400
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	5900
			Trichloroethane[1,1,1-]	7500
			Trichloroethene	2600
			Trichlorofluoromethane	1200
54-24372	55–57	MD54-05-61747	Acetone	30.0
			Butanone[2-]	28.0
			Dichlorodifluoromethane	180
			Dichloroethane[1,1-]	25.0
			Dichloroethene[1,1-]	38.0
			Methyl-2-pentanone[4-]	10.0
			Styrene	90.0
			Tetrachloroethene	190

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24372 (continued)	55–57	MD54-05-61747	Toluene	1800
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	130
			Trichloroethane[1,1,1-]	970
			Trichloroethene	200
			Trichlorofluoromethane	360
	185–187	MD54-05-61746	Acetone	21.0
			Butanone[2-]	22.0
			Dichlorodifluoromethane	86.0
			Dichloroethane[1,1-]	25.0
			Dichloroethene[1,1-]	47.0
			Methyl-2-pentanone[4-]	10.0
			Methylene Chloride	57.0
			Styrene	95.0
			Tetrachloroethene	180
			Toluene	1400
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	63.0
			Trichloroethane[1,1,1-]	750
			Trichloroethene	210
			Trichlorofluoromethane	150
			Xylene[1,3-]+Xylene[1,4-]	7.40
54-24373	65–67	MD54-05-60305	Acetone	128
			Butanone[2-]	3.83
			Chloroform	9.76
			Dichlorodifluoromethane	939
			Dichloroethane[1,1-]	13.8
			Dichloroethene[1,1-]	31.7
			Dichloropropane[1,2-]	55.4
			Methylene Chloride	149
			Tetrachloroethene	94.9
			Toluene	3.50
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	605
			Trichloroethane[1,1,1-]	1200
			Trichloroethene	69.8
			Trichlorofluoromethane	1460
	187–189	MD54-05-60304	Acetone	28.5
			Dichlorodifluoromethane	203
			Dichloroethene[1,1-]	5.55
			Dichloropropane[1,2-]	9.24

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result ($\mu g/m^3$)
54-24373 (continued)	187–189	MD54-05-60304	Methylene Chloride	25.0
			Tetrachloroethene	18.3
			Toluene	4.90
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	115
			Trichloroethane[1,1,1-]	229
			Trichloroethene	10.2
			Trichlorofluoromethane	270
54-24374	10–12	MD54-05-60306	Dichloroethane[1,1-]	117
			Methylene Chloride	41.7
			Tetrachloroethene	217
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	4290 (J)*
			Trichloroethane[1,1,1-]	8720
			Trichloroethene	193
			Trichlorofluoromethane	101
	139–141	MD54-05-60307	Acetone	228
			Dichloroethane[1,1-]	93.0
			Dichloroethene[1,1-]	365
			Dichloropropane[1,2-]	69.3
			Methylene Chloride	29.5
			Tetrachloroethene	183
			Toluene	32.0
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1990 (J)*
			Trichloroethane[1,1,1-]	5180
			Trichloroethene	274
			Trichlorofluoromethane	101
54-24375	30–32	MD54-05-60309	Dichloroethane[1,1-]	485
			Dichloroethene[1,1-]	1470
			Tetrachloroethene	11500
			Toluene	181
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	9190 (J)*
			Trichloroethane[1,1,1-]	43100
			Trichloroethene	1130
			Trichlorofluoromethane	500
	157–159	MD54-05-60308	Dichloroethane[1,1-]	380
			Dichloroethene[1,1-]	1820
			Methylene Chloride	104
			Tetrachloroethene	11500
			Toluene	162

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24375 (continued)	157–159	MD54-05-60308	Trichloro-1,2,2-trifluoroethane[1,1,2-]	8420 (J)*
			Trichloroethane[1,1,1-]	36000
			Trichloroethene	1400
			Trichlorofluoromethane	511
54-24376	35–37	MD54-05-60311	Dichloroethane[1,1-]	129
			Dichloroethene[1,1-]	246
			Styrene	93.7
			Tetrachloroethene	149
			Toluene	565
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1230 (J+)*
			Trichloroethane[1,1,1-]	6000
			Trichloroethene	258
			Trichlorofluoromethane	78.6
	158–160	MD54-05-60310	Acetone	49.9
			Butanone[2-]	5.89
			Dichloroethane[1,1-]	64.7
			Dichloroethene[1,1-]	166
			Methyl-2-pentanone[4-]	16.4
			Styrene	119
			Tetrachloroethene	74.6
			Toluene	1020
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	421 (J+)*
			Trichloroethane[1,1,1-]	2340
			Trichloroethene	161
			Trichlorofluoromethane	33.7
54-24377	45–47	MD54-05-60313	Dichloroethane[1,1-]	76.9
			Dichloroethene[1,1-]	234
			Methylene Chloride	12.8
			Styrene	123
			Tetrachloroethene	122
			Toluene	603
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1380 (J+)*
			Trichloroethane[1,1,1-]	3540
			Trichloroethene	215
			Trichlorofluoromethane	73.0
	150–152	MD54-05-60312	Acetone	57.0
			Butanone[2-]	9.43
			Dichloroethane[1,1-]	48.5

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24377 (continued)	150–152	MD54-05-60312	Dichloroethene[1,1-]	178
			Methyl-2-pentanone[4-]	19.2
			Methylene Chloride	8.33
			Styrene	145
			Tetrachloroethene	67.8
			Toluene	1280
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	758 (J+)*
			Trichloroethane[1,1,1-]	2020
			Trichloroethene	134
			Trichlorofluoromethane	43.2
			Xylene[1,3-]+Xylene[1,4-]	13.0
54-24378	30–32	MD54-05-60315	Dichloroethane[1,1-]	7280
			Dichloroethene[1,1-]	5550
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	22200 (J)*
			Trichloroethane[1,1,1-]	464000
			Trichloroethene	4080
	136–138	MD54-05-60314	Dichloroethane[1,1-]	12900
			Dichloroethene[1,1-]	13900
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	28300 (J)*
			Trichloroethane[1,1,1-]	709000
			Trichloroethene	7520
54-24379	20–22	MD54-05-60317	Dichloroethane[1,1-]	1460
			Dichloroethene[1,1-]	3650
			Tetrachloroethene	664
			Toluene	279
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	375 (J)*
			Trichloroethane[1,1,1-]	32700
			Trichloroethene	1240
	144–146	MD54-05-60316	Dichloroethane[1,1-]	6070
			Dichloroethene[1,1-]	15100
			Tetrachloroethene	2030
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1530 (J)*
			Trichloroethane[1,1,1-]	98200
			Trichloroethene	4780
54-24380	20–22	MD54-05-60319	Chloroform	1850
			Dichloroethane[1,1-]	295
			Dichloroethene[1,1-]	396
			Tetrachloroethene	813

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24380 (continued)	20–22	MD54-05-60319	Toluene	128
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	2990 (J+)*
			Trichloroethane[1,1,1-]	14700
			Trichloroethene	3440
			Trichlorofluoromethane	163
	155–157	MD54-05-60318	Chloroform	683
			Dichloroethane[1,1-]	445
			Dichloroethene[1,1-]	753
			Methylene Chloride	79.8
			Styrene	76.6
			Tetrachloroethene	813
			Toluene	716
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	2990 (J+)*
			Trichloroethane[1,1,1-]	16900
			Trichloroethene	4030
			Trichlorofluoromethane	236
54-24381	15–17	MD54-05-60321	Dichloroethane[1,1-]	1660
			Dichloroethene[1,1-]	3800
			Tetrachloroethene	949
			Toluene	309
			Trichloroethane[1,1,1-]	54500
			Trichloroethene	462
	143–145	MD54-05-60320	Dichloroethane[1,1-]	1780
			Dichloroethene[1,1-]	5150
			Tetrachloroethene	746
			Toluene	377
			Trichloroethane[1,1,1-]	51300
			Trichloroethene	537
54-24382	28–29	MD54-05-60323	Chloroform	57.0
			Dichloroethane[1,1-]	950
			Dichloroethene[1,1-]	1100
			Ethanol	59.0 (J)*
			Tetrachloroethene	310
			Trichloroethane[1,1,1-]	8400
			Trichloroethene	90.0
	107–109	MD54-05-60322	Acetone	83.0 (J)*
			Butanone[2-]	8.50
			Chloroform	8.60

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result ($\mu g/m^3$)
54-24382 (continued)	107–109	MD54-05-60322	Dichloroethane[1,1-]	180
			Dichloroethane[1,2-]	9.00
			Dichloroethene[1,1-]	170
			Methylene Chloride	5.30
			n-Heptane	8.90
			Propanol[2-]	47.0
			Styrene	400
			Tetrachloroethene	37.0
			Toluene	44.0
			Trichloroethane[1,1,1-]	1100
			Trichloroethene	18.0
			Vinyl Chloride	2.90
			Xylene[1,3-]+Xylene[1,4-]	15.0
54-24383	10–11	MD54-05-60324	Acetone	23.0 (J)*
			Butanol[1-]	13.0
			Butanone[2-]	4.30
			Dichloroethane[1,1-]	7.60
			Dichloroethene[1,1-]	13.0
			Ethyltoluene[4-]	13.0
			Styrene	8.10
			Trichloroethane[1,1,1-]	80.0
			Trimethylbenzene[1,2,4-]	10.0
			Xylene[1,3-]+Xylene[1,4-]	13.0
	107–109	MD54-05-60359	Acetone	27.0 (J)*
			Butanone[2-]	2.80
			Dichloroethane[1,1-]	52.0
			Dichloroethene[1,1-]	95.0
			Propanol[2-]	8.90
			Styrene	220
			Tetrachloroethene	44.0
			Toluene	30.0
			Trichloroethane[1,1,1-]	440
			Trichloroethene	12.0
			Xylene[1,3-]+Xylene[1,4-]	8.40
54-24384	10–12	MD54-05-60327	Acetone	58.0 (J)*
			Dichloroethane[1,1-]	4.40
			Dichloroethene[1,1-]	9.20
			Propanol[2-]	77.0

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m^3)
54-24384 (continued)	10–12	MD54-05-60327	Styrene	130
			Toluene	32.0
			Trichloroethane[1,1,1-]	68.0
			Trichloroethene	47.0
			Xylene[1,3-]+Xylene[1,4-]	12.0
	65–67	MD54-05-60326	Acetone	112
			Dichloroethane[1,1-]	113
			Dichloroethene[1,1-]	285
			Hexane	5.64
			Methyl-2-pentanone[4-]	16.8
			Tetrachloroethene	42.0
			Toluene	10.2
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	60.5
			Trichloroethane[1,1,1-]	1960
			Trichloroethene	41.9
			Xylene[1,3-]+Xylene[1,4-]	16.5
54-24385	30–32	MD54-05-60329	Dichloroethane[1,1-]	3880
			Dichloroethene[1,1-]	5550
			Tetrachloroethene	5630
			Toluene	162
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1070 (J+)*
			Trichloroethane[1,1,1-]	65400
			Trichloroethene	859
	134–136	MD54-05-60328	Dichloroethane[1,1-]	5660
			Dichloroethene[1,1-]	8320
			Tetrachloroethene	4880
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1070 (J+)*
			Trichloroethane[1,1,1-]	70900
			Trichloroethene	1130
54-24386	35–37	MD54-05-60331	Dichloroethane[1,1-]	4040
			Dichloroethene[1,1-]	4750
			Tetrachloroethene	1150
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	996 (J+)*
			Trichloroethane[1,1,1-]	98200
			Trichloroethene	1020
	156–158	MD54-05-60330	Dichloroethane[1,1-]	33200
			Dichloroethene[1,1-]	59400
			Tetrachloroethene	5490

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m^3)
54-24386 (continued)	156–158	MD54-05-60330	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5440 (J+)*
			Trichloroethane[1,1,1-]	447000
			Trichloroethene	8590
54-24387	10–11	MD54-05-60333	Acetone	51.0 (J)*
			Butanone[2-]	5.50
			Dichloroethene[1,1-]	5.00
			Ethyltoluene[4-]	13.0
			Styrene	16.0
			Toluene	7.80
			Trichloroethane[1,1,1-]	41.0
			Trichloroethene	20.0
			Trimethylbenzene[1,2,4-]	23.0
			Trimethylbenzene[1,3,5-]	5.50
			Xylene[1,2-]	5.80
			Xylene[1,3-]+Xylene[1,4-]	14.0
	80–82	MD54-05-60332	Acetone	123
			Butanone[2-]	9.43
			Dichloroethane[1,1-]	5.66
			Dichloroethene[1,1-]	7.53
			Ethanol	9.04
			Hexane	7.75
			Methyl-2-pentanone[4-]	9.83
			Toluene	13.9
			Trichloroethane[1,1,1-]	65.4
			Trichloroethene	29.0
			Trimethylbenzene[1,2,4-]	4.91
			Xylene[1,3-]+Xylene[1,4-]	20.8
54-24388	25–27	MD54-05-60335	Dichloroethane[1,1-]	2180
			Dichloroethene[1,1-]	2810
			Tetrachloroethene	2030
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	5590 (J)*
			Trichloroethane[1,1,1-]	125000
			Trichloroethene	2850
	129–131	MD54-05-60334	Dichloroethane[1,1-]	2670
			Dichloroethene[1,1-]	5150
			Tetrachloroethene	1970
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	7350 (J)*

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24388 (continued)	129–131	MD54-05-60334	Trichloroethane[1,1,1-]	125000
			Trichloroethene	4190
54-24389	20–22	MD54-05-60337	Acetone	13.0 (J)*
			Butanone[2-]	15.0
			Carbon Tetrachloride	16.0
			Chloroform	21.0
			Dichlorodifluoromethane	22.0
			Dichloroethane[1,1-]	28.0
			Dichloroethene[1,1-]	82.0
			Methyl-2-pentanone[4-]	7.90
			Styrene	85.0
			Tetrachloroethene	630
			Toluene	1200
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	320
			Trichloroethane[1,1,1-]	1700
			Trichloroethene	460
			Trichlorofluoromethane	12.0
			Xylene[1,3-]+Xylene[1,4-]	6.60
	147–149	MD54-05-60336	Acetone	35.0 (J)*
			Butanone[2-]	28.0
			Carbon Tetrachloride	23.0
			Chloroform	42.0
			Dichlorodifluoromethane	110
			Dichloroethane[1,1-]	92.0
			Dichloroethene[1,1-]	310
			Methyl-2-pentanone[4-]	14.0
			Methylene Chloride	27.0
			Styrene	70.0
			Tetrachloroethene	920
			Toluene	2600
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	590
			Trichloroethane[1,1,1-]	3700
			Trichloroethene	1100
			Trichlorofluoromethane	57.0
54-24390	30–32	MD54-05-60339	Dichloroethane[1,1-]	2180
			Dichloroethene[1,1-]	3250
			Tetrachloroethene	1360
			Toluene	365

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24390 (continued)	30–32	MD54-05-60339	Trichloro-1,2,2-trifluoroethane[1,1,2-]	21400 (J)*
			Trichloroethane[1,1,1-]	142000
	158–160	MD54-05-60338	Dichloroethane[1,1-]	1420
			Dichloroethene[1,1-]	3680
			Tetrachloroethene	2370
			Toluene	678
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	19100 (J)*
			Trichloroethane[1,1,1-]	109000
			Trichloroethene	644
54-24391	25–27	MD54-05-60341	Dichloroethane[1,1-]	324
			Dichloroethene[1,1-]	325
			Styrene	97.9
			Tetrachloroethene	2780
			Toluene	377
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1530 (J+)*
			Trichloroethane[1,1,1-]	22400
			Trichloroethene	140
			Trichlorofluoromethane	432
	165–167	MD54-05-60340	Dichloroethane[1,1-]	186
			Dichloroethene[1,1-]	475
			Styrene	72.4
			Tetrachloroethene	949
			Toluene	829
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1150 (J+)*
			Trichloroethane[1,1,1-]	7630
			Trichloroethene	193
			Trichlorofluoromethane	376
54-24392	25–27	MD54-05-60343	Acetone	13.0 (J)*
			Butanone[2-]	12.0
			Dichlorodifluoromethane	20.0
			Dichloroethane[1,1-]	14.0
			Dichloroethene[1,1-]	40.0
			Methyl-2-pentanone[4-]	6.40
			Styrene	60.0
			Tetrachloroethene	140
			Toluene	880
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	31.0
			Trichloroethane[1,1,1-]	580

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24392 (continued)	25–27	MD54-05-60343	Trichloroethene	150
			Trichlorofluoromethane	12.0
			Xylene[1,3-]+Xylene[1,4-]	4.60
	144–146	MD54-05-60342	Acetone	36.0 (J)*
			Butanone[2-]	18.0
			Carbon Disulfide	4.50
			Chloroform	10.0
			Dichlorodifluoromethane	100
			Dichloroethane[1,1-]	35.0
			Dichloroethene[1,1-]	170
			Methyl-2-pentanone[4-]	8.20
			Methylene Chloride	4.80
			Styrene	66.0
			Tetrachloroethene	210
			Toluene	970
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	190
			Trichloroethane[1,1,1-]	1300
			Trichloroethene	220
			Trichlorofluoromethane	51.0
			Xylene[1,3-]+Xylene[1,4-]	14.0
54-24393	35–37	MD54-05-60345	Chlorodifluoromethane	3890
			Chloroform	29.3
			Dichlorodifluoromethane	1930
			Dichloroethane[1,1-]	190
			Dichloroethene[1,1-]	174
			Styrene	59.6
			Tetrachloroethene	305
			Toluene	414
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	4370 (J)*
			Trichloroethane[1,1,1-]	4420
			Trichloroethene	156
			Trichlorofluoromethane	1120
			Xylene[1,3-]+Xylene[1,4-]	60.8
	156–158	MD54-05-60344	Chlorodifluoromethane	2050
			Chloroform	18.1
			Dichlorodifluoromethane	2080
			Dichloroethane[1,1-]	194
			Dichloroethene[1,1-]	317

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24393 (continued)	156–158	MD54-05-60344	Methylene Chloride	13.9
			Styrene	15.8
			Tetrachloroethene	393
			Toluene	226
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	4440 (J)*
			Trichloroethane[1,1,1-]	4800
			Trichloroethene	193
			Trichlorofluoromethane	1240
54-24394	50–52	MD54-05-61749	Chloroform	150
			Dichlorodifluoromethane	1100
			Dichloroethane[1,1-]	1600
			Dichloroethene[1,1-]	930
			Tetrachloroethene	640
			Toluene	95.0
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	21000
			Trichloroethane[1,1,1-]	18000
			Trichloroethene	32000
			Trichlorofluoromethane	2200
	163–165	MD54-05-61748	Chloroform	120
			Dichlorodifluoromethane	1900
			Dichloroethane[1,1-]	960
			Dichloroethene[1,1-]	740
			Methylene Chloride	46.0
			Tetrachloroethene	580
			Toluene	120
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	9200
			Trichloroethane[1,1,1-]	13000
			Trichloroethene	12000
			Trichlorofluoromethane	2500
54-24395	40–42	MD54-05-60349	Bromodichloromethane	26.1
			Chloroform	73.2
			Dichlorodifluoromethane	1580
			Dichloroethane[1,1-]	48.5
			Methylene Chloride	11.8
			Tetrachloroethene	183
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	5280 (J)*
			Trichloroethane[1,1,1-]	4360
			Trichloroethene	134
			Trichlorofluoromethane	3870

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24395 (continued)	170–172	MD54-05-60349	Acetone	112
			Bromodichloromethane	23.4
			Chloroform	48.8
			Dichlorodifluoromethane	1090
			Dichloroethane[1,1-]	34.4
			Dichloropropane[1,2-]	18.0
			Methanol	301
			Methylene Chloride	30.9
			Tetrachloroethene	149
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	2680 (J)*
			Trichloroethane[1,1,1-]	2560
			Trichloroethene	172
			Trichlorofluoromethane	2250
54-24396	10–12	MD54-05-60351	Acetone	126
			Dichloroethane[1,1-]	80.9
			Dichloroethene[1,1-]	242
			Dichloropropane[1,2-]	24.5
			Methylene Chloride	16.7
			Tetrachloroethene	156
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1530 (J)*
			Trichloroethane[1,1,1-]	4470
			Trichloroethene	231
			Trichlorofluoromethane	61.8
	131–133	MD54-05-60350	Acetone	109
			Dichloroethane[1,1-]	166
			Dichloroethene[1,1-]	674
			Dichloropropane[1,2-]	32.3
			Methylene Chloride	34.7
			Tetrachloroethene	291
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	2530 (J)*
			Trichloroethane[1,1,1-]	7090
			Trichloroethene	537
			Trichlorofluoromethane	157
54-24397	15–17	MD54-05-60353	Acetone	209
			Butanone[2-]	7.37
			Dichloroethane[1,1-]	36.0
			Dichloroethene[1,1-]	119

Table B-3.1-2 (continued)

Borehole Location	Depth (ft)	Sample ID	Analyte	Result (µg/m³)
54-24397 (continued)	15–17	MD54-05-60353	Dichloropropane[1,2-]	17.1
			Methylene Chloride	10.1
			Tetrachloroethene	94.9
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1380 (J+)*
			Trichloroethane[1,1,1-]	2290
			Trichloroethene	80.6
			Trichlorofluoromethane	44.4
	125–127	MD54-05-60352	Acetone	147
			Butanone[2-]	7.37
			Dichloroethane[1,1-]	44.5
			Dichloroethene[1,1-]	214
			Dichloropropane[1,2-]	20.3
			Methylene Chloride	11.1
			Tetrachloroethene	81.3
			Toluene	13.6
			Trichloro-1,2,2-trifluoroethane[1,1,2-]	1150 (J+)*
			Trichloroethane[1,1,1-]	2400
			Trichloroethene	107
			Trichlorofluoromethane	67.4
54-24523	485–700	MD54-05-60366	Acetone	71.2
			Butanone[2-]	5.89
			Toluene	7.53

* Data qualifier definitions are included in Appendix A.

Table B-3.1-3
Tritium Detected in 2005 Pore-Gas Samples Collected from MDA G

Borehole Location	Depth (ft)	Sample ID	Result*	Units
54-24361	30–32	MD54-05-61531	26,348	pCi/L
	138–140	MD54-05-61530	7372	pCi/L
54-24362	35–37	MD54-05-61533	56,407	pCi/L
	135–137	MD54-05-61532	54,716	pCi/L
54-24363	12–14	MD54-05-61534	48,251	pCi/L
54-24364	65–67	MD54-05-61537	11,656	pCi/L
	130–132	MD54-05-61536	11,824	pCi/L
54-24366	12–14	MD54-05-61538	72,696	pCi/L
54-24367	30–31	MD54-05-61541	191,464	pCi/L
	153–155	MD54-05-61540	14,564	pCi/L
54-24368	95–97	MD54-05-61543	3757	pCi/L
	192–194	MD54-05-61542	7241	pCi/L
54-24369	65–67	MD54-05-61545	27,214	pCi/L
	184–186	MD54-05-61544	6788	pCi/L
54-24371	40–42	MD54-05-61549	8256	pCi/L
	141–143	MD54-05-61548	13,460	pCi/L
54-24372	55–57	MD54-05-61551	12,062	pCi/L
	185–187	MD54-05-61550	10,406	pCi/L
54-24373	65–67	MD54-05-60305	9159	pCi/L
	187–189	MD54-05-60304	3007	pCi/L
54-24374	10–12	MD54-05-61555	7,151,180	pCi/L
	139–141	MD54-05-61554	357,367	pCi/L
54-24375	30–32	MD54-05-61557	14,557	pCi/L
	157–159	MD54-05-61556	4726	pCi/L
54-24376	158–160	MD54-05-61558	46,766	pCi/L
54-24377	150–152	MD54-05-61560	31,117	pCi/L
54-24378	30–32	MD54-05-61563	7,746,915	pCi/L
	136–138	MD54-05-61562	2,500,041	pCi/L
54-24379	20–22	MD54-05-61565	8518	pCi/L
	144–146	MD54-05-61564	56,704	pCi/L
54-24380	20–22	MD54-05-61567	5289	pCi/L
	155–157	MD54-05-61566	4739	pCi/L
54-24381	15–17	MD54-05-61569	10,575	pCi/L
	143–145	MD54-05-61568	8046	pCi/L
54-24382	28–29	MD54-05-61571	5129	pCi/L
	107–109	MD54-05-61570	13,291	pCi/L
54-24383	10–11	MD54-05-60325	4194	pCi/L

Table B-3.1-3 (continued)

Borehole Location	Depth (ft)	Sample ID	Result*	Units
54-24384	10–12	MD54-05-60327	11,593	pCi/L
	65–67	MD54-05-60326	981	pCi/L
54-24385	30–32	MD54-05-61577	883,169	pCi/L
	134–136	MD54-05-61576	32,526	pCi/L
54-24386	35–37	MD54-05-61579	15,465,802	pCi/L
	156–158	MD54-05-61578	384,049	pCi/L
54-24387	10–11	MD54-05-60333	5873	pCi/L
54-24388	25–27	MD54-05-61583	276,187	pCi/L
54-24389	20–22	MD54-05-61584	13,678	pCi/L
	147–149	MD54-05-61585	7110	pCi/L
54-24390	30–32	MD54-05-61587	12,172	pCi/L
	158–160	MD54-05-61586	4194	pCi/L
54-24391	25–27	MD54-05-61589	9420	pCi/L
	165–167	MD54-05-61588	14,860	pCi/L
54-24392	25–27	MD54-05-61591	12,381	pCi/L
	144–146	MD54-05-61590	8595	pCi/L
54-24393	35–37	MD54-05-61593	3379	pCi/L
54-24394	163–165	MD54-05-61594	2535	pCi/L
54-24396	131–133	MD54-05-61598	30,035	pCi/L
54-24397	15–17	MD54-05-61601	2,936,902	pCi/L
54-25105	485–700	MD54-05-61604	11,588	pCi/L

* Tritium pore-vapor concentrations have been corrected for silica gel bound water (Marczak 2009, 106500).

Table B-3.1-4
Gravimetric Moisture Content and Matric Potential in Samples Collected from MDA G at BH 54-25423

Sample Number	Sample Depth (ft)	Matrix	Gravimetric Moisture Content (%, g/g)	Matric Potential (bars)
MD54-05-59235	11.5	Qbt 2	3.0	8.0
MD54-05-59237	22.0	Qbt 2	4.5	1.3
MD54-05-59239	32.0	Qbt 2	2.1	2.9
MD54-05-59241	42.0	Qbt 2	4.8	6.0
MD54-05-59243	52.0	Qbt 2	6.4	2.0
MD54-05-59245	62.0	Qbt 2	2.4	4.0
MD54-05-59248	82.0	Qbt 1v	5.3	3.4
MD54-05-59250	92.0	Qbt 1vc	10.0	2.7
MD54-05-59252	102.0	Qbt 1g	10.8	5.0
MD54-05-59253	107.0	Qbt 1g	5.7	2.8
MD54-05-59255	117.0	Qbt 1g	5.4	2.9
MD54-05-59256	122.0	Qbt 1g	4.0	3.3
MD54-05-59258	142.0	Qbt 1g	6.4	3.0
MD54-05-59260	157.0	Qbt 1g	8.3	2.9
MD54-05-59261	162.0	Qbt 1g	7.8	2.1
MD54-05-59262	167.0	Qbt 1g	7.6	1.5
MD54-05-59264	177.0	Qct	6.1	2.4
MD54-05-59265	182.0	Qct	9.3	1.4
MD54-05-59266	185.0	Qct	7.3	4.9
MD54-05-59268	197.0	Qbog	27.2	0.6
MD54-05-59270	207.0	Tcb	0.4	48.0
MD54-05-59310	210.0	Tcb	1.2	3.7
MD54-05-59272	217.0	Tcb	2.7	19.6
MD54-05-59273	222.0	Tcb	2.1	2.1
MD54-05-59274	227.0	Tcb	0.7	7.9
MD54-05-59275	232.0	Tcb	0.5	14.8
MD54-05-59276	237.0	Tcb	0.2	95.1
MD54-05-59277	242.0	Tcb	0.4	27.6
MD54-05-59278	247.0	Tcb	2.1	50.6
MD54-05-59279	254.5	Tcb	0.9	7.3
MD54-05-59281	265.0	Tcb	0.2	15.1
MD54-05-59282	271.5	Tcb	1.4	5.5
MD54-05-59283	276.2	Tcb	0.8	15.7
MD54-05-59284	281.3	Tcb	2.1	1.1
MD54-05-59285	286.4	Tcb	0.7	11.6
MD54-05-59286	291.3	Tcb	1.6	2.4

Table 3.1-4 (continued)

Sample Number	Sample Depth (ft)	Matrix	Gravimetric Moisture Content (%, g/g)	Matric Potential (bars)
MD54-05-59287	296.1	Tcb	3.1	3.3
MD54-05-59289	301.1	Tcb	3.0	5.0
MD54-05-59288	301.5	Tcb	0.8	4.9
MD54-05-59291	316.7	Tcb	5.2	4.4
MD54-05-59292	321.8	Tcb	5.2	1.5
MD54-05-59293	326.9	Tcb	0.8	4.9
MD54-05-59294	331.6	Tcb	1.8	2.4
MD54-05-59295	336.0	Tcb	0.7	4.3
MD54-05-59296	341.9	Tcb	1.0	3.5
MD54-05-59297	346.8	Tcb	0.7	3.1
MD54-05-59298	351.0	Tcb	0.6	2.3
MD54-05-59299	356.9	Tcb	0.7	6.0
MD54-05-59301	366.9	Tcb	0.8	8.8
MD54-05-59302	371.4	Tcb	0.7	8.2
MD54-05-59303	376.1	Tcb	0.6	12.2
MD54-05-59304	381.3	Tcb	0.8	21.7
MD54-05-59305	386.7	Tcb	0.5	12.6
MD54-05-59306	391.6	Tcb	1.0	3.5
MD54-05-59307	396.7	Tcb	0.6	32.7
MD54-05-59308	401.4	Tcb	0.6	8.3
MD54-05-59309	407.0	Tcb	0.6	6.9
MD54-05-59311	436.5	Tcb	0.6	6.3
MD54-05-59312	456.7	Tcb	0.6	8.7
MD54-05-59313	482.3	Tcb	5.4	335.0
MD54-05-59314	494.0	Tcb	7.5	22.7
MD54-05-59315	545.0	Tcb	11.3	3.2

Table B-3.2-1
Summary of MDA G Supplemental Investigation
Pore-Gas Sampling Port Construction

Borehole ID	Sample Port Depths in ft (Unit Sampled)					
BH-2b (54-27436)	45 (Qbt 2)	70 (Qbt 1v)	115 (Qbt 1g)	163 (Qbo)	185 (Tb 4)	—*
BH-10 (54-24370)	40 (Qbt 2)	72.5 (Qbt 1v)	120 (Qbt 1g)	174.7 (Qct)	200 (Qbo)	243.7 (Tb 4)
BH-26 (54-24386)	40 (Qbt 2)	83 (Qbt 1g)	117 (Qct)	135 (Qbo)	195 (Tb 4)	—
BH-34 (54-24394)	50 (Qbt 2)	100 (Qbt 1v)	150 (Qbt 1g)	192.5 (Qct)	245.25 (Qbo)	300.5 (Tb 4)
BH-37 (54-24397)	50 (Qbt 1v)	90 (Qbt 1g)	130 (Qbt 1g)	165 (Qct)	188 (Qbo)	239.75 (Tb 4)

* — = Sixth sampling port not necessary.

Table B-3.2-2
MDA G Supplemental Investigation VOC Pore-Gas Results

Sample ID	Location ID	Depth Interval (ft)	Acetone	Butanone[2-]	Carbon Disulfide	Chlorodifluoromethane	Chloroethane	Chloroform	Cyclohexane	Dichlorodifluoromethane	Dichloroethane[1,1-]
MD54-07-75257	54-24370	35–45	—*	—	—	—	—	660	—	13000	15000
MD54-07-75258	54-24370	67.5–77.5	—	—	—	—	—	740	—	17000	18000
MD54-07-75259	54-24370	115–125	—	—	—	—	—	510	—	19000	12000
MD54-07-75260	54-24370	169.5–180	—	—	120	—	93	160	—	13000	4000
MD54-07-75262	54-24370	195–205	—	—	—	—	—	—	—	15000	3400
MD54-07-75261	54-24370	237.5–249.5	—	—	—	—	—	—	—	1500	240
MD54-07-75263	54-24386	37.5–42.5	—	—	2100	—	—	—	—	—	36000
MD54-07-75264	54-24386	80.5–86	—	—	1200	—	—	—	—	—	32000
MD54-07-75266	54-24386	115–120	2600	—	1300	—	—	—	—	—	32000
MD54-07-75265	54-24386	130–136	—	—	620	—	—	—	—	—	17000
MD54-07-75267	54-24386	191–201	—	—	—	—	—	—	—	—	1900
MD54-07-75268	54-24394	45–55	—	—	190	—	—	—	—	1400	2300
MD54-07-75269	54-24394	95–105	—	—	—	—	—	140	340	1500	1700
MD54-07-75270	54-24394	145–154.8	—	—	—	—	—	130	270	1900	1200
MD54-07-75271	54-24394	190–195	—	—	—	130	—	110	210	2200	760
MD54-07-75272	54-24394	240–250	—	—	—	140	—	71	150	2200	390
MD54-07-75273	54-24394	296.5–306.5	—	—	3.9	14	—	4.5	15	220	39
MD54-07-75251	54-27436	40–50	—	—	—	—	—	—	—	—	1100
MD54-07-75252	54-27436	65–75	—	—	—	—	—	—	—	—	1100
MD54-07-75253	54-27436	110–120	—	—	—	—	—	360	—	400	1200
MD54-07-75254	54-27436	160–166	—	—	—	—	—	330	—	290	940
MD54-07-75255	54-27436	180–191.5	20	4.6	—	—	—	34	27	64	130

Table B-3.2-2 (continued)

Sample ID	Location ID	Depth Interval (ft)	Dichloroethene[1,1-]	Dichloroethene[cis-1,2-]	Methylene Chloride	Tetrachloroethene	Toluene	Trichloro-1,2,2-trifluoroethane[1,1,2-]	Trichloroethane[1,1,1-]	Trichloroethene	Trichlorofluoromethane
MD54-07-75257	54-24370	35–45	5100	470	—	1900	—	44000	170000	21000	14000
MD54-07-75258	54-24370	67.5–77.5	7000	700	—	2100	—	50000	190000	26000	15000
MD54-07-75259	54-24370	115–125	6400	620	420	1500	—	39000	120000	16000	12000
MD54-07-75260	54-24370	169.5–180	4300	270	430	690	—	22000	53000	6000	7100
MD54-07-75262	54-24370	195–205	4900	280	460	740	—	23000	54000	6300	7900
MD54-07-75261	54-24370	237.5–249.5	630	15	37	120	170	2400	4900	560	800
MD54-07-75263	54-24386	37.5–42.5	41000	—	—	6500	—	4700	790000	6400	—
MD54-07-75264	54-24386	80.5–86	46000	—	—	6100	1200 (J)	4000	640000	7900	—
MD54-07-75266	54-24386	115–120	56000	—	—	5900	4700	2800	400000	8300	—
MD54-07-75265	54-24386	130–136	33000	—	—	3400	—	1600	240000	4800	—
MD54-07-75267	54-24386	191–201	3400	—	—	440	—	200	23000	600	—
MD54-07-75268	54-24394	45–55	1100	—	280	540	—	73000	32000	83000	3300
MD54-07-75269	54-24394	95–105	1100	—	—	450	—	28000	22000	30000	2600
MD54-07-75270	54-24394	145–154.8	1100	—	74	470	—	13000	16000	17000	2800
MD54-07-75271	54-24394	190–195	990	—	60	480	—	9000	13000	9400	3100
MD54-07-75272	54-24394	240–250	980	—	58	380	—	6000	9100	4200	3000
MD54-07-75273	54-24394	296.5–306.5	180	—	—	45	—	470	880	290	250
MD54-07-75251	54-27436	40–50	860	—	—	10000	—	1500	21000	190000	—
MD54-07-75252	54-27436	65–75	910	—	—	7300	—	1400	20000	130000	—
MD54-07-75253	54-27436	110–120	730	—	230	3900	—	910	16000	56000	—
MD54-07-75254	54-27436	160–166	680	—	100	1300	—	440	10000	21000	—
MD54-07-75255	54-27436	180–191.5	230	—	10	160	—	120	1700	1800	31

Note: All values are reported in µg/m^3.

* — = Concentration (µg/m^3) was below the method detection limit for the analyte.

Table B-3.2-3
MDA G Supplemental
Investigation Tritium Pore-Gas Results

Borehole ID	Sample Depth Interval (ft)	Sample ID	Result (pCi/L)*
BH-37 (54-24397)	45–55	MD54-07-75283	8,960,000
	84–95	MD54-07-75284	1,072,000
	125–135	MD54-07-75285	540,000
	160–168	MD54-07-75286	107,800
	194–192	MD54-07-75287	205,600
	232.5–244	MD54-07-75288	3500

* Tritium pore-vapor concentrations have been corrected for silica gel bound water (Marczak 2009, 106500).

Appendix C

Volatile Organic Compound Contaminant Screening Method and Soil-Vapor Plume Characteristics

C-1.0 INTRODUCTION

This appendix describes the methodology used to screen vapor-phase volatile organic compounds (VOCs) detected in the vadose zone beneath Material Disposal Area (MDA) G. The Compliance Order on Consent (the Consent Order) does not specifically address cleanup standards, screening levels (SLs), or other regulatory criteria for soil vapor. A screening method that compares vapor-phase concentrations with screening values (SVs) is presented in the periodic monitoring reports for vapor-sampling activities at the Los Alamos National Laboratory (the Laboratory) (e.g., LANL 2010, 108496) and is discussed below as a Tier I screening evaluation. Although volatile organic compounds (VOCs) fall below these SVs at some sites (e.g., at MDA H), many VOCs exceed the SV at MDA G. Therefore, a two-tiered screening approach is applied at MDA G to further identify vapor-phase VOCs and vadose-zone concentrations that could potentially affect groundwater at concentrations exceeding applicable cleanup levels (Figure C-1.0-1). The screening process utilizes all data from a select period of record and is initially inclusive of constituents with low frequency of detection or other variables that are considered later in the screening process as part of an uncertainty analysis. The screening approach is demonstrated using the most recently reported soil-vapor monitoring data from MDA G (LANL 2010, 108496). The Tier I methodology is extremely conservative and does not consider dilution or attenuation. If Tier I SLs are not exceeded, VOCs would not be able to contaminate groundwater above cleanup levels, and no further screening is necessary. If Tier I SLs are exceeded, less conservative, more realistic screening using the Tier II method should be performed.

- For the Tier I screen, the method uses Henry's law to identify the vapor-phase VOC concentration threshold that would have to be exceeded for a given VOC to potentially impact the groundwater at concentrations exceeding applicable groundwater standards. If the Tier I SL is exceeded for a given VOC, the Tier II screen is applied.
- For the Tier II screen, the analysis considers the migration of the VOCs to the water table and subsequent mixing with groundwater. This analysis includes migration of VOCs through the vadose zone in both the pore water and vapor phases. The resulting groundwater concentration following mixing immediately beneath the site is calculated and compared with applicable groundwater standards. If that calculated groundwater concentration exceeds a standard, further evaluation of the soil-vapor data is required to assess the potential impact that the particular VOC may have on groundwater.

The screening approach is presented below in section C-2.0 using soil-vapor data collected during fiscal year (FY) 2009 and presented in the MDA G periodic monitoring report for vapor-sampling activities (LANL 2010, 109955). The results of the two-tiered screening process identified four VOCs of potential concern: 1,1-dichloroethene (DCE), tetrachloroethene (PCE), 1,1,1-trichloroethane (TCA), and trichloroethene (TCE). In addition, Tier II screening concentrations are calculated for all VOCs that have been detected at MDA G over the last four sampling events. In section C-3.0, the characteristics of the four VOCs within the subsurface vapor plume at MDA G are summarized based on their current distributions and their behavior with time. Section C-4.0 briefly describes the VOC transport mechanisms at MDA G.

C-2.0 SCREENING METHODOLOGY

C-2.1 Tier I Soil-Vapor Screen Based on Henry's Law Partitioning

As part of ongoing soil-vapor monitoring activities at MDA G, the proposed Tier I screening analysis is conducted to evaluate the potential for contamination of groundwater by VOCs in soil vapor using SLs based on groundwater cleanup levels in the Consent Order. The analysis evaluates the groundwater concentration that would be in equilibrium with the maximum soil-vapor concentrations of VOCs detected at MDA G if the soil-vapor concentration were in equilibrium with ground water according to Henry's law partitioning. The equilibrium between air and water concentrations is described by the following equation:

$$C_{water} = C_{air}/H ,$$ **Equation C-2.1-1**

where C_{water} = the volumetric concentration of the contaminant in water,

C_{air} = the volumetric concentration of the contaminant in air (or soil vapor), and

H = the dimensionless Henry's law constant.

If the predicted concentration of a particular VOC in groundwater is less than the SL, then no potential exists for exceedances of groundwater cleanup levels.

Because no SLs for soil vapor address the potential for groundwater contamination, the screening evaluation is based on groundwater standards or tap water SLs and the Henry's Law constant that describe the equilibrium between vapor and water concentrations. The source of Henry's Law constant is the New Mexico Environment Department's (NMED's) technical background document (NMED 2009, 106420) or the U.S. Environmental Protection Agency (EPA) regional screening tables (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/ressoil_sl_table_run_MAY2010.pdf). The preceding link contains the most current Henry's law constant. The following dimensionless form of Henry's law constant is used:

$$H = \frac{C_{air}}{C_{water}} .$$ **Equation C-2.1-2**

Equation C-2.1-2 can be used to calculate the following SV:

$$SV = \frac{C_{air}}{1000 \times H \times SL} ,$$ **Equation C-2.1-3**

where C_{air} = the concentration of a particular VOC in the soil-vapor sample (µg/m^3),

SL = the screening level (µg/L), and

1000 = a conversion factor [to convert liters (L) to cubic meters (m^3)].

The SLs are the groundwater standards or tap water SLs. The groundwater standards are either the EPA maximum contaminant levels (MCL) or New Mexico Water Quality Control Commission (NMWQCC) groundwater standards, whichever are lower. If there are no MCLs or NMWQCC standards, the EPA regional tap water SL (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/ressoil_sl_table_run_MAY2010.pdf) is used and adjusted to 10^{-5} risk for carcinogens. The numerator in Equation C-2.1-3 represents the actual concentration of the VOC in soil vapor, and the denominator represents the concentration of the VOC in soil vapor needed to exceed the SL. Therefore, if the SV is less than 1, the concentration of the VOC in soil vapor will not exceed the SL, even if the VOC plume is in direct contact with groundwater.

Table C-2.1-1 presents the calculated concentrations of contaminants in soil vapor corresponding to groundwater SLs for the Tier 1 screening. Table C-2.1-2 presents the results of the Tier I screen for the fiscal year (FY) 2009 soil-vapor data collected at MDA G (LANL 2010, 108496). Five VOCs were identified in the Tier I screen.

C-2.2 Tier II Soil-Vapor Screen Based on Mixing and Dilution in the Regional Aquifer

Constituents identified in the Tier I screen, are further evaluated using a Tier II screening analysis. The Tier I SVs presented in Table C-2.1-1 basically assume that vapors present in the vadose zone located several hundred feet above the water table are in equilibrium with groundwater. However, the vapors must actually migrate downward to the water table and then mix with groundwater. If contaminants reach the water table of the regional aquifer, they will mix with the clean groundwater flowing under ambient flux conditions, and contaminants will be diluted. The resulting contaminant concentration in the groundwater is therefore lower than at the source in the vadose zone. A dimensionless dilution factor is used to account for this process, and its application is described by EPA and in other regulatory documents (EPA 1996, 059902; NMED 2006, 092513). The factor can be used to estimate the groundwater impact in the process of evaluating and selecting remedies.

When contaminants migrate through the vadose zone in the water phase, the following equation can be applied to calculate the dimensionless dilution factor for water-phase transport (F_{dw}):

$$F_{dw} = \frac{C_{wt}^{w}}{C_{aq}^{w}} = 1 + \frac{kI\,d_m}{RL}$$ **Equation C-2.2-1**

where C_{wt}^{w} is the contaminant concentration in the infiltrating water [M/L^3], C_{aq}^{w} is the contaminant concentration in the regional aquifer within the mixing zone [M/L^3], I is the hydraulic gradient in the regional aquifer [L/L], R is the infiltration rate through the vadose zone [L/T], L is the length of the source at the top of the regional aquifer parallel to ground water flow, [L], k is the aquifer hydraulic conductivity [L/T], d_m is aquifer mixing zone depth [L], which is calculated as:

$$d_m = \begin{cases} if\ d_a \le d_c & d_a \\ if\ d_a > d_c & d_c \end{cases}$$ **Equation C-2.2-2**

where

$$d_c = 0.1058300524L + d_a\left(1 - \exp\left(-\frac{RL}{kI\,d_a}\right)\right)$$ **Equation C-2.2-3**

and d_a [L] is the aquifer thickness where the mixing is expected to occur (e.g., well-screen length) and d_c [L] is the computed depth within which the contaminants are expected to migrate. If $d_a > d_c$, a conservative assumption is made that the mixing zone is equal to the well screen. Equations C-2.2-1, C-2.2-2, and C-2.2-3 are based on EPA guidance document (EPA 1996, 059902; Equations 37 and 45, respectively). They account for the impact of infiltration, which carries the contaminants, on the structure of groundwater flow in the regional aquifer.

If the contaminants migrate through the vadose zone in the vapor phase, then diffusion of contaminants through the vadose zone and partitioning of the contaminants at the water table should be taken into account. In the case of contaminant diffusion through the vadose zone, the water table can be viewed as a boundary at which contaminants leave the vadose zone and migrate into the regional aquifer. The diffusive flux depends on the contaminant concentrations at the vadose-zone source and at the water table. When the groundwater flux along the water table is relatively slow compared to diffusive vapor flux in the vadose zone, it is important to account for the contaminant concentration at the water table (the concentration is initially zero but will increase with time).

Diffusion coefficients [L^2/T] in air, D_a, and water, D_w, are available to characterize migration of contaminants at MDA G in the free air and water phases, respectively. The values for the air diffusion coefficients were either estimated using the EPA calculator (http://www.epa.gov/athens/learn2model/part-two/onsite/estdiffusion-ext.html) or taken from already-published reports (LANL 2010, 110852). These coefficients can be modified to account for diffusion through a porous medium using the following equation (Millington and Quirk 1961, 110521):

$$D_{gp} = D_g \frac{(n-\theta)^{10/3}}{n^2}$$ **Equation C-2.2-4**

$$D_{wp} = D_w n^{4/3}$$ **Equation C-2.2-5**

where n is porosity of the porous medium [L^3/L^3], and θ [L^3/L^3] is the volumetric water content.

Henry's law defines the amount of the gas-phase (soil-vapor) contaminant that will be dissolved in the regional groundwater, as defined by Equation C-2.1-1. At the water table, Henry's law is expressed using the concentrations of the gas, C^g_{wt} [M/L^3], and the water, C^w_{wt} [M/L^3], phases along the regional water table at equilibrium:

$$C^w_{wt} = \frac{C^g_{wt}}{H}$$ **Equation C-2.2-6**

where *H* is the dimensionless Henry's law constant. Henry's law constant depends on the properties of the VOC (e.g., its volatility) and on the temperature and pressure.

Truex et al. (2009, 108331) have proposed a technique to compute the dimensionless dilution factor of the vapor-phase contaminants (F_{dg}) next to the water table into the regional aquifer:

$$F_{dg} = \frac{C^g_{wt}}{C^w_{dg}} = \frac{2Hd_a}{d_m}$$ **Equation C-2.2-7**

where the mixing zone depth is calculated as

$$d_m = \sqrt{\frac{2d_a D_{wp}}{Rr}}$$ **Equation C-2.2-8**

It is important to note that the mixing zone is created by molecular diffusion only. Truex et al. (2009, 108331) also proposed an approach to compute the dilution factor of the vapor-phase contaminants into the regional aquifer taking into account diffusion of the contaminant in the vadose zone under steady-state conditions:

$$F_{dg} = \frac{C^g_{vz}}{C^w_{dg}} = \frac{2Hd_a\left[1 + \frac{d_{vz}}{Hd_a D_{gp}}\sqrt{\frac{Rrd_a D_{wp}}{2}}\right]}{d_m}$$ **Equation C-2.2-9**

where d_{vz} is the vertical distance between the vapor contaminant source and the regional water table (if the contaminant source is at the ground surface, it will be the thickness of the vadose zone), and C^g_{vz} is the source vapor concentration in the vadose zone. A steady-state condition is a conservative assumption for the expected values for diffusion coefficients (0.1–0.01 m^2/d), vadose-zone thickness (~250 m; the basalt section of the vadose zone is about 200 m), and available time for contaminant migration through the vadose zone (approximately 20 to 50 yr). Equation C-2.2-9 takes into account the impact of the vapor-contaminant concentration at the water table on the diffusive flux of the vapor-phase contaminants occurring through the vadose zone. However, it does not account for aquifer dispersion. If vertical dispersion causes the plume to exceed the aquifer thickness under consideration in this analysis, the dispersion will increase mixing in the regional aquifer. However, this is not expected to occur within the current range of aquifer thickness values considered (aquifer thickness greater than 3 m). On the other hand, dispersion in the aquifer may increase the vapor-phase contaminant flux since it will decrease the contaminant concentration in the liquid phase at the water table, which will decrease the contaminant concentration in the vapor phase adjacent to the regional water table (the fractionation between the vapor and liquid-phase concentrations at the water table interface is assumed to be at steady-state and controlled by the Henry's law constant). As a result, it is not expected that the vertical dispersion will increase vertical mixing of contaminants in the regional aquifer.

The analysis presented above follows the methodology of Truex et al (2009, 108331), which is based on an assumption that the considered thickness of the regional aquifer (d_a above; *U* in Truex et al [2009, 108331]) is equal to the lateral length of the source area parallel to ground water flow (*L*). However, this is not the case in the present analyses where the considered thickness of the regional aquifer is 3 m (~10 ft), representing the length of a typical monitoring screen in the regional aquifer beneath MDA G, and the source length is considered to be on the order of 100 m The source length is based on spatial analyses of the observed concentrations presented in section C-3.1; the analysis takes into account the spacing between vapor-monitoring wells because high concentrations are generally not observed in adjacent wells. As a result, Equation C-2.2-9 is modified accordingly:

$$F_{dg} = \frac{d_a}{L}\frac{2Hd_a\left[1+\frac{d_{vz}}{Hd_aD_{ep}}\sqrt{\frac{\pi Hd_aD_{wv}}{8}}\right]}{d_m}$$ **Equation C-2.2-10**

Equations C-2.2-1 and C-2.2-10 are used to calculate the dilution factors for various VOCs at MDA G migrating in the water and vapor phases, respectively. The dilution factors are applied to compute SVs for each VOC representing the contaminant concentrations in the vapor phase at the source that produce concentrations in the regional aquifer equal to the groundwater SLs for both the pore water and the vapor-phase pathways. The SV is then derived using the lower of the two values for a given VOC. Tier II specific SVs for MDA G are presented in Table C-2.1-1. If the currently observed contaminant concentration in the vapor phase is higher than the SV for a given VOC, this VOC fails the Tier II analysis, and it is a chemical of potential concern (COPC).

The Tier I analyses identified five VOCs as COPCs (Tables C-2.1-1 and C-2.1-2). These five VOCs are analyzed using the Tier II methodology for the pore water and vapor migration, as demonstrated in Table C-2.1-1. The table summarizes the information about the regional aquifer, vadose zone, and contaminants applied in the Tier II analysis to solve Equations C-2.2-1 and C-2.2-10. Table C-2.1-1 not only presents the Tier II analysis, it also defines the Tier II SLs for all VOC constituents detected at the site over the last four sampling rounds, as compiled in Table C-2.1-2. Based on the obtained SLs, four chemicals are COPCs after the Tier II analysis: 1,1-DCE; PCE; TCA; and TCE, as shown in Table C-2.1-2.

C-2.3 Additional Data Analysis and Uncertainty Evaluation

For those VOCs that do not pass the Tier II screen, additional data analysis and uncertainty evaluation are warranted (Figure C-1.0-1). This is the last step in the analysis and helps determine if a corrective measure is warranted.

Additional data analysis may include determining the frequency of detection of the particular chemical (i.e., is the problem persistent?) and/or the number of ports where the contaminant concentration exceeds the SL (i.e., how large is the affected area?). Additionally, more thorough evaluation of the data to determine the extent of the vapor-phase plume (is it approaching the regional aquifer?) and of time trends (are concentrations increasing or decreasing?) may provide additional information on the potential for impacting the regional aquifer. These kinds of analyses are presented below in section C-3.0. Data analyses using a numerical model of the vapor-phase plume can also be employed to estimate potential plume growth and associated uncertainties, although no numerical modeling is applied here. Some or all of these types of analyses might be performed depending on the vapor-plume characteristics.

C-3.0 CHARACTERISTICS OF THE SUBSURFACE VAPOR PLUME

This section investigates the characteristics of the VOC vapor plumes at MDA G. Four VOCs were identified as having the potential to impact groundwater during the Tier II screen: 1,1-DCE; PCE; TCA; and TCE. These same constituents also had the highest reported SVs in the most recent periodic monitoring report for vapor-sampling activities at MDA G (LANL 2010, 108496). According to the screening process (Figure C-1.0-1), additional data and uncertainty analysis for these constituents are warranted.

The data are interpreted using two methods. First, the current distributions of soil-vapor concentrations for the VOCs are assessed in section C-3.1. In addition, the current contaminant masses for TCA and TCE in the subsurface beneath MDA G are estimated based on the available field sampling. Defining both the distribution and the mass of VOCs is an important part of the design process for a soil-vapor extraction (SVE) system because these characteristics dictate the number and placement of extraction wells required to effectively capture the volatile contaminants, inform the proper placement of vapor-monitoring wells, and provide design criteria for an off-gas treatment system, if required.

Second, a summary of the time-history concentration data for the four VOCs is presented in section C-3.2 for those areas of MDA G at which the four VOCs (1,1-DCE, PCE, TCA, and TCE) exceed the Tier II SLs. The histories illustrate concentrations trends that are used to draw conclusions about the time-dependent nature of the sources. Data available from 1997 to the most current sampling event are used.

C-3.1 Distributions and Mass Estimates of VOCs in the Subsurface

This section presents estimates for the distributions of the contaminants from the Tier II screen and contaminant masses for TCA and TCE in the subsurface beneath MDA G. These estimates are calculated using soil-vapor data collected from vapor monitoring wells shown in Figure 2.4-4 of the corrective measures evaluation (CME) and based on vapor-sampling data gathered during the fourth quarter FY2009 sampling at MDA G (LANL 2010, 108496). A combination of analytical data and field SVs for TCA and TCE concentrations gathered at approximately 130 ports in 20 pore-gas monitoring boreholes and one open borehole are used in the analyses (Table 2.4-1 of the CME). For the other two constituents, analytical data from 42 ports in 20 pore-gas monitoring boreholes and one open borehole are used.

The distributions and mass estimates for TCA and TCE were developed as part of the supplemental SVE pilot test conducted at MDA G in May 2010 (LANL 2010, 109657) and are summarized below. The TCA and TCE mass estimates include distributions in three phases: soil vapor, dissolved into pore water, and adsorbed onto solid media, based on chemical partitioning. The mathematical approach and assumptions used to estimate the total VOC mass are included in the MDA G supplemental SVE pilot test report (LANL 2010, 109657). The same approach is also presented in the revised MDA L CME report (LANL 2010, 110852). The Tier II screening criteria presented in section C-2.2 were developed after the data analysis was developed for the supplemental SVE test. Multiples of the Tier I screening criteria (e.g., 10, 20, and 30 times the Tier I criteria) are used for many of the figures and in the discussion that follows.

The method estimates the TCE and TCA contaminant mass contained within an area defined by 10 times the Tier I vapor-phase concentration SV (Table C-3.1-1). The vapor concentrations equivalent to 10 times the Tier I screening limits are 423,000 $\mu g/m^3$ for TCA and 20,000 $\mu g/m^3$ for TCE (LANL 2010, 108496). These values exceed the calculated Tier II SVs of 74,500 $\mu g/m^3$ and 5100 $\mu g/m^3$ for TCA and TCE, respectively, presented in Table C-2.1-1, and a higher estimated mass would be calculated using these threshold values.

C-3.1.3 Summary of Current VOC Distributions

This section includes illustrations of the three-dimensional vapor-plume distributions for TCA and TCE as well as the mass estimates derived from the combination of those distributions with the overlapping geologic framework. Plan-view maps that illustrate the lateral extents of TCA and TCE are presented in Figures C-3.1-1 and C-3.1-2, respectively. The concentration contours shown in the plan views define the maximum extents of the plumes within the Tshirege Member of the Bandelier Tuff, where the highest concentrations were detected, rather than showing the contours at a specific elevation or depth. Figures C-3.1-3 and C-3.1-4 show east-west cross-sections through the TCA and TCE plumes, respectively.

Figure C-3.1-1 shows two areas of elevated TCA concentrations: a western area located near Pits 29 and 30, and an eastern area near Pits 2, 4, and 5. These areas are defined by one or two vapor-monitoring wells with maximum concentrations of approximately 20 times the Tier I SV. The highest TCA concentrations are located at the eastern side of MDA G.

Figure C-3.1-2 shows three areas of elevated TCE concentrations: a western area located near Pit 33, a central area near Pit 6, and a southeastern area near Pit 3. The TCE distribution is not particularly similar to that of TCA. Maximum concentrations in excess of 30 times the Tier I SV of 2000 $\mu g/m^3$ are present in the three areas. The highest TCE concentrations are located at the western side of MDA G.

Figures C-3.1-3 and C-3.1-4 show the TCA and TCE plumes, respectively, in cross-section. The TCA and TCE plumes are ellipsoidal in shape with vertical extents being greater than lateral extents. The plumes are almost entirely contained within the Bandelier Tuff with most of the plume mass constrained to the Tshirege Member, which makes up the upper 250 ft of the Bandelier Tuff at MDA G.

Mass estimates were calculated for the current plume distributions shown in Figures C-3.1-1 through C-3.1-4 (LANL 2010, 109657) and are presented in Table C-3.1-1. These estimates account for all three phases (pore gas, pore water, and adsorbed) and exclude regions where vapor-phase plumes were predicted to be less than 10 times the vapor-phase SVs. The estimated subsurface masses are 210 kg and 79 kg for TCA and TCE, respectively. Despite the greater overall extent of the TCE plumes, the overall mass of TCE is just over one-third of that determined for TCA. The breakdown of mass by geology reiterates that approximately 93% and 95% of the masses of TCA and TCE, respectively, are within the Tshirege Member of the Bandelier Tuff. The breakdown of mass according to geologic strata may be used to help guide the placement and length of screened intervals in extraction boreholes for maximizing the removal efficiency of the system.

Figure C-3.1-5 provides a map view of the overlapping plume extents for TCA and TCE based on a contour interval of 10 times the respective Tier I SV for each compound. The TCA and TCE plumes are, for the most part, not collocated so any SVE remedial actions may need to cover multiple areas across MDA G.

DCE(1,1-) and PCE were identified in the Tier II screen in addition to TCA and TCE. The Tier II SLs presented in Table C-2.1-2 are compared with the pore gas concentrations in Figure C-3.1-6 and show that these two constituents only exceed their Tier II SVs at the eastern side of MDA G near Pits 1 through 5. DCE(1,1-) exceeds its Tier II SV at seven monitoring boreholes: 54-24386, 54-22116, 54-02032, 54-01126, 54-02009, 54-01121, and 54-01128. PCE exceeds its Tier II SV at two monitoring boreholes—54-24386 and 54-22116.

C-3.2 Time-History Analyses of Soil-Vapor Concentrations

Time-history soil-vapor concentration data for the four VOCs identified during the Tier II screen (TCA; 1,1-DCE; TCE; and PCE,) were reviewed to discern time trends in concentrations. This review included analytical data from 20 vapor-monitoring boreholes at MDA G beginning in 1997. The period of record for some of these boreholes is, however, much shorter because several of the boreholes were installed between 2002 and 2005.

C-3.2.1 Eastern Plume Area Near Pits 1 Through 5

As noted above, the four VOCs (TCA, 1,1-DCE, TCE, and PCE) exceed the Tier II SVs at the eastern side of MDA G near Pits 1 through 5. The data from eight vapor-monitoring boreholes located in this area indicate that concentrations at this location are either generally decreasing or are variable, showing no clear trend. Two possible exceptions to this observation are at the shallowest ports in boreholes 54-24386 (37 ft) and 54-01121 (19 ft). However, these trends are uncertain because they are based on only five and four data points, respectively, and pore-gas data are naturally variable (ASTM 2006, 110404). Because concentrations remain higher than the Tier II SVs for the four VOCS some 40 to 50 yr after disposal units in this area were closed, this area is considered to be an ongoing source for VOC vapors, although the concentrations may be declining.

The concentrations and mass of TCA near the SVE pilot test area west of Pits 2 and 4 was evaluated using field-screening data from 2008 (just before the 2008 extraction test) and routine monitoring data in 2009. This analysis is presented in the report for the supplemental SVE pilot test (LANL 2010, 109657). The analysis showed that the maximum TCA concentration within the 2008 pilot test area decreased from over 30 times the Tier I SV before the test to between 20 and 25 times the SV 10 mo after the test. In addition, the TCA mass in the affected area remained reduced by approximately 44% compared with the pretest mass over the same period. This result indicates that although the TCA source may be continuing in this area, the SVE pilot test had a long-term impact within the radius of influence of the extraction well in terms of decreasing the mass and the maximum concentration of the TCA vapor plume.

C-3.2.2 Central Plume Area Near Pit 6

TCE exceeds the Tier II SV at the center of MDA G near Pit 6 at vapor-monitoring borehole 54-27436. The three other VOCs do not exceed their SVs at this location. The TCE data from this monitoring borehole indicates decreasing concentrations at the shallowest port (40 ft based on four data points) and potentially increasing concentrations at the deepest port (180 ft based on five data points). These trends are again considered to be uncertain because they are based on only few data points, and pore-gas data are variable (ASTM 2006, 110404). This area is considered to be a potentially ongoing source of limited extent for TCE vapors.

C-3.2.3 Western Plume Area Near Pits 29 and 33

TCA exceeds its Tier II SV at the western end of MDA G near Pit 29 at vapor monitoring borehole 54-24370. In addition, TCE exceeds its Tier II SV near Pit 29 at vapor-monitoring borehole 54-24370 and near Pit 33 at borehole 54-24394.The two other VOCs do not exceed their SVs at this location. Both the TCA and TCE data from these two monitoring boreholes indicate variable concentrations with no clear trend. This area is considered to be a potentially ongoing source with limited extent for TCA and TCE vapors.

C-4.0 VAPOR TRANSPORT AT MDA G

The sources of VOC vapors at MDA G are thought to be associated with mixed wastes disposed of in the pits and shafts at the site, with VOCs being a component of the waste rather than a primary waste form. The VOCS are not expected to be present in the waste disposal units as solvents in a liquid phase. The source may be ongoing because VOC vapors are emanating from mixed wastes contained in drums or other containers that limit their rate of escape. Volatilization of VOCs present in the waste will affect soil vapor located in fill material within the disposal units before diffusing further to subsurface soil vapor outside of the disposal units.

The conceptual model for vapor transport at MDA G is that VOCs in the waste or in pore water volatilize to form soil vapor as determined by Henry's law partitioning. It is likely that the previous vapor concentrations were higher than current levels because uncontainerized wastes would evaporate and enter the subsurface more readily than containerized wastes. Under natural conditions, the shape and growth of the plume are diffusion-driven. Vapor-phase diffusion is a relatively rapid process that is faster than unsaturated liquid flow at MDA G and accounts for the observed migration to depth of VOCs in soil vapor within the Bandelier Tuff (Stauffer et al. 2005, 090537). Diffusive growth is somewhat buffered by Henry's law partitioning; as the vapor plume migrates, it partitions into uncontaminated pore water, which acts as a sink for VOCs and, in turn, slows the diffusive process. Diffusion theoretically spreads contamination spherically along concentration gradients. However, topography plays a role in vapor transport at MDA G. With low vapor concentrations along the top and sides of the mesas, the steepest concentration gradients are toward the surface, which leads to preferential vapor transport toward the external mesa boundaries and yields releases to the atmosphere, as observed from the surface flux survey conducted at the site (Trujillo et al. 1998, 058242). Asphalt, which currently covers part of the site, decreases this mechanism somewhat because it partially blocks the vapors from exiting at the surface. Diffusive gradients also spread soil vapors downward toward the regional aquifer. Shallow vapors will tend to diffuse out of the mesa at the surface while deeper vapors may diffuse downward. Uniform diffusive behavior is thought to occur in the high porosity tuff.

It is uncertain if diffusion through the low-porosity, fractured Cerros del Rio basalt will be uniform or follow preferential pathways. Open, interconnected air pathways probably occur between the top of the Cerros del Rio volcanic series and the regional aquifer beneath MDA G (see Appendix E). The Cerros del Rio sequence is a stratified stack of massive lava flows separated by interflow breccias, cinder and scoria beds, and volcanic sediments. This volcanic sequence is made up of approximately 50% lavas and 50% porous interflow deposits. Lava flows (generally <20 ft thick) are separated by interflow breccias and thick deposits of porous cinder and scoria. Borehole video logs indicate the lavas are variably fractured. Air pathways in these volcanic rocks include high- and low-angle fractures in the massive lava flows and open interconnected pores in the breccias, cinders, scoria, and sediments. The basaltic sediments beneath the Cerros del Rio rocks consist of porous sands and gravels.

During active SVE, advective air flow also controls vapor-phase migration. Vacuum applied during extraction pulls air containing vapors toward and out of the borehole. During the SVE test at MDA G (see section 2.4.4), vapors were extracted near the higher-concentration area west of Pits 2, 4 and 5. This removal of higher concentration vapors can slow subsequent diffusion away from the source areas or even reverse gradients toward the extraction boreholes following SVE.

C-5.0 RESULTS

This appendix presents a two-tiered, risk-based screening approach to identify VOCs that could potentially impact the regional aquifer (Figure C-1.0-1). The screening approach is demonstrated using the most recently reported soil-vapor monitoring data from MDA G. As part of this screen, five VOC COPCs were identified using the Tier I screen; four VOC COPCs were identified by applying the Tier II screen. These four VOCs are TCA, TCE, 1,1-DCE, and PCE. Also, MDA G–specific Tier II SVs for soil-vapor concentrations were developed to use in future comparison of soil-vapor data.

Further data analyses, including spatial and temporal analyses, were performed on contaminant concentration data for the four VOCs identified during the Tier II screening process. The analysis identifies three comingled plume areas across MDA G.

- An eastern plume present near Pits 1 through 5 has concentrations of TCA, TCE, 1,1-DCE and PCE that exceed Tier II SVs. This area is considered to be an ongoing source of VOC vapors. However, the SVE pilot test conducted in 2008 had a long-term impact within the radius of influence of the extraction well in terms of decreasing the mass and the maximum concentration of the TCA vapor plume (LANL 2010, 109657).
- A central plume near Pit 6 has concentrations of TCE that exceed the Tier II SV. This area is considered to be a potentially ongoing source of limited extent for TCE vapors.
- A western plume near Pits 29 and 33 has concentrations of TCE and TCA (near Pit 29 only) that exceed their respective Tier II SVs. This area is considered to be a potentially ongoing source of limited extent for TCE and TCA vapors.

The sources of VOC vapors at MDA G are thought to be associated with mixed wastes disposed in the pits and shafts at the site, with VOCs being a component of the waste rather than a primary waste form. They are not expected to be present as a liquid phase. The source may be ongoing because VOC vapors are emanating from mixed wastes contained in drums or other containers that limit their rate of escape.

The mass distributions of TCA and TCE were calculated, and most mass (93% and 95% for TCA and TCE, respectively) is located within Tshirege Member of the Bandelier Tuff. However, uncertainty is associated with the vapor-phase diffusion of contaminants through the Cerros del Rio basalts toward the regional aquifer.

C-6.0 REFERENCES

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

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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Trujillo, V., R. Gilkeson, M. Morgenstern, and D. Krier, June 1998. "Measurement of Surface Emission Flux Rates for Volatile Organic Compounds at Technical Area 54," Los Alamos National Laboratory report LA-13329, Los Alamos, New Mexico. (Trujillo et al. 1998, 058242)

Tier I Screening

Use the existing Henry's Law calculation for an initial screen. If contaminant exceeds the Tier I Screen, then carry forward to the Tier II Evaluation. If contaminant does not exceed the Tier I Screen then there is no risk to groundwater and no problem warranting action.

Tier II Evaluation

Use a calculation for vapor-phase transport to the regional aquifer that takes into account unit-specific parameters. Contaminants that exceed the Tier II Evaluation are subjected to additional data analysis and uncertainty evaluation. Contaminants that do not exceed the Tier II Evaluation require no further action.

Additional Data Analysis and Uncertainty Evaluation

Additional data analysis and the uncertainty evaluation may include 3-Dimensional Modeling, frequency of detection, etc., and is used to support the remedial decision, as warranted.

Pore Gas Decision Analysis Flow-Chart

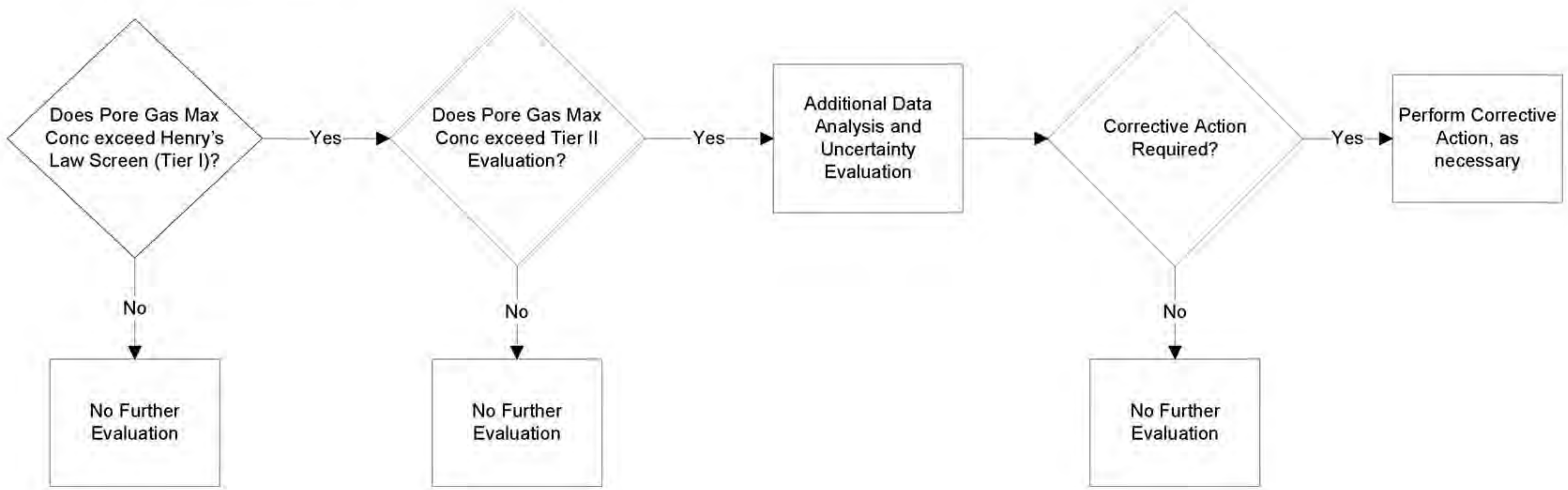

Figure C-1.0-1 Two-tiered screening method to identify vapor-phase VOCs that could potentially affect groundwater

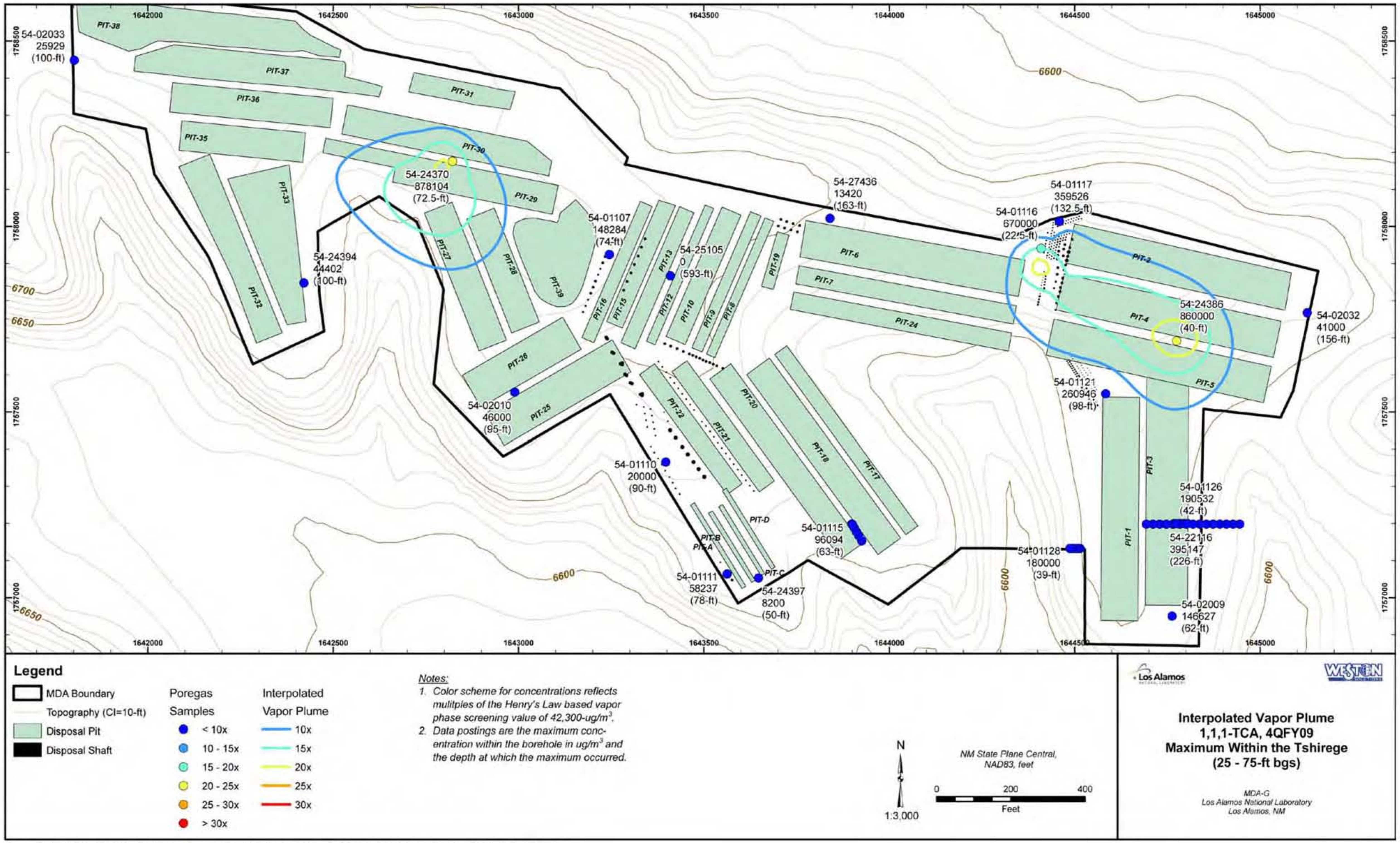

Figure C-3.1-1 Interpolated vapor plume for TCA at MDA G based on fourth quarter FY2009 data, maximum concentration within the Tshirege (25 to 75 ft below ground surface [bgs])

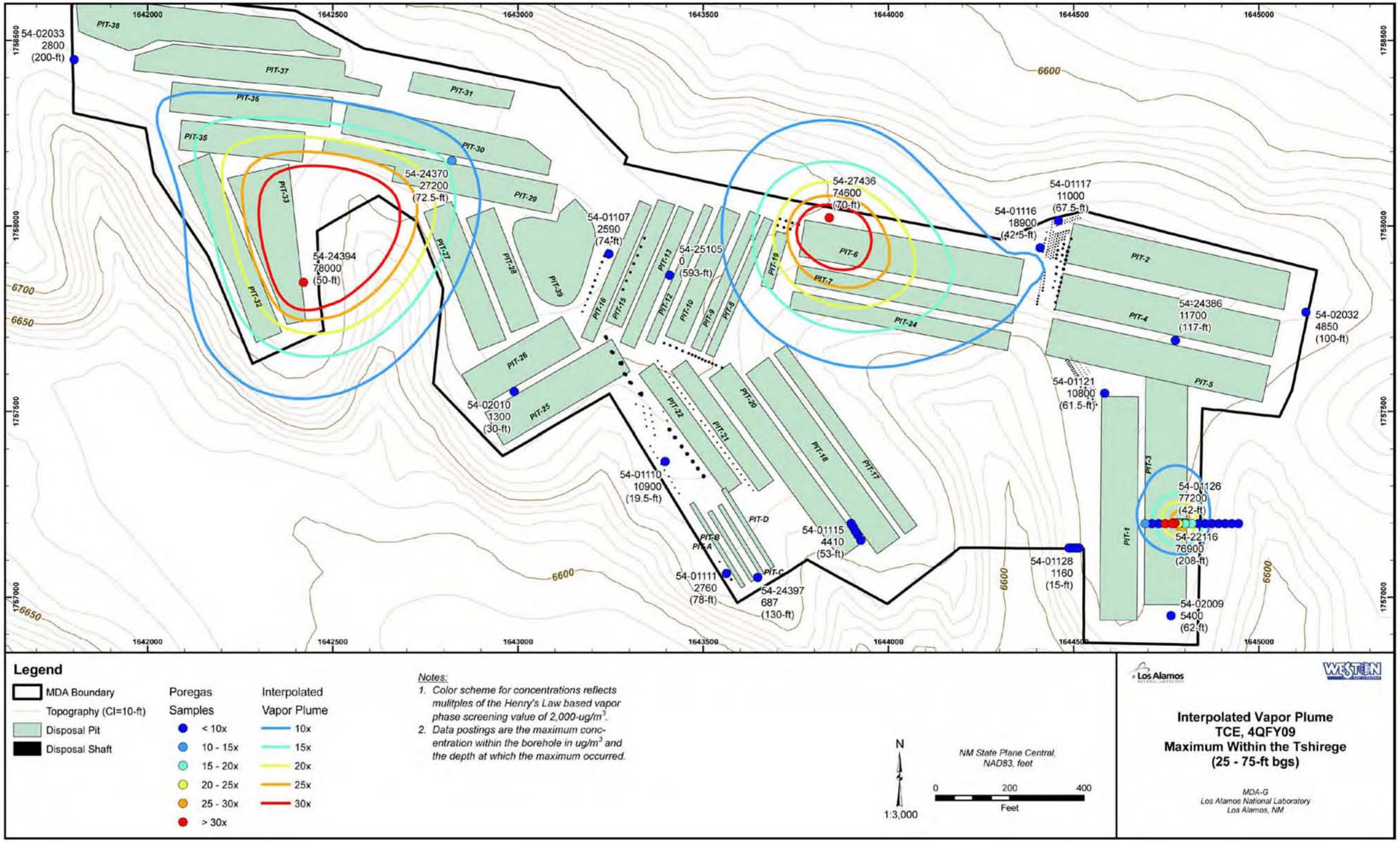

Figure C-3.1-2 Interpolated vapor plume for TCE at MDA G based on fourth quarter FY2009 data, maximum concentration within the Tshirege (25 to 75 ft bgs)

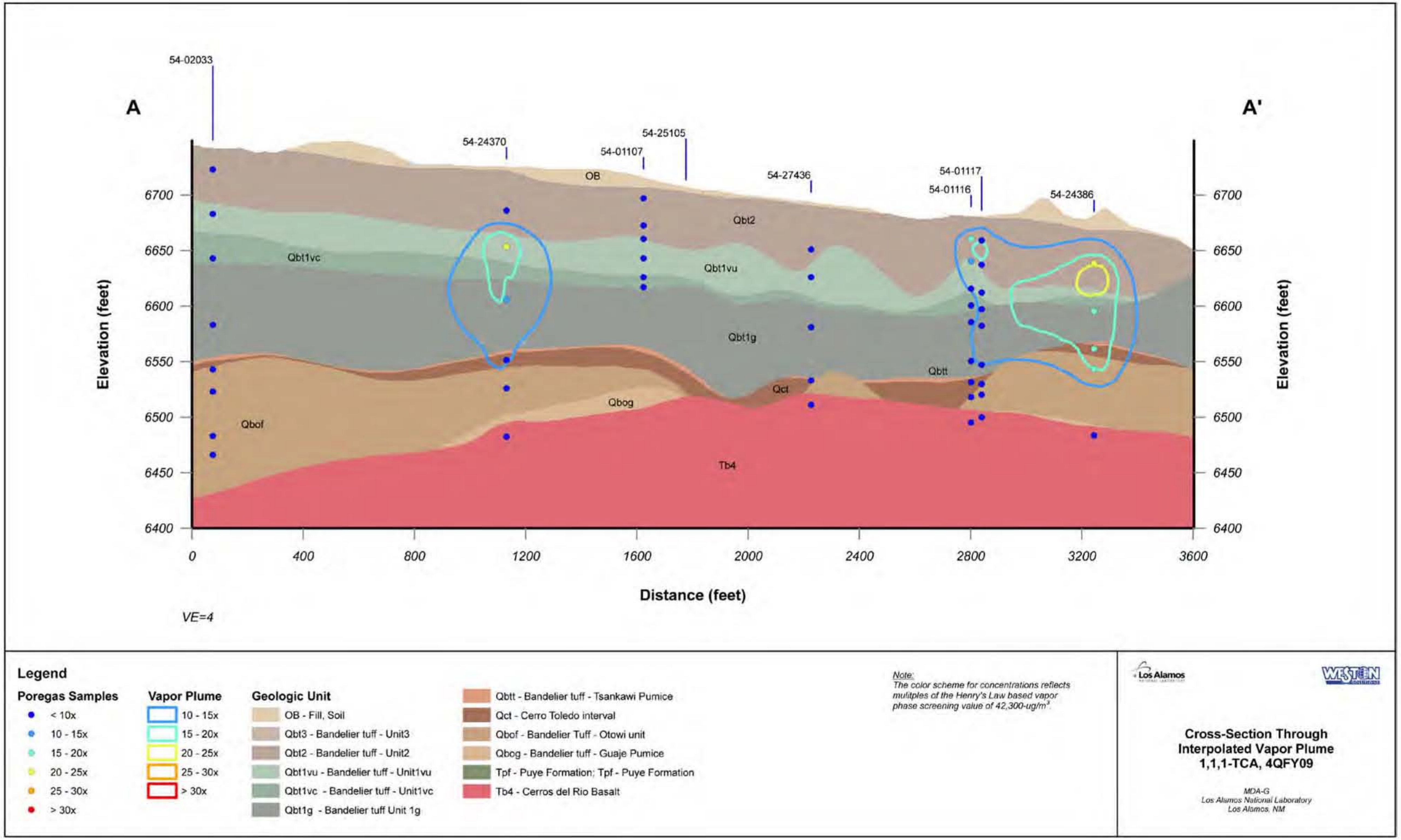

Figure C-3.1-3 East-west cross-section through interpolated vapor plume for TCA at MDA G based on fourth quarter FY2009 data

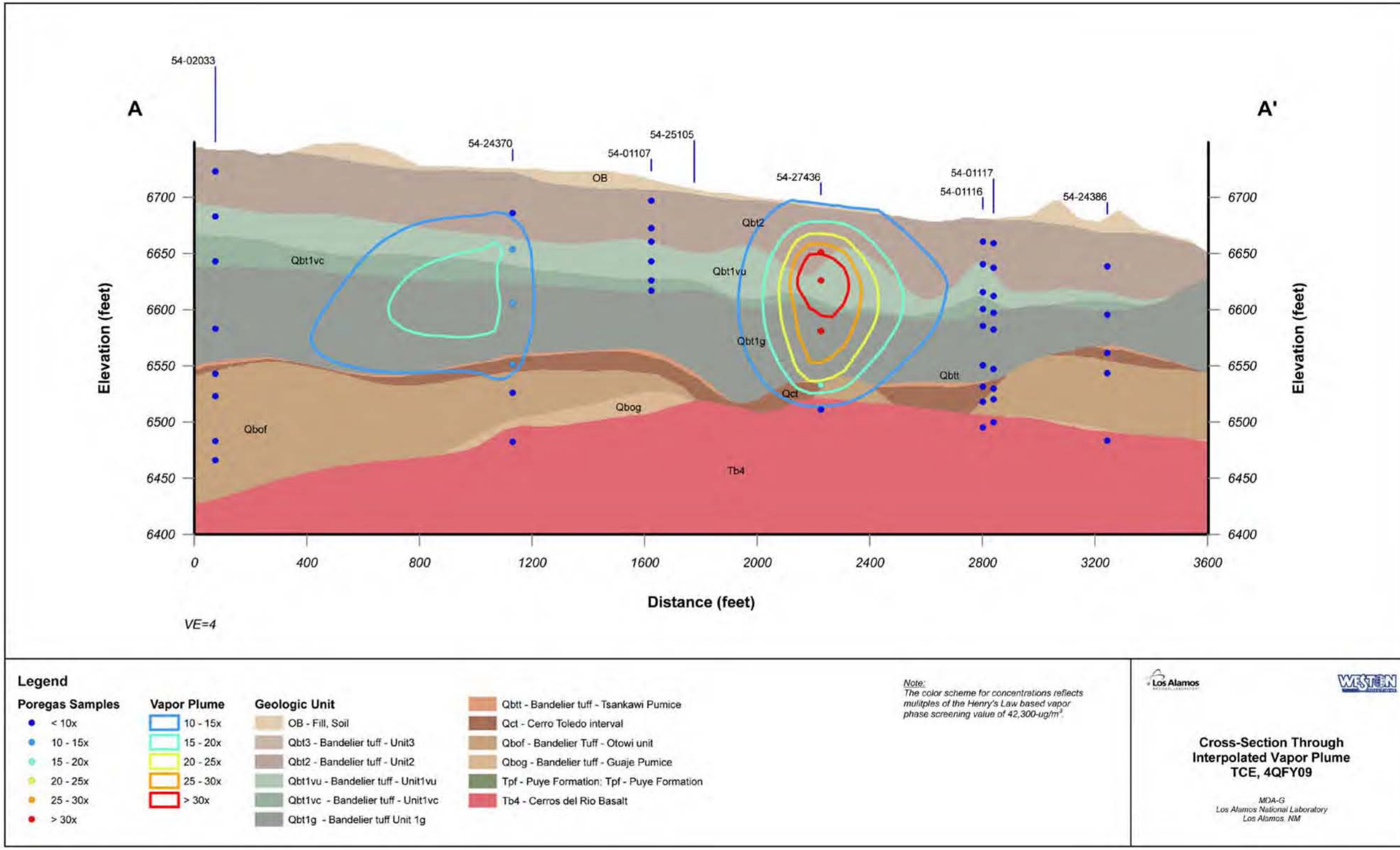

Figure C-3.1-4 East-west cross-section through interpolated vapor plume for TCE at MDA G based on fourth quarter FY2009 data

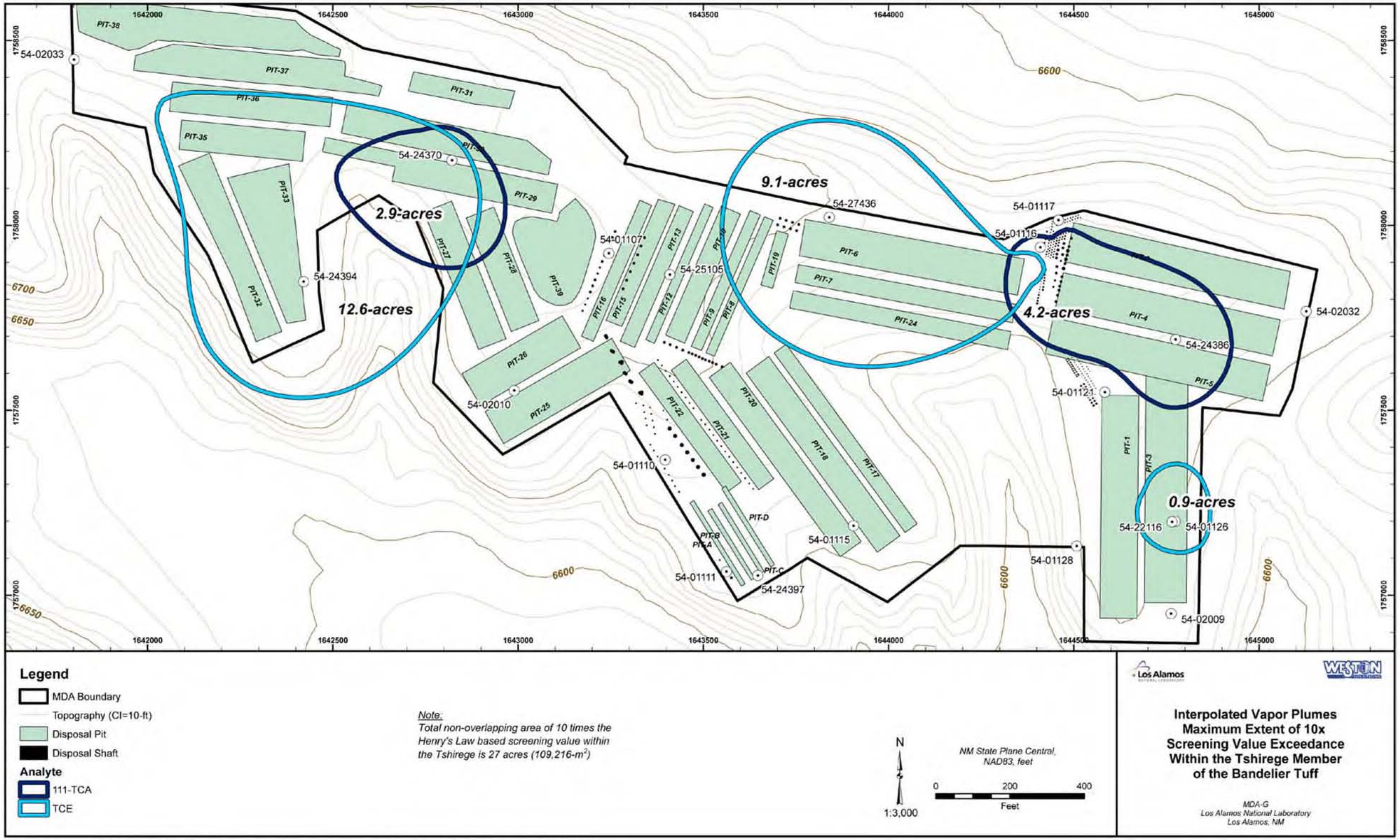

Figure C-3.1-5 Overlapping extents of 10 times Tier I SV contours for interpolated vapor plumes for TCA and TCE at MDA G based on fourth quarter FY2009 data. Plotted contour values shown are 423,000 μg/m^3 and 20,000 μg/m^3 for TCA and TCE, respectively.

Table C-2.1-1
Henry's Law Constants, Groundwater SLs, and the Laboratory-Recommended Tier I and Tier II Vapor-Phase Screening Concentrations for MDA G

VOC	Henry's Law Constant[a] (dimensionless)	Groundwater SL (µg/L)	Source of Groundwater SL	Tier I Pore-Gas Concentrations Corresponding to Groundwater Standard (µg/m³)	MDA G Specific Tier II Calculated Pore-Gas Screening Concentrations (µg/m³)
Acetone	0.0016	22,000	EPA regional SL	35,200	806,000
Benzene	0.228	5	EPA MCL	1140	11,100
Butadiene[1,3-]	3	0.018	EPA regional SL	54	331
Butanone[2-]	0.0023	7100	EPA regional SL	16,330	374,000
Carbon Disulfide	0.59	1000	EPA regional SL	590,000	1.25×10^{7}
Carbon Tetrachloride	1.1	5	EPA MCL	5500	23,700
Chlorodifluoromethane	1.7	100,000	EPA regional SL	170,000,000	1.52×10^{9}
Chloroform	0.15	100	NMWQCC	15,000	241,000
Cyclohexane	6.1	13,000	EPA regional SL	79,300,000	1.57×10^{8}
Dichlorodifluoromethane	14	390	EPA regional SL	5,460,000	9.79×10^{6}
Dichloroethane[1,1-]	0.23	25	NMWQCC	5750	59,100
Dichloroethene[1,1-]	1.1	5	NMWQCC	5500	18,700
Dichloroethene[cis-1,2-]	0.17	70	EPA MCL	11,900	152,000
Ethanol	na[b]	na	na	na	na
Ehylbenzene	0.323	700	EPA MCL	226,100	2.09×10^{6}
Ethyltoluene[4-]	na	na	na	na	na
Hexane	74	880	EPA regional SL	65,120,000	1.09×10^{8}
Methanol	0.00019	18,000	EPA regional SL	3420	78,300
Methylene Chloride	0.13	5	EPA MCL	650	9420
n-Heptane	na	na	na	na	na
Propylene	na	na	na	na	na
Tetrachloroethene	0.72	5	EPA MCL	3600	7500
Toluene	0.272	750	NMWQCC	204,000	647,000
Trichloro-1,2,2-trifluoroethane[1,1,2-]	22	59,000	EPA regional SL	1,298,000,000	7.96×10^{8}
Trichloroethane[1,1,1-]	0.705	60	NMWQCC	42,300	74,500
Trichloroethene	0.4	5	EPA MCL	2000	5130
Trichlorofluoromethane	4	1300	EPA regional SL	5,200,000	1.19×10^{7}
Trimethylbenzene[1,2,4-]	0.25	15	EPA regional SL	3750	47,200
Trimethylbenzene[1,3,5-]	0.36	370	EPA regional SL	133,200	40,500
Xylene[1,2-]	0.213	1400	EPA regional SL	298,200	3.88×10^{6}
Xylene[1,3-]+Xylene[1,4-]	0.27	10,000[c]	EPA MCL	2,700,000	2.41×10^{7}

Notes: Tier 1 screening concentration is the calculated concentration in pore gas exceeding groundwater standard derived from the denominator of Equation C-2.1-3 for an SV of 1.0. Tier II screening concentration is the lower concentration of that calculated for the pore water or vapor-phase flow path based on Equations C-2.2-1 and C-2.2-10.

[a] From NMED (2009, 106420, Appendix B).

[b] na = Not available.

[c] SL for xylene[1,3-]+xylene[1,4-] is for xylene mixture.

Table C-2.1-2
Screening of VOCs Detected during FY2009 in Pore Gas at MDA G

VOCs	Maximum Pore-Gas Concentration (µg/m³)	Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard (µg/m³)	Tier I SV (unitless)	Tier I Potential for Groundwater Impact[a]	Tier II Potential for Groundwater Impact
Acetone	54	35,200	0.0015	No	No
Butanone[2-]	15	16,330	0.00092	No	No
Carbon Disulfide	8	590,000	0.000014	No	No
Chlorodifluoromethane	330	170,000,000	0.0000019	No	No
Chloroform	270	15,000	0.018	No	No
Cyclohexane	12,000	79,300,000	0.00015	No	No
Dichlorodifluoromethane	7200	5,460,000	0.0013	No	No
Dichloroethane[1,1-]	41,000	5750	7.1	Yes	No
Dichloroethene[1,1-]	49,000	5500	8.9	Yes	Yes
Ethanol	8.1	na[b]	na	na	na
Methanol	270	3420	0.079	No	No
Methylene Chloride	380	650	0.58	No	No
Tetrachloroethene	21,000	3600	5.8	Yes	Yes
Toluene	450	204,000	0.0022	No	No
Trichloro-1,2,2-trifluoroethane[1,1,2-]	140,000	1,298,000,000	0.00011	No	No
Trichloroethane[1,1,1-]	860,000	42,300	20	Yes	Yes
Trichloroethene	78,000	2000	39	Yes	Yes
Trichlorofluoromethane	13,000	5,200,000	0.0025	No	No

Notes: Calculated concentrations in pore gas corresponding to groundwater SLs derived from denominator of Equation 3.0-3. SV derived from Equation 3.0-3.

[a] If the SV is less than 1, then the concentration of the VOC in pore gas does not exceed the groundwater screening level. The VOC is not a threat to groundwater if the SV is less than 1.

[b] na = Not available.

Table C-3.1-1
Total Contaminant Mass (kg) of TCA and TCE
Exceeding 10 Times the Tier I Vapor-Phase SL

Analyte	Tshirege Only	Below Tshirege	Total
TCA	195	16	210
TCE	75	4	79

Source: LANL 2010, 109657.

Appendix D

Contaminants Detected in Deep Groundwater Monitoring Wells Downgradient of Material Disposal Area G

D-1.0 INTRODUCTION

Groundwater monitoring at Los Alamos National Laboratory (LANL or the Laboratory) is currently conducted in accordance with the 2010 Interim Facility-Wide Groundwater Monitoring Plan (hereafter, the 2010 Interim Plan) (LANL 2010, 109830). Wells downgradient of Material Disposal Area (MDA) G include deep (perched-intermediate and regional) groundwater wells R-22, R-39, R-41, R-49, R-55, and R-57. Additional wells assigned to the Technical Area (TA-54) monitoring network include those specific to MDA L (R-21, R-38, R-53, R-54, and R-56) and MDA H (R-20, R-37, R-40, R-40i, and R-52) and one deep groundwater monitoring well (R-51) upgradient of these three MDAs. In addition, two deep groundwater monitoring wells (R-23 and R-23i) are located further downgradient of TA-54 in Pajarito Canyon. Table D-1.0-1 summarizes relevant information about the screened intervals and sampling systems installed in each of the 17 deep groundwater monitoring wells in the TA-54 monitoring well network. The remainder of this appendix focuses on the six monitoring wells specific to MDA G and the TA-54 monitoring network. For completeness, two monitoring wells (R-23 and R-23i) that monitor potential contaminant sources in the Pajarito Watershed are also included in this appendix because they are also downgradient of MDA G.

Section D-2.0 reviews the geochemical performance of each screened interval in the wells specific to MDA G, focusing on the ability of each screen to provide reliable data for chemicals of potential concern (COPCs). Section D-3.0 summarizes organic chemicals detected at these monitoring wells, as well as trace metals and other inorganic analytes detected at concentrations exceeding groundwater BVs, and identifies possible sources for these constituents. Based on these analyses, section D-4.0 presents conclusions concerning the transport of COPCs in the vadose zone below MDA G to deep groundwater downgradient of MDA G.

D-2.0 GEOCHEMICAL PERFORMANCE OF MONITORING WELLS

Evaluations of the geochemical performances of four of the wells specific to MDA G (R-22, R-39, R-41, and R-49) and wells R-23 and R-23i were previously reported in the TA-54 Well Evaluation and Network Recommendations, Revision 1" (hereafter the TA-54 Network Evaluation, Rev. 1) (LANL 2007, 098548, Appendix B) and in the 2010 Interim Plan (LANL 2010, 109830, Table F-2.0-1). These evaluations focus on the recovery of each screened interval from residual effects of drilling, construction, development, and rehabilitation activities and on the capability of each screened interval to provide water-quality data that are reliable and representative of predrilling conditions for COPCs. These earlier evaluations are updated in this appendix based on the most recent water-quality samples, and the protocol is extended to include samples from newly completed wells R-55 and R-57. The evaluation protocol is the same as that used in the TA-54 Network Evaluation, Rev. 1, and the 2010 Interim Plan, which is based on the approach described in the "Well Screen Analysis Report, Revision 2" (LANL 2007, 096330).

Key observations based on the evaluations are summarized below, focusing on the implications for reliable and representative detections of vadose-zone COPCs from MDA G.

- R-23 meets geochemical-monitoring objectives unconditionally. This well may show the presence of local contaminants, which affects the applicability of some of the geochemical evaluation criteria, as documented in section D-3.0. This well is capable of providing representative data for all MDA G COPCs.
- R-23i piezometer (port 1) meets geochemical-monitoring objectives unconditionally. This screen shows the presence of local contaminants, which affects the applicability of some of the geochemical evaluation criteria, as documented in section D-3.0. This piezometer is considered capable of providing representative data for all MDA G COPCs.

- R-23i screen 1 (port 2) meets geochemical-monitoring objectives unconditionally. This screen is known to show the presence of local contaminants, which affects the applicability of some of the geochemical evaluation criteria, as documented in section D-3.0. This screen is considered capable of providing representative data for all MDA G COPCs.
- R-23i screen 2 (port 3) meets geochemical-monitoring objectives unconditionally. This screen is known to show the presence of contaminants, which affects the applicability of some of the geochemical evaluation criteria, as documented in section D-3.0. This screen is capable of providing representative data for all MDA G COPCs.
- R-39 meets geochemical-monitoring objectives unconditionally. This screen is capable of providing representative data for all MDA G COPCs.
- R-41 screen 1. This screen has been dry since installation.
- R-41 screen 2 meets geochemical-monitoring objectives unconditionally. This screen is capable of providing representative data for all MDA G COPCs.
- R-49 screen 1 meets geochemical-monitoring objectives conditionally. Evaluation of water-quality samples collected in 2009 indicates the presence of residual constituents from products and materials introduced downhole during drilling and well construction. Geochemical conditions improved significantly following an extended purge of this screen on June 10–11, 2010. This screen is expected to be capable of providing representative data for all MDA G COPCs. The geochemical performance of this screen will continue to be reassessed as additional data become available.
- R-49 screen 2 meets geochemical-monitoring objectives unconditionally. This screen is expected to be capable of providing representative data for all MDA G COPCs.
- R-55 screen 1 meets geochemical-monitoring objectives unconditionally. There is no evidence of the presence of residual effects of drilling or construction in the first characterization sample collected from this screen on September 9, 2010, following well development. This screen is expected to be capable of providing representative data for all MDA G COPCs.
- R-55 screen 2 meets geochemical-monitoring objectives unconditionally. There is no evidence of the presence of residual effects of drilling or construction in the first characterization sample collected from this screen on September 14, 2010, following well development. This screen is expected to be capable of providing representative data for all MDA G COPCs.
- R-57 screen 1 meets geochemical-monitoring objectives unconditionally. There is no evidence of the presence of residual effects of drilling or construction in the first characterization sample collected from this screen on July 1, 2010, following well development. This screen is expected to be capable of providing representative data for all MDA G COPCs.
- R-57 screen 2 meets geochemical-monitoring objectives unconditionally. There is no evidence of the presence of residual effects of drilling or construction in the first characterization sample collected from this screen on June 25, 2010, following well development. This screen is expected to be capable of providing representative data for all MDA G COPCs.
- R-22 was redeveloped in April to July 2009, focusing on screens 1 and 5. Before redevelopment, geochemical conditions in screen 1 were sulfate-reducing and indicated the apparent presence of residual inorganic and organic chemicals associated with materials used downhole during drilling or well construction. Evaluation of the samples collected at the end of an extended purge of screen 1 in June to July 2, 2009, indicated that water quality had mostly stabilized and that oxidizing regional aquifer water was being drawn into the screen (LANL 2009, 106796). Screen 1 may be a viable monitoring zone, capable of providing representative data for all MDA G COPCs.

D-3.0 SCREENING PROTOCOL AND RESULTS

Sampling of the monitoring wells for MDA G began in 2001 and 2003 following the completion of R-22 and R-23, respectively. Since then, nearly 200 sampling events have taken place at 17 screens in 8 wells. COPC monitoring data collected during these sampling events are evaluated using a two-tier screening protocol for this corrective measures evaluation.

1. The first tier compares COPC data against groundwater background concentrations.

   - Naturally occurring inorganic COPCs are compared against groundwater background values (BVs) determined in the Groundwater Background Investigation Report, Revision 4 (hereafter GBIR R4) (LANL 2010, 110535). Groundwater BVs consist of upper tolerance limits (UTLs) for those constituents detected at a sufficiently high detection rate (≥25%) for a sufficient number of sample results (≥10); if these statistical criteria were not met, then the BV is set at the maximum method detection limit (MDL) reported by the analytical laboratory (GBIR R4, section 3.7). Because organic COPCs are not present in uncontaminated groundwater, the first-tier screening results in the identification of all organic COPCs detected at each monitored location.

2. The second-tier screening compares COPC data against the lowest applicable regulatory standard or other risk-based screening level.

   - Groundwater perchlorate data are compared with the screening level of 4 µg/L established in Section VIII.A.1.a of the Compliance Order on Consent (the Consent Order).
   - Regulated COPCs are compared against the lowest applicable regulatory standard. New Mexico Water Quality Control Commission (NMWQCC) groundwater standards apply to the dissolved (filtered) portion of specified contaminants; however, the standards for mercury, organic compounds, and organic constituents apply to the total (unfiltered) concentrations of the contaminants. As a conservative screening measure, the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) standards are considered appropriate screening values for both filtered and unfiltered concentrations.
   - For constituents having no other regulatory standard and for which toxicological information is published, the EPA regional screening levels (RSL) for tap water are used. For these screening levels, the tables indicate a risk type of C (cancer) or N (noncancer). For the cancer-risk type, the risk levels are for 10^{-6} excess cancer risk. The Consent Order specifies screening with these values at a risk level of 10^{-5} (rather than 10^{-6}) excess cancer risk. For these constituents, the 10^{-6} risk-level values have been multiplied by a factor of 10 to adjust them to the 10^{-5} risk level. As a conservative screening measure, the EPA RSL values are considered appropriate screening values for both filtered and unfiltered concentrations.

The outcome of the screening protocol is summarized in a set of frequency of detection tables that summarize detections of organic compounds as well as inorganic constituents detected above groundwater background concentrations. The detection status for an analytical result is established using the combined set of laboratory-assigned validation qualifiers and reason codes assigned during data validation. For detected constituents, the screening tables include summary information such as the total number of samples collected for each analyte at the location where it was detected; the numbers of detections; the mean and maximum detected values; the number of detections exceeding groundwater BVs (for inorganic constituents); and the number of detections exceeding the lowest applicable regulatory or risk-based screening levels. For this report, analytical data for field duplicates are also included in the statistical analysis as one indication of the reproducibility of detected and nondetected results. In the discussion that follows, screening results for well R-22 are presented separately from those for the other monitoring wells because the bulk of the analytical data from well R-22 have been identified as nonrepresentative because of potential residual effects from drilling products (LANL 2009, 106796). Data from R-22 that are associated with redevelopment activities that took place between May and July 2009 are also discussed.

- Table D-3.0-1 summarizes organic chemicals detected at wells R-23, R-23i, R-39, R-41, R-49, R-55 and R-57. Table D-3.0-2 summarizes organic chemicals detected at well R-22 before and after redevelopment in 2009.
- For inorganic constituents, Table D-3.0-3 summarizes screening results for R-23, R-23i, R-39, R-41, R-49, R-55 and R-57, and Table D-3.0-4 summarizes those results for well R-22 before redevelopment in 2009.

The final set of frequency of detection tables tally the number of individual sampling events (as opposed to the number of individual samples) in which each COPC has been detected. Table D-3.0-5a tallies the number of events in which each organic COPC has been detected at R-23, R-23i, R-39, R-41, R-49, R-55 and R-57; Table D-3.0-5b summarizes the number of events in which each inorganic COPC has been detected at these wells above the groundwater BV. Similarly, Tables D-3.0-6a and D-3.0-6b summarize the number of events in which each organic and inorganic COPC, respectively, have been detected at well R-22.

D-3.1 Organic COPC Detections

Among organic COPCs, 33 organic compounds have been detected in samples collected at wells R-23, R-23i, R-39, R-41, R-49, R-55 and R-57 (Table D-3.0-1). The list includes 10 volatile organic compounds (VOCs), 9 semivolatile organic compounds (SVOCs), 2 polychlorinated biphenyls (PCBs), 4 pesticides, and 8 dioxin/furans. The vast majority of these cases are sporadic detections at low concentrations at or below the practical quantitation limit (PQL) of the analytical method.

- Of the 55 cases in which an organic compound was detected at a screen, 44 of those cases were one-time occurrences; 8 cases involved analytes detected twice at a location, which often reflected the detection of the analyte in the field duplicate for that sample. In only four instances was an organic compound detected in more than two samples from the same location: acetone and bis(2-ethylhexyl)phthalate at R-23, and chloromethane and toluene at R-39.
- Of the 33 organic compounds that have been detected, only four compounds have been detected above the PQL listed in Table D-3.0-1: acetone at R-23; toluene at R-23i, R-39, and R-41; benzoic acid at R-23 and R-39; and diethylphthalate at R-23 and R-39.
- Three organic compounds have been detected once each above a screening level: benzo(b)fluoranthrene and indeno(1,2,3-cd)pyrene at R-55, and bis(2-ethylhexyl)phthalate at R-23. Methylene chloride was also detected above one-half the screening level at R-23 and R-49. In all of these cases, the screening level is less than the PQL.
- None of the detected compounds has been consistently detected beyond the first 2 yr following well completion or installation of a sampling system. For example, the compound detected with the highest frequency (acetone at R-23) was present at 6420 µg/L in the sample collected from this well at the end of development (October 17, 2002) but has shown only nondetects or detections below the PQL of 5 µg/L since June 29, 2004.

As summarized in Table D-3.0-5a, the majority of cases for which an organic analyte has been detected more than once have occurred at three wells: R-23, R-23i, and R-39.

At well R-22, 33 organic compounds have been detected (Table D-3.0-2). The list includes 11 VOCs, 19 SVOCs, 4 pesticides, and 5 high explosive compounds. For the majority of these cases, the detections are sporadic and at low concentrations at or below the PQL of the analytical method and are observed only in samples collected during the first 2 yr of monitoring (2001 to 2002) when the Westbay sampling system was being used. Three VOCs were detected in samples collected following redevelopment of screens 1 and 5 in May to July 2009: carbon disulfide, chloromethane, and toluene.

D.3-2 Inorganic COPC Detections

Among inorganic COPCs, 25 constituents have been detected above groundwater BVs in samples collected at wells R-23, R-23i, R-39, R-41, R-49, R-55 and R-57 (Table D-3.0-3). The list includes eight general inorganics and 17 trace metals. Of these, three trace metals (lead, manganese, and zinc) and one general inorganic constituent (total dissolved solids) have been detected at concentrations above the lowest applicable standards.

- General inorganic constituents consistently detected above the UTLs established in GBIR R4 (LANL 2010, 110535) include chloride, magnesium, nitrate-nitrite, sulfate, and total dissolved solids at R-23i, and nitrate-nitrite at R-23. As discussed below, these constituents are most likely derived from sources in upper Pajarito Watershed transported downcanyon by surface water and alluvial groundwater. Detections of these analytes above UTLs at other wells included in this evaluation are either limited to a single sample, or else exceed the UTL only slightly. For example, average nitrate-nitrite concentrations in five regional screens (R-39, R-41, R-49, and R-57 screen 1) fall within a narrow range of 0.56 to 0.61 mg/L compared with the UTL of 0.58 mg/L (LANL 2010, 110535), such that the slightly higher concentrations are likely to be representative of background in this part of the regional aquifer. The R-23 analytical result in which the concentration of total dissolved solids (2900 mg/L) exceeds one-half of the lowest applicable standard (one-half standard = 500 mg/L) appears to be an analytical reporting error because such a high concentration is inconsistent with concentrations reported for individual dissolved constituents, none of which are out of line with the overall stable geochemical trends at this well.
- Filtered concentrations of trace metals consistently detected above background screening levels established in GBIR R4 (LANL 2010, 110535) include molybdenum at R-41 (average = 5.3 µg/L, compared with UTL = 3.4 µg/L) and zinc at the R-23i piezometer (average = 9 µg/L, compared with MDL = 3.3 µg/L).
- Total (unfiltered) concentrations of trace metals consistently detected above background screening levels established in GBIR R4 (LANL 2010, 110535) include aluminum (R-39, R-41, and R-49 screen 1); arsenic (R-23i); lead (R-23 and R-49 screen 1); manganese (R-23); molybdenum (R-41); and uranium (R-49 screen 1).
- Trace metal concentrations were reported above a regulatory or risk-based screening level in three isolated instances: manganese at R-23 (207 µg/L, compared with the New Mexico groundwater standard of 200 µg/L); total lead at R-23i screen 2 (22 µg/L, compared with the EPA MCL of 15 µg/L); and total zinc at R-23i screen 2 (262 µg/L compared with EPA regional screening level of 180 µg/L). These instances occurred in the first postdevelopment sampling event at these wells.

Table D-3.0-5b summarizes the number of sampling events for which each inorganic analyte has been detected above the groundwater BV at each location. The majority of cases for which a mobile COPC (chloride, nitrate, and sulfate) has been detected significantly above the background UTL more than once have occurred at two wells: R-23 and R-23i. Although nitrate concentrations are elevated slightly above the UTL at R-39, R-41, R-49, R-55 and R-57, these concentrations may be representative of local regional background groundwater. Among metals detected significantly above UTLs, the most frequent exceedances also are observed at R-23i for total arsenic, filtered and total magnesium, and filtered zinc; and at R-23 for total lead and total manganese. Based on temporal trends in the data, recurring instances of elevated concentrations of selected trace metals at R-39 (total aluminum), R-41 (filtered and total molybdenum), and R-49 screen 1 (total lead and total uranium) may signify these screened intervals may still be in the process of recovering to ambient geochemical conditions following perturbance associated with drilling and well-construction activities.

At well R-22, 33 inorganic constituents have been detected above groundwater background concentrations (Table D-3.0-4). The list includes 11 general inorganics and 19 trace metals. Elevated concentrations of many constituents which persisted after the first 2 yr following well completion appear to be associated with reducing conditions which developed in the vicinity of screens 1, 4, and 5 because of the incomplete removal of organic drilling products and the leaching of constituents from the bentonite in the annular seal at screen 3 (LANL 2007, 098548). Table D-3.0-6b summarizes the number of sampling events for which each inorganic analyte has been detected above the groundwater BV at each screened interval.

D.3-3 Tritium Detections

Tritium has also been detected above natural BVs in perched-intermediate and regional groundwater downgradient of MDA G, in wells R-22 and R-23i (Table D-3.0-7). None of the tritium activities measured in the monitoring wells exceed the EPA MCL of 20,000 pCi/L. Tritium is not a hazardous waste or hazardous-waste constituent that is regulated under the Consent Order. The Laboratory has provided these data because the presence or absence of tritium at a location provides a useful tracer of flow and transport pathways because it travels conservatively in groundwater.

- At well R-23i, tritium activities average 152 pCi/L in the R-23i piezometer and approximately 30 pCi/L in the two deeper screened intervals. The UTL for the perched-intermediate zone is 36 pCi/L (LANL 2010, 110535). Therefore, the tritium activity is elevated in the R-23i piezometer.
- At well R-23, tritium has been detected three times using the low-level detection method, with a maximum value of 0.9 pCi/L. However, tritium activity at this location does not exceed the screening level of 6.26 pCi/L for regional groundwater background (LANL 2010, 110535).
- Before the redevelopment of well R-22, which occurred between May and July 2009, tritium had been reported at activities between approximately 2 pCi/L and 4 pCi/L in samples collected from screen 1, and between 4 pCi/L and 18 pCi/L in samples collected from screen 5. During the redevelopment at R-22, tritium activities in samples collected from these two screens were all below the minimum detectable activity of the low-level detection method, indicating extended purging removed preexisting tritium that had probably been introduced into screens 1 and 5 during or shortly after drilling (LANL 2009, 106796).
- Activities of tritium in wells R-39, R-41, R-49, and R-57 are below the minimum detectable activity of the low-level detection method. Tritium data are not yet available for new well R-55.

The piezometer in well R-23i is the only location that shows evidence of elevated tritium activity. Potential tritium sources in the lower portions of the Pajarito Watershed include MDA G, TA-18 and elsewhere in the upper Pajarito Watershed, local fallout from TA-16 air emissions, and global-fallout tritium in precipitation during the mid-1960s, which had activities as high as 6200 pCi/L. However, R-23i is located far downgradient of MDA G and its water chemistry is thought to be impacted by local infiltration of surface water and alluvial groundwater in Pajarito Canyon (LANL 2009, 106939). There is no evidence that R-23i and other wells downgradient of MDA G are impacted by tritium that is sourced at MDA G.

D.3-4 COPC Sources

Sources of the COPCs detected in deep groundwater wells R-22, R-23, R-23i, R-39, R-41, R-49, R-55, and R-57 have not been determined with certainty. Four candidate sources are discussed here.

- *MDA G.* The vapor-phase organics detected at highest concentrations in the pore gas at MDA G are 1,1,1-trichloroethane [TCA]; 1,1,2-trichloro-1,2,2-trifluoroethane; TCE, 1,1-dichloroethene; 1,1-dichloroethane; and tetrachloroethene (LANL 2010, 108496, Table 3.0-2). Of these six VOCs, only TCE has been detected in the monitoring wells downgradient of MDA G (Table D-3.0-5a). Two primary lines of evidence indicate MDA G is not the likely source of the TCE or other organics detected in the deep groundwater wells downgradient of MDA G. First, none of the VOCs detected at the highest concentrations in the vapor phase below MDA G have been detected in the six regional wells closest to MDA G; the location at which TCE was detected (R-23i) is considerably downgradient of MDA G and is along a potential line of infiltration beneath Pajarito Canyon. Secondly, the VOCs detected with the greatest frequency in the wells closest to MDA G—chloromethane and toluene—are either not detected in the vapor plume beneath MDA G or else are detected only at relatively low levels. Therefore, indications are that the largely sporadic detections of VOCs in regional groundwater immediately downgradient of MDA G (as summarized in Table D-3.0-5a) are not associated with the vapor-phase contamination beneath and sourced from MDA G.
- *TA-18 or other sources in the Pajarito Watershed.* R-23 and R-23i are located within Pajarito Canyon downgradient of TA-18. Borehole samples and alluvial groundwater samples have indicated the presence of inorganic, organic, and radionuclide COPCs in the subsurface beneath the canyon bottom (LANL 2009, 106939). Water levels at well R-23i appear to be impacted by surface water flow and alluvial water levels in Pajarito Canyon, especially at alluvial well PCO-3. Infiltration near R-23i and R-23 may be focused through the Cerros del Rio basalt, which is located close to the surface in this part of the canyon (LANL 2009, 106939). Therefore, it is possible the water chemistry at wells R-23i and R-23 may be impacted by surface water and alluvial groundwater in Pajarito Canyon.
- *Residual materials or products used downhole such as during drilling or installation activities.* A large proportion of the VOC and SVOC detections occur during the initial year of sampling or in the first year following screen rehabilitation and sampling-system conversion activities. In these cases, the analyte typically shows a maximum concentration in the first one or two sampling rounds and decreases steadily thereafter because of its gradual removal from the screen interval via advective flow, purging, and biodegradation. Organic VOC detections frequently occur along with elevated concentrations of total organic carbon, acetone, or other common indicators of residual organic products. Organic analytes, which could be present in residual downhole products primarily as a result of their introduction into the product during the manufacturing process, include acetone, toluene, benzene, and the plasticizer bis(2-ethylhexyl)phthalate.
- *Sporadic low-level detections.* Some of the sporadic low-level detections may be the result of field or laboratory contamination or analytical errors. For example, acetone, 2-butanone, chloromethane, and toluene are among the VOCs detected with the greatest frequency in equipment blanks, field blanks, and field trip blanks collected during groundwater sampling events. Analytical error may also be the case for the single detections of benzo(a)pyrene, benzo(b)fluoranthene, 4-methylphenol, and phenol reported for screened intervals at well R-22.

Groundwater characterization and monitoring is ongoing at TA-54 in accordance with annual revisions to the IFGMP. Monitoring frequency and analyte suites are specified in annual updates to the Interim Plan (LANL 2010, 109830).

D-4.0 CONCLUSIONS

The outcome of the screening process is summarized in Tables D-3.0-5a and D-3.0-5b, which list monitoring wells at which an organic analyte was detected or a BV for an inorganic analyte was exceeded at least once. The conditions under which these constituents are observed are described in Table D-3.0-1 (organic COPCs) and D-3.0-3 (inorganic COPCs).

The analysis of existing groundwater monitoring data presented in this appendix suggests a low probability that the organic COPCs detected in the perched-intermediate zone or in the regional aquifer downgradient of MDA G are from vapor-phase transport from the MDA G VOC vapor plume. Detections at wells immediately downgradient of MDA G are sporadic, and none of the detected compounds has been consistently detected beyond the first 2 yr following well completion or installation of a sampling system. The analysis also indicates that if the VOCs detected in the groundwater are associated with MDA G, then detectable concentrations of TCA and several other VOCs found in the MDA G plume should also be present.

In addition, the analysis of existing groundwater monitoring data suggests a low probability that inorganic COPCs and tritium have migrated through the unsaturated zone from MDA G to deep groundwater.

D-5.0 REFERENCES

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Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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Table D-1.0-1
Information for Wells in the TA-54 Monitoring Well Network

Well	Screen	Depth (ft bgs)	Screen Lithology	Sampling Events[a] Total N	Sampling Events[a] Earliest	Sampling Events[a] Most Recent	Sampling System	Chronology of Key Events Relevant to Water-Quality Evaluation
Wells immediately downgradient of MDA G								
R-22	Screen 1	907	Cerros del Rio basalt	19	13-Mar-01	26-Feb-09	Westbay	• Well completed on 19-Oct-00. Portland cement was used in the annular space above screens 1 and 2, between screens 2 and 3, and between screens 3 and 4. • Screens 1 and 2 did not produce sufficient water for pump development prior to installation of the sampling system. • Westbay multiport sampling system installed on 8-Dec-00 (Ball et al. 2002, 071471). • Westbay system removed between 19-Apr-09 and 3-May-09 for redevelopment focused on screens 1 and 5. • Several specific-capacity tests, purging, and sampling events were conducted between 13-May-09 and 2-Jul-09 in configurations that included a single packer and double packers as well as open-hole (no packers). Analytical samples were collected from screen 1 during the extended purging activity conducted from 23-Jun-09 to 2-Jul-09, using a pneumatic Bennett pump and inflatable packer. Analytical samples were collected from screen 5 during the extended hydraulic testing and purging activity conducted from 17-May-09 to 27-May-09 using a 10-hp pump and single inflatable packer above the pump. • The sample collected from screen 1 at the end of redevelopment on 2-Jul-09 is included in the statistical summaries of analyte detections (section D-3.0). Data for earlier samples and other screens are discussed in the text but are not included in the statistical summaries. • Four temporary inflatable packers were installed on 28-May-09 and 30-May-09 to isolate the five screens from one another. • Well R-22 was removed from sampling under the 2010 Interim Plan until a decision has been made concerning its final post-conversion configuration.
				15 (4)[b]	24-Jun-09	2-Jul-09	Bennett pump	
	Screen 2	963	Cerros del Rio basalt	19	12-Mar-01	26-Feb-09	Westbay	
	Screen 3	1274	Upper Puye fanglomerates	19	8-Mar-01	27-Feb-09	Westbay	
	Screen 4	1378	Older basalt (clay-altered)	19	7-Mar-01	26-Feb-09	Westbay	
	Screen 5	1448	Lower Puye fanglomerates	20	6-Mar-01	26-Feb-09	Westbay	
				29 (8)[b]	18-May-09	26-May-09	10-HP pump, single inflatable packer	
R-39	Single	859	Cerros del Rio dacite?	8	19-Feb-09	8-Oct-10	Dedicated pump	• Fluid-assisted air-rotary drilling in an open borehole using AQF-2 foaming agent from surface to 717 ft bgs; no foam was added from 717 ft bgs to TD. • Drilling completed on 12-Nov-08. Regional water table at 824 ft bgs (13-Nov-08). • Well completed by 1-Dec-08. • Well development and aquifer testing completed on 22-Dec-08. • Dedicated submersible pump installed on 19-Feb-09.

Table D-1.0-1 (continued)

Well	Screen	Depth (ft bgs)	Screen Lithology	Sampling Events[a] Total N	Earliest	Most Recent	Sampling System	Chronology of Key Events Relevant to Water-Quality Evaluation
R-41	Screen 1	~935	Unassigned quartzo-feldspathic gravels	0	na	na	na	• Dual-rotary fluid-assisted drilling using AQF-2 foaming agent from surface to 775 ft bgs; no foam was added from 775 ft bgs to TD. • Drilling completed on 21-Feb-09. • Well completed on 19-Mar-09. Regional water table at 960 ft bgs (22-Mar-09). • Only the lower screen interval produced water and was able to be developed. • Dedicated submersible pump installed in screen 2 on 6-Jul-09, with a Baski inflatable packer installed between screens 1 and 2. • Screen 1 has been dry since installation.
	Screen 2	965	Unassigned quartzo-feldspathic gravels	6	2-Apr-09	8-Oct-10	Dedicated pump	
R-49	Screen 1	845	Dacitic lavas and breccias with minor intercalated sediments	6	23-Jun-09	7-Oct-10	Baski dual-APV	• Dual-rotary fluid-assisted drilling using AQF-2 foaming agent from surface to 577 ft bgs; no foam was added from 577 ft bgs to TD. • Drilling completed on 30-Apr-09. • Well completed on 1-Jun-09. Regional water table at 832 ft bgs (composite depth, 9-Jun-09). • Well development and aquifer testing completed on 23-Jun-09. • Baski dual-APV sampling system installed on 20-Aug-09.
	Screen 2	906	Unassigned Totavi-like fluvial clastics	6	18-Jun-09	7-Oct-10	Baski dual-APV	
R-55	Screen 1	~870	Puye Formation	1	9-Sep-10	9-Sep-10	Portable pump	• Dual-rotary fluid-assisted drilling using AQF-2 foaming agent from surface to 682 ft bgs; no foam was added from 682 ft bgs to TD. • Drilling completed on 29-Jun-10. Regional water table at 843.5 ft bgs (composite depth, 30-Jun-10). • Well completed on 25-Aug-10. • Baski system scheduled to be installed in late 2010.
	Screen 2	~1000	Chamita Formation	1	14-Sep-10	14-Sep-10	Portable pump	
R-57	Screen 1	910	Cerros del Rio dacitic lava flow(s)	1	1-Jul-10	1-Jul-10	Portable 5-HP pump	• Dual-rotary fluid-assisted drilling using AQF-2 foaming agent from surface to 786 ft bgs; no foam was added from 786 ft bgs to TD. • Drilling completed on 24-Apr-10. Regional water table at 879 ft bgs (composite depth, 27-Apr-10). • Well completed on 8-Jun-10. • Baski dual-APV system scheduled to be installed in Nov-10.
	Screen 2	972	Totavi Lentil Puye Formation	1	25-Jun-10	25-Jun-10	Portable 10-HP pump	

Table D-1.0-1 (continued)

Well	Screen	Depth (ft bgs)	Screen Lithology	Sampling Events[a] Total N	Earliest	Most Recent	Sampling System	Chronology of Key Events Relevant to Water-Quality Evaluation
Wells immediately downgradient of MDA L								
R-21	Single	889	Puye Formation	22	31-Mar-04	11-Oct-10	Dedicated pump	• Well completed on 26-Nov-02. • Dedicated submersible pump installed on 14-Feb-03.
R-32	Screen 1	871	Cerros del Rio basalt and river gravels	9	1-Mar-04	7-Jul-07	Westbay	• Well completed on 12-Aug-02. • Westbay multiport sampling system installed on 17-Nov-02. Screen 2 never used for water-quality sampling. • Westbay system removed 18-Sep-07 for well rehabilitation and conversion to single completion well at screen 1 (LANL 2007, 100572). • Screens 2 and 3 plugged and abandoned on 20-Sep-07 due to unfavorable geochemical conditions resulting from residual drilling, construction and development products (LANL 2007, 100572). • Baski k-packer and dedicated submersible pump installed on 7-Nov-07 (LANL 2007, 100572).
	Screen 3	976	Puye Formation	10	3-Mar-04	6-Jul-07	Westbay	
	Single	868	Cerros del Rio basalt and river gravels	12	14-Dec-07	14-Oct-10	Dedicated pump	
R-38	Single	821	Puye Formation	6	6-Feb-09	11-Oct-10	Dedicated pump	• Dual-rotary fluid-assisted drilling using AQF-2 foaming agent from surface to 515 ft bgs; no foam was added from 515 ft bgs to TD. • Drilling completed on 6-Nov-08. Regional water table at 810 ft bgs (7-Nov-08). • Well completed on 7-Dec-08. • Dedicated submersible pump installed 12-Jan-09.
R-53	Screen 1	849	Puye Formation	2	19-Apr-10	12-Oct-10	Baski dual-APV	• Dual-rotary fluid-assisted drilling using AQF-2 foaming agent from surface to 725 ft bgs; no foam was added from 725 ft bgs to TD. • Drilling completed on 7-Mar-10. Regional water table at 840 ft bgs (composite depth, 9-Mar-10). • Well completed on 29-Mar-10. • Baski dual-APV sampling system installed by 7-Jul-10.
	Screen 2	960	Puye Formation	2	14-Apr-10	12-Oct-10	Baski dual-APV	
R-54	Screen 1	830	Cerros del Rio basaltic sediments	4	15-Feb-10	13-Oct-10	Baski dual-APV	• Dual-rotary fluid-assisted drilling using AQF-2 foaming agent from surface to 705 ft bgs; no foam was added from 705 ft bgs to TD. • Drilling completed on 6-Jan-10. • Well completed on 29-Jan-10. Regional water table at 815 ft bgs (9-Feb-10). • Baski dual-APV sampling system and pump installed on 17-May-10 (LANL 2010, 109828).
	Screen 2	915	Puye Formation	4	21-Feb-10	13-Oct-10	Baski dual-APV	

Table D-1.0-1 (continued)

Well	Screen	Depth (ft bgs)	Screen Lithology	Sampling Events[a] Total N	Earliest	Most Recent	Sampling System	Chronology of Key Events Relevant to Water-Quality Evaluation
R-56	Screen 1	945	Puye Formation dacitic lavas and silty gravels	1	19-Aug-10	19-Aug-10	Portable submersible pump	• Dual-rotary fluid-assisted drilling using AQF-2 foaming agent from surface to 819 ft bgs; no foam was added from 819 ft bgs to TD. • Drilling completed on 13-Jun-10. Regional water table at 925 ft bgs (composite depth, 15-Jun-10). • Well completed on 19-Jul-10 (LANL 2010, 110482). • Baski dual-APV system scheduled to be installed in late 2010.
	Screen 2	1047	Puye Formation dacitic lavas and silty gravels	1	13-Aug-10	13-Aug-10	Portable submersible pump	
Wells immediately downgradient of MDA H								
R-20	Screen 1	905	Puye Formation	6	11-Mar-04	6-Jun-06	Westbay	• Well completed on 15-Sep-02. Westbay multiport sampling system installed on 18-Jan-03. • Westbay system removed 28-Jun-06; screens 1, 2, and 3 isolated by temporary packers. • Packers removed on 12-Nov-07 for redevelopment, abandonment of screen 3, and testing activities. Single packer installed between screens 1 and 2 on 5-Dec-07. • Screen 3 plugged and abandoned on 18-Nov-07 due to unfavorable geochemical conditions resulting from residual drilling, construction and development products. • Baski dual-pump sampling system and Baski k-packer installed on 22-May-08 (LANL 2008, 103100). • Potential cross flow between screened intervals in 2009 because of underinflated packer; water-quality samples not affected (LANL 2010, 108783).
				4	6-Jul-06	30-Nov-07	Temporary	
				10	21-Jun-08	20-Oct-10	Baski dual-pump	
	Screen 2	1147	Pumiceous fanglomerates	6	10-Mar-04	7-Jun-06	Westbay	
				3	8-Jul-06	4-Dec-07	Temporary	
				9	23-Jun-08	11-Oct-10	Baski dual-pump	
	Screen 3	1330	Santa Fe Group sediments	6	9-Mar-04	8-Jun-06	Westbay	
				4	7-Jul-06	19-Jan-07	Temporary	
R-37	Screen 1	929	Puye Formation basaltic gravels	7	13-Jul-09	12-Oct-10	Baski dual-pump	• Well completed 6-Jun-09. • Baski dual-pump system installed 19-Dec-09.
	Screen 2	1026	Puye Formation dacite clastics	7	22-Jun-09	14-Oct-10	Baski dual-pump	
R-40i	Single	650	Cerros del Rio basalt	7	28-Jan-09	28-Jul-10	Dedicated pump	• Two-inch diameter well installed in annulus of well R-40. • Development methods were limited to bailing, or bailing and swabbing. • The well is sampled using a dedicated submersible pump.
R-40	Screen 1	752	Cerros del Rio basalt	6	21-Apr-09	28-Jul-10	Baski	• Well completed on 5-Jan-09. • Sampling system installed in well on Jun-09.
	Screen 2	849	Puye fanglomerates	6	15-Jan-09	27-Jul-10	Baski	

Table D-1.0-1 (continued)

Well	Screen	Depth (ft bgs)	Screen Lithology	Sampling Events[a] Total N	Earliest	Most Recent	Sampling System	Chronology of Key Events Relevant to Water-Quality Evaluation
R-52	Screen 1	1035	Puye Formation	3	2-May-10	12-Oct-10	Baski dual-APV	• Fluid-assisted air-rotary and dual-rotary drilling using AQF-2 foaming agent from surface to 915 ft bgs; no foam was added from 915 ft bgs to TD. • Drilling completed on 6-Feb-10. Regional water table at 1021 ft bgs (composite depth, 7-Feb-10). • Well completed on 5-Apr-10. • Baski dual-APV sampling system installed by 19-Jul-10.
	Screen 2	1107	Puye Formation	3	23-Apr-10	12-Oct-10	Baski dual-APV	
Wells downgradient of MDAs G, H and L								
R-23i	Piezometer (Port 1)	400	Cerros del Rio basalt	12	6-Sep-07	21-Oct-10	Portable pump	• Well completed on 10-Nov-05. • Sampling system installed in well on 15-Dec-06. • Piezometer installed in well annulus. Development methods were limited to bailing, or bailing and swabbing. Geochemistry appears to be affected by seasonal water-level changes (LANL 2010, 109830, Table F-4.0-1). Sampled using portable Bennett pump. • Some samples from Screen 2 in 2009 potentially affected by cross flow (LANL 2010, 109830, Table F-4.0-1). Sampling system removed for repairs in Dec-09. • Well was redeveloped in Jan-10 before reinstallation of the Baski sampling system.
	Screen 1 (Port 2)	470	Cerros del Rio basalt	22	3-Oct-06	18-Oct-10	Baski dual-pump	
	Screen 2 (Port 3)	524	Cerros del Rio basalt (interflow sediments)	16	11-Oct-06	18-Oct-10	Baski dual-pump	
R-23	Single	816	Santa Fe Group sediments	24	17-Dec-03	12-Aug-10	Dedicated pump	• Well completed on 2-Oct-02. • Dedicated submersible pump installed on 14-Feb-03.

Table D-1.0-1 (continued)

Well	Screen	Depth (ft bgs)	Screen Lithology	Sampling Events[a] Total Nr.	Sampling Events[a] Earliest	Sampling Events[a] Most Recent	Sampling System	Chronology of Key Events Relevant to Water-Quality Evaluation
Wells up-gradient of MDAs G, H and L								
R-51	Screen 1	915	Puye Formation	4	8-Mar-10	19-Oct-10	Baski dual-APV	• Fluid-assisted air-rotary and dual-rotary drilling using AQF-2 foaming agent from surface to 776 ft bgs; no foam was added from 776 ft bgs to TD. • Drilling completed on 14-Jan-10. • Well completed on 8-Feb-10. Regional water table at 891 ft bgs (composite depth, 17-Feb-10). • Well development completed on 8-Mar-10 (upper screen) and 22-Feb-10 (lower screen). Baski dual-APV sampling system installed on 7-May-10.
	Screen 2	1031	Puye Formation	4	22-Feb-10	19-Oct-10	Baski dual-APV	

Sources: Well completion reports for R-20 (LANL 2003, 079600); R-21 (Kleinfelder 2003, 090047); R-22 (Ball et al. 2002, 071471); R-23 (LANL 2003, 079601); R-23i (Kleinfelder 2006, 092495); R-32 (LANL 2003, 079602); R-37 (LANL 2009, 107116); R-38 (LANL 2009, 105298); R-39 (LANL 2009, 105620); R-40 (LANL 2009, 106432); R-41 (LANL 2009, 106453); R-49 (LANL 2009, 107450); R-51 (LANL 2010, 109949); R-52 (LANL 2010, 110533); R-53 (LANL 2010, 110516); R-54 (LANL 2010, 109828). Fact sheets for R-55 (LANL 2010, 110717); R-56 (LANL 2010, 110482), and R-57 (LANL 2010, 109836). Well rehabilitation and conversion reports for R-20 (LANL 2008, 100473) and R-32 (LANL 2007, 100572). Well redevelopment report for R-22 (LANL 2009, 106796). Assessment of cross flow in monitoring wells with inflatable packers (LANL 2010, 108783).

Notes: APV = access port valve; ft bgs = feet below ground surface; hp = horsepower; N = number; TD = total depth.

[a] Sampling events for analyses by off-site laboratories.

[b] The first number indicates the number of discrete sampling events for perchlorate; the number in parentheses indicates the number of discrete sampling events for VOCs.

Table D-3.0-1
Statistical Summary of Organic Analytes and High Explosives Detected in Groundwater Samples Collected from Wells R-23, R-23i, R-39, R-41, R-49, R-55, and R-57, through October 31, 2010

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
VOCs														
Acetone	R-23	816	Single dedicated pump	38	9	722	6420	5	22000	EPA TAP RSL	—[d]	11000	—	Max Oct-02. Not detected above 5 µg/L after Mar-04
	R-23i	524	Baski dual-pump	16	1	1	1	5	22000	EPA TAP RSL	—	11000	—	Detected once below PQL
Acetonitrile	R-23	816	Single dedicated pump	30	1	9	9	25	130	EPA TAP RSL	—	65	—	Detected once below PQL; not detected in field duplicate (FD)
	R-23i	470	Baski dual-pump	21	1	7	7	25	130	EPA TAP RSL	—	65	—	Detected once below PQL; not detected in FD
Chloromethane	R-23	816	Single dedicated pump	38	1	0.4	0.4	1	190	EPA TAP RSL	—	95	—	Detected once below PQL; not detected in FD
	R-23i	400	Portable pump	15	2	0.5	0.7	1	190	EPA TAP RSL	—	95	—	Detected below PQL in primary sample and FD (Jun-09)
	R-23i	470	Baski dual-pump	21	2	0.3	0.4	1	190	EPA TAP RSL	—	95	—	Detected below PQL in primary sample and FD (Jun-09)
	R-39	859	Single dedicated pump	14	4	0.4	0.5	1	190	EPA TAP RSL	—	95	—	Detected below PQL in 3 events
	R-41	965	Single dedicated pump	11	1	0.3	0.3	1	190	EPA TAP RSL	—	95	—	Detected once below PQL; not detected in FD
	R-49	845	Baski dual-APV	8	1	0.5	0.5	1	190	EPA TAP RSL	—	95	—	Detected once below PQL in Jun-09
Methylene Chloride	R-23	816	Single dedicated pump	38	1	4.3	4.3	10	5	EPA Primary MCL	—	2.5	1	Detected once below PQL in Jun-08
	R-49	906	Baski dual-APV	8	1	4.1	4.1	10	5	EPA MCL	—	2.5	1	Detected once below PQL; not detected in FD

Table D-3.0-1 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
Naphthalene	R-23	816	Single dedicated pump	30	1	0.7	0.7	1	30	NM GW STD	—	15	—	Detected once below PQL; not detected in FD
Toluene	R-23i	400	Portable pump	15	1	0.6	0.6	1	750	NM GW STD	—	375	—	Detected once below PQL
	R-23i	470	Baski dual-pump	21	2	15	16	1	750	NM GW STD	—	375	—	Detected only in first event (Oct-06)
	R-23i	524	Baski dual-pump	16	1	3.5	3.5	1	750	NM GW STD	—	375	—	Detected only in first event (Oct-06)
	R-39	859	Single dedicated pump	14	3	1.6	2.4	1	750	NM GW STD	—	375	—	Detected above PQL only in first event (Feb-09)
	R-41	965	Single dedicated pump	11	1	7.5	7.5	1	750	NM GW STD	—	375	—	Detected only in first event (Apr-09)
	R-49	845	Baski dual-APV	8	1	0.3	0.3	1	750	NM GW STD	—	375	—	Detected only in first event (Jun-09)
	R-49	906	Baski dual-APV	8	2	0.4	0.5	1	750	NM GW STD	—	375	—	Detected only in one event (Mar-10)
	R-55	~870	Temporary	1	1	0.3	0.3	1	750	NM GW STD	—	375	—	Detected below PQL in first event
Trichlorobenzene[1,2,3-]	R-23	816	Single dedicated pump	30	1	0.6	0.6	1	29	EPA TAP RSL	—	14	—	Detected once below PQL; not detected in FD
Trichloroethene (TCE)	R-23i	470	Baski dual-pump	21	2	0.3	0.3	1	5	EPA MCL	—	2.5	—	Detected in one event (Jun-09)
Trimethylbenzene[1,2,4-]	R-23	816	Single dedicated pump	38	1	0.3	0.3	1	15	EPA TAP RSL	—	7.5	—	Detected once below PQL; not detected in FD
Xylene[1,3-]+Xylene[1,4-]	R-23	816	Single dedicated pump	32	1	0.3	0.3	2	1200[e]	EPA TAP RSL	—	600	—	Detected once below PQL; not detected in FD (Jul-05)
	R-23i	524	Baski dual-pump	16	1	0.3	0.3	2	1200	EPA TAP RSL	—	600	—	Detected below PQL in first event (Oct-06)

Table D-3.0-1 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
SVOCs														
Benzoic Acid	R-23	816	Single dedicated pump	37	1	24	24	20	150000	EPA TAP RSL	—	75000	—	Detected once below PQL; not detected in FD
	R-39	859	Single dedicated pump	14	1	20	20	20	150000	EPA TAP RSL	—	75000	—	Detected once (Aug-10)
Benzo(b)fluoranthene	R-55	~1000	Temporary	1	1	0.42	0.42	1	0.29	EPA TAP RSL	1	0.14	1	Detected below PQL in first event
Benzo(k)fluoranthene	R-55	~1000	Temporary	1	1	0.47	0.47	1	2.9	EPA TAP RSL	—	1.5	—	Detected below PQL in first event
Bis(2-ethylhexyl)phthalate	R-23	816	Single dedicated pump	37	4	3.6	7.6	10	6	EPA MCL	1	3	2	Max in Dec-03. All other detections ≤ 3.25 µg/L
Butylbenzylphthalate	R-23	816	Single dedicated pump	37	1	2	2	10	350	EPA TAP RSL	—	175	—	Detected once below PQL (Dec-03)
Diethylphthalate	R-23	816	Single dedicated pump	37	2	12	14	10	29000	EPA TAP RSL	—	14500	—	Detected once each in Mar-10 and Aug-10; not detected in corresponding FDs
	R-39	859	Single dedicated pump	14	1	12	12	10	29000	EPA TAP RSL	—	14500	—	Detected once in Aug-10
Dioxane[1,4-]	R-23i	400	Portable pump	10	1	1.2	1.2	10	61	EPA TAP RSL	—	31	—	Detected once below PQL (Jun-09)
Indeno(1,2,3-cd)pyrene	R-55	~1000	Temporary	1	1	0.47	0.47	1	0.29	EPA TAP RSL	1	0.14	1	Detected below PQL in first event
Phenol	R-23	816	Single dedicated pump	37	1	2.0	2.0	10	5	NM GW STD	—	2.5	—	Detected once below PQL (Dec-08)

Table D-3.0-1 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
PCBs														
Aroclor-1242	R-23i	400	Portable pump	8	1	0.06	0.06	0.5	0.5	EPA MCL	—	0.25	—	Detected once below PQL (Mar-09)
Aroclor-1254	R-23i	400	Portable pump	8	1	0.09	0.09	0.5	0.5	EPA MCL	—	0.25	—	Detected once below PQL (Mar-09)
Pesticides														
DDD[4,4']	R-23	816	Single dedicated pump	28	1	0.006	0.006	0.04	2.8	EPA TAP RSL	—	1.4	—	Detected once below PQL (Mar-07)
Endosulfan Sulfate	R-23	816	Single dedicated pump	28	2	0.010	0.011	0.04	—	—	—	—	—	Detected below PQL in Dec-03 and Sep-04
Endrin Aldehyde	R-23	816	Single dedicated pump	28	1	0.033	0.033	0.04	—	—	—	—	—	Detected once below PQL (Dec-03)
	R-23i	524	Baski dual-pump	8	1	0.007	0.007	0.04	—	—	—	—	—	Detected once below PQL (Sep-09)
Endrin Ketone	R-23	816	Single dedicated pump	28	2	0.009	0.010	0.04	—	—	—	—	—	Detected below PQL in Dec 03 and Sep-04
Dioxin/Furans														
Heptachlorodibenzodioxin [1,2,3,4,6,7,8-]	R-23i	524	Baski dual-pump	3	1	7.E-7	7.E-7	5.E-5	—	—	—	—	—	Detected once below PQL (1-Dec-09)
	R-49	906	Baski dual-APV	6	1	7.E-7	7.E-7	5.E-5	—	—	—	—	—	Detected once below PQL (1-Sep-09)
Heptachlorodibenzodioxins (Total)	R-23i	524	Baski dual-pump	3	1	2.E-6	2.E-6	5.E-5	—	—	—	—	—	Detected once below PQL (1-Dec-09)
	R-39	859	Single dedicated pump	9	1	3.E-6	3.E-6	5.E-5	—	—	—	—	—	Detected once below PQL (2-Sep-09)
	R-49	906	Baski dual-APV	6	1	2.E-6	2.E-6	5.E-5	—	—	—	—	—	Detected once below PQL (1-Sep-09)

Table D-3.0-1 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
Heptachlorodibenzofuran [1,2,3,4,6,7,8-]	R-23	816	Single dedicated pump	6	1	2.E-5	2.E-5	5.E-5	—	—	—	—	—	Detected once below PQL (25-Feb-09)
Heptachlorodibenzofurans (Total)	R-23	816	Single dedicated pump	6	1	2.E-5	2.E-5	5.E-5	—	—	—	—	—	Detected once below PQL (25-Feb-09)
Hexachlorodibenzofuran [1,2,3,4,7,8-]	R-23	816	Single dedicated pump	6	1	3.E-6	3.E-6	5.E-5	—	—	—	—	—	Detected once below PQL (25-Feb-09)
Hexachlorodibenzofurans (Total)	R-23	816	Single dedicated pump	6	1	1.E-5	1.E-5	5.E-5	—	—	—	—	—	Detected once below PQL (25-Feb-09)
Octachlorodibenzodioxin [1,2,3,4,6,7,8,9-]	R-39	859	Single dedicated pump	9	1	1.E-6	1.E-6	1.E-4	—	—	—	—	—	Detected once below PQL (12-Mar-09)
Octachlorodibenzofuran [1,2,3,4,6,7,8,9-]	R-23	816	Single dedicated pump	6	1	2.E-5	2.E-5	1.E-4	—	—	—	—	—	Detected once below PQL (25-Feb-09)
	R-23i	400	Portable pump	5	1	9.E-7	9.E-7	1.E-4	—	—	—	—	—	Detected once below PQL (3-Dec-09)
High Explosive Compounds – None detected														

[a] Detection statistics are shown for a screen only for those analytes detected at least once. The tabulated statistics include data for field duplicates. Thus, two detections of a given analyte do not necessarily imply the analyte was detected in two different sampling events.

[b] PQL values from LANL (2010, 109830, section C-4.1).

[c] Screening level = lowest applicable regulatory standard (if one exists), or risk-based screening level (if no regulatory standard exists), as prescribed by the Consent Order and implemented as documented in Appendix B of the 2010 IFGMP (LANL 2010, 109830):

- EPA Primary MCL = EPA maximum contaminant level (primary standard for drinking water) (40 Code of Federal Regulations Part 141).
- EPA Tap RSL = EPA regional screening level for tapwater (available online at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm).
- NM GW Std = New Mexico Water Quality Control Commission Standards for Groundwater (New Mexico Administrative Code 20.6.2.3103).

[d] — = None.

[e] The EPA TAP RSL table does not provide a screening level specifically for Xylene[1,3-] + Xylene [1,4-] as a combined analysis. However, the three individual xylene isomers (1,2-Xylene, 1,3-Xylene, and 1,4-Xylene) all have the same screening level of 1200 µg/L. This value is adopted as the applicable screening in the table above to screen the analytical data for Xylene[1,3-] + Xylene [1,4-].

Table D-3.0-2
Statistical Summary of Organic Analytes and High Explosives Detected in Groundwater Samples Collected from Well R-22

Analyte	Well	Port Depth (ft bgs)	Sampling System for Detected Analytes	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
VOCs														
Acetone	R-22	907	Westbay	8	2	7	13	5	22000	EPA Tap RSL	—[d]	11000	—	Detected once above PQL (Mar-01)
		1274	Westbay	20	1	3	3	5	22000	EPA Tap RSL	—	11000	—	Detected once below PQL (Mar-02)
		1378	Westbay	9	5	14	32	5	22000	EPA Tap RSL	—	11000	—	Not detected after Mar-02
		1448	Westbay	17	3	12	16	5	22000	EPA Tap RSL	—	11000	—	Not detected after Mar-02
Butanone[2-]	R-22	1378	Westbay	9	1	7	7	5	7100	EPA Tap RSL	—	3550	—	Detected once above PQL (Mar-01)
		1448	Westbay	17	2	9	9	5	7100	EPA Tap RSL	—	3550	—	Detected twice above PQL (Mar-01 and Jun-01)
Carbon Disulfide	R-22	1448	Temporary	6	1	2	2	5	1000	EPA Tap RSL	—	500	—	Not detected prior to redevelopment
Chloroform	R-22	1274	Westbay	20	1	0.9	0.9	1	80	EPA Primary MCL	—	40	—	Detected once below PQL (Mar-01)
Chloromethane	R-22	907	Temporary	6	2	0.4	0.5	1	190	EPA Tap RSL	—	95	—	Not detected prior to redevelopment
		1448	Temporary	10	1	0.4	0.4	1	190	EPA Tap RSL	—	95	—	Not detected prior to redevelopment
Dichlorobenzene[1,4-]	R-22	963	Westbay	19	1	0.2	0.2	10	75	EPA Primary MCL	—	38	—	Detected once in Feb-02
		1274	Westbay	20	1	0.2	0.2	10	75	EPA Primary MCL	—	38	—	Detected once in Mar-02
		1378	Westbay	9	1	0.2	0.2	10	75	EPA Primary MCL	—	38	—	Detected once in Mar-02
Diethyl Ether	R-22	963	Westbay	8	1	0.3	0.3	1	7300	EPA Tap RSL	—	3650	—	Detected once below PQL (Jun-08)
Isopropylbenzene	R-22	907	Westbay	8	6	0.7	1.0	1	680	EPA Tap RSL	—	340	—	Detected in samples prior to redevelopment; not detected in post-development samples
		1448	Westbay	17	1	0.2	0.2	1	680	EPA Tap RSL	—	340	—	Detected once below PQL (Mar-02)
Methylene Chloride	R-22	907	Westbay	8	1	2.2	2.2	10	5	EPA Primary MCL	—	2.5	—	Detected once below PQL (Feb-02)
		962	Westbay	19	1	0.6	0.6	10	5	EPA Primary MCL	—	2.5	—	Detected once below PQL (Dec-01)
		1274	Westbay	20	1	2.4	2.4	10	5	EPA Primary MCL	—	2.5	—	Detected once below PQL (Sep-07)
Naphthalene	R-22	907	Westbay	6	1	0.3	0.3	1	30	NM GW Std	—	15	—	Detected once below PQL (Jul-02)

Table D-3.0-2 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System for Detected Analytes	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
Toluene	R-22	907	Temporary	6	2	1.0	1.8	1	750	NM GW Std	—	375	—	Not detected prior to redevelopment
		1378	Westbay	9	1	0.2	0.2	1	750	NM GW Std	—	375	—	Detected once below PQL (Dec-01)
		1448	Westbay	17	12	0.5	0.8	1	750	NM GW Std	—	375	—	All detections below PQL
		1448	Temporary	10	3	3.1	6.9	1	750	NM GW Std	—	375	—	—
SVOCs														
Acenaphthene	R-22	1448	Westbay	9	1	0.4	0.4	1	2200	EPA Tap RSL	—	1100	—	Detected once below PQL (Dec-01)
Acenaphthylene	R-22	1448	Westbay	9	1	0.4	0.4	1	—	—	—	—	—	Detected once below PQL (Dec-01)
Anthracene	R-22	1448	Westbay	9	1	0.4	0.4	1	11000	EPA Tap RSL	—	5500	—	Detected once below PQL (Dec-01)
Benzo(a)pyrene	R-22	1448	Westbay	9	1	0.23	0.23	1	0.2	EPA Primary MCL	1	0.1	1	Detected once below PQL (Dec-01)
Benzo(b)fluoranthene	R-22	1448	Westbay	9	1	0.4	0.4	1	0.29	EPA Tap RSL	1	0.14	1	Detected once below PQL (Dec-01)
Benzo(k)fluoranthene	R-22	1448	Westbay	9	1	0.4	0.4	1	2.9	EPA Tap RSL	—	1.5	—	Detected once below PQL (Dec-01)
Benzoic Acid	R-22	907	Westbay	8	3	10	16	20	150000	EPA Tap RSL	—	75000	—	Detected three times below PQL
		1378	Westbay	9	1	10	10	20	150000	EPA Tap RSL	—	75000	—	Detected once below PQL (Mar-01)
		1448	Westbay	9	1	11	11	20	150000	EPA Tap RSL	—	75000	—	Detected once below PQL (Mar-01)
Bis(2-ethylhexyl)phthalate	R-22	907	Westbay	8	1	4.6	4.6	10	6	EPA Primary MCL	—	3	1	Detected once below PQL (Jun-05)
		1274	Westbay	17	3	2.4	3.9	10	6	EPA Primary MCL	—	3	1	Detected three times below PQL
		1448	Westbay	9	2	0.9	1.0	10	6	EPA Primary MCL	—	3	—	Detected below PQL in Dec-01
Butylbenzylphthalate	R-22	1448	Westbay	9	1	9.8	9.8	10	350	EPA Tap RSL	—	175	—	Detected once below PQL (Mar-02)
Chloronapthalene[2-]	R-22	1448	Westbay	9	1	0.46	0.46	1	2900	EPA Tap RSL	—	1450	—	Detected once below PQL (Dec-01)
Diethylphthalate	R-22	1448	Westbay	9	1	1	1	10	29000	EPA Tap RSL	—	14500	—	Detected once below PQL (Dec-01)
Fluoranthene	R-22	1448	Westbay	9	1	0.4	0.4	1	1500	EPA Tap RSL	—	750	—	Detected once below PQL (Dec-01)
Fluorene	R-22	1448	Westbay	9	1	0.4	0.4	1	1500	EPA Tap RSL	—	750	—	Detected once below PQL (Dec-01)
Methylnaphthalene[2-]	R-22	1448	Westbay	9	1	0.4	0.4	1	150	EPA Tap RSL	—	75	—	Detected once below PQL (Dec-01)

Table D-3.0-2 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System for Detected Analytes	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
Methylphenol[4-]	R-22	907	Westbay	7	1	44	44	10	180	EPA Tap RSL	—	90	—	Detected once above PQL (Mar-01)
		1378	Westbay	8	1	210	210	10	180	EPA Tap RSL	1	90	1	Detected once above PQL (Mar-01)
		1448	Westbay	7	1	60	60	10	180	EPA Tap RSL	—	90	—	Detected once above PQL (Mar-01)
Pentachlorophenol	R-22	1448	Westbay	9	1	6.2	6.2	10	1	EPA Primary MCL	1	0.5	1	Detected once below PQL (Dec-01)
Phenanthrene	R-22	1274	Westbay	17	1	0.1	0.1	1	—	—	—	—	—	Detected once below PQL (Mar-02)
		1448	Westbay	9	1	0.4	0.4	1	—	—	—	—	—	Detected once below PQL (Dec-01)
Phenol	R-22	1378	Westbay	9	1	32	32	10	5	NM GW STD	1	2.5	1	Detected once above PQL (Mar-01)
		1448	Westbay	9	1	19	19	10	5	NM GW STD	1	2.5	1	Detected once above PQL (Mar-01)
Pyrene	R-22	1448	Westbay	9	1	0.5	0.5	1	1100	EPA Tap RSL	—	550	—	Detected once below PQL (Dec-01)
PCBs – None detected														
Pesticides														
BHC[gamma-]	R-22	1274	Westbay	12	1	0.01	0.01	0.02	0.2	EPA Primary MCL	—	0.1	—	Detected once below PQL (Mar-01)
DDD[4,4']	R-22	1274	Westbay	12	1	0.01	0.01	0.04	2.8	EPA Primary MCL	—	1.4	—	Detected once below PQL (Aug-06)
DDE[4,4'-]	R-22	1274	Westbay	12	1	0.02	0.02	0.04	2.0	EPA Primary MCL	—	1.0	—	Detected once below PQL (Aug-06)
DDT[4,4'-]	R-22	907	Westbay	6	1	0.01	0.01	0.04	2.0	EPA Primary MCL	—	1.0	—	Detected once below PQL (Nov-01)
		963	Westbay	15	1	0.01	0.01	0.04	2.0	EPA Primary MCL	—	1.0	—	Detected once below PQL (Dec-01)
		1274	Westbay	12	2	0.01	0.01	0.04	2.0	EPA Primary MCL	—	1.0	—	Detected twice below PQL (Dec-01 and Mar-02)
		1378	Westbay	7	2	0.02	0.02	0.04	2.0	EPA Primary MCL	—	1.0	—	Detected twice below PQL (Dec-01 and Mar-02)
		1448	Westbay	7	2	0.01	0.02	0.04	2.0	EPA Primary MCL	—	1.0	—	Detected twice below PQL (Dec-01)
High Explosive Compounds														
Amino-2,6-dinitrotoluene[4-]	R-22	907	Westbay	6	1	0.42	0.42	0.32	73	EPA Tap RSL	—	36	—	Detected once above PQL (Feb-02)
Amino-4,6-dinitrotoluene[2-]	R-22	907	Westbay	6	1	0.51	0.51	0.32	73	EPA Tap RSL	—	36	—	Detected once above PQL (Feb-02)

Table D-3.0-2 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System for Detected Analytes	No. of Analyses[a]	No. of Detects[a]	Average Detect (µg/L)	Maximum Detect (µg/L)	PQL[b] (µg/L)	Screening Level[b] (µg/L)	Screening Level Source[c]	No.> Screening Level	1/2 Screening Level (µg/L)	No. > 1/2 Screening Level	Comments
Nitrobenzene	R-22	1378	Westbay	6	1	0.02	0.02	0.32	1.2	EPA Tap RSL	—	0.6	—	Detected once below PQL (Nov-03)
RDX	R-22	1448	Westbay	6	1	0.34	0.34	0.32	6.1	EPA Tap RSL	—	3.0	—	Detected once above PQL (Mar-02)
Trinitrobenzene[1,3,5-]	R-22	963	Westbay	16	1	0.12	0.12	0.32	1100	EPA Tap RSL	—	550	—	Detected once below PQL (Mar-01)
Dioxin/Furans – None detected														

[a] Detection statistics are shown for a screen only for those analytes detected at least once. The tabulated statistics include data for field duplicates. Thus, two detections of a given analyte do not necessarily imply the analyte was detected in two different sampling events.

[b] PQL values from(LANL (2010, 109830, section C-4.1).

[c] Screening level = lowest-applicable regulatory standard (if one exists), or risk-based screening level (if no regulatory standard exists), as prescribed by the Consent Order and implemented as documented in Appendix B of the 2010 IFGMP (LANL 2010, 109830):

- EPA Primary MCL = EPA maximum contaminant level (40 Code of Federal Regulations Part 141).
- EPA Tap RSL = EPA regional screening level for tapwater (available online at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm).
- NM GW Std = New Mexico Water Quality Control Commission Standards for Groundwater (New Mexico Administrative Code 20.6.2.3103).

[d] — = None.

Table D-3.0-3
Statistical Summary of Inorganic COPCs Detected above Groundwater BVs in Samples Collected from Wells R-23, R-23i, R-39, R-41, R-49, R-55, and R-57, through October 31, 2010

Analyte	Well	Port Depth (ft bgs)	Hydrologic Zone	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Unit	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
General Inorganics (F) detected at least once above groundwater BVs																	
Chloride	R-23i	400	Intermediate	12	12	25.3	36.7	mg/L	4.26	UTL	12	250	NM GW Std	—[c]	125	—	—
		470	Intermediate	18	18	7.6	8.5	mg/L	4.26	UTL	18	250	NM GW Std	—	125	—	—
		524	Intermediate	14	14	8.5	9.1	mg/L	4.26	UTL	14	250	NM GW Std	—	125	—	—
Magnesium	R-23i	400	Intermediate	12	12	9.6	13.7	mg/L	4.78	UTL	12	—	—	—	—	—	—
		470	Intermediate	18	18	5.8	6.4	mg/L	4.78	UTL	18	—	—	—	—	—	—
		524	Intermediate	14	14	5.8	6.1	mg/L	4.78	UTL	14	—	—	—	—	—	—
Nitrate-Nitrite as N	R-23i	470	Intermediate	20	17	0.71	0.97	mg/L	0.66	UTL	13	10	EPA Primary MCL	—	5	—	—
		524	Intermediate	14	14	0.80	0.93	mg/L	0.66	UTL	13	10	EPA Primary MCL	—	5	—	—
	R-23	816	Regional	36	35	1.19	1.95	mg/L	0.58	UTL	31	10	EPA Primary MCL	—	5	—	—
	R-39	859	Regional	9	9	0.61	0.74	mg/L	0.58	UTL	6	10	EPA Primary MCL	—	5	—	—
	R-41	965	Regional	8	8	0.60	0.76	mg/L	0.58	UTL	6	10	EPA Primary MCL	—	5	—	—
	R-49	845	Regional	6	6	0.59	0.68	mg/L	0.58	UTL	4	10	EPA Primary MCL	—	5	—	—
		906	Regional	6	6	0.56	0.76	mg/L	0.58	UTL	4	10	EPA Primary MCL	—	5	—	—
	R-55	~870	Regional	1	1	0.76	0.76	mg/L	0.58	UTL	1	10	EPA Primary MCL	—	5	—	—
		~1000	Regional	1	1	0.70	0.70	mg/L	0.58	UTL	1	10	EPA Primary MCL	—	5	—	—
	R-57	910	Regional	1	1	0.60	0.60	mg/L	0.58	UTL	1	10	EPA Primary MCL	—	5	—	—
		972	Regional	1	1	0.74	0.74	mg/L	0.58	UTL	1	10	EPA Primary MCL	—	5	—	—
Sodium	R-23i	400	Intermediate	12	12	18.2	33.7	mg/L	32.9	UTL	1	—	—	—	—	—	—
Sulfate	R-23i	400	Intermediate	12	12	14.1	27.5	mg/L	9.83	UTL	12	600	NM GW Std	—	300	—	—
		470	Intermediate	18	18	8.2	13.1	mg/L	9.83	UTL	6	600	NM GW Std	—	300	—	—

Table D-3.0-3 (continued)

Analyte	Well	Port Depth (ft bgs)	Hydrologic Zone	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Unit	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Total Dissolved Solids	R-23i	400	Intermediate	12	12	211	271	mg/L	220	UTL	5	1000	NM GW Std	—	500	—	—
	R-23	816	Regional	33	33	231	2900	mg/L	188	UTL	1	1000	NM GW Std	1	500	1	Peak value is suspect (see text). Without this outlier, average = 148 mg/L; max = 172 mg/L.
	R-49	906		6	6	154	222	mg/L	220	UTL	1	1000	NM GW Std	—	500	—	—
General Inorganics (UF) detected at least once above groundwater BVs																	
Calcium	R-23i	400	Intermediate	12	12	27.9	40.5	mg/L	38.8	UTL	1	—	—	—	—	—	—
		524	Intermediate	14	14	22.2	39.7	mg/L	38.8	UTL	1	—	—	—	—	—	—
Chloride	R-23	816	Regional	4	4	3.7	3.8	mg/L	3.2	UTL	4	—	—	—	—	—	—
Cyanide (Total)	R-23i	470	Intermediate	11	1	0.005	0.005	mg/L	0.0025	MDL	1	0.2	EPA Primary MCL	—	0.1	—	—
	R-23	816	Regional	29	2	0.003	0.004	mg/L	0.0025	MDL	2	0.2	EPA Primary MCL	—	0.1	—	—
Magnesium	R-23i	400	Intermediate	12	12	9.8	14.1	mg/L	4.3	UTL	12	—	—	—	—	—	—
		470	Intermediate	18	18	5.7	6.4	mg/L	4.3	UTL	18	—	—	—	—	—	—
		524	Intermediate	14	14	6.1	9.5	mg/L	4.3	UTL	14	—	—	—	—	—	—
	R-23	816	Regional	35	35	4.2	4.6	mg/L	4.5	UTL	1	—	—	—	—	—	—
	R-49	845	Regional	6	6	4.0	5.0	mg/L	4.5	UTL	1	—	—	—	—	—	—
Sodium	R-23i	400	Intermediate	12	12	18.0	32.7	mg/L	31.1	UTL	1	—	—	—	—	—	—
		470	Intermediate	18	18	63.6	903	mg/L	31.1	UTL	1	—	—	—	—	—	—
Sulfate	R-23	816	Regional	4	4	5.4	5.5	mg/L	5.2	UTL	4	—	—	—	—	—	—
Metals (F) detected at least once above groundwater BVs																	
Aluminum	R-23	816	Regional	35	3	79	168	µg/L	68	MDL	1	5000	NM GW Std	—	2500	—	—
	R-41	965	Regional	8	1	163	163	µg/L	68	MDL	1	5000	NM GW Std	—	2500	—	—
	R-49	845	Regional	6	1	331	331	µg/L	68	MDL	1	5000	NM GW Std	—	2500	—	—
	R-57	910	Regional	1	1	201	201	µg/L	68	MDL	1	5000	NM GW Std	—	2500	—	—

Table D-3.0-3 (continued)

Analyte	Well	Port Depth (ft bgs)	Hydrologic Zone	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Unit	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level[b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Arsenic	R-23i	400	Intermediate	12	4	3.7	4.7	µg/L	3.4	UTL	3	10	EPA Primary MCL	—	5	—	—
	R-49	906	Regional	6	1	4.9	4.9	µg/L	3.7	UTL	1	10	EPA Primary MCL	—	5	—	—
Beryllium	R-23	816	Regional	35	1	1.6	1.6	µg/L	1	MDL	1	4	EPA Primary MCL	—	2	—	—
Cobalt	R-23i	400	Intermediate	12	1	1.1	1.1	µg/L	1	MDL	1	50	NM GW Std	—	25	—	—
		524	Intermediate	14	1	1.1	1.1	µg/L	1	MDL	1	50	NM GW Std	—	25	—	—
	R-23	816	Regional	35	1	1.6	1.6	µg/L	1	MDL	1	50	NM GW Std	—	25	—	—
	R-41	965	Regional	8	2	1.4	1.6	µg/L	1	MDL	1	50	NM GW Std	—	25	—	—
	R-49	845	Regional	6	1	1.2	1.2	µg/L	1	MDL	1	50	NM GW Std	—	25	—	—
		906	Regional	6	1	1.0	1.0	µg/L	1	MDL	1	50	NM GW Std	—	25	—	—
Copper	R-23	816	Regional	35	1	27	27	µg/L	3	MDL	1	1000	NM GW Std	—	500	—	—
	R-39	859	Regional	9	1	4	4	µg/L	3	MDL	1	1000	NM GW Std	—	500	—	—
Iron	R-23	816	Regional	35	6	59	169	µg/L	30	MDL	5	1000	NM GW Std	—	500	—	—
	R-41	965	Regional	8	1	116	116	µg/L	30	MDL	1	1000	NM GW Std	—	500	—	—
	R-49	845	Regional	6	1	78	78	µg/L	30	MDL	1	1000	NM GW Std	—	500	—	—
	R-57	910	Regional	1	1	54	54	µg/L	30	MDL	1	1000	NM GW Std	—	500	—	—
		972	Regional	1	1	36	36	µg/L	30	MDL	1	1000	NM GW Std	—	500	—	—
Lead	R-23	816	Regional	35	6	1.3	2.0	µg/L	1.8	MDL	1	15	EPA Primary MCL	—	7.5	—	—
Manganese	R-23	816	Regional	35	10	28	207	µg/L	36	UTL	1	200	NM GW Std	1	100	1	Max in first sample (Oct-06)
	R-41	965	Regional	8	8	19	55	µg/L	36	UTL	2	200	NM GW Std	—	100	—	—
Mercury	R-23	816	Regional	36	1	0.072	0.072	µg/L	0.07	MDL	1	2	EPA Primary MCL	—	1	—	—
Molybdenum	R-23i	400	Regional	12	10	3.6	23.4	µg/L	5.3	UTL	1	1000	NM GW Std	—	500	—	—
	R-41	965	Regional	8	8	5.3	8.7	µg/L	3.4	UTL	8	1000	NM GW Std	—	500	—	—
	R-49	845	Regional	6	6	3.4	5.9	µg/L	3.4	UTL	2	1000	NM GW Std	—	500	—	—
Nickel	R-23i	400	Intermediate	12	11	1.2	3.5	µg/L	3.0	UTL	1	200	NM GW Std	—	100	—	—

Table D-3.0-3 (continued)

Analyte	Well	Port Depth (ft bgs)	Hydrologic Zone	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Unit	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Thallium	R-23	816	Regional	35	6	0.31	0.57	µg/L	0.4	MDL	1	2	EPA Primary MCL	—	1	—	—
Uranium	R-23i	400	Regional	12	10	2.8	18.9	µg/L	2.2	UTL	1	30	EPA Primary MCL	—	15	1	Peak value is suspect; out-of-line with trend. Without this outlier, average = 1.0 µg/L; max = 1.7 µg/L.
Zinc	R-23i	400	Intermediate	12	9	9	21	µg/L	3.3	MDL	9	180	EPA Tap RSL	—	90	—	—
		470	Intermediate	18	11	8	31	µg/L	3.3	MDL	9	180	EPA Tap RSL	—	90	—	—
		524	Intermediate	14	5	4	7	µg/L	3.3	MDL	4	180	EPA Tap RSL	—	90	—	—
	R-23	816	Regional	35	11	12	30	µg/L	25	UTL	2	180	EPA Tap RSL	—	90	—	—
	R-39	859	Regional	9	7	12	28	µg/L	25	UTL	1	180	EPA Tap RSL	—	90	—	—
Metals (UF) detected at least once above groundwater BVs																	
Aluminum	R-23i	524	Intermediate	14	2	3092	6080	µg/L	5524	UTL	1	37000	EPA Tap RSL	—	18500	—	—
	R-23	816	Regional	35	4	40	70	µg/L	68	MDL	1	37000	EPA Tap RSL	—	18500	—	—
	R-39	859	Regional	9	5	185	261	µg/L	68	MDL	5	37000	EPA Tap RSL	—	18500	—	—
	R-41	965	Regional	8	3	270	361	µg/L	68	MDL	3	37000	EPA Tap RSL	—	18500	—	—
	R-49	845	Regional	6	6	1131	3020	µg/L	68	MDL	6	37000	EPA Tap RSL	—	18500	—	—
Arsenic	R-23i	400	Intermediate	12	5	3.8	4.9	µg/L	1	MDL	5	10	EPA Primary MCL	—	5	—	—
		470	Intermediate	18	6	2.1	2.5	µg/L	1	MDL	6	10	EPA Primary MCL	—	5	—	—
		524	Intermediate	14	6	2.3	3.8	µg/L	1	MDL	6	10	EPA Primary MCL	—	5	—	—
Barium	R-49	845	Regional	6	6	56	121	µg/L	73	UTL	1	2000	EPA Primary MCL	—	1000	—	—
Beryllium	R-23i	524	Intermediate	14	1	1.4	1.4	µg/L	1	MDL	1	4	EPA Primary MCL	—	2	—	—
Boron	R-23i	470	Intermediate	18	15	21	64	µg/L	42	UTL	1	7300	EPA Primary MCL	—	3650	—	—

Table D-3.0-3 (continued)

Analyte	Well	Port Depth (ft bgs)	Hydrologic Zone	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Unit	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Chromium	R-23i	400	Intermediate	12	8	6	18	µg/L	11	UTL	1	100	EPA Primary MCL	—	50	—	—
		524	Intermediate	14	8	13	82	µg/L	11	UTL	1	100	EPA Primary MCL	—	50	1	—
	R-23	816	Regional	35	29	4	20	µg/L	10	UTL	1	100	EPA Primary MCL	—	50	—	—
Cobalt	R-23i	400	Intermediate	12	1	1.0	1.0	µg/L	1	MDL	1	11	EPA Tap RSL	—	5.5	—	—
	R-23	816	Regional	35	1	1.9	1.9	µg/L	1	MDL	1	11	EPA Tap RSL	—	5.5	—	—
Copper	R-23i	400	Intermediate	12	3	3.4	3.5	µg/L	3	MDL	3	1500	EPA Tap RSL	—	750	—	—
		470	Intermediate	18	1	3.1	3.1	µg/L	3	MDL	1	1500	EPA Tap RSL	—	750	—	—
		524	Intermediate	14	1	25	25	µg/L	3	MDL	1	1500	EPA Tap RSL	—	750	—	—
	R-23	816	Regional	35	2	3.2	3.2	µg/L	3	MDL	2	1500	EPA Tap RSL	—	750	—	—
	R-39	859	Regional	9	2	7.8	8.9	µg/L	3	MDL	2	1500	EPA Tap RSL	—	750	—	—
	R-41	965	Regional	8	1	7.7	7.7	µg/L	3	MDL	1	1500	EPA Tap RSL	—	750	—	—
Iron	R-23i	524	Intermediate	14	8	1168	8890	µg/L	2265	UTL	1	26000	EPA Tap RSL	—	13000	—	—
	R-49	845	Regional	6	6	542	1510	µg/L	748	UTL	1	26000	EPA Tap RSL	—	13000	—	—
Lead	R-23i	524	Intermediate	14	1	21.9	21.9	µg/L	4.8	UTL	1	15	EPA Primary MCL	1	7.5	1	Detected only in first sample
	R-23	816	Regional	34	23	2.0	14.2	µg/L	0.5	MDL	21	15	EPA Primary MCL	—	7.5	1	—
	R-41	965	Regional	8	1	0.54	0.54	µg/L	0.5	MDL	1	15	EPA Primary MCL	—	7.5	—	—
	R-49	845	Regional	6	6	3.3	8.8	µg/L	0.5	MDL	6	15	EPA Primary MCL	—	7.5	1	—
Manganese	R-23i	524	Intermediate	14	2	230	453	µg/L	143	UTL	1	880	EPA Tap RSL	—	440	1	—
	R-23	816	Regional	34	34	73	604	µg/L	41	UTL	12	880	EPA Tap RSL	—	440	1	—
	R-41	965	Regional	8	8	11	51	µg/L	41	UTL	1	880	EPA Tap RSL	—	440	—	—
	R-49	845	Regional	6	6	25	51	µg/L	41	UTL	1	880	EPA Tap RSL	—	440	—	—
Mercury	R-23i	400	Intermediate	12	1	0.10	0.10	µg/L	0.07	MDL	1	2	EPA Primary MCL	—	1	—	—
		524	Intermediate	14	1	0.13	0.13	µg/L	0.07	MDL	1	2	EPA Primary MCL	—	1	—	—

Table D-3.0-3 (continued)

Analyte	Well	Port Depth (ft bgs)	Hydrologic Zone	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Unit	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Molybdenum	R-23i	400	Intermediate	12	10	4.2	28.8	µg/L	2.9	UTL	2	180	EPA Tap RSL	—	90	—	—
		470	Intermediate	18	16	2.3	3.4	µg/L	2.9	UTL	1	180	EPA Tap RSL	—	90	—	—
	R-39	859	Regional	9	9	2.2	5.0	µg/L	3.6	UTL	1	180	EPA Tap RSL	—	90	—	—
	R-41	965	Regional	8	8	4.0	7.4	µg/L	3.6	UTL	6	180	EPA Tap RSL	—	90	—	—
	R-49	845	Regional	6	6	3.2	5.6	µg/L	3.6	UTL	2	180	EPA Tap RSL	—	90	—	—
Nickel	R-23i	400	Intermediate	12	11	1.9	5.2	µg/L	4.8	UTL	1	730	EPA Tap RSL	—	365	—	—
		470	Intermediate	18	18	1.3	5.8	µg/L	4.8	UTL	1	730	EPA Tap RSL	—	365	—	—
		524	Intermediate	14	14	3.8	36.3	µg/L	4.8	UTL	1	730	EPA Tap RSL	—	365	—	—
	R-23	816	Regional	35	28	1.8	9.4	µg/L	4.5	UTL	2	730	EPA Tap RSL	—	365	—	—
	R-49	845	Regional	6	6	2.5	6.2	µg/L	4.5	UTL	1	730	EPA Tap RSL	—	365	—	—
Thallium	R-49	845	Regional	6	1	0.47	0.47	µg/L	0.4	MDL	1	2	EPA Primary MCL	—	1	—	—
Uranium	R-23i	400	Perched	12	11	3.0	22.7	µg/L	5.0	UTL	1	30	EPA Primary MCL	—	15	1	Peak value is suspect; out-of-line with trend. Without this outlier, average = 1.0 µg/L; max = 1.7 µg/L
	R-41	965	Regional	8	8	0.7	1.2	µg/L	1.1	UTL	1	30	EPA Primary MCL	—	15	—	—
	R-49	845	Regional	6	6	2.4	4.6	µg/L	1.1	UTL	6	30	EPA Primary MCL	—	15	—	—

Table D-3.0-3 (continued)

Analyte	Well	Port Depth (ft bgs)	Hydrologic Zone	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Unit	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level[b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Zinc	R-23i	470	Intermediate	18	12	11	43	µg/L	34	UTL	2	180	EPA Tap RSL	—	90	—	—
		524	Intermediate	14	5	55	262	µg/L	34	UTL	1	180	EPA Tap RSL	1	90	1	Max in first sample (Oct-06); <5 µg/L in other samples
	R-39	859	Regional	9	8	24	53	µg/L	43	UTL	1	180	EPA Tap RSL	—	90	—	—

Notes: Detection statistics are shown for a screen only for those general inorganics and trace metals detected at least once above the groundwater BV. Screening Level = Lowest applicable regulatory standard or other type of screening level. F = filtered; UF = unfiltered.

[a] The tabulated statistics include data for field duplicates. Thus, two detections of a given analyte do not necessarily imply the analyte was detected in two different sampling events.

[b] Type of Screening Level = reference for lowest-applicable water-quality screening level, as prescribed by the Consent Order and implemented as documented in Appendix B of the 2010 IFGMP (LANL 2010, 109830):

- EPA Primary MCL = EPA maximum contaminant level (40 Code of Federal Regulations Part 141).
- EPA Tap RSL = EPA regional screening level for tapwater (available online at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm).
- NM GW Std = New Mexico Water Quality Control Commission Standards for Groundwater (New Mexico Administrative Code 20.6.2.3103).

[c] — = None.

Table D-3.0-4
Statistical Summary of Inorganic COPCs Detected above Groundwater BVs in Samples Collected from Wells R-22 (Regional Groundwater)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Units	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level[b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
General Inorganics (F) detected at least once above groundwater BVs																	
Calcium	R-22	907	Westbay	5	5	60	72	mg/L	21	UTL	5	—[c]	—	—	—	—	—
		963	Westbay	16	16	14	59	mg/L	21	UTL	1	—	—	—	—	—	—
		1274	Westbay	14	14	19	35	mg/L	21	UTL	1	—	—	—	—	—	—
		1378	Westbay	6	6	48	61	mg/L	21	UTL	6	—	—	—	—	—	—
		1448	Westbay	6	6	36	38	mg/L	21	UTL	6	—	—	—	—	—	—
Chloride	R-22	907	Westbay	5	5	4.9	10.2	mg/L	7.3	UTL	1	—	—	—	—	—	—
		1378	Westbay	7	7	7.8	8.3	mg/L	7.3	UTL	7	—	—	—	—	—	—
Cyanide (Total)	R-22	907	Westbay	1	1	0.005	0.005	mg/L	0.0025	MDL	1	0.2	NM GW Std	—	0.1	—	—
		1274	Westbay	4	1	0.003	0.003	mg/L	0.0025	MDL	1	0.2	NM GW Std	—	0.1	—	—
Fluoride	R-22	907	Westbay	5	4	0.44	0.62	mg/L	0.54	UTL	1	1.6	NM GW Std	—	0.8	—	—
		1274	Westbay	14	14	0.52	0.67	mg/L	0.54	UTL	4	1.6	NM GW Std	—	0.8	—	—
		1378	Westbay	7	7	0.64	0.80	mg/L	0.54	UTL	5	1.6	NM GW Std	—	0.8	—	—
Magnesium	R-22	907	Westbay	5	5	16.2	21.3	mg/L	4.5	UTL	5	—	—	—	—	—	—
		963	Westbay	16	16	5.3	15.9	mg/L	4.5	UTL	11	—	—	—	—	—	—
		1274	Westbay	14	14	5.5	11.0	mg/L	4.5	UTL	13	—	—	—	—	—	—
		1378	Westbay	6	6	12.5	15.0	mg/L	4.5	UTL	5	—	—	—	—	—	—
		1448	Westbay	6	6	6.4	7.3	mg/L	4.5	UTL	6	—	—	—	—	—	—
Nitrate-Nitrite as N	R-22	963	Westbay	16	16	0.72	0.90	mg/L	0.58	UTL	14	10	EPA Primary MCL	—	5	—	—
		1274	Westbay	13	13	0.51	0.98	mg/L	0.58	UTL	6	10	EPA Primary MCL	—	5	—	—

Table D-3.0-4 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Units	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level[b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Perchlorate	R-22	963	Westbay	21	13	0.64	4	µg/L	0.52	UTL	1	4	NMED GW Cons	—	2	1	Max of 4 µg/L (Dec-01) obtained using unreliable analytical method (EPA Method 314); subsequent samples analyzed by more sensitive EPA Method SW846 6850 are all < 0.4 µg/L
		1378	Westbay	7	1	4.0	4	µg/L	0.52	UTL	1	4	NMED GW Cons	—	2	1	See above comment
		1448	Westbay	38	33	0.51	4	µg/L	0.52	UTL	1	4	NMED GW Cons	—	2	1	See above comment
Potassium	R-22	907	Westbay	5	5	4.2	4.7	mg/L	3.1	UTL	5	—	—	—	—	—	—
		963	Westbay	16	16	2.6	4.0	mg/L	3.1	UTL	4	—	—	—	—	—	—
		1274	Westbay	14	14	6.6	9.7	mg/L	3.1	UTL	14	—	—	—	—	—	—
		1378	Westbay	6	6	4.8	5.6	mg/L	3.1	UTL	6	—	—	—	—	—	—
		1448	Westbay	6	6	4.4	5.3	mg/L	3.1	UTL	6	—	—	—	—	—	—
Sodium	R-22	1274	Westbay	14	14	24	54	mg/L	28	UTL	4	—	—	—	—	—	—
		1378	Westbay	6	6	38	45	mg/L	28	UTL	5	—	—	—	—	—	—
Sulfate	R-22	1274	Westbay	14	14	12.2	31	mg/L	5.2	UTL	14	—	—	—	—	—	—
Total Dissolved Solids	R-22	907	Westbay	4	4	370	401	mg/L	188	UTL	4	1000	NM GW Std	—	500	—	—
		1378	Westbay	4	4	271	348	mg/L	188	UTL	3	1000	NM GW Std	—	500	—	—
		1448	Westbay	3	3	221	240	mg/L	188	UTL	3	1000	NM GW Std	—	500	—	—

Table D-3.0-4 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Units	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
General Inorganics (UF) detected at least once above groundwater BVs																	
Calcium	R-22	907	Westbay	8	8	68	78	mg/L	21	UTL	8	—	—	—	—	—	—
		1274	Westbay	18	18	17	33	mg/L	21	UTL	1	—	—	—	—	—	—
		1378	Westbay	8	8	43	55	mg/L	21	UTL	8	—	—	—	—	—	—
		1448	Westbay	9	9	35	39	mg/L	21	UTL	9	—	—	—	—	—	—
Chloride	R-22	907	Westbay	4	4	3.9	4.1	mg/L	3.2	UTL	4	—	—	—	—	—	—
		1274	Westbay	7	7	4.5	4.7	mg/L	3.2	UTL	7	—	—	—	—	—	—
		1378	Westbay	3	3	8.4	9.1	mg/L	3.2	UTL	3	—	—	—	—	—	—
Cyanide (Total)	R-22	963	Westbay	17	1	0.0025	0.0025	mg/L	0.0025	MDL	1	0.2	EPA Primary MCL	—	0.1	—	—
		1378	Westbay	8	4	0.0056	0.0111	mg/L	0.0025	MDL	4	0.2	EPA Primary MCL	—	0.1	—	—
Fluoride	R-22	1378	Westbay	3	3	0.60	0.63	mg/L	0.52	UTL	3	1.5	EPA Tap RSL	—	0.75	—	—
Magnesium	R-22	907	Westbay	8	8	19.1	22.8	mg/L	4.5	UTL	8	—	—	—	—	—	—
		963	Westbay	21	21	4.6	5.1	mg/L	4.5	UTL	14	—	—	—	—	—	—
		1274	Westbay	18	18	4.9	11	mg/L	4.5	UTL	14	—	—	—	—	—	—
		1378	Westbay	8	8	11.4	14	mg/L	4.5	UTL	8	—	—	—	—	—	—
		1448	Westbay	9	9	6.0	6.4	mg/L	4.5	UTL	9	—	—	—	—	—	—
Potassium	R-22	907	Westbay	8	8	4.4	4.7	mg/L	3.0	UTL	8	—	—	—	—	—	—
		963	Westbay	21	21	2.6	3.2	mg/L	3.0	UTL	5	—	—	—	—	—	—
		1274	Westbay	18	18	6.4	10	mg/L	3.0	UTL	18	—	—	—	—	—	—
		1378	Westbay	8	8	4.6	5.7	mg/L	3.0	UTL	8	—	—	—	—	—	—
		1448	Westbay	9	9	4.5	5.1	mg/L	3.0	UTL	9	—	—	—	—	—	—
Sodium	R-22	1274	Westbay	18	18	24	60	mg/L	28	UTL	4	—	—	—	—	—	—
		1378	Westbay	8	8	45	56	mg/L	28	UTL	8	—	—	—	—	—	—
Sulfate	R-22	1274	Westbay	7	7	6.4	7.5	mg/L	5.2	UTL	7	—	—	—	—	—	—

Table D-3.0-4 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Units	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Metals (F) detected at least once above groundwater BVs																	
Aluminum	R-22	1448	Westbay	6	1	175	175	µg/L	68	MDL	1	5000	NM GW Std	—	2500	—	—
Antimony	R-22	1274	Westbay	16	1	1.3	1.3	µg/L	1	MDL	1	6	EPA Primary MCL	—	3	—	—
Barium	R-22	907	Westbay	5	5	172	198	µg/L	75	UTL	5	1000	NM GW STD	—	500	—	—
		963	Westbay	16	14	25	171	µg/L	75	UTL	1	1000	NM GW STD	—	500	—	—
		1274	Westbay	14	13	144	175	µg/L	75	UTL	13	1000	NM GW STD	—	500	—	—
		1378	Westbay	6	6	318	360	µg/L	75	UTL	6	1000	NM GW STD	—	500	—	—
		1448	Westbay	6	6	133	144	µg/L	75	UTL	6	1000	NM GW STD	—	500	—	—
Beryllium	R-22	1274	Westbay	15	1	1.6	1.6	µg/L	1	MDL	1	4	EPA Primary MCL	—	2	—	—
Boron	R-22	1274	Westbay	14	10	25	46	µg/L	35	UTL	1	750	NM GW STD	—	375	—	—
		1378	Westbay	6	4	95	97	µg/L	35	UTL	4	750	NM GW STD	—	375	—	—
Cadmium	R-22	1274	Westbay	16	1	1.2	1.2	µg/L	0.63	MDL	1	5	EPA Primary MCL	—	2.5	—	—
Cobalt	R-22	963	Westbay	16	1	2.7	2.7	µg/L	1	MDL	1	50	NM GW STD	—	25	—	
Iron	R-22	907	Westbay	7	7	10447	14900	µg/L	30	MDL	7	1000	NM GW STD	7	500	7	Max concentration in Feb-02; most recently exceeded standard in Feb-09.
		963	Westbay	16	1	7840	7840	µg/L	30	MDL	1	1000	NM GW STD	1	500	1	Single exceedance occurred in Dec-01.
		1378	Westbay	6	6	3270	5700	µg/L	30	MDL	6	1000	NM GW STD	5	500	6	Exceeded standard Mar-01 to Mar-02; exceeded 1/2-stnd in Jul-05.
		1448	Westbay	6	6	2069	4300	µg/L	30	MDL	6	1000	NM GW STD	5	500	5	Exceeded standard Mar-01 to Mar-02.
Lead	R-22	1274	Westbay	15	1	20	20	µg/L	1.83	MDL	1	15	EPA Primary MCL	1	7.5	1	Exceeded standard once in Jun-01

Table D-3.0-4 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Units	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level[b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Manganese	R-22	907	Westbay	7	7	3366	4410	µg/L	36	UTL	7	200	NM GW STD	7	100	7	Max concentration in Feb-02; most recently exceeded standard in Feb-09.
		963	Westbay	16	4	861	3430	µg/L	36	UTL	1	200	NM GW STD	1	100	1	Single exceedance occurred in Dec-01.
		1274	Westbay	14	4	63	200	µg/L	36	UTL	1	200	NM GW STD	1	100	1	Single exceedance occurred in Mar-01.
		1378	Westbay	6	6	1242	1600	µg/L	36	UTL	6	200	NM GW STD	6	100	6	—
		1448	Westbay	6	6	536	630	µg/L	36	UTL	6	200	NM GW STD	6	100	6	—
Mercury	R-22	963	Westbay	16	1	0.079	0.079	µg/L	0.07	MDL	1	2	EPA Primary MCL	—	1	—	Detected once above PQL (Jun-08)
Molybdenum	R-22	907	Westbay	5	5	28	40	µg/L	3.4	UTL	5	1000	NM GW STD	—	500	—	—
		963	Westbay	16	5	6	25	µg/L	3.4	UTL	1	1000	NM GW STD	—	500	—	—
		1274	Westbay	14	9	7	16	µg/L	3.4	UTL	7	1000	NM GW STD	—	500	—	—
		1378	Westbay	6	6	18	42	µg/L	3.4	UTL	6	1000	NM GW STD	—	500	—	—
		1448	Westbay	6	6	25	31	µg/L	3.4	UTL	6	1000	NM GW STD	—	500	—	—
Nickel	R-22	907	Westbay	5	2	17	25	µg/L	3.4	UTL	2	200	NM GW STD	—	100	—	—
		963	Westbay	16	5	1.3	3.7	µg/L	3.4	UTL	1	200	NM GW STD	—	100	—	—
Strontium	R-22	907	Westbay	5	5	313	366	µg/L	192	UTL	5	22000	EPA Tap RSL	—	11000	—	—
		963	Westbay	16	16	67	311	µg/L	192	UTL	1	22000	EPA Tap RSL	—	11000	—	—
		1274	Westbay	14	14	567	940	µg/L	192	UTL	14	22000	EPA Tap RSL	—	11000	—	—
		1378	Westbay	6	6	940	1100	µg/L	192	UTL	6	22000	EPA Tap RSL	—	11000	—	—
		1448	Westbay	6	6	292	312	µg/L	192	UTL	6	22000	EPA Tap RSL	—	11000	—	—
Thallium	R-22	1274	Westbay	16	2	0.51	0.62	µg/L	0.4	MDL	2	2	EPA Primary MCL	—	1	—	—

Table D-3.0-4 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Units	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Uranium	R-22	1274	Westbay	13	13	4.0	15	µg/L	1.7	UTL	13	30	EPA Primary MCL	—	15	1	Detected once above 1/2 standard (Mar-01); after Jun-01, all detections are < 3 µg/L
Zinc	R-22	1274	Westbay	10	5	12.4	51	µg/L	25	UTL	1	10000	NM GW STD	—	5000	—	Detected once above UTL (Jun-01); all other detections < 3 µg/L
Metals (UF) detected at least once above groundwater BVs																	
Antimony	R-22	963	Westbay	22	1	3.7	3.7	µg/L	1	MDL	1	6	EPA Primary MCL	—	3	1	Detected once (Jun-05)
		1448	Westbay	21	1	1.5	1.5	µg/L	1	MDL	1	6	EPA Primary MCL	—	3	—	Detected once (Jun-01)
Barium	R-22	907	Westbay	8	8	222	250	µg/L	73	UTL	8	2000	EPA Primary MCL	—	1000	—	—
		1274	Westbay	18	17	127	187	µg/L	73	UTL	16	2000	EPA Primary MCL	—	1000	—	—
		1378	Westbay	8	8	343	362	µg/L	73	UTL	8	2000	EPA Primary MCL	—	1000	—	—
		1448	Westbay	9	9	134	143	µg/L	73	UTL	9	2000	EPA Primary MCL	—	1000	—	—
Boron	R-22	907	Westbay	8	5	34	42	µg/L	38	UTL	1	7300	EPA Primary MCL	—	3650	—	—
		1274	Westbay	18	14	28	51	µg/L	38	UTL	2	7300	EPA Primary MCL	—	3650	—	—
		1378	Westbay	8	8	101	115	µg/L	38	UTL	8	7300	EPA Primary MCL	—	3650	—	—
		1448	Westbay	9	4	33	45	µg/L	38	UTL	1	7300	EPA Primary MCL	—	3650	—	—
Chromium	R-22	907	Westbay	8	3	11.9	31.4	µg/L	10.3	UTL	1	100	EPA Primary MCL	—	50	—	—
		963	Westbay	21	12	7.4	20.1	µg/L	10.3	UTL	3	100	EPA Primary MCL	—	50	—	—
		1274	Westbay	18	13	10.2	47	µg/L	10.3	UTL	4	100	EPA Primary MCL	—	50	—	—
Cobalt	R-22	907	Westbay	8	2	1.7	2.0	µg/L	1	MDL	2	11	EPA Tap RSL	—	5.5	—	—
		963	Westbay	21	1	1.2	1.2	µg/L	1	MDL	1	11	EPA Tap RSL	—	5.5	—	—
		1274	Westbay	18	1	1.05	1.05	µg/L	1	MDL	1	11	EPA Tap RSL	—	5.5	—	—

Table D-3.0-4 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Units	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Copper	R-22	907	Westbay	8	3	3.9	6.3	µg/L	3	MDL	2	1500	EPA Tap RSL	—	750	—	—
		1274	Westbay	18	2	3.7	4.1	µg/L	3	MDL	2	1500	EPA Tap RSL	—	750	—	—
		1378	Westbay	8	1	3.0	3.0	µg/L	3	MDL	1	1500	EPA Tap RSL	—	750	—	—
Iron	R-22	907	Westbay	9	9	17633	22200	µg/L	748	UTL	9	26000	EPA RSL	—	13000	8	Max concentration in Nov-03; most recently exceeded 1/2-stnd in Jun-05.
		1378	Westbay	8	8	4905	8300	µg/L	748	UTL	8	26000	EPA RSL	—	13000	—	—
		1448	Westbay	9	9	2282	5200	µg/L	748	UTL	9	26000	EPA RSL	—	13000	—	—
Manganese	R-22	907	Westbay	9	9	3520	4320	µg/L	41	UTL	9	880	EPA Tap RSL	9	440	9	—
		1274	Westbay	18	12	24	160	µg/L	41	UTL	1	880	EPA Tap RSL	—	440	—	—
		1378	Westbay	8	8	1071	1600	µg/L	41	UTL	8	880	EPA Tap RSL	5	440	5	—
		1448	Westbay	9	9	499	650	µg/L	41	UTL	9	880	EPA Tap RSL	—	440	8	—
Mercury	R-22	1274	Westbay	18	2	0.45	0.84	µg/L	0.07	MDL	1	2	EPA Primary MCL	—	1	—	—
Molybdenum	R-22	907	Westbay	8	8	23.7	32	µg/L	3.6	UTL	8	180	EPA Tap RSL	—	90	—	—
		963	Westbay	21	9	1.9	4.5	µg/L	3.6	UTL	1	180	EPA Tap RSL	—	90	—	—
		1274	Westbay	18	14	7.3	22	µg/L	3.6	UTL	8	180	EPA Tap RSL	—	90	—	—
		1378	Westbay	8	8	9.9	23	µg/L	3.6	UTL	6	180	EPA Tap RSL	—	90	—	—
		1448	Westbay	9	9	22.8	28	µg/L	3.6	UTL	9	180	EPA Tap RSL	—	90	—	—
Nickel	R-22	907	Westbay	8	6	24.4	31.5	µg/L	4.5	UTL	6	730	EPA Tap RSL	—	365	—	—
		963	Westbay	21	11	2.6	8.1	µg/L	4.5	UTL	2	730	EPA Tap RSL	—	365	—	—
		1274	Westbay	18	13	4.8	27	µg/L	4.5	UTL	2	730	EPA Tap RSL	—	365	—	—
		1378	Westbay	8	6	4.5	7.0	µg/L	4.5	UTL	3	730	EPA Tap RSL	—	365	—	—
		1448	Westbay	9	3	7.0	14.8	µg/L	4.5	UTL	1	730	EPA Tap RSL	—	365	—	—
Silver	R-22	963	Westbay	21	2	1.9	2.3	µg/L	1	MDL	2	180	EPA Tap RSL	—	90	—	—
		1378	Westbay	8	1	2.8	2.8	µg/L	1	MDL	1	180	EPA Tap RSL	—	90	—	—

Table D-3.0-4 (continued)

Analyte	Well	Port Depth (ft bgs)	Sampling System	No. of Analyses[a]	No. of Detects[a]	Average Detected Value	Max Detected Value	Units	BV	Type of BV	No. > BV	Screening Level Value	Type of Screening Level [b]	No.> Screening Level Value	1/2 Screening Level Value	No. > 1/2 Screening Level Value	Comments
Strontium	R-22	907	Westbay	8	8	359	412	µg/L	191	UTL	8	22000	EPA Tap RSL	—	11000	—	—
		1274	Westbay	18	18	541	1000	µg/L	191	UTL	18	22000	EPA Tap RSL	—	11000	—	—
		1378	Westbay	8	8	891	1100	µg/L	191	UTL	8	22000	EPA Tap RSL	—	11000	—	—
		1448	Westbay	9	9	291	330	µg/L	191	UTL	9	22000	EPA Tap RSL	—	11000	—	—
Thallium	R-22	963	Westbay	22	4	0.35	0.53	µg/L	0.4	MDL	2	2	EPA Primary MCL	—	1	—	—
		1273	Westbay	20	4	0.42	0.52	µg/L	0.4	MDL	3	2	EPA Primary MCL	—	1	—	—
		1448	Westbay	11	2	0.33	0.53	µg/L	0.4	MDL	1	2	EPA Primary MCL	—	1	—	—
Uranium	R-22	1274	Westbay	17	17	3	16	µg/L	1.1	UTL	17	30	EPA Primary MCL	—	15	1	Detected once above 1/2 standard (Mar-01); all other detections < 4 µg/L

Notes: Detection statistics are shown for a screen only for those general inorganics and trace metals detected at least once above the groundwater BV. Screening Level = Lowest applicable regulatory standard or other type of screening level. F = filtered; UF = unfiltered.

[a] The tabulated statistics include data for field duplicates. Thus, two detections of a given analyte do not necessarily imply the analyte was detected in two different sampling events.

[b] Type of Screening Level = reference for lowest-applicable water-quality screening level, as prescribed by the Consent Order and implemented as documented in Appendix B of the 2010 IFGMP (LANL 2010, 109830):

- EPA Primary MCL = EPA maximum contaminant level (40 Code of Federal Regulations Part 141).
- EPA Tap RSL = EPA regional screening level for tapwater (available online at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm).
- NM GW Std = New Mexico Water Quality Control Commission Standards for Groundwater (New Mexico Administrative Code 20.6.2.3103).

[c] — = None.

Table D-3.0-5a
Sampling Events in which an Organic COPC Was Detected
at Wells R-23, R-23i, R-39, R-41, R-49, R-55, and R-57, through October 31, 2010

		R-23i				R-41	R-49		R-55		R-57	
Analyte	R-23	Port 1	Port 2	Port 3	R-39	Scr 2	Scr 1	Scr 2	Scr 1	Scr 2	Scr 1	Scr 2
Port Depth (ft bgs) >	816	400	470	524	859	965	845	906	870	1000	910	972
Dioxins/Furans												
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	—*	—	—	1	–	—	—	1	—	—	—	—
Heptachlorodibenzodioxins (Total)	–	—	—	1	1	—	—	1	—	—	—	—
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	1	—	—	–	–	—	—	—	—	—	—	—
Heptachlorodibenzofurans (Total)	1	—	—	–	–	–	–	—	—	—	—	—
Hexachlorodibenzofuran[1,2,3,4,7,8-]	1	—	—	–	–	—	—	—	—	—	—	—
Hexachlorodibenzofurans (Total)	1	—	—	–	–	—	—	—	—	—	—	—
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	–	—	—	–	1	—	—	—	—	—	—	—
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	1	1	–	–	–	—	—	—	—	—	—	—
PCBs												
Aroclor-1242	—	1	—	—	—	—	—	—	—	—	—	—
Aroclor-1254	—	1	—	—	—	—	—	—	—	—	—	—
Pesticides												
DDD[4,4'-]	1	—	—	—	—	—	—	—	—	—	—	—
Endosulfan Sulfate	2	—	—	—	—	—	—	—	—	—	—	—
Endrin Aldehyde	1	—	—	1	—	—	—	—	—	—	—	—
Endrin Ketone	2	—	—	—	—	—	—	—	—	—	—	—
SVOCs												
Benzo(b)fluoranthene	—	—	—	—	—	—	—	—	—	1	—	—
Benzo(k)fluoranthene	—	—	—	—	—	—	—	—	—	1	—	—
Benzoic acid	1	—	—	—	1	—	—	—	—	—	—	—
Bis(2-ethylhexyl)phthalate	4	—	—	—	—	—	—	—	—	—	—	—
Butylbenzylphthalate	1	—	—	—	—	—	—	—	—	—	—	—
Diethylphthalate	2	—	—	—	1	—	—	—	—	—	—	—
Dioxane[1,4-]	—	—	—	—	—	—	—	—	—	—	—	—
Indeno(1,2,3-cd)pyrene	—	—	—	—	—	—	—	—	—	1	—	—
Phenol	1	—	—	—	—	—	—	—	—	—	—	—
VOCs												
Acetone	7	—	—	1	—	—	—	—	—	—	—	—
Acetonitrile	1	—	1	—	—	—	—	—	—	—	—	—
Chloromethane	1	1	1	–	3	1	1	—	—	—	—	—
Methylene Chloride	1	—	—	—	—	—	—	1	—	—	—	—
Naphthalene	1	—	—	—	—	—	—	—	—	—	—	—
Toluene	—	1	1	1	2	1	1	1	1	—	—	—

Table D-3.0-5a (continued)

Analyte	R-23	R-23i			R-39	R-41	R-49		R-55		R-57	
		Port 1	Port 2	Port 3		Scr 2	Scr 1	Scr 2	Scr 1	Scr 2	Scr 1	Scr 2
Port Depth (ft bgs) >	816	400	470	524	859	965	845	906	870	1000	910	972
Trichlorobenzene[1,2,3-]	1	—	—	—	—	—	—	—	—	—	—	—
Trichloroethene	–	—	—	—	—	—	—	—	—	—	—	—
Trimethylbenzene[1,2,4-]	1	—	—	—	—	—	—	—	—	—	—	—
Xylene[1,3-]+Xylene[1,4-]	1	—	—	1	—	—	—	—	—	—	—	—

* — = Not detected.

Table D-3.0-5b
Sampling Events in which Inorganic COPCs Were Detected above Groundwater BVs at Wells R-23, R-23i, R-39, R-41, R-49, R-55, and R-57, through October 31, 2010

Analyte	R-23	R-23i			R-39	R-41	R-49		R-55		R-57	
		Port 1	Port 2	Port 3		Scr 2	Scr 1	Scr 2	Scr 1	Scr 2	Scr 1	Scr 2
Port Depth (ft bgs) >	816	400	470	524	859	965	845	906	870	1000	910	972
General Inorganics (Filtered)												
Chloride	—*	11	16	13	—	—	—	—	—	—	—	—
Magnesium	—	11	16	13	—	—	—	—	—	—	—	—
Nitrate-Nitrite as Nitrogen	21	–	11	12	7	5	4	4	1	1	1	1
Sodium	—	1	—	—	—	—	—	—	—	—	—	—
Sulfate	—	10	2	—	—	—	—	—	—	—	—	—
Total Dissolved Solids	1	5	—	—	—	—	—	1	—	—	—	—
General Inorganics (Unfiltered)												
Calcium	—	1	—	1	—	—	—	—	—	—	—	—
Chloride	2	—	—	—	—	—	—	—	—	—	—	—
Cyanide (Total)	2	—	1	—	—	—	—	—	—	—	—	—
Magnesium	1	11	16	13	—	—	1	—	—	—	—	—
Sodium	—	1	1	—	—	—	—	—	—	—	—	—
Sulfate	2	—	—	—	—	—	—	—	—	—	—	—
Metals (Filtered)												
Aluminum	1	—	—	1	—	1	1	—	—	—	1	—
Arsenic	—	3	—	—	—	—	—	1	—	—	—	—
Beryllium	1	—	—	—	—	—	—	—	—	—	—	—
Cobalt	1	1	—	1	–	2	1	1	—	—	—	–
Copper	1	—	—	—	1	—	—	—	—	—	—	—
Iron	5	—	—	—	—	1	1	—	—	—	1	1
Lead	1	—	—	—	—	—	—	—	—	—	—	—

Table D-3.0-5b (continued)

Analyte	R-23	R-23i Port 1	R-23i Port 2	R-23i Port 3	R-39	R-41 Scr 2	R-49 Scr 1	R-49 Scr 2	R-55 Scr 1	R-55 Scr 2	R-57 Scr 1	R-57 Scr 2
Port Depth (ft bgs) >	816	400	470	524	859	965	845	906	870	1000	910	972
Manganese	1	—	—	—	—	2	—	—	—	—	—	—
Mercury	1	—	—	—	—	—	—	—	—	—	—	—
Molybdenum	—	1	—	—	—	8	2	—	—	—	—	—
Nickel	—	1	—	—	—	—	—	—	—	—	—	—
Thallium	1	—	—	—	—	—	—	—	—	—	—	—
Uranium	—	1	—	—	—	—	—	—	—	—	—	—
Zinc	2	9	9	4	1	—	—	—	—	—	—	—
Metals (Unfiltered)												
Aluminum	1	—	—	1	5	3	6	—	—	—	—	—
Arsenic	—	5	6	6	—	—	—	—	—	—	—	—
Barium	—	—	—	—	—	—	1	—	—	—	—	—
Beryllium	—	—	–	1	—	—	—	—	—	—	—	—
Boron	—	—	1	–	—	—	—	—	—	—	—	—
Chromium	1	1	—	1	—	—	—	—	—	—	—	—
Cobalt	1	1	—	—	—	—	—	—	—	—	—	—
Copper	2	3	1	–	2	1	—	—	—	—	—	—
Iron	—	—	—	1	—	–	1	—	—	—	—	—
Lead	21	—	—	—	—	1	6	—	—	—	—	—
Manganese	12	—	—	—	—	1	1	—	—	—	—	—
Mercury	—	1	—	1	—	—	—	—	—	—	—	—
Molybdenum	—	2	1	–	1	6	2	—	—	—	—	—
Nickel	2	1	1	1	–	–	1	—	—	—	—	—
Thallium	—	—	—	—	—	—	1	—	—	—	—	—
Uranium	—	1	—	—	—	1	6	—	—	—	—	—
Zinc	—	—	2	1	1	—	—	—	—	—	—	—

*— = Not detected above groundwater BV.

Table D-3.0-6a
Sampling Events in which an Organic COPC was Detected at Well R-22

Analyte	Westbay Sampling System					Temporary Sampling System (after redevelopment)	
	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5	Screen 1	Screen 5
Port Depth (ft bgs) >	907	963	1274	1378	1448	907	1448
High Explosive Compounds							
Amino-2,6-dinitrotoluene[4-]	1	—	—	—	—	*Not sampled for high explosive compounds*	
Amino-4,6-dinitrotoluene[2-]	1	—	—	—	—		
Nitrobenzene	—	—	—	1	—		
RDX	—	—	—	–	1		
Trinitrobenzene[1,3,5-]	—	1	—	—	—		
Pesticides							
BHC[gamma-]	—	—	1	—	—	*Not sampled for pesticides or PCBs*	
DDD[4,4'-]	—	—	1	—	—		
DDE[4,4'-]	—	—	1	—	—		
DDT[4,4'-]	1	1	2	2	1		
SVOCs							
Acenaphthene	—	—	—	—	1	*Not sampled for SVOCs*	
Acenaphthylene	—	—	—	—	1		
Anthracene	—	—	—	—	1		
Benzo(a)pyrene	—	—	—	—	1		
Benzo(b)fluoranthene	—	—	—	—	1		
Benzo(k)fluoranthene	—	—	—	—	1		
Benzoic acid	3	—	—	1	1		
Bis(2-ethylhexyl)phthalate	1	—	3	—	2		
Butylbenzylphthalate	—	—	—	—	1		
Chloronaphthalene[2-]	—	—	—	—	1		
Diethylphthalate	—	—	—	—	1		
Fluoranthene	—	—	—	—	1		
Fluorene	—	—	—	—	1		
Methylnaphthalene[2-]	—	—	—	—	1		
Methylphenol[4-]	1	—	—	1	1		
Pentachlorophenol	—	—	—	—	1		
Phenanthrene	—	—	1	—	1		
Phenol	—	—	–	1	1		
Pyrene	—	—	—	—	1		

Table D-3.0-6a (continued)

Analyte	Westbay Sampling System					Temporary Sampling System (after redevelopment)	
	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5	Screen 1	Screen 5
Port Depth (ft bgs) >	907	963	1274	1378	1448	907	1448
VOCs							
Acetone	2	—	1	5	3	—	—
Butanone[2-]	—	—	–	1	2	—	—
Carbon Disulfide	—	—	—	—	—	—	1
Chloroform	—	—	1	—	—	—	—
Chloromethane	—	—	—	—	—	2	1
Dichlorobenzene[1,4-]	—	1	1	1	–	–	–
Diethyl Ether	—	1	—	—	–	—	—
Isopropylbenzene	6	—	—	—	1	—	—
Methylene Chloride	1	1	1	—	—	—	—
Naphthalene	1	—	—	—	—	—	—
Toluene	—	—	—	1	11	2	3

* — = Not detected.

Table D-3.0-6b
Sampling Events in which Inorganic COPCs Were Detected above Groundwater BVs at Well R-22

Analyte	Westbay Sampling System					Temporary Sampling System (after redevelopment)	
	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5	Screen 1	Screen 5
Port Depth (ft bgs) >	907	963	1274	1378	1448	907	1448
General Inorganics (Filtered)							
Calcium	5	1	1	4	5	*Only onsite analytical data are available (LANL 2009, 106796)*	
Chloride	1	–	–	5	–		
Cyanide (Total)	1	–	1	–	–		
Fluoride	1	–	4	5	–		
Magnesium	5	10	11	5	5		
Nitrate-Nitrite as N	–	14	6	–	–		
Perchlorate	–	1	–	1	1		
Potassium	5	3	13	5	5		
Sodium	–	–	4	4	–		
Sulfate	–	–	12	–	–		
Total Dissolved Solids	4	–	–	3	3		

Table D-3.0-6b (continued)

Analyte	Westbay Sampling System					Temporary Sampling System (after redevelopment)	
	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5	Screen 1	Screen 5
Port Depth (ft bgs) >	907	963	1274	1378	1448	907	1448
General Inorganics (Unfiltered)							
Calcium	7	—	1	7	7	*Only onsite analytical data are available (LANL 2009, 106796)*	
Chloride	3	—	5	3	—		
Cyanide (Total)	—	1	—	4	—		
Fluoride	—	—	—	3	—		
Magnesium	7	12	13	7	7		
Potassium	7	4	16	7	7		
Sodium	—	—	4	7	—		
Sulfate	—	—	5	—	—		
Metals (Filtered)							
Aluminum	—	—	—	—	1	*Only onsite analytical data are available (LANL 2009, 106796)*	
Antimony	—	—	1	—	—		
Barium	5	1	12	5	5		
Boron	—	—	1	3	—		
Cadmium	—	—	1	—	—		
Cobalt	—	1	—	—	—		
Iron	6	1	2	5	5		
Lead	—	—	1	—	—		
Manganese	6	1	1	5	5		
Mercury	—	1	—	—	—		
Molybdenum	6	1	6	5	5		
Nickel	2	1	—	—	—		
Strontium	5	1	13	5	5		
Thallium	—	—	2	—	—		
Uranium	—	—	12	—	—		
Zinc	—	—	1	—	—		
Metals (Unfiltered)							
Antimony	—	1	—	—	1	*Only onsite analytical data are available (LANL 2009, 106796)*	
Barium	7	—	14	7	7		
Boron	1	—	2	7	1		
Chromium	1	3	4	—	—		
Cobalt	2	1	1	—	—		
Copper	2	—	1	1	—		
Iron	8	—	—	7	7		
Manganese	8	—	1	7	7		
Mercury	—	—	1	—	—		

Table D-3.0-6b (continued)

Analyte	Westbay Sampling System					Temporary Sampling System (after redevelopment)	
	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5	Screen 1	Screen 5
Port Depth (ft bgs) >	907	963	1274	1378	1448	907	1448
Molybdenum	7	1	7	6	7		
Nickel	5	2	2	3	1		
Silver	—	1	—	1	—		
Strontium	7	—	16	7	7		
Thallium	—	2	3	—	1		
Uranium	—	—	15	—	—		

*— = Not detected above groundwater BV.

Table D-3.0-7
Average and Maximum Tritium Activities in Groundwater Collected from Monitoring Network Wells Specific to MDA G, through October 2010

Well	Port Depth (ft bg)	Lab Code	No. of Analyses	No. of Detects	Average (pCi/L)	Max (pCi/L)	MDA (pCi/L)	Screening Level (pCi/L)	No. > Screening Level	Comments
Screens Completed in Perched-Intermediate Groundwater										
R-23i	400	UMTL	8	8	152	240	0.3	36.08	6	—*
	470	UMTL	11	11	27	31	0.3	36.08	—	—
		ARSL	2	2	19	22	2.8	36.08	—	—
	524	UMTL	15	15	34	38	0.3	36.08	3	—
		ARSL	1	1	28	28	2.1	36.08	—	—
Screens Completed in Regional Aquifer										
R-22	907	UMTL	23	23	2.8	3.8	0.3	6.26	—	Before redevelopment
		ARSL	2	1	4.0	4.0	3.1	6.26	—	Before redevelopment
		UMTL	6	0	—	—	0.3	6.26	—	After redevelopment
	963	UMTL	17	3	25.6	76.8	0.3	6.26	1	Before redevelopment
		ARSL	2	0	—	—	3.5	6.26	—	Before redevelopment
	1274	UMTL	20	4	0.5	1.2	0.3	6.26	—	Before redevelopment
		ARSL	2	0	—	—	3.2	6.26	—	Before redevelopment
	1378	UMTL	19	3	194	582	0.3	6.26	1	Before redevelopment
		ARSL	2	0	—	—	4.0	6.26	—	Before redevelopment
	1448	UMTL	19	19	10.3	18.5	0.3	6.26	18	Before redevelopment
		ARSL	2	1	3.9	3.9	3.4	6.26	—	Before redevelopment
		UMTL	38	0	—	—	0.3	6.26	—	After redevelopment
R-23	816	UMTL	29	3	0.8	0.9	0.3	6.26	—	—
		ARSL	2	0	—	—	2.2	6.26	—	—
R-39	859	UMTL	7	0	—	—	0.3	6.26	—	—
		ARSL	1	0	—	—	3.3	6.26	—	—
R-41	965	UMTL	5	0	—	—	0.3	6.26	—	—
		ARSL	2	0	—	—	2.1	6.26	—	—
R-49	845	UMTL	4	0	—	—	0.3	6.26	—	—
		ARSL	1	0	—	—	2.1	6.26	—	—
	906	UMTL	4	0	—	—	0.3	6.26	—	—
		ARSL	1	0	—	—	1.9	6.26	—	—

Table D-3.0-7 (continued)

Well	Port Depth (ft bg)	Lab Code	No. of Analyses	No. of Detects	Average (pCi/L)	Max (pCi/L)	MDA (pCi/L)	Screening Level (pCi/L)	No. > Screening Level	Comments
R-55		—	—	—	—	—	—	—	—	Data not available
		—	—	—	—	—	—	—	—	Data not available
R-57	910	ARSL	1	0	—	—	1.9	6.26	—	—
	972	ARSL	1	0	—	—	3.1	6.26	—	—

*— = Not applicable (tritium not detected at this location or no comments concerning the results shown).

ARSL = American Radiological Services Laboratory; UMTL = University of Miami Tritium Laboratory.

Appendix E

Technical Area 54 Groundwater Monitoring Network

E-1.0 INTRODUCTION

This appendix discusses the sitewide geology and hydrology of Technical Area 54 (TA-54). Section E-1.1 is a discussion of site geology that includes TA-54 stratigraphy (section E-1.1.1), seismic hazards (section E-1.1.2), and cliff retreat (section E-1.1.3). Section E-2.1 discusses the regional aquifer hydrology near Material Disposal Area (MDA) G.

E-1.1 Geology

The following discussion describes the site-wide geology for TA-54. MDA-specific descriptions of geology are presented in the approved work plans for MDA G and MDA L (LANL 2004, 087624; LANL 2004, 087833). Upper vadose-zone geology in the vicinity of the MDAs was characterized through borehole logging discussed in MDAs G and L investigation reports (LANL 2005, 090513; LANL 2006, 091888; LANL 2007, 096409). Additional information about vadose-zone and regional-aquifer geology around TA-54 was collected during installation of deep wells to monitor perched-intermediate and regional groundwater. These site-wide groundwater-monitoring wells included R-20, R-21, R-22, R-23, R-32, R-37, R-38, R-39, R-40, R-41, R-49, R-51, R-52, R-53, R-54, R-55, R-56, and R-57. Collectively, the investigations described above confirm that the site-wide geology for TA-54 is consistent with the regional geology described by Broxton and Reneau (1995, 049726, pp. 8–19).

E-1.1.1 TA-54 Stratigraphy

The stratigraphy in the vicinity of TA-54 includes Quaternary Bandelier Tuff (including Cerro Toledo deposits), Pliocene Cerros del Rio volcanic series and Puye Formation (fanglomerate, Totavi lentil, and lacustrine facies), Miocene Jemez alluvial fan deposits (fanglomerate and pumiceous facies), and Chamita Formation. The Bandelier Tuff and the Cerros del Rio volcanic series are the primary units making up the vadose zone. Cerros del Rio volcanic rocks in the vicinity of MDA G, the Puye Formation (including the Totavi lentil), Miocene Jemez alluvial fan deposits, and the Chamita Formation are part of the regional aquifer. Figure E-1.1-1 shows the locations of intermediate and regional monitoring wells in the vicinity of TA-54. Figures E-1.1-2, E-1.1-3, and E-1.1-4 show north-to-south geologic cross sections for TA-54, based on boreholes in the vicinity. The Bandelier Tuff forms the upper vadose at TA-54.

Bandelier Tuff

The Bandelier Tuff has two members, each consisting of a basal pumice fall overlain by a petrologically related succession of ash-flow tuffs (Bailey et al. 1969, 021498). The lower Bandelier Tuff includes the Otowi Member and its basal pumice fall deposit, the Guaje Pumice Bed. The upper Bandelier Tuff is made up of the Tshirege Member and its basal pumice fall, the Tsankawi Pumice Bed. The Cerro Toledo interval is an informal name given to stratified volcaniclastic sediments and tephra deposited between the Otowi and Tshirege Members.

The following description of Bandelier Tuff uses the term welding to distinguish between tuff that is less compacted (or noncompacted) and porous (nonwelded) and that which is 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 tuff shows adhesion (welding) of pumice and ash, but nonwelded tuff does not. The term devitrified is applied to tuff in which the volcanic glass has crystallized to a fine-grained mineral assemblage of alkali feldspar and silica polymorphs (cristobalite and tridymite).

Tshirege Member (Qbt)

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 (Smith and Bailey 1966, 021584; Broxton and Reneau 1995, 049726). The properties related to groundwater flow and contaminant migration (e.g., density, porosity, degree of welding, fracture content, and mineralogy) vary both vertically and laterally as a result of localized emplacement temperature, thickness, gas content, and composition. As a result, the groundwater flow and contaminant transport occurring through these units are expected to be impacted by their heterogeneities. The Tshirege Member thins eastward across TA-54, ranging in thickness from 235 ft (72 m) near MDAs H and J to 128 ft (39 m) on the east side of MDA G.

Tshirege Member Unit 2 (Qbt 2)

Unit 2 of the Tshirege Member of the Bandelier Tuff is a competent unit that forms the caprock of Mesita del Buey. It is the host unit for most disposal pits and shafts at TA-54. The thickness of unit 2 varies from 36 ft to 65 ft (11 m to 19.8 m). Where exposed, unit 2 forms a medium brown, vertical cliff that stands out in marked contrast to the slope-forming, lighter colored tuffs below. It is a moderately welded ash-flow tuff composed of crystal-rich, devitrified pumice fragments in a matrix of ash, shards, and phenocrysts (primarily sanidine and quartz). Vapor-phase crystallization of flattened shards and pumices is extensive in this unit.

Unit 2 is extensively fractured as a result of contraction during postdepositional cooling. 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. At MDA G, Purtymun et al. (1978, 005728) measured an average fracture spacing of 3 to 5.6 ft (0.9 to 1.7 m), and Purtymun and Kennedy (1971, 004798) cite a maximum aperture of 2 in. (51 mm). Reneau and Vaniman (1998, 063135) mapped the walls of Pit 39 at MDA G and measured average fracture spacing of 3.2 to 4.2 ft (1.0–1.3 m) and average apertures of 0.12 to 0.21 in. (3.1 to 5.3 mm) (with a maximum of 3.9 in. [10 cm]). The fractures are often filled with clays, calcite, and fine detritus to a depth of approximately 10 ft (3 m); 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, properties that have implications for the transport of metals and radionuclides in fractures. Opal and calcite may be found 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 moisture at depth in fractures (Reneau and Vaniman 1998, 063135).

The base of unit 2 is marked by a series of thin (less than 3.9-in.- [10-cm-] thick) discontinuous, stratified, crystal-rich, and fines-depleted sandy surge deposits. Cross beds and planar bedding structures are often observed in these deposits.

Tshirege Member Unit 1v (Qbt 1v)

Tshirege Member unit 1v is a light-colored vapor-phase-altered cooling unit underlying unit 2. This unit forms generally sloping outcrops, which contrast with the near-vertical cliffs of unit 2. Unit 1v is further subdivided into units 1v(u) and 1v(c).

Unit 1v(u). The uppermost portion of unit 1v is devitrified and vapor-phase-altered ash-fall and ash-flow tuff; it is designated unit 1v(u), where *u* signifies upper. This unit thins eastward across TA-54, ranging in thickness from 100 ft (30 m) near MDAs H and J to 25 ft (8 m) on the east side of MDA G. Unit 1v(u) is nonwelded at its base and becomes partly welded in its interior. Only the more prominent cooling fractures originating in unit 2 continue into the more welded upper section of unit 1v(u), but these die out in the lower, less consolidated section. More typically, fractures in unit 2 do not extend into unit 1v(u).

Unit 1v(c). Beneath unit 1v(u) is unit 1v(c), where c stands for colonnade, named for the columnar jointing visible in cliffs formed in this unit. 1v(c) is an orangish brown nonwelded, devitrified ash-flow tuff at its base and top; it becomes more welded in its interior. Unit 1v(c) varies in thickness from 6 ft to 15 ft (1.8 m to 3 m) at TA-54. The basal contact of unit 1 v(c) is marked by a rapid vertical change (within 0.7 ft [0.2 m]) from devitrified (crystallized) matrix in unit 1 v(c) to vitric (glassy) matrix in the underlying unit 1g. In many outcrops, the transition from devitrified to vitric rock matrix forms a prominent erosional recess termed the vapor-phase notch; at other locations this transition is marked by a prominent bench. No depositional break is associated with the vapor-phase notch, indicating that this mineralogic transition developed within the interior of the cooling ash-flow sheet after the tuffs were deposited.

Tshirege Member Unit 1g (Qbt 1g)

Unit 1g is a white to tan vitric, pumiceous, nonwelded ash-flow tuff. This unit thins eastward across TA-54, ranging in thickness from 100 ft (30 m) near MDAs H and J to 50 ft (16 m) on the east side of MDA G. Few fractures are observed in the outcrops of this unit where exposed in nearby areas, 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 (1.5 m to 6.1 m) of unit 1g are discolored by oxidation, possibly by development of ferric oxyhydroxides. This portion of unit 1g is resistant to erosion, helping to preserve the vapor-phase notch in the outcrops. A pumice-poor surge deposit forms the base of unit 1g locally.

Tsankawi Pumice Bed (Qbtt)

The Tsankawi Pumice Bed is the basal fall deposit of the Tshirege Member of the Bandelier Tuff. It is a crudely stratified deposit of gravel-sized vitric pumice and quartz and sanidine crystals. The maximum thickness of the Tsankawi Pumice Bed is 2 ft (0.6 m). Despite being thin, this pumice-fall unit was uniformly deposited throughout the area and is expected to be laterally continuous.

Cerro Toledo Interval (Qct)

The Cerro Toledo interval represents channelized fluvial deposits that consist of thin beds of tuffaceous sandstone, siltstone, and ash and pumice falls that were deposited between the Tshirege and Otowi Members of the Bandelier Tuff. The Cerro Toledo interval also includes localized gravel- and cobble-rich fluvial deposits eroded from Tschicoma Formation dacite lavas in the eastern Jemez Mountains. This unit reaches a maximum thickness of 55 ft (17 m) at well R-56, but because it fills channels eroded into the top of the Otowi Member, its thickness is variable and these deposits are absent in many areas of TA-54.

Otowi Member (Qbo)

The Otowi Member is a white to tan, vitric, pumiceous, nonwelded ash-flow tuff. The pumice is fully inflated, supporting tubular structures, which have not collapsed as a result of welding. The matrix is an unsorted mix of glass shards, phenocrysts, perlite clasts, volcanic lithics, and minute, broken pumice fragments. Otowi ash-flow tuffs thin eastward against a paleotopographic high formed by Cerros del Rio volcanics near White Rock. These tuffs are continuous under TA-54, but unit thicknesses decrease eastward, ranging between 250 ft (76 m) near MDAs H and J to 45 ft (14 m) on the east side of MDA G.

Guaje Pumice Bed (Qbog)

The Guaje Pumice Bed (Qbog) is the basal fall deposit of the Otowi Member. It is a stratified, fines-depleted deposit of gravel to pea-sized vitric pumice and quartz and sanidine crystals. Borehole data indicate that the maximum thickness of this unit at TA-54 ranges between 5 ft (1.5 m) and 19 ft (5.8 m). This pumice-fall unit was deposited throughout the area and is expected to be laterally continuous. It is potentially important for the vadose zone flow and transport because higher moisture content and zones of saturations occur within this unit at other areas of the Laboratory beneath wet canyons (e.g., Los Alamos Canyon). Site investigations indicate that saturated conditions do not occur in the Guaje Pumice Bed at TA-54.

Cerros del Rio Volcanic Series (Tb4)

Basaltic rocks of the Cerros del Rio volcanic field crop out primarily in White Rock Canyon and east of the Rio Grande in the Caja del Rio (Griggs and Hem 1964, 092516; Smith et al. 1970, 009752; Kelley 1978, 011659; Sawyer et al. 2007, 106130). The northwest part of the volcanic field extends beneath the Pajarito Plateau where it is covered by thick deposits of Bandelier Tuff (Dransfield and Gardner 1985, 006612; Broxton and Reneau 1996, 055429). Cerros del Rio volcanic rocks interfinger with the upper Puye Formation west of the Rio Grande and unconformably overlie the Tesuque Formation east of the river. Discontinuous thin beds of fine-grained cemented sandstone and siltstone (possible paleosols or eolian deposits) and coarse-grained volcanic colluvium occur at the top of the Cerros del Rio volcanics. Sediments directly beneath individual lava flows show varying degrees of cementation and mineralogic alteration due to thermal contact metamorphism.

The Cerros del Rio volcanic series is a thick sequence of stacked lava flows that are separated by interflow breccias, cinder or scoria zones, volcaniclastic and riverine sediments, phreatomagmatic deposits, and lake beds. The lava flows generally have massive interiors made up of dense, variably fractured impermeable rock. Cuttings samples of lavas and related deposits were analyzed by x-ray fluorescence for major and trace elements to correlate lavas from borehole to borehole in the vicinity of TA-54 (Figures E-1.1-2, E-1.1-3, and E-1.1-4). The lava flows range in composition from basalt to dacite, with the more silicic rock types (dacites) occurring at the base of the volcanic pile and less evolved flows (tholeiites and alkali basalts) at the top (Figure E-1.1-5). The volcanic sequence thickens eastward, ranging from approximately 300-ft- (91 m) thick near MDAs H and J to approximately 775 ft (236 m) near the east end of MDA G. The thickest deposits generally coincide with a south-southwest draining paleovalley that is defined by structure contours at the base of the unit Figure E-1.1-6). An isolated occurrence of anomalously-thick (983 ft [300 m]) Cerros del Rio volcanic deposits occurs at well R-22; this anomalous occurrence is discussed further below.

The Cerros del Rio volcanic series was erupted primarily between 2.8 Ma and 2.3 Ma (WoldeGabriel et al. 1996, 054427; WoldeGabriel et al. 2001, 092523; Sawyer et al. 2007, 106130). Overlapping argon-40/argon-39 ages of 2.40 ±0.09 and 2.50 ±0.33 were obtained for dacite and overlying tholeiite lavas, respectively, at well R-22.

Rapid lateral facies variations of the volcanic rocks and their intercalated deposits are common at TA-54 (Figures E-1.1-2, E-1.1-3, and E-1.1-4). These variations reflect dynamic landscape processes associated with the rapid growth of overlapping volcanoes in a basin-floor environment that included the ancestral Rio Grande floodplain and the western alluvial slope of the Española basin. The thickest volcanic deposits overlie thick, laterally continuous Totavi lentil (Tpt) riverine deposits in the vicinity of MDA G and to the east. The presence of phreatomagmatic deposits within the volcanic sequence indicates that erupting magmas frequently interacted explosively with the ancestral Rio Grande and its saturated floodplain sediments. Lavas flowing into low-lying areas periodically blocked the ancestral Rio Grande, causing lake sediment (lacustrine) deposits to form behind temporary lava dams. Riverine deposits intercalated within the volcanic sequence mark the changing course of the ancestral Rio Grande in response to the continuously evolving basin-floor topography. These intercalated riverine deposits are associated with temporary river channels, and the deposits are probably not laterally continuous.

The presence of volcanic vents in the vicinity of TA-54 is inferred from the presence of thick cinder and phreatomagmatic deposits that commonly accumulate near their source vents. Cinder deposits more than 50-ft- (16 m) thick occur in wells R-20, R-21, R-22, R-34, R-39, R-41, R-49, R-53, R-54, R-55, and R-56. These cinder deposits range in composition from basalt to dacite, indicating that there are multiple vents in the vicinity. Thick (>25 ft [>7.6 m]) basaltic phreatomagmatic deposits occur in wells R-38, R-41, R-49, R-55, and R-57, suggesting maar volcanoes are located near the east end of MDA G. Additionally, structure contours for the top of the Cerros del Rio volcanics shows that a broad north-trending paleotopographic high area also occurs near the east end of MDA G (Figure E-1.1-7). This paleotopographic high likely represents a volcanic constructional highland formed by coalesced volcanic vents. Structure contours for the top of the dacite lava indicate that a small dome and flow complex may have been buried by subsequent Cerros del Rio lavas near the east end of MDA G.

Well R-22 may have intersected a vent conduit, dike, or set of dikes for the upper tholeiitic lavas at the east end of TA-54. All of the wells at the east end of TA-54 (e.g., R-23, R-39, R-41, R-55, R-49, and R-57) show a consistent volcanic stratigraphy of basaltic lavas (tholeiite and alkali basalt) overlying more evolved lava types (trachyandesite and dacite). However, well R-22 is the only location where tholeiites are found beneath dacite lavas. The lowermost tholeiites at R-22 occur at 213 ft (65 m) deeper than the base of the volcanic pile (dacite lava) and 785 ft (239 m) deeper than tholeiites at R-57, located only 215 ft (66 m) to the west.

It is possible that the deep tholeiites at R-22 represent older lavas filling a very deep and narrow south-draining paleocanyon, but such a canyon would have been cut into poorly consolidated riverine sediments that were unlikely to support such a steep-walled feature. Moreover, closely-spaced boreholes in the vicinity do not intersect any igneous lithologies this deep, as would be expected if there were a lava-filled canyon with lateral extent. The alternative interpretation offered here is that R-22 was drilled obliquely through a vent conduit related to the upper tholeiitic lavas. Chemical compositions of the shallow and deep tholeiites at R-22 are similar; these similarities permit, but do not prove, a relationship between the two.

The Cerros del Rio volcanic series is largely in the vadose zone at TA-54. However, the base of these volcanic deposits extends more than 150 ft beneath the regional water table in the vicinity of MDA G (Figure E-1.1-8). Under unsaturated and saturated conditions, groundwater flow in lava interiors is impacted by the fractures, with properties of groundwater flow and contaminant transport (direction, magnitude, etc.) influenced by fracture aperture, fracture density, fracture orientation, fracture connectivity, and fracture-filling materials. Groundwater flow and contaminant transport is also impacted by the interflow zones made up of highly-porous and highly-permeable breccias, cinder and scoria deposits, and sedimentary deposits. The nonfractured volcanic rocks and clay-filled fractured zones are expected to have low saturated permeability. Zones with significant, connected open fractures, lava tubes, and interflow zones are expected to have higher saturated permeability and low matrix porosity, a combination of properties that can lead to fast travel times. Over short distances (meters to tens of meters), the direction and magnitude of the groundwater flow and contaminant transport within these volcanic rocks are highly uncertain because of the complex internal stratigraphy of these rocks. However, it is likely that the combined fracture- and porous-flow paths form an integrated flow network over a scale of tens to hundreds of meters, and that more predictable flow directions and magnitudes can be determined when the water-table hydraulic gradients are applied to flow paths averaged over longer distances. Poorly connected or isolated groundwater pockets may occur in this setting, but these zones are stagnant and do not pose a risk for contaminant transport.

Puye Formation (Tpf, Tpt, and Tpl)

The Puye Formation is generally subdivided into three interfingering facies: fanglomerate (Tpf), Totavi lentil riverine deposits (Tpt), and lacustrine beds (Tpl). At TA-54, the dominant facies are fanglomerate and riverine deposits. Lacustrine beds of the Puye Formation are minor at TA-54 and they (and thin riverine deposits) are included within the Cerros del Rio volcanic series where these strata are interbedded within the thick stacks of lava flows.

The fanglomerate facies of the Puye Formation was deposited as broad, coalescing alluvial fans shed eastward from the Jemez volcanic field into the western Española basin (Griggs and Hem 1964, 092516; Bailey at el. 1969, 021498). The sources for these alluvial-fan deposits were large overlapping dacite to low-silica rhyolite dome complexes of the Tschicoma Formation that are located in the eastern part of the Jemez Mountains. The dome complexes erupted between approximately 3 Ma and 5 Ma (Broxton et al. 2007, 106121). The fanglomerate deposits are a heterogeneous assemblage of clast- to matrix-supported conglomerates with associated gravels and lithic sandstones. Clasts in the coarsest deposits consist of subangular to subrounded cobbles and boulders of lava and tuff in a poorly sorted matrix of ash, silts, and sands. Debris flow deposits are common throughout the unit. Primary and reworked ash- and pumice-fall deposits of dacitic to rhyolitic composition are interbedded with the conglomerates and gravels. At TA-54, the fanglomerate facies thins eastward; it is >263–ft- (>80 m) thick at well R-52 and is absent on the east side of MDA G.

During the early Pliocene, before the development of the Cerros del Rio volcanic field, the distal parts of Puye alluvial fans merged with ancestral Rio Grande axial river sediments (Totavi lentil) that were being deposited over a basin floor that was at least 3- to 6-km wide. As a result, fanglomerate and riverine deposits are interbedded in the vicinity of MDA G and eastward. The riverine deposits consist of poorly-consolidated conglomerate containing well-rounded cobbles and gravels of Precambrian quartzite, granite, and pegmatite with subrounded to subangular cobbles and boulders of silicic to intermediate and rarer basaltic volcanic rocks. Precambrian clasts commonly make up >80% of the clasts in the deposits. These deposits also contain subordinate subangular to subrounded clasts of volcanic rocks from the Jemez volcanic field in some horizons. Loose, well-sorted, fine to coarse, quartz and microcline sands occur as lenses within the conglomerate. The early Pliocene Totavi deposits are up to 203-ft- (62 m) thick and formed laterally continuous deposits beneath MDA G and to the east; these deposits probably reflect basin-floor sediments. The ancestral Rio Grande flowed north to south, so it is expected that Totavi deposits contain stacked channel sands and gravels with the same orientation and with length-to-width dimensions on the order of 0.5 km to 3 km and 50 m, respectively. This may cause large-scale anisotropy of flow and transport properties of the aquifer medium, with preferential flow along permeable channel deposits. Totavi deposits west of MDA G are much thinner (<40 ft [12 m]) or they are highly mixed with Puye fanglomerate; the deposits in this area probably represent an area of overlap between the western alluvial slope and the basin floor.

During the late Plicocene, the eastern Jemez Mountains remained structurally high and continued to supply sediment to Puye alluvial fans in the western Española basin. However, the onset of Cerros del Rio volcanism had three major effects on the Puye depositional patterns: (1) concurrent sedimentation and volcanism led to interfingering of Puye and Cerros del Rio deposits, (2) growth of a constructional volcanic highlands on the basin floor provided an eastern source of volcaniclastic sediments that became incorporated into the Puye Formation, and (3) areas of Totavi lentil deposition became more restricted in areal distribution and frequently shifted laterally as lavas dammed and diverted the Rio Grande.

Miocene Jemez Alluvial Fan Deposits (Tjfp)

Miocene Jemez alluvial fan deposits generally include a lower fanglomerate part and an upper subunit of pumiceous sands and gravels (Broxton and Vaniman 2005, 090038). Only the upper pumiceous subunit was encountered in boreholes at TA-54. These deposits share similarities with the overlying Puye Formation in terms of source region and depositional setting, and they are interpreted as alluvial fans shed eastward from the Jemez volcanic field into the western Española basin during the Miocene. However, there appears to be a 2 hiatus in deposition between these two fan deposits throughout the Pajarito Plateau. Core samples collected from well SCI-2 in Sandia Canyon, located 1.4 mi (2.3 km) north of TA-54, showed that a poorly developed oxidized paleosol occurs at the top of the Miocene Jemez alluvial fan deposits at that location. However, the lateral extent and continuity of the paleosol is not known. Additionally, Formation Microimager geophysical logs collected at R-20 indicate that bedding in these pumiceous sediments dips towards the south-southwest, possibly indicating post-depositional tilting of the Miocene units before the Puye Formation was deposited. The pumiceous sediments are 115–ft- (35 m) thick at well R-20 and pinch out eastward, probably in the vicinity of MDA L.

The pumiceous sediments consist of well-bedded horizons of light-colored reworked pumiceous sands and subordinate gravels of rhyolite and dacite. Deposits typically contain up to 30% subangular to rounded vitric rhyolite pumice admixed with 70% to 90% ash and lithic sands. Some intervals contain as much as 90% subangular to angular pumice that represent primary fall deposits or reworked deposits that underwent minimal transport. Pumice clasts are characterized by sparse phenocrysts of quartz, sanidine, and plagioclase. Seven pumice samples collected from boreholes across the Pajarito Plateau yielded argon-40/argon-39 feldspar ages ranging between 6.44 Ma ±0.46 Ma and 7.50 Ma ±0.30 Ma. The ages overlap the 6.01 Ma ±0.05 Ma to 7.1 Ma ±0.2 Ma ages reported for the Bearhead Rhyolite in outcrops southwest of the Pajarito Plateau (Justet and Spell 2001, 093391). Microprobe analyses of glass and whole rock analyses of pumices closely match the chemistry of the Bearhead Rhyolite.

These pumiceous deposits are entirely within the regional aquifer and should have relatively high permeability based on their sandy lithology. The material deposited within individual beds is relatively uniform and their heterogeneity is primarily associated with bedding. The south-southwest dip of these deposits may cause some preferential groundwater flow toward the east-southeast along the strike of bedding. However, beneath TA-54, these beds are too deep in the regional aquifer for preferential flow to be a concern at MDAs H and J and these beds are thin to absent beneath MDAs L and G.

Chamita Formation (Tcar)

The Chamita Formation of the Santa Fe Group is made up basin-floor axial river deposits consisting of the Hernandez and Vallito Members. The Hernandez Member represents ancestral Rio Chama deposits and the Vallito Member represents ancestral Rio Grande deposits. These south-flowing river systems merged in the vicinity of Buckman Mesa (Koning et al. 2007, 106122), and the separate members are grouped at the formation level in the vicinity of TA-54. The Chamita Formation is >1285 ft (391 m) below ground surface (bgs) at well PM-2 and >559–ft- (170 m) thick at well R-16. Most water supply wells on the Pajarito Plateau are completed in this formation. The Chamita Formation ranges in age between 6 Ma and 13 Ma. The upper part of the formation overlaps in age with Miocene Jemez alluvial fan deposits, and it is likely the alluvial fans interfinger with axial river sediments in the western part of the basin floor. The Chamita Formation is overlain by Miocene pumiceous alluvial fan deposits at well R-20 and by riverine deposits of the Totavi lentil at well R-57.

The Chamita Formation consists of fine- to coarse-grained quartz sands and silty sands with minor microcline and felsic to intermediate volcanics; fine- to coarse-grained volcanic lithic sands; and sandy and silty gravels dominated by well-rounded felsic to intermediate volcanics and 1% to 3% Precambrian quartzite. Some gravel deposits also contain subangular to subrounded intermediate volcanic clasts that probably represent input of sediment from tributary streams draining the Miocene Jemez volcanic field. These stratified deposits are variably cemented by calcite with poorly- to non-cemented sands and gravels intercalated with cemented sandstones.

The Chamita Formation is entirely within the regional aquifer at TA-54. These rocks should have relatively good permeability characteristics because they contain relatively abundant, sorted, coarse-grained channel fills. However, intercalated silt-rich sands and gravels are likely to be less transmissive than clean channel sands and gravels, providing vertical stratification and hydraulic compartmentalization. Because of their accumulation as axial deposits in a north-to-south-flowing river, these sediments probably contain north to south oriented stacked channel sands and gravels with long length to width dimensions similar to the Totavi lentil. This may cause large-scale anisotropy of flow and transport properties of the aquifer medium with preferential north to south orientation.

Basaltic lava flows are intercalated within the Chamita Formation at wells PM-2 and R-22. These basalts are deep within the regional aquifer and show varying degrees of alteration of groundmass minerals and phenocrysts, with fractures that appear to be at least partly sealed by smectite. Alteration minerals typically include smectite; calcite may also occur. At well PM-2, upper and lower basalt flows are 52-ft-16 m] and 94–ft- [29 m] thick, respectively. At well R-22, the basalt sequence is 68-ft [21 m] thick. The basalt at R-22 yielded a argon-40/argon-39 age of 8.97 Ma ±0.11 Ma. The basalts at PM-2 occur at greater depths than the R-22 basalt. Assuming they are correlative, these basalts appear to have a westward component of dip.

E-1.1.2 Seismic Hazards

A seismic hazard evaluation was conducted at several sites around the Laboratory to estimate ground motion from possible earthquakes (tectonics) (Wong et al. 1995, 070097). The objective was to determine the seismic hazard criteria for designing new nuclear facilities. The evaluation led to the conclusion that within 100 yr, an earthquake with a magnitude of 6 or greater is considered likely to occur in the Pajarito fault system.

While TA-54, including MDA G, was not included in the study, its geology is similar to two of the sites evaluated in the study (TA-18 and TA-46). Results of the study were applied in the safety analysis report for MDA G, which includes the Laboratory’s radioactive waste disposal facility (Benchmark Environmental Corporation 1995, 063300). Such an earthquake was determined not to pose a hazard from waste buried below the surface at MDA G.

E-1.1.3 Cliff Retreat

The MDAs at TA-54 are located on Mesita del Buey adjacent to Pajarito Canyon and Cañada del Buey, and cliff retreat is a primary process by which the canyon walls erode. In recognition of this process, siting of disposal pits at MDA G included a 50-ft setback from the mesa edges to avoid the possibility of exposure of waste by cliff retreat (Purtymun and Kennedy 1971, 004798; Rogers 1977, 005707). Geomorphic studies at DP and Pajarito Mesas indicate that mass wasting and cliff retreat on the Pajarito Plateau occurs by detachment of fracture-bounded blocks in relatively small rockfalls along shallow canyons similar to those bordering Mesita del Buey at MDA G (Broxton and Eller 1995, 058207; Reneau and Raymond 1995, 054709). Larger-scale mass wasting involving landsliding along canyon walls only occurs where canyons are deeper, including Los Alamos Canyon adjacent to DP Mesa and Pajarito Canyon adjacent to Pajarito Mesa. Using various lines of evidence, including the size of fracture-bounded blocks and long-term evolution of the canyons, and assuming a 10,000-yr period of interest, the studies at DP and Pajarito Mesas supported the use of a 50-ft setback from mesa edges for shallow canyons as those that exist adjacent to MDA G (Broxton and Eller 1995, 058207; Reneau and Raymond 1995, 054709). Larger setbacks were recommended adjacent to deeper canyons where larger-scale mass wasting occurs.

E-2.1 Regional Aquifer Monitoring Wells near MDA G

Information about the hydrogeological properties of the regional aquifer can be obtained by analysis of the ambient water-level transients and pumping drawdowns observed at the monitoring wells near MDA G. The aquifer properties are important to evaluate groundwater flow and contaminant transport in the regional aquifer. The hydrogeological conditions at the monitoring wells are important to take into account in analysis evaluating monitoring well capabilities to characterize regional groundwater flow, and to detect potential contaminants originating from MDA G. Drawdown data are collected during the pumping tests (up to 24-hours long) conducted at each of the monitoring wells. Drawdown data are also obtained as a result of the water-supply pumping at the municipal wells on the Pajarito Plateau; the transient analysis of the water-supply pumping effect is computationally intensive but allows for a cost-effective estimation of the effective large-scale properties of the aquifer(Harp and Vesselinov 2010, 111220).

Hydrogeologic information obtained from the regional monitoring wells adjacent to MDA G (R-21, R-32, R-39, R-41, R-49, R-55, R-56, and R-57) is summarized below.

R-21

R-21 is a single-screen monitoring well; the screen length is 18 ft from 5749 to 5767 ft above mean sea level (amsl). The screen is placed within the Puye Formation just below massive Cerros del Rio lavas. Hydraulic conductivity is estimated to be approximately 1 ft/d. The top of the screen is approximately 85 ft below the regional water table, which is located within Cerros del Rio lavas.

Water-level data from R-21 shows a barometric efficiency of approximately 90% with an average effective total lag time of approximately 2 hours. The barometric efficiency of the well (less than 100%) suggests that the saturated zone screened by R-21 appears to be under unconfined or partially confined aquifer conditions because some of the barometric pressure changes are propagated through the vadose zone and impact the water levels in the aquifer near R-21. This is an important observation because the water level at R-21 is 85 ft above the top of the well screen.

Transients in the water-level data demonstrate that R-21 is impacted by the water-supply pumping at PM-2 and PM-4. The water-level transients also allowed the estimation of the effective large-scale properties regional aquifer between the water-supply wells and R-21 (Table E-2.1-2).

R-32

The uppermost screen of R-32 is completed in interflow river gravel units intercalated within Cerros del Rio lavas. In the original well configuration, screens 2 and 3 were completed in the sediments of the Puye Formation. Screens 2 and 3 had similar hydraulic heads. The screen 1 water level does not respond to pumping at any supply well, although the groundwater at screens 2 and 3 showed well-defined responses to PM-2 and PM-4 (McLin 2005, 090073; McLin 2006, 092218). This indicates that the groundwater at screen 1 is not in direct communication with the groundwater at screens 2 and 3.

In 2007, R-32 was converted into a single-screen well by plugging screens 2 and 3. The water level observed in the new well is approximately 6 ft lower than the water level observed in screen 1 of the Westbay system. The new data is considered to be more representative of water-table conditions at this location. Water-level data collected during a single-screen pumping test conducted at R-32 demonstrated late time reduction of the pumping drawdown. This drawdown behavior may be due to various hydrogeologic factors: (1) phreatic aquifer conditions, (2) leaky aquifer conditions (e.g., leakage or slow drainage from the unconfined zone in the Cerros del Rio lava), (3) three-dimensional flow (partial penetration well) effects, or (4) combinations of the above. The hydraulic conductivity of screen 1 when drilled and after conversion is estimated to be 2 ft/d and 10 ft/d, respectively. The development during well conversion potentially improved the hydraulic connection of the screen within the aquifer.

The water level in screen 1 is within the Cerros del Rio lavas approximately 70 ft above the screened interval. Based on existing data, the aquifer is phreatic (under water-table conditions) within the Cerros del Rio lavas, and is confined within the Puye Formation. The regional water table is located within the Cerros del Rio lavas, and the potentiometric surface associated with confined hydraulic heads within the underlying Puye Formation is also located within the Cerros del Rio lavas. The vertical component of the hydraulic gradient at R-32 is on the order of 0.02 (~2 ft head difference over ~100 ft separation distance; Table E-2.1-3). Because of the relatively low permeability of the Cerros del Rio lavas, screen 1 was placed as close as possible to the regional water table in riverine sediments between lava flows. The pumping-test drawdown data suggests that the pumping of R-32 potentially drains groundwater from the overlaying lavas.

The water-level transients observed at R-32 allowed the estimation of the effective large-scale properties regional aquifer between the water-supply wells and R-32 (Table E-2.1-2).

R-39

R-39 is completed in the regional aquifer in volcanic sediments just below the base of the Cerros del Rio lavas. The well screen is 10 feet long, between 859.0 ft bgs and 869.0 ft bgs. The upper half of the well screen is within the base of dacite lava of the Cerros del Rio volcanic series, and the bottom half extends into underlying unconsolidated volcanic sediments. The water level is 32.3 ft above the top of the screen. The overlying low-permeable lava might be expected to cause confined conditions. However, water-level data from R-39 showed a barometric efficiency of approximately 70 % with a lag time of approximately 10.5 hours, suggesting the aquifer is under phreatic (unconfined) conditions.

Pumping R-39 at 1.7 gpm for 24 hours produced approximately 18 ft drawdown. Hydraulic conductivity is estimated to be ~1 ft/d. The water-level data collected during a single-screen pumping test demonstrated late time reduction of the pumping drawdown. This drawdown behavior may be due to various hydrogeologic factors: (1) phreatic aquifer conditions, (2) leaky aquifer conditions (e.g., leakage or slow drainage from the unconfined zone in the Cerros del Rio lava), (3) three-dimensional flow (partial penetration well) effects, or (4) combinations of the above. Therefore, the pumping-test drawdown data suggest that the pumping of R-39 drains groundwater from the overlaying lavas.

Pumping at R-39 did not cause discernable drawdown in the upper screens at R-22 (approximately 700 ft to the north). Drawdown was expected at R-22 based on the existing hydrogeologic data. The lack of drawdown may be an indication of aquifer complexity (leaky aquifer, laterally changing volcanic geology, faulting, or other factors providing effectively hydraulic separation between the two wells). R-22 upper well screens are in basaltic lavas and the R-39 well screen is partly in dacite lava; this indicates the aquifer is laterally heterogeneous. It is important to note during air drilling of R-39, there was response observed in R-22 screen 2 (a 0.2-ft magnitude head rise and decline). R-39 water level responds to the pumping from Totavi sediments at R-49 screen 2 and R-57 screen 2 (a replacement of R-22 screen 2); these responses indicate Puye and Totavi aquifer sediments underlying the Cerros del Rio lavas are hydraulically connected in this area.

Transients in the R-39 water-level data show no apparent response to the water-supply pumping from PM-4. PM-2 has been off-line since R-39 was installed.

R-41

R-41 is completed in Totavi silts, sands and gravels located below the Cerros del Rio lavas; the contact between the lava and riverine deposits is 920 ft bgs. Screen 1 is dry; it is 9.7 ft long, extending from 928.0 ft bgs to 937.7 ft bgs. Screen 1 was included in the well design as insurance that the top of the aquifer could be monitored in the event the water table at R-41 was similar to that at nearby well R-22; following well installation, the water level at R-41 has remained lower than screen 1. Screen 2 is also 9.7 ft long from 965.3 ft bgs to 975 ft bgs. The static water level measured in screen 2 is 960.37 ft bgs. The regional water table is less than 5 ft above screen 2. The filter pack outside screen 2 extends above the water table. Hydraulic conductivity is estimated to be 3 ft/d.

None of the screens in R-22 showed any response to pumping of R-41 screen 2. Barometric pressure response showed that R-41 screen 2 has a barometric efficiency near 100%, suggesting that the top of the aquifer is not connected with the atmosphere (however, it can be either confined or unconfined).

R-41 aquifer test data showed an increase in the time-drawdown slope rather than the flattening normally seen during the pumping tests near MDA G. This may suggest that the screened interval is not well connected to the deeper aquifer sediments. Additional analyses of the pumping test data suggest that significant groundwater flow during pumping from zones near the regional water table and above the pumped screen, behind the blank casing.

Transients in the R-41 water-level data do not show apparent response to water-supply pumping.

R-49

Well R-49 is drilled through Cerros del Rio lavas and into underlying Totavi sediments; the contact between the lavas and riverine sediments is at 897 ft bgs. Screen 1 is 10 ft long and is set between the depths of 845 ft bgs and 855 ft bgs in the dacitic lava breccia. Screen 2 is 20.8 ft long and is set from 905.6 ft bgs to 926.4 ft bgs in Totavi coarse-grained sedimentary deposits.

The composite water level in R-49 is 832.14 ft bgs. After the screens were isolated with packers, the screen 1 water level rose 22.64 ft to 809.50 ft bgs (5775.04 ft amsl) and the screen 2 water level dropped 0.83 ft to 832.97 ft bgs (5751.57 ft amsl). The head difference of 23.47 ft over ~55 ft vertical distance implies an aquitard occurs between the two screens. The vertical component of the hydraulic gradient at R-49 is on the order of 0.4.

R-49 screen 1 responded to barometric pressure with approximately 75% barometric efficiency and a 7-hour lag time. This suggests delayed propagation of the barometric fluctuations through the vadose zone. It also suggests that the upper screen is under phreatic conditions. R-49 screen 2 showed near 100% barometric efficiency; this suggests that the saturated zone is not connected with the atmosphere (it can be either confined or unconfined).

R-49 screen 1 produced 1.5 gpm for 1440 min with approximately 20 ft of drawdown (specific capacity of 0.075 gpm/ft). Pumping-test analysis produced hydraulic conductivity estimates of 0.7 ft/d.

R-49 screen 2 produced 23.4 gpm for 1440 min with approximately 7 ft of drawdown (specific capacity of 3.34 gpm/ft). Pumping-test analysis produced hydraulic conductivity estimates between 18 ft/d and 133 ft/d.

Pumping R-49 screen 2 caused a drawdown of 0.06 ft in screen 1. Model simulations suggested that for a range of upper zone storage coefficient values (10-4 to 10-2), the corresponding aquitard leakance ranged from 1.4 x 10-4 to 3.1 x 10-3 1/d, respectively.

Pumping R-49 screen 2 caused a drawdown of 0.06 ft in R-39 (1100 ft east of R-49). This drawdown response implies a transmissivity ranging from 100,000 to 400,000 gpd/ft (hydraulic conductivity from 133 ft/d to 533 ft/d), depending on the assumed value of the storage coefficient (10-4 to 10-2).

Transients in the R-49 water-level data show no apparent response to the water-supply pumping.

R-55

Both screens at R-55 lie within riverine sands and gravels. Screen 1 is set within the Totavi lentil and screen 2 is set in the underlying Chamita Formation. Screen 1 is 20.6 ft long (from 860.0 ft bgs to 880.6 ft bgs), and screen 2 is 21.0 ft long and is positioned approximately 114 ft beneath screen 1 (from 994.4 ft bgs to 1015.4 ft bgs).

The composite static water level is 834.67 ft bgs (5699.19 ft amsl). When the screen zones are isolated, the water level in screen 1 rose 0.11 ft (834.56 ft bgs; 5699.30 ft amsl), and the water level in screen 2 declined 2.66 ft (837.33 ft bgs; 5696.53 ft amsl). The water levels show a head difference of 2.77 ft over vertical distance of approximately 114 ft; the vertical component of the hydraulic gradient is ~0.03. The significant head difference implies resistive sediments separating the two screen zones.

A comparison of barometric pressure and R-55 water-level data showed a high barometric efficiency for each zone.

Pumping screen 1 at 17.4 gpm with 0.97 ft of drawdown (specific capacity of 17.9 gpm/ft) for 1438 min had no discernable effect on water levels in screen 2. It also had no effect on water levels monitored at R-23, R-39, R-41, and R-49. Analysis of the screen 1 pumping tests showed an average hydraulic conductivity value of 128 ft/d for the screened interval. Late-time drawdown/recovery curves flattened almost completely, consistent with partial penetration effects (vertical growth of the cone of depression) or leakage from highly transmissive overlying and/or underlying sediments and likely delayed yield of the unconfined aquifer.

Pumping screen 2 at 4.3 gpm with 40.1 ft of drawdown for 1440 min caused no effect on water levels monitored at R-23, R-39, R-41, and R-49. Pumping-test data suggest very low specific capacity (0.11 gpm/ft) and low effective hydraulic conductivity (0.3 ft/d).

Transients in the R-55 water-level data show no apparent response to the water-supply pumping. Water-supply pumping responses are not expected based on data for other wells in the area.

R-56

Both R-56 screens are placed within sands and gravels of the Puye Formation. Screen 1 is 20.6 ft long, extending from 945.0 to 965.6 ft bgs. Screen 2 is 20.5 ft long and is positioned approximately 76 ft beneath screen 1, extending from 1041.4 to 1067.1 ft bgs. The composite static water level is 924.04 ft bgs (5856.84 ft amsl). When packers isolated the screen zones, the water level in screen 1 rose 2.19 ft (921.85 ft bgs; 5859.03 ft amsl), and water level in screen 2 declined 1.81 ft (925.85 ft; 5855.03 ft amsl). The head difference is 4.0 ft over vertical distance of approximately ~76 ft; the vertical component of the hydraulic gradient is ~0.05 (the vertical distance between the screens does not account for the extent of the filter packs).

Pumping screen 1 at 5.6 gpm for 1440 min produces ~5.5 ft drawdown at the pumped screen, but no apparent drawdown is observed in the lower screen as well as in any of the other nearby monitoring wells, except at R-53 screen 1, which is located 906 ft NNW of R-56. The pumping drawdown R-53 screen 1 is ~0.1 ft. The fairly quick response between the two wells suggests locally confined conditions in the area between R-56 screen 1 and R-53 screen 1. Hydraulic conductivity at R-56 screen 1 is estimated to be 6.6 ft/d. The late drawdown data showed steady flattening over time, with a very flat slope after a few hours of pumping. This drawdown behavior could indicate (1) three-dimensional flow (partial penetration well) effects, (2) increased aquifer transmissivity away from the well, or (3) leakage or slow drainage from the unconfined zone in the Cerros del Rio lava.

Pumping screen 2 at 15.0 gpm for 1440 min produces ~12.5 ft drawdown at the pumped screen, but no apparent drawdown in the upper screen. However, the pumping caused drawdowns of 1.1 ft in R-21 (783 ft S), 0.5 ft in R-53 screen 2 (906 ft NNW), and 0.08 ft in R-54 screen 2 (1793 ft NW). The fairly quick responses in the nearby monitoring wells again suggest locally confined aquifer conditions. There was no discernable drawdown effect at any of the other monitored locations. Average hydraulic conductivity at R-56 screen 2 is estimated to be 13.3 ft/d. The late drawdown data suggest a boundary effect with a corresponding hydraulic conductivity of 7.1 ft/d. This may have been an indication of an actual lateral reduction in aquifer conductivity or the presence of an aquifer boundary such as a fault or pinch out. The computed 2:1 ratio in conductivity is symptomatic of a linear boundary (fault or pinch out). The late drawdown data show steady flattening over time, with a very flat slope after a few hours of pumping. This could indicate (1) three-dimensional flow (partial penetration well) effects, or (2) aquifer leakage.

The lack of responses during pumping tests and the head difference between the two R-56 screens suggests that highly resistive sediments separate the two screens. The Puye Formation is overlain by lava flows of the Cerros del Rio lava at a depth of 945 ft (the top of screen 1). It is suspected that the lava flows (due to their low permeability) might act as an aquitard, confining the screen 1 aquifer zone. This observation is supported by analysis of the pumping test data. Based on existing data, the aquifer is expected to be phreatic (under water-table conditions) within the Cerros del Rio lavas and confined within Puye Sediments. The regional water table is located within the Cerros del Rio lavas; the potentiometric surface associated with confined hydraulic heads within the underlying sediments is also located within the Cerros del Rio lavas. Screen 1 is approximately 20 ft below the regional water table. Because of the apparent low permeability of the lavas, screen 1 was set in the sediments below the lavas as the best location to monitor the top of the regional aquifer at R-56. The pumping-test data suggests that the pumping of screen 1 potentially drains groundwater from the overlaying lavas.

Because R-56 was recently installed, the available water level data are insufficient to evaluate responses to pumping at water-supply wells. However, it is expected that both R-56 screens will be responding to the water-supply pumping at PM-2 and PM-4 based on data for other wells in the area.

R-57

R-57 is a replacement well for R-22. R-57 screen 1 lays within dacitic lavas of the Cerros del Rio volcanic series. Screen 1 is 20.5 ft long, extending from 910 ft bgs to 930.5 ft (bgs). Screen 2, is completed within riverine sands and gravels of the Totavi lentil. Screen 2 is 20.6 ft long, placed from 971.5 ft bgs to 992.1 ft bgs. The composite static head is 896.67 ft bgs (5750.33 ft amsl).

When packers isolated the screen zones, the water level in screen 1 rose 7.16 ft (889.51 ft bgs; 5757.49 ft amsl), and the water level in screen 2 declined 1.11 ft (897.78 ft bgs; 5749.22 ft amsl). The head difference of 8.27 ft over ~40 ft vertical distance implies a hydraulically resistive zone between the two screens. The vertical component of the hydraulic gradient is ~0.2. Pumping either screen had no observable effect on the other, which confirms hydraulic disconnection between the two screens. No specific aquitards are identified in the saturated interval penetrated by R-57; possibly the hydraulic disconnection is caused by poor vertical connection of fractures in the dacite lava to the underlying sediments or baking of sediments at the contact between the dacite and the Totavi lentil. It is assumed that the thickness of the upper zone is 60 ft from the static water level of 889.51 ft bgs to the basal contact of the dacite at 950 ft. The thickness of the lower zone can be more than 100-ft thick.

A comparison of barometric pressure and R-57 water level data shows a fairly high barometric efficiency for both screen zones.

Pumping R-57 screen 1 at 7.1 gpm for 1438 min with 3.27 ft of drawdown (specific capacity of 2.17 gpm/ft) had no discernable effect on water levels at R-39, R-41 screen 2, or R-49 screens 1 and 2. Pumping screen 2 at 16.5 gpm for 1440 min with 1.67 ft of drawdown (specific capacity of 9.9 gpm/ft) had no effect on water levels at the upper R-57 screen, R-41 screen 2 ,and R-49 screen 1, but induces 0.1 to 0.2 ft of drawdown in R-39 and R-49 screen 2.

Analysis of the screen 1 pumping tests shows an average hydraulic conductivity value of 10.4 ft/d. The pumping-test data suggests dual-porosity characteristics suggesting prominent bedrock fracture effects–either classical dual-porosity effects or a major void that was dewatered during testing. Late drawdown and recovery data provided indirect evidence of the possibility of a nearby low-permeability boundary (this may be caused by pinching of the hydrostratigraphic unit, facies boundaries, or faults).

Analysis of the screen 2 pumping tests suggests a transmissivity of 19,200 gpd/ft for the screened interval of perhaps a somewhat greater thickness. This corresponds to an average hydraulic conductivity of approximately 125 ft/d or possibly less, depending on the sediment thickness represented by the computed transmissivity. Late drawdown and recovery water levels show significant flattening of the data curve, implying an overall transmissivity for the aquifer penetrated by screen 2 well in excess of 20,000 gpd/ft

Distance-drawdown analysis of the response to pumping R-57 screen 2 observed at R-39 and R-49 screen 2 suggests an area-wide aquifer transmissivity of 46,000 gpd/ft and an estimated storage coefficient of 3.3 x 10-4.

Because R-57 was recently installed, the available water level data are insufficient to evaluate responses to pumping at water-supply wells. However, it is expected that both R-57 screens will not respond to the water-supply pumping based on data for other wells in the area.

E-2.0 SUMMARY

Table E-2.1-1 presents information about the regional monitoring wells near MDA G related to estimated hydraulic conductivity based on conducted pumping test, hydrodynamic conditions at the screens (unconfined, partially-confined, or confined), and the submergence of the uppermost screen below the regional water table.

Table E-2.1-2 summarizes the information regarding the water-level transients observed in the regional monitoring wells near TA-54 and whether these transients are related to the water-supply pumping. When a sufficient amount of data is available, the water-level transients are analyzed to evaluate the large-scale aquifer properties (transmissivity and specific storage; Table E-2.1-2). For many of the newer regional wells in the TA-54 monitoring network, the period of record for water levels is insufficient to analyze the transients.

Table E-2.1-3 summarizes the estimated vertical component of the hydraulic gradient at the monitoring wells with more than one screen near TA-54. The highest values for the vertical component of the hydraulic gradient are observed at R-20, R-49, R-57, and R-22. R-20 is located close to PM-2, and its water levels have been strongly impacted by the water-supply pumping (Table E-2.1-2); therefore, the high value is probably caused by the water-supply pumping. However, R-49, R-57, and R-22, all located east of MDA G, do not appear to be impacted by the water-supply pumping. In this case, the high values for the vertical component of the hydraulic gradient are probably caused by either three-dimensional groundwater flow effects or stronger vertical stratification (hydraulic separation) in the upper section of the regional aquifer. In either case, the groundwater flow may be impacted by the spatial extent of the Cerros del Rio lavas and/or the Totavi lentil sediments within the regional aquifer.

The regional monitoring-well network downgradient of MDA G is a redundant system that is designed to provide reliable detection of potential contaminants reaching the regional aquifer in an area of considerable hydrogeologic complexity. The wells are located both near the facility boundary and at more distal locations along the dominant regional flow direction as well as along potential local flow directions to the northeast. Because of the difficulties associated with monitoring groundwater in lavas beneath MDA G, the network is made up of two-screen wells with an upper well screen placed as close to the water table as possible to monitor the first arrival of contaminants in the aquifer and a lower screen placed in permeable aquifer sediments to monitor the primary groundwater pathways downgradient of the facility. The monitoring wells located downgradient of MDA G (R-41, R-57, R-49, and R-39) are screened in sections of the regional aquifer that appear to be the best locations for monitoring potential contaminants. The design of these wells includes at least one well screen that is placed in relatively high permeable sediments in close proximity to the regional water table (section E-2.1.1).

Hydrogeologic data also suggest that the screened regional-aquifer zones at the monitoring wells near MDA G are either unconfined or partially confined. This suggests that the upper well screens and the regional water table are potentially hydraulically connected. The cross-well hydraulic responses between R-57, R-49, and R-39 during the performed pumping tests demonstrate that the well screens are in good hydraulic communication with the aquifer and will be expected to provide early detection of potential contaminants originating from MDA G. At R-41, the relatively low water level and the lack of cross-well pumping responses lead to uncertainties related to (1) the groundwater flow direction in the regional aquifer near R-41, and (2) the hydraulic connection of the saturated zone tapped by R-41 with the rest of aquifer. Various hydrogeological conceptual models to explain the R-41 water-level data are discussed below.

E-2.1 Regional Aquifer Water-Table Maps

Groundwater flow directions and fluxes that control contaminant transport in the aquifer are generally dictated by the shape of the regional water table (Freeze and Cherry 1979, 088742, Chapter 5; Vesselinov 2005, 090040). The general shape of the regional water table beneath the Laboratory is predominantly controlled by the areas of regional recharge to the west (flanks of Sierra de los Valles and the Pajarito fault zone) and discharge to the east (the Rio Grande and the White Rock Canyon Springs). The structure of the regional phreatic flow is also expected to be impacted by (1) local infiltration zones (e.g., beneath wet canyons), (2) heterogeneity and anisotropy in the aquifer properties, and (3) discharge zones (water-supply wells and springs).

Information about the elevation of the regional water table is provided by existing data from monitoring wells (water levels) and selected springs (for example, the White Rock Canyon Springs; discharge elevations of the springs are applied as an estimate of the local elevation of the regional water table). Well data are predominantly applied to map the elevation of the regional water table; spring discharge elevations are used in the vicinity of White Rock Canyon to provide additional constraints on the water-table elevation.

Water-table elevations under the plateau vary in time due to transient effects that include pumping of the water-supply wells and large- and small-scale variability in aquifer recharge. In general, water-level maps are representative of specific periods of time. The interpretation of water-level data not representative for the same period of time is a source of uncertainty in the mapping process. Differences in the depths of screen placements and local hydrogeologic conditions also complicate the interpretation of the water-level data. In addition, up to a month (depending on the local hydrogeological conditions) is required for the water levels in the recently-drilled wells to equilibrate after being disturbed by drilling, development, and pump testing.

The process of water-table contouring is theoretically constrained by conformity rules (Freeze and Cherry, 1972, 088742): (1) the contour lines should be perpendicular to the flowpaths; (2) the length and the width of the flownet cells formed by the contour lines between two adjacent flowpaths should have the same ratios. These rules are theoretically valid only for the case of two-dimensional (lateral) groundwater flow in a uniform, isotropic aquifer with no recharge/discharge sources within flownet cells. Deviations from the conformity rules are caused by three-dimensional flow effects, aquifer heterogeneity and anisotropy as well as recharge/discharge sources within flownet cells. Here, the regional water table maps are contoured by attempting to satisfy four goals simultaneously: (1) to match the water-level data at the monitoring wells, (2) to account for issues of data representativeness (confined in contrast to unconfined hydrodynamic conditions at the screens; submergence of the screen below the regional water table; water-level transients; etc.), (3) to preserve flownet conformity, and (4) to account for conceptual models of groundwater flow in the regional aquifer. Because of the existing uncertainties in the data and knowledge about the site, a series of alternative conceptual-model assumptions pertaining to the regional groundwater flow have been evaluated. The actual contouring is performed using a combination of manual and automated techniques; the automated contouring is performed using the Minimum Curvature method.

E-2.2 Water-Table Map Based on March 2009 Data

A Laboratory-wide water-table map based on monthly averaged regional-aquifer water-level data from March 2009 is presented in Figure E-2.2-1. The development of this water-table map is discussed in detail in the 2010 General Facility Information (GFI) Report (LANL 2010, 109084). This version of the map does not include water-level data from the recently drilled monitoring wells near TA-54: R-41, R-51, R-52, R-53, R-54, R-55, R-56, and R-57. The R-41 water level was available at the time this map was developed, but it was not included in the analyses because the well had just been installed and it was not yet known if the measured water level was representative of this location (LANL 2010, 109084).

The distribution of hydrostratigraphic units at the regional water table and the estimated thickness of the Cerros del Rio lavas beneath the regional water table are presented in Figure E-1.1-8. The thickness of the lavas is evaluated using the March 2009 version of the water-table map (LANL 2010 109084) and an updated version of the 2009 geologic framework model (Cole et al. 2010, 106101), based on the new geologic data collected at the recently drilled wells at TA-54.

The hydrogeological properties and thickness of Cerros del Rio lavas below the water table is thought to affect flow directions at TA-54 (Figure E-1.1-8). The effective saturated hydraulic permeability of the Cerros del Rio lavas depends on the permeabilities of (1) the intact lava matrix, (2) fractures separating lava blocks and their fracture-lining minerals, and (3) interbedded sediments between lava flows. Permeabilities of these lavas are also a function of the spatial distribution and interconnection of the fractures and interbedded sediments. The permeability of the intact lava matrix is expected to be quite low. However, high permeability fractures and interbedded sediments can lead to relatively high local groundwater flow velocities and preferential flows though the phreatic zone. Depending on the hydrogeological properties and spatial connection between the fractures and interbedded sediments, the groundwater volume flowing through the fractures is expected to be relatively low. As a result, the effective saturated hydraulic permeability of the Cerros del Rio lavas is also expected to be relatively low. Although total groundwater flux through the phreatic system may be lower than to other parts of the plateau, focusing flow into fractures or interbedded sediments may lead to higher groundwater transport velocities than would be encountered where the phreatic system is found in sediments (such as the Puye Formation). The low effective permeability of the Cerros del Rio lavas is supported by the observed steep gradients in the areas where these rocks occur at the top of the regional aquifer (Figure E-2.2-1). The hydraulic gradient along the regional water-table beneath MDA G is 0.02 m/m; it is among the highest hydraulic gradients observed beneath the Laboratory.

E-2.3 Preliminary Water-Table Map Based on July–September 2010 Data

An updated water-table map for the TA-54 MDA G area is also constructed based on monthly averaged water-level data from July–September 2010 (Figure E-2.3-1). The analysis is preliminary and the mapping process follows the procedures discussed in the 2010 GFI Report (LANL 2010, 109084). The analysis of the water-table contours in the updated map includes preliminary water-level data from the new wells in the area near MDA G (including R-41, R-55, R-56, and R-57). It is important to note that the water levels measurements at R-55, R-56, and R-57 are preliminary; it is expected that it will take some time for the water levels to equilibrate in these wells post drilling and development.

A visual comparison of both water-table maps (Figures E-2.2-1 and E-2.3-1) demonstrates some similarities in the predicted groundwater flow directions in the regional aquifer beneath MDA G; however, there are also important differences caused by the relatively low water level observed at R-41.

Based on the expected structure of the regional groundwater flow, it was anticipated that R-41 and R-57 would have similar water levels (e.g., 2009 version of the water-table map; Figure E-2.2-1). However, the R-41 water level is approximately 60 ft lower than the water levels observed approximately 600 ft to the south at R-57 and R-22; R-41 screen 2 and R-57 screen 1 are screened at similar elevations, but R-41 is within the Totavi sands and gravels and R-57 is within Cerros del Rio dacite lava. The R-41 water level (5699 ft amsl) is almost equivalent with the preliminary water level measured at the new well R-55 (5699 ft amsl), approximately 2000 ft east of R-41. The R-41 water level is also similar with the water levels observed in R-22 screen 3 (5699 ft amsl), which is located within the Chamita Formation and at an elevation approximately 400 ft deeper.

Various hydrogeological conceptual models can be proposed to explain the R-41 water-level data. The first conceptual model is that R-41 is in a localized area that is hydraulically disconnected from the rest of the regional aquifer. This conceptual model is somewhat consistent with the interpretation of the pumping-test data collected during the development of R-41; pumping-test data suggest that R-41 is screening spatially limited (bounded) zone of saturation. The second plausible explanation is that the aquifer zones screened at R-22/R-57 and R-41, respectively, are in two different flow domains of the regional aquifer that are hydraulically disconnected due to lateral changes in geology (e.g., sedimentary deposits in contrast to lavas). Geologic logs for wells in the vicinity of R-41 show that the rocks in this area are heterogeneous and there is considerable lateral variability over short distances (Figure E-1.1-4). The heterogeneity and lateral variability of the rock units may explain the differences in water levels between R-41 and R-57 if the aquifer is compartmentalized by juxtaposing lithologies of strongly contrasting hydraulic properties. The third conceptual model is that the R-41 saturated zone is not disconnected from the rest of the aquifer and the observed water level is due to complexities in the groundwater flow. In this case, the flow complexity is expected to be caused by spatial extent of the lavas and/or Totavi lentil riverine deposits within the regional aquifer. The lavas extent within the regional aquifer terminates between R-57 and R-41. As a result of lava heterogeneity, the discharge of groundwater accumulated in the lavas may be spatially nonuniform, which may be the cause for the differences in the R-41, R-57, and R-39 water levels. In addition, the riverine deposits appear to be highly permeable and their spatial extent within the regional aquifer is predominantly to the east of MDA G. As a result, the highly permeable Totavi lentil riverine deposits may be capable of sustaining high lateral groundwater flow rates that cause a sharp decline in the elevation of the regional water table to the east of MDA G, similar to the water-level decline observed at R-41. Under this conceptual model, it is also possible that the lavas and the riverine deposits create a complex three-dimensional groundwater flow structure. In this case, the relatively thick Totavi lentil riverine deposits may facilitate vertical groundwater flow from the shallow into the deep zone of the regional aquifer after the regional groundwater flow in the lavas is discharged into the more permeable aquifer sediments near R-41. This conceptualization is somewhat supported by the similarity in the water levels in R-41 and R-22 screen 3 (~5699 ft amsl). It is also supported by relatively high values for the vertical component of the hydraulic gradient in the wells east of MDA G (Table E-2.1-3). However, this conceptual model is not supported by other observations: (1) despite their coarse-grained nature, the sediments at the top of the aquifer at R-41 contain considerable silt and do not appear to be very permeable; (2) highly-permeable Totavi lentil riverine deposits are observed at R-57, but their occurrence does not result in lower water levels at R-57 and R-22. It is also plausible that the actual hydrogeologic conditions are some combination of conceptual elements from all the models described above.

The preliminary water-table map based on July–September 2010 water-level data (Figure E-2.3-1) is constructed assuming that the third conceptual model discussed above is representative of the actual groundwater flow conditions. Therefore, the R-41 water level is interpolated with the other water levels observed nearby. The obtained flow structure suggests that the discharge of the regional groundwater accumulated in the lavas beneath MDA G is non-uniform and creates relatively high water levels near R-57 and relatively low water levels near R-39 and R-41. The groundwater flow potentially has a northeastern component near R-41. The contour intervals of the water-table elevation to the east of R-41 do not follow the conformity rules for water-table mapping (discussed above) for the case of two-dimensional flow. However, they can be explained if there is dominant, downward vertical groundwater flow that is potentially consistent with the applied conceptual model and supported by the relatively high values for the vertical component of the hydraulic gradient in the wells east of MDA G (Table E-2.1-3). It is important to note that the water-level data from R-55 and R-57 are preliminary and new analyses based on more representative data may change the current water-table map.

In the area directly beneath MDA G, the regional water table is located within the Cerros del Rio lavas (Figure E-2.3-1). The measured water levels at the regional monitoring wells around MDA G represent unconfined, partially-confined, or confined hydrogeologic conditions (Table E-2.1-1). The uppermost well screens at the wells upgradient from MDA G (R-21, R-56, R-32) are located in the sediments below the lavas (Pliocene clastic sedimentary deposits; interbedded Puye Formation and Totavi lentil), but the water levels are within the overlying Cerros del Rio lavas. The downgradient wells, R-49 and R-57, have upper screens placed in Cerros del Rio dacite breccia and dacite lava, respectively, and lower screens are within the Totavi lentil. At R-39, the screen straddles the lavas and the underlying volcaniclastic sediments. At R-41, the two screens are within Totavi sediments, but the upper screen is dry.

The northeastward direction of the groundwater flow near MDAs G, H, J, and L (e.g., in the area between wells R-40 and R-38; Figures E-2.2-1 and E-2.3-1) may indicate a complex three-dimensional structure of the groundwater flow that is potentially influenced by hydrostratigraphy, aquifer recharge, and/or water supply pumping in the deep sections of the regional aquifer. For example, it is plausible that the shape of regional water table near wells R-40, R-20. and R-54 is influenced by the water-supply pumping in PM-2; preliminary water-level data suggest that the water elevation at R-54 is higher than at R-20 (Figure E-2.3-1).

The presence of the low permeable Cerros del Rio lavas (Tb4) below the regional water table in the area beneath MDA G may act as a hydrogeologic barrier that diverts flow northeastward in the R-40 area (Figures E-2.2-1 and E-2.3-1). The impact of this hydrogeologic barrier on the groundwater flow may have been observed during the pumping tests conducted in R-53, R-56, and R-38; the drawdowns observed during the pumping tests conducted at these wells are impacted by boundary effects (Table E-2.1-1). The distribution of hydrostratigraphic units at the regional water table and the estimated thickness of the Cerros del Rio lavas beneath the regional water table are presented in Figure E-1.1-8; as already discussed, this figure is created using the 2009 version of the water-table map, which does not include water-level data R-41, R-51, R-52, R-53, R-54, R-55, R-56, and R-57. The relatively lower water levels and flat hydraulic gradients in the area north of R-38 are potentially caused by flow-through highly permeable Puye Formation sediments (as indicated by the pumping test results from wells at R-28, R-11, R-13, R-44, and R-45). The three-dimensional structure of the groundwater flow may also be influenced by the general trends of (1) decreased thickness of the Puye Formation at the top of the regional aquifer, and (2) decreased depth of the Santa Fe Group sediments below the regional water table in the area north of R-38 (LANL 2009, 106939, Figure O-4.0-1).

Additional data and hydrogeological analyses can be applied to reduce the conceptual uncertainty associated with the regional groundwater flow as additional data are gathered at these newly completed wells such as R-55, R-56, and R-57.

E-3.0 REFERENCES

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Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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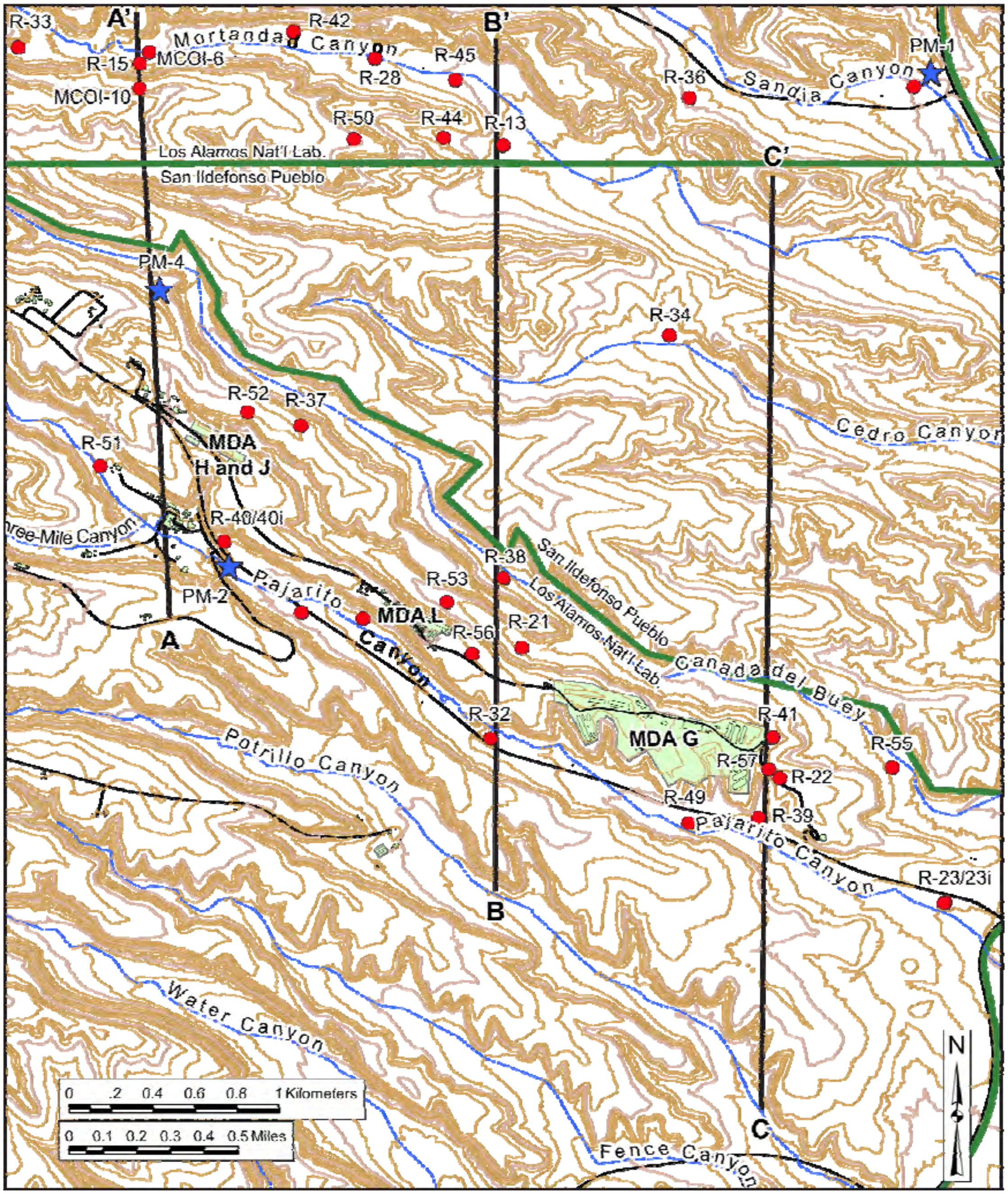

Figure E-1.1-1 Map showing location of perched-intermediate and regional wells (red circles) in the vicinity of TA-54. The locations of north-south cross sections shown in Figures E-1.1-2 (A-A'), E-1.1-3 (B-B'), and E-1.1-4 (C-C') are indicated by solid lines. Municipal supply wells are shown as blue stars

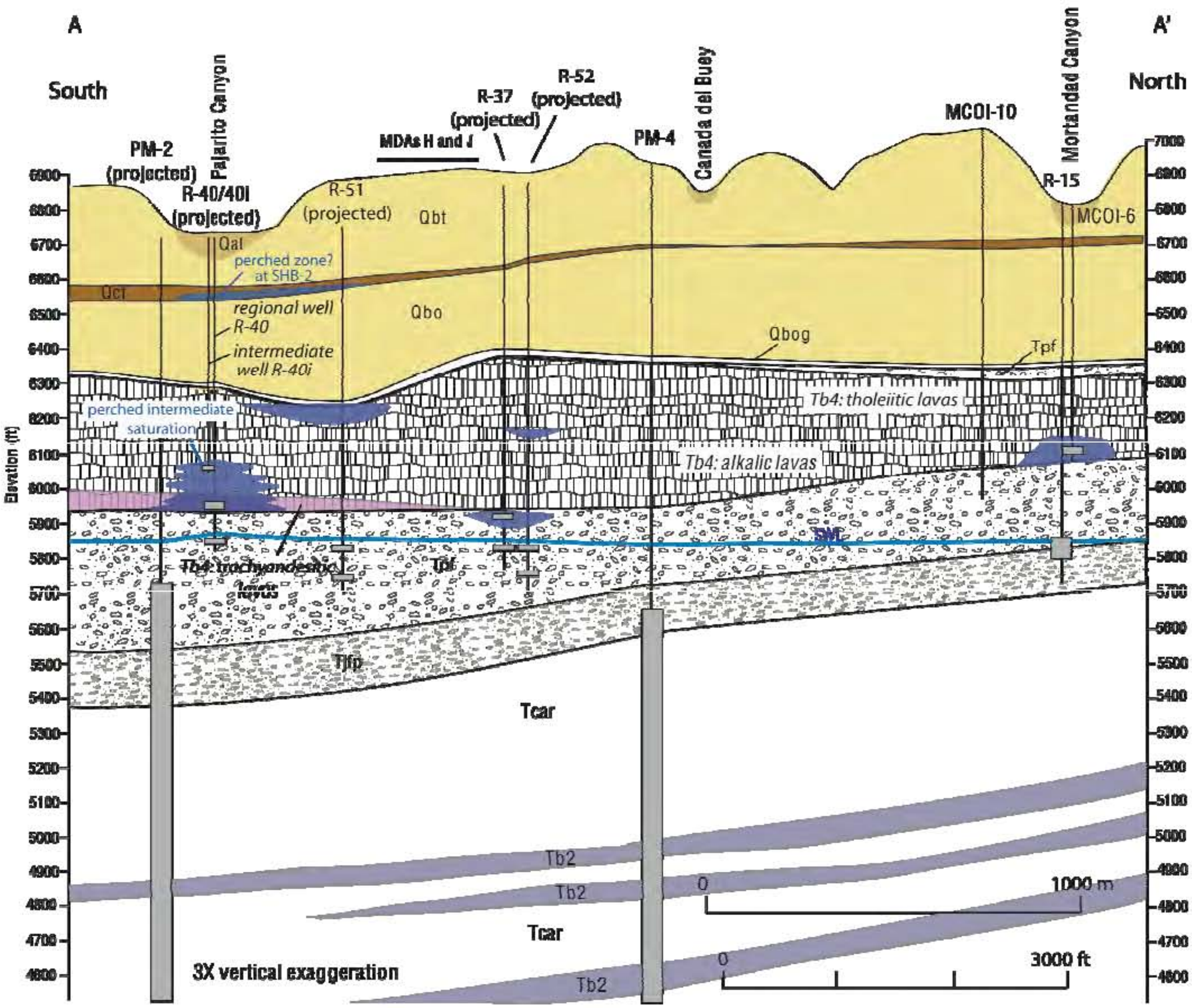

Figure E-1.1-2 North-south cross-section A-A' near MDAs H and J. See Figure E-1.1-1 for location of cross section

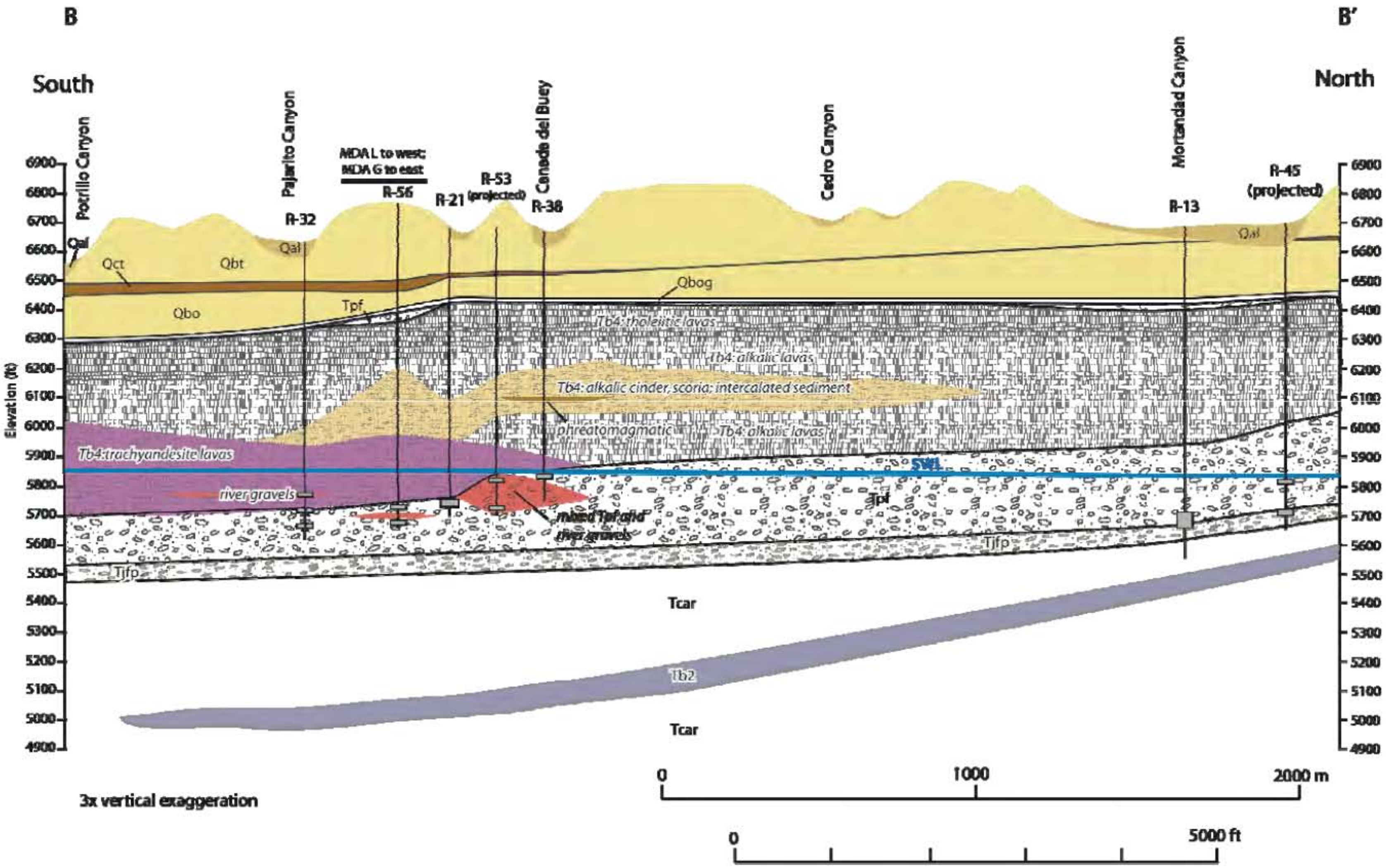

Figure E-1.1-3 North-south cross-section B-B' east of MDA L and west of MDA G. See Figure E-1.1-1 for location of cross-section

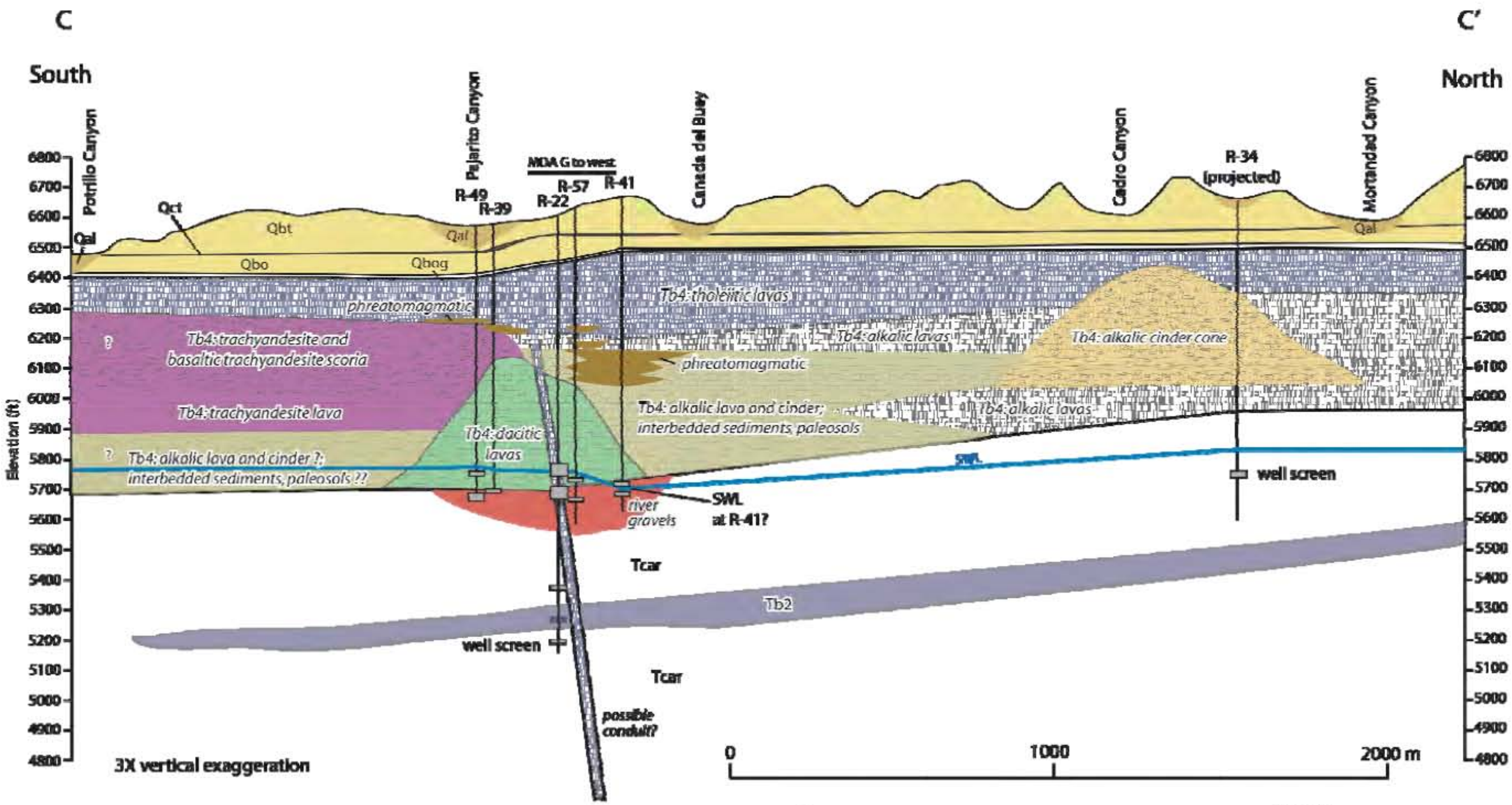

Figure E-1.1-4 North-south cross-section C-C' near east end of MDA G. See Figure E-1.1-1 for location of cross section.

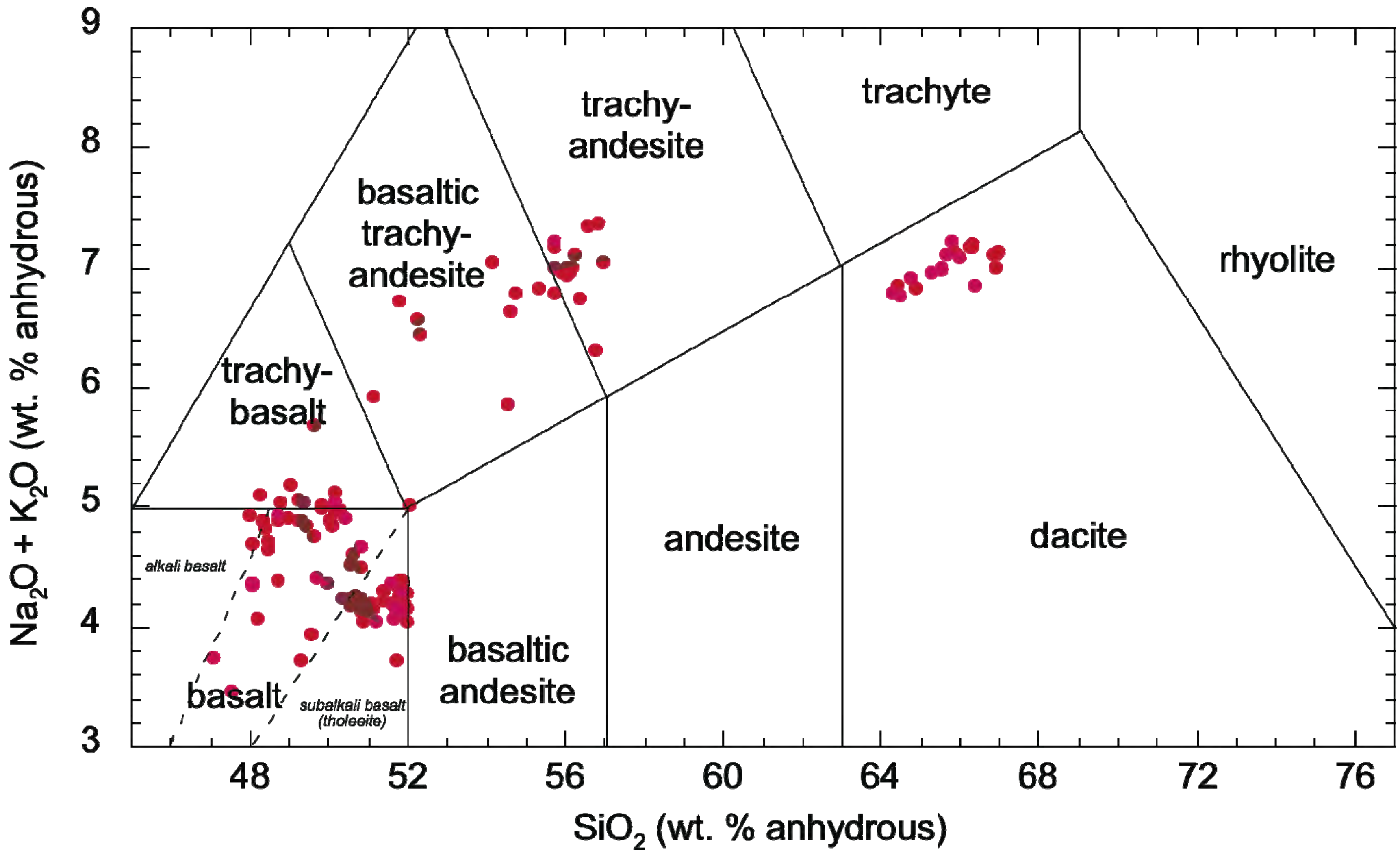

Figure E-1.1-5 Alkali-silica diagram showing chemical classification of Cerros del Rio volcanic rocks in the vicinity of TA-54. Gray arrow shows the eruption sequence from oldest to youngest rocks

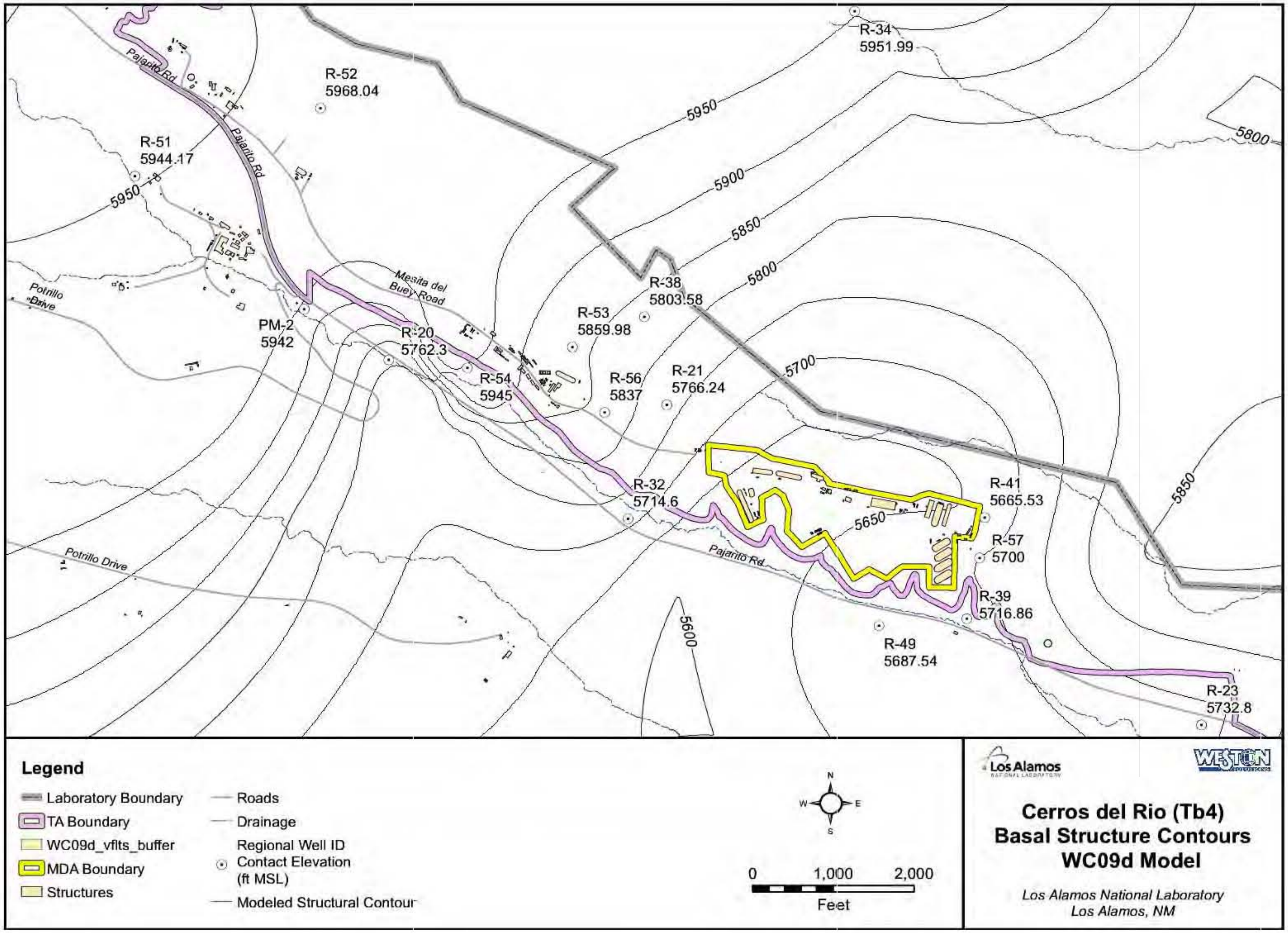

Figure E-1.1-6 Structure contour map for the base of Cerros del Rio volcanic rocks in the vicinity of TA-54

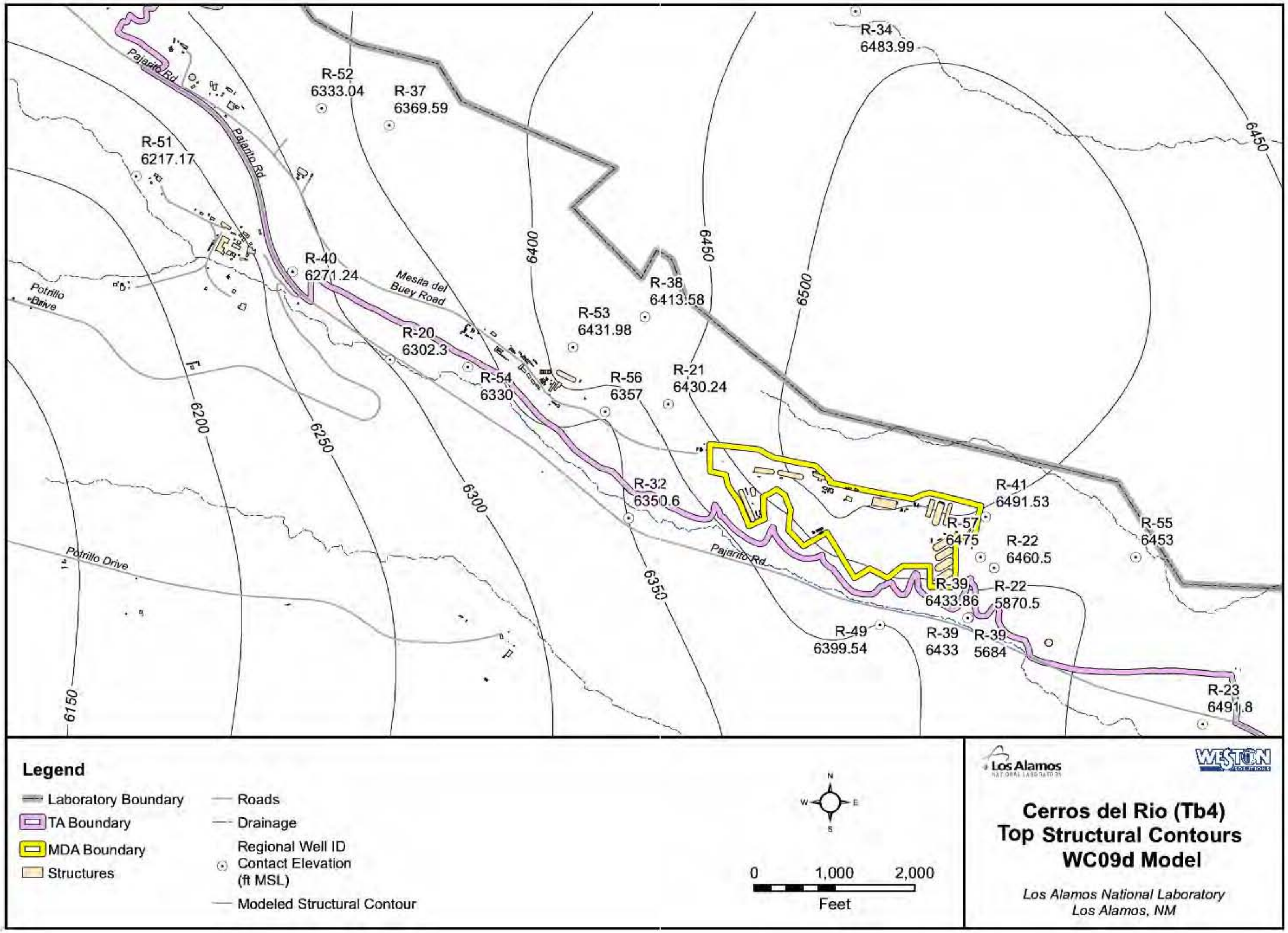

Figure E-1.1-7 Structure contour map for the top of Cerros del Rio volcanic rocks in the vicinity of TA-54

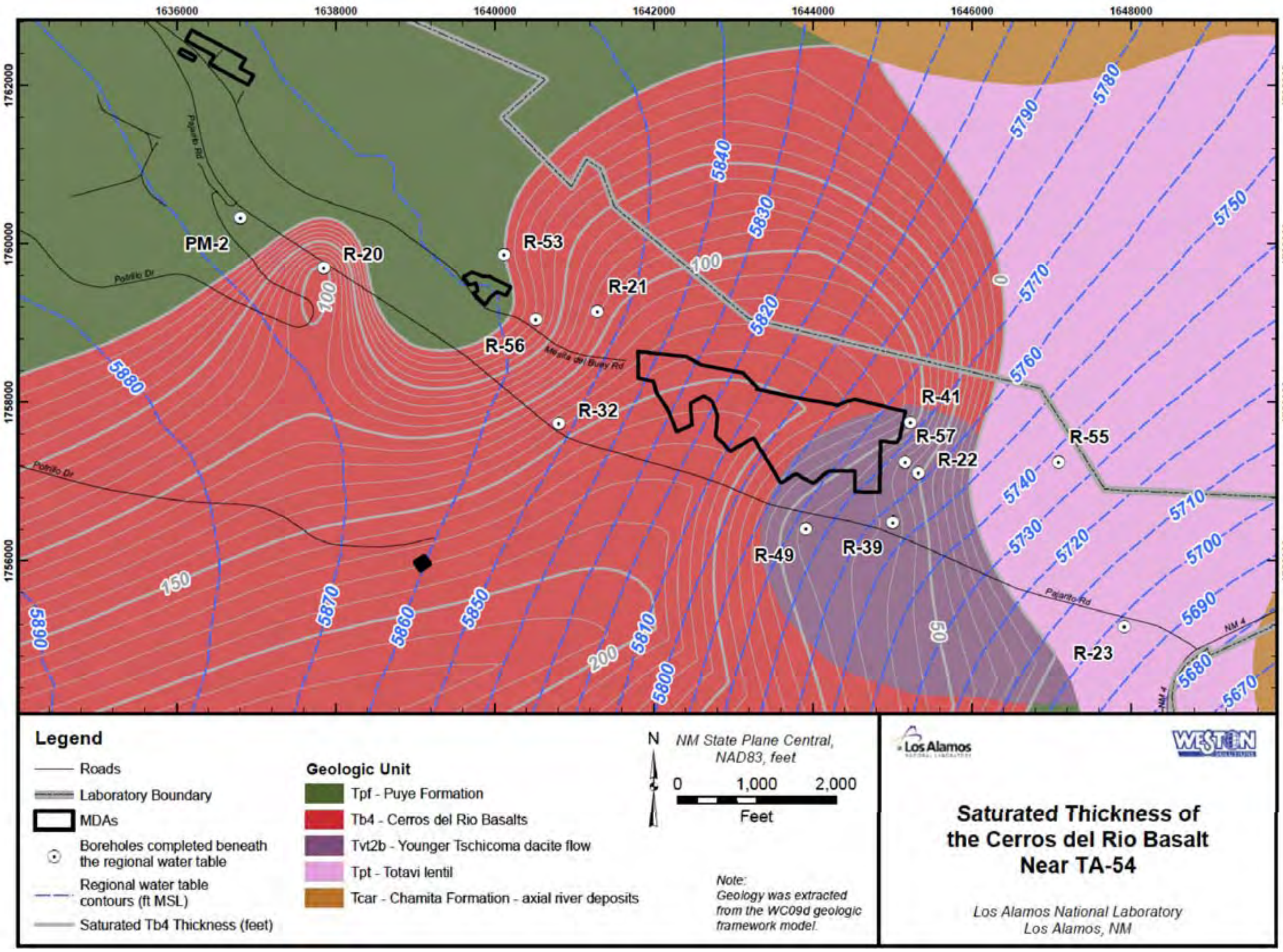

Figure E-1.1-8 Hydrostratigraphy at the regional water table and estimated thickness of Cerros del Rio lavas beneath the regional water table (gray contours). Groundwater-level contour map is based on average data representative for March 2009 (LANL 2010, 109084). The water-table contours (blue dashed contours) do not include wells installed after March 2009. Recently acquired data shows the base of the lavas at R-41 is above the water table

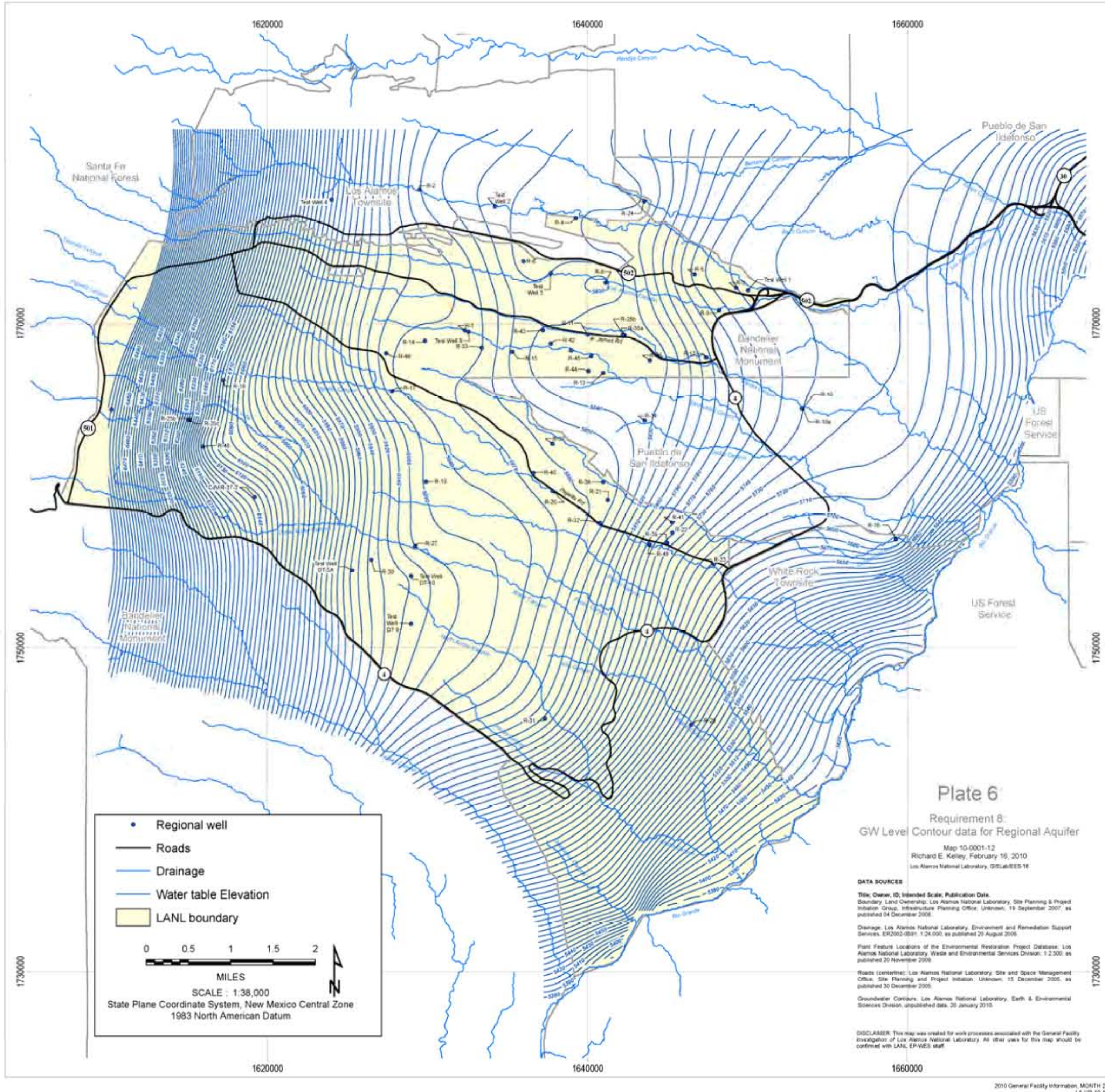

Figure E-2.2-1 Groundwater-level contour map based on average data representative for March 2009 (LANL 2010, 109084)

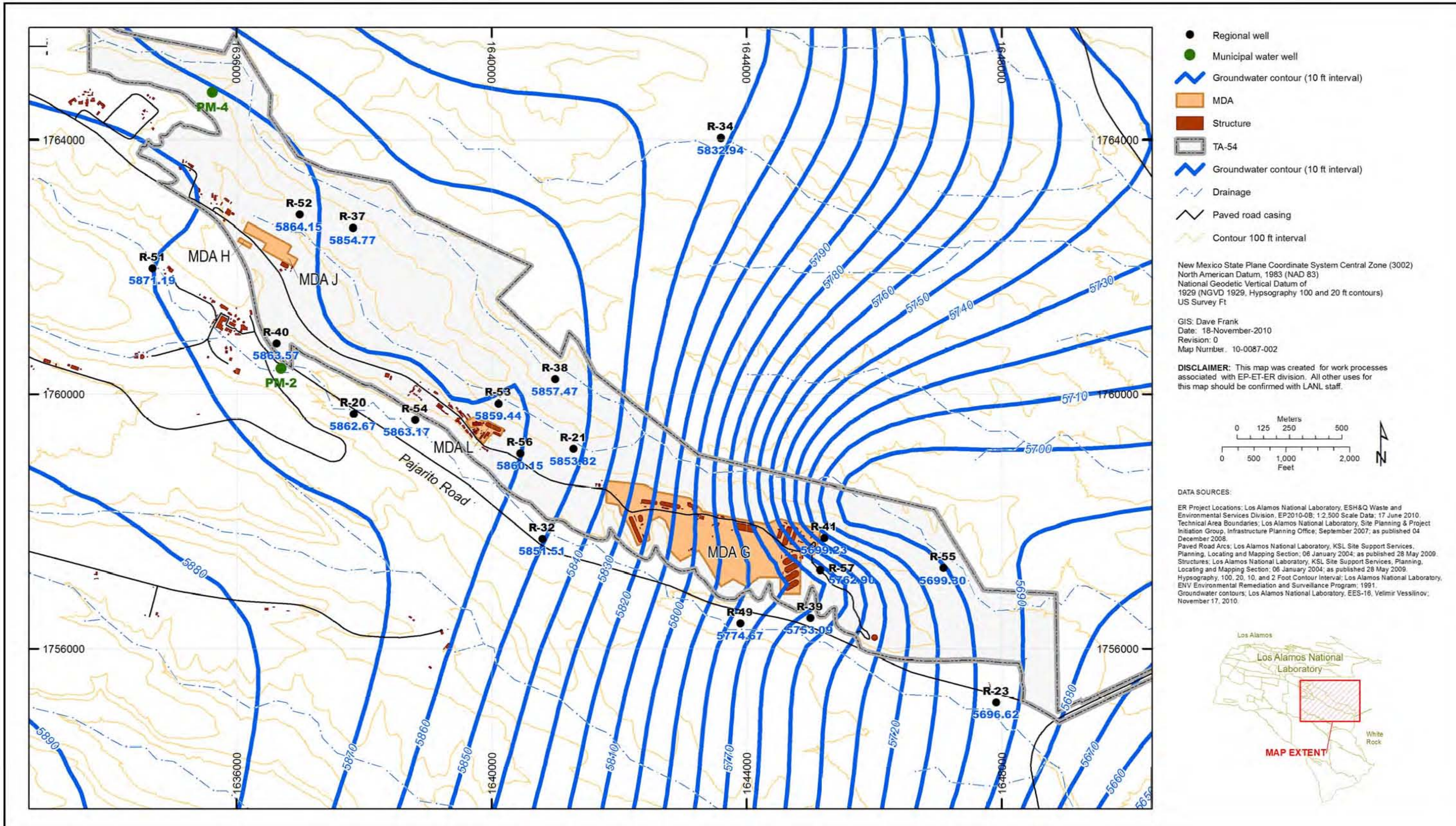

Figure E-2.3-1 Preliminary water-table map based on data representative for July–September 2010 regional water levels in the area near MDA G

Table E-2.1-1
Hydrogeologic Characteristics of the Monitoring Wells in the Area Near MDA G

Well Screen	k [ft/d]	Unit	Submergence Below the Water Table	Hydrodynamic Conditions	Comments based on the Pumping Tests Conducted at the Screens
R-53#1	26	Tpf mixed with Tpt	20	unconfined or partly confined	pumping test complicated due to gases in the aquifer
R-53#2	7	Tpf mixed with Tpt	120	unconfined or partly confined	drawdown equilibration at late pumping times; boundary effects
R-56#1	7	Tpf	23	unconfined or partly confined	drawdown equilibration at late pumping times; boundary effects
R-56#2	7	Tpf	120	confined	drawdown equilibration at late pumping times; boundary effects
R-38	37	Tpf	11	unconfined	no drawdown equilibration at late pumping times; boundary effects
R-21	1	Tpf	85	confined	—[a]
R-32#1	10	Tpt within Tb4	70	unconfined or partly confined	—
R-32#2	ND[b]	Tpf	135	confined	plugged and abandoned
R-32#3	0.5	Tpf	200	confined	plugged and abandoned
R-49#1	0.7	Tb4 (dacite breccia)	35	unconfined or partly confined	drawdown equilibration at late pumping times
R-49#2	133	Tpt	96	confined	drawdown equilibration at late pumping times
R-41#2	3	Tpt	5	unconfined	sharp drawdown increase at late pumping times
R-57#1	10	Tb4 (dacite)	20	unconfined or partly confined	low permeability boundary effects
R-57#2	125	Tpt	91	unconfined or partly confined	drawdown equilibration at late pumping times
R-39	1	Tpf	32	unconfined or partly confined	drawdown equilibration at late pumping times
R-55#1	128	Tpt	25	unconfined or partly confined	drawdown equilibration at late pumping times
R-55#2	0.3	Tcar	140	confined	—
R-23	ND	Tpt	-12	unconfined or partly confined	no pumping test conducted

Note: Wells are ordered from west to east, approximately following the general groundwater flow directions of the regional aquifer.

Table E-2.1-2: Estimates of effective aquifer hydraulic properties in the area near TA-54 based on analysis of the water-level transients observed at the monitoring wells caused by water-supply pumping (wells are ordered from west to east, approximately following the general groundwater flow directions of the regional aquifer).

[a] — = No estimate for aquifer properties because no apparent pumping drawdowns are observed.

[b] ND = Currently there is no sufficient data to estimate aquifer properties.

Table E-2.1-2
Water-Level Transients Observed in the Regional Monitoring Wells Near TA-54

Well Screen	PM-2		PM-4		Comment
	T [m²/d]	S [-]	T [m²/d]	S [-]	
R-51#1	ND[a]	ND	ND	ND	Small response to PM-4; more data needed
R-51#2	ND	ND	ND	ND	Responses to PM-4; PM-2 also expected
R-52#1	ND	ND	ND	ND	Small response to PM-4; more data needed
R-52#2	ND	ND	ND	ND	Small response to PM-4; more data needed
R-40#2	ND	ND	ND	ND	Responses to PM-4; PM-2 also expected
R-37#2	ND	ND	ND	ND	Small response to PM-4; more data needed
R-20#1	4.2E+03	3.9E-02	8.5E+03	1.5E-02	Responses to PM-2 and PM-4 only
R-20#2	1.9E+03	6.2E-03	3.2E+03	8.9E-04	Responses to PM-2 and PM-4 only
R-20#3	4.5E+02	9.1E-04	7.9E+02	2.2E-05	Responses to PM-2 and PM-4 only
R-54#1	ND	ND	ND	ND	Potentially small response to PM-4; more data needed
R-54#2	ND	ND	ND	ND	Responses to PM-4; PM-2 also expected
R-53#1	—[b]	—	—	—	No apparent water-supply pumping response
R-53#2	ND	ND	ND	ND	Responses to PM-4; PM-2 also expected
R-56#1	ND	ND	ND	ND	Water-supply responses expected; more data needed
R-56#2	ND	ND	ND	ND	Water-supply responses expected; more data needed
R-38	—	—	—	—	No apparent water-supply pumping response
R-21	1.7E+03	2.9E-02	1.1E+03	9.3E-03	Responses to PM-2 and PM-4 only
R-32#1	—	—	—	—	No apparent water-supply pumping response
R-32#2	3.1E+03	6.0E-03	3.8E+03	2.5E-03	Responses to PM-2 and PM-4 only
R-32#3	3.1E+03	2.9E-03	4.0E+03	1.5E-03	Responses to PM-2 and PM-4 only
R-49#1	—	—	—	—	No apparent water-supply pumping response
R-49#2	—	—	—	—	No apparent water-supply pumping response
R-41#2	—	—	—	—	No apparent water-supply pumping response
R-57#1	ND	ND	ND	ND	More data needed; water-supply responses not expected
R-57#2	ND	ND	ND	ND	More data needed; water-supply responses not expected
R-39	—	—	—	—	No apparent water-supply pumping response
R-55#1	ND	ND	ND	ND	More data needed; water-supply responses not expected
R-55#2	ND	ND	ND	ND	More data needed; water-supply responses not expected
R-23	—	—	—	—	No apparent water-supply pumping response

[a] — = No estimate for aquifer properties because no apparent pumping drawdowns are observed.

[b] ND = Currently there is no sufficient data to estimate aquifer properties.

Table E-2.1-3
Vertical Component of the Hydraulic Gradient at the Monitoring Wells Near TA-54

Well	Value (ft/ft)
R-51	0.02
R-52	0.03
R-20	0.2
R-54	-0.03
R-53	0.09
R-56	0.05
R-32	0.02
R-49	0.4
R-57	0.2
R-22	0.2
R-55	0.03

Note: Wells are ordered from west to east, approximately following the general groundwater flow directions of the regional aquifer.

Appendix F

U.S. Department of Energy Requirements at Area G

F-1.0 DOE ORDER 435.1, RADIOACTIVE-WASTE MANAGEMENT

Portions of Area G at Technical Area 54 are used for radioactive waste disposal and are therefore regulated by the U.S. Department of Energy (DOE) through its authority under the Atomic Energy Act. DOE implements this authority via Order 435.1 and Order 5400.5, and performance objectives are included in Order 435.1 to further limit the potential for exposure from disposed low-level waste (LLW). In an effort to present a comprehensive corrective measures evaluation for Material Disposal Area (MDA) G, Los Alamos National Laboratory (the Laboratory) has voluntarily provided information on DOE closure requirements and performance objectives applicable to LLW disposal facilities. The following sections outline the performance criteria, closure requirements and performance objectives for Area G under Orders 435.1 and 5400.5.

DOE Order 435.1 requires that radioactive waste be managed in a manner that protects worker and public health and safety and the environment. In accordance with Order 435.1, the long-term performance of a LLW disposal facility is evaluated through a series of performance objectives. These criteria are designed to achieve the following:

- Ensure the health and safety of the public
- Protect groundwater resources
- Safeguard persons who may inadvertently intrude into the buried waste
- Maintain radiation doses from DOE facilities at levels that are as low as reasonably achievable (ALARA)

F-1.1 Performance Objectives

DOE Order 435.1 does not set specific closure design criteria for LLW disposal facilities, but instead establishes specific objectives for the performance of the closed facility. Compliance with the performance objectives is demonstrated through the preparation and maintenance of site-specific radiological performance assessments and composite analyses. The performance assessment addresses waste disposed of after September 26, 1988; the composite analysis includes all radioactive waste disposed at a given facility as well as other sources of radioactive material that may interact with releases from that facility. The results of the performance assessment are evaluated with respect to the following objectives and limits to determine, with a reasonable degree of certainty, that the disposal facility will perform safely for a period of at least 1000 yr following closure.

- All-Pathway: Dose to representative members of the public shall not exceed 25 mrem in a year total effective dose equivalent (TEDE) from all exposure pathways, excluding the dose from radon and its progeny.
- Air-Pathway: Dose to representative members of the public via the air pathway shall not exceed 10 mrem in a year TEDE, excluding the dose from radon and its progeny.
- Release of Radon: Release of radon shall be less than an average flux of 20 pCi/m^2/s at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/L of radon in air may be applied at the boundary of the facility.
- Groundwater Protection: The average annual concentration of beta-particle and photon radioactivity from anthropogenic radionuclides in drinking water must not exceed an annual dose equivalent to the total body or any internal organ of 4 mrem/yr.

The "All-Pathway" performance objective addresses exposures that may be received from any and all modes of exposure, including exposures from airborne contaminants (except radon and its progeny). The air pathway performance objective addresses exposures from all sources of airborne radioactivity at DOE facilities, excluding the contributions of radon and its progeny. Compliance with these performance objectives must be demonstrated over a period of 1000 yr following closure of the disposal facility, at the point(s) of maximum exposure.

Releases of radon gas (i.e., radon-220 and radon-222) are subject to the requirements in 40 Code of Federal Regulations 61, Subpart Q (http://www.epa.gov/enviro/html/rad/rad_subpart_q.html), which limit releases to an average flux of 20 $pCi/m^2/s$ at the surface of the disposal facility. An incremental increase of radon (0.5 pCi/L) at the point of assessment may also be used to demonstrate compliance with the "Release of Radon" performance objective. Compliance must be demonstrated for a period of 1000 yr following closure of the disposal facility.

The performance assessment must also include an assessment of impacts to groundwater resources. Potential impacts are to be assessed on a site-specific basis in accordance with a hierarchical set of criteria. In general, these criteria require that the LLW disposal site comply with applicable state or federal regulations for water resource protection. Potential impacts are to be evaluated at the point of highest groundwater concentration outside of a 100 meters (330 ft) buffer zone for a period of 1000 yr following facility closure.

Finally, the performance assessment must consider impacts for a person who inadvertently intrudes into the disposed waste after a 100-yr active institutional control period. Projected intruder exposures are subject to chronic and acute dose limits of 100 and 500 mrem/yr, respectively, excluding contributions of radon in air. Compliance with these objectives must also be demonstrated for a period of 1000 yr following closure of the disposal facility.

The primary performance objective for the composite analysis is to ensure DOE's primary dose limit of 100 mrem/yr is met. This limit, established in Order 5400.5, takes into account radioactivity coming from all sources and all exposure pathways. Order 435.1 imposes a dose constraint of 30 mrem/yr on the composite analysis to ensure any exposures received in conjunction with the disposal facility do not constitute an extraordinary portion of the primary dose limit. Potential exposures are to be evaluated at the point(s) of maximum exposure accessible to members of the public. Additionally, airborne releases from all activities, excluding the contributions of radon and its progeny, must not result in exposures that are greater than 10 mrem/yr. Compliance with these objectives must be demonstrated for a period of 1000 yr following closure of the disposal facility.

F-1.2 Closure

Order 435.1 requires DOE sites to prepare closure plans for LLW disposal facilities. The objective of final closure is to achieve long-term stability of the waste in a manner that protects human health and safety and the environment, and minimizes the need for active maintenance. Satisfactory long-term performance of the closed facility will depend largely on the final remedy for the disposal units. As discussed, the effectiveness of final closure is measured against performance objectives using the performance assessment and composite analysis. Although not regulated by NMED, the requirements under Order 435.1 will not be less stringent than those required by RCRA.

A closure plan has been developed for the radioactive waste that is projected for disposal at Area G that describes the conceptual closure design for the site. This conceptual closure calls for installation of a cover over disposed radioactive waste. The proposed final cover design for Area G was developed using an iterative approach in which successive cover designs underwent long-term analysis using the SIBERIA landscape evolution computer code. The result was an optimized design that is expected to be capable of meeting design criteria under a range of potential site conditions that could occur over the 1000-yr compliance period.

The cover design was evaluated in Revision 4 of the Performance Assessment and Composite Analysis for Los Alamos National Laboratory, Technical Area 54, Area G (French et al. 2008, 106890). The modeling results suggest the facility is capable of satisfying all Order 435.1 performance objectives. The proposed cover will effectively limit the degree to which plants and animals inhabiting the closed site can penetrate into the buried waste. The thickness and engineered aspects of the final cover (e.g., rock armor around the edge of the facility) will mitigate the effects of surface erosion and limit the degree to which inadvertent human intrusion disrupts the waste. The hydraulic properties of the cover are expected to limit the amount of water that percolates through the waste, thereby minimizing exposures received by persons living downgradient of the disposal facility. The cover design described in the Area G performance assessment and composite analysis may change depending on the remedial alternative selected by NMED for closure of MDA G. The corrective measures implementation process may provide an opportunity for improving the cover design to provide a more cost-effective solution while still meeting closure requirements under Order 435.1. The findings of any such evaluations will be used to update the Order 435.1 closure plan, performance assessment, and composite analysis as appropriate.

F-2.0 DOE ORDER 5400.5, RADIATION PROTECTION OF THE PUBLIC AND THE ENVIRONMENT

The primary objective of Order 5400.5 is to operate facilities and conduct activities so radiation exposures to members of the public are maintained within limits (established in the order) that control radioactive contamination and are ALARA. The order requires that DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and nonroutine releases and to assess radiological doses to members of the public and the environment.

Order 5400.5 requires that exposure of members of the public to radiation sources as a consequence of routine DOE activities must not cause, in a year, an effective dose equivalent greater than 100 mrem. The limit of 100 mrem is the sum of the effective dose equivalent from exposures to radiation sources external to the body during the year plus the committed effective dose equivalent from radionuclides taken into the body during the year. The dose limits apply to both operational facilities and those that have been closed. If a facility is removed, but radioactive contamination remains, then the dose limits in Order 5400.5 remain applicable to the property. The DOE cannot release the property from its control unless it can be demonstrated that the exposure to a member of the public will be below 100 mrem/yr. In accordance with DOE Policy 454.1, Use of Institutional Controls, DOE will implement institutional controls and maintain them into the future as long as necessary to protect human health and the environment.

Compliance with the dose limits is demonstrated by monitoring effluent discharges, conducting dose evaluations, and reporting the results of these evaluations.

Monitoring and Surveillance. General requirements for routine effluent monitoring are part of the environmental monitoring plan prescribed in DOE 5400.1. Specific requirements for radiological effluent monitoring and environmental surveillance are prescribed in DOE publication DOE\EH-0173T. These monitoring requirements are applicable to all DOE and DOE-contractor operations that are subject to the standards and requirements of this Order.

Dose Evaluations. Doses to members of the public in the vicinity of DOE activities are evaluated and documented to demonstrate compliance with the dose limits of Order 5400.5 and to assess exposures of the public from unplanned events. Collective doses to the public within 80 km of the site are also evaluated and documented at least annually.

F-3.0 REFERENCE

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

Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

French, S., R. Shuman, G.L. Cole, K.J. Crowell, M.S. Day, C.W. Gable, M.O. Gard, J.J. Whicker, D.G. Levitt, B.D. Newman, B.A. Robinson, E.P. Springer, and P.H. Stauffer, October 2008. "Performance Assessment and Composite Analysis for Los Alamos National Laboratory Material Disposal, Area G, Revision 4," Los Alamos National Laboratory document LA-UR-08-06764, Los Alamos, New Mexico. (French et al. 2008, 106890)

Appendix G

Supporting Information for Cost Estimates for Material Disposal Area G

G-1.0 INTRODUCTION

This appendix provides the basis for the cost estimates, summary cost information, assumptions, estimate details, and material and labor pricing data used in developing the cost estimates for corrective measures evaluation (CME) technologies for the Material Disposal Area (MDA) G at Technical Area 54 (TA-54) at Los Alamos National Laboratory (the Laboratory) (section 8 of the CME report). The estimates are intended to be consistent with U.S. Environmental Protection Agency (EPA) guidance on developing and documenting costs estimated during feasibility studies (EPA 2000, 071540). Cost estimates are expected to be within the accepted standard accuracy range of +50% to –30% established by EPA for remedial alternative estimates at the alternatives screening stage (EPA 2000, 071540, p. 2-4).

G-1.1 Compliance Order on Consent Requirements

The Compliance Order on Consent (hereafter, the Consent Order) requires the following: capital costs shall include, without limitation, construction and installation costs; equipment costs; land development costs; and indirect costs, including engineering costs, legal fees, permitting fees, startup and shakedown costs, and contingency allowances. Operation and maintenance (O&M) costs shall include, without limitation, operating labor and materials costs; maintenance labor and materials costs; replacement costs; utilities; monitoring and reporting costs; administrative costs; indirect costs; and contingency allowances. All costs shall be calculated based on their net present value (PV).

As presented in guidance documents, confusion often exists with the terms “direct” and “indirect” costs. Therefore, in this report the term “capital” costs includes planning, design, construction, management-related activities, and both labor and professional services for installing the remedial alternative. Recurring operations, maintenance, and monitoring costs, including regular annual costs and periodic costs, are separated out from capital costs. Periodic costs include 5-yr reviews, equipment replacement, and major repairs.

G-2.0 METHOD

This estimate has been developed based on a bottoms-up approach using WINEST. The assumptions used in the calculations are discussed in sections G-3.0 and G-4.0. The construction pricing is based on the 2010 RS Means Database for equipment and materials and the current Davis Bacon Wage Rates for construction in Los Alamos. A labor factor was used to increase the project cost on labor because of the remote location of the site or for additional rigor for a site. The basic estimating units generally reflect a normal standard for construction costs. Many special work situations and job conditions may require additional material or labor work hours. The quantities used here are for estimating purposes only and vary slightly from quantities stated within the site history section. The actual design and operations will vary when the corrective measure implementation (CMI) is completed

G-2.1 Capital Costs

Capital costs consist of construction and installation costs; equipment costs; land development costs; and indirect costs, including engineering costs, legal fees, permitting fees, startup and shakedown costs, and contingency allowances. Detailed estimates of capital cost in calendar year 2010 dollars are provided below and in section 8 tables of the CME report.

G-2.2 Operation and Maintenance Costs

The O&M costs include operating labor and materials costs; maintenance labor and materials costs; replacement costs; utilities; monitoring and reporting costs; administrative costs; indirect costs; and contingency allowances. Detailed estimates of monitoring, inspection, and maintenance costs in 2010 dollars are provided below and in section 8 tables of the CME report.

G-2.3 PV Analysis

To compare one technology's costs with other technologies that spend money over different time periods, the costs were discounted to a 2010 net PV, as recommended in "A Guide to Developing and Documenting Cost Estimates during the Feasibility Study" (EPA 2000, 071540). PV costs for a technology are the sum of all capital costs and continuing costs. Presentation of capital and operating and maintenance costs as PV is consistent with the CME requirements contained in Section VII.D.4.b.v of the Consent Order. The principle is also embraced for federal programs. The Office of Management and Budget (OMB) Circular A-94 states, "The standard criterion for deciding whether a government program can be justified on economic principles is net present value" (Office of Management and Budget 1992, 094804, p. 3). The OMB circular Appendix C (revised December 2009) recommends the use of a real discount rate of .9% for activities lasting three years and 2.7% for the activities between 20 to 30 yr. These assumptions have been used in the calculation of the net PV for the alternatives within this CME.

Net PV was calculated according to the following formula:

$$PV_{total} = \sum_{t=1}^{t=n} \frac{1}{(1+i)^t} \cdot C_t$$

Equation G-2.3-1

Where PV_{total} = present single sum of money

t = specific year
n = final project year
i = the discounted interest rate
C_t = cost in year *t* in base year dollars

The discount factor, the $1/(1 + i)^t$ term from the PV equation, has been calculated for the interest rates listed above. The PV analyses are presented in the cost estimate tables in Section 8.

G-2.4 General Assumptions

The estimate is based on an 8-h work day and 5-d work week. No overtime is included. On-site activities will be conducted under Hazardous Waste Operations and Emergency Response (HAZWOPER) requirements. Safety levels are based on the Occupational Safety and Health Administration regulations in 29 Code of Federal Regulations Part 1910. Most activities are set to safety level D.

All appropriate site-related plans (e.g., general safety plan, quality assurance plan, waste management plan, work plan, hoisting and rigging plan, and health and safety plan) will be prepared and submitted by the subcontractor. All plans will be reviewed and approved by the Laboratory as necessary so as not to adversely impact the project schedule.

Attachment G-1 is the detailed cost assembly report for the estimates described below. All technologies except no action will include institutional controls (site control, fencing, signage, guards and access control, reports) and monitoring and maintenance. Monitoring and maintenance for pits and shafts includes the following: maintenance of the cover, maintenance of fencing and other controls. Moisture monitoring will only occur for the vegetative and evapotranspiration (ET) cover. Pore-gas monitoring will occur for all vadose zone technologies.

G-3.0 TECHNOLOGIES FOR PITS AND SHAFTS

Seven corrective measures technologies, plus the no action technology, are included below for the pits and shafts (PS).

G-3.1 Technology PS-1: No Action

For this technology, the site is walked away from as-is. There is no cost.

G-3.2 Technology PS-3a: Vegetative Cover

This technology includes the following tasks:

- Regrading of the existing soil surface and installation of a vegetative cover over the mesa top at Area G
- Site surveillance and monitoring and maintenance of the cover
- Institutional controls for 100 yr

G-3.2.1 Assumptions

The following assumptions were used to develop the cost estimate for this technology:

- Area to be covered by the vegetative cover is 51 acres and is shown in Figure 7.3-1.
- Approximately 10,250 ft of fencing to be installed around the site.
- Construction of a vegetative cover consisting of 1 ft of fill (82,280 yd^3) and 6 in. of topsoil (41,140 yd^3), native vegetation, and a moisture-monitoring system.
- Edge slopes covering 56,564 yd^2 as shown in Figure 7.3-1 and consisting of 2-ft-deep class C riprap rock armor (4190 yd^3).
- Construction of a vegetative cover consisting of 1 ft of crushed tuff from TA-61 (a 23-mi round trip) and 6 in. of topsoil from a location within a 50-mi radius (100-mi roundtrip), native vegetation; riprap armored slopes, and a moisture monitoring system. Assuming a 15-yd^3 truck capacity, delivery of materials to TA-54 would result in 496,955 truck miles.
- A gravel access road is included in the estimate to facilitate O&M on the site.
- It will take up to 24 mo to complete readiness reviews and construction of the cover, and the cover will be irrigated for 1 yr to establish vegetation.
- Moisture monitoring will occur for 30 yr.
- Cover maintenance, including visual inspection, removal of debris and large woody plants, and erosion control for a period of 30 yr.

- Periodic revegetation of bare areas and mowing of the entire site every 5 yr for 30 yr.
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G-3.3 Technology PS-3b: ET Cover

This technology includes the following tasks:

- Regrading of the existing soil surface and installation of an ET cover over the mesa top at Area G
- Site surveillance and monitoring and maintenance of the cover
- Institutional controls for 100 yr

G-3.3.1 Assumptions

The following assumptions were used to develop the cost estimate for this technology:

- Area to be covered by the ET cover is 51 acres and is shown in Figure 7.3-1.
- Approximately 10,250 ft of fencing to be installed around the site.
- Construction of the ET cover consisting of 1.5-ft.-thick vegetated topsoil-gravel admixture (123,420 yd^3) at the surface and below that is a 3.5-ft-thick infiltration layer composed of crushed tuff mixed with soil and amendments (287,980 yd^3) to provide water storage and minimize infiltration.
- Edge slopes covering 56,564 yd^2 as shown in Figure 7.3-1 and consisting of 2-ft-deep class C riprap rock armor (4190 yd^3).
- Construction of an ET cover consisting of 3.5 ft of crushed tuff from TA-61 (23-mi roundtrip), 1.5 ft of gravel admixture and vegetated topsoil from a location within a 50-mi radius (100-mi roundtrip), and moisture-monitoring equipment, Assuming a 15 yd^3 truck capacity, delivery of materials to TA-54 would result in 1,292,277 truck miles; A gravel access road is included in the estimate to facilitate O&M on the site.
- It will take up to 24 mo to complete readiness reviews and construction. The cover will be irrigated for 1 yr to establish vegetation.
- Cover maintenance, including visual inspection, removal of debris and large woody plants, and erosion control for a period of 30 yr.
- Moisture monitoring will occur for 30 yr.
- Periodic revegetation of bare areas and mowing of the entire site every 5 yr.
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G 3.4 Technology PS-4a: Excavation of Pits and Shafts with On-Site Disposal in a Corrective Action Management Unit/Resource Conservation and Recovery Act Landfill

This technology includes the following:

- Excavation, analysis and segregation of the waste in the pits and shafts regulated by the Consent Order (Figure G-3.4-1) using standard excavation methods (Figures G-3.4-2 and G-3.4-3).

- Construction of three excavation enclosures with supplied air and high-efficiency particulate air (HEPA) filters to control releases and for weather protection
- Construction of an on-site waste analysis, segregation, and treatment facility
- Construction, operation and closure of Corrective Action Management Unit (CAMU)/Resource Conservation and Recovery Act (RCRA) disposal facility
- Installation of an ET cover over the disposal facility
- Site surveillance and monitoring and maintenance of the cover
- Institutional controls for 100 yr

G-3.4.1 Assumptions

The assumptions for this technology are as follows:

- Excavation of both pits and shafts using standard excavation equipment.
- Excavation is assumed to be performed under an enclosure (three total for estimating purposes) to maintain control of airborne particulate, avoid stormwater infiltration, and reduce downtime because of the weather.
- An on-site waste analysis, segregation, size-reduction, and treatment facility will be constructed under the following assumptions for cost estimating purposes.
- Designed for multiple process lines depending on waste types and disposal packaging requirements.
- Facility cost estimates are scaled based on capital costs for the Hanford Site Environmental Restoration Disposal Facility (ERDF).
- Total capital costs for ERDF are estimated to be approximately $6B and assume a waste production rate of approximately 3000 yd^3/day. Assuming MDA G waste analysis, segregation, size-reduction, and treatment facilities will process approximately 902,815 yd^3 (waste) / 30 yr * 250 work days/yr = 120 yd^3/d. This is approximately 4% of the throughput needed for ERDF. Using this value, the facility capital cost is estimated to be $6B * 4% = $240M.
- Excavation, segregation, analysis, treatment, and disposal activities will be complete within a 30-yr period based on the assumption of a productivity of 1,654,535 yd^3 (total volume) / 30 yr * 250 work days/yr = 220 yd^3/d being excavated and processed. Based on activities at MDA B and North Ancho, 220 yd is a reasonable estimate for a feasible productivity rate at this site.
- Backfilling the excavation will require clean fill to be imported from TA-61 to complete filling the excavation. At 23-mi roundtrip with a 15-yd^3 truck capacity, truck miles are 1,384,316.
- On-site treatment for mixed low-level waste (MLLW) includes both thermal desorption and macroencapsulation.
- Assume 85% of the MLLW will need on-site treatment, and the remaining 15% will already be in an immobile state not requiring thermal desorption or macroencapsulation.
- Three 600-ft long access roads will be required to access the shaft excavations.
- Approximately 10,250 ft of fencing to be installed around the site.

The following are estimated quantities for the purposes of cost estimating. Detailed estimates of waste and excavation quantity associated with each group are presented in Tables G-3.4-1 and G-3.4-2.

Transporting the transuranic (TRU), polychlorinated biphenyl (PCB), and RCRA waste to Clive, UT (1450-mi roundtrip) and a 15-yd^3 truck capacity would result in 5,351,273 truck miles. Transporting the MLLW to the onsite CAMU/RCRA landfill (20-mi roundtrip) would result in 1,130,033 truck miles.

Pits:

- Total excavated volume – 1,491,253 yd^3
- Total waste volume in pits – 898,924 yd^3
    - ❖ Total TRU – 54,536 yd^3
    - ❖ Total MLLW – 844,388 yd^3
    - ❖ MLLW requiring on-site treatment (85%) – 717,730 yd^3
    - ❖ MLLW not requiring treatment (15%) – 126,658 yd^3
- Material suitable for backfill – 592,329 yd^3

Shafts:

- Total excavated volume – 163,282 yd^3
- Total waste volume in shafts – 3891 yd^3
    - ❖ PCBs requiring off-site disposal – 754 yd^3
    - ❖ Total RCRA – 68 yd^3
    - ❖ Total MLLW – 3069 yd^3
- MLLW requiring on-site treatment (85%) – 2,609 yd^3
- MLLW not requiring treatment (15%) – 460 yd^3
- Material suitable for backfill – 159,391 yd^3

Total:

- Total excavated volume – 1,654,535 yd^3
- Total waste volume in pits and shafts – 902,815 yd^3
    - ❖ Total TRU – 54,536 yd^3
    - ❖ PCBs requiring off-site disposal – 754 yd^3
    - ❖ Total RCRA – 68 yd^3
    - ❖ Total MLLW – 847,457 yd^3

      MLLW requiring on-site treatment (85%) – 720,339 yd^3

      MLLW not requiring treatment (15%) – 127,118 yd^3
- Material suitable for backfill – 751,720 yd^3.
- A CAMU or RCRA landfill will be constructed to a depth of 12 ft. With the needed capacity of 847,457 yd^3 of MLLW, the landfill is assumed to be 43 acres in area for estimating purposes. The facility is assumed to be constructed at TA-54.

- The construction cost estimate for the CAMU or RCRA landfill are based on constructions cost data obtained from Washington Closure Hanford River Corridor Landfill Expansion Project. The average cost was $1,100,000.00 per acre.
- Operations costs of the CAMU or RCRA landfill are based on the needed disposal volumes. The assumption was made that 847,457 yd^3 will be disposed of over 30 yr for a yearly disposal volume of 28,248 yd^3/yr. At an operational cost of $2800/$yd^3$ the yearly operational cost of the facility is assumed to be $79M/yr for cost estimating purposes.
- The CAMU or RCRA landfill cover was assumed to be closed using the previously discussed ET cover encompassing the total 51 acres.
- Construction of the ET cover consisting of 1.5-ft.-thick vegetated topsoil-gravel admixture (123,420 yd^3) at the surface and below that is a 3.5-ft-thick infiltration layer composed of crushed tuff mixed with soil and amendments (287,980 yd^3) to provide water storage and minimize infiltration.
- Edge slopes covering 56,564 yd^2 as shown in Figure 7.3-1 and consisting of 2-ft-deep class C riprap rock armor (4190 yd^3).
- Assuming a 5-ft ET cover constructed over the CAMU or RCRA landfill will require the delivery of crushed tuff from TA-61 (23-mi roundtrip) and topsoil from a location within a 50-mi radius (100-mi roundtrip). Assuming a 15 yd^3-truck capacity for fill, delivery of materials to TA-54 would result in 862,701 truck miles to construct the CAMU or RCRA landfill and fill the MDA G excavated area. Total truck miles for this technology are 8,728,324 mi.
- A gravel access road is included in the estimate to facilitate O&M on the site.
- It will take up to 24 mo to complete readiness reviews and construction. The cover will be irrigated for 1 yr to establish vegetation.
- Cover maintenance, including visual inspection, removal of debris and large woody plants, and erosion control for a period of 30 yr.
- Moisture monitoring will occur for 30 yr.
- Periodic revegetation of bare areas included and mowing of the entire site every 5 yr.
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G 3.5 Technology PS-4B: Excavation of Pits and Shafts with Off-Site Disposal

This technology includes the following tasks:

- Excavation, analysis and segregation of the waste in the pits and shafts regulated by the Consent Order (Figure G-3.4-1) using standard excavation methods(Figures G-3.4-2 and G-3.4-3)
- Construction of three excavation enclosures with supplied air and HEPA filters to control releases and for weather protection
- Construction of an on-site waste analysis, and segregation facility
- Off-site treatment and disposal of wastes
- Site surveillance, monitoring and maintenance of the site
- Institutional controls for 100 yr

G-3.5.1 Assumptions

The following assumptions were used to develop the cost estimate for this technology:

- Excavation of both pits and shafts using standard excavation equipment.
- Excavation is assumed to be performed under an enclosure (three total for estimating purposes) to maintain control of airborne particulate, avoid stormwater infiltration, and reduce downtime because of the weather.
- Excavation, segregation, analysis, treatment and disposal activities will be complete within a 30-yr period based on the assumption of a productivity of 1,654,535 yd^3 (total volume) / 30 yr * 250 work days/yr = 220 yd^3/d being excavated and processed. Based on activities at MDA B and North Ancho, 220 yd is a reasonable estimate for a feasible productivity rate at this site.
- Backfilling the excavation will require clean fill to be imported from TA-61 to complete filling the excavation. At 23-mi roundtrip with a 15-yd^3 truck capacity, truck miles are 1,384,316.
- Three 600-ft-long access roads will be required to access the shaft excavations.
- Approximately 10250 ft of fencing to be installed around the site.
- The following are estimated quantities for the purposes of cost estimating. Detailed estimates of waste and excavation quantity associated with each group are presented in Tables G-3.4-1 and G-3.4-2.
- Transporting the TRU, RCRA, and MLLW to Clive, UT (1450-mi roundtrip) and assuming 15-yd^3 truck capacity would result in 87,272,116 truck miles. Total truck miles for this technology are 88,656,433 mi.

Pits:

- Total excavated volume – 1,491,253 yd^3
- Total waste volume in pits – 898,924 yd^3
    - Total TRU – 54,536 yd^3
    - Total MLLW requiring off-site disposal – 844,388 yd^3
- Material suitable for backfill – 592,329 yd^3

Shafts:

- Total excavated volume – 163,282 yd^3
- Total waste volume in shafts – 3,891 yd^3
    - PCBs requiring off-site disposal – 754 yd^3
    - Total RCRA requiring off-site disposal – 68 yd^3
    - Total MLLW requiring off-site disposal – 3069 yd^3
- Material suitable for backfill – 159,391 yd^3

Total:

- Total excavated volume – 1,654,535 yd^3
- Total waste volume in pits and shafts – 902,815 yd^3
    - Total TRU – 54,536 yd^3
    - PCBs requiring off-site disposal – 754 yd^3
    - Total RCRA requiring off-site disposal – 68 yd^3
    - Total MLLW requiring off-site disposal – 847,457 yd^3
- Material suitable for backfill – 751,720 yd^3
- All waste is assumed to be treated and disposed of off-site.
- The excavated area will be graded and seeded.
- A gravel access road is included in the estimate to facilitate O&M on the site.
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G 3.6 Technology PS-4C: Excavation of Pits and Over-Coring Retrieval of Shafts with On-Site Disposal in a CAMU/RCRA Landfill

This technology includes the following tasks:

- Excavation, analysis and segregation of the waste in the pits and shafts that are regulated by the Consent Order (Figure G-3.4-1) using standard excavation methods for the pits (Figure G-3.4-2) and over-coring of the shafts
- Construction of three excavation enclosures with supplied air and HEPA filters to control releases and for weather protection
- Construction of an on-site waste analysis, segregation, and treatment facility
- Construction, operation, and closure of CAMU/RCRA disposal facility
- Installation of an ET cover over the disposal facility
- Site surveillance and monitoring and maintenance of the cover
- Institutional controls for 100 yr

G-3.6.1 Assumptions

The assumptions for this technology are as follows:

- Excavation of pits and shafts using standard excavation equipment for the pits and over-coring equipment for the shafts.
- Excavation is assumed to be performed under an enclosure (three total for estimating purposes) to maintain control of airborne particulate, avoid stormwater infiltration, and reduce downtime because of the weather.
- An on-site waste analysis, segregation, size-reduction, and treatment facility will be constructed under the following assumptions for cost estimating purposes.

- Designed for multiple process lines depending on waste types and disposal packaging requirements.
- Facility cost estimates are scaled based on capital costs for the Hanford Site ERDF.
- Total capital costs for ERDF are estimated to be approximately $6B and assume a waste production rate of approximately 3000 yd^3/day. Assuming MDA G waste analysis, segregation, size-reduction, and treatment facilities will process approximately 902,815 yd^3 (waste)/30 yr * 250 work d/yr = 120 yd^3/d. This is approximately 4% of the throughput needed for ERDF. Using this value, the facility capital cost is estimated to be $6B * 4% = $240M.
- Excavation, segregation, analysis, treatment and disposal activities will be complete within a 30 yr period based on the assumption of a productivity of 1,654,535 yd^3 (total volume) / 30 yr * 250 work d/yr = 220 yd^3/d being excavated and processed. Based on activities at MDA B and North Ancho, 220 yd is a reasonable estimate for a feasible productivity rate at this site.
- Backfilling the excavation will require clean fill to be imported from TA-61 to complete filling the excavation. At 23-mi roundtrip with a 15-yd^3 truck capacity, truck miles are 1,384,316.
- On-site treatment for MLLW includes both thermal desorption and macroencapsulation.
- 85% of the MLLW is assumed to need on-site treatment and the remaining 15% is assumed to already be in an immobile state not requiring thermal desorption or macroencapsulation.
- 10,250 ft of fencing around the site.
- The following are estimated quantities for the purposes of cost estimating. Detailed estimates of waste and excavation quantity associated with each group are presented in table G.3.4-1 and G-3.6-1.
- Transporting the TRU, PCBs, and RCRA waste to Clive, UT (1450-mi roundtrip) and a 15-yd^3 truck capacity would result in 5,351,273 truck miles. Transporting the MLLW to the on-site CAMU/RCRA Landfill (20-mi roundtrip) would result in 1,130,033 truck miles.

Pits:

- Total excavated volume – 1,491,253 yd^3
- Total waste volume in pits – 898,924 yd^3
  - ❖ Total TRU – 54,536 yd^3
  - ❖ Total MLLW – 844,388 yd^3

    MLLW requiring on-site treatment (85%) – 717,730 yd^3

    MLLW not requiring treatment (15%) – 126,658 yd^3
- Material suitable for backfill – 592,329 yd^3

Shafts:

- Total retrieved volume – 3891 yd^3
- Total waste volume in shafts – 3891 yd^3
  - ❖ PCBs requiring off-site disposal – 754 yd^3
  - ❖ Total RCRA – 68 yd^3

- Total MLLW – 3069 yd^3

  MLLW requiring on-site treatment (85%) – 2609 yd^3

  MLLW not requiring treatment (15%) – 460 yd^3

- Material suitable for backfill – 0 yd^3

Total:

- Total excavated and retrieved volume – 1,495,144 yd^3
- Total waste volume in pits and shafts – 902,815 yd^3
  - Total TRU – 54,536 yd^3
  - PCBs requiring off-site disposal – 754 yd^3
  - Total RCRA – 68 yd^3
  - Total MLLW – 847,457 yd^3

    MLLW requiring on-site treatment (85%) – 720,339 yd^3

    MLLW not requiring treatment (15%) – 127,118 yd^3
- Material suitable for backfill – 592,329 yd^3
- A CAMU or RCRA landfill will be constructed to a depth of 12 ft. With the needed capacity of 847,457 yd^3 of MLLW the landfill will be assumed to be 43 acres in area for estimating purposes. The facility is assumed to be constructed at TA-54.
- The construction cost estimate for the CAMU or RCRA landfill are based on constructions cost data obtained from Washington Closure Hanford River Corridor Landfill Expansion Project. The average cost was $1,100,000.00 per acre.
- Operations costs of the CAMU or RCRA landfill are based on the needed disposal volumes. The assumption was made that 847,457 yd^3 will be disposed of over 30 yr for a yearly disposal volume of 28,248 yd^3/yr. At an operational cost of $2800/ yd^3 the yearly operational cost of the facility is assumed to be $79M/yr for cost estimating purposes.
- The CAMU or RCRA landfill cover was assumed to be closed using the previously discussed ET cover encompassing the total 51 acres.
- Construction of the ET cover consisting of 1.5-ft.-thick vegetated topsoil-gravel admixture (123,420 yd^3) at the surface and below that is a 3.5-ft-thick infiltration layer composed of crushed tuff mixed with soil and amendments (287,980 yd^3) to provide water storage and minimize infiltration.
- Edge slopes covering 56,564 yd^2 as shown in Figure 7.3-1 and consisting of 2 ft deep class C riprap rock armor (4190 yd^3).
- Assuming a 5 ft ET cover would be constructed over the CAMU or RCRA landfill will require the delivery of crushed tuff from TA-61 (23-mi roundtrip) and topsoil from a location within a 50-mi radius (100-mi roundtrip). Assuming a 15-yd^3 truck capacity for fill, delivery of materials to TA-54 would result in 862,701 truck miles to construct the CAMU or RCRA landfill and fill the MDA G excavated area. Total truck miles for this technology are 8,728,324 mi.
- A gravel access road is included in the estimate to facilitate O&M on the site.

- It will take up to 24 mo to complete readiness reviews and construction. The cover will be irrigated for 1 yr to establish vegetation.
- Cover maintenance, including visual inspection, removal of debris and large woody plants, and erosion control for a period of 30 yr.
- Moisture monitoring will occur for 30 yr.
- Periodic revegetation of bare areas included and mowing of the entire site every 5 yr.
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G 3.7 Technology PS-4d: Excavation of Pits and Over-Coring Retrieval of Shafts with Off-Site Disposal

This technology includes the following tasks:

- Excavation, analysis and segregation of the waste in the pits and shafts that are regulated by the Consent Order (Figure G-3.4-1) using standard excavation methods for the pits (Figure G-3.4-2) and over-coring of the shafts
- Construction of three excavation enclosures with supplied air and HEPA filters to control releases and for weather protection
- Construction of an on-site waste analysis and segregation facility
- Site surveillance and monitoring and maintenance of the cover
- Institutional controls for 100 yr

G-3.7.1 Assumptions

The assumptions for this technology are as follows:

- Excavation of pits and shafts using standard excavation equipment for the pits and over-coring equipment for the shafts.
- Excavation is assumed to be performed under an enclosure (three total for estimating purposes) to maintain control of airborne particulate, avoid stormwater infiltration, and reduce downtime due to weather.
- Excavation, segregation, analysis, treatment and disposal activities will be complete within a 30 yr period based on the assumption of a productivity of 1,654,535 yd^3 (total volume) / 30 yr * 250 work d/yr = 220 yd^3/d being excavated and processed. Based on activities at MDA-B and North Ancho, 220 yd is a reasonable estimate for a feasible productivity rate at this site.
- Backfilling the excavation will require clean fill to be imported from TA-61 to complete filling the excavation. At 23-mi roundtrip with a 15-yd^3 truck capacity, truck miles are 1,384,316.
- Approximately 10,250 ft of fencing to be installed around the site.
- The following are estimated quantities for the purposes of cost estimating. Detailed estimates of waste and excavation quantity associated with each group are presented in Tables G-3.4-1 and G-3.6-1.

- Transporting the TRU, RCRA, and MLLW to Clive, UT (1450-mi roundtrip) and assuming 15-yd^3 truck capacity would result in 87,272,116 truck miles. Total truck miles for this technology are 88,656,433 mi.

Pits:

- Total excavated volume – 1,491,253 yd^3
- Total waste volume in pits – 898,924 yd^3
  - ❖ Total TRU – 54,536 yd^3
  - ❖ Total MLLW requiring off-site disposal – 844,388 yd^3
- Material suitable for backfill – 592,329 yd^3

Shafts:

- Total retrieved volume – 3891 yd^3
- Total waste volume in shafts – 3891 yd^3
  - ❖ PCBs requiring off-site disposal – 754 yd^3
  - ❖ Total RCRA requiring off-site disposal – 68 yd^3
  - ❖ Total MLLW requiring off-site disposal – 3069 yd^3
- Material suitable for backfill – 0 yd^3

Total:

- Total excavated and retrieved volume – 1,495,144 yd^3
- Total waste volume in pits and shafts – 902,815 yd^3
  - ❖ Total TRU – 54,536 yd^3
  - ❖ PCBs requiring off-site disposal – 754 yd^3
  - ❖ Total RCRA requiring off-site disposal – 68 yd^3
  - ❖ Total MLLW requiring off-site disposal – 847,457 yd^3
- Material suitable for backfill – 592,329 yd^3
- All waste is assumed to be treated and disposed of off-site.
- The excavated area will be regarded and seeded.
- A gravel access road is included in the estimate to facilitate O&M on the site.
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G-3.8 Technology PS-5: Ex-Situ Treatment

This technology includes the following tasks:

- Excavation, analysis and segregation of the waste in the pits and shafts regulated by the Consent Order using standard excavation methods
- Construction of three excavation enclosures with supplied air and HEPA filters to control releases and for weather protection
- Construction of an on-site waste analysis, segregation, and treatment facility
- Institutional controls for 100 yr

G-3.8.1 Assumptions

The assumptions for this technology are as follows:

- Excavation of both pits and shafts using standard excavation equipment.
- Excavation is assumed to be performed under an enclosure (three total for estimating purposes) to maintain control of airborne particulate, avoid stormwater infiltration, and reduce downtime due to weather.
- An on-site waste analysis, segregation, size-reduction, and treatment facility will be constructed under the following assumptions for cost estimating purposes.
- Designed for multiple process lines depending on waste types and disposal packaging requirements.
- Facility cost estimates are scaled based on capital costs for the Hanford Site ERDF.
- Total capital costs for ERDF are estimated to be approximately $6B and assume a waste production rate of approximately 3000 yd^3/d. Assuming MDA G waste analysis, segregation, size-reduction, and treatment facilities will process approximately 902,815 yd^3 (waste)/30 yr * 250 work days/yr = 120 yd^3/d. This is approximately 4% of the throughput needed for ERDF. Using this value, the facility capital cost is estimated to be $6B * 4% = $240M.
- Excavation, segregation, analysis, treatment, and disposal activities will be complete within a 30-yr period based on the assumption of a productivity of 1,654,535 yd^3 (total volume) / 30 yr * 250 work days/yr = 220 yd^3/d being excavated and processed. Based on activities at MDA B and North Ancho, 220 yd is a reasonable estimate for a feasible productivity rate at this site.
- Backfill will come from TA-61, a 23-mi roundtrip.
- Onsite treatment for MLLW includes both thermal desorption and secondary treatment chosen during the CMI to meet standards.
- 85% of the MLLW is assumed to need on-site treatment and the remaining 15% is assumed to be shipped off-site. Of the 85% of the MLLW receiving treatment 55% will be cleaned to meet necessary standard to be returned to the excavation at MDA G, and the remaining 30% will be shipped off-site as industrial waste.
- Three 600-ft-long access roads will be required to access the shaft excavations.
- Approximately 10,250 ft of fencing to be installed around the site.

- The following are estimated quantities for the purposes of cost estimating. Detailed estimates of waste and excavation quantity associated with each group are presented in Tables G-3.4-1 and G-3.4-2.

Pits:

- Total excavated volume – 1,491,253 yd^3
- Total waste volume in pits – 898,924 yd^3
  - ❖ Total TRU – 54,536 yd^3
  - ❖ Total MLLW – 844,388 yd^3

    MLLW requiring on-site treatment (85%) – 717,730 yd^3

    MLLW not requiring treatment (15%) – 126,658 yd^3
- Material suitable for backfill – 592,329 yd^3

Shafts:

- Total excavated volume – 163,282 yd^3
- Total waste volume in shafts – 3891 yd^3
  - ❖ PCBs requiring off-site disposal – 754 yd^3
  - ❖ Total RCRA – 68 yd^3
  - ❖ Total MLLW – 3,069 yd^3

    MLLW requiring on-site treatment (85%) – 2609 yd^3

    MLLW not requiring treatment (15%) – 460 yd^3
- Material suitable for backfill – 159,391 yd^3

Total:

- Total excavated volume – 1,654,535 yd^3
- Total waste volume in pits and shafts – 902,815 yd^3
  - ❖ Total TRU – 54,536 yd^3
  - ❖ PCBs requiring off-site disposal – 754 yd^3
  - ❖ Total RCRA – 68 yd^3
  - ❖ Total MLLW – 847,457 yd^3

    MLLW requiring on-site treatment (85%) – 720,339 yd^3

    MLLW not requiring treatment (15%) – 127,118 yd^3
- Material suitable for backfill – 751,720 yd^3
- Operations costs of the segregation, analysis, and treatment facility are based on the need for eight staff members working the facility. This cost is estimated to be $3,640,000/yr.

- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G-4.0 TECHNOLOGIES FOR THE VADOSE ZONE

Three corrective measures technologies plus the no action technology are included below for the vadose zone (VZ).

G-4.1 Technology VZ-1 – No Action

For this technology, the site is walked away from as-is. There is no cost.

G-4.2 Technology VZ-2a – Monitored Natural Attenuation

- This technology includes the following tasks:
- Pore-gas monitoring for 30 yr
- Institutional controls for 100 yr

G-4.2.1 Assumptions

- Approximately 10,250 ft of fencing to be installed around the site.
- Abandonment of eight existing Flexible Liner Underground Technology (FLUTe) monitoring wells.
- Construction of eight new stainless-steel monitoring wells.
- Pore-gas monitoring of 20 boreholes with a total of 40 samples monitored twice per year (80 samples) for the first 3 yr, and one time a year (40 samples) for the remaining 27 yr.
- Laboratory analytical costs double from current TO-15 costs to account for the increase in analytical needed to meet the requirement of monitoring natural attenuation.
- All drill cuttings are assumed to be disposed of as low-level waste (LLW).
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.

G-4.3 Technology VZ-2b – Soil-Gas Venting

This technology includes the following tasks:

- Completion of soil-gas venting boreholes to remove volatile organic compounds (VOCs) from the waste in the vadose zone
- Pore-gas monitoring for 30 yr
- Institutional controls for 100 yr

G-4.3.1 Assumptions

- Approximately 10,250 ft of fencing to be installed around the site.
- Installation of 433 venting boreholes (assumes 10-m radius of influence [ROI] with 20% overlap):
  - ❖ Western trichlorethene (TCE)/1,1,1-trichloroethane (TCA) plume – 12.6 acres, 203 boreholes
  - ❖ Eastern TCE plume – 9.1 acres, 147 boreholes
  - ❖ Eastern TCA plume – 4.2 acres, 68 boreholes
  - ❖ Southeastern TCE plume – 0.9 acres, 15 boreholes
- Each borehole – 71/8-in.-outside diameter (O.D.) x 150 ft (assume hollow-stem auger [HSA] installation), 14-in. O.D. to 50 ft below ground surface (bgs); 10-in. casing from 0 to 50 ft bgs.
- VOC monitoring of extraction boreholes, including two monitoring events for each extraction borehole first 3 yr; 1 event per year for subsequent 27 yr.
- Abandonment of eight existing FLUTe monitoring wells.
- Construction of eight new stainless-steel monitoring wells.
- Pore-gas monitoring of 20 boreholes with a total of 40 samples monitored twice per year (80 samples) for the first 3 yr, and one time a year (40 samples) for the remaining 27 yr.
- All drill cuttings are assumed to be disposed of as LLW.
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G-4.4 Technology VZ-2c – Soil-Vapor Extraction

This technology includes the following tasks:

- SVE to remove VOCs from the waste in the vadose zone
- Pore-gas monitoring for 30 yr
- Institutional controls for 100 yr

G-4.4.1 Assumptions

- Approximately 10,250 ft of fencing to be installed around the site.
- Installation of 20 active extraction boreholes:
  - ❖ Western TCE/TCA plume – 12.6 acres, nine extraction boreholes
  - ❖ Eastern TCE plume – 9.1 acres, seven extraction boreholes
  - ❖ Eastern TCA plume – 4.2 acres, three extraction boreholes
  - ❖ Southeastern TCE plume – 0.9 acres, one extraction boreholes
- Each extraction borehole – 71/8-in.–O.D. x 150 ft (assume HSA installation), 14-in.-O.D. to 50 ft bgs; 10-in. casing 0 to 50 ft bgs.
- Four SVE units: 16 horse power (hp), 12 hp, 5 hp, and 2 hp.

- Active SVE for 180 d/yr (one unit per plume area – 4 units, each running 180 d/yr) for 3 yr.
- 58, 400-lb granular activated carbon drums for each 180 d of operation (total for all four SVE units)
- VOC monitoring of extraction boreholes including 2 monitoring events for each extraction borehole first 3 yr; 1 event per year for subsequent 27 yr.
- Abandonment of eight existing FLUTe monitoring wells.
- Construction of eight new stainless-steel monitoring wells.
- Pore-gas monitoring of 20 boreholes with a total of 40 samples monitored twice per year (80 samples) for the first 3 yr, and one time a year (40 samples) for the remaining 27 yr.
- All drill cuttings are assumed to be disposed of as LLW.
- Indirect O&M cost for Professional Management based on 26% of direct O&M costs.
- Design costs calculated using the percentage method (16% of direct capital costs).

G-5.0 REFERENCES

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

Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

EPA (U.S. Environmental Protection Agency), July 2000. "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," EPA 540-R-00-002, prepared by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency Office of Emergency and Remedial Response, Washington, D.C. (EPA 2000, 071540)

Office of Management and Budget, October 29, 1992. "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Circular No. A-94, Washington, D.C. (Office of Management and Budget 1992, 094804)

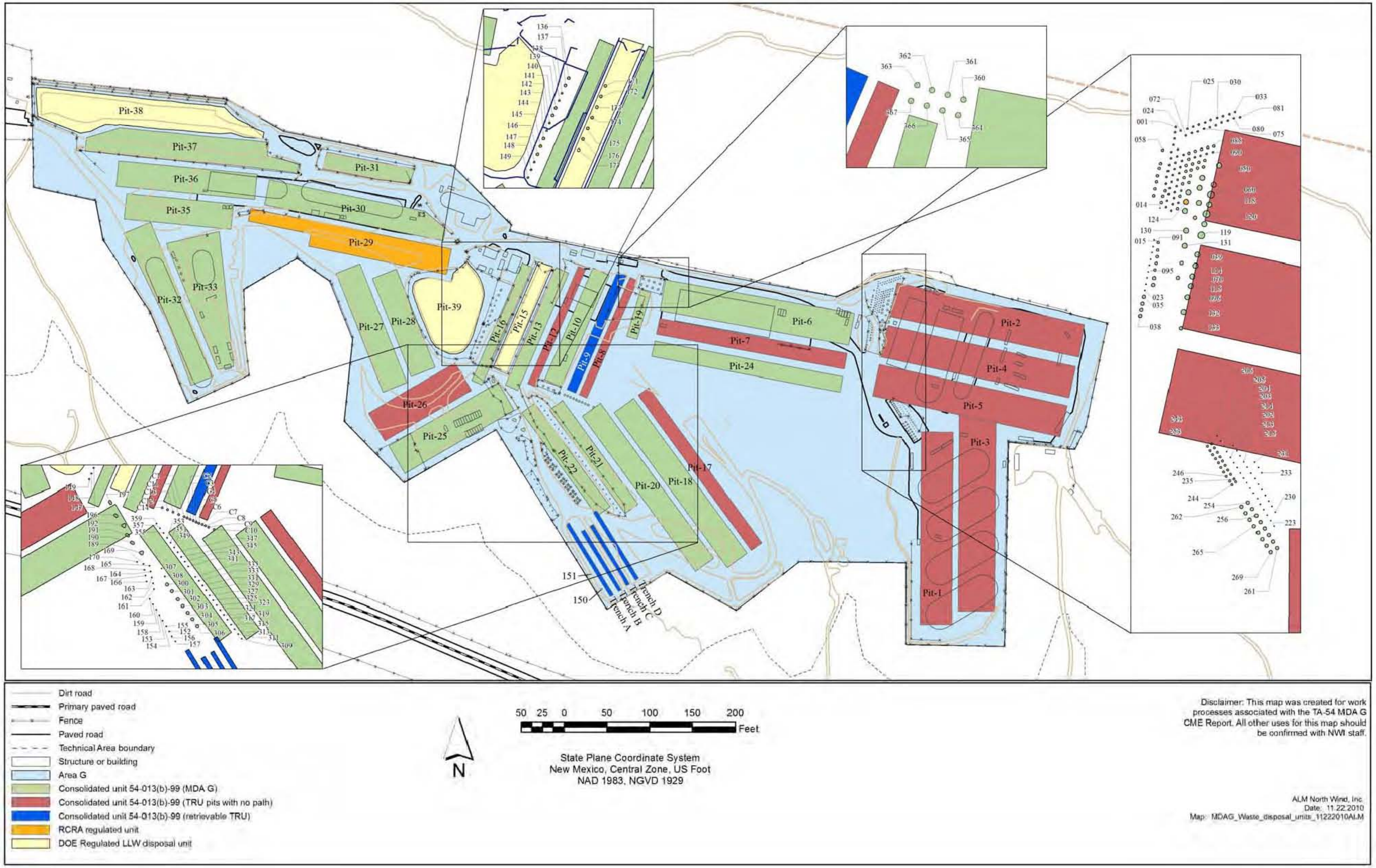

Figure G-3.4-1 Area G waste disposal units with shaft groupings

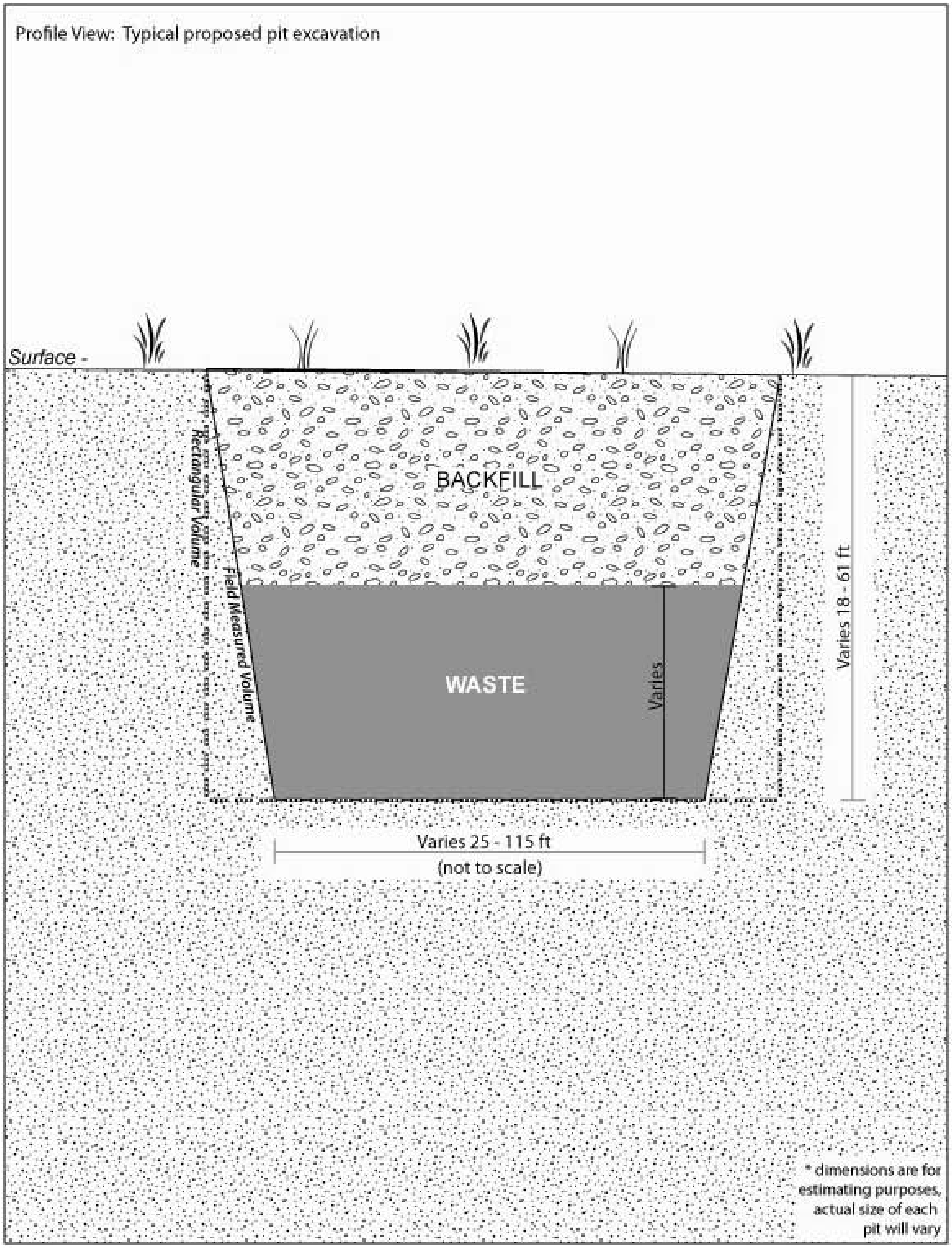

Figure G-3.4-2 Typical proposed pit excavation

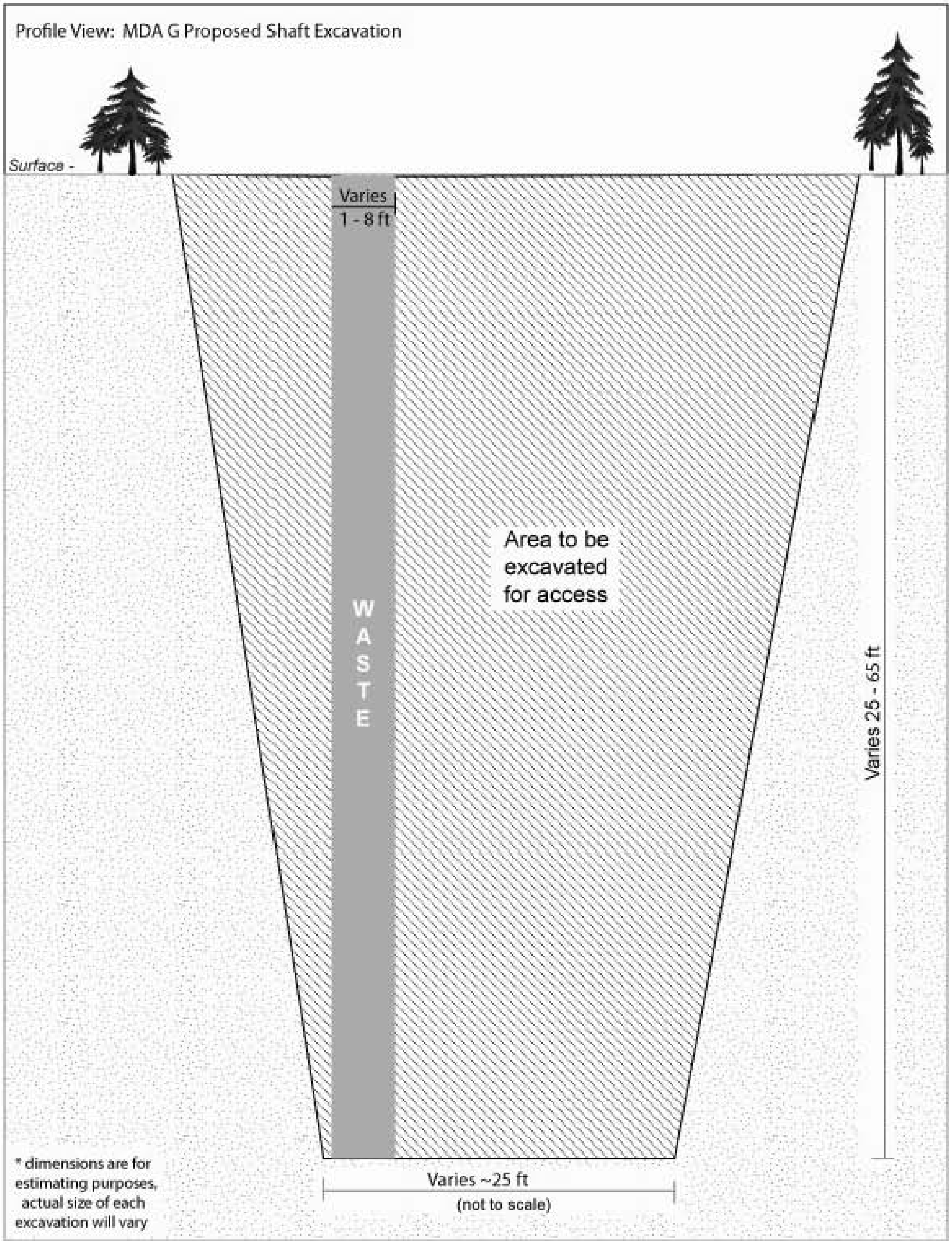

Figure G-3.4-3 MDA G proposed shaft excavation

Table G-3.4-1
Technologies PS-4a through PS-4d, Excavation of Pits

Pit No.	Dimensions (length × width × depth)	Rectangular Vol. of Pit (yd^3)	Field Measured Pit Vol. (yd^3)	Estimated Waste Volume (yd^3)	Estimated TRU Waste Volume (yd^3)[a]	Estimated MLLW Waste Volume (yd^3)	Estimated Total Waste Volume (yd^3)	Estimated Materials Suitable for Backfill (yd^3)	Estimated MLLW Suitable for On-Site Disposal with Treatment (yd^3)[b]	Estimated MLLW Suitable for On-Site Disposal without Treatment (yd^3)[c]
1	616 ft × 113 ft × 20 ft	51561	37080	5529	5529	31551	37080	14481	26818	4733
2	618 ft × 104 ft × 26 ft	61892	42911	6407	6407	36504	42911	18981	31028	5476
3	655 ft × 115 ft × 33 ft	92064	56759	9473	9473	47286	56759	35305	40193	7093
4	600 ft × 110 ft × 34 ft	83111	44950	8212	8212	36738	44950	38161	31227	5511
5	600 ft × 100 ft × 29 ft	64444	41258	6624	6624	34634	41258	23186	29439	5195
6	600 ft × 113 ft × 26 ft	65289	43933	6696		43933	43933	21356	37343	6590
7	600 ft × 50 ft × 30 ft	33333	17101	4343	4343	12758	17101	16232	10844	1914
8	400 ft × 25 ft × 25 ft	9259	6528	2311	2311	4217	6528	2731	3584	633
10	380 ft × 57 ft × 27 ft	21660	15549	4016		15549	15549	6111	13217	2332
12	400 ft × 25 ft × 25 ft	9259	7303	2363	2363	4940	7303	1956	4199	741
13	400 ft × 42 ft × 28 ft	17422	12107	1931		12107	12107	5315	10291	1816
16	400 ft × 25 ft × 25 ft	9259	8081	2235		8081	8081	1178	6869	1212
17	600 ft × 46 ft × 24 ft	24533	17399	4962	4962	12437	17399	7134	10571	1866
18	600 ft × 75 ft × 40 ft	66667	46685	12358		46685	46685	19982	39682	7003
19	153 ft × 30 ft × 18 ft	3060	1371	0		1371	1371	1689	1165	206
20	600 ft × 71 ft × 36 ft	56800	37454	14899		37454	37454	19346	31836	5618
21	402 ft × 56 ft × 26 ft	21678	13328	3607		13328	13328	8350	11329	1999
22	413 ft × 56 ft × 33 ft	28268	17690	3744		17690	17690	10578	15037	2654
24	600 ft × 58 ft × 30 ft	38667	23388	7327		23388	23388	15279	19880	3508
25	395 ft × 103 ft × 39 ft	58767	47000	6530		47000	47000	11767	39950	7050

Table G-3.4-1 (continued)

Pit No.	Dimensions (length × width × depth)	Rectangular Vol. of Pit (yd^3)	Field Measured Pit Vol. (yd^3)	Estimated Waste Volume (yd^3)	Estimated TRU Waste Volume (yd^3)[1]	Estimated MLLW Waste Volume (yd^3)	Estimated Total Waste Volume (yd^3)	Estimated Materials Suitable for Backfill (yd^3)	Estimated MLLW Suitable for On-Site Disposal with Treatment (yd^3)[2]	Estimated MLLW Suitable for On-Site Disposal without Treatment (yd^3)[3]
26	310 ft × 100 ft × 36 ft	41333	22209	4312	4312	17897	22209	19124	15212	2685
27	400 ft × 80 ft × 46 ft	54519	26946	7441		26946	26946	27573	22904	4042
28	330 ft × 83 ft × 40 ft	40578	21381	4422		21381	21381	19197	18174	3207
29	658 ft × 80 ft × 50 ft	97481	45795	9784		45795	45795	51686	38926	6869
30	568 ft × 39 ft × 35 ft	42843	28716	13464		28716	28716	14127	24409	4307
31	280 ft × 52 ft × 25 ft	13481	13481	2702		13481	13481	0	11459	2022
32	518 ft × 74 ft × 51 ft	72405	36364	5367		36364	36364	36041	30909	5455
33	425 ft × 115 ft × 40 ft	72407	59930	7776		59930	59930	12477	50941	8990
35	363 ft × 83 ft × 40 ft	44636	20957	3361		20957	20957	23679	17813	3144
36	435 ft × 83 ft × 43 ft	57501	28057	4491		28057	28057	29444	23848	4209
37	731 ft × 83 ft × 61 ft	137076	57213	24299		57213	57213	79863	48631	8582
Totals		**1491253**	**898924**	**200986**	**54536**	**844388**	**898924**	**592329**	**717730**	**126658**

Note: Blank cell indicates this waste type/material is not known to be found in the pit.

[a] Newly generated TRU equal volume of waste in pit in Table 2.1-1.

[b] 85% of estimated of MLLW waste volume

[c] 15% of estimated MLLW waste volume. MLLW that was previously stabilized.

Table G-3.4-2
Technologies PS-4a and PS-4b, Shaft Bulk Excavation

	Shaft Excavation Area (SY)	Shaft Excavation Volume (yd^3)	Diameter/ Depth (ft)	Shaft Volume (yd^3)	PCB (yd^3)[a]	RCRA (yd^3)[b]	MLLW (yd^3)[c]	Total Estimated Waste (yd^3)	Estimated Materials Suitable for Backfill (yd^3)
GROUP 1: 1-20, 22, 24-96, 99-112-, 114, 115, 118-123, 125-135									
Total	260 ft × 120 ft	75,111	—	2103	0	0	2,103	2,103	73,008
GROUP 2: 136, 138-140									
Total	100 ft × 50 ft	12,037	—	188	0	0	188	188	11,849
GROUP 3: 150,151									
Total	85 ft × 50 ft	10,231	—	79	0	0	79	79	10,153
GROUP 4: 152-160									
Total	175 ft × 45 ft	18,958	—	105	0	0	105	105	18,854
GROUP 5: 189-192, 196									
Total	175 ft × 60 ft	25,278	—	595	0	0	595	595	24,683
GROUP 6 – PCBs: C1-10, C12, C13									
Total	180 ft × 50 ft	21,667	—	754	754	0	0	754	20,913
RCRA: 124, 144, 145									
Total	**n/a**[d]		—	**68**	**0**	**68**	**0**	**68**	**0**
Grand Total	—	**163282**		**3,891**	**754**	**68**	**3,069**	**3,891**	**159,460**

Note: Blank cell indicates this waste type/material is not known to be found in the shafts
[a] Estimated PCB waste volume is equal to shaft volume as shown in Table 2.1-3.
[b] Estimated RCRA waste volume is equal to shaft volume as shown in Table 2.1-3.
[c] Estimated MLLW waste volume is equal to shaft volume as shown in Table 2.1-3.
[d] Shafts within other excavation areas.

Table G-3.6-1
Technologies PS-4c and PS-4d, Over-Coring of Shafts

Shaft No.	Diameter/ Depth (ft)	Shaft Volume (yd^3)	PCB (yd^3)[a]	RCRA (yd^3)[b]	MLLW (yd^3)[c]	Total Estimated Waste (yd^3)	Estimated Materials Suitable for Backfill (yd^3)
1	2/25	2.9	—	—	2.9	2.9	0.0
2	2/25	2.9	—	—	2.9	2.9	0.0
3	2/25	2.9	—	—	2.9	2.9	0.0
4	2/25	2.9	—	—	2.9	2.9	0.0
5	2/25	2.9	—	—	2.9	2.9	0.0
6	2/25	2.9	—	—	2.9	2.9	0.0
7	2/25	2.9	—	—	2.9	2.9	0.0
8	2/25	2.9	—	—	2.9	2.9	0.0
9	2/25	2.9	—	—	2.9	2.9	0.0
10	2/25	2.9	—	—	2.9	2.9	0.0
11	3/25	6.5	—	—	6.5	6.5	0.0
12	3/25	6.5	—	—	6.5	6.5	0.0
13	3/25	6.5	—	—	6.5	6.5	0.0
14	1/25	0.7	—	—	0.7	0.7	0.0
15	1/25	0.7	—	—	0.7	0.7	0.0
16	1/25	0.7	—	—	0.7	0.7	0.0
17	1/25	0.7	—	—	0.7	0.7	0.0
18	1/25	0.7	—	—	0.7	0.7	0.0
19	1/25	0.7	—	—	0.7	0.7	0.0
20	1/25	0.7	—	—	0.7	0.7	0.0
22	1/25	0.7	—	—	0.7	0.7	0.0
24	2/25	2.9	—	—	2.9	2.9	0.0
25	2/25	2.9	—	—	2.9	2.9	0.0
26	2/25	2.9	—	—	2.9	2.9	0.0
27	2/25	2.9	—	—	2.9	2.9	0.0
28	2/25	2.9	—	—	2.9	2.9	0.0
29	2/25	2.9	—	—	2.9	2.9	0.0
30	2/25	2.9	—	—	2.9	2.9	0.0
31	2/25	2.9	—	—	2.9	2.9	0.0
32	2/25	2.9	—	—	2.9	2.9	0.0
33	2/25	2.9	—	—	2.9	2.9	0.0
34	6/60	63.3	—	—	63.3	63.3	0.0
35	3/40	10.5	—	—	10.5	10.5	0.0
36	3/40	10.5	—	—	10.5	10.5	0.0
37	3/40	10.5	—	—	10.5	10.5	0.0
38	3/40	10.5	—	—	10.5	10.5	0.0

Table G-3.6-1 (continued)

Shaft No.	Diameter/ Depth (ft)	Shaft Volume (yd^3)	PCB (yd^3)[a]	RCRA (yd^3)[b]	MLLW (yd^3)[c]	Total Estimated Waste (yd^3)	Estimated Materials Suitable for Backfill (yd^3)
39	6/60	63.3	—	—	63.3	63.3	0.0
40	2/25	2.9	—	—	2.9	2.9	0.0
41	2/25	2.9	—	—	2.9	2.9	0.0
42	2/25	2.9	—	—	2.9	2.9	0.0
43	2/25	2.9	—	—	2.9	2.9	0.0
44	2/25	2.9	—	—	2.9	2.9	0.0
45	2/25	2.9	—	—	2.9	2.9	0.0
46	2/25	2.9	—	—	2.9	2.9	0.0
47	2/25	2.9	—	—	2.9	2.9	0.0
48	2/25	2.9	—	—	2.9	2.9	0.0
49	2/25	2.9	—	—	2.9	2.9	0.0
50	6/60	63.3	—	—	63.3	63.3	0.0
51	2/25	2.9	—	—	2.9	2.9	0.0
52	2/25	2.9	—	—	2.9	2.9	0.0
53	2/25	2.9	—	—	2.9	2.9	0.0
54	2/25	2.9	—	—	2.9	2.9	0.0
55	2/25	2.9	—	—	2.9	2.9	0.0
56	2/25	2.9	—	—	2.9	2.9	0.0
57	2/25	2.9	—	—	2.9	2.9	0.0
58	3/25	6.5	—	—	6.5	6.5	0.0
59	6/60	63.3	—	—	63.3	63.3	0.0
60	3/25	6.5	—	—	6.5	6.5	0.0
61	3/25	6.5	—	—	6.5	6.5	0.0
62	3/25	6.5	—	—	6.5	6.5	0.0
63	3/25	6.5	—	—	6.5	6.5	0.0
64	3/25	6.5	—	—	6.5	6.5	0.0
65	3/25	6.5	—	—	6.5	6.5	0.0
66	3/25	6.5	—	—	6.5	6.5	0.0
67	2/25	2.9	—	—	2.9	2.9	0.0
68	2/25	2.9	—	—	2.9	2.9	0.0
69	2/25	2.9	—	—	2.9	2.9	0.0
70	6/60	63.3	—	—	63.3	63.3	0.0
71	2/25	2.9	—	—	2.9	2.9	0.0
72	2/25	2.9	—	—	2.9	2.9	0.0
73	2/25	2.9	—	—	2.9	2.9	0.0
74	2/25	2.9	—	—	2.9	2.9	0.0
75	2/25	2.9	—	—	2.9	2.9	0.0

Table G-3.6-1 (continued)

Shaft No.	Diameter/ Depth (ft)	Shaft Volume (yd^3)	PCB (yd^3)[a]	RCRA (yd^3)[b]	MLLW (yd^3)[c]	Total Estimated Waste (yd^3)	Estimated Materials Suitable for Backfill (yd^3)
76	2/25	2.9	—	—	2.9	2.9	0.0
77	2/25	2.9	—	—	2.9	2.9	0.0
78	2/25	2.9	—	—	2.9	2.9	0.0
79	2/25	2.9	—	—	2.9	2.9	0.0
80	2/25	2.9	—	—	2.9	2.9	0.0
81	2/25	2.9	—	—	2.9	2.9	0.0
82	3/25	6.5	—	—	6.5	6.5	0.0
83	3/25	6.5	—	—	6.5	6.5	0.0
84	3/25	6.5	—	—	6.5	6.5	0.0
85	3/25	6.5	—	—	6.5	6.5	0.0
86	3/25	6.5	—	—	6.5	6.5	0.0
87	2/25	2.9	—	—	2.9	2.9	0.0
88	2/25	2.9	—	—	2.9	2.9	0.0
89	2/25	2.9	—	—	2.9	2.9	0.0
90	2/25	2.9	—	—	2.9	2.9	0.0
91	3/50	13.1	—	—	13.1	13.1	0.0
92	3/50	13.1	—	—	13.1	13.1	0.0
93	3/50	13.1	—	—	13.1	13.1	0.0
94	3/50	13.1	—	—	13.1	13.1	0.0
95	3/50	13.1	—	—	13.1	13.1	0.0
96	6/50	52.4	—	—	52.4	52.4	0.0
99	3/60	15.7	—	—	15.7	15.7	0.0
100	3/60	15.7	—	—	15.7	15.7	0.0
101	3/60	15.7	—	—	15.7	15.7	0.0
102	3/60	15.7	—	—	15.7	15.7	0.0
103	3/60	15.7	—	—	15.7	15.7	0.0
104	3/60	15.7	—	—	15.7	15.7	0.0
105	3/60	15.7	—	—	15.7	15.7	0.0
106	3/60	15.7	—	—	15.7	15.7	0.0
107	3/60	15.7	—	—	15.7	15.7	0.0
108	3/60	15.7	—	—	15.7	15.7	0.0
109	2/60	7.0	—	—	7.0	7.0	0.0
110	3/60	15.7	—	—	15.7	15.7	0.0
111	2/60	7.0	—	—	7.0	7.0	0.0
112	3/60	15.7	—	—	15.7	15.7	0.0
114	6/60	62.8	—	—	62.8	62.8	0.0
115	6/60	62.8	—	—	62.8	62.8	0.0

Table G-3.6-1 (continued)

Shaft No.	Diameter/ Depth (ft)	Shaft Volume (yd^3)	PCB (yd^3)[a]	RCRA (yd^3)[b]	MLLW (yd^3)[c]	Total Estimated Waste (yd^3)	Estimated Materials Suitable for Backfill (yd^3)
118	8/62	121.0	—	—	121.0	121.0	0.0
119	8/62	115.4	—	—	115.4	115.4	0.0
120	8/63	115.4	—	—	115.4	115.4	0.0
121	4/60	27.9	—	—	27.9	27.9	0.0
122	4/60	27.9	—	—	27.9	27.9	0.0
123	6/60	62.8	—	—	62.8	62.8	0.0
124	6/65	68.1	—	68.1	-	68.1	0.0
125	6/65	68.1	—	—	68.1	68.1	0.0
126	6/65	68.1	—	—	68.1	68.1	0.0
127	6/65	68.1	—	—	68.1	68.1	0.0
128	6/65	68.1	—	—	68.1	68.1	0.0
129	3/65	17.0	—	—	17.0	17.0	0.0
130	6/65	68.1	—	—	68.1	68.1	0.0
131	6/65	68.1	—	—	68.1	68.1	0.0
132	6/65	68.1	—	—	68.1	68.1	0.0
133	4/65	30.3	—	—	30.3	30.3	0.0
134	3/65	17.0	—	—	17.0	17.0	0.0
135	3/65	17.0	—	—	17.0	17.0	0.0
136	6/65	68.1	—	—	68.1	68.1	0.0
138	4/60	27.9	—	—	27.9	27.9	0.0
139	4/60	27.9	—	—	27.9	27.9	0.0
140	6/61	63.9	—	—	63.9	63.9	0.0
144	0	0.0	—	—	0.0	0.0	0.0
145	0	0.0	—	—	0.0	0.0	0.0
150	6/60	62.8	—	—	62.8	62.8	0.0
151	3/60	15.7	—	—	15.7	15.7	0.0
152	3/60	15.7	—	—	15.7	15.7	0.0
153	3/60	15.7	—	—	15.7	15.7	0.0
154	3/65	17.0	—	—	17.0	17.0	0.0
155	3/65	17.0	—	—	17.0	17.0	0.0
156	3/45	11.8	—	—	11.8	11.8	0.0
157	3/45	11.8	—	—	11.8	11.8	0.0
158	2/45	5.2	—	—	5.2	5.2	0.0
159	2/45	5.2	—	—	5.2	5.2	0.0
160	2/45	5.2	—	—	5.2	5.2	0.0
189	8/65	121.0	—	—	121.0	121.0	0.0
190	8/65	121.0	—	—	121.0	121.0	0.0

Table G-3.6-1 (continued)

Shaft No.	Diameter/ Depth (ft)	Shaft Volume (yd^3)	PCB (yd^3)[a]	RCRA (yd^3)[b]	MLLW (yd^3)[c]	Total Estimated Waste (yd^3)	Estimated Materials Suitable for Backfill (yd^3)
191	8/65	121.0	—	—	121.0	121.0	0.0
192	8/65	121.0	—	—	121.0	121.0	0.0
196	6/53	111.0	—	—	111.0	111.0	0.0
C1	6/60	62.8	62.8	—	—	62.8	0.0
C2	6/60	62.8	62.8	—	—	62.8	0.0
C3	6/60	62.8	62.8	—	—	62.8	0.0
C4	6/60	62.8	62.8	—	—	62.8	0.0
C5	6/60	62.8	62.8	—	—	62.8	0.0
C6	6/60	62.8	62.8	—	—	62.8	0.0
C7	6/60	62.8	62.8	—	—	62.8	0.0
C8	6/60	62.8	62.8	—	—	62.8	0.0
C9	6/60	62.8	62.8	—	—	62.8	0.0
C10	6/60	62.8	62.8	—	—	62.8	0.0
C12	6/65	62.8	62.8	—	—	62.8	0.0
C13	6/65	62.8	62.8	—	—	62.8	0.0
Total		3891	754	68	3069	3891	0.0

Note: Blank cell indicates this waste type/material is not known to be found in the shafts

[a] Estimated PCB waste volume is equal to shaft volume as shown in Table 2.1-3.

[b] Estimated RCRA waste volume is equal to shaft volume as shown in Table 2.1-3.

[c] Estimated MLLW waste volume is equal to shaft volume as shown in Table 2.1-3.

Attachment G-1

Detailed Cost Estimate Report

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1	**Project WBS: 1 - MDA G CME**										
1.PS3a	**Project WBS: 1.PS3a - Vegetative Cover**										
1.PS3a.1	**Project WBS: 1.PS3a.1 - Vegetative Cover - Direct Costs**										
1.PS3a.1.1	**Project WBS: 1.PS3a.1.1 - Vegetative Cover - DC - Fence**										
1.PS3a.1.1	**Project WBS: 1.PS3a.1.1 - Vegetative Cover - DC - Fence**										
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS3a.1.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.PS3a.1.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.PS3a.1.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.PS3a.1.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.PS3a.1.1	**Vegetative Cover - DC - Fence Total**				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS3a.1.1	**Vegetative Cover - DC - Fence Total**				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS3a.1.2	**Project WBS: 1.PS3a.1.2 - Vegetative Cover - DC - Vegetative Cover**										
	Veg Cover				**107,161.5**	**8,406,662.25**	**3,869,454.93**		**5,422,472.94**		**17,698,590**
1.PS3a.1.2	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	304,920.0	SY	3	9,045.4	709,595.06			160,582.16		870,177
1.PS3a.1.2	Fine grading, select gravel, 6" deep, hand grading, including compaction	246,840.0	SY	18	55,797.0	4,377,196.29			46,124.32		4,423,321
1.PS3a.1.2	Basecourse Material and Delivery	82,280.0	CY	35			2,865,298.73				2,865,299
1.PS3a.1.2	Backfill, bulk, 6" to 12" lifts, dozer backfilling	82,280.0	CY	8	4,679.6	367,106.83			283,727.48		650,834
1.PS3a.1.2	Compaction, 2 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	82,280.0	CY	2	1,559.9	122,368.94			72,683.09		195,052
1.PS3a.1.2	Compaction, water for, 3000 gallon truck, 6 mile haul	82,280.0	CY	6	3,414.9	267,893.11	160,736.27		86,661.67		515,291
1.PS3a.1.2	Borrow, common earth, 3 C.Y. bucket, loading and/or spreading, front end loader, wheel-mounted	41,140.0	CY	3	1,169.9	91,776.71			19,569.69		111,346
1.PS3a.1.2	Borrow, Topsoil, Retrieval and Drop	43,321.0	ton	39	17,635.7	1,383,496.57			308,035.26		1,691,532
1.PS3a.1.2	Soils for earthwork, common borrow, spread with 200 H.P. dozer, includes load at pit and haul, 23 miles round trip, excludes compaction	51,425.0	CY	112	9,037.7	708,995.74	646,439.35		4,413,119.21		5,768,554
1.PS3a.1.2	Cobble Material and Delivery for edging	5,656.5	TN	35			196,980.58				196,981
1.PS3a.1.2	Backfill, bulk, 6" to 12" lifts, dozer backfilling	4,190.0	CY	8	238.3	18,694.43			14,448.45		33,143
1.PS3a.1.2	Fine grading, select gravel, 8" deep, hand grading, including compaction	56,564.0	SY	7	4,522.9	354,813.78			14,412.96		369,227
1.PS3a.1.2	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	6.0	EA	1,306	60.2	4,724.80			3,108.66		7,833
	Re-Seeding				**31,255.4**	**2,451,937.62**	**2,145,508.66**		**549,752.82**		**5,147,199**
1.PS3a.1.2	Fine grading, fine grade for small irregular areas, to 15,000 S.Y.	246,840.0	SY	9	22,260.3	1,746,289.62			427,706.60		2,173,996
1.PS3a.1.2	Geotextile Subsurface Drainage Filtration, TRM , hand layed, ideal conditions	246,840.0	SY	10	6,168.8	483,930.35	2,096,560.05				2,580,490
1.PS3a.1.2	Seeding, mechanical seeding, 215 lb/acre	51.0	acre	2,779	1,021.5	80,133.75	48,948.61		12,648.67		141,731
1.PS3a.1.2	Rent water truck, off highway, 6000 gallon capacity - Rent per day	80.0	days	3,137	1,804.8	141,583.90			109,397.56		250,981
1.PS3a.1.2	**Vegetative Cover - DC - Vegetative Cover Total**				**138,416.9**	**10,858,599.87**	**6,014,963.58**		**5,972,225.76**		**22,845,789**
1.PS3a.1.4	**Project WBS: 1.PS3a.1.4 - Vegetative Cover - DC - Road**										
	Pits Excavation DC				**1,305.1**	**95,154.99**	**75,147.46**		**5,437.81**		**175,740**
1.PS3a.1.4	Temporary, roads, excl surfacing. O&M	4,446.0	SY	40	1,305.1	95,154.99	75,147.46		5,437.81		175,740
1.PS3a.1.4	**Vegetative Cover - DC - Road Total**				**1,305.1**	**95,154.99**	**75,147.46**		**5,437.81**		**175,740**
1.PS3a.1.5	**Project WBS: 1.PS3a.1.5 - Vegetative Cover - DC - Project Costs**										
	Veg Cover				**101,699.5**	**6,121,200.24**	**431,897.40**	**1,699,912.85**		**3,567.31**	**8,256,578**
1.PS3a.1.5	Field Non-Manual - JHRS	29,057.0	hour	112	29,057.0	3,262,676.36					3,262,676
1.PS3a.1.5	Craft Distributable - Labor	36,321.3	hour	79	36,321.3	2,858,523.89					2,858,524
1.PS3a.1.5	Craft Distributable - Materials	36,321.3	hour	12	36,321.3		431,897.40				431,897
1.PS3a.1.5	Excavation permit	3.0	ea	1,189						3,567.31	3,567
1.PS3a.1.5	Storm water prevention	1.0	lsum	1,699,913				1,699,912.85			1,699,913
1.PS3a.1.5	**Vegetative Cover - DC - Project Costs Total**				**101,699.5**	**6,121,200.24**	**431,897.40**	**1,699,912.85**		**3,567.31**	**8,256,578**
1.PS3a.1	**Vegetative Cover - Direct Costs Total**				**246,984.7**	**17,516,025.14**	**7,312,311.53**	**1,699,912.85**	**6,005,663.14**	**3,567.31**	**32,537,480**
1.PS3a.2	**Project WBS: 1.PS3a.2 - Vegetative Cover - Indirect Costs**										
1.PS3a.2.1	**Project WBS: 1.PS3a.2.1 - Vegetative Cover - IC - Design**										
	Veg Cover							**7,524,487.47**			**7,524,487**
1.PS3a.2.1	Vegetative Mat Design	1.0	lsum	7,524,487				7,524,487.47			7,524,487
1.PS3a.2.1	**Vegetative Cover - IC - Design Total**							**7,524,487.47**			**7,524,487**
1.PS3a.2.2	**Project WBS: 1.PS3a.2.2 - Vegetative Cover - IC - Professional Management**										
	Veg Cover				**84,937.2**	**18,646,620.52**					**18,646,621**
1.PS3a.2.2	Professional Management	1.0	lsum	18,646,621	84,937.2	18,646,620.52					18,646,621
1.PS3a.2.2	**Vegetative Cover - IC - Professional Management Total**				**84,937.2**	**18,646,620.52**					**18,646,621**
1.PS3a.2.3	**Project WBS: 1.PS3a.2.3 - Vegetative Cover - IC - Contingency**										
	Veg Cover				**3.0**					**29,354,294.00**	**29,354,294**
1.PS3a.2.3	Contingency - Cost 30%	1.0	lsum	17,612,576	1.0					17,612,576.40	17,612,576

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS3a.2.3	Contingency - Schedule 10%	1.0	lsum	5,870,859	1.0					5,870,858.80	5,870,859
1.PS3a.2.3	Contingency - TPRA 10%	1.0	lsum	5,870,859	1.0					5,870,858.80	5,870,859
1.PS3a.2.3	**Vegetative Cover - IC - Contingency Total**				**3.0**					**29,354,294.00**	**29,354,294**
1.PS3a.2	**Vegetative Cover - Indirect Costs Total**				**84,940.2**	**18,646,620.52**		**7,524,487.47**		**29,354,294.00**	**55,525,402**
1.PS3a.3	**Project WBS: 1.PS3a.3 - Vegetative Cover - Direct Operations & Maintenance**										
1.PS3a.3.1	**Project WBS: 1.PS3a.3.1 - Vegetative Cover - DOM - Cover Maintenance & Inspections**										
	Veg Cover				**11,541.7**	**1,273,549.25**	**66,775.67**		**8,337.25**		**1,348,662**
1.PS3a.3.1	TDR Monitoring	1.0	EA	67,404	150.4	13,203.39	54,200.63				67,404
1.PS3a.3.1	TDR Moisture Monitoring (30 years)	1.0	lsum	572,114	3,974.2	572,114.19					572,114
1.PS3a.3.1	Site Maintenance for 30 years.	1.0	lsum	239,969	3,271.3	219,056.76	12,575.04		8,337.25		239,969
1.PS3a.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.PS3a.3.1	**Vegetative Cover - DOM - Cover Maintenance & Inspections Total**				**11,541.7**	**1,273,549.25**	**66,775.67**		**8,337.25**		**1,348,662**
1.PS3a.3	**Vegetative Cover - Direct Operations & Maintenance Total**				**11,541.7**	**1,273,549.25**	**66,775.67**		**8,337.25**		**1,348,662**
1.PS3a.4	**Project WBS: 1.PS3a.4 - Vegetative Cover - Indirect Operations & Maintenance**										
1.PS3a.4.2	**Project WBS: 1.PS3a.4.2 - Vegetative Cover - IOM - Professional Management**										
	Veg Cover				**1,139.6**	**250,180.83**					**250,181**
1.PS3a.4.2	Professional Management (years 31-100)	1.0	lsum	36,781	167.5	36,780.80					36,781
1.PS3a.4.2	Professional Management (years 1-30)	1.0	lsum	213,400	972.1	213,400.04					213,400
1.PS3a.4.2	**Vegetative Cover - IOM - Professional Management Total**				**1,139.6**	**250,180.83**					**250,181**
1.PS3a.4.3	**Project WBS: 1.PS3a.4.3 - Vegetative Cover - IOM - Contingency**										
	Veg Cover				**3.0**					**799,421.50**	**799,422**
1.PS3a.4.3	Contingency - Cost 30%	1.0	lsum	479,653	1.0					479,652.90	479,653
1.PS3a.4.3	Contingency - Schedule 10%	1.0	lsum	159,884	1.0					159,884.30	159,884
1.PS3a.4.3	Contingency - TPRA 10%	1.0	lsum	159,884	1.0					159,884.30	159,884
1.PS3a.4.3	**Vegetative Cover - IOM - Contingency Total**				**3.0**					**799,421.50**	**799,422**
1.PS3a.4	**Vegetative Cover - Indirect Operations & Maintenance Total**				**1,142.6**	**250,180.83**				**799,421.50**	**1,049,602**
1.PS3a	**Vegetative Cover Total**				**344,609.1**	**37,686,375.75**	**7,379,087.20**	**9,224,400.32**	**6,014,000.40**	**30,157,282.81**	**90,461,146**
1.PS3b	**Project WBS: 1.PS3b - ET Cover**										
1.PS3b.1	**Project WBS: 1.PS3b.1 - ET Cover - Direct Cost**										
1.PS3b.1.1	**Project WBS: 1.PS3b.1.1 - ET Cover - DC - Fence**										
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS3b.1.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.PS3b.1.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.PS3b.1.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.PS3b.1.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.PS3b.1.1	**ET Cover - DC - Fence Total**				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS3b.1.2	**Project WBS: 1.PS3b.1.2 - ET Cover - DC - ET Cover**										
	ET Cover				**199,466.8**	**15,289,245.80**	**18,332,670.46**		**16,011,594.74**		**49,633,511**
1.PS3b.1.2	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	304,920.0	SY	3	9,045.4	709,595.06			160,582.16		870,177
1.PS3b.1.2	Fine grading, select gravel, 6" deep, hand grading, including compaction	246,840.0	SY	18	55,797.0	4,377,196.29			46,124.32		4,423,321
1.PS3b.1.2	Basecourse Material and Delivery	287,980.0	CY	35			10,028,545.55				10,028,546
1.PS3b.1.2	Backfill, bulk, 6" to 12" lifts, dozer backfilling	287,980.0	CY	8	16,378.6	1,284,873.90			993,046.18		2,277,920
1.PS3b.1.2	Compaction, 2 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	287,980.0	CY	2	5,459.5	428,291.30			254,390.80		682,682
1.PS3b.1.2	Compaction, water for, 3000 gallon truck, 6 mile haul	287,980.0	CY	6	11,952.1	937,625.90	562,576.95		303,315.84		1,803,519
1.PS3b.1.2	Borrow, common earth, 3 C.Y. bucket, loading and/or spreading, front end loader, wheel-mounted	123,420.0	CY	3	3,509.7	275,330.12			58,709.07		334,039
1.PS3b.1.2	Borrow, Topsoil, Retrieval and Drop	129,962.0	ton	39	52,906.8	4,150,457.76			924,098.67		5,074,556
1.PS3b.1.2	Soils for earthwork, common borrow, spread with 200 H.P. dozer, includes load at pit and haul, 23 miles round trip, excludes compaction	154,275.0	CY	112	27,113.2	2,126,987.21	1,939,318.04		13,239,357.64		17,305,663
1.PS3b.1.2	Cobble Material and Delivery for edging	166,617.0	TN	35			5,802,229.92				5,802,230
1.PS3b.1.2	Fine grading, select gravel, 8" deep, hand grading, including compaction	56,564.0	SY	18	17,006.1	975,469.03			14,412.96		989,882
1.PS3b.1.2	Backfill, bulk, 6" to 12" lifts, dozer backfilling	4,190.0	CY	8	238.3	18,694.43			14,448.45		33,143
1.PS3b.1.2	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	6.0	EA	1,306	60.2	4,724.80			3,108.66		7,833
	Re-Seeding				**31,255.4**	**2,451,937.62**	**2,145,508.66**		**549,752.82**		**5,147,199**
1.PS3b.1.2	Fine grading, fine grade for small irregular areas, to 15,000 S.Y.	246,840.0	SY	9	22,260.3	1,746,289.62			427,706.60		2,173,996
1.PS3b.1.2	Geotextile Subsurface Drainage Filtration, TRM , hand layed, ideal conditions	246,840.0	SY	10	6,168.8	483,930.35	2,096,560.05				2,580,490

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS3b.1.2	Seeding, mechanical seeding, 215 lb/acre	51.0	acre	2,779	1,021.5	80,133.75	48,948.61		12,648.67		141,731
1.PS3b.1.2	Rent water truck, off highway, 6000 gallon capacity - Rent per day	80.0	days	3,137	1,804.8	141,583.90			109,397.56		250,981
1.PS3b.1.2	**ET Cover - DC - ET Cover Total**				**230,722.2**	**17,741,183.42**	**20,478,179.12**		**16,561,347.57**		**54,780,710**
1.PS3b.1.4	**Project WBS: 1.PS3b.1.4 - ET Cover - DC - Project Costs**										
	ET Cover				**167,618.4**	**10,105,402.02**	**781,446.64**	**3,348,385.35**	**5,437.81**	**3,567.31**	**14,244,239**
1.PS3b.1.4	Temporary, roads, excl surfacing for O & M Use	4,446.0	SY	40	1,305.1	95,154.99	75,147.46		5,437.81		175,740
1.PS3b.1.4	Field Non-Manual - JHRS	47,518.1	hour	112	47,518.1	5,335,588.03					5,335,588
1.PS3b.1.4	Craft Distributable - Labor	59,397.6	hour	79	59,397.6	4,674,659.01					4,674,659
1.PS3b.1.4	Craft Distributable - Materials	59,397.6	hour	12	59,397.6		706,299.18				706,299
1.PS3b.1.4	Excavation permit	3.0	ea	1,189						3,567.31	3,567
1.PS3b.1.4	Storm water prevention	1.0	lsum	3,348,385				3,348,385.35			3,348,385
1.PS3b.1.4	**ET Cover - DC - Project Costs Total**				**167,618.4**	**10,105,402.02**	**781,446.64**	**3,348,385.35**	**5,437.81**	**3,567.31**	**14,244,239**
1.PS3b.1	**ET Cover - Direct Cost Total**				**403,903.8**	**28,287,655.48**	**22,049,928.84**	**3,348,385.35**	**16,594,784.95**	**3,567.31**	**70,284,322**
1.PS3b.2	**Project WBS: 1.PS3b.2 - ET Cover - Indirect Cost**										
1.PS3b.2.1	**Project WBS: 1.PS3b.2.1 - ET Cover - IC - Design**										
	ET Cover							**16,253,671.86**			**16,253,672**
1.PS3b.2.1	ET Mat Design	1.0	lsum	16,253,672				16,253,671.86			16,253,672
1.PS3b.2.1	**ET Cover - IC - Design Total**							**16,253,671.86**			**16,253,672**
1.PS3b.2.2	**Project WBS: 1.PS3b.2.2 - ET Cover - IC - Professional Management**										
	ET Cover				**183,473.1**	**40,278,630.58**					**40,278,631**
1.PS3b.2.2	Professional Management	1.0	lsum	40,278,631	183,473.1	40,278,630.58					40,278,631
1.PS3b.2.2	**ET Cover - IC - Professional Management Total**				**183,473.1**	**40,278,630.58**					**40,278,631**
1.PS3b.2.3	**Project WBS: 1.PS3b.2.3 - ET Cover - IC - Contingency**										
	ET Cover				**3.0**					**63,408,313.50**	**63,408,314**
1.PS3b.2.3	Contingency - Cost 30%	1.0	lsum	38,044,988	1.0					38,044,988.10	38,044,988
1.PS3b.2.3	Contingency - Schedule 10%	1.0	lsum	12,681,663	1.0					12,681,662.70	12,681,663
1.PS3b.2.3	Contingency - TPRA 10%	1.0	lsum	12,681,663	1.0					12,681,662.70	12,681,663
1.PS3b.2.3	**ET Cover - IC - Contingency Total**				**3.0**					**63,408,313.50**	**63,408,314**
1.PS3b.2	**ET Cover - Indirect Cost Total**				**183,476.1**	**40,278,630.58**		**16,253,671.86**		**63,408,313.50**	**119,940,616**
1.PS3b.3	**Project WBS: 1.PS3b.3 - ET Cover - Direct Operations & Maintenance**										
1.PS3b.3.1	**Project WBS: 1.PS3b.3.1 - ET Cover - DOM - Cover Maintenance & Inspections**										
	ET Cover				**11,541.7**	**1,273,549.25**	**66,775.67**		**8,337.25**		**1,348,662**
1.PS3b.3.1	TDR Monitoring of ET Cover	1.0	EA	67,404	150.4	13,203.39	54,200.63				67,404
1.PS3b.3.1	TDR Moisture Monitoring (30 years)	1.0	lsum	572,114	3,974.2	572,114.19					572,114
1.PS3b.3.1	Site Maintenance for 30 years.	1.0	lsum	239,969	3,271.3	219,056.76	12,575.04		8,337.25		239,969
1.PS3b.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.PS3b.3.1	**ET Cover - DOM - Cover Maintenance & Inspections Total**				**11,541.7**	**1,273,549.25**	**66,775.67**		**8,337.25**		**1,348,662**
1.PS3b.3	**ET Cover - Direct Operations & Maintenance Total**				**11,541.7**	**1,273,549.25**	**66,775.67**		**8,337.25**		**1,348,662**
1.PS3b.4	**Project WBS: 1.PS3b.4 - ET Cover - Indirect Operations & Maintenance**										
1.PS3b.4.2	**Project WBS: 1.PS3b.4.2 - ET Cover - IOM - Professional Management**										
	ET Cover				**1,139.6**	**250,180.83**					**250,181**
1.PS3b.4.2	Professional Management (years 31-100)	1.0	lsum	36,781	167.5	36,780.80					36,781
1.PS3b.4.2	Professional Management (years 1-30)	1.0	lsum	213,400	972.1	213,400.04					213,400
1.PS3b.4.2	**ET Cover - IOM - Professional Management Total**				**1,139.6**	**250,180.83**					**250,181**
1.PS3b.4.3	**Project WBS: 1.PS3b.4.3 - ET Cover - IOM - Contingency**										
	ET Cover				**3.0**					**799,421.50**	**799,422**
1.PS3b.4.3	Contingency - Cost 30%	1.0	lsum	479,653	1.0					479,652.90	479,653
1.PS3b.4.3	Contingency - Schedule 10%	1.0	lsum	159,884	1.0					159,884.30	159,884
1.PS3b.4.3	Contingency - TPRA 10%	1.0	lsum	159,884	1.0					159,884.30	159,884
1.PS3b.4.3	**ET Cover - IOM - Contingency Total**				**3.0**					**799,421.50**	**799,422**
1.PS3b.4	**ET Cover - Indirect Operations & Maintenance Total**				**1,142.6**	**250,180.83**				**799,421.50**	**1,049,602**
1.PS3b	**ET Cover Total**				**600,064.2**	**70,090,016.14**	**22,116,704.51**	**19,602,057.22**	**16,603,122.20**	**64,211,302.31**	**192,623,202**
1.PS4a	**Project WBS: 1.PS4a - Excavation of pits and shafts with on-site disposal in a CAMU/RCRA landfill**										
1.PS4a.1	**Project WBS: 1.PS4a.1 - Excavation, Treatment, Onsite - Direct Cost**										
1.PS4a.1.1	**Project WBS: 1.PS4a.1.1 - Excavation, Treatment, Onsite - DC - Fence**										

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
	Fencing				5,563.2	441,070.03	790,303.08		27,999.57		1,259,373
1.PS4a.1.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.PS4a.1.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.PS4a.1.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.PS4a.1.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.PS4a.1.1	**Excavation, Treatment, Onsite - DC - Fence Total**				5,563.2	441,070.03	790,303.08		27,999.57		1,259,373
1.PS4a.1.2	**Project WBS: 1.PS4a.1.2 - Excavation, Treatment, Onsite - DC - Excavation**										
1.PS4a.1.2.01	**Project WBS: 1.PS4a.1.2.01 - Excavation, Treatment, Onsite - DC - Pits - Excavation - MLLW**										
	Pits Excavation DC				3,030,300.8	237,099,842.38	18,628,451.10		77,591,834.77	1,404,577.68	334,724,706
1.PS4a.1.2.01	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	1,020,464.0	B.C.Y.	35	409,677.7	32,138,613.47			3,900,797.38		36,039,411
1.PS4a.1.2.01	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	605,426.0	B.C.Y.	294	2,269,524.4	178,040,846.82					178,040,847
1.PS4a.1.2.01	Site Tuff Processing - Dozer D9 rip tuff material	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS4a.1.2.01	Site Tuff Processing - 980 Frontend loader	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS4a.1.2.01	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS4a.1.2.01	Site Tuff Processing - 963 Hydraulic Excavator	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS4a.1.2.01	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	415,038.0	CY	2	10,299.6	638,710.79					638,711
1.PS4a.1.2.01	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	415,038.0	CY	0					186,128.79		186,129
1.PS4a.1.2.01	Site Tuff Processing - Rock crusher plant rental	360.0	MNTH	47,564					17,123,096.14		17,123,096
1.PS4a.1.2.01	Site Tuff Processing - Rock crusher plant : Scheduled Maintenance	2.0	EA	6,795						13,589.76	13,590
1.PS4a.1.2.01	Site Tuff Processing - Screening plant rental	30.0	MNTH	26,330					789,904.73		789,905
1.PS4a.1.2.01	Site Tuff Processing - Screening plant : Scheduled Maintenance	2.0	EA	4,077						8,153.86	8,154
1.PS4a.1.2.01	Dozer D9 rental	360.0	MNTH	49,949					17,981,697.10		17,981,697
1.PS4a.1.2.01	Dozer D9 Scheduled Maintenance	30.0	YR	12,322						369,659.62	369,660
1.PS4a.1.2.01	Dozer D9 Ripper replacement	60.0	SET	1,100	451.2	35,172.96				30,841.96	66,015
1.PS4a.1.2.01	Dozer cutting edge replacement	180.0	EA	2,192	2,707.2	211,037.76	183,461.74				394,500
1.PS4a.1.2.01	980, 7 cy frontend loader rental	360.0	MNTH	28,426					10,233,496.10		10,233,496
1.PS4a.1.2.01	980 Loader: Scheduled Maintenance	30.0	YR	9,963						298,899.44	298,899
1.PS4a.1.2.01	980-7cy loader bucket teeth replacement.	210.0	EA	2,000	1,579.2	123,105.36	296,800.33				419,906
1.PS4a.1.2.01	825H High speed compactor (sheepsfoot) rental	360.0	MNTH	17,981					6,473,141.88		6,473,142
1.PS4a.1.2.01	825H: Scheduled Maintenance	30.0	YR	10,098						302,944.26	302,944
1.PS4a.1.2.01	963 Hydraulic Excavator rental	360.0	MNTH	31,664					11,399,089.71		11,399,090
1.PS4a.1.2.01	963 Hydraulic Excavator : Scheduled Maintenance	30.0	YR	12,485						374,543.27	374,543
1.PS4a.1.2.01	963 Hydraulic Excavator tip long replacement.	270.0	EA	1,313	2,030.4	158,278.32	196,299.48				354,578
1.PS4a.1.2.01	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	540,342.7	ton	33			17,926,408.75				17,926,409
1.PS4a.1.2.01	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	1,275,580.0	L.C.Y.	10	95,520.6	7,493,448.44			5,742,160.64		13,235,609
1.PS4a.1.2.01	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	1,275,580.0	L.C.Y.	13	174,113.5	13,658,943.99			2,860,508.10		16,519,452
1.PS4a.1.2.01	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	1,020,464.0	E.C.Y.	1	8,705.7	682,947.20			416,049.18		1,098,996
1.PS4a.1.2.01	Excavation permit	5.0	ea	1,189						5,945.52	5,946
1.PS4a.1.2.01	Track out device	3.0	EA	9,316	33.8	2,467.26	25,480.80				27,948
1.PS4a.1.2.01	Clean out track out device.	23.0	EA	2,863	518.9	37,831.40			28,007.17		65,839
1.PS4a.1.2.01	Rent toilet portable chemical	360.0	mnth	679					244,615.66		244,616
1.PS4a.1.2.01	Chemical toilet cleaning.	360.0	mnth	2,691	12,182.4	755,470.43			213,142.19		968,613
1.PS4a.1.2.01	Chemical toilet cleaning (labor)	360.0	mnth	2,011	12,182.4	724,011.33					724,011
	Re-Seeding				3,578.3	165,460.53	3,119,631.06		107,001.87		3,392,093
1.PS4a.1.2.01	Reveg - Seeding athletic fields, seeding utility mix with mulch and fertilizer, 7 lb. per M.S.F., hydro or air seeding	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS4a.1.2.01	Reveg - Hydroseeding materials.	1.0	lsum	2,022,902			2,022,901.85				2,022,902
1.PS4a.1.2.01	Reveg - Mulching athletic fields,	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS4a.1.2.01	Reveg - Mulch and Humate materials.	1.0	LS	907,509			907,508.81				907,509
1.PS4a.1.2.01	Reveg - Rent water truck, off highway, 6000 gallon capacity - Rent per day	40.0	days	1,367	902.4				54,698.78		54,699
1.PS4a.1.2.01	**Excavation, Treatment, Onsite - DC - Pits - Excavation - MLLW Total**				3,033,879.2	237,265,302.90	21,748,082.17		77,698,836.65	1,404,577.68	338,116,799
1.PS4a.1.2.02	**Project WBS: 1.PS4a.1.2.02 - Excavation, Treatment, Onsite - DC - Pits - Excavation - MLLW Waste**										
	Pits Excavation Waste				4,390.2	344,404.99		113,121,410.96	209,810.38		113,675,626
1.PS4a.1.2.02	MLLW - CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	514,612.1	E.C.Y.	1	4,390.2	344,404.99			209,810.38		554,215
1.PS4a.1.2.02	Treatment - Mob/Demob VOC treatment plant.	1.0	ea	220,834				220,833.58			220,834
1.PS4a.1.2.02	Treatment - Processing VOC soil.	540,342.7	tn	209				112,900,577.38			112,900,577
1.PS4a.1.2.02	**Excavation, Treatment, Onsite - DC - Pits - Excavation - MLLW Waste Total**				4,390.2	344,404.99		113,121,410.96	209,810.38		113,675,626
1.PS4a.1.2.03	**Project WBS: 1.PS4a.1.2.03 - Excavation, Treatment, Onsite - DC - Pits - Excavation - MLLW & TRU**										
	Pits Excavation DC				1,435,179.4	112,508,900.47	8,680,400.55		6,039,905.57		127,229,207
1.PS4a.1.2.03	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	470,789.0	B.C.Y.	35	189,004.0	14,827,084.25			1,799,624.97		16,626,709
1.PS4a.1.2.03	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	293,498.0	B.C.Y.	294	1,100,218.5	86,310,519.30					86,310,519

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4a.1.2.03	Site Tuff Processing - Dozer D9 rip tuff material	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS4a.1.2.03	Site Tuff Processing - 980 Frontend loader	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS4a.1.2.03	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS4a.1.2.03	Site Tuff Processing - 963 Hydraulic Excavator	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS4a.1.2.03	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	177,291.0	CY	2	4,399.7	272,836.89					272,837
1.PS4a.1.2.03	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	177,291.0	CY	0					79,508.28		79,508
1.PS4a.1.2.03	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	261,647.0	ton	33			8,680,400.55				8,680,401
1.PS4a.1.2.03	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	588,487.0	L.C.Y.	10	44,068.3	3,457,091.67			2,649,137.56		6,106,229
1.PS4a.1.2.03	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	588,487.0	L.C.Y.	13	80,327.0	6,301,534.18			1,319,691.30		7,621,225
1.PS4a.1.2.03	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	470,789.0	E.C.Y.	1	4,016.3	315,076.31			191,943.45		507,020
1.PS4a.1.2.03	**Excavation, Treatment, Onsite - DC - Pits - Excavation - MLLW & TRU Total**				**1,435,179.4**	**112,508,900.47**	**8,680,400.55**		**6,039,905.57**		**127,229,207**
1.PS4a.1.2.04	**Project WBS: 1.PS4a.1.2.04 - Excavation, Treatment, Onsite - DC - Pits - Excavation - MLLW & TRU Waste**										
	Pits Excavation Waste				**16,856,483.4**	**1,319,228,798.88**	**560,952,302.32**	**1,280,608,620.10**	**134,415,367.33**		**3,295,205,089**
1.PS4a.1.2.04	CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	203,117.7	E.C.Y.	1	460.9	31,053.61			82,812.28		113,866
1.PS4a.1.2.04	Treatment - Processing VOC soil.	213,273.6	tn								
1.PS4a.1.2.04	TRU - Waste container delivery.	819.0	ea	24,693	246,354.7	16,210,982.48			4,012,362.08		20,223,345
1.PS4a.1.2.04	TRU - Waste container unload on site and handling during project.	16,361.0	ea	78,265	14,764,178.2	1,158,212,735.73			122,288,222.47		1,280,500,958
1.PS4a.1.2.04	TRU - Waste containers.	16,361.0	ea	34,286			560,952,302.32				560,952,302
1.PS4a.1.2.04	TRU - Fill waste containers.	16,361.0	ea	9,340	1,845,489.6	144,774,027.06			8,031,970.50		152,805,998
1.PS4a.1.2.04	TRU - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	54,536.0	cy	18,924				1,032,025,040.18			1,032,025,040
1.PS4a.1.2.04	TRU - Trucking cost per 43,000 pound load	3,273.0	Trip	75,950				248,583,579.92			248,583,580
1.PS4a.1.2.04	**Excavation, Treatment, Onsite - DC - Pits - Excavation - MLLW & TRU Waste Total**				**16,856,483.4**	**1,319,228,798.88**	**560,952,302.32**	**1,280,608,620.10**	**134,415,367.33**		**3,295,205,089**
1.PS4a.1.2.05	**Project WBS: 1.PS4a.1.2.05 - Excavation, Treatment, Onsite - DC - Shafts - Excavation - PCB**										
	Shaft 1 DC				**52,934.3**	**4,120,163.02**	**59,318.69**		**983,679.04**		**5,163,161**
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	75,111.0	B.C.Y.	35	30,154.2	2,365,554.69			287,117.23		2,652,672
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	2,103.0	B.C.Y.	294	7,883.4	618,440.41					618,440
1.PS4a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	73,008.0	CY	2	1,800.8	140,378.94					140,379
1.PS4a.1.2.05	Site Tuff Processing - 980 Frontend loader	73,008.0	CY	2	1,800.8	140,378.94					140,379
1.PS4a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	73,008.0	CY	1	905.9	70,617.45					70,617
1.PS4a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	73,008.0	CY	1	905.9	70,617.45					70,617
1.PS4a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	73,008.0	CY	2	1,811.8	112,353.56					112,354
1.PS4a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	73,008.0	CY	0					32,741.32		32,741
1.PS4a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	1,788.0	ton	33			59,318.69				59,319
1.PS4a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	93,888.8	L.C.Y.	10	7,030.8	551,553.42			422,650.31		974,204
1.PS4a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	93,888.8	L.C.Y.	2					210,546.99		210,547
1.PS4a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	75,111.0	E.C.Y.	1	640.8	50,268.16			30,623.20		80,891
	Shaft 2 DC				**9,992.9**	**778,665.07**	**5,566.93**		**157,707.45**		**941,939**
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	12,037.0	B.C.Y.	35	4,832.4	379,094.70			46,012.30		425,107
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	188.0	B.C.Y.	294	704.7	55,286.16					55,286
1.PS4a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	11,849.0	CY	2	292.3	22,783.12					22,783
1.PS4a.1.2.05	Site Tuff Processing - 980 Frontend loader	11,849.0	CY	2	292.3	22,783.12					22,783
1.PS4a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	11,849.0	CY	1	147.0	11,461.02					11,461
1.PS4a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	11,849.0	CY	1	147.0	11,461.02					11,461
1.PS4a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	11,849.0	CY	2	294.0	18,234.68					18,235
1.PS4a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	11,849.0	CY	0					5,313.83		5,314
1.PS4a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	167.8	ton	33			5,566.93				5,567
1.PS4a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	15,046.3	L.C.Y.	10	1,126.7	88,389.83			67,732.31		156,122
1.PS4a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	15,046.3	L.C.Y.	13	2,053.8	161,115.64			33,741.45		194,857
1.PS4a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	12,037.0	E.C.Y.	1	102.7	8,055.78			4,907.56		12,963
	Shaft 3 DC				**8,198.9**	**638,675.62**	**2,355.50**		**134,082.12**		**775,113**
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	10,231.0	B.C.Y.	35	4,107.4	322,216.32			39,108.74		361,325
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	79.0	B.C.Y.	294	296.1	23,231.95					23,232
1.PS4a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	10,153.0	CY	2	250.4	19,522.07					19,522
1.PS4a.1.2.05	Site Tuff Processing - 980 Frontend loader	10,153.0	CY	2	250.4	19,522.07					19,522
1.PS4a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	10,153.0	CY	1	126.0	9,820.55					9,821
1.PS4a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	10,153.0	CY	1	126.0	9,820.55					9,821
1.PS4a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	10,153.0	CY	2	252.0	15,624.67					15,625
1.PS4a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	10,153.0	CY	0					4,553.24		4,553
1.PS4a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	71.0	ton	33			2,355.50				2,355
1.PS4a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	12,788.8	L.C.Y.	10	957.7	75,128.05			57,569.93		132,698
1.PS4a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	12,788.8	L.C.Y.	13	1,745.6	136,942.27			28,678.97		165,621
1.PS4a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	10,231.0	E.C.Y.	1	87.3	6,847.11			4,171.24		11,018

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
	Shaft 4 DC				**15,041.3**	**1,171,589.11**	**3,108.59**		**248,471.78**		**1,423,169**
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	18,958.0	B.C.Y.	35	7,610.9	597,065.49			72,468.32		669,534
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	105.0	B.C.Y.	294	393.6	30,877.91					30,878
1.PS4a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	18,854.0	CY	2	465.0	36,252.25					36,252
1.PS4a.1.2.05	Site Tuff Processing - 980 Frontend loader	18,854.0	CY	2	465.0	36,252.25					36,252
1.PS4a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	18,854.0	CY	1	233.9	18,236.65					18,237
1.PS4a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	18,854.0	CY	1	233.9	18,236.65					18,237
1.PS4a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	18,854.0	CY	2	467.9	29,014.82					29,015
1.PS4a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	18,854.0	CY	0					8,455.30		8,455
1.PS4a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	93.7	ton	33			3,108.59				3,109
1.PS4a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	23,697.5	L.C.Y.	10	1,774.6	139,211.96			106,676.85		245,889
1.PS4a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	23,697.5	L.C.Y.	13	3,234.6	253,753.45			53,142.01		306,895
1.PS4a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	18,958.0	E.C.Y.	1	161.7	12,687.67			7,729.29		20,417
	Shaft 5 DC				**21,716.1**	**1,692,623.32**	**17,616.46**		**331,099.79**		**2,041,340**
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	25,278.0	B.C.Y.	35	10,148.2	796,108.31			96,626.98		892,735
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	595.0	B.C.Y.	294	2,230.4	174,974.82					174,975
1.PS4a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	24,683.0	CY	2	608.8	47,460.19					47,460
1.PS4a.1.2.05	Site Tuff Processing - 980 Frontend loader	24,683.0	CY	2	608.8	47,460.19					47,460
1.PS4a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	24,683.0	CY	1	306.3	23,874.79					23,875
1.PS4a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	24,683.0	CY	1	306.3	23,874.79					23,875
1.PS4a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	24,683.0	CY	2	612.5	37,985.19					37,985
1.PS4a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	24,683.0	CY	0					11,069.39		11,069
1.PS4a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	531.0	ton	33			17,616.46				17,616
1.PS4a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	31,597.5	L.C.Y.	10	2,366.1	185,620.84			142,239.55		327,860
1.PS4a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	31,597.5	L.C.Y.	13	4,313.0	338,346.86			70,857.89		409,205
1.PS4a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	25,278.0	E.C.Y.	1	215.6	16,917.34			10,305.99		27,223
	Shaft 6 DC				**19,498.0**	**1,520,292.51**	**26,265.44**		**283,384.86**		**1,829,943**
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	21,667.0	B.C.Y.	35	8,698.5	682,383.05			82,823.67		765,207
1.PS4a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	754.0	B.C.Y.	294	2,826.5	221,732.79					221,733
1.PS4a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	20,913.0	CY	2	515.8	40,211.27					40,211
1.PS4a.1.2.05	Site Tuff Processing - 980 Frontend loader	20,913.0	CY	2	515.8	40,211.27					40,211
1.PS4a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	20,913.0	CY	1	259.5	20,228.23					20,228
1.PS4a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	20,913.0	CY	1	259.5	20,228.23					20,228
1.PS4a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	20,913.0	CY	2	519.0	32,183.46					32,183
1.PS4a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	20,913.0	CY	0					9,378.69		9,379
1.PS4a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	791.7	ton	33			26,265.44				26,265
1.PS4a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	27,083.8	L.C.Y.	10	2,028.1	159,104.63			121,920.42		281,025
1.PS4a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	27,083.8	L.C.Y.	13	3,696.9	290,013.50			60,735.73		350,749
1.PS4a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	20,913.0	E.C.Y.	1	178.4	13,996.06			8,526.35		22,522
1.PS4a.1.2.05	**Excavation, Treatment, Onsite - DC - Shafts - Excavation - PCB Total**				**127,381.5**	**9,922,008.65**	**114,231.60**		**2,138,425.04**		**12,174,665**
1.PS4a.1.2.06	**Project WBS: 1.PS4a.1.2.06 - Excavation, Treatment, Onsite - DC - Shafts - Excavation - PCB Waste**										
	Shaft 1 Waste				**15.3**	**1,196.62**		**392,268.73**	**728.98**		**394,194**
1.PS4a.1.2.06	Treatment - Processing VOC soil.	1,877.4	tn	209				392,268.73			392,269
1.PS4a.1.2.06	Shafts 1 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	1,788.0	E.C.Y.	1	15.3	1,196.62			728.98		1,926
	Shaft 2 Waste				**1.4**	**112.30**		**36,813.59**	**68.41**		**36,994**
1.PS4a.1.2.06	Shafts 2 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	167.8	E.C.Y.	1	1.4	112.30			68.41		181
1.PS4a.1.2.06	Treatment - Processing VOC soil.	176.2	tn	209				36,813.59			36,814
	Shaft 3 Waste				**0.6**	**44.94**		**14,742.99**	**27.38**		**14,815**
1.PS4a.1.2.06	Shafts 3 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	67.2	E.C.Y.	1	0.6	44.94			27.38		72
1.PS4a.1.2.06	Treatment - Processing VOC soil.	70.6	tn	209				14,742.99			14,743
	Shaft 4 Waste				**0.8**	**59.73**		**19,592.54**	**36.39**		**19,689**
1.PS4a.1.2.06	Shafts 4 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	89.3	E.C.Y.	1	0.8	59.73			36.39		96
1.PS4a.1.2.06	Treatment - Processing VOC soil.	93.8	tn	209				19,592.54			19,593
	Shaft 5 Waste				**4.3**	**338.47**		**110,967.29**	**206.20**		**111,512**
1.PS4a.1.2.06	Shafts 5 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	505.8	E.C.Y.	1	4.3	338.47			206.20		545
1.PS4a.1.2.06	Treatment - Processing VOC soil.	531.1	tn	209				110,967.29			110,967
	Shaft 6 Waste				**2,561.1**	**200,908.32**		**768,354.43**	**11,167.76**		**980,431**
1.PS4a.1.2.06	Shafts 6 PCB - Fill waste containers.	227.0	ea	934	2,560.6	200,869.51			11,144.11		212,014
1.PS4a.1.2.06	Shafts 6 PCB - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	754.0	cy	1,002				755,692.51			755,693
1.PS4a.1.2.06	Shafts RCRA CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	58.0	E.C.Y.	1	0.5	38.82			23.65		62
1.PS4a.1.2.06	Shafts RCRA Treatment - Processing VOC soil.	60.6	tn	209				12,661.92			12,662

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4a.1.2.06	**Excavation, Treatment, Onsite - DC - Shafts - Excavation - PCB Waste Total**				**2,583.4**	**202,660.39**		**1,342,739.57**	**12,235.11**		**1,557,635**
1.PS4a.1.2.07	**Project WBS: 1.PS4a.1.2.07 - Excavation, Treatment, Onsite - DC - Road**										
	Pits Excavation DC				**32,470.9**	**2,367,445.84**	**1,869,660.68**		**135,292.03**		**4,372,399**
1.PS4a.1.2.07	Temporary, roads, excl surfacing. O&M	4,446.0	SY	40	1,305.1	95,154.99	75,147.46		5,437.81		175,740
1.PS4a.1.2.07	Temporary, roads, excl surfacing.	106,170.0	SY	40	31,165.8	2,272,290.86	1,794,513.22		129,854.22		4,196,658
1.PS4a.1.2.07	**Excavation, Treatment, Onsite - DC - Road Total**				**32,470.9**	**2,367,445.84**	**1,869,660.68**		**135,292.03**		**4,372,399**
1.PS4a.1.2.08	**Project WBS: 1.PS4a.1.2.08 - Excavation, Treatment, Onsite - DC - Containment**										
	Pits Excavation DC				**1,440,000.0**	**191,534,061.09**		**535,096,754.32**			**726,630,815**
1.PS4a.1.2.08	Moveable Covers	3.0	ea	67,242,127	1,440,000.0	191,534,061.09		10,192,319.13			201,726,380
1.PS4a.1.2.08	Moveable Covers Mob/Demob	618.0	ea	849,360				524,904,435.19			524,904,435
1.PS4a.1.2.08	**Excavation, Treatment, Onsite - DC - Containment Total**				**1,440,000.0**	**191,534,061.09**		**535,096,754.32**			**726,630,815**
1.PS4a.1.2.09	**Project WBS: 1.PS4a.1.2.09 - Excavation, Treatment, Onsite - DC - CAMU/RCRA**										
	Pits Excavation Waste							**488,042,214.34**			**488,042,214**
1.PS4a.1.2.09	CAMU/RCRA Site - Permiting and Landfill	43.0	acre	1,868,592				80,349,449.14			80,349,449
1.PS4a.1.2.09	On-Site Waste analysis, segregation, size reduction & treatment facility	1.0	lsum	407,692,765				407,692,765.20			407,692,765
	ET Cover				**190,421.4**	**14,579,650.74**	**18,332,670.46**		**15,851,012.59**		**48,763,334**
1.PS4a.1.2.09	Fine grading, select gravel, 6" deep, hand grading, including compaction	246,840.0	SY	18	55,797.0	4,377,196.29			46,124.32		4,423,321
1.PS4a.1.2.09	Basecourse Material and Delivery	287,980.0	CY	35			10,028,545.55				10,028,546
1.PS4a.1.2.09	Backfill, bulk, 6" to 12" lifts, dozer backfilling	287,980.0	CY	8	16,378.6	1,284,873.90			993,046.18		2,277,920
1.PS4a.1.2.09	Compaction, 2 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	287,980.0	CY	2	5,459.5	428,291.30			254,390.80		682,682
1.PS4a.1.2.09	Compaction, water for, 3000 gallon truck, 6 mile haul	287,980.0	CY	6	11,952.1	937,625.90	562,576.95		303,315.84		1,803,519
1.PS4a.1.2.09	Borrow, common earth, 3 C.Y. bucket, loading and/or spreading, front end loader, wheel-mounted	123,420.0	CY	3	3,509.7	275,330.12			58,709.07		334,039
1.PS4a.1.2.09	Borrow, Topsoil, Retrieval and Drop	129,962.0	ton	39	52,906.8	4,150,457.76			924,098.67		5,074,556
1.PS4a.1.2.09	Soils for earthwork, common borrow, spread with 200 H.P. dozer, includes load at pit and haul, 23 miles round trip, excludes compaction	154,275.0	CY	112	27,113.2	2,126,987.21	1,939,318.04		13,239,357.64		17,305,663
1.PS4a.1.2.09	Cobble Material and Delivery for edging	166,617.0	TN	35			5,802,229.92				5,802,230
1.PS4a.1.2.09	Fine grading, select gravel, 8" deep, hand grading, including compaction	56,564.0	SY	18	17,006.1	975,469.03			14,412.96		989,882
1.PS4a.1.2.09	Backfill, bulk, 6" to 12" lifts, dozer backfilling	4,190.0	CY	8	238.3	18,694.43			14,448.45		33,143
1.PS4a.1.2.09	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	6.0	EA	1,306	60.2	4,724.80			3,108.66		7,833
	Re-Seeding				**31,255.4**	**2,451,937.62**	**2,145,508.66**		**549,752.82**		**5,147,199**
1.PS4a.1.2.09	Fine grading, fine grade for small irregular areas, to 15,000 S.Y.	246,840.0	SY	9	22,260.3	1,746,289.62			427,706.60		2,173,996
1.PS4a.1.2.09	Geotextile Subsurface Drainage Filtration, TRM , hand layed, ideal conditions	246,840.0	SY	10	6,168.8	483,930.35	2,096,560.05				2,580,490
1.PS4a.1.2.09	Seeding, mechanical seeding, 215 lb/acre	51.0	acre	2,779	1,021.5	80,133.75	48,948.61		12,648.67		141,731
1.PS4a.1.2.09	Rent water truck, off highway, 6000 gallon capacity - Rent per day	80.0	days	3,137	1,804.8	141,583.90			109,397.56		250,981
1.PS4a.1.2.09	**Excavation, Treatment, Onsite - DC - CAMU/RCRA Total**				**221,676.8**	**17,031,588.36**	**20,478,179.12**	**488,042,214.34**	**16,400,765.41**		**541,952,747**
1.PS4a.1.2.10	**Project WBS: 1.PS4a.1.2.10 - Excavation, Treatment, Onsite - DC - Project Costs**										
	Pits Excavation DC				**16,211,725.6**	**975,768,992.90**	**130,001,865.18**	**76,038,386.93**		**3,567.31**	**1,181,812,812**
1.PS4a.1.2.10	Field Non-Manual - JHRS	4,631,921.6	hour	112	4,631,921.6	520,097,088.17					520,097,088
1.PS4a.1.2.10	Craft Distributable - Labor	5,789,902.0	hour	79	5,789,902.0	455,671,904.73					455,671,905
1.PS4a.1.2.10	Craft Distributable - Materials	5,789,902.0	hour	12	5,789,902.0		68,847,950.40				68,847,950
1.PS4a.1.2.10	Craft Distrib for interior excavation work	360.0	mnth	169,872			61,153,914.78				61,153,915
1.PS4a.1.2.10	Storm water prevention	1.0	LS	76,038,387				76,038,386.93			76,038,387
1.PS4a.1.2.10	Excavation permit	3.0	ea	1,189						3,567.31	3,567
1.PS4a.1.2.10	**Excavation, Treatment, Onsite - DC - Project Costs Total**				**16,211,725.6**	**975,768,992.90**	**130,001,865.18**	**76,038,386.93**		**3,567.31**	**1,181,812,812**
1.PS4a.1.2	**Excavation, Treatment, Onsite - DC - Excavation Total**				**39,365,770.4**	**2,866,174,164.48**	**743,844,721.61**	**2,494,250,126.22**	**237,050,637.52**	**1,408,144.99**	**6,342,727,795**
1.PS4a.1	**Excavation, Treatment, Onsite - Direct Cost Total**				**39,371,333.5**	**2,866,615,234.52**	**744,635,024.70**	**2,494,250,126.22**	**237,078,637.09**	**1,408,144.99**	**6,343,987,168**
1.PS4a.2	**Project WBS: 1.PS4a.2 - Excavation, Treatment, Onsite - Indirect Cost**										
1.PS4a.2.1	**Project WBS: 1.PS4a.2.1 - Excavation, Treatment, Onsite - IC - Design**										
	Pits Excavation DC							**1,459,852,283.68**			**1,459,852,284**
1.PS4a.2.1	Design	1.0	lsum	1,459,852,284				1,459,852,283.68			1,459,852,284
1.PS4a.2.1	**Excavation, Treatment, Onsite - IC - Design Total**							**1,459,852,283.68**			**1,459,852,284**
1.PS4a.2.2	**Project WBS: 1.PS4a.2.2 - Excavation, Treatment, Onsite - IC - Professional Management**										
	Pits Excavation DC				**16,478,964.3**	**3,617,696,440.51**					**3,617,696,441**
1.PS4a.2.2	Professional Management	1.0	lsum	3,617,696,441	16,478,964.3	3,617,696,440.51					3,617,696,441
1.PS4a.2.2	**Excavation, Treatment, Onsite - IC - Professional Management Total**				**16,478,964.3**	**3,617,696,440.51**					**3,617,696,441**
1.PS4a.2.3	**Project WBS: 1.PS4a.2.3 - Excavation, Treatment, Onsite - IC - Contingency**										
	Pits Excavation DC				**3.0**					**5,710,767,946.50**	**5,710,767,947**
1.PS4a.2.3	Contingency - Cost 30%	1.0	lsum	3,426,460,768	1.0					3,426,460,767.90	3,426,460,768

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4a.2.3	Contingency - Schedule 10%	1.0	lsum	1,142,153,589	1.0					1,142,153,589.30	1,142,153,589
1.PS4a.2.3	Contingency - TPRA 10%	1.0	lsum	1,142,153,589	1.0					1,142,153,589.30	1,142,153,589
1.PS4a.2.3	**Excavation, Treatment, Onsite - IC - Contingency Total**				**3.0**					**5,710,767,946.50**	**5,710,767,947**
1.PS4a.2	**Excavation, Treatment, Onsite - Indirect Cost Total**				**16,478,967.3**	**3,617,696,440.51**		**1,459,852,283.68**		**5,710,767,946.50**	**10,788,316,671**
1.PS4a.3	**Project WBS: 1.PS4a.3 - Excavation, Treatment, Onsite - Direct Operations & Maintenance**										
1.PS4a.3.1	**Project WBS: 1.PS4a.3.1 - Excavation, Treatment, Onsite - DOM - Cover Maintenance & Inspections**										
	Pits Excavation DC				**2,319,963.0**	**333,586,642.10**	**66,775.67**		**8,337.25**		**333,661,755**
1.PS4a.3.1	CAMU/RCRA Operations (30 years)	1.0	lsum	332,313,093	2,308,421.4	332,313,092.85					332,313,093
1.PS4a.3.1	TDR Moisture Monitoring (30 years)	1.0	lsum	572,114	3,974.2	572,114.19					572,114
1.PS4a.3.1	TDR Monitoring of ET Cover	1.0	EA	67,404	150.4	13,203.39	54,200.63				67,404
1.PS4a.3.1	Site Maintenance for 30 years.	1.0	lsum	239,969	3,271.3	219,056.76	12,575.04		8,337.25		239,969
1.PS4a.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.PS4a.3.1	**Excavation, Treatment, Onsite - DOM - Cover Maintenance & Inspections Total**				**2,319,963.0**	**333,586,642.10**	**66,775.67**		**8,337.25**		**333,661,755**
1.PS4a.3	**Excavation, Treatment, Onsite - Direct Operations & Maintenance Total**				**2,319,963.0**	**333,586,642.10**	**66,775.67**		**8,337.25**		**333,661,755**
1.PS4a.4	**Project WBS: 1.PS4a.4 - Excavation, Treatment, Onsite - Indirect Operations & Maintenance**										
1.PS4a.4.2	**Project WBS: 1.PS4a.4.2 - Excavation, Treatment, Onsite - IOM - Professional Management**										
	Pits Excavation DC				**291,834.7**	**64,067,702.69**					**64,067,703**
1.PS4a.4.2	Professional Management (years 31-100)	1.0	lsum	75,819	345.4	75,818.65					75,819
1.PS4a.4.2	Professional Management (years 1-30)	1.0	lsum	63,991,884	291,489.3	63,991,884.04					63,991,884
1.PS4a.4.2	**Excavation, Treatment, Onsite - IOM - Professional Management Total**				**291,834.7**	**64,067,702.69**					**64,067,703**
1.PS4a.4.3	**Project WBS: 1.PS4a.4.3 - Excavation, Treatment, Onsite - IOM - Contingency**										
	Pits Excavation DC				**3.0**					**198,866,728.60**	**198,866,729**
1.PS4a.4.3	Contingency - Cost 30%	1.0	lsum	119,318,837	1.0					119,318,837.00	119,318,837
1.PS4a.4.3	Contingency - Schedule 10%	1.0	lsum	39,773,946	1.0					39,773,945.80	39,773,946
1.PS4a.4.3	Contingency - TPRA 10%	1.0	lsum	39,773,946	1.0					39,773,945.80	39,773,946
1.PS4a.4.3	**Excavation, Treatment, Onsite - IOM - Contingency Total**				**3.0**					**198,866,728.60**	**198,866,729**
1.PS4a.4	**Excavation, Treatment, Onsite - Indirect Operations & Maintenance Total**				**291,837.7**	**64,067,702.69**				**198,866,728.60**	**262,934,431**
1.PS4a	**Excavation of pits and shafts with on-site disposal in a CAMU/RCRA landfill Total**				**58,462,101.6**	**6,881,966,019.82**	**744,701,800.37**	**3,954,102,409.91**	**237,086,974.35**	**5,911,042,820.09**	**17,728,900,025**
1.PS4b	**Project WBS: 1.PS4b - Excavation of pits and shafts with off-site disposal**										
1.PS4b.1	**Project WBS: 1.PS4b.1 - Bulk Excavation with Offsite Disposal - Direct Cost**										
1.PS4b.1.1	**Project WBS: 1.PS4b.1.1 - Excavation, Offsite - DC - Fence**										
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS4b.1.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.PS4b.1.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.PS4b.1.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.PS4b.1.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.PS4b.1.1	**Excavation, Offsite - DC - Fence Total**				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS4b.1.2	**Project WBS: 1.PS4b.1.2 - Excavation, Offsite - DC - Excavation**										
1.PS4b.1.2.01	**Project WBS: 1.PS4b.1.2.01 - Excavation, Offsite - DC - Excavation - Pits - MLLW**										
	Pits Excavation DC				**3,039,346.2**	**237,809,437.43**	**21,791,935.20**		**77,752,416.93**	**1,398,632.16**	**338,752,422**
1.PS4b.1.2.01	Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	304,920.0	SY	3	9,045.4	709,595.06			160,582.16		870,177
1.PS4b.1.2.01	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	1,020,464.0	B.C.Y.	35	409,677.7	32,138,613.47			3,900,797.38		36,039,411
1.PS4b.1.2.01	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	605,426.0	B.C.Y.	294	2,269,524.4	178,040,846.82					178,040,847
1.PS4b.1.2.01	Site Tuff Processing - Dozer D9 rip tuff material	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS4b.1.2.01	Site Tuff Processing - 980 Frontend loader	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS4b.1.2.01	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	415,038.0	CY	1	5,149.8	401,448.16					401,448

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4b.1.2.01	Site Tuff Processing - 963 Hydraulic Excavator	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS4b.1.2.01	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	415,038.0	CY	2	10,299.6	638,710.79					638,711
1.PS4b.1.2.01	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	415,038.0	CY	0					186,128.79		186,129
1.PS4b.1.2.01	Site Tuff Processing - Rock crusher plant rental	360.0	MNTH	47,564					17,123,096.14		17,123,096
1.PS4b.1.2.01	Site Tuff Processing - Rock crusher plant : Scheduled Maintenance	2.0	EA	6,795						13,589.76	13,590
1.PS4b.1.2.01	Site Tuff Processing - Screening plant rental	30.0	MNTH	26,330					789,904.73		789,905
1.PS4b.1.2.01	Site Tuff Processing - Screening plant : Scheduled Maintenance	2.0	EA	4,077						8,153.86	8,154
1.PS4b.1.2.01	Dozer D9 rental	360.0	MNTH	49,949					17,981,697.10		17,981,697
1.PS4b.1.2.01	Dozer D9 Scheduled Maintenance	30.0	YR	12,322						369,659.62	369,660
1.PS4b.1.2.01	Dozer D9 Ripper replacement	60.0	SET	1,100	451.2	35,172.96				30,841.96	66,015
1.PS4b.1.2.01	Dozer cutting edge replacement	180.0	EA	2,192	2,707.2	211,037.76	183,461.74				394,500
1.PS4b.1.2.01	980, 7 cy frontend loader rental	360.0	MNTH	28,426					10,233,496.10		10,233,496
1.PS4b.1.2.01	980 Loader: Scheduled Maintenance	30.0	YR	9,963						298,899.44	298,899
1.PS4b.1.2.01	980-7cy loader bucket teeth replacement.	210.0	EA	2,000	1,579.2	123,105.36	296,800.33				419,906
1.PS4b.1.2.01	825H High speed compactor (sheepsfoot) rental	360.0	MNTH	17,981					6,473,141.88		6,473,142
1.PS4b.1.2.01	825H: Scheduled Maintenance	30.0	YR	10,098						302,944.26	302,944
1.PS4b.1.2.01	963 Hydraulic Excavator rental	360.0	MNTH	31,664					11,399,089.71		11,399,090
1.PS4b.1.2.01	963 Hydraulic Excavator : Scheduled Maintenance	30.0	YR	12,485						374,543.27	374,543
1.PS4b.1.2.01	963 Hydraulic Excavator tip long replacement.	270.0	EA	1,313	2,030.4	158,278.32	196,299.48				354,578
1.PS4b.1.2.01	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	635,697.3	ton	33			21,089,892.84				21,089,893
1.PS4b.1.2.01	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	1,275,580.0	L.C.Y.	10	95,520.6	7,493,448.44			5,742,160.64		13,235,609
1.PS4b.1.2.01	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	1,275,580.0	L.C.Y.	13	174,113.5	13,658,943.99			2,860,508.10		16,519,452
1.PS4b.1.2.01	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	1,020,464.0	E.C.Y.	1	8,705.7	682,947.20			416,049.18		1,098,996
1.PS4b.1.2.01	Track out device	3.0	EA	9,316	33.8	2,467.26	25,480.80				27,948
1.PS4b.1.2.01	Clean out track out device.	23.0	EA	2,863	518.9	37,831.40			28,007.17		65,839
1.PS4b.1.2.01	Rent toilet portable chemical	360.0	mnth	679					244,615.66		244,616
1.PS4b.1.2.01	Chemical toilet cleaning.	360.0	mnth	2,691	12,182.4	755,470.43			213,142.19		968,613
1.PS4b.1.2.01	Chemical toilet cleaning (labor)	360.0	mnth	2,011	12,182.4	724,011.33					724,011
	Re-Seeding				**3,578.3**	**165,460.53**	**3,119,631.06**		**107,001.87**		**3,392,093**
1.PS4b.1.2.01	Reveg - Seeding athletic fields, seeding utility mix with mulch and fertilizer, 7 lb. per M.S.F., hydro or air seeding	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS4b.1.2.01	Reveg - Hydroseeding materials.	1.0	lsum	2,022,902			2,022,901.85				2,022,902
1.PS4b.1.2.01	Reveg - Mulching athletic fields,	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS4b.1.2.01	Reveg - Mulch and Humate materials.	1.0	LS	907,509			907,508.81				907,509
1.PS4b.1.2.01	Reveg - Rent water truck, off highway, 6000 gallon capacity - Rent per day	40.0	days	1,367	902.4				54,698.78		54,699
1.PS4b.1.2.01	**Excavation, Offsite - DC - Excavation - Pits - MLLW Total**				**3,042,924.5**	**237,974,897.96**	**24,911,566.26**		**77,859,418.80**	**1,398,632.16**	**342,144,515**
1.PS4b.1.2.02	**Project WBS: 1.PS4b.1.2.02 - Excavation, Offsite - DC - Excavation - Pits - MLLW Waste**										
	Pits Excavation Waste				**18,712,061.1**	**1,464,460,048.78**	**622,728,713.20**	**1,421,587,487.27**	**149,121,473.56**		**3,657,897,723**
1.PS4b.1.2.02	Waste container delivery.	9,082.0	ea	2,469	273,186.6	17,976,607.47			4,449,369.94		22,425,977
1.PS4b.1.2.02	Waste container unload on site and handling during project.	181,628.0	ea	7,827	16,390,110.7	1,285,763,058.94			135,755,439.52		1,421,518,498
1.PS4b.1.2.02	Waste containers.	181,628.0	ea	3,429			622,728,713.20				622,728,713
1.PS4b.1.2.02	Fill waste containers.	181,628.0	ea	934	2,048,763.8	160,720,382.37			8,916,664.10		169,637,046
1.PS4b.1.2.02	Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	605,426.0	cy	1,892				1,145,692,371.96			1,145,692,372
1.PS4b.1.2.02	Trucking cost per 43,000 pound load	36,326.0	Trip	7,595				275,895,115.31			275,895,115
1.PS4b.1.2.02	**Excavation, Offsite - DC - Excavation - Pits - MLLW Waste Total**				**18,712,061.1**	**1,464,460,048.78**	**622,728,713.20**	**1,421,587,487.27**	**149,121,473.56**		**3,657,897,723**
1.PS4b.1.2.03	**Project WBS: 1.PS4b.1.2.03 - Excavation, Offsite - DC - Excavation - Pits - MLLW & TRU**										
	Pits Excavation w/TRU DC				**1,435,179.4**	**112,508,900.47**	**9,273,421.53**		**6,039,905.57**		**127,822,228**
1.PS4b.1.2.03	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	470,789.0	B.C.Y.	35	189,004.0	14,827,084.25			1,799,624.97		16,626,709
1.PS4b.1.2.03	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	293,498.0	B.C.Y.	294	1,100,218.5	86,310,519.30					86,310,519
1.PS4b.1.2.03	Site Tuff Processing - Dozer D9 rip tuff material	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS4b.1.2.03	Site Tuff Processing - 980 Frontend loader	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS4b.1.2.03	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS4b.1.2.03	Site Tuff Processing - 963 Hydraulic Excavator	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS4b.1.2.03	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	177,291.0	CY	2	4,399.7	272,836.89					272,837
1.PS4b.1.2.03	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	177,291.0	CY	0					79,508.28		79,508
1.PS4b.1.2.03	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	279,522.0	ton	33			9,273,421.53				9,273,422
1.PS4b.1.2.03	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	588,487.0	L.C.Y.	10	44,068.3	3,457,091.67			2,649,137.56		6,106,229
1.PS4b.1.2.03	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	588,487.0	L.C.Y.	13	80,327.0	6,301,534.18			1,319,691.30		7,621,225
1.PS4b.1.2.03	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	470,789.0	E.C.Y.	1	4,016.3	315,076.31			191,943.45		507,020
1.PS4b.1.2.03	**Excavation, Offsite - DC - Excavation - Pits - MLLW & TRU Total**				**1,435,179.4**	**112,508,900.47**	**9,273,421.53**		**6,039,905.57**		**127,822,228**
1.PS4b.1.2.04	**Project WBS: 1.PS4b.1.2.04 - Excavation, Offsite - DC - Excavation - Pits - MLLW & TRU Waste**										
	Pits Excavation w/TRU Waste				**7,385,704.1**	**578,026,455.32**	**245,792,491.91**	**561,102,228.96**	**58,858,750.77**		**1,443,779,927**
1.PS4b.1.2.04	Waste container delivery.	3,585.0	ea	2,469	107,836.8	7,096,029.27			1,756,330.24		8,852,360
1.PS4b.1.2.04	Waste container unload on site and handling during project.	71,689.0	ea	7,827	6,469,215.4	507,493,712.05			53,582,992.18		561,076,704
1.PS4b.1.2.04	Waste containers.	71,689.0	ea	3,429			245,792,491.91				245,792,492
1.PS4b.1.2.04	Fill waste containers.	71,689.0	ea	934	808,651.9	63,436,714.01			3,519,428.35		66,956,142
1.PS4b.1.2.04	Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	238,962.0	cy	1,892				452,205,456.31			452,205,456
1.PS4b.1.2.04	Trucking cost per 43,000 pound load	14,338.0	Trip	7,595				108,896,772.65			108,896,773
	Pits Excavation w/TRU Waste				**16,856,022.6**	**1,319,197,745.28**	**560,952,302.32**	**1,280,608,620.10**	**134,332,555.05**		**3,295,091,223**

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4b.1.2.04	Waste container delivery.	819.0	ea	24,693	246,354.7	16,210,982.48			4,012,362.08		20,223,345
1.PS4b.1.2.04	Waste container unload on site and handling during project.	16,361.0	ea	78,265	14,764,178.2	1,158,212,735.73			122,288,222.47		1,280,500,958
1.PS4b.1.2.04	Waste containers.	16,361.0	ea	34,286			560,952,302.32				560,952,302
1.PS4b.1.2.04	Fill waste containers.	16,361.0	ea	9,340	1,845,489.6	144,774,027.06			8,031,970.50		152,805,998
1.PS4b.1.2.04	Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	54,536.0	cy	18,924				1,032,025,040.18			1,032,025,040
1.PS4b.1.2.04	Trucking cost per 43,000 pound load	3,273.0	Trip	75,950				248,583,579.92			248,583,580
1.PS4b.1.2.04	**Excavation, Offsite - DC - Excavation - Pits - MLLW & TRU Waste Total**				**24,241,726.6**	**1,897,224,200.60**	**806,744,794.23**	**1,841,710,849.05**	**193,191,305.82**		**4,738,871,150**
1.PS4b.1.2.05	**Project WBS: 1.PS4b.1.2.05 - Excavation, Offsite - DC - Excavation - Shafts - PCB**										
	Shaft 1 DC				**65,749.8**	**5,125,526.20**	**69,769.13**		**983,679.04**		**6,178,974**
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	75,111.0	B.C.Y.	35	30,154.2	2,365,554.69			287,117.23		2,652,672
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	2,103.0	B.C.Y.	294	7,883.4	618,440.41					618,440
1.PS4b.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	73,008.0	CY	2	1,800.8	140,378.94					140,379
1.PS4b.1.2.05	Site Tuff Processing - 980 Frontend loader	73,008.0	CY	2	1,800.8	140,378.94					140,379
1.PS4b.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	73,008.0	CY	1	905.9	70,617.45					70,617
1.PS4b.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	73,008.0	CY	1	905.9	70,617.45					70,617
1.PS4b.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	73,008.0	CY	2	1,811.8	112,353.56					112,354
1.PS4b.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	73,008.0	CY	0					32,741.32		32,741
1.PS4b.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	2,103.0	ton	33			69,769.13				69,769
1.PS4b.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	93,888.8	L.C.Y.	10	7,030.8	551,553.42			422,650.31		974,204
1.PS4b.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	93,888.8	L.C.Y.	13	12,815.6	1,005,363.19			210,546.99		1,215,910
1.PS4b.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	75,111.0	E.C.Y.	1	640.8	50,268.16			30,623.20		80,891
	Shaft 2 DC				**9,992.9**	**778,665.07**	**6,548.94**		**157,707.45**		**942,921**
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	12,037.0	B.C.Y.	35	4,832.4	379,094.70			46,012.30		425,107
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	188.0	B.C.Y.	294	704.7	55,286.16					55,286
1.PS4b.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	11,849.0	CY	2	292.3	22,783.12					22,783
1.PS4b.1.2.05	Site Tuff Processing - 980 Frontend loader	11,849.0	CY	2	292.3	22,783.12					22,783
1.PS4b.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	11,849.0	CY	1	147.0	11,461.02					11,461
1.PS4b.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	11,849.0	CY	1	147.0	11,461.02					11,461
1.PS4b.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	11,849.0	CY	2	294.0	18,234.68					18,235
1.PS4b.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	11,849.0	CY	0					5,313.83		5,314
1.PS4b.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	197.4	ton	33			6,548.94				6,549
1.PS4b.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	15,046.3	L.C.Y.	10	1,126.7	88,389.83			67,732.31		156,122
1.PS4b.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	15,046.3	L.C.Y.	13	2,053.8	161,115.64			33,741.45		194,857
1.PS4b.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	12,037.0	E.C.Y.	1	102.7	8,055.78			4,907.56		12,963
	Shaft 3 DC				**8,198.9**	**638,675.62**	**2,753.61**		**134,082.12**		**775,511**
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	10,231.0	B.C.Y.	35	4,107.4	322,216.32			39,108.74		361,325
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	79.0	B.C.Y.	294	296.1	23,231.95					23,232
1.PS4b.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	10,153.0	CY	2	250.4	19,522.07					19,522
1.PS4b.1.2.05	Site Tuff Processing - 980 Frontend loader	10,153.0	CY	2	250.4	19,522.07					19,522
1.PS4b.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	10,153.0	CY	1	126.0	9,820.55					9,821
1.PS4b.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	10,153.0	CY	1	126.0	9,820.55					9,821
1.PS4b.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	10,153.0	CY	2	252.0	15,624.67					15,625
1.PS4b.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	10,153.0	CY	0					4,553.24		4,553
1.PS4b.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	83.0	ton	33			2,753.61				2,754
1.PS4b.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	12,788.8	L.C.Y.	10	957.7	75,128.05			57,569.93		132,698
1.PS4b.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	12,788.8	L.C.Y.	13	1,745.6	136,942.27			28,678.97		165,621
1.PS4b.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	10,231.0	E.C.Y.	1	87.3	6,847.11			4,171.24		11,018
	Shaft 4 DC				**15,041.3**	**1,171,589.11**	**3,657.65**		**248,471.78**		**1,423,719**
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	18,958.0	B.C.Y.	35	7,610.9	597,065.49			72,468.32		669,534
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	105.0	B.C.Y.	294	393.6	30,877.91					30,878
1.PS4b.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	18,854.0	CY	2	465.0	36,252.25					36,252
1.PS4b.1.2.05	Site Tuff Processing - 980 Frontend loader	18,854.0	CY	2	465.0	36,252.25					36,252
1.PS4b.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	18,854.0	CY	1	233.9	18,236.65					18,237
1.PS4b.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	18,854.0	CY	1	233.9	18,236.65					18,237
1.PS4b.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	18,854.0	CY	2	467.9	29,014.82					29,015
1.PS4b.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	18,854.0	CY	0					8,455.30		8,455
1.PS4b.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	110.3	ton	33			3,657.65				3,658
1.PS4b.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	23,697.5	L.C.Y.	10	1,774.6	139,211.96			106,676.85		245,889
1.PS4b.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	23,697.5	L.C.Y.	13	3,234.6	253,753.45			53,142.01		306,895
1.PS4b.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	18,958.0	E.C.Y.	1	161.7	12,687.67			7,729.29		20,417
	Shaft 5 DC				**21,716.1**	**1,692,623.32**	**20,726.71**		**331,099.79**		**2,044,450**
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	25,278.0	B.C.Y.	35	10,148.2	796,108.31			96,626.98		892,735
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	595.0	B.C.Y.	294	2,230.4	174,974.82					174,975

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4b.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	24,683.0	CY	2	608.8	47,460.19					47,460
1.PS4b.1.2.05	Site Tuff Processing - 980 Frontend loader	24,683.0	CY	2	608.8	47,460.19					47,460
1.PS4b.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	24,683.0	CY	1	306.3	23,874.79					23,875
1.PS4b.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	24,683.0	CY	1	306.3	23,874.79					23,875
1.PS4b.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	24,683.0	CY	2	612.5	37,985.19					37,985
1.PS4b.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	24,683.0	CY	0					11,069.39		11,069
1.PS4b.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	624.8	ton	33			20,726.71				20,727
1.PS4b.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	31,597.5	L.C.Y.	10	2,366.1	185,620.84			142,239.55		327,860
1.PS4b.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	31,597.5	L.C.Y.	13	4,313.0	338,346.86			70,857.89		409,205
1.PS4b.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	25,278.0	E.C.Y.	1	215.6	16,917.34			10,305.99		27,223
	Shaft 6 DC				**19,498.0**	**1,520,292.51**	**26,265.44**		**283,384.86**		**1,829,943**
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	21,667.0	B.C.Y.	35	8,698.5	682,383.05			82,823.67		765,207
1.PS4b.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	754.0	B.C.Y.	294	2,826.5	221,732.79					221,733
1.PS4b.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	20,913.0	CY	2	515.8	40,211.27					40,211
1.PS4b.1.2.05	Site Tuff Processing - 980 Frontend loader	20,913.0	CY	2	515.8	40,211.27					40,211
1.PS4b.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	20,913.0	CY	1	259.5	20,228.23					20,228
1.PS4b.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	20,913.0	CY	1	259.5	20,228.23					20,228
1.PS4b.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	20,913.0	CY	2	519.0	32,183.46					32,183
1.PS4b.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	20,913.0	CY	0					9,378.69		9,379
1.PS4b.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	791.7	ton	33			26,265.44				26,265
1.PS4b.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	27,083.8	L.C.Y.	10	2,028.1	159,104.63			121,920.42		281,025
1.PS4b.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	27,083.8	L.C.Y.	13	3,696.9	290,013.50			60,735.73		350,749
1.PS4b.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	20,913.0	E.C.Y.	1	178.4	13,996.06			8,526.35		22,522
1.PS4b.1.2.05	**Excavation, Offsite - DC - Excavation - Shafts - PCB Total**				**140,197.1**	**10,927,371.84**	**129,721.47**		**2,138,425.04**		**13,195,518**
1.PS4b.1.2.06	**Project WBS: 1.PS4b.1.2.06 - Excavation, Offsite - DC - Excavation - Shafts - PCB Waste**										
	Shaft 1 Waste				**65,021.7**	**5,088,616.95**	**2,163,442.96**	**4,944,224.36**	**518,287.41**		**12,714,572**
1.PS4b.1.2.06	MLLW - Waste container delivery.	32.0	ea	2,469	962.6	63,339.73			15,677.15		79,017
1.PS4b.1.2.06	MLLW - Waste container unload on site and handling during project.	631.0	ea	7,827	56,941.4	4,466,913.09			471,632.58		4,938,546
1.PS4b.1.2.06	MLLW - Waste containers.	631.0	ea	3,429			2,163,442.96				2,163,443
1.PS4b.1.2.06	MLLW - Fill waste containers.	631.0	ea	934	7,117.7	558,364.14			30,977.69		589,342
1.PS4b.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	2,103.0	cy	1,892				3,979,662.35			3,979,662
1.PS4b.1.2.06	MLLW - Trucking cost per 43,000 pound load	127.0	Trip	7,595				964,562.01			964,562
	Shaft 2 Waste				**5,876.9**	**459,885.49**	**195,429.87**	**446,906.01**	**46,871.93**		**1,149,093**
1.PS4b.1.2.06	MLLW - Waste container delivery.	3.0	ea	2,469	90.2	5,938.10			1,469.73		7,408
1.PS4b.1.2.06	MLLW - Waste container unload on site and handling during project.	57.0	ea	7,827	5,143.7	403,508.79			42,603.89		446,113
1.PS4b.1.2.06	MLLW - Waste containers.	57.0	ea	3,429			195,429.87				195,430
1.PS4b.1.2.06	MLLW - Fill waste containers.	57.0	ea	934	643.0	50,438.60			2,798.30		53,237
1.PS4b.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	188.0	cy	1,892				355,766.30			355,766
1.PS4b.1.2.06	MLLW - Trucking cost per 43,000 pound load	12.0	Trip	7,595				91,139.72			91,140
	Shaft 3 Waste				**2,496.6**	**195,094.48**	**82,286.26**	**187,472.42**	**20,096.54**		**484,950**
1.PS4b.1.2.06	MLLW - Waste container delivery.	2.0	ea	2,469	60.2	3,958.73			979.82		4,939
1.PS4b.1.2.06	MLLW - Waste container unload on site and handling during project.	24.0	ea	7,827	2,165.8	169,898.44			17,938.48		187,837
1.PS4b.1.2.06	MLLW - Waste containers.	24.0	ea	3,429			82,286.26				82,286
1.PS4b.1.2.06	MLLW - Fill waste containers.	24.0	ea	934	270.7	21,237.30			1,178.23		22,416
1.PS4b.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	79.0	cy	1,892				149,497.54			149,498
1.PS4b.1.2.06	MLLW - Trucking cost per 43,000 pound load	5.0	Trip	7,595				37,974.88			37,975
	Shaft 4 Waste				**3,308.8**	**258,806.39**	**109,715.02**	**358,193.77**	**26,468.77**		**753,184**
1.PS4b.1.2.06	MLLW - Waste container delivery.	2.0	ea	2,469	60.2	3,958.73			979.82		4,939
1.PS4b.1.2.06	MLLW - Waste container unload on site and handling during project.	32.0	ea	7,827	2,887.7	226,531.25			23,917.98		250,449
1.PS4b.1.2.06	MLLW - Waste containers.	32.0	ea	3,429			109,715.02				109,715
1.PS4b.1.2.06	MLLW - Fill waste containers.	32.0	ea	934	361.0	28,316.41			1,570.98		29,887
1.PS4b.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	105.0	cy	1,892				198,699.26			198,699
1.PS4b.1.2.06	MLLW - Trucking cost per 43,000 pound load	21.0	Trip	7,595				159,494.51			159,495
	Shaft 5 Waste				**18,442.8**	**1,443,368.38**	**613,718.37**	**1,399,381.63**	**146,988.02**		**3,603,456**
1.PS4b.1.2.06	MLLW - Waste container delivery.	9.0	ea	2,469	270.7	17,814.30			4,409.20		22,223
1.PS4b.1.2.06	MLLW - Waste container unload on site and handling during project.	179.0	ea	7,827	16,153.0	1,267,159.18			133,791.18		1,400,950
1.PS4b.1.2.06	MLLW - Waste containers.	179.0	ea	3,429			613,718.37				613,718
1.PS4b.1.2.06	MLLW - Fill waste containers.	179.0	ea	934	2,019.1	158,394.90			8,787.65		167,183
1.PS4b.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	595.0	cy	1,892				1,125,962.48			1,125,962
1.PS4b.1.2.06	MLLW - Trucking cost per 43,000 pound load	36.0	Trip	7,595				273,419.15			273,419
	Shaft 6 Waste				**2,560.6**	**200,869.51**		**755,692.51**	**11,144.11**		**967,706**
1.PS4b.1.2.06	PCB - Fill waste containers.	227.0	ea	934	2,560.6	200,869.51			11,144.11		212,014
1.PS4b.1.2.06	PCB - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	754.0	cy	1,002				755,692.51			755,693
	Shaft RCRA Waste				**2,192.1**	**171,202.51**	**72,000.48**	**166,656.31**	**17,706.95**		**427,566**
1.PS4b.1.2.06	RCRA - Waste container delivery.	2.0	ea	2,469	60.2	3,958.73			979.82		4,939
1.PS4b.1.2.06	RCRA - Waste container unload on site and handling during project.	21.0	ea	7,827	1,895.0	148,661.13			15,696.17		164,357
1.PS4b.1.2.06	RCRA - Waste containers.	21.0	ea	3,429			72,000.48				72,000
1.PS4b.1.2.06	RCRA - Fill waste containers.	21.0	ea	934	236.9	18,582.64			1,030.95		19,614

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4b.1.2.06	RCRA - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	68.0	cy	1,892				128,681.43			128,681
1.PS4b.1.2.06	RCRA - Trucking cost per 43,000 pound load	5.0	Trip	7,595				37,974.88			37,975
1.PS4b.1.2.06	**Excavation, Offsite - DC - Excavation - Shafts - PCB Waste Total**				**99,899.4**	**7,817,843.70**	**3,236,592.96**	**8,258,527.02**	**787,563.73**		**20,100,527**
1.PS4b.1.2.07	**Project WBS: 1.PS4b.1.2.07 - Excavation, Offsite - DC - Road**										
	Pits Excavation DC				**32,470.9**	**2,367,445.84**	**1,869,660.68**		**135,292.03**		**4,372,399**
1.PS4b.1.2.07	Temporary, roads, excl surfacing.	106,170.0	SY	40	31,165.8	2,272,290.86	1,794,513.22		129,854.22		4,196,658
1.PS4b.1.2.07	Temporary, roads, excl surfacing. O&M	4,446.0	SY	40	1,305.1	95,154.99	75,147.46		5,437.81		175,740
1.PS4b.1.2.07	**Excavation, Offsite - DC - Road Total**				**32,470.9**	**2,367,445.84**	**1,869,660.68**		**135,292.03**		**4,372,399**
1.PS4b.1.2.08	**Project WBS: 1.PS4b.1.2.08 - Excavation, Offsite - DC - Containment**										
	Pits Excavation DC				**1,440,000.0**	**191,534,061.09**		**535,096,754.32**			**726,630,815**
1.PS4b.1.2.08	Moveable Covers	3.0	ea	67,242,127	1,440,000.0	191,534,061.09		10,192,319.13			201,726,380
1.PS4b.1.2.08	Moveable Covers Mob/Demob	618.0	ea	849,360				524,904,435.19			524,904,435
1.PS4b.1.2.08	**Excavation, Offsite - DC - Containment Total**				**1,440,000.0**	**191,534,061.09**		**535,096,754.32**			**726,630,815**
1.PS4b.1.2.09	**Project WBS: 1.PS4b.1.2.09 - Excavation, Offsite - DC - Project Costs**										
	Pits Excavation DC				**34,405,015.7**	**2,070,806,544.15**	**207,265,122.90**	**38,496,772.59**		**5,945.52**	**2,316,574,385**
1.PS4b.1.2.09	Excavation permit	5.0	ea	1,189						5,945.52	5,946
1.PS4b.1.2.09	Storm water prevention	1.0	LS	38,496,773				38,496,772.59			38,496,773
1.PS4b.1.2.09	Field Non-Manual - JHRS	9,830,004.5	hour	112	9,830,004.5	1,103,765,809.94					1,103,765,810
1.PS4b.1.2.09	Craft Distributable - Labor	12,287,505.6	hour	79	12,287,505.6	967,040,734.21					967,040,734
1.PS4b.1.2.09	Craft Distributable - Materials	12,287,505.6	hour	12	12,287,505.6		146,111,208.12				146,111,208
1.PS4b.1.2.09	Craft Distrib for interior excavation work	360.0	mnth	169,872			61,153,914.78				61,153,915
1.PS4b.1.2.09	**Excavation, Offsite - DC - Project Costs Total**				**34,405,015.7**	**2,070,806,544.15**	**207,265,122.90**	**38,496,772.59**		**5,945.52**	**2,316,574,385**
1.PS4b.1.2	**Excavation, Offsite - DC - Excavation Total**				**83,549,474.7**	**5,995,621,314.42**	**1,676,159,593.21**	**3,845,150,390.26**	**429,273,384.55**	**1,404,577.68**	**11,947,609,260**
1.PS4b.1	**Bulk Excavation with Offsite Disposal - Direct Cost Total**				**83,555,037.9**	**5,996,062,384.46**	**1,676,949,896.30**	**3,845,150,390.26**	**429,301,384.12**	**1,404,577.68**	**11,948,868,633**
1.PS4b.2	**Project WBS: 1.PS4b.2 - Excavation, Offsite - Indirect Cost**										
1.PS4b.2.1	**Project WBS: 1.PS4b.2.1 - Excavation, Offsite - IC - Design**										
	Pits Excavation DC							**2,763,247,564.59**			**2,763,247,565**
1.PS4b.2.1	Design	1.0	lsum	2,763,247,565				2,763,247,564.59			2,763,247,565
1.PS4b.2.1	**Excavation, Offsite - IC - Design Total**							**2,763,247,564.59**			**2,763,247,565**
1.PS4b.2.2	**Project WBS: 1.PS4b.2.2 - Excavation, Offsite - IC - Professional Management**										
	Pits Excavation DC				**31,191,825.7**	**6,847,672,871.01**					**6,847,672,871**
1.PS4b.2.2	Professional Management	1.0	lsum	6,847,672,871	31,191,825.7	6,847,672,871.01					6,847,672,871
1.PS4b.2.2	**Excavation, Offsite - IC - Professional Management Total**				**31,191,825.7**	**6,847,672,871.01**					**6,847,672,871**
1.PS4b.2.3	**Project WBS: 1.PS4b.2.3 - Excavation, Offsite - IC - Contingency**										
	Pits Excavation DC				**3.0**					**10,779,894,534.50**	**10,779,894,535**
1.PS4b.2.3	Contingency - Cost 30%	1.0	lsum	6,467,936,721	1.0					6,467,936,720.70	6,467,936,721
1.PS4b.2.3	Contingency - Schedule 10%	1.0	lsum	2,155,978,907	1.0					2,155,978,906.90	2,155,978,907
1.PS4b.2.3	Contingency - TPRA 10%	1.0	lsum	2,155,978,907	1.0					2,155,978,906.90	2,155,978,907
1.PS4b.2.3	**Excavation, Offsite - IC - Contingency Total**				**3.0**					**10,779,894,534.50**	**10,779,894,535**
1.PS4b.2	**Excavation, Offsite - Indirect Cost Total**				**31,191,828.7**	**6,847,672,871.01**		**2,763,247,564.59**		**10,779,894,534.50**	**20,390,814,970**
1.PS4b.3	**Project WBS: 1.PS4b.3 - Excavation, Offsite - Direct Operations & Maintenance**										
1.PS4b.3.1	**Project WBS: 1.PS4b.3.1 - Excavation, Offsite - DOM - Cover Maintenance & Inspections**										
	Pits Excavation DC				**4,145.7**	**469,174.90**					**469,175**
1.PS4b.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.PS4b.3.1	**Excavation, Offsite - DOM - Cover Maintenance & Inspections Total**				**4,145.7**	**469,174.90**					**469,175**
1.PS4b.3	**Excavation, Offsite - Direct Operations & Maintenance Total**				**4,145.7**	**469,174.90**					**469,175**
1.PS4b.4	**Project WBS: 1.PS4b.4 - Excavation, Offsite - Indirect Operations & Maintenance**										
1.PS4b.4.2	**Project WBS: 1.PS4b.4.2 - Excavation, Offsite - IOM - Professional Management**										
	Pits Excavation DC				**372.6**	**81,794.13**					**81,794**
1.PS4b.4.2	Professional Management (years 100)	1.0	lsum	81,794	372.6	81,794.13					81,794
1.PS4b.4.2	**Excavation, Offsite - IOM - Professional Management Total**				**372.6**	**81,794.13**					**81,794**
1.PS4b.4.3	**Project WBS: 1.PS4b.4.3 - Excavation, Offsite - IOM - Contingency**										
	Pits Excavation DC				**3.0**					**275,484.50**	**275,485**
1.PS4b.4.3	Contingency - Cost 30%	1.0	lsum	165,291	1.0					165,290.70	165,291

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4b.4.3	Contingency - Schedule 10%	1.0	lsum	55,097	1.0					55,096.90	55,097
1.PS4b.4.3	Contingency - TPRA 10%	1.0	lsum	55,097	1.0					55,096.90	55,097
1.PS4b.4.3	**Excavation, Offsite - IOM - Contingency Total**				**3.0**					**275,484.50**	**275,485**
1.PS4b.4	**Excavation, Offsite - Indirect Operations & Maintenance Total**				**375.6**	**81,794.13**				**275,484.50**	**357,279**
1.PS4b	**Excavation of pits and shafts with off-site disposal Total**				**114,751,388.0**	**12,844,286,224.50**	**1,676,949,896.30**	**6,608,397,954.85**	**429,301,384.12**	**10,781,574,596.68**	**32,340,510,056**
1.PS4c	**Project WBS: 1.PS4c - Excavation of pits and over-coring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill**										
1.PS4c.1	**Project WBS: 1.PS4c.1 - Excavation & Overcore, Treatment, Onsite - Direct Cost**										
1.PS4c.1.1	**Project WBS: 1.PS4c.1.1 - Excavation & Overcore, Treatment, Onsite - Fence**										
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS4c.1.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.PS4c.1.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.PS4c.1.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.PS4c.1.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.PS4c.1.1	**Excavation & Overcore, Treatment, Onsite - Fence Total**				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS4c.1.2	**Project WBS: 1.PS4c.1.2 - Excavation & Overcore, Treatment, Onsite - Excavation**										
1.PS4c.1.2.01	**Project WBS: 1.PS4c.1.2.01 - Excavation & Overcore, Treatment, Onsite - Excavation - Pits - MLLW**										
	Pits Excavation DC				**3,034,691.0**	**237,444,247.37**	**18,628,451.10**		**77,801,645.15**	**1,404,577.68**	**335,278,921**
1.PS4c.1.2.01	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	1,020,464.0	B.C.Y.	35	409,677.7	32,138,613.47			3,900,797.38		36,039,411
1.PS4c.1.2.01	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	605,426.0	B.C.Y.	294	2,269,524.4	178,040,846.82					178,040,847
1.PS4c.1.2.01	Site Tuff Processing - Dozer D9 rip tuff material	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS4c.1.2.01	Site Tuff Processing - 980 Frontend loader	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS4c.1.2.01	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS4c.1.2.01	Site Tuff Processing - 963 Hydraulic Excavator	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS4c.1.2.01	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	415,038.0	CY	2	10,299.6	638,710.79					638,711
1.PS4c.1.2.01	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	415,038.0	CY	0					186,128.79		186,129
1.PS4c.1.2.01	Site Tuff Processing - Rock crusher plant rental	360.0	MNTH	47,564					17,123,096.14		17,123,096
1.PS4c.1.2.01	Site Tuff Processing - Rock crusher plant : Scheduled Maintenance	2.0	EA	6,795						13,589.76	13,590
1.PS4c.1.2.01	Site Tuff Processing - Screening plant rental	30.0	MNTH	26,330					789,904.73		789,905
1.PS4c.1.2.01	Site Tuff Processing - Screening plant : Scheduled Maintenance	2.0	EA	4,077						8,153.86	8,154
1.PS4c.1.2.01	Dozer D9 rental	360.0	MNTH	49,949					17,981,697.10		17,981,697
1.PS4c.1.2.01	Dozer D9 Scheduled Maintenance	30.0	YR	12,322						369,659.62	369,660
1.PS4c.1.2.01	Dozer D9 Ripper replacement	60.0	SET	1,100	451.2	35,172.96				30,841.96	66,015
1.PS4c.1.2.01	Dozer cutting edge replacement	180.0	EA	2,192	2,707.2	211,037.76	183,461.74				394,500
1.PS4c.1.2.01	980, 7 cy frontend loader rental	360.0	MNTH	28,426					10,233,496.10		10,233,496
1.PS4c.1.2.01	980 Loader: Scheduled Maintenance	30.0	YR	9,963						298,899.44	298,899
1.PS4c.1.2.01	980-7cy loader bucket teeth replacement.	210.0	EA	2,000	1,579.2	123,105.36	296,800.33				419,906
1.PS4c.1.2.01	825H High speed compactor (sheepsfoot) rental	360.0	MNTH	17,981					6,473,141.88		6,473,142
1.PS4c.1.2.01	825H: Scheduled Maintenance	30.0	YR	10,098						302,944.26	302,944
1.PS4c.1.2.01	963 Hydraulic Excavator rental	360.0	MNTH	31,664					11,399,089.71		11,399,090
1.PS4c.1.2.01	963 Hydraulic Excavator : Scheduled Maintenance	30.0	YR	12,485						374,543.27	374,543
1.PS4c.1.2.01	963 Hydraulic Excavator tip long replacement.	270.0	EA	1,313	2,030.4	158,278.32	196,299.48				354,578
1.PS4c.1.2.01	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	540,342.7	ton	33			17,926,408.75				17,926,409
1.PS4c.1.2.01	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	1,275,580.0	L.C.Y.	10	95,520.6	7,493,448.44			5,742,160.64		13,235,609
1.PS4c.1.2.01	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	1,275,580.0	L.C.Y.	13	174,113.5	13,658,943.99			2,860,508.10		16,519,452
1.PS4c.1.2.01	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	1,020,464.0	E.C.Y.	1	8,705.7	682,947.20			416,049.18		1,098,996
1.PS4c.1.2.01	CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	514,612.1	E.C.Y.	1	4,390.2	344,404.99			209,810.38		554,215
1.PS4c.1.2.01	Excavation permit	5.0	ea	1,189						5,945.52	5,946
1.PS4c.1.2.01	Track out device	3.0	EA	9,316	33.8	2,467.26	25,480.80				27,948
1.PS4c.1.2.01	Clean out track out device.	23.0	EA	2,863	518.9	37,831.40			28,007.17		65,839
1.PS4c.1.2.01	Rent toilet portable chemical	360.0	mnth	679					244,615.66		244,616
1.PS4c.1.2.01	Chemical toilet cleaning.	360.0	mnth	2,691	12,182.4	755,470.43			213,142.19		968,613
1.PS4c.1.2.01	Chemical toilet cleaning (labor)	360.0	mnth	2,011	12,182.4	724,011.33					724,011
	Re-Seeding				**3,578.3**	**165,460.53**	**3,119,631.06**		**107,001.87**		**3,392,093**
1.PS4c.1.2.01	Reveg - Seeding athletic fields, seeding utility mix with mulch and fertilizer, 7 lb. per M.S.F., hydro or air seeding	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS4c.1.2.01	Reveg - Hydroseeding materials.	1.0	lsum	2,022,902			2,022,901.85				2,022,902
1.PS4c.1.2.01	Reveg - Mulching athletic fields,	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS4c.1.2.01	Reveg - Mulch and Humate materials.	1.0	LS	907,509			907,508.81				907,509
1.PS4c.1.2.01	Reveg - Rent water truck, off highway, 6000 gallon capacity - Rent per day	40.0	days	1,367	902.4				54,698.78		54,699
1.PS4c.1.2.01	**Excavation & Overcore, Treatment, Onsite - Excavation - Pits - MLLW Total**				**3,038,269.4**	**237,609,707.89**	**21,748,082.17**		**77,908,647.03**	**1,404,577.68**	**338,671,015**

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4c.1.2.02	**Project WBS: 1.PS4c.1.2.02 - Excavation & Overcore, Treatment, Onsite - Excavation - Pits - MLLW Waste**										
	Pits Excavation Waste							**113,121,410.96**			**113,121,411**
1.PS4c.1.2.02	Mob/Demob VOC treatment plant.	1.0	ea	220,834				220,833.58			220,834
1.PS4c.1.2.02	Processing VOC soil.	540,342.7	tn	209				112,900,577.38			112,900,577
1.PS4c.1.2.02	**Excavation & Overcore, Treatment, Onsite - Excavation - Pits - MLLW Waste Total**							**113,121,410.96**			**113,121,411**
1.PS4c.1.2.03	**Project WBS: 1.PS4c.1.2.03 - Excavation & Overcore, Treatment, Onsite - Excavation - Pits - MLLW & TRU**										
	Pits Excavation DC				**1,435,179.4**	**37,624,456.09**	**8,680,400.55**		**6,039,905.57**		**52,344,762**
1.PS4c.1.2.03	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	470,789.0	B.C.Y.	30	189,004.0	12,208,489.91			1,799,624.97		14,008,115
1.PS4c.1.2.03	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	293,498.0	B.C.Y.	53	1,100,218.5	15,465,668.70					15,465,669
1.PS4c.1.2.03	Site Tuff Processing - Dozer D9 rip tuff material	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS4c.1.2.03	Site Tuff Processing - 980 Frontend loader	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS4c.1.2.03	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS4c.1.2.03	Site Tuff Processing - 963 Hydraulic Excavator	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS4c.1.2.03	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	177,291.0	CY	2	4,399.7	272,836.89					272,837
1.PS4c.1.2.03	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	177,291.0	CY	0					79,508.28		79,508
1.PS4c.1.2.03	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	261,647.0	ton	33			8,680,400.55				8,680,401
1.PS4c.1.2.03	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	588,487.0	L.C.Y.	10	44,068.3	2,969,433.29			2,649,137.56		5,618,571
1.PS4c.1.2.03	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	588,487.0	L.C.Y.	11	80,327.0	5,412,637.89			1,319,691.30		6,732,329
1.PS4c.1.2.03	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	470,789.0	E.C.Y.	1	4,016.3	270,631.55			191,943.45		462,575
1.PS4c.1.2.03	**Excavation & Overcore, Treatment, Onsite - Excavation - Pits - MLLW & TRU Total**				**1,435,179.4**	**37,624,456.09**	**8,680,400.55**		**6,039,905.57**		**52,344,762**
1.PS4c.1.2.04	**Project WBS: 1.PS4c.1.2.04 - Excavation & Overcore, Treatment, Onsite - Excavation - Pits - MLLW & TRU Waste**										
	Pits Excavation w/TRU Waste				**1,732.8**	**116,761.56**		**44,561,928.16**	**82,812.28**		**44,761,502**
1.PS4c.1.2.04	CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	203,117.7	E.C.Y.	1	1,732.8	116,761.56			82,812.28		199,574
1.PS4c.1.2.04	Processing VOC soil.	213,273.6	tn	209				44,561,928.16			44,561,928
	Pits Excavation w/TRU Waste				**16,856,022.6**	**1,319,197,745.28**	**560,952,302.32**	**1,280,608,620.10**	**134,332,555.05**		**3,295,091,223**
1.PS4c.1.2.04	TRU - Waste container delivery.	819.0	ea	24,693	246,354.7	16,210,982.48			4,012,362.08		20,223,345
1.PS4c.1.2.04	TRU - Waste container unload on site and handling during project.	16,361.0	ea	78,265	14,764,178.2	1,158,212,735.73			122,288,222.47		1,280,500,958
1.PS4c.1.2.04	TRU - Waste containers.	16,361.0	ea	34,286			560,952,302.32				560,952,302
1.PS4c.1.2.04	TRU - Fill waste containers.	16,361.0	ea	9,340	1,845,489.6	144,774,027.06			8,031,970.50		152,805,998
1.PS4c.1.2.04	TRU - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	54,536.0	cy	18,924				1,032,025,040.18			1,032,025,040
1.PS4c.1.2.04	TRU - Trucking cost per 43,000 pound load	3,273.0	Trip	75,950				248,583,579.92			248,583,580
1.PS4c.1.2.04	**Excavation & Overcore, Treatment, Onsite - Excavation - Pits - MLLW & TRU Waste Total**				**16,857,755.4**	**1,319,314,506.84**	**560,952,302.32**	**1,325,170,548.26**	**134,415,367.33**		**3,339,852,725**
1.PS4c.1.2.05	**Project WBS: 1.PS4c.1.2.05 - Excavation & Overcore, Treatment, Onsite - Excavation - Shafts - PCB**										
	Shaft 1 DC				**845.9**	**66,361.53**	**874,356.77**	**21,573,742.16**	**27,390.09**		**22,541,851**
1.PS4c.1.2.05	Overcoring shaft size < 3' x 40'	83.0	ea	169,872				14,099,374.80			14,099,375
1.PS4c.1.2.05	Overcoring shaft size < 3' x 60'	30.0	ea	169,872				5,096,159.56			5,096,160
1.PS4c.1.2.05	Overcoring shaft size < 8' x 65'	14.0	ea	169,872				2,378,207.80			2,378,208
1.PS4c.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	26,355.1	ton	33			874,356.77				874,357
1.PS4c.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	3,882.5	L.C.Y.	10	290.7	22,807.91			17,477.49		40,285
1.PS4c.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	3,882.5	L.C.Y.	13	530.0	41,573.91			8,706.57		50,280
1.PS4c.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	2,958.1	E.C.Y.	1	25.2	1,979.71			1,206.03		3,186
	Shaft 2 DC				**75.1**	**5,891.97**	**7,763.18**	**679,487.94**	**2,433.57**		**695,577**
1.PS4c.1.2.05	Overcoring shaft size < 3' x 60'	2.0	ea	169,872				339,743.97			339,744
1.PS4c.1.2.05	Overcoring shaft size < 8' x 65'	2.0	ea	169,872				339,743.97			339,744
1.PS4c.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	234.0	ton	33			7,763.18				7,763
1.PS4c.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	344.2	L.C.Y.	10	25.8	2,022.02			1,549.45		3,571
1.PS4c.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	344.2	L.C.Y.	13	47.0	3,685.70			771.87		4,458
1.PS4c.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	275.3	E.C.Y.	1	2.3	184.25			112.25		296
	Shaft 3 DC				**12.9**	**1,008.24**	**928.93**	**339,743.97**	**416.43**		**342,098**
1.PS4c.1.2.05	Overcoring shaft size < 3' x 60'	2.0	ea	169,872				339,743.97			339,744
1.PS4c.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	28.0	ton	33			928.93				929
1.PS4c.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	58.9	L.C.Y.	10	4.4	346.01			265.14		611
1.PS4c.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	58.9	L.C.Y.	13	8.0	630.70			132.08		763
1.PS4c.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	47.1	E.C.Y.	1	0.4	31.52			19.20		51
	Shaft 4 DC				**93.0**	**7,292.26**	**10,089.82**	**1,528,847.87**	**3,011.94**		**1,549,242**
1.PS4c.1.2.05	Overcoring shaft size < 3' x 60'	7.0	ea	169,872				1,189,103.90			1,189,104
1.PS4c.1.2.05	Overcoring shaft size < 8' x 65'	2.0	ea	169,872				339,743.97			339,744
1.PS4c.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	304.1	ton	33			10,089.82				10,090
1.PS4c.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	426.0	L.C.Y.	10	31.9	2,502.55			1,917.68		4,420
1.PS4c.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	426.0	L.C.Y.	13	58.1	4,561.62			955.31		5,517

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4c.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	340.8	E.C.Y.	1	2.9	228.08			138.95		367
	Shaft 5 DC				130.2	10,212.59	14,128.00	849,359.93	4,218.14		877,919
1.PS4c.1.2.05	Overcoring shaft size < 3' x 60'	1.0	ea	169,872				169,871.99			169,872
1.PS4c.1.2.05	Overcoring shaft size < 8' x 65'	4.0	ea	169,872				679,487.94			679,488
1.PS4c.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	425.9	ton	33			14,128.00				14,128
1.PS4c.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	596.6	L.C.Y.	10	44.7	3,504.75			2,685.66		6,190
1.PS4c.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	596.6	L.C.Y.	13	81.4	6,388.41			1,337.88		7,726
1.PS4c.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	477.3	E.C.Y.	1	4.1	319.43			194.60		514
	Shaft 6 DC				105.8	8,297.94	11,478.90	2,038,463.83	3,427.32		2,061,668
1.PS4c.1.2.05	Overcoring shaft size < 3' x 60'	10.0	ea	169,872				1,698,719.86			1,698,720
1.PS4c.1.2.05	Overcoring shaft size < 8' x 65'	2.0	ea	169,872				339,743.97			339,744
1.PS4c.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	346.0	ton	33			11,478.90				11,479
1.PS4c.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	484.8	L.C.Y.	10	36.3	2,847.68			2,182.15		5,030
1.PS4c.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	484.8	L.C.Y.	13	66.2	5,190.72			1,087.06		6,278
1.PS4c.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	387.8	E.C.Y.	1	3.3	259.54			158.11		418
1.PS4c.1.2.05	Excavation & Overcore, Treatment, Onsite - Excavation - Shafts - PCB Total				1,262.8	99,064.53	918,745.59	27,009,645.69	40,897.50		28,068,353
1.PS4c.1.2.06	Project WBS: 1.PS4c.1.2.06 - Excavation & Overcore, Treatment, Onsite - Excavation - Shafts - PCB Waste										
	Shaft 1 Waste				214.5	16,827.66		5,516,333.84	10,251.36		5,543,413
1.PS4c.1.2.06	Shaft 1 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	25,144.0	E.C.Y.	1	214.5	16,827.66			10,251.36		27,079
1.PS4c.1.2.06	Processing VOC soil.	26,401.2	tn	209				5,516,333.84			5,516,334
	Shaft 2 Waste				1.9	149.24		48,923.90	90.92		49,164
1.PS4c.1.2.06	Shaft 2 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	223.0	E.C.Y.	1	1.9	149.24			90.92		240
1.PS4c.1.2.06	Processing VOC soil.	234.2	tn	209				48,923.90			48,924
	Shaft 3 Waste				0.2	17.87		5,871.29	10.89		5,900
1.PS4c.1.2.06	shaft 3 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	26.7	E.C.Y.	1	0.2	17.87			10.89		29
1.PS4c.1.2.06	Processing VOC soil.	28.1	tn	209				5,871.29			5,871
	Shaft 4 Waste				2.5	193.87		635,571.87	118.10		635,884
1.PS4c.1.2.06	Shaft 4 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	289.7	E.C.Y.	1	2.5	193.87			118.10		312
1.PS4c.1.2.06	Processing VOC soil.	3,041.8	tn	209				635,571.87			635,572
	Shaft 5 Waste				3.5	271.52		89,007.43	165.41		89,444
1.PS4c.1.2.06	Shaft 5 CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	405.7	E.C.Y.	1	3.5	271.52			165.41		437
1.PS4c.1.2.06	Processing VOC soil.	426.0	tn	209				89,007.43			89,007
	Shaft 6 Waste				789.6	61,942.14		231,318.08	3,436.51		296,697
1.PS4c.1.2.06	PCB - Fill waste containers.	70.0	ea	934	789.6	61,942.14			3,436.51		65,379
1.PS4c.1.2.06	PCB - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	230.8	cy	1,002				231,318.08			231,318
	Shaft RCRA Waste				0.5	38.82		12,661.92	23.65		12,724
1.PS4c.1.2.06	Shafts RCRA CAMU/RCRA Pad - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	58.0	E.C.Y.	1	0.5	38.82			23.65		62
1.PS4c.1.2.06	Shafts RCRA Treatment - Processing VOC soil.	60.6	tn	209				12,661.92			12,662
1.PS4c.1.2.06	Excavation & Overcore, Treatment, Onsite - Excavation - Shafts - PCB Waste Total				1,012.7	79,441.11		6,539,688.33	14,096.83		6,633,226
1.PS4c.1.2.07	Project WBS: 1.PS4c.1.2.07 - Excavation & Overcore, Treatment, Onsite - Road										
	Pits Excavation DC				32,470.9	2,367,445.84	1,869,660.68		135,292.03		4,372,399
1.PS4c.1.2.07	Temporary, roads, excl surfacing. O&M	4,446.0	SY	40	1,305.1	95,154.99	75,147.46		5,437.81		175,740
1.PS4c.1.2.07	Temporary, roads, excl surfacing.	106,170.0	SY	40	31,165.8	2,272,290.86	1,794,513.22		129,854.22		4,196,658
1.PS4c.1.2.07	Excavation & Overcore, Treatment, Onsite - Road Total				32,470.9	2,367,445.84	1,869,660.68		135,292.03		4,372,399
1.PS4c.1.2.08	Project WBS: 1.PS4c.1.2.08 - Excavation & Overcore, Treatment, Onsite - Containment										
	Pits Excavation DC				1,440,000.0	191,534,061.09		535,096,754.32			726,630,815
1.PS4c.1.2.08	Moveable Covers	3.0	ea	67,242,127	1,440,000.0	191,534,061.09		10,192,319.13			201,726,380
1.PS4c.1.2.08	Moveable Covers Mob/Demob	618.0	ea	849,360				524,904,435.19			524,904,435
1.PS4c.1.2.08	Excavation & Overcore, Treatment, Onsite - Containment Total				1,440,000.0	191,534,061.09		535,096,754.32			726,630,815
1.PS4c.1.2.09	Project WBS: 1.PS4c.1.2.09 - Excavation & Overcore, Treatment, Onsite - CAMU/RCRA										
	Pits Excavation DC							488,042,214.34			488,042,214
1.PS4c.1.2.09	CAMU/RCRA Site - Permiting and Landfill	43.0	acre	1,868,592				80,349,449.14			80,349,449
1.PS4c.1.2.09	On-Site Waste analysis, segregation, size reduction & treatment facility	1.0	lsum	407,692,765				407,692,765.20			407,692,765
	ET Cover				190,421.4	14,938,281.53	18,332,670.46		15,851,012.59		49,121,965
1.PS4c.1.2.09	Fine grading, select gravel, 6" deep, hand grading, including compaction	246,840.0	SY	18	55,797.0	4,377,196.29			46,124.32		4,423,321
1.PS4c.1.2.09	Basecourse Material and Delivery	287,980.0	CY	35			10,028,545.55				10,028,546
1.PS4c.1.2.09	Backfill, bulk, 6" to 12" lifts, dozer backfilling	287,980.0	CY	8	16,378.6	1,284,873.90			993,046.18		2,277,920
1.PS4c.1.2.09	Compaction, 2 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	287,980.0	CY	2	5,459.5	428,291.30			254,390.80		682,682
1.PS4c.1.2.09	Compaction, water for, 3000 gallon truck, 6 mile haul	287,980.0	CY	6	11,952.1	937,625.90	562,576.95		303,315.84		1,803,519

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4c.1.2.09	Borrow, common earth, 3 C.Y. bucket, loading and/or spreading, front end loader, wheel-mounted	123,420.0	CY	3	3,509.7	275,330.12			58,709.07		334,039
1.PS4c.1.2.09	Borrow, Topsoil, Retrieval and Drop	129,962.0	ton	39	52,906.8	4,150,457.76			924,098.67		5,074,556
1.PS4c.1.2.09	Soils for earthwork, common borrow, spread with 200 H.P. dozer, includes load at pit and haul, 23 miles round trip, excludes compaction	154,275.0	CY	112	27,113.2	2,126,987.21	1,939,318.04		13,239,357.64		17,305,663
1.PS4c.1.2.09	Cobble Material and Delivery for edging	166,617.0	TN	35			5,802,229.92				5,802,230
1.PS4c.1.2.09	Fine grading, select gravel, 8" deep, hand grading, including compaction	56,564.0	SY	24	17,006.1	1,334,099.82			14,412.96		1,348,513
1.PS4c.1.2.09	Backfill, bulk, 6" to 12" lifts, dozer backfilling	4,190.0	CY	8	238.3	18,694.43			14,448.45		33,143
1.PS4c.1.2.09	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	6.0	EA	1,306	60.2	4,724.80			3,108.66		7,833
	Re-Seeding				**31,255.4**	**2,451,937.62**	**2,145,508.66**		**549,752.82**		**5,147,199**
1.PS4c.1.2.09	Fine grading, fine grade for small irregular areas, to 15,000 S.Y.	246,840.0	SY	9	22,260.3	1,746,289.62			427,706.60		2,173,996
1.PS4c.1.2.09	Geotextile Subsurface Drainage Filtration, TRM , hand layed, ideal conditions	246,840.0	SY	10	6,168.8	483,930.35	2,096,560.05				2,580,490
1.PS4c.1.2.09	Seeding, mechanical seeding, 215 lb/acre	51.0	acre	2,779	1,021.5	80,133.75	48,948.61		12,648.67		141,731
1.PS4c.1.2.09	Rent water truck, off highway, 6000 gallon capacity - Rent per day	80.0	days	3,137	1,804.8	141,583.90			109,397.56		250,981
1.PS4c.1.2.09	**Excavation & Overcore, Treatment, Onsite - CAMU/RCRA Total**				**221,676.8**	**17,390,219.15**	**20,478,179.12**	**488,042,214.34**	**16,400,765.41**		**542,311,378**
1.PS4c.1.2.10	**Project WBS: 1.PS4c.1.2.10 - Excavation & Overcore, Treatment, Onsite - Project Costs**										
	Pits Excavation DC				**16,123,233.4**	**970,442,725.39**	**129,626,056.39**	**71,972,933.40**		**3,567.31**	**1,172,045,282**
1.PS4c.1.2.10	Storm water prevention	1.0	LS	71,972,933				71,972,933.40			71,972,933
1.PS4c.1.2.10	Field Non-Manual - JHRS	4,606,638.1	hour	112	4,606,638.1	517,258,120.71					517,258,121
1.PS4c.1.2.10	Craft Distributable - Labor	5,758,297.6	hour	79	5,758,297.6	453,184,604.69					453,184,605
1.PS4c.1.2.10	Craft Distributable - Materials	5,758,297.6	hour	12	5,758,297.6		68,472,141.61				68,472,142
1.PS4c.1.2.10	Craft Distrib for interior excavation work	360.0	mnth	169,872			61,153,914.78				61,153,915
1.PS4c.1.2.10	Excavation permit	3.0	ea	1,189						3,567.31	3,567
1.PS4c.1.2.10	**Excavation & Overcore, Treatment, Onsite - Project Costs Total**				**16,123,233.4**	**970,442,725.39**	**129,626,056.39**	**71,972,933.40**		**3,567.31**	**1,172,045,282**
1.PS4c.1.2	**Excavation & Overcore, Treatment, Onsite - Excavation Total**				**39,150,860.7**	**2,776,461,627.94**	**744,273,426.81**	**2,566,953,195.31**	**234,954,971.70**	**1,408,144.99**	**6,324,051,367**
1.PS4c.1	**Excavation & Overcore, Treatment, Onsite - Direct Cost Total**				**39,156,423.9**	**2,776,902,697.98**	**745,063,729.89**	**2,566,953,195.31**	**234,982,971.27**	**1,408,144.99**	**6,325,310,739**
1.PS4c.2	**Project WBS: 1.PS4c.2 - Excavation & Overcore, Treatment, Onsite - Indirect Cost**										
1.PS4c.2.1	**Project WBS: 1.PS4c.2.1 - Excavation & Overcore, Treatment, Onsite - IC - Design**										
	Pits Excavation DC							**1,462,766,060.26**			**1,462,766,060**
1.PS4c.2.1	Design	1.0	lsum	1,462,766,060				1,462,766,060.26			1,462,766,060
1.PS4c.2.1	**Excavation & Overcore, Treatment, Onsite - IC - Design Total**							**1,462,766,060.26**			**1,462,766,060**
1.PS4c.2.2	**Project WBS: 1.PS4c.2.2 - Excavation & Overcore, Treatment, Onsite - IC - Professional Management**										
	Pits Excavation DC				**16,511,855.3**	**3,624,917,143.03**					**3,624,917,143**
1.PS4c.2.2	Professional Management	1.0	lsum	3,624,917,143	16,511,855.3	3,624,917,143.03					3,624,917,143
1.PS4c.2.2	**Excavation & Overcore, Treatment, Onsite - IC - Professional Management Total**				**16,511,855.3**	**3,624,917,143.03**					**3,624,917,143**
1.PS4c.2.3	**Project WBS: 1.PS4c.2.3 - Excavation & Overcore, Treatment, Onsite - Indirect Cost**										
	Pits Excavation DC				**3.0**					**5,706,496,970.40**	**5,706,496,970**
1.PS4c.2.3	Contingency - Cost 30%	1.0	lsum	3,423,898,182	1.0					3,423,898,182.00	3,423,898,182
1.PS4c.2.3	Contingency - Schedule 10%	1.0	lsum	1,141,299,394	1.0					1,141,299,394.20	1,141,299,394
1.PS4c.2.3	Contingency - TPRA 10%	1.0	lsum	1,141,299,394	1.0					1,141,299,394.20	1,141,299,394
1.PS4c.2.3	**Excavation & Overcore, Treatment, Onsite - Indirect Cost Total**				**3.0**					**5,706,496,970.40**	**5,706,496,970**
1.PS4c.2	**Excavation & Overcore, Treatment, Onsite - Indirect Cost Total**				**16,511,858.3**	**3,624,917,143.03**		**1,462,766,060.26**		**5,706,496,970.40**	**10,794,180,174**
1.PS4c.3	**Project WBS: 1.PS4c.3 - Excavation & Overcore, Treatment, Onsite - Direct Operations & Maintenance**										
1.PS4c.3.1	**Project WBS: 1.PS4c.3.1 - Excavation & Overcore, Treatment, Onsite - DOM - Cover Maintenance & Inspections**										
	Pits Excavation DC				**2,319,963.0**	**333,586,642.10**	**66,775.67**		**8,337.25**		**333,661,755**
1.PS4c.3.1	TDR Moisture Monitoring (30 years)	1.0	lsum	572,114	3,974.2	572,114.19					572,114
1.PS4c.3.1	TDR Monitoring of ET Cover	1.0	EA	67,404	150.4	13,203.39	54,200.63				67,404
1.PS4c.3.1	CAMU/RCRA Operations (30 years)	1.0	lsum	332,313,093	2,308,421.4	332,313,092.85					332,313,093
1.PS4c.3.1	Site Maintenance for 30 years.	1.0	lsum	239,969	3,271.3	219,056.76	12,575.04		8,337.25		239,969
1.PS4c.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.PS4c.3.1	**Excavation & Overcore, Treatment, Onsite - DOM - Cover Maintenance & Inspections Total**				**2,319,963.0**	**333,586,642.10**	**66,775.67**		**8,337.25**		**333,661,755**
1.PS4c.3	**Excavation & Overcore, Treatment, Onsite - Direct Operations & Maintenance Total**				**2,319,963.0**	**333,586,642.10**	**66,775.67**		**8,337.25**		**333,661,755**

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4c.4	**Project WBS: 1.PS4c.4 - Excavation & Overcore, Treatment, Onsite - Indirect Operations & Maintenance**										
1.PS4c.4.2	**Project WBS: 1.PS4c.4.2 - Excavation & Overcore, Treatment, Onsite - IOM - Professional Management**										
	Pits Excavation DC				**292,160.6**	**64,139,236.46**					**64,139,236**
1.PS4c.4.2	Professional Management (years 31-100)	1.0	lsum	147,352	671.2	147,352.42					147,352
1.PS4c.4.2	Professional Management (years 1-30)	1.0	lsum	63,991,884	291,489.3	63,991,884.04					63,991,884
1.PS4c.4.2	**Excavation & Overcore, Treatment, Onsite - IOM - Professional Management Total**				**292,160.6**	**64,139,236.46**					**64,139,236**
1.PS4c.4.3	**Project WBS: 1.PS4c.4.3 - Excavation & Overcore, Treatment, Onsite - IOM - Contingency**										
	Pits Excavation DC				**3.0**					**178,900,495.50**	**178,900,496**
1.PS4c.4.3	Contingency - Cost 30%	1.0	lsum	119,340,297	1.0					119,340,297.30	119,340,297
1.PS4c.4.3	Contingency - Schedule 10%	1.0	lsum	29,780,099	1.0					29,780,099.10	29,780,099
1.PS4c.4.3	Contingency - TPRA 10%	1.0	lsum	29,780,099	1.0					29,780,099.10	29,780,099
1.PS4c.4.3	**Excavation & Overcore, Treatment, Onsite - IOM - Contingency Total**				**3.0**					**178,900,495.50**	**178,900,496**
1.PS4c.4	**Excavation & Overcore, Treatment, Onsite - Indirect Operations & Maintenance Total**				**292,163.6**	**64,139,236.46**				**178,900,495.50**	**243,039,732**
1.PS4c	**Excavation of pits and over-coring retrieval of shafts with on-site disposal in a CAMU/RCRA landfill Total**				**58,280,408.8**	**6,799,545,719.57**	**745,130,505.56**	**4,029,719,255.57**	**234,991,308.53**	**5,886,805,610.89**	**17,696,192,400**
1.PS4d	**Project WBS: 1.PS4d - Excavation of pits and over-coring retrieval of shafts with off-site disposal**										
1.PS4d.1	**Project WBS: 1.PS4d.1 - Excavation & Overcore, Offsite - Direct Cost**										
1.PS4d.1.1	**Project WBS: 1.PS4d.1.1 - Excavation & Overcore, Offsite - DC - Fence**										
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS4d.1.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.PS4d.1.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.PS4d.1.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.PS4d.1.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.PS4d.1.1	**Excavation & Overcore, Offsite - DC - Fence Total**				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS4d.1.2	**Project WBS: 1.PS4d.1.2 - Excavation & Overcore, Offsite - DC - Excavation**										
1.PS4d.1.2.01	**Project WBS: 1.PS4d.1.2.01 - Excavation & Overcore, Offsite - DC - Excavation - Pits - MLLW**										
	Pits Excavation DC				**3,086,097.9**	**241,477,038.67**	**21,791,935.20**		**77,637,959.09**	**1,408,144.99**	**342,315,078**
1.PS4d.1.2.01	Fine grading, select gravel, 6" deep, hand grading, including compaction	246,840.0	SY	18	55,797.0	4,377,196.29			46,124.32		4,423,321
1.PS4d.1.2.01	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	1,020,464.0	B.C.Y.	35	409,677.7	32,138,613.47			3,900,797.38		36,039,411
1.PS4d.1.2.01	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	605,426.0	B.C.Y.	294	2,269,524.4	178,040,846.82					178,040,847
1.PS4d.1.2.01	Site Tuff Processing - Dozer D9 rip tuff material	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS4d.1.2.01	Site Tuff Processing - 980 Frontend loader	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS4d.1.2.01	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS4d.1.2.01	Site Tuff Processing - 963 Hydraulic Excavator	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS4d.1.2.01	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	415,038.0	CY	2	10,299.6	638,710.79					638,711
1.PS4d.1.2.01	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	415,038.0	CY	0					186,128.79		186,129
1.PS4d.1.2.01	Site Tuff Processing - Rock crusher plant rental	360.0	MNTH	47,564					17,123,096.14		17,123,096
1.PS4d.1.2.01	Site Tuff Processing - Rock crusher plant : Scheduled Maintenance	2.0	EA	6,795						13,589.76	13,590
1.PS4d.1.2.01	Site Tuff Processing - Screening plant rental	30.0	MNTH	26,330					789,904.73		789,905
1.PS4d.1.2.01	Site Tuff Processing - Screening plant : Scheduled Maintenance	2.0	EA	4,077						8,153.86	8,154
1.PS4d.1.2.01	Dozer D9 rental	360.0	MNTH	49,949					17,981,697.10		17,981,697
1.PS4d.1.2.01	Dozer D9 Scheduled Maintenance	30.0	YR	12,322						369,659.62	369,660
1.PS4d.1.2.01	Dozer D9 Ripper replacement	60.0	SET	1,100	451.2	35,172.96				30,841.96	66,015
1.PS4d.1.2.01	Dozer cutting edge replacement	180.0	EA	2,192	2,707.2	211,037.76	183,461.74				394,500
1.PS4d.1.2.01	980, 7 cy frontend loader rental	360.0	MNTH	28,426					10,233,496.10		10,233,496
1.PS4d.1.2.01	980 Loader: Scheduled Maintenance	30.0	YR	9,963						298,899.44	298,899
1.PS4d.1.2.01	980-7cy loader bucket teeth replacement.	210.0	EA	2,000	1,579.2	123,105.36	296,800.33				419,906
1.PS4d.1.2.01	825H High speed compactor (sheepsfoot) rental	360.0	MNTH	17,981					6,473,141.88		6,473,142
1.PS4d.1.2.01	825H: Scheduled Maintenance	30.0	YR	10,098						302,944.26	302,944
1.PS4d.1.2.01	963 Hydraulic Excavator rental	360.0	MNTH	31,664					11,399,089.71		11,399,090
1.PS4d.1.2.01	963 Hydraulic Excavator : Scheduled Maintenance	30.0	YR	12,485						374,543.27	374,543
1.PS4d.1.2.01	963 Hydraulic Excavator tip long replacement.	270.0	EA	1,313	2,030.4	158,278.32	196,299.48				354,578
1.PS4d.1.2.01	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	635,697.3	ton	33			21,089,892.84				21,089,893
1.PS4d.1.2.01	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	1,275,580.0	L.C.Y.	10	95,520.6	7,493,448.44			5,742,160.64		13,235,609
1.PS4d.1.2.01	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	1,275,580.0	L.C.Y.	13	174,113.5	13,658,943.99			2,860,508.10		16,519,452
1.PS4d.1.2.01	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	1,020,464.0	E.C.Y.	1	8,705.7	682,947.20			416,049.18		1,098,996
1.PS4d.1.2.01	Excavation permit	5.0	ea	1,189						5,945.52	5,946

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4d.1.2.01	Track out device	3.0	EA	9,316	33.8	2,467.26	25,480.80				27,948
1.PS4d.1.2.01	Clean out track out device.	23.0	EA	2,863	518.9	37,831.40			28,007.17		65,839
1.PS4d.1.2.01	Rent toilet portable chemical	360.0	mnth	679					244,615.66		244,616
1.PS4d.1.2.01	Chemical toilet cleaning.	360.0	mnth	2,691	12,182.4	755,470.43			213,142.19		968,613
1.PS4d.1.2.01	Chemical toilet cleaning (labor)	360.0	mnth	2,011	12,182.4	724,011.33					724,011
1.PS4d.1.2.01	Excavation permit	3.0	ea	1,189						3,567.31	3,567
	Re-Seeding				**3,578.3**	**165,460.53**	**3,119,631.06**		**107,001.87**		**3,392,093**
1.PS4d.1.2.01	Reveg - Seeding athletic fields, seeding utility mix with mulch and fertilizer, 7 lb. per M.S.F., hydro or air seeding	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS4d.1.2.01	Reveg - Hydroseeding materials.	1.0	lsum	2,022,902			2,022,901.85				2,022,902
1.PS4d.1.2.01	Reveg - Mulching athletic fields,	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS4d.1.2.01	Reveg - Mulch and Humate materials.	1.0	LS	907,509			907,508.81				907,509
1.PS4d.1.2.01	Reveg - Rent water truck, off highway, 6000 gallon capacity - Rent per day	40.0	days	1,367	902.4				54,698.78		54,699
1.PS4d.1.2.01	**Excavation & Overcore, Offsite - DC - Excavation - Pits - MLLW Total**				**3,089,676.2**	**241,642,499.19**	**24,911,566.26**		**77,744,960.97**	**1,408,144.99**	**345,707,171**
1.PS4d.1.2.02	**Project WBS: 1.PS4d.1.2.02 - Excavation & Overcore, Offsite - DC - Excavation - Pits - MLLW Waste**										
	Pits Excavation Waste				**18,712,061.1**	**1,464,460,048.78**	**622,728,713.20**	**1,421,587,487.27**	**149,121,473.56**		**3,657,897,723**
1.PS4d.1.2.02	Waste container delivery.	9,082.0	ea	2,469	273,186.6	17,976,607.47			4,449,369.94		22,425,977
1.PS4d.1.2.02	Waste container unload on site and handling during project.	181,628.0	ea	7,827	16,390,110.7	1,285,763,058.94			135,755,439.52		1,421,518,498
1.PS4d.1.2.02	Waste containers.	181,628.0	ea	3,429			622,728,713.20				622,728,713
1.PS4d.1.2.02	Fill waste containers.	181,628.0	ea	934	2,048,763.8	160,720,382.37			8,916,664.10		169,637,046
1.PS4d.1.2.02	Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	605,426.0	cy	1,892				1,145,692,371.96			1,145,692,372
1.PS4d.1.2.02	Trucking cost per 43,000 pound load	36,326.0	Trip	7,595				275,895,115.31			275,895,115
1.PS4d.1.2.02	**Excavation & Overcore, Offsite - DC - Excavation - Pits - MLLW Waste Total**				**18,712,061.1**	**1,464,460,048.78**	**622,728,713.20**	**1,421,587,487.27**	**149,121,473.56**		**3,657,897,723**
1.PS4d.1.2.03	**Project WBS: 1.PS4d.1.2.03 - Excavation & Overcore, Offsite - DC - Excavation - Pits - MLLW & TRU**										
	Pits Excavation DC				**1,435,179.4**	**112,508,900.47**	**9,273,421.53**		**6,039,905.57**		**127,822,228**
1.PS4d.1.2.03	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	470,789.0	B.C.Y.	35	189,004.0	14,827,084.25			1,799,624.97		16,626,709
1.PS4d.1.2.03	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	293,498.0	B.C.Y.	294	1,100,218.5	86,310,519.30					86,310,519
1.PS4d.1.2.03	Site Tuff Processing - Dozer D9 rip tuff material	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS4d.1.2.03	Site Tuff Processing - 980 Frontend loader	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS4d.1.2.03	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS4d.1.2.03	Site Tuff Processing - 963 Hydraulic Excavator	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS4d.1.2.03	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	177,291.0	CY	2	4,399.7	272,836.89					272,837
1.PS4d.1.2.03	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	177,291.0	CY	0					79,508.28		79,508
1.PS4d.1.2.03	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	279,522.0	ton	33			9,273,421.53				9,273,422
1.PS4d.1.2.03	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	588,487.0	L.C.Y.	10	44,068.3	3,457,091.67			2,649,137.56		6,106,229
1.PS4d.1.2.03	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	588,487.0	L.C.Y.	13	80,327.0	6,301,534.18			1,319,691.30		7,621,225
1.PS4d.1.2.03	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	470,789.0	E.C.Y.	1	4,016.3	315,076.31			191,943.45		507,020
1.PS4d.1.2.03	**Excavation & Overcore, Offsite - DC - Excavation - Pits - MLLW & TRU Total**				**1,435,179.4**	**112,508,900.47**	**9,273,421.53**		**6,039,905.57**		**127,822,228**
1.PS4d.1.2.04	**Project WBS: 1.PS4d.1.2.04 - Excavation & Overcore, Offsite - DC - Excavation - Pits - MLLW & TRU Waste**										
	Pits Excavation w/TRU Waste				**7,385,704.1**	**578,026,455.32**	**245,792,491.91**	**561,102,228.96**	**58,858,750.77**		**1,443,779,927**
1.PS4d.1.2.04	Waste container delivery.	3,585.0	ea	2,469	107,836.8	7,096,029.27			1,756,330.24		8,852,360
1.PS4d.1.2.04	Waste container unload on site and handling during project.	71,689.0	ea	7,827	6,469,215.4	507,493,712.05			53,582,992.18		561,076,704
1.PS4d.1.2.04	Waste containers.	71,689.0	ea	3,429			245,792,491.91				245,792,492
1.PS4d.1.2.04	Fill waste containers.	71,689.0	ea	934	808,651.9	63,436,714.01			3,519,428.35		66,956,142
1.PS4d.1.2.04	Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	238,962.0	cy	1,892				452,205,456.31			452,205,456
1.PS4d.1.2.04	Trucking cost per 43,000 pound load	14,338.0	Trip	7,595				108,896,772.65			108,896,773
	Pits Excavation w/TRU Waste				**16,856,022.6**	**1,319,197,745.28**	**560,952,302.32**	**1,280,608,620.10**	**134,332,555.05**		**3,295,091,223**
1.PS4d.1.2.04	Waste container delivery.	819.0	ea	24,693	246,354.7	16,210,982.48			4,012,362.08		20,223,345
1.PS4d.1.2.04	Waste container unload on site and handling during project.	16,361.0	ea	78,265	14,764,178.2	1,158,212,735.73			122,288,222.47		1,280,500,958
1.PS4d.1.2.04	Waste containers.	16,361.0	ea	34,286			560,952,302.32				560,952,302
1.PS4d.1.2.04	Fill waste containers.	16,361.0	ea	9,340	1,845,489.6	144,774,027.06			8,031,970.50		152,805,998
1.PS4d.1.2.04	Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	54,536.0	cy	18,924				1,032,025,040.18			1,032,025,040
1.PS4d.1.2.04	Trucking cost per 43,000 pound load	3,273.0	Trip	75,950				248,583,579.92			248,583,580
1.PS4d.1.2.04	**Excavation & Overcore, Offsite - DC - Excavation - Pits - MLLW & TRU Waste Total**				**24,241,726.6**	**1,897,224,200.60**	**806,744,794.23**	**1,841,710,849.05**	**193,191,305.82**		**4,738,871,150**
1.PS4d.1.2.05	**Project WBS: 1.PS4d.1.2.05 - Excavation & Overcore, Offsite - DC - Excavation - Shafts - PCB**										
	Shaft 1 DC				**845.9**	**66,361.53**	**1,028,655.02**	**21,573,742.16**	**27,390.09**		**22,696,149**
1.PS4d.1.2.05	Overcoring shaft size < 3' x 40'	83.0	ea	169,872				14,099,374.80			14,099,375
1.PS4d.1.2.05	Overcoring shaft size < 3' x 60'	30.0	ea	169,872				5,096,159.56			5,096,160
1.PS4d.1.2.05	Overcoring shaft size < 8' x 65'	14.0	ea	169,872				2,378,207.80			2,378,208
1.PS4d.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	31,006.0	ton	33			1,028,655.02				1,028,655
1.PS4d.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	3,882.5	L.C.Y.	10	290.7	22,807.91			17,477.49		40,285
1.PS4d.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	3,882.5	L.C.Y.	13	530.0	41,573.91			8,706.57		50,280
1.PS4d.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	2,958.1	E.C.Y.	1	25.2	1,979.71			1,206.03		3,186
	Shaft 2 DC				**75.1**	**5,891.97**	**9,133.68**	**679,487.94**	**2,433.57**		**696,947**

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4d.1.2.05	Overcoring shaft size < 3' x 60'	2.0	ea	169,872				339,743.97			339,744
1.PS4d.1.2.05	Overcoring shaft size < 8' x 65'	2.0	ea	169,872				339,743.97			339,744
1.PS4d.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	275.3	ton	33			9,133.68				9,134
1.PS4d.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	344.2	L.C.Y.	10	25.8	2,022.02			1,549.45		3,571
1.PS4d.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	344.2	L.C.Y.	13	47.0	3,685.70			771.87		4,458
1.PS4d.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	275.3	E.C.Y.	1	2.3	184.25			112.25		296
	Shaft 3 DC				**12.9**	**1,008.24**	**928.93**	**339,743.97**	**416.43**		**342,098**
1.PS4d.1.2.05	Overcoring shaft size < 3' x 60'	2.0	ea	169,872				339,743.97			339,744
1.PS4d.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	28.0	ton	33			928.93				929
1.PS4d.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	58.9	L.C.Y.	10	4.4	346.01			265.14		611
1.PS4d.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	58.9	L.C.Y.	13	8.0	630.70			132.08		763
1.PS4d.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	47.1	E.C.Y.	1	0.4	31.52			19.20		51
	Shaft 4 DC				**93.0**	**7,292.26**	**11,870.37**	**1,528,847.87**	**3,011.94**		**1,551,022**
1.PS4d.1.2.05	Overcoring shaft size < 3' x 60'	7.0	ea	169,872				1,189,103.90			1,189,104
1.PS4d.1.2.05	Overcoring shaft size < 8' x 65'	2.0	ea	169,872				339,743.97			339,744
1.PS4d.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	357.8	ton	33			11,870.37				11,870
1.PS4d.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	426.0	L.C.Y.	10	31.9	2,502.55			1,917.68		4,420
1.PS4d.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	426.0	L.C.Y.	13	58.1	4,561.62			955.31		5,517
1.PS4d.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	340.8	E.C.Y.	1	2.9	228.08			138.95		367
	Shaft 5 DC				**130.2**	**10,212.59**	**16,621.18**	**849,359.93**	**4,218.14**		**880,412**
1.PS4d.1.2.05	Overcoring shaft size < 3' x 60'	1.0	ea	169,872				169,871.99			169,872
1.PS4d.1.2.05	Overcoring shaft size < 8' x 65'	4.0	ea	169,872				679,487.94			679,488
1.PS4d.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	501.0	ton	33			16,621.18				16,621
1.PS4d.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	596.6	L.C.Y.	10	44.7	3,504.75			2,685.66		6,190
1.PS4d.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	596.6	L.C.Y.	13	81.4	6,388.41			1,337.88		7,726
1.PS4d.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	477.3	E.C.Y.	1	4.1	319.43			194.60		514
	Shaft 6 DC				**105.7**	**8,295.45**	**13,502.63**	**2,038,463.83**	**3,426.31**		**2,063,688**
1.PS4d.1.2.05	Overcoring shaft size < 3' x 60'	10.0	ea	169,872				1,698,719.86			1,698,720
1.PS4d.1.2.05	Overcoring shaft size < 8' x 65'	2.0	ea	169,872				339,743.97			339,744
1.PS4d.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	407.0	ton	33			13,502.63				13,503
1.PS4d.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	484.6	L.C.Y.	10	36.3	2,846.80			2,181.48		5,028
1.PS4d.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	484.6	L.C.Y.	13	66.1	5,189.11			1,086.72		6,276
1.PS4d.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	387.8	E.C.Y.	1	3.3	259.54			158.11		418
1.PS4d.1.2.05	**Excavation & Overcore, Offsite - DC - Excavation - Shafts - PCB Total**				**1,262.8**	**99,062.04**	**1,080,711.81**	**27,009,645.69**	**40,896.49**		**28,230,316**
1.PS4d.1.2.06	**Project WBS: 1.PS4d.1.2.06 - Excavation & Overcore, Offsite - DC - Excavation - Shafts - PCB Waste**										
	Shaft 1 Waste				**91,503.4**	**7,161,093.96**	**3,044,591.68**	**6,949,737.10**	**729,364.40**		**17,884,787**
1.PS4d.1.2.06	MLLW - Waste container delivery.	45.0	ea	2,469	1,353.6	89,071.50			22,045.99		111,117
1.PS4d.1.2.06	MLLW - Waste container unload on site and handling during project.	888.0	ea	7,827	80,133.1	6,286,242.19			663,723.82		6,949,966
1.PS4d.1.2.06	MLLW - Waste containers.	888.0	ea	3,429			3,044,591.68				3,044,592
1.PS4d.1.2.06	MLLW - Fill waste containers.	888.0	ea	934	10,016.6	785,780.27			43,594.59		829,375
1.PS4d.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	2,958.1	cy	1,892				5,597,831.29			5,597,831
1.PS4d.1.2.06	MLLW - Trucking cost per 43,000 pound load	178.0	Trip	7,595				1,351,905.81			1,351,906
	Shaft 2 Waste				**8,230.6**	**643,010.72**	**270,858.94**	**617,700.06**	**66,355.23**		**1,597,925**
1.PS4d.1.2.06	MLLW - Waste container delivery.	7.0	ea	2,469	210.6	13,855.57			3,429.38		17,285
1.PS4d.1.2.06	MLLW - Waste container unload on site and handling during project.	79.0	ea	7,827	7,129.0	559,249.02			59,047.50		618,297
1.PS4d.1.2.06	MLLW - Waste containers.	79.0	ea	3,429			270,858.94				270,859
1.PS4d.1.2.06	MLLW - Fill waste containers.	79.0	ea	934	891.1	69,906.13			3,878.35		73,784
1.PS4d.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	262.2	cy	1,892				496,180.44			496,180
1.PS4d.1.2.06	MLLW - Trucking cost per 43,000 pound load	16.0	Trip	7,595				121,519.62			121,520
	Shaft 3 Waste				**1,045.3**	**81,619.26**	**34,285.94**	**74,610.49**	**8,455.21**		**198,971**
1.PS4d.1.2.06	MLLW - Waste container delivery.	1.0	ea	2,469	30.1	1,979.37			489.91		2,469
1.PS4d.1.2.06	MLLW - Waste container unload on site and handling during project.	10.0	ea	7,827	902.4	70,791.02			7,474.37		78,265
1.PS4d.1.2.06	MLLW - Waste containers.	10.0	ea	3,429			34,285.94				34,286
1.PS4d.1.2.06	MLLW - Fill waste containers.	10.0	ea	934	112.8	8,848.88			490.93		9,340
1.PS4d.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	31.4	cy	1,892				59,420.54			59,421
1.PS4d.1.2.06	MLLW - Trucking cost per 43,000 pound load	2.0	Trip	7,595				15,189.95			15,190
	Shaft 4 Waste				**10,637.0**	**832,167.09**	**353,145.21**	**804,415.54**	**84,982.03**		**2,074,710**
1.PS4d.1.2.06	MLLW - Waste container delivery.	6.0	ea	2,469	180.5	11,876.20			2,939.46		14,816
1.PS4d.1.2.06	MLLW - Waste container unload on site and handling during project.	103.0	ea	7,827	9,294.7	729,147.46			76,985.98		806,133
1.PS4d.1.2.06	MLLW - Waste containers.	103.0	ea	3,429			353,145.21				353,145
1.PS4d.1.2.06	MLLW - Fill waste containers.	103.0	ea	934	1,161.8	91,143.43			5,056.58		96,200
1.PS4d.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	340.8	cy	1,892				644,921.03			644,921
1.PS4d.1.2.06	MLLW - Trucking cost per 43,000 pound load	21.0	Trip	7,595				159,494.51			159,495
	Shaft 5 Waste				**14,859.5**	**1,162,649.39**	**493,717.57**	**1,123,484.39**	**118,619.57**		**2,898,471**
1.PS4d.1.2.06	MLLW - Waste container delivery.	8.0	ea	2,469	240.6	15,834.93			3,919.29		19,754
1.PS4d.1.2.06	MLLW - Waste container unload on site and handling during project.	144.0	ea	7,827	12,994.6	1,019,390.63			107,630.89		1,127,022
1.PS4d.1.2.06	MLLW - Waste containers.	144.0	ea	3,429			493,717.57				493,718
1.PS4d.1.2.06	MLLW - Fill waste containers.	144.0	ea	934	1,624.3	127,423.83			7,069.39		134,493

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4d.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	477.3	cy	1,892				903,230.07			903,230
1.PS4d.1.2.06	MLLW - Trucking cost per 43,000 pound load	29.0	Trip	7,595				220,254.32			220,254
	Shaft 6 Waste				**1,319.8**	**103,531.86**		**388,670.50**	**5,743.88**		**497,946**
1.PS4d.1.2.06	PCB - Fill waste containers.	117.0	ea	934	1,319.8	103,531.86			5,743.88		109,276
1.PS4d.1.2.06	PCB - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	387.8	cy	1,002				388,670.50			388,671
	Shaft RCRA Waste				**2,192.1**	**171,202.51**	**72,000.48**	**166,656.31**	**17,706.95**		**427,566**
1.PS4d.1.2.06	RCRA - Waste container delivery.	2.0	ea	2,469	60.2	3,958.73			979.82		4,939
1.PS4d.1.2.06	RCRA - Waste container unload on site and handling during project.	21.0	ea	7,827	1,895.0	148,661.13			15,696.17		164,357
1.PS4d.1.2.06	RCRA - Waste containers.	21.0	ea	3,429			72,000.48				72,000
1.PS4d.1.2.06	RCRA - Fill waste containers.	21.0	ea	934	236.9	18,582.64			1,030.95		19,614
1.PS4d.1.2.06	RCRA - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	68.0	cy	1,892				128,681.43			128,681
1.PS4d.1.2.06	RCRA - Trucking cost per 43,000 pound load	5.0	Trip	7,595				37,974.88			37,975
1.PS4d.1.2.06	**Excavation & Overcore, Offsite - DC - Excavation - Shafts - PCB Waste Total**				**129,787.7**	**10,155,274.78**	**4,268,599.82**	**10,125,274.39**	**1,031,227.25**		**25,580,376**
1.PS4d.1.2.07	**Project WBS: 1.PS4d.1.2.07 - Excavation & Overcore, Offsite - DC - Road**										
	Pits Excavation DC				**32,470.9**	**2,367,445.84**	**1,869,660.68**		**135,292.03**		**4,372,399**
1.PS4d.1.2.07	Temporary, roads, excl surfacing. O&M	4,446.0	SY	40	1,305.1	95,154.99	75,147.46		5,437.81		175,740
1.PS4d.1.2.07	Temporary, roads, excl surfacing.	106,170.0	SY	40	31,165.8	2,272,290.86	1,794,513.22		129,854.22		4,196,658
1.PS4d.1.2.07	**Excavation & Overcore, Offsite - DC - Road Total**				**32,470.9**	**2,367,445.84**	**1,869,660.68**		**135,292.03**		**4,372,399**
1.PS4d.1.2.08	**Project WBS: 1.PS4d.1.2.08 - Excavation & Overcore, Offsite - DC - Containment**										
	Pits Excavation DC				**1,440,000.0**	**191,534,061.09**		**535,096,754.32**			**726,630,815**
1.PS4d.1.2.08	Moveable Covers	3.0	ea	67,242,127	1,440,000.0	191,534,061.09		10,192,319.13			201,726,380
1.PS4d.1.2.08	Moveable Covers Mob/Demob	618.0	ea	849,360				524,904,435.19			524,904,435
1.PS4d.1.2.08	**Excavation & Overcore, Offsite - DC - Containment Total**				**1,440,000.0**	**191,534,061.09**		**535,096,754.32**			**726,630,815**
1.PS4d.1.2.10	**Project WBS: 1.PS4d.1.2.10 - Excavation & Overcore, Offsite - DC - Project Costs**										
	Pits Excavation DC				**34,361,409.6**	**2,068,181,933.92**	**207,079,936.61**	**39,798,178.07**			**2,315,060,049**
1.PS4d.1.2.10	Storm water prevention	1.0	LS	39,798,178				39,798,178.07			39,798,178
1.PS4d.1.2.10	Field Non-Manual - JHRS	9,817,545.6	hour	112	9,817,545.6	1,102,366,859.83					1,102,366,860
1.PS4d.1.2.10	Craft Distributable - Labor	12,271,932.0	hour	79	12,271,932.0	965,815,074.09					965,815,074
1.PS4d.1.2.10	Craft Distributable - Materials	12,271,932.0	hour	12	12,271,932.0		145,926,021.83				145,926,022
1.PS4d.1.2.10	Craft Distrib for interior excavation work	360.0	mnth	169,872			61,153,914.78				61,153,915
1.PS4d.1.2.10	**Excavation & Overcore, Offsite - DC - Project Costs Total**				**34,361,409.6**	**2,068,181,933.92**	**207,079,936.61**	**39,798,178.07**			**2,315,060,049**
1.PS4d.1.2	**Excavation & Overcore, Offsite - DC - Excavation Total**				**83,443,574.3**	**5,988,173,426.72**	**1,677,957,404.13**	**3,875,328,188.81**	**427,305,061.69**	**1,408,144.99**	**11,970,172,226**
1.PS4d.1	**Excavation & Overcore, Offsite - Direct Cost Total**				**83,449,137.5**	**5,988,614,496.76**	**1,678,747,707.21**	**3,875,328,188.81**	**427,333,061.27**	**1,408,144.99**	**11,971,431,599**
1.PS4d.2	**Project WBS: 1.PS4d.2 - Excavation & Overcore, Offsite - Indirect Cost**										
1.PS4d.2.1	**Project WBS: 1.PS4d.2.1 - Excavation & Overcore, Offsite - IC - Design**										
	Pits Excavation DC							**2,768,465,385.86**			**2,768,465,386**
1.PS4d.2.1	Design	1.0	lsum	2,768,465,386				2,768,465,385.86			2,768,465,386
1.PS4d.2.1	**Excavation & Overcore, Offsite - IC - Design Total**							**2,768,465,385.86**			**2,768,465,386**
1.PS4d.2.2	**Project WBS: 1.PS4d.2.2 - Excavation & Overcore, Offsite - IC - Professional Management**										
	Pits Excavation DC				**31,250,725.1**	**6,860,603,284.33**					**6,860,603,284**
1.PS4d.2.2	Professional Management	1.0	lsum	6,860,603,284	31,250,725.1	6,860,603,284.33					6,860,603,284
1.PS4d.2.2	**Excavation & Overcore, Offsite - IC - Professional Management Total**				**31,250,725.1**	**6,860,603,284.33**					**6,860,603,284**
1.PS4d.2.3	**Project WBS: 1.PS4d.2.3 - Excavation & Overcore, Offsite - IC - Contingency**										
	Pits Excavation DC				**3.0**					**10,800,250,134.50**	**10,800,250,135**
1.PS4d.2.3	Contingency - Cost 30%	1.0	lsum	6,480,150,081	1.0					6,480,150,080.70	6,480,150,081
1.PS4d.2.3	Contingency - Schedule 10%	1.0	lsum	2,160,050,027	1.0					2,160,050,026.90	2,160,050,027
1.PS4d.2.3	Contingency - TPRA 10%	1.0	lsum	2,160,050,027	1.0					2,160,050,026.90	2,160,050,027
1.PS4d.2.3	**Excavation & Overcore, Offsite - IC - Contingency Total**				**3.0**					**10,800,250,134.50**	**10,800,250,135**
1.PS4d.2	**Excavation & Overcore, Offsite - Indirect Cost Total**				**31,250,728.1**	**6,860,603,284.33**		**2,768,465,385.86**		**10,800,250,134.50**	**20,429,318,805**
1.PS4d.3	**Project WBS: 1.PS4d.3 - Excavation & Overcore, Offsite - Direct Operations & Maintenance**										
1.PS4d.3.1	**Project WBS: 1.PS4d.3.1 - Excavation & Overcore, Offsite - DOM - Cover Maintenance & Inspections**										
	Pits Excavation DC				**4,145.7**	**469,174.90**					**469,175**
1.PS4d.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS4d.3.1	**Excavation & Overcore, Offsite - DOM - Cover Maintenance & Inspections Total**				**4,145.7**	**469,174.90**					**469,175**
1.PS4d.3	**Excavation & Overcore, Offsite - Direct Operations & Maintenance Total**				**4,145.7**	**469,174.90**					**469,175**
1.PS4d.4	**Project WBS: 1.PS4d.4 - Excavation & Overcore, Offsite - Indirect Operations & Maintenance**										
1.PS4d.4.2	**Project WBS: 1.PS4d.4.2 - Excavation & Overcore, Offsite - IOM - Professional Management**										
	Pits Excavation DC				**372.6**	**81,794.13**					**81,794**
1.PS4d.4.2	Professional Management (years 100)	1.0	lsum	81,794	372.6	81,794.13					81,794
1.PS4d.4.2	**Excavation & Overcore, Offsite - IOM - Professional Management Total**				**372.6**	**81,794.13**					**81,794**
1.PS4d.4.3	**Project WBS: 1.PS4d.4.3 - Excavation & Overcore, Offsite - IOM - Contingency**										
	Pits Excavation DC				**3.0**					**275,484.50**	**275,485**
1.PS4d.4.3	Contingency - Cost 30%	1.0	lsum	165,291	1.0					165,290.70	165,291
1.PS4d.4.3	Contingency - Schedule 10%	1.0	lsum	55,097	1.0					55,096.90	55,097
1.PS4d.4.3	Contingency - TPRA 10%	1.0	lsum	55,097	1.0					55,096.90	55,097
1.PS4d.4.3	**Excavation & Overcore, Offsite - IOM - Contingency Total**				**3.0**					**275,484.50**	**275,485**
1.PS4d.4	**Excavation & Overcore, Offsite - Indirect Operations & Maintenance Total**				**375.6**	**81,794.13**				**275,484.50**	**357,279**
1.PS4d	**Excavation of pits and over-coring retrieval of shafts with off-site disposal Total**				**114,704,386.8**	**12,849,768,750.12**	**1,678,747,707.21**	**6,643,793,574.67**	**427,333,061.27**	**10,801,933,763.99**	**32,401,576,857**
1.PS5a	**Project WBS: 1.PS5a - Ex-situ Treatment**										
1.PS5a.1	**Project WBS: 1.PS5a.1 - Ex-situ Treatment, Onsite - Direct Cost**										
1.PS5a.1.1	**Project WBS: 1.PS5a.1.1 - Ex-situ Treatment DC - Fence**										
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS5a.1.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.PS5a.1.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.PS5a.1.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.PS5a.1.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.PS5a.1.1	**Ex-situ Treatment DC - Fence Total**				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.PS5a.1.2	**Project WBS: 1.PS5a.1.2 - Ex-situ Treatment - DC - Excavation**										
1.PS5a.1.2.01	**Project WBS: 1.PS5a.1.2.01 - Ex-situ Treatment - DC - Pits - Excavation - MLLW**										
	Pits Excavation DC				**3,030,300.8**	**237,099,842.38**	**10,192,494.63**		**77,591,834.77**	**1,404,577.68**	**326,288,749**
1.PS5a.1.2.01	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	1,020,464.0	B.C.Y.	35	409,677.7	32,138,613.47			3,900,797.38		36,039,411
1.PS5a.1.2.01	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	605,426.0	B.C.Y.	294	2,269,524.4	178,040,846.82					178,040,847
1.PS5a.1.2.01	Site Tuff Processing - Dozer D9 rip tuff material	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS5a.1.2.01	Site Tuff Processing - 980 Frontend loader	415,038.0	CY	2	10,237.2	798,030.27					798,030
1.PS5a.1.2.01	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS5a.1.2.01	Site Tuff Processing - 963 Hydraulic Excavator	415,038.0	CY	1	5,149.8	401,448.16					401,448
1.PS5a.1.2.01	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	415,038.0	CY	2	10,299.6	638,710.79					638,711
1.PS5a.1.2.01	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	415,038.0	CY	0					186,128.79		186,129
1.PS5a.1.2.01	Site Tuff Processing - Rock crusher plant rental	360.0	MNTH	47,564					17,123,096.14		17,123,096
1.PS5a.1.2.01	Site Tuff Processing - Rock crusher plant : Scheduled Maintenance	2.0	EA	6,795						13,589.76	13,590
1.PS5a.1.2.01	Site Tuff Processing - Screening plant rental	30.0	MNTH	26,330					789,904.73		789,905
1.PS5a.1.2.01	Site Tuff Processing - Screening plant : Scheduled Maintenance	2.0	EA	4,077						8,153.86	8,154
1.PS5a.1.2.01	Dozer D9 rental	360.0	MNTH	49,949					17,981,697.10		17,981,697
1.PS5a.1.2.01	Dozer D9 Scheduled Maintenance	30.0	YR	12,322						369,659.62	369,660
1.PS5a.1.2.01	Dozer D9 Ripper replacement	60.0	SET	1,100	451.2	35,172.96				30,841.96	66,015
1.PS5a.1.2.01	Dozer cutting edge replacement	180.0	EA	2,192	2,707.2	211,037.76	183,461.74				394,500
1.PS5a.1.2.01	980, 7 cy frontend loader rental	360.0	MNTH	28,426					10,233,496.10		10,233,496
1.PS5a.1.2.01	980 Loader: Scheduled Maintenance	30.0	YR	9,963						298,899.44	298,899
1.PS5a.1.2.01	980-7cy loader bucket teeth replacement.	210.0	EA	2,000	1,579.2	123,105.36	296,800.33				419,906
1.PS5a.1.2.01	825H High speed compactor (sheepsfoot) rental	360.0	MNTH	17,981					6,473,141.88		6,473,142
1.PS5a.1.2.01	825H: Scheduled Maintenance	30.0	YR	10,098						302,944.26	302,944
1.PS5a.1.2.01	963 Hydraulic Excavator rental	360.0	MNTH	31,664					11,399,089.71		11,399,090
1.PS5a.1.2.01	963 Hydraulic Excavator : Scheduled Maintenance	30.0	YR	12,485						374,543.27	374,543
1.PS5a.1.2.01	963 Hydraulic Excavator tip long replacement.	270.0	EA	1,313	2,030.4	158,278.32	196,299.48				354,578
1.PS5a.1.2.01	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	286,063.8	ton	33			9,490,452.28				9,490,452
1.PS5a.1.2.01	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	1,275,580.0	L.C.Y.	10	95,520.6	7,493,448.44			5,742,160.64		13,235,609

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS5a.1.2.01	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	1,275,580.0	L.C.Y.	13	174,113.5	13,658,943.99			2,860,508.10		16,519,452
1.PS5a.1.2.01	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	1,020,464.0	E.C.Y.	1	8,705.7	682,947.20			416,049.18		1,098,996
1.PS5a.1.2.01	Excavation permit	5.0	ea	1,189						5,945.52	5,946
1.PS5a.1.2.01	Track out device	3.0	EA	9,316	33.8	2,467.26	25,480.80				27,948
1.PS5a.1.2.01	Clean out track out device.	23.0	EA	2,863	518.9	37,831.40			28,007.17		65,839
1.PS5a.1.2.01	Rent toilet portable chemical	360.0	mnth	679					244,615.66		244,616
1.PS5a.1.2.01	Chemical toilet cleaning.	360.0	mnth	2,691	12,182.4	755,470.43			213,142.19		968,613
1.PS5a.1.2.01	Chemical toilet cleaning (labor)	360.0	mnth	2,011	12,182.4	724,011.33					724,011
	Re-Seeding				**3,578.3**	**165,460.53**	**3,119,631.06**		**107,001.87**		**3,392,093**
1.PS5a.1.2.01	Reveg - Seeding athletic fields, seeding utility mix with mulch and fertilizer, 7 lb. per M.S.F., hydro or air seeding	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS5a.1.2.01	Reveg - Hydroseeding materials.	1.0	lsum	2,022,902			2,022,901.85				2,022,902
1.PS5a.1.2.01	Reveg - Mulching athletic fields,	1,185.0	Msf	172	1,338.0	82,730.26	94,610.20		26,151.55		203,492
1.PS5a.1.2.01	Reveg - Mulch and Humate materials.	1.0	LS	907,509			907,508.81				907,509
1.PS5a.1.2.01	Reveg - Rent water truck, off highway, 6000 gallon capacity - Rent per day	40.0	days	1,367	902.4				54,698.78		54,699
1.PS5a.1.2.01	**Ex-situ Treatment - DC - Pits - Excavation - MLLW Total**				**3,033,879.2**	**237,265,302.90**	**13,312,125.70**		**77,698,836.65**	**1,404,577.68**	**329,680,843**
1.PS5a.1.2.02	**Project WBS: 1.PS5a.1.2.02 - Ex-situ Treatment - DC - Pits - Excavation - MLLW Waste**										
	Pits Excavation Waste				**2,878,049.4**	**223,682,724.18**	**129,857,948.45**	**840,379,276.53**	**25,044,630.45**		**1,218,964,580**
1.PS5a.1.2.02	MLLW - Waste container delivery.	1,363.0	ea	2,469	40,999.0	2,697,876.68			667,748.43		3,365,625
1.PS5a.1.2.02	MLLW - Waste container unload on site and handling during project.	27,245.0	ea	7,827	2,458,588.8	192,870,122.12			20,363,913.88		213,234,036
1.PS5a.1.2.02	MLLW - Waste containers.	27,245.0	ea	3,429			93,412,049.85				93,412,050
1.PS5a.1.2.02	MLLW - Fill waste containers.	27,245.0	ea	934	307,323.6	24,108,765.27			1,337,538.89		25,446,304
1.PS5a.1.2.02	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	90,814.0	cy	1,892				171,854,045.03			171,854,045
1.PS5a.1.2.02	MLLW - Trucking cost per 43,000 pound load	5,449.0	Trip	7,595				41,385,026.79			41,385,027
1.PS5a.1.2.02	Treatment - Mob/Demob VOC treatment plant.	1.0	ea	220,834				220,833.58			220,834
1.PS5a.1.2.02	Treatment - Processing VOC soil.	540,342.7	tn	209				112,900,577.38			112,900,577
1.PS5a.1.2.02	Treatment - Secondary Treatment	514,612.0	B.C.Y.	999				514,018,793.75			514,018,794
1.PS5a.1.2.02	Industrial Waste - Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 CY truck, cycle 20 miles, 35 MPH, excludes loading equipment	283,795.0	L.C.Y.	24	71,137.9	4,005,960.12			2,675,429.25		6,681,389
1.PS5a.1.2.02	Industrial Waste - Selective demolition, dump charges, typical urban city, reclamation station, usual charge, includes tipping fees only	238,388.0	ton	153			36,445,898.59				36,445,899
1.PS5a.1.2.02	**Ex-situ Treatment - DC - Pits - Excavation - MLLW Waste Total**				**2,878,049.4**	**223,682,724.18**	**129,857,948.45**	**840,379,276.53**	**25,044,630.45**		**1,218,964,580**
1.PS5a.1.2.03	**Project WBS: 1.PS5a.1.2.03 - Ex-situ Treatment - DC - Pits - Excavation - MLLW & TRU**										
	Pits Excavation w/TRU DC				**1,435,179.4**	**112,508,900.47**	**4,703,013.00**		**6,039,905.57**		**123,251,819**
1.PS5a.1.2.03	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	470,789.0	B.C.Y.	35	189,004.0	14,827,084.25			1,799,624.97		16,626,709
1.PS5a.1.2.03	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	293,498.0	B.C.Y.	294	1,100,218.5	86,310,519.30					86,310,519
1.PS5a.1.2.03	Site Tuff Processing - Dozer D9 rip tuff material	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS5a.1.2.03	Site Tuff Processing - 980 Frontend loader	177,291.0	CY	2	4,373.0	340,893.09					340,893
1.PS5a.1.2.03	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS5a.1.2.03	Site Tuff Processing - 963 Hydraulic Excavator	177,291.0	CY	1	2,199.8	171,485.85					171,486
1.PS5a.1.2.03	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	177,291.0	CY	2	4,399.7	272,836.89					272,837
1.PS5a.1.2.03	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	177,291.0	CY	0					79,508.28		79,508
1.PS5a.1.2.03	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	141,759.5	ton	33			4,703,013.00				4,703,013
1.PS5a.1.2.03	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	588,487.0	L.C.Y.	10	44,068.3	3,457,091.67			2,649,137.56		6,106,229
1.PS5a.1.2.03	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	588,487.0	L.C.Y.	13	80,327.0	6,301,534.18			1,319,691.30		7,621,225
1.PS5a.1.2.03	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	470,789.0	E.C.Y.	1	4,016.3	315,076.31			191,943.45		507,020
1.PS5a.1.2.03	**Ex-situ Treatment - DC - Pits - Excavation - MLLW & TRU Total**				**1,435,179.4**	**112,508,900.47**	**4,703,013.00**		**6,039,905.57**		**123,251,819**
1.PS5a.1.2.04	**Project WBS: 1.PS5a.1.2.04 - Ex-situ Treatment - DC - Pits - Excavation - MLLW & TRU Waste**										
	Pits Excavation w/TRU Waste				**1,130,391.6**	**87,974,560.16**	**48,379,198.94**	**331,612,617.96**	**9,674,245.35**		**477,640,622**
1.PS5a.1.2.04	MLLW - Waste container delivery.	538.0	ea	2,469	16,183.0	1,064,899.23			263,572.01		1,328,471
1.PS5a.1.2.04	MLLW - Waste container unload on site and handling during project.	10,754.0	ea	7,827	970,441.0	76,128,658.22			8,037,934.66		84,166,593
1.PS5a.1.2.04	MLLW - Waste containers.	10,754.0	ea	3,429			36,871,102.37				36,871,102
1.PS5a.1.2.04	MLLW - Fill waste containers.	10,754.0	ea	934	121,305.1	9,516,082.28			527,946.16		10,044,028
1.PS5a.1.2.04	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	35,844.0	cy	1,892				67,830,250.73			67,830,251
1.PS5a.1.2.04	MLLW - Trucking cost per 43,000 pound load	2,151.0	Trip	7,595				16,336,794.39			16,336,794
1.PS5a.1.2.04	Treatment - Processing VOC soil.	213,274.0	tn	209				44,562,011.74			44,562,012
1.PS5a.1.2.04	Treatment - Secondary Treatment	203,117.7	B.C.Y.	999				202,883,561.10			202,883,561
1.PS5a.1.2.04	Industrial Waste - Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 CY truck, cycle 20 miles, 35 MPH, excludes loading equipment	89,611.0	L.C.Y.	24	22,462.5	1,264,920.43			844,792.51		2,109,713
1.PS5a.1.2.04	Industrial Waste - Selective demolition, dump charges, typical urban city, reclamation station, usual charge, includes tipping fees only	75,273.0	ton	153			11,508,096.57				11,508,097
	Pits Excavation w/TRU Waste				**16,856,022.6**	**1,319,197,745.28**	**560,952,302.32**	**1,280,608,620.10**	**134,332,555.05**		**3,295,091,223**
1.PS5a.1.2.04	TRU - Waste container delivery.	819.0	ea	24,693	246,354.7	16,210,982.48			4,012,362.08		20,223,345
1.PS5a.1.2.04	TRU - Waste container unload on site and handling during project.	16,361.0	ea	78,265	14,764,178.2	1,158,212,735.73			122,288,222.47		1,280,500,958
1.PS5a.1.2.04	TRU - Waste containers.	16,361.0	ea	34,286			560,952,302.32				560,952,302
1.PS5a.1.2.04	TRU - Fill waste containers.	16,361.0	ea	9,340	1,845,489.6	144,774,027.06			8,031,970.50		152,805,998

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS5a.1.2.04	TRU - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	54,536.0	cy	18,924				1,032,025,040.18			1,032,025,040
1.PS5a.1.2.04	TRU - Trucking cost per 43,000 pound load	3,273.0	Trip	75,950				248,583,579.92			248,583,580
1.PS5a.1.2.04	**Ex-situ Treatment - DC - Pits - Excavation - MLLW & TRU Waste Total**				**17,986,414.2**	**1,407,172,305.44**	**609,331,501.26**	**1,612,221,238.05**	**144,006,800.40**		**3,772,731,845**
1.PS5a.1.2.05	**Project WBS: 1.PS5a.1.2.05 - Ex-situ Treatment - DC - Shafts - Excavation - PCB**										
	Shaft 1 DC				**52,934.3**	**4,120,163.02**	**32,976.94**		**983,679.04**		**5,136,819**
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	75,111.0	B.C.Y.	35	30,154.2	2,365,554.69			287,117.23		2,652,672
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	2,103.0	B.C.Y.	294	7,883.4	618,440.41					618,440
1.PS5a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	73,008.0	CY	2	1,800.8	140,378.94					140,379
1.PS5a.1.2.05	Site Tuff Processing - 980 Frontend loader	73,008.0	CY	2	1,800.8	140,378.94					140,379
1.PS5a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	73,008.0	CY	1	905.9	70,617.45					70,617
1.PS5a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	73,008.0	CY	1	905.9	70,617.45					70,617
1.PS5a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	73,008.0	CY	2	1,811.8	112,353.56					112,354
1.PS5a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	73,008.0	CY	0					32,741.32		32,741
1.PS5a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	994.0	ton	33			32,976.94				32,977
1.PS5a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	93,888.8	L.C.Y.	10	7,030.8	551,553.42			422,650.31		974,204
1.PS5a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	93,888.8	L.C.Y.	2					210,546.99		210,547
1.PS5a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	75,111.0	E.C.Y.	1	640.8	50,268.16			30,623.20		80,891
	Shaft 2 DC				**9,992.9**	**778,665.07**	**2,952.66**		**157,707.45**		**939,325**
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	12,037.0	B.C.Y.	35	4,832.4	379,094.70			46,012.30		425,107
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	188.0	B.C.Y.	294	704.7	55,286.16					55,286
1.PS5a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	11,849.0	CY	2	292.3	22,783.12					22,783
1.PS5a.1.2.05	Site Tuff Processing - 980 Frontend loader	11,849.0	CY	2	292.3	22,783.12					22,783
1.PS5a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	11,849.0	CY	1	147.0	11,461.02					11,461
1.PS5a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	11,849.0	CY	1	147.0	11,461.02					11,461
1.PS5a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	11,849.0	CY	2	294.0	18,234.68					18,235
1.PS5a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	11,849.0	CY	0					5,313.83		5,314
1.PS5a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	89.0	ton	33			2,952.66				2,953
1.PS5a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	15,046.3	L.C.Y.	10	1,126.7	88,389.83			67,732.31		156,122
1.PS5a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	15,046.3	L.C.Y.	13	2,053.8	161,115.64			33,741.45		194,857
1.PS5a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	12,037.0	E.C.Y.	1	102.7	8,055.78			4,907.56		12,963
	Shaft 3 DC				**8,198.9**	**638,675.62**	**1,237.46**		**134,082.12**		**773,995**
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	10,231.0	B.C.Y.	35	4,107.4	322,216.32			39,108.74		361,325
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	79.0	B.C.Y.	294	296.1	23,231.95					23,232
1.PS5a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	10,153.0	CY	2	250.4	19,522.07					19,522
1.PS5a.1.2.05	Site Tuff Processing - 980 Frontend loader	10,153.0	CY	2	250.4	19,522.07					19,522
1.PS5a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	10,153.0	CY	1	126.0	9,820.55					9,821
1.PS5a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	10,153.0	CY	1	126.0	9,820.55					9,821
1.PS5a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	10,153.0	CY	2	252.0	15,624.67					15,625
1.PS5a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	10,153.0	CY	0					4,553.24		4,553
1.PS5a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	37.3	ton	33			1,237.46				1,237
1.PS5a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	12,788.8	L.C.Y.	10	957.7	75,128.05			57,569.93		132,698
1.PS5a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	12,788.8	L.C.Y.	13	1,745.6	136,942.27			28,678.97		165,621
1.PS5a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	10,231.0	E.C.Y.	1	87.3	6,847.11			4,171.24		11,018
	Shaft 4 DC				**15,041.3**	**1,171,589.11**	**1,645.53**		**248,471.78**		**1,421,706**
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	18,958.0	B.C.Y.	35	7,610.9	597,065.49			72,468.32		669,534
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	105.0	B.C.Y.	294	393.6	30,877.91					30,878
1.PS5a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	18,854.0	CY	2	465.0	36,252.25					36,252
1.PS5a.1.2.05	Site Tuff Processing - 980 Frontend loader	18,854.0	CY	2	465.0	36,252.25					36,252
1.PS5a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	18,854.0	CY	1	233.9	18,236.65					18,237
1.PS5a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	18,854.0	CY	1	233.9	18,236.65					18,237
1.PS5a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	18,854.0	CY	2	467.9	29,014.82					29,015
1.PS5a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	18,854.0	CY	0					8,455.30		8,455
1.PS5a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	49.6	ton	33			1,645.53				1,646
1.PS5a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	23,697.5	L.C.Y.	10	1,774.6	139,211.96			106,676.85		245,889
1.PS5a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	23,697.5	L.C.Y.	13	3,234.6	253,753.45			53,142.01		306,895
1.PS5a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	18,958.0	E.C.Y.	1	161.7	12,687.67			7,729.29		20,417
	Shaft 5 DC				**21,716.1**	**1,692,623.32**	**9,329.09**		**331,099.79**		**2,033,052**
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	25,278.0	B.C.Y.	35	10,148.2	796,108.31			96,626.98		892,735
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	595.0	B.C.Y.	294	2,230.4	174,974.82					174,975
1.PS5a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	24,683.0	CY	2	608.8	47,460.19					47,460
1.PS5a.1.2.05	Site Tuff Processing - 980 Frontend loader	24,683.0	CY	2	608.8	47,460.19					47,460
1.PS5a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	24,683.0	CY	1	306.3	23,874.79					23,875

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS5a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	24,683.0	CY	1	306.3	23,874.79					23,875
1.PS5a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	24,683.0	CY	2	612.5	37,985.19					37,985
1.PS5a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	24,683.0	CY	0					11,069.39		11,069
1.PS5a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	281.2	ton	33			9,329.09				9,329
1.PS5a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	31,597.5	L.C.Y.	10	2,366.1	185,620.84			142,239.55		327,860
1.PS5a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	31,597.5	L.C.Y.	13	4,313.0	338,346.86			70,857.89		409,205
1.PS5a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	25,278.0	E.C.Y.	1	215.6	16,917.34			10,305.99		27,223
	Shaft 6 DC				**19,498.0**	**1,520,292.51**	**11,820.61**		**283,384.86**		**1,815,498**
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, 3/8 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	21,667.0	B.C.Y.	35	8,698.5	682,383.05			82,823.67		765,207
1.PS5a.1.2.05	Excavating, trench or continuous footing, common earth, by hand with pick and shovel, 2' to 6' deep, light soil, excludes sheeting or dewatering	754.0	B.C.Y.	294	2,826.5	221,732.79					221,733
1.PS5a.1.2.05	Site Tuff Processing - Dozer D9 rip tuff material	20,913.0	CY	2	515.8	40,211.27					40,211
1.PS5a.1.2.05	Site Tuff Processing - 980 Frontend loader	20,913.0	CY	2	515.8	40,211.27					40,211
1.PS5a.1.2.05	Site Tuff Processing - 825H High speed compactor (sheepsfoot)	20,913.0	CY	1	259.5	20,228.23					20,228
1.PS5a.1.2.05	Site Tuff Processing - 963 Hydraulic Excavator	20,913.0	CY	1	259.5	20,228.23					20,228
1.PS5a.1.2.05	Site Tuff Processing - Crew, Water wagon 1,000 gal tuff processing	20,913.0	CY	2	519.0	32,183.46					32,183
1.PS5a.1.2.05	Site Tuff Processing - Equipment only. Water wagon 1,000 gal tuff processing	20,913.0	CY	0					9,378.69		9,379
1.PS5a.1.2.05	Fill - Off Site acquired and stocpiled Tuff - Borrow, material only,	356.3	ton	33			11,820.61				11,821
1.PS5a.1.2.05	Fill - Fill, from stockpile, 300 H.P. dozer, 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	27,083.8	L.C.Y.	10	2,028.1	159,104.63			121,920.42		281,025
1.PS5a.1.2.05	Fill - Backfill, structural, common earth, 80 H.P. dozer, 300' haul	27,083.8	L.C.Y.	13	3,696.9	290,013.50			60,735.73		350,749
1.PS5a.1.2.05	Fill - Compaction, 2 passes, 12" lifts, riding, sheepsfoot or wobbly wheel roller	20,913.0	E.C.Y.	1	178.4	13,996.06			8,526.35		22,522
1.PS5a.1.2.05	**Ex-situ Treatment - DC - Shafts - Excavation - PCB Total**				**127,381.5**	**9,922,008.65**	**59,962.30**		**2,138,425.04**		**12,120,396**
1.PS5a.1.2.06	**Project WBS: 1.PS5a.1.2.06 - Ex-situ Treatment - DC - Shafts - Excavation - PCB Waste**										
	Shaft 1 Waste				**9,992.5**	**777,607.44**	**427,079.07**	**634,924.23**	**85,554.27**	**2,178,124.08**	**4,103,289**
1.PS5a.1.2.06	MLLW - Waste container delivery.	5.0	ea	2,469	150.4	9,896.83			2,449.55		12,346
1.PS5a.1.2.06	MLLW - Waste container unload on site and handling during project.	95.0	ea	7,827	8,572.8	672,514.65			71,006.49		743,521
1.PS5a.1.2.06	MLLW - Waste containers.	95.0	ea	3,429			325,716.45				325,716
1.PS5a.1.2.06	MLLW - Fill waste containers.	95.0	ea	934	1,071.6	84,064.33			4,663.84		88,728
1.PS5a.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	315.4	cy	1,892				596,949.35			596,949
1.PS5a.1.2.06	MLLW - Trucking cost per 43,000 pound load	5.0	Trip	7,595				37,974.88			37,975
1.PS5a.1.2.06	Treatment - Processing VOC soil.	1,877.0	tn	209						392,185.15	392,185
1.PS5a.1.2.06	Treatment - Secondary Treatment	1,788.0	B.C.Y.	999						1,785,938.93	1,785,939
1.PS5a.1.2.06	Industrial Waste - Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 CY truck, cycle 20 miles, 35 MPH, excludes loading equipment	788.6	L.C.Y.	24	197.7	11,131.63			7,434.39		18,566
1.PS5a.1.2.06	Industrial Waste - Selective demolition, dump charges, typical urban city, reclamation station, usual charge, includes tipping fees only	663.0	ton	153			101,362.61				101,363
	Shaft 2 Waste				**961.4**	**74,650.43**	**39,911.19**	**293,810.93**	**8,323.31**		**416,696**
1.PS5a.1.2.06	MLLW - Waste container delivery.	1.0	ea	2,469	30.1	1,979.37			489.91		2,469
1.PS5a.1.2.06	MLLW - Waste container unload on site and handling during project.	9.0	ea	7,827	812.2	63,711.91			6,726.93		70,439
1.PS5a.1.2.06	MLLW - Waste containers.	9.0	ea	3,429			30,857.35				30,857
1.PS5a.1.2.06	MLLW - Fill waste containers.	9.0	ea	934	101.5	7,963.99			441.84		8,406
1.PS5a.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	28.2	cy	1,892				53,364.94			53,365
1.PS5a.1.2.06	MLLW - Trucking cost per 43,000 pound load	6.0	Trip	7,595				45,569.86			45,570
1.PS5a.1.2.06	Treatment - Processing VOC soil.	167.8	tn	209				35,060.56			35,061
1.PS5a.1.2.06	Treatment - Secondary Treatment	160.0	B.C.Y.	999				159,815.56			159,816
1.PS5a.1.2.06	Industrial Waste - Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 CY truck, cycle 20 miles, 35 MPH, excludes loading equipment	70.5	L.C.Y.	24	17.7	995.16			664.63		1,660
1.PS5a.1.2.06	Industrial Waste - Selective demolition, dump charges, typical urban city, reclamation station, usual charge, includes tipping fees only	59.2	ton	153			9,053.84				9,054
	Shaft 3 Waste				**443.6**	**34,253.15**	**17,521.21**	**111,879.42**	**3,955.08**		**167,609**
1.PS5a.1.2.06	MLLW - Waste container delivery.	1.0	ea	2,469	30.1	1,979.37			489.91		2,469
1.PS5a.1.2.06	MLLW - Waste container unload on site and handling during project.	4.0	ea	7,827	361.0	28,316.41			2,989.75		31,306
1.PS5a.1.2.06	MLLW - Waste containers.	4.0	ea	3,429			13,714.38				13,714
1.PS5a.1.2.06	MLLW - Fill waste containers.	4.0	ea	934	45.1	3,539.55			196.37		3,736
1.PS5a.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	11.9	cy	1,892				22,481.40			22,481
1.PS5a.1.2.06	MLLW - Trucking cost per 43,000 pound load	1.0	Trip	7,595				7,594.98			7,595
1.PS5a.1.2.06	Treatment - Processing VOC soil.	70.5	tn	209				14,730.45			14,730
1.PS5a.1.2.06	Treatment - Secondary Treatment	67.2	B.C.Y.	999				67,072.59			67,073
1.PS5a.1.2.06	Industrial Waste - Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 CY truck, cycle 20 miles, 35 MPH, excludes loading equipment	29.6	L.C.Y.	24	7.4	417.82			279.05		697
1.PS5a.1.2.06	Industrial Waste - Selective demolition, dump charges, typical urban city, reclamation station, usual charge, includes tipping fees only	24.9	ton	153			3,806.83				3,807
	Shaft 4 Waste				**547.6**	**42,355.47**	**22,188.17**	**146,124.90**	**4,844.00**		**215,513**
1.PS5a.1.2.06	MLLW - Waste container delivery.	1.0	ea	2,469	30.1	1,979.37			489.91		2,469
1.PS5a.1.2.06	MLLW - Waste container unload on site and handling during project.	5.0	ea	7,827	451.2	35,395.51			3,737.18		39,133
1.PS5a.1.2.06	MLLW - Waste containers.	5.0	ea	3,429			17,142.97				17,143
1.PS5a.1.2.06	MLLW - Fill waste containers.	5.0	ea	934	56.4	4,424.44			245.47		4,670
1.PS5a.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	15.8	cy	1,892				29,804.89			29,805

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS5a.1.2.06	MLLW - Trucking cost per 43,000 pound load	1.0	Trip	7,595				7,594.98			7,595
1.PS5a.1.2.06	Treatment - Processing VOC soil.	93.7	tn	209				19,577.92			19,578
1.PS5a.1.2.06	Treatment - Secondary Treatment	89.3	B.C.Y.	999				89,147.12			89,147
1.PS5a.1.2.06	Industrial Waste - Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 CY truck, cycle 20 miles, 35 MPH, excludes loading equipment	39.4	L.C.Y.	24	9.9	556.16			371.44		928
1.PS5a.1.2.06	Industrial Waste - Selective demolition, dump charges, typical urban city, reclamation station, usual charge, includes tipping fees only	33.0	ton	153			5,045.20				5,045
	Shaft 5 Waste				**2,857.1**	**222,136.00**	**121,222.65**	**830,579.73**	**24,589.60**		**1,198,528**
1.PS5a.1.2.06	MLLW - Waste container delivery.	2.0	ea	2,469	60.2	3,958.73			979.82		4,939
1.PS5a.1.2.06	MLLW - Waste container unload on site and handling during project.	27.0	ea	7,827	2,436.5	191,135.74			20,180.79		211,317
1.PS5a.1.2.06	MLLW - Waste containers.	27.0	ea	3,429			92,572.04				92,572
1.PS5a.1.2.06	MLLW - Fill waste containers.	27.0	ea	934	304.6	23,891.97			1,325.51		25,217
1.PS5a.1.2.06	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	89.3	cy	1,892				168,894.37			168,894
1.PS5a.1.2.06	MLLW - Trucking cost per 43,000 pound load	6.0	Trip	7,595				45,569.86			45,570
1.PS5a.1.2.06	Treatment - Processing VOC soil.	531.0	tn	209				110,948.49			110,948
1.PS5a.1.2.06	Treatment - Secondary Treatment	505.8	B.C.Y.	999				505,167.01			505,167
1.PS5a.1.2.06	Industrial Waste - Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 CY truck, cycle 20 miles, 35 MPH, excludes loading equipment	223.1	L.C.Y.	24	55.9	3,149.56			2,103.47		5,253
1.PS5a.1.2.06	Industrial Waste - Selective demolition, dump charges, typical urban city, reclamation station, usual charge, includes tipping fees only	187.4	ton	153			28,650.61				28,651
	Shaft 6 Waste				**3,003.1**	**235,064.78**	**16,986.11**	**846,422.11**	**15,060.54**		**1,113,534**
1.PS5a.1.2.06	Shafts 6 PCB - Fill waste containers.	227.0	ea	934	2,560.6	200,869.51			11,144.11		212,014
1.PS5a.1.2.06	Shafts 6 PCB - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	754.0	cy	1,002				755,692.51			755,693
1.PS5a.1.2.06	Shafts RCRA MLLW - Waste container delivery.	1.0	ea	2,469	30.1	1,979.37			489.91		2,469
1.PS5a.1.2.06	Shafts RCRA MLLW - Waste container unload on site and handling during project.	4.0	ea	7,827	361.0	28,316.41			2,989.75		31,306
1.PS5a.1.2.06	Shafts RCRA MLLW - Waste containers.	4.0	ea	3,429			13,714.38				13,714
1.PS5a.1.2.06	Shafts RCRA MLLW - Fill waste containers.	4.0	ea	934	45.1	3,539.55			196.37		3,736
1.PS5a.1.2.06	Shafts RCRA MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	10.2	cy	1,892				19,302.21			19,302
1.PS5a.1.2.06	Shafts RCRA MLLW - Trucking cost per 43,000 pound load	1.0	Trip	7,595				7,594.98			7,595
1.PS5a.1.2.06	Shafts RCRA Treatment - Processing VOC soil.	29.2	tn	209				6,099.03			6,099
1.PS5a.1.2.06	Shafts RCRA Treatment - Secondary Treatment	57.8	B.C.Y.	999				57,733.37			57,733
1.PS5a.1.2.06	Shafts RCRA Industrial Waste - Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 CY truck, cycle 20 miles, 35 MPH, excludes loading equipment	25.5	L.C.Y.	24	6.4	359.95			240.40		600
1.PS5a.1.2.06	Shafts RCRA Industrial Waste - Selective demolition, dump charges, typical urban city, reclamation station, usual charge, includes tipping fees only	21.4	ton	153			3,271.73				3,272
1.PS5a.1.2.06	**Ex-situ Treatment - DC - Shafts - Excavation - PCB Waste Total**				**17,805.3**	**1,386,067.27**	**644,908.39**	**2,863,741.32**	**142,326.79**	**2,178,124.08**	**7,215,168**
1.PS5a.1.2.07	**Project WBS: 1.PS5a.1.2.07 - Ex-situ Treatment - DC - Road**										
	Pits Excavation DC				**32,470.9**	**2,367,445.84**	**1,869,660.68**		**135,292.03**		**4,372,399**
1.PS5a.1.2.07	Temporary, roads, excl surfacing. O&M	4,446.0	SY	40	1,305.1	95,154.99	75,147.46		5,437.81		175,740
1.PS5a.1.2.07	Temporary, roads, excl surfacing.	106,170.0	SY	40	31,165.8	2,272,290.86	1,794,513.22		129,854.22		4,196,658
1.PS5a.1.2.07	**Ex-situ Treatment - DC - Road Total**				**32,470.9**	**2,367,445.84**	**1,869,660.68**		**135,292.03**		**4,372,399**
1.PS5a.1.2.08	**Project WBS: 1.PS5a.1.2.08 - Ex-situ Treatment - DC - Containment**										
	Pits Excavation DC				**1,440,000.0**	**191,534,061.09**		**535,096,754.32**			**726,630,815**
1.PS5a.1.2.08	Moveable Covers	3.0	ea	67,242,127	1,440,000.0	191,534,061.09		10,192,319.13			201,726,380
1.PS5a.1.2.08	Moveable Covers Mob/Demob	618.0	ea	849,360				524,904,435.19			524,904,435
1.PS5a.1.2.08	**Ex-situ Treatment - DC - Containment Total**				**1,440,000.0**	**191,534,061.09**		**535,096,754.32**			**726,630,815**
1.PS5a.1.2.09	**Project WBS: 1.PS5a.1.2.09 - Ex-situ Treatment - DC - CAMU/RCRA**										
	Pits Excavation Waste							**407,692,765.20**			**407,692,765**
1.PS5a.1.2.09	On-Site Waste analysis, segregation, size reduction & treatment facility	1.0	lsum	407,692,765				407,692,765.20			407,692,765
1.PS5a.1.2.09	**Ex-situ Treatment - DC - CAMU/RCRA Total**							**407,692,765.20**			**407,692,765**
1.PS5a.1.2.10	**Project WBS: 1.PS5a.1.2.10 - Ex-situ Treatment - DC - Project Costs**										
	Pits Excavation DC						**61,153,914.78**	**65,767,455.34**		**3,567.31**	**126,924,937**
1.PS5a.1.2.10	Field Non-Manual - JHRS		hour	112							
1.PS5a.1.2.10	Craft Distributable - Labor		hour	79							
1.PS5a.1.2.10	Craft Distributable - Materials		hour	7							
1.PS5a.1.2.10	Craft Distrib for interior excavation work	360.0	mnth	169,872			61,153,914.78				61,153,915
1.PS5a.1.2.10	Storm water prevention	1.0	LS	65,767,455				65,767,455.34			65,767,455
1.PS5a.1.2.10	Excavation permit	3.0	ea	1,189						3,567.31	3,567
1.PS5a.1.2.10	**Ex-situ Treatment - DC - Project Costs Total**						**61,153,914.78**	**65,767,455.34**		**3,567.31**	**126,924,937**
1.PS5a.1.2	**Ex-situ Treatment - DC - Excavation Total**				**26,951,179.8**	**2,185,838,815.84**	**820,933,034.55**	**3,464,021,230.78**	**255,206,216.92**	**3,586,269.07**	**6,729,585,567**
1.PS5a.1	**Ex-situ Treatment, Onsite - Direct Cost Total**				**26,956,743.0**	**2,186,279,885.88**	**821,723,337.63**	**3,464,021,230.78**	**255,234,216.49**	**3,586,269.07**	**6,730,844,940**
1.PS5a.2	**Project WBS: 1.PS5a.2 - Ex-situ Treatment - Indirect Cost**										
1.PS5a.2.1	**Project WBS: 1.PS5a.2.1 - Ex-situ Treatment - IC - Design**										
	Pits Excavation DC							**1,556,548,277.44**			**1,556,548,277**

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.PS5a.2.1	Design	1.0	lsum	1,556,548,277				1,556,548,277.44			1,556,548,277
1.PS5a.2.1	**Ex-situ Treatment - IC - Design Total**							**1,556,548,277.44**			**1,556,548,277**
1.PS5a.2.2	**Project WBS: 1.PS5a.2.2 - Ex-situ Treatment - IC - Professional Management**										
	Pits Excavation DC				**17,570,478.8**	**3,857,321,199.16**					**3,857,321,199**
1.PS5a.2.2	Professional Management	1.0	lsum	3,857,321,199	17,570,478.8	3,857,321,199.16					3,857,321,199
1.PS5a.2.2	**Ex-situ Treatment - IC - Professional Management Total**				**17,570,478.8**	**3,857,321,199.16**					**3,857,321,199**
1.PS5a.2.3	**Project WBS: 1.PS5a.2.3 - Ex-situ Treatment - IC - Contingency**										
	Pits Excavation DC				**3.0**					**6,072,357,208.50**	**6,072,357,209**
1.PS5a.2.3	Contingency - Cost 30%	1.0	lsum	3,643,414,325	1.0					3,643,414,325.10	3,643,414,325
1.PS5a.2.3	Contingency - Schedule 10%	1.0	lsum	1,214,471,442	1.0					1,214,471,441.70	1,214,471,442
1.PS5a.2.3	Contingency - TPRA 10%	1.0	lsum	1,214,471,442	1.0					1,214,471,441.70	1,214,471,442
1.PS5a.2.3	**Ex-situ Treatment - IC - Contingency Total**				**3.0**					**6,072,357,208.50**	**6,072,357,209**
1.PS5a.2	**Ex-situ Treatment - Indirect Cost Total**				**17,570,481.8**	**3,857,321,199.16**		**1,556,548,277.44**		**6,072,357,208.50**	**11,486,226,685**
1.PS5a.3	**Project WBS: 1.PS5a.3 - Ex-situ Treatment - Direct Operations & Maintenance**										
1.PS5a.3.1	**Project WBS: 1.PS5a.3.1 - Ex-situ Treatment - DOM - Cover Maintenance & Inspections**										
	Pits Excavation DC				**1,543,093.3**	**222,011,235.81**					**222,011,236**
1.PS5a.3.1	Operation of Sorting and Segregation Facitliy (30 years)	1.0	lsum	221,542,061	1,538,947.6	221,542,060.91					221,542,061
1.PS5a.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.PS5a.3.1	**Ex-situ Treatment - DOM - Cover Maintenance & Inspections Total**				**1,543,093.3**	**222,011,235.81**					**222,011,236**
1.PS5a.3	**Ex-situ Treatment - Direct Operations & Maintenance Total**				**1,543,093.3**	**222,011,235.81**					**222,011,236**
1.PS5a.4	**Project WBS: 1.PS5a.4 - Ex-situ Treatment - Indirect Operations & Maintenance**										
1.PS5a.4.2	**Project WBS: 1.PS5a.4.2 - Ex-situ Treatment - IOM - Professional Management**										
	Pits Excavation DC				**194,088.4**	**42,609,035.83**					**42,609,036**
1.PS5a.4.2	Professional Management (years 31-100)	1.0	lsum	36,781	167.5	36,780.80					36,781
1.PS5a.4.2	Professional Management (years 1-30)	1.0	lsum	42,572,255	193,920.8	42,572,255.04					42,572,255
1.PS5a.4.2	**Ex-situ Treatment - IOM - Professional Management Total**				**194,088.4**	**42,609,035.83**					**42,609,036**
1.PS5a.4.3	**Project WBS: 1.PS5a.4.3 - Ex-situ Treatment - IOM - Contingency**										
	Pits Excavation DC				**3.0**					**132,310,136.00**	**132,310,136**
1.PS5a.4.3	Contingency - Cost 30%	1.0	lsum	79,386,082	1.0					79,386,081.60	79,386,082
1.PS5a.4.3	Contingency - Schedule 10%	1.0	lsum	26,462,027	1.0					26,462,027.20	26,462,027
1.PS5a.4.3	Contingency - TPRA 10%	1.0	lsum	26,462,027	1.0					26,462,027.20	26,462,027
1.PS5a.4.3	**Ex-situ Treatment - IOM - Contingency Total**				**3.0**					**132,310,136.00**	**132,310,136**
1.PS5a.4	**Ex-situ Treatment - Indirect Operations & Maintenance Total**				**194,091.4**	**42,609,035.83**				**132,310,136.00**	**174,919,172**
1.PS5a	**Ex-situ Treatment Total**				**46,264,409.4**	**6,308,221,356.68**	**821,723,337.63**	**5,020,569,508.23**	**255,234,216.49**	**6,208,253,613.57**	**18,614,002,033**
1.VZ2a	**Project WBS: 1.VZ2a - Monitoring Natual Attenuation**										
1.VZ2a.1	**Project WBS: 1.VZ2a.1 - Monitoring Natural Attenuation - Direct Cost**										
1.VZ2a.1.2	**Project WBS: 1.VZ2a.1.2 - Monitoring Natural Attenuation - DC - Demo**										
	Add/Remove Monitoring Ports				**290.8**	**24,039.72**	**1,076.31**		**14,646.63**		**39,763**
1.VZ2a.1.2	Removal of Monitoring Tubing	32.0	hour	779	120.3	11,312.23			13,610.42		24,923
1.VZ2a.1.2	Structural concrete, ready mix, lightweight, 110 #/C.F., 3000 psi, includes local aggregate, sand, portland cement and water, excludes all additives and treatments	96.0	CF	78	90.2	6,382.85	1,076.31				7,459
1.VZ2a.1.2	Labor for refilling the shaft after tubing removal	16.0	hour	298	60.2	4,769.70					4,770
1.VZ2a.1.2	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	2.0	EA	1,306	20.1	1,574.93			1,036.22		2,611
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.VZ2a.1.2	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.VZ2a.1.2	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.VZ2a.1.2	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.VZ2a.1.2	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.VZ2a.1.2	**Monitoring Natural Attenuation - DC - Demo Total**				**5,854.0**	**465,109.75**	**791,379.39**		**42,646.21**		**1,299,135**
1.VZ2a.1.3	**Project WBS: 1.VZ2a.1.3 - Monitoring Natural Attenuation - DC - Install**										

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
	VZ - Project Costs				**6,231.5**	**609,637.14**	**101,338.70**		**13,703.46**		**724,679**
1.VZ2a.1.3	Directional drilling, small equipment to 300', not to exceed 12" dia, small unit mobilization to site, excluding cost of conduit	5.0	EA	3,187	150.6	11,815.20			4,119.40		15,935
1.VZ2a.1.3	Well Head, hand holes, precast concrete, with concrete cover, 2' x 2' x 3' deep, excludes excavation, backfill and cast in place concrete	5.0	EA	2,870	156.3	11,054.60	3,270.04		26.98		14,352
1.VZ2a.1.3	Structural excavation for minor structures, bank measure, normal soil, pits to 6' deep, hand pits	2.5	CY	737	23.5	1,843.52					1,844
1.VZ2a.1.3	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 CY truck, cycle 6 miles, 15 MPH, excludes loading equipment	23.0	CY	33	6.4	505.73			258.16		764
1.VZ2a.1.3	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	4.0	EA	1,306	40.2	3,149.87			2,072.44		5,222
1.VZ2a.1.3	Pipe, steel, black, welded, 10" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	400.0	LF	400	1,239.6	127,571.30	31,256.45		1,304.62		160,132
1.VZ2a.1.3	Pipe, steel, black, welded, 2" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	1,680.0	LF	116	1,655.7	170,397.46	22,688.10		2,597.00		195,683
1.VZ2a.1.3	Structural concrete, ready mix, normal weight, 3000 psi, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments	24.0	CF	6			152.48				152
1.VZ2a.1.3	Structural concrete, placing, elevated slab, pumped, less than 6" thick, includes vibrating, excludes material	24.0	CF	6	1.9	137.42			11.01		148
1.VZ2a.1.3	Bentonite clay, 50# bag, 1 per 10' of rod	368.0	EA	65			23,754.90				23,755
1.VZ2a.1.3	Aggregate, sand, washed, for concrete, loaded at the pit, includes material only	2.7	CY	42			113.20				113
1.VZ2a.1.3	Backfill, heavy soil, by hand, no compaction	25.6	CY	2,655	866.3	67,960.27					67,960
1.VZ2a.1.3	Pipe, stainless steel, butt weld, 1/4" diameter, schedule 5, type 304, includes weld joint and clevis type hangers 10' OC	4,000.0	LF	54	1,885.4	194,034.38	18,264.64		2,989.75		215,289
1.VZ2a.1.3	Elbow, 90 Deg., stainless steel, long, butt weld, 1/2", schedule 5, type 304, includes the weld machine	30.0	EA	388	102.8	10,583.69	883.67		162.06		11,629
1.VZ2a.1.3	Mud Dauber (monitoring port)	30.0	EA	390	102.8	10,583.69	955.22		162.06		11,701
	VZ - Installation Costs				**961.6**	**159,817.38**					**159,817**
1.VZ2a.1.3	Project Geologist	64.0	hour	170	64.0	10,862.09					10,862
1.VZ2a.1.3	Field Technician	64.0	hour	143	64.0	9,169.30					9,169
1.VZ2a.1.3	Radiological Control Technician	64.0	hour	143	64.0	9,169.30					9,169
1.VZ2a.1.3	Health and Safety Officer - Site	64.0	hour	170	64.0	10,862.09					10,862
1.VZ2a.1.3	Project Engineer - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2a.1.3	Project Manager	400.0	hour	170	400.0	67,888.09					67,888
1.VZ2a.1.3	Health and Safety Officer - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2a.1.3	Project Scientist - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2a.1.3	Health and Safety Officer - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2a.1.3	Health and Safety Officer - Site	200.0	hour	170	200.0	33,944.04					33,944
	VZ - Annual Operations				**1,184.0**	**183,809.21**					**183,809**
1.VZ2a.1.3	Field Technician - Daily	168.0	hour	143	168.0	24,069.41					24,069
1.VZ2a.1.3	Project Engineer - Starup	200.0	hour	170	200.0	33,944.04					33,944
1.VZ2a.1.3	Field Technician - Startup	200.0	hour	143	200.0	28,654.06					28,654
1.VZ2a.1.3	Radiological Control Technician - Startup	200.0	hour	143	200.0	28,654.06					28,654
1.VZ2a.1.3	Maintenance	80.0	hour	143	80.0	11,461.63					11,462
1.VZ2a.1.3	Project Manager	336.0	hour	170	336.0	57,026.00					57,026
	VZ - Waste				**740.7**	**57,727.29**	**24,000.16**	**58,714.55**	**6,065.62**		**146,508**
1.VZ2a.1.3	MLLW - Waste container delivery.	1.0	ea	2,469	30.1	1,979.37			489.91		2,469
1.VZ2a.1.3	MLLW - Waste container unload on site and handling during project.	7.0	ea	7,827	631.7	49,553.71			5,232.06		54,786
1.VZ2a.1.3	MLLW - Waste containers.	7.0	ea	3,429			24,000.16				24,000
1.VZ2a.1.3	MLLW - Fill waste containers.	7.0	ea	934	79.0	6,194.21			343.65		6,538
1.VZ2a.1.3	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	23.0	cy	1,892				43,524.60			43,525
1.VZ2a.1.3	MLLW - Trucking cost per 43,000 pound load	2.0	Trip	7,595				15,189.95			15,190
1.VZ2a.1.3	**Monitoring Natural Attenuation - DC - Install Total**				**9,117.9**	**1,010,991.02**	**125,338.86**	**58,714.55**	**19,769.08**		**1,214,814**
1.VZ2a.1.4	**Project WBS: 1.VZ2a.1.4 - Monitoring Natural Attenuation - DC - Project Cost**										
	VZ - Project Costs				**30,478.0**	**2,876,389.76**	**44,496.27**	**160,454.71**		**3,567.31**	**3,084,908**
1.VZ2a.1.4	Storm water prevention	1.0	LS	160,455				160,454.71			160,455
1.VZ2a.1.4	Field Non-Manual - JHRS	22,994.0	hour	112	22,994.0	2,581,890.08					2,581,890
1.VZ2a.1.4	Craft Distributable - Labor	3,742.0	hour	79	3,742.0	294,499.68					294,500
1.VZ2a.1.4	Craft Distributable - Materials	3,742.0	hour	12	3,742.0		44,496.27				44,496
1.VZ2a.1.4	Excavation permit	3.0	ea	1,189						3,567.31	3,567
1.VZ2a.1.4	**Monitoring Natural Attenuation - DC - Project Cost Total**				**30,478.0**	**2,876,389.76**	**44,496.27**	**160,454.71**		**3,567.31**	**3,084,908**
1.VZ2a.1	**Monitoring Natural Attenuation - Direct Cost Total**				**45,449.8**	**4,352,490.53**	**961,214.51**	**219,169.26**	**62,415.29**	**3,567.31**	**5,598,857**
1.VZ2a.2	**Project WBS: 1.VZ2a.2 - Monitoring Natural Attenuation - Indirect Cost**										
1.VZ2a.2.1	**Project WBS: 1.VZ2a.2.1 - Monitoring Natural Attenuation - IC - Design**										
	VZ - Project Costs							**1,294,769.27**			**1,294,769**
1.VZ2a.2.1	Design	1.0	lsum	1,294,769				1,294,769.27			1,294,769
1.VZ2a.2.1	**Monitoring Natural Attenuation - IC - Design Total**							**1,294,769.27**			**1,294,769**

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.VZ2a.2.2	**Project WBS: 1.VZ2a.2.2 - Monitoring Natural Attenuation - IC - Professional Management**										
	VZ - Project Costs				**14,615.5**	**3,208,600.11**					**3,208,600**
1.VZ2a.2.2	Professional Management	1.0	lsum	3,208,600	14,615.5	3,208,600.11					3,208,600
1.VZ2a.2.2	**Monitoring Natural Attenuation - IC - Professional Management Total**				**14,615.5**	**3,208,600.11**					**3,208,600**
1.VZ2a.2.3	**Project WBS: 1.VZ2a.2.3 - Monitoring Natural Attenuation - IC - Contingency**										
	VZ - Project Costs				**3.0**					**5,051,113.00**	**5,051,113**
1.VZ2a.2.3	Contingency - Cost 30%	1.0	lsum	3,030,668	1.0					3,030,667.80	3,030,668
1.VZ2a.2.3	Contingency - Schedule 10%	1.0	lsum	1,010,223	1.0					1,010,222.60	1,010,223
1.VZ2a.2.3	Contingency - TPRA 10%	1.0	lsum	1,010,223	1.0					1,010,222.60	1,010,223
1.VZ2a.2.3	**Monitoring Natural Attenuation - IC - Contingency Total**				**3.0**					**5,051,113.00**	**5,051,113**
1.VZ2a.2	**Monitoring Natural Attenuation - Indirect Cost Total**				**14,618.5**	**3,208,600.11**		**1,294,769.27**		**5,051,113.00**	**9,554,482**
1.VZ2a.3	**Project WBS: 1.VZ2a.3 - Monitoring Natural Attenuation - Direct Operations & Maintenance**										
1.VZ2a.3.1	**Project WBS: 1.VZ2a.3.1 - Monitoring Natural Attenuation - DOM - Cover Maintenance & Inspections**										
	VZ - Project Costs				**4,145.7**	**469,174.90**					**469,175**
1.VZ2a.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.VZ2a.3.1	**Monitoring Natural Attenuation - DOM - Cover Maintenance & Inspections Total**				**4,145.7**	**469,174.90**					**469,175**
1.VZ2a.3.2	**Project WBS: 1.VZ2a.3.2 - Monitoring Natural Attenuation - DOM - Subsurface VOC Monitoring**										
	VZ - Project Costs				**1,777.3**	**156,695.34**		**1,263,892.51**			**1,420,588**
1.VZ2a.3.2	Sub Surface Monitoring 3 years	1.0	lsum	336,366	420.8	37,102.20		299,263.48			336,366
1.VZ2a.3.2	Sub Surface Monitoring 27 years	1.0	lsum	1,084,222	1,356.4	119,593.14		964,629.02			1,084,222
1.VZ2a.3.2	**Monitoring Natural Attenuation - DOM - Subsurface VOC Monitoring Total**				**1,777.3**	**156,695.34**		**1,263,892.51**			**1,420,588**
1.VZ2a.3	**Monitoring Natural Attenuation - Direct Operations & Maintenance Total**				**5,923.0**	**625,870.25**		**1,263,892.51**			**1,889,763**
1.VZ2a.4	**Project WBS: 1.VZ2a.4 - Monitoring Natural Attenuation - Indirect Operations & Maintenance**										
1.VZ2a.4.2	**Project WBS: 1.VZ2a.4.2 - Monitoring Natural Attenuation - IOM - Professional Management**										
	VZ - Project Costs				**2,964.6**	**650,826.36**					**650,826**
1.VZ2a.4.2	Professional Management (years 31-100)	1.0	lsum	36,781	167.5	36,780.80					36,781
1.VZ2a.4.2	Professional Management (years 4-30)	1.0	lsum	417,677	1,902.6	417,677.06					417,677
1.VZ2a.4.2	Professional Management (years 0-3)	1.0	lsum	196,369	894.5	196,368.50					196,369
1.VZ2a.4.2	**Monitoring Natural Attenuation - IOM - Professional Management Total**				**2,964.6**	**650,826.36**					**650,826**
1.VZ2a.4.3	**Project WBS: 1.VZ2a.4.3 - Monitoring Natural Attenuation - IOM - Contingency**										
	VZ - Project Costs				**3.0**					**1,270,294.50**	**1,270,295**
1.VZ2a.4.3	Contingency - Cost 30%	1.0	lsum	762,177	1.0					762,176.70	762,177
1.VZ2a.4.3	Contingency - Schedule 10%	1.0	lsum	254,059	1.0					254,058.90	254,059
1.VZ2a.4.3	Contingency - TPRA 10%	1.0	lsum	254,059	1.0					254,058.90	254,059
1.VZ2a.4.3	**Monitoring Natural Attenuation - IOM - Contingency Total**				**3.0**					**1,270,294.50**	**1,270,295**
1.VZ2a.4	**Monitoring Natural Attenuation - Indirect Operations & Maintenance Total**				**2,967.6**	**650,826.36**				**1,270,294.50**	**1,921,121**
1.VZ2a	**Monitoring Natual Attenuation Total**				**68,958.9**	**8,837,787.25**	**961,214.51**	**2,777,831.04**	**62,415.29**	**6,324,974.81**	**18,964,223**
1.VZ2b	**Project WBS: 1.VZ2b - Soil Gas Venting**										
1.VZ2b.1	**Project WBS: 1.VZ2b.1 - Soil Gas Venting - Direct Cost**										
	VZ - Project Costs				**141,942.3**	**20,727,709.93**	**2,000,735.78**		**437,468.36**		**23,165,914**
1.VZ2b.1	Well Head, precast concrete, with concrete cover, 2' x 2' x 3' deep, excludes excavation, backfill and cast in place concrete	433.0	EA	1,247	3,599.8	254,608.64	283,185.09		2,336.44		540,130
1.VZ2b.1	Structural excavation for minor structures, bank measure, normal soil, pits to 6' deep, hand pits	217.0	B.C.Y.	196	542.5	42,557.76					42,558
1.VZ2b.1	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 CY truck, cycle 4 miles, 15 MPH, no loading equipment	1,342.3	L.C.Y.	98	1,610.8	126,360.08			5,176.04		131,536

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.VZ2b.1	Directional drilling, small equipment to 300', not to exceed 12" dia, small unit mobilization to site, excluding cost of conduit	433.0	EA	1,452	3,468.9	272,126.74			356,739.66		628,866
1.VZ2b.1	Pipe, steel, black, welded, 8" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	21,650.0	LF	166	17,843.4	1,836,382.13	1,691,755.10		70,612.39		3,598,750
1.VZ2b.1	Pipe, steel, black, welded, 2" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	1,299.0	LF	42	340.5	35,040.89	17,542.76		2,008.04		54,592
1.VZ2b.1	Structural concrete, ready mix, normal weight, 3000 psi, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments	1,299.0	CF	77	1,299.0	91,877.35	8,252.82				100,130
1.VZ2b.1	Structural concrete, placing, elevated slab, pumped, less than 6" thick, includes vibrating, excludes material	1,299.0	CF	2	28.0	1,978.12			595.79		2,574
1.VZ2b.1	Structural excavation for minor structures, bank measure, normal soil, pits to 6' deep, hand pits	217.0	B.C.Y.	257	542.5	55,832.24					55,832
1.VZ2b.1	Project Geologist	3,464.0	hour	170	3,464.0	587,910.86					587,911
1.VZ2b.1	Field Technician	3,464.0	hour	143	3,464.0	496,288.38					496,288
1.VZ2b.1	Radiological Control Technician	3,464.0	hour	143	3,464.0	496,288.38					496,288
1.VZ2b.1	Health and Safety Officer - Site	3,464.0	hour	170	3,464.0	587,910.86					587,911
1.VZ2b.1	Project Engineer - Readiness	1,429.0	hour	170	1,429.0	242,530.20					242,530
1.VZ2b.1	Project Manager	18,186.0	hour	170	18,186.0	3,086,531.99					3,086,532
1.VZ2b.1	Health and Safety Officer - Readiness	1,429.0	hour	170	1,429.0	242,530.20					242,530
1.VZ2b.1	Project Scientist - Readiness	1,429.0	hour	170	1,429.0	242,530.20					242,530
1.VZ2b.1	Field Technician - Daily	9,093.0	hour	143	9,093.0	1,302,757.01					1,302,757
1.VZ2b.1	Health and Safety Officer - Readiness	1,429.0	hour	170	1,429.0	242,530.20					242,530
1.VZ2b.1	Project Engineer - Starup	10,825.0	hour	170	10,825.0	1,837,221.42					1,837,221
1.VZ2b.1	Field Technician - Startup	10,825.0	hour	143	10,825.0	1,550,901.20					1,550,901
1.VZ2b.1	Health and Safety Officer - Site	10,825.0	hour	170	10,825.0	1,837,221.42					1,837,221
1.VZ2b.1	Radiological Control Technician - Startup	10,825.0	hour	143	10,825.0	1,550,901.20					1,550,901
1.VZ2b.1	Maintenance	4,330.0	hour	143	4,330.0	620,360.48					620,360
1.VZ2b.1	Project Manager	18,186.0	hour	170	18,186.0	3,086,531.99					3,086,532
	VZ - Waste				**42,254.9**	**3,306,802.30**	**1,405,723.64**	**3,205,878.47**	**336,865.32**		**8,255,270**
1.VZ2b.1	MLLW - Waste container delivery.	21.0	ea	2,469	631.7	41,566.70			10,288.13		51,855
1.VZ2b.1	MLLW - Waste container unload on site and handling during project.	410.0	ea	7,827	36,998.4	2,902,431.64			306,449.06		3,208,881
1.VZ2b.1	MLLW - Waste containers.	410.0	ea	3,429			1,405,723.64				1,405,724
1.VZ2b.1	MLLW - Fill waste containers.	410.0	ea	934	4,624.8	362,803.96			20,128.13		382,932
1.VZ2b.1	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	1,365.0	cy	1,892				2,583,090.40			2,583,090
1.VZ2b.1	MLLW - Trucking cost per 43,000 pound load	82.0	Trip	7,595				622,788.07			622,788
	Add/Remove Monitoring Ports				**15,059.9**	**1,578,265.49**	**102,415.00**		**751,403.41**		**2,432,084**
1.VZ2b.1	Removal of Monitoring Tubing	1,732.0	hour	779	6,512.3	612,274.27			736,663.73		1,348,938
1.VZ2b.1	Structural concrete, ready mix, lightweight, 110 #/C.F., 3000 psi, includes local aggregate, sand, portland cement and water, excludes all additives and treatments	96.0	CF	78	90.2	6,382.85	1,076.31				7,459
1.VZ2b.1	Labor for refilling the shaft after tubing removal	16.0	hour	298	60.2	4,769.70					4,770
1.VZ2b.1	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	2.0	EA	1,306	20.1	1,574.93			1,036.22		2,611
1.VZ2b.1	Pipe, steel, black, welded, 10" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	400.0	LF	400	1,239.6	127,571.30	31,256.45		1,304.62		160,132
1.VZ2b.1	Pipe, steel, black, welded, 2" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	1,680.0	LF	116	1,655.7	170,397.46	22,688.10		2,597.00		195,683
1.VZ2b.1	Structural concrete, ready mix, normal weight, 3000 psi, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments	24.0	CF	6			152.48				152
1.VZ2b.1	Structural concrete, placing, elevated slab, pumped, less than 6" thick, includes vibrating, excludes material	24.0	CF	6	1.9	137.42			11.01		148
1.VZ2b.1	Bentonite clay, 50# bag, 1 per 10' of rod	368.0	EA	65			23,754.90				23,755
1.VZ2b.1	Aggregate, sand, washed, for concrete, loaded at the pit, includes material only	2.7	CY	42			113.20				113
1.VZ2b.1	Backfill, heavy soil, by hand, no compaction	25.6	CY	2,655	866.3	67,960.27					67,960
1.VZ2b.1	Pipe, stainless steel, butt weld, 1/4" diameter, schedule 5, type 304, includes weld joint and clevis type hangers 10' OC	4,000.0	LF	54	1,885.4	194,034.38	18,264.64		2,989.75		215,289
1.VZ2b.1	Elbow, 90 Deg., stainless steel, long, butt weld, 1/2", schedule 5, type 304, includes the weld machine	30.0	EA	388	102.8	10,583.69	883.67		162.06		11,629
1.VZ2b.1	Mud Dauber (monitoring port)	30.0	EA	390	102.8	10,583.69	955.22		162.06		11,701
1.VZ2b.1	Directional drilling, small equipment to 300', not to exceed 12" dia, small unit mobilization to site, excluding cost of conduit	5.0	EA	3,187	150.6	11,815.20			4,119.40		15,935
1.VZ2b.1	Well Head, hand holes, precast concrete, with concrete cover, 2' x 2' x 3' deep, excludes excavation, backfill and cast in place concrete	5.0	EA	2,870	156.3	11,054.60	3,270.04		26.98		14,352
1.VZ2b.1	Structural excavation for minor structures, bank measure, normal soil, pits to 6' deep, hand pits	2.5	CY	737	23.5	1,843.52					1,844
1.VZ2b.1	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 CY truck, cycle 6 miles, 15 MPH, excludes loading equipment	23.0	CY	33	6.4	505.73			258.16		764
1.VZ2b.1	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	4.0	EA	1,306	40.2	3,149.87			2,072.44		5,222
1.VZ2b.1	Project Geologist	64.0	hour	170	64.0	10,862.09					10,862
1.VZ2b.1	Field Technician	64.0	hour	143	64.0	9,169.30					9,169
1.VZ2b.1	Radiological Control Technician	64.0	hour	143	64.0	9,169.30					9,169
1.VZ2b.1	Health and Safety Officer - Site	64.0	hour	170	64.0	10,862.09					10,862
1.VZ2b.1	Project Engineer - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2b.1	Project Manager	400.0	hour	170	400.0	67,888.09					67,888
1.VZ2b.1	Health and Safety Officer - Readiness	26.4	hour	170	26.4	4,480.61					4,481

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.VZ2b.1	Project Scientist - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2b.1	Field Technician - Daily	168.0	hour	143	168.0	24,069.41					24,069
1.VZ2b.1	Health and Safety Officer - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2b.1	Project Engineer - Starup	200.0	hour	170	200.0	33,944.04					33,944
1.VZ2b.1	Field Technician - Startup	200.0	hour	143	200.0	28,654.06					28,654
1.VZ2b.1	Health and Safety Officer - Site	200.0	hour	170	200.0	33,944.04					33,944
1.VZ2b.1	Radiological Control Technician - Startup	200.0	hour	143	200.0	28,654.06					28,654
1.VZ2b.1	Maintenance	80.0	hour	143	80.0	11,461.63					11,462
1.VZ2b.1	Project Manager	336.0	hour	170	336.0	57,026.00					57,026
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.VZ2b.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.VZ2b.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.VZ2b.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.VZ2b.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.VZ2b.1	**Soil Gas Venting - Direct Cost Total**				**204,820.3**	**26,053,847.75**	**4,299,177.51**	**3,205,878.47**	**1,553,736.66**		**35,112,640**
1.VZ2b.1.4	**Project WBS: 1.VZ2b.1.4 - Soil Gas Venting - DC - Project Cost**										
	VZ - Project Costs				**143,374.0**	**8,629,550.43**	**608,880.65**	**1,585,391.46**		**3,567.31**	**10,827,390**
1.VZ2b.1.4	Storm water prevention	1.0	LS	1,585,391				1,585,391.46			1,585,391
1.VZ2b.1.4	Field Non-Manual - JHRS	40,964.0	hour	112	40,964.0	4,599,658.41					4,599,658
1.VZ2b.1.4	Craft Distributable - Labor	51,205.0	hour	79	51,205.0	4,029,892.02					4,029,892
1.VZ2b.1.4	Craft Distributable - Materials	51,205.0	hour	12	51,205.0		608,880.65				608,881
1.VZ2b.1.4	Excavation permit	3.0	ea	1,189						3,567.31	3,567
1.VZ2b.1.4	**Soil Gas Venting - DC - Project Cost Total**				**143,374.0**	**8,629,550.43**	**608,880.65**	**1,585,391.46**		**3,567.31**	**10,827,390**
1.VZ2b.2	**Project WBS: 1.VZ2b.2 - Soil Gas Venting - Indirect Cost**										
1.VZ2b.2.1	**Project WBS: 1.VZ2b.2.1 - Soil Gas Venting - IC - Design**										
	VZ - Project Costs							**8,120,833.39**			**8,120,833**
1.VZ2b.2.1	Design	1.0	lsum	8,120,833				8,120,833.39			8,120,833
1.VZ2b.2.1	**Soil Gas Venting - IC - Design Total**							**8,120,833.39**			**8,120,833**
1.VZ2b.2.2	**Project WBS: 1.VZ2b.2.2 - Soil Gas Venting - IC - Professional Management**										
	VZ - Project Costs				**14,667.0**	**3,219,910.04**					**3,219,910**
1.VZ2b.2.2	Professional Management	1.0	lsum	3,219,910	14,667.0	3,219,910.04					3,219,910
1.VZ2b.2.2	**Soil Gas Venting - IC - Professional Management Total**				**14,667.0**	**3,219,910.04**					**3,219,910**
1.VZ2b.2.3	**Project WBS: 1.VZ2b.2.3 - Soil Gas Venting - IC - Contingency**										
	VZ - Project Costs				**3.0**					**28,640,386.50**	**28,640,387**
1.VZ2b.2.3	Contingency - Cost 30%	1.0	lsum	17,184,232	1.0					17,184,231.90	17,184,232
1.VZ2b.2.3	Contingency - Schedule 10%	1.0	lsum	5,728,077	1.0					5,728,077.30	5,728,077
1.VZ2b.2.3	Contingency - TPRA 10%	1.0	lsum	5,728,077	1.0					5,728,077.30	5,728,077
1.VZ2b.2.3	**Soil Gas Venting - IC - Contingency Total**				**3.0**					**28,640,386.50**	**28,640,387**
1.VZ2b.2	**Soil Gas Venting - Indirect Cost Total**				**14,670.0**	**3,219,910.04**		**8,120,833.39**		**28,640,386.50**	**39,981,130**
1.VZ2b.3	**Project WBS: 1.VZ2b.3 - Soil Gas Venting - Direct Operations & Maintenance**										
1.VZ2b.3.1	**Project WBS: 1.VZ2b.3.1 - Soil Gas Venting - DOM - Cover Maintenance & Inspections**										
	VZ - Project Costs				**4,145.7**	**469,174.90**					**469,175**
1.VZ2b.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.VZ2b.3.1	**Soil Gas Venting - DOM - Cover Maintenance & Inspections Total**				**4,145.7**	**469,174.90**					**469,175**
1.VZ2b.3.2	**Project WBS: 1.VZ2b.3.2 - Soil Gas Venting - DOM - Subsurface VOC Monitoring**										
	VZ - Project Costs				**17,531.9**	**1,545,725.30**		**12,467,700.56**			**14,013,426**
1.VZ2b.3.2	Sub Surface Monitoring 27 years	1.0	lsum	1,084,222	1,356.4	119,593.14		964,629.02			1,084,222
1.VZ2b.3.2	Sub Surface Monitoring 3 years	1.0	lsum	336,366	420.8	37,102.20		299,263.48			336,366
1.VZ2b.3.2	Soil GAs Venting Monitoring	1.0	lsum	12,592,838	15,754.6	1,389,029.95		11,203,808.06			12,592,838
1.VZ2b.3.2	**Soil Gas Venting - DOM - Subsurface VOC Monitoring Total**				**17,531.9**	**1,545,725.30**		**12,467,700.56**			**14,013,426**
1.VZ2b.3	**Soil Gas Venting - Direct Operations & Maintenance Total**				**21,677.6**	**2,014,900.20**		**12,467,700.56**			**14,482,601**
1.VZ2b.4	**Project WBS: 1.VZ2b.4 - Soil Gas Venting - Indirect Operations & Maintenance**										

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.VZ2b.4.2	**Project WBS: 1.VZ2b.4.2 - Soil Gas Venting - IOM - Professional Management**										
	VZ - Project Costs				**35,832.5**	**7,866,450.82**					**7,866,451**
1.VZ2b.4.2	Professional Management (years 31-100)	1.0	lsum	3,294,876	15,008.5	3,294,875.69					3,294,876
1.VZ2b.4.2	Professional Management (years 4-30)	1.0	lsum	4,445,797	20,251.0	4,445,797.02					4,445,797
1.VZ2b.4.2	Professional Management (years 0-3)	1.0	lsum	125,778	572.9	125,778.11					125,778
1.VZ2b.4.2	**Soil Gas Venting - IOM - Professional Management Total**				**35,832.5**	**7,866,450.82**					**7,866,451**
1.VZ2b.4.3	**Project WBS: 1.VZ2b.4.3 - Soil Gas Venting - IOM - Contingency**										
	VZ - Project Costs				**3.0**					**11,174,526.00**	**11,174,526**
1.VZ2b.4.3	Contingency - Cost 30%	1.0	lsum	6,704,716	1.0					6,704,715.60	6,704,716
1.VZ2b.4.3	Contingency - Schedule 10%	1.0	lsum	2,234,905	1.0					2,234,905.20	2,234,905
1.VZ2b.4.3	Contingency - TPRA 10%	1.0	lsum	2,234,905	1.0					2,234,905.20	2,234,905
1.VZ2b.4.3	**Soil Gas Venting - IOM - Contingency Total**				**3.0**					**11,174,526.00**	**11,174,526**
1.VZ2b.4	**Soil Gas Venting - Indirect Operations & Maintenance Total**				**35,835.5**	**7,866,450.82**				**11,174,526.00**	**19,040,977**
1.VZ2b	**Soil Gas Venting Total**				**420,377.4**	**47,784,659.24**	**4,908,058.16**	**25,379,803.88**	**1,553,736.66**	**39,818,479.81**	**119,444,738**
1.VZ2c	**Project WBS: 1.VZ2c - Soil Vapor Extraction**										
1.VZ2c.1	**Project WBS: 1.VZ2c.1 - Soil Vapor Extraction Direct Cost**										
	VZ - Project Costs				**455,875.7**	**9,110,345.72**	**595,780.70**	**305,769.57**	**114,811.85**		**10,126,708**
1.VZ2c.1	SVE Unit - Contractors Price	4.0	ea	59,455	15.0			237,820.78			237,821
1.VZ2c.1	SVE Piping Equipment (1 per extraction borehole)	20.0	ea	3,397				67,948.79			67,949
1.VZ2c.1	Well Head, precast concrete, with concrete cover, 2' x 2' x 3' deep, excludes excavation, backfill and cast in place concrete	20.0	EA	2,870	625.2	44,218.41	13,080.14		107.92		57,406
1.VZ2c.1	Structural excavation for minor structures, bank measure, normal soil, pits to 6' deep, hand pits	10.0	B.C.Y.	737	94.0	7,374.06					7,374
1.VZ2c.1	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 CY truck, cycle 4 miles, 15 MPH, no loading equipment	62.0	L.C.Y.	358	279.7	21,945.21			239.08		22,184
1.VZ2c.1	Directional drilling, small equipment to 300', not to exceed 12" dia, small unit mobilization to site, excluding cost of conduit	20.0	EA	3,187	602.5	47,260.81			16,477.58		63,738
1.VZ2c.1	Pipe, steel, black, welded, 8" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	1,000.0	LF	400	3,098.9	318,928.26	78,141.11		3,261.54		400,331
1.VZ2c.1	Pipe, steel, black, welded, 2" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	4,200.0	LF	116	4,139.2	425,993.66	56,720.26		6,492.51		489,206
1.VZ2c.1	Structural concrete, ready mix, normal weight, 3000 psi, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments	60.0	CF	6			381.19				381
1.VZ2c.1	Structural concrete, placing, elevated slab, pumped, less than 6" thick, includes vibrating, excludes material	60.0	CF	6	4.9	343.54			27.52		371
1.VZ2c.1	Structural excavation for minor structures, bank measure, normal soil, pits to 6' deep, hand pits	10.0	B.C.Y.	967	94.0	9,674.16					9,674
1.VZ2c.1	Electrical Underground Ducts and Manholes, hand holes, precast concrete, with concrete cover, 2' x 2' x 3' deep, excludes excavation, backfill and cast in place concrete	60.0	EA	3,112	1,875.5	147,130.97	39,240.43		323.76		186,695
1.VZ2c.1	Directional drilling, small equipment to 300', not to exceed 12" dia, small unit mobilization to site, excluding cost of conduit	60.0	EA	3,187	1,807.4	141,782.43			49,432.75		191,215
1.VZ2c.1	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 CY truck, cycle 4 miles, 15 MPH, no loading equipment	186.0	L.C.Y.	358	839.2	65,835.64			717.23		66,553
1.VZ2c.1	Bentonite clay, 50# bag, 1 per 10' of rod	2,760.0	EA	65			178,161.74				178,162
1.VZ2c.1	Aggregate, sand, washed, for concrete, loaded at the pit, includes material only	19.8	CY	42			824.05				824
1.VZ2c.1	Backfill, heavy soil, by hand, no compaction	12,360.0	L.C.Y.	435	418,262.4	5,373,236.74					5,373,237
1.VZ2c.1	Pipe, stainless steel, butt weld, 1/4" diameter, schedule 5, type 304, includes weld joint and clevis type hangers 10' OC	47,880.0	LF	54	22,567.7	2,322,591.51	218,627.69		35,787.27		2,577,006
1.VZ2c.1	Elbow, 90 Deg., stainless steel, long, butt weld, 1/2", schedule 5, type 304, includes the weld machine	360.0	EA	388	1,234.1	127,004.32	10,604.09		1,944.69		139,553
1.VZ2c.1	Project Manager	336.0	hour	170	336.0	57,026.00					57,026
	VZ - Installation Costs				**7,564.0**	**1,199,124.08**					**1,199,124**
1.VZ2c.1	Project Geologist	1,600.0	hour	170	1,600.0	271,552.36					271,552
1.VZ2c.1	Field Technician	1,600.0	hour	143	1,600.0	229,232.51					229,233
1.VZ2c.1	Radiological Control Technician	1,600.0	hour	143	1,600.0	229,232.51					229,233
1.VZ2c.1	Health and Safety Officer - Site	1,600.0	hour	170	1,600.0	271,552.36					271,552
1.VZ2c.1	Project Engineer - Readiness	66.0	hour	170	66.0	11,201.53					11,202
1.VZ2c.1	Project Manager	400.0	hour	170	400.0	67,888.09					67,888
1.VZ2c.1	Health and Safety Officer - Readiness	66.0	hour	170	66.0	11,201.53					11,202
1.VZ2c.1	Project Scientist - Readiness	66.0	hour	170	66.0	11,201.53					11,202
1.VZ2c.1	Health and Safety Officer - Readiness	66.0	hour	170	66.0	11,201.53					11,202
1.VZ2c.1	Health and Safety Officer - Site	500.0	hour	170	500.0	84,860.11					84,860
	VZ - Waste				**2,699.7**	**211,022.45**	**89,143.45**	**206,421.64**	**21,689.59**		**528,277**
1.VZ2c.1	MLLW - Waste container delivery.	2.0	ea	2,469	60.2	3,958.73			979.82		4,939
1.VZ2c.1	MLLW - Waste container unload on site and handling during project.	26.0	ea	7,827	2,346.2	184,056.64			19,433.36		203,490
1.VZ2c.1	MLLW - Waste containers.	26.0	ea	3,429			89,143.45				89,143
1.VZ2c.1	MLLW - Fill waste containers.	26.0	ea	934	293.3	23,007.08			1,276.42		24,283

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.VZ2c.1	MLLW - Mixed Waste, ship off site. Packaging, Handling, Shipping and Disposal fees.	85.0	cy	1,892				160,851.78			160,852
1.VZ2c.1	MLLW - Trucking cost per 43,000 pound load	6.0	Trip	7,595				45,569.86			45,570
	Add/Remove Monitoring Ports				**14,717.5**	**1,463,902.53**	**102,415.00**		**751,145.25**		**2,317,463**
1.VZ2c.1	Removal of Monitoring Tubing	1,732.0	hour	779	6,512.3	612,274.27			736,663.73		1,348,938
1.VZ2c.1	Structural concrete, ready mix, lightweight, 110 #/C.F., 3000 psi, includes local aggregate, sand, portland cement and water, excludes all additives and treatments	96.0	CF	78	90.2	6,382.85	1,076.31				7,459
1.VZ2c.1	Labor for refilling the shaft after tubing removal	16.0	hour	298	60.2	4,769.70					4,770
1.VZ2c.1	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	2.0	EA	1,306	20.1	1,574.93			1,036.22		2,611
1.VZ2c.1	Pipe, steel, black, welded, 10" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	400.0	LF	400	1,239.6	127,571.30	31,256.45		1,304.62		160,132
1.VZ2c.1	Pipe, steel, black, welded, 2" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	1,680.0	LF	116	1,655.7	170,397.46	22,688.10		2,597.00		195,683
1.VZ2c.1	Structural concrete, ready mix, normal weight, 3000 psi, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments	24.0	CF	6			152.48				152
1.VZ2c.1	Structural concrete, placing, elevated slab, pumped, less than 6" thick, includes vibrating, excludes material	24.0	CF	6	1.9	137.42			11.01		148
1.VZ2c.1	Bentonite clay, 50# bag, 1 per 10' of rod	368.0	EA	65			23,754.90				23,755
1.VZ2c.1	Aggregate, sand, washed, for concrete, loaded at the pit, includes material only	2.7	CY	42			113.20				113
1.VZ2c.1	Backfill, heavy soil, by hand, no compaction	25.6	CY	435	866.3	11,129.03					11,129
1.VZ2c.1	Pipe, stainless steel, butt weld, 1/4" diameter, schedule 5, type 304, includes weld joint and clevis type hangers 10' OC	4,000.0	LF	54	1,885.4	194,034.38	18,264.64		2,989.75		215,289
1.VZ2c.1	Elbow, 90 Deg., stainless steel, long, butt weld, 1/2", schedule 5, type 304, includes the weld machine	30.0	EA	388	102.8	10,583.69	883.67		162.06		11,629
1.VZ2c.1	Mud Dauber (monitoring port)	30.0	EA	390	102.8	10,583.69	955.22		162.06		11,701
1.VZ2c.1	Directional drilling, small equipment to 300', not to exceed 12" dia, small unit mobilization to site, excluding cost of conduit	5.0	EA	3,187	150.6	11,815.20			4,119.40		15,935
1.VZ2c.1	Well Head, hand holes, precast concrete, with concrete cover, 2' x 2' x 3' deep, excludes excavation, backfill and cast in place concrete	5.0	EA	2,870	156.3	11,054.60	3,270.04		26.98		14,352
1.VZ2c.1	Structural excavation for minor structures, bank measure, normal soil, pits to 6' deep, hand pits	2.5	CY	737	23.5	1,843.52					1,844
1.VZ2c.1	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	4.0	EA	1,306	40.2	3,149.87			2,072.44		5,222
1.VZ2c.1	Project Geologist	64.0	hour	170	64.0	10,862.09					10,862
1.VZ2c.1	Field Technician	64.0	hour	143	64.0	9,169.30					9,169
1.VZ2c.1	Radiological Control Technician	64.0	hour	143	64.0	9,169.30					9,169
1.VZ2c.1	Health and Safety Officer - Site	64.0	hour	170	64.0	10,862.09					10,862
1.VZ2c.1	Project Engineer - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2c.1	Project Manager	400.0	hour	170	400.0	67,888.09					67,888
1.VZ2c.1	Health and Safety Officer - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2c.1	Project Scientist - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2c.1	Field Technician - Daily	168.0	hour	143	168.0	24,069.41					24,069
1.VZ2c.1	Health and Safety Officer - Readiness	26.4	hour	170	26.4	4,480.61					4,481
1.VZ2c.1	Project Engineer - Starup	200.0	hour	170	200.0	33,944.04					33,944
1.VZ2c.1	Field Technician - Startup	200.0	hour	143	200.0	28,654.06					28,654
1.VZ2c.1	Health and Safety Officer - Site	200.0	hour	170	200.0	33,944.04					33,944
1.VZ2c.1	Radiological Control Technician - Startup	200.0	hour	143	200.0	28,654.06					28,654
1.VZ2c.1	Maintenance	80.0	hour	143	80.0	11,461.63					11,462
	Fencing				**5,563.2**	**441,070.03**	**790,303.08**		**27,999.57**		**1,259,373**
1.VZ2c.1	Fence, chain link industrial, aluminized steel, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, includes excavation, in concrete, excludes barbed wire	10,250.0	LF	117	5,143.9	407,826.02	766,122.65		24,028.39		1,197,977
1.VZ2c.1	Fence, chain link industrial, galvanized steel, add for corner post, 6 ga. wire, 2-1/2" posts @ 10' OC, 8' high, 3" diameter, includes excavation, in concrete	34.0	EA	368	76.7	6,084.46	6,064.43		358.09		12,507
1.VZ2c.1	Fence, chain link industrial, double swing gates, 8' high, 20' opening, includes excavation, posts & hardware in concrete	2.0	Opng	10,239	165.5	13,122.99	5,605.78		1,749.68		20,478
1.VZ2c.1	Signs, stock, aluminum, reflectorized, .080" aluminum, 24" x 24", excludes posts	103.0	EA	276	177.0	14,036.56	12,510.22		1,863.41		28,410
1.VZ2c.1	**Soil Vapor Extraction Direct Cost Total**				**486,420.0**	**12,425,464.81**	**1,577,642.24**	**512,191.22**	**915,646.27**		**15,430,945**
1.VZ2c.1.4	**Project WBS: 1.VZ2c.1.4 - SVE - DC - Project Cost**										
	VZ - Project Costs				**340,494.0**	**20,494,023.63**	**1,446,009.80**	**1,018,421.62**		**3,567.31**	**22,962,022**
1.VZ2c.1.4	Storm water prevention	1.0	LS	1,018,422				1,018,421.62			1,018,422
1.VZ2c.1.4	Field Non-Manual - JHRS	97,284.0	hour	112	97,284.0	10,923,571.14					10,923,571
1.VZ2c.1.4	Craft Distributable - Labor	121,605.0	hour	79	121,605.0	9,570,452.48					9,570,452
1.VZ2c.1.4	Craft Distributable - Materials	121,605.0	hour	12	121,605.0		1,446,009.80				1,446,010
1.VZ2c.1.4	Excavation permit	3.0	ea	1,189						3,567.31	3,567
	Add/Remove Monitoring Ports				**6.4**	**505.73**			**258.16**		**764**
1.VZ2c.1.4	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 CY truck, cycle 6 miles, 15 MPH, excludes loading equipment	23.0	CY	33	6.4	505.73			258.16		764
1.VZ2c.1.4	**SVE - DC - Project Cost Total**				**340,500.4**	**20,494,529.36**	**1,446,009.80**	**1,018,421.62**	**258.16**	**3,567.31**	**22,962,786**
1.VZ2c.2	**Project WBS: 1.VZ2c.2 - Soil Vapor Extraction Indirect Cost**										
1.VZ2c.2.1	**Project WBS: 1.VZ2c.2.1 - Soil Vapor Extraction - IC - Design**										
	VZ - Project Costs							**5,014,850.19**			**5,014,850**

WBS9 Code	Item Description	Quantity	Unit	Gross Unit Price	Labor Hours	Labor Total - Gross	Mat Total - Gross	Subs Total - Gross	Equip Total - Gross	Other Total - Gross	Gross Total Costs
1.VZ2c.2.1	Design	1.0	lsum	5,014,850				5,014,850.19			5,014,850
1.VZ2c.2.1	Soil Vapor Extraction - IC - Design Total							5,014,850.19			5,014,850
1.VZ2c.2.2	Project WBS: 1.VZ2c.2.2 - Soil Vapor Extraction - IC - Professional Management										
	VZ - Project Costs				40,292.9	8,845,667.65					8,845,668
1.VZ2c.2.2	Professional Management	1.0	lsum	8,845,668	40,292.9	8,845,667.65					8,845,668
1.VZ2c.2.2	Soil Vapor Extraction - IC - Professional Management Total				40,292.9	8,845,667.65					8,845,668
1.VZ2c.2.3	Project WBS: 1.VZ2c.2.3 - Soil Vapor Extraction - IC - Contingency										
	VZ - Project Costs				3.0					26,127,124.50	26,127,125
1.VZ2c.2.3	Contingency - Cost 30%	1.0	lsum	15,676,275	1.0					15,676,274.70	15,676,275
1.VZ2c.2.3	Contingency - Schedule 10%	1.0	lsum	5,225,425	1.0					5,225,424.90	5,225,425
1.VZ2c.2.3	Contingency - TPRA 10%	1.0	lsum	5,225,425	1.0					5,225,424.90	5,225,425
1.VZ2c.2.3	Soil Vapor Extraction - IC - Contingency Total				3.0					26,127,124.50	26,127,125
1.VZ2c.2	Soil Vapor Extraction Indirect Cost Total				40,295.9	8,845,667.65		5,014,850.19		26,127,124.50	39,987,642
1.VZ2c.3	Project WBS: 1.VZ2c.3 - Soil Vapor Extraction - Direct Operations & Maintenance										
1.VZ2c.3.1	Project WBS: 1.VZ2c.3.1 - Soil Vapor Extraction - DOM - Cover Maintenance & Inspections										
	VZ - Project Costs				56,190.6	6,359,139.18					6,359,139
1.VZ2c.3.1	Annual Long Term Monitoring Report - 100 years	1.0	lsum	469,175	4,145.7	469,174.90					469,175
1.VZ2c.3.1	Active SVE Operation (3 years)	1.0	lsum	5,726,126	50,597.2	5,726,125.56					5,726,126
1.VZ2c.3.1	Active SVE Monitoring (3 years)	1.0	lsum	163,839	1,447.7	163,838.71					163,839
1.VZ2c.3.1	Soil Vapor Extraction - DOM - Cover Maintenance & Inspections Total				56,190.6	6,359,139.18					6,359,139
1.VZ2c.3.2	Project WBS: 1.VZ2c.3.2 - Soil Vapor Extraction - DOM - Subsurface VOC Monitoring										
	VZ - Project Costs				1,777.3	156,695.34		1,263,892.51			1,420,588
1.VZ2c.3.2	Sub Surface Monitoring 27 years	1.0	lsum	1,084,222	1,356.4	119,593.14		964,629.02			1,084,222
1.VZ2c.3.2	Sub Surface Monitoring 3 years	1.0	lsum	336,366	420.8	37,102.20		299,263.48			336,366
1.VZ2c.3.2	Soil Vapor Extraction - DOM - Subsurface VOC Monitoring Total				1,777.3	156,695.34		1,263,892.51			1,420,588
1.VZ2c.3	Soil Vapor Extraction - Direct Operations & Maintenance Total				57,967.9	6,515,834.52		1,263,892.51			7,779,727
1.VZ2c.4	Project WBS: 1.VZ2c.4 - Soil Vapor Extraction Indirect Operations & Maintenance										
1.VZ2c.4.2	Project WBS: 1.VZ2c.4.2 - Soil Vapor Extraction - IOM - Professional Management										
	VZ - Project Costs				8,113.7	1,781,244.61					1,781,245
1.VZ2c.4.2	Professional Management (years 31-100)	1.0	lsum	36,781	167.5	36,780.80					36,781
1.VZ2c.4.2	Professional Management (years 4-30)	1.0	lsum	417,677	1,902.6	417,677.06					417,677
1.VZ2c.4.2	Professional Management (years 0-3)	1.0	lsum	1,326,787	6,043.6	1,326,786.75					1,326,787
1.VZ2c.4.2	Soil Vapor Extraction - IOM - Professional Management Total				8,113.7	1,781,244.61					1,781,245
1.VZ2c.4.3	Project WBS: 1.VZ2c.4.3 - Soil Vapor Extraction - IOM - Contingency										
	VZ - Project Costs				3.0					4,780,486.00	4,780,486
1.VZ2c.4.3	Contingency - Cost 30%	1.0	lsum	2,868,292	1.0					2,868,291.60	2,868,292
1.VZ2c.4.3	Contingency - Schedule 10%	1.0	lsum	956,097	1.0					956,097.20	956,097
1.VZ2c.4.3	Contingency - TPRA 10%	1.0	lsum	956,097	1.0					956,097.20	956,097
1.VZ2c.4.3	Soil Vapor Extraction - IOM - Contingency Total				3.0					4,780,486.00	4,780,486
1.VZ2c.4	Soil Vapor Extraction Indirect Operations & Maintenance Total				8,116.7	1,781,244.61				4,780,486.00	6,561,731
1.VZ2c	Soil Vapor Extraction Total				933,301.0	50,062,740.95	3,023,652.03	7,809,355.53	915,904.43	30,911,177.81	92,722,831
1	MDA G CME Total				394,830,005.1	45,898,249,650.01	5,705,641,963.47	26,321,376,151.23	1,609,096,123.72	39,761,033,622.78	119,295,397,511
	Grand Total				394,830,005.1	45,898,249,650.01	5,705,641,963.47	26,321,376,151.23	1,609,096,123.72	39,761,033,622.78	119,295,397,511

Acronyms and Abbreviations for Attachment G-1

CAMU	corrective action management unit
CF	cubic foot
CME	corrective measures evaluation
CMI	corrective measure implementation
CY	cubic yard
DC	direct capital (cost)
DOM	direct operations and maintenance
EA	each
EPA	Environmental Protection Agency (U.S.)
ET	evapotranspiration
HAZWOPER	Hazardous Waste Operations and Emergency Response
H.P.	horse power
IC	indirect capital (cost)
IOM	indirect operations and maintenance
LSUM	lump sum
JHRS	job hours
LDR	land disposal restriction
LF	linear foot
LLW	low-level waste
MDA	material disposal area
MNTH	month
MPH	mile per hour
MSF	thousands of square feet
O&M	operation and maintenance
OC	on center
OMB	Office of Management and Budget
opng	opening
PI	pit and impoundments
PV	present value
RCRA	Resource Conservation and Recovery Act
S	shafts
spec	specification

SVE	soil-vapor extraction
SY	square yard
TA	technical area
TN	ton
TPRA	technical programmatic risk assessment
TRM	turf-reinforcing mat
VOC	volatile organic compound
VZ	vadose zone
WBS	work breakdown structure
YR	year

Appendix H

Proposed Long-Term Subsurface Vapor-Monitoring Plan for Material Disposal Area G at Technical Area 54

H-1.0 INTRODUCTION

The following plan describes the proposed subsurface monitoring activities and the frequency at which they will be conducted within the vadose zone in and around Material Disposal Area (MDA) G at Los Alamos National Laboratory (the Laboratory). The objective of the monitoring is to evaluate vapor phase volatile organic compound (VOC) concentrations over time to assess the effectiveness of soil-vapor extraction (SVE) and to identify any potential new releases of VOCs from the disposal units.

H-2.0 HISTORICAL DATA REVIEW

Pore-gas monitoring activities have been conducted at MDA G since 1985 to characterize VOC and tritium concentrations present in the vadose zone beneath MDA G. Quarterly pore-gas monitoring began in 1990 after the U.S. Environmental Protection Agency (EPA) issued Module VIII of the Laboratory's Hazardous Waste Facility Permit, which included requirements for quarterly pore-gas sampling at MDA G as an input to the Resource Conservation and Recovery Act facility investigation. The Compliance Order on Consent (the Consent Order) further required pore-gas monitoring during the site investigations and submittal of a long-term pore-gas monitoring plan. Currently, pore-gas monitoring activities are implemented in accordance with the revised long-term vapor-monitoring plan, provided as part of the MDA G CME Plan (LANL 2007, 099372), and a subsequent table of revised pore-gas monitoring locations, approved by NMED (Shen 2008, 103907).

Because sampling methods and resulting data quality have changed substantially over the years, pore-gas data before 1996 were not subject to the current quality assurance (QA)/quality control (QC) procedures. Data collected from 1997 to the present have been subjected to rigorous QA/QC procedures. Results of long-term pore-gas monitoring activities at MDA G have concluded that VOCs and tritium are the primary constituents in the subsurface at MDA G. The primary VOCs include TCA (1,1,1-trichloroethane) and TCE (trichloroethene). Ongoing analyses of pore-gas monitoring data continue to support the presence of two TCA plumes: one within the western portion of MDA G in the vicinity of Pit 29, and the other within the eastern portion of MDA G in the vicinity of Pits 2, 4, and 5. Three TCE plumes are present at MDA G: one comingled with the western TCA plume; the second located within the central portion of MDA G, near Pits 6, 7, and 24; and the third located within the southeast portion of MDA G in the vicinity of Pit 3.

The nature and extent of the VOC plume is discussed in more detail in section 3.2.4 of the corrective measures evaluation (CME) report and in Appendixes B and C. Appendix C provides present-day mass estimates for TCA and TCE of 210 kg and 79 kg, respectively, accounting for both vapor and liquid phases. Of these masses, they are located in the three plumes described above, and approximately 95% of the mass of the TCA and TCE is within the Tshirege Member of the Bandelier Tuff within the 423,000 $\mu g/m^3$ and 20,000 $\mu g/m^3$ contours, respectively. These concentrations represent 10 times the screening values for these constituents, as defined in the pore gas periodic monitoring reports (e.g., LANL 2010, 109955) and the Tier I screening levels defined in Appendix C. Decreasing concentrations and masses are present in deeper units.

The sources of VOC vapors at MDA G are thought to be associated with mixed wastes disposed of in the pits and shafts at the site, with VOCs being a component of the waste rather than a primary waste form. The VOCS are not expected to be present in the waste disposal units as solvents in a liquid phase. The source may be ongoing because VOC vapors are emanating from mixed wastes contained in drums or other containers that limit their rate of escape. These observations indicate that annual pore-gas monitoring will be sufficient to identify changes in the nature and extent of the VOC plumes.

The existing pore-gas monitoring program has been successful in defining the nature and extent of the vapor-phase VOC plumes at MDA G. Annual (once per year) pore-gas monitoring is therefore proposed at all pore-gas monitoring boreholes located laterally within VOC plume areas where TCA and TCE concentrations are 10 times their respective screening values. Biannual (once every 2 yr) pore-gas monitoring is proposed at all monitoring boreholes located outside VOC plume areas where TCA and TCE concentrations are 10 times their respective screening values.

Pore-gas monitoring activities that are part of any active SVE activities will be conducted twice per year during the active extraction period to assess SVE performance: once before and once after active extraction. The twice annual monitoring activities will be conducted in extraction boreholes and pore-gas monitoring boreholes located laterally within the VOC plume areas where TCA and TCE concentrations are 10 times their respective screening values. Monitoring will be conducted annually at all remaining monitoring borehole locations during the active extraction period. Real-time monitoring activities proposed as part of any active SVE system will be documented in an SVE work plan, which will be provided in the MDA G corrective measures implementation (CMI) plan.

H-3.0 MONITORING DISTRIBUTION AND FREQUENCY

The monitoring distribution and frequency has been developed to identify releases from the source regions (disposal units) and to assess the performance of active SVE. If evaluation of pore-gas monitoring data indicates changes to the nature and extent of the vapor plume (e.g., increasing VOC concentrations), NMED will be informed of the change. The Laboratory will consult with NMED to determine an appropriate and revised (if necessary) monitoring distribution and frequency if VOC concentrations are found to be increasing during the monitoring period. The Laboratory will also consult with NMED to establish adequate SVE system performance criteria (i.e., specific reduction in vapor-phase VOC concentrations) and whether those standards have been met following active SVE. SVE performance standards and criteria for revising pore-gas monitoring frequency and reporting requirements will be documented in the CMI plan.

Subsurface pore-gas monitoring activities will be conducted for a total of 30 yr and will assume active SVE will be conducted during the first 3 yr of that period. During the 3 yr of active SVE, pore-gas monitoring will be conducted twice per year at each extraction borehole and at all monitoring boreholes located laterally within the VOC plume areas where TCA and TCE concentrations are 10 times their respective screening values: once before active extraction and once after active extraction. Pore-gas monitoring would be conducted once per year at all remaining monitoring boreholes located laterally within the VOC plume areas where TCA and TCE concentrations are 10 times their respective screening values during this same period. Sampling ports and intervals in each borehole will be sampled according to the approach described in section H-4.0.

Following the active SVE period (years 4 through 30), pore-gas monitoring will be conducted once per year at all extraction boreholes and monitoring boreholes located within the VOC plume areas where TCA and TCE concentrations are 10 times their respective screening values. Monitoring boreholes located outside this area will be monitored once every 2 yr during this period.

The Laboratory will replace the eight existing pore-gas monitoring boreholes currently constructed with the Flexible Liner Underground Technology (FLUTe) sampling system and sampled as part of ongoing NMED-approved pore-gas monitoring activities (locations 54-01107, 54-01110, 54-01111, 54-01115, 54-01121, 54-01126, 54-01128, and 54-22116), with eight new pore-gas monitoring boreholes constructed with dedicated stainless-steel sampling systems. The proposed new monitoring boreholes will be constructed within the immediate vicinity of the boreholes they are replacing. All new monitoring boreholes will be constructed with ports in stratigraphic units and at depths currently sampled as part of ongoing NMED-approved pore-gas monitoring activities.

H-4.0 MONITORING METHODS

Pore-gas monitoring activities will include a combination of field-screening and laboratory analytical methods. To assess the lateral and vertical extent of vapor-phase VOC concentrations at MDA G, every accessible sampling port within each pore-gas monitoring borehole will first undergo field screening. VOC samples will then be collected for laboratory analysis from a minimum of two sampling ports in each pore-gas monitoring borehole: the port depth associated with the bottom of the nearest disposal unit and the deepest port, or total depth. Monitoring activities will be conducted in accordance with the Laboratory's Standard Operating Procedure 5074, Sampling Subsurface Vapor*,* or equivalent, in the following manner:

- Each accessible sampling port or interval will be purged with a portable, low-flow vacuum pump to ensure that formation air is drawn into the sample train.
- Pore gas from each accessible sample port or interval will be field screened for carbon dioxide (CO_2) and oxygen (O_2) to ensure that air samples are representative of subatmospheric conditions.
- Field-screening of VOCs, CO_2, and water vapor will be performed. Differential pressure (kPa) will also be measured at each accessible sample port or interval using a manometer to provide data on static pressure conditions.

Once field-screening activities provide consistent measurements, pore-gas samples will be collected from the two sampling ports, described above, in evacuated stainless-steel SUMMA canisters. Samples will then be submitted to an off-site analytical laboratory for analysis of VOCs using EPA Method TO-15.

During each sampling event, two types of field QA samples will be collected and analyzed: a duplicate sample and an equipment blank of zero-grade air (a common term for air certified to be free from VOC contamination) or nitrogen drawn through the sampling apparatus in the working area. Analytical laboratory QA for EPA Method TO-15 includes internal standards, surrogates, replicates, blanks, laboratory control samples, and reference standards.

H-5.0 REPORTING

Pore-gas monitoring activities and results will be provided in an annual report in accordance with the requirements of Section XI.D of the Consent Order. This report will include recommendations for future monitoring and remedial actions based on data results and trends.

H-6.0 REFERENCES

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

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), October 2007. "Interim Subsurface Vapor-Monitoring Plan for Material Disposal Area L at Technical Area 54, Revision 1," Los Alamos National Laboratory document LA-UR-07-7040, Los Alamos, New Mexico. (LANL 2007, 099372)

LANL (Los Alamos National Laboratory), July 2010. "Periodic Monitoring Report for Vapor-Sampling Activities at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, Second Quarter Fiscal Year 2010," Los Alamos National Laboratory document LA-UR-10-3957, Los Alamos, New Mexico. (LANL 2010, 109955)

Shen, H., May 15, 2008. RE: MDA G 3rd Quarter Sampling Event [and previous correspondence, including attached revised Table D-1]. E-mail message to S. Paris (LANL) from H. Shen (NMED), Santa Fe, New Mexico. (Shen 2008, 103907)