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Corrective Measures Evaluation Plan for Material Disposal Area G at Technical Area 54, Revision 2

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EXECUTIVE SUMMARY

This corrective measures evaluation (CME) plan describes the regulatory basis and the technical approach for the CME for Material Disposal Area (MDA) G [Consolidated Unit 54-013(b)-99], Technical Area 54, at the Los Alamos National Laboratory. MDA G was used for the disposal of low-level radioactive waste, certain radioactively contaminated infectious waste, asbestos-contaminated material, and polychlorinated biphenyls. It was also used for the retrievable storage of transuranic waste. The disposal site is located within a 63-acre site (Area G) that was used for a variety of waste management functions since 1957. MDA G consists of 32 pits, 194 shafts, and 4 trenches.

This plan identifies specific corrective measures that have a high likelihood of being effective in preventing future releases from the site and describes a process for the detailed evaluation of corrective measure alternatives to ensure compliance with regulatory requirements. The alternatives presented include source containment/source stabilization, source removal, contaminant extraction, or combinations of these alternatives. These alternatives will be evaluated against the no further action/continued institutional controls alternative in the CME report.

The CME will develop preconceptual engineering designs for the alternatives that pass the initial screening to support evaluation of the alternative’s long-term performance. Mathematical models will be used to simulate processes that may result in releases of contamination and potential future impacts to human health and the environment. Models will simulate surface erosion, biotic intrusion, cover infiltration, and vapor transport. Each alternative will be evaluated against threshold criteria, including its capability to protect human health and the environment, achieve media cleanup levels, achieve source control, and meet waste-management standards for any contaminated media sent for off-site disposal. Alternatives that pass the threshold criteria will be evaluated against balancing criteria, including long-term reliability and effectiveness, reduction of toxicity, mobility and volume, short-term effectiveness, implementability, and cost. The relative performance of each alternative will be presented, a cost-benefit analysis will be performed, and a preferred remedy will be selected in the CME report. Tradeoffs between the evaluation criteria will be stated explicitly and will be summarized in tables.

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1.0 INTRODUCTION

This corrective measures evaluation (CME) plan describes the regulatory basis and technical approach for the CME for Material Disposal Area (MDA) G, Consolidated Unit 54-013(b)-99, at Technical Area (TA) 54 at Los Alamos National Laboratory (the Laboratory or LANL). MDA G is situated in the east-central portion of the Laboratory on Mesita del Buey with Pajarito Canyon to the south and Cañada del Buey to the north (Figure 1.0-1). MDA G was used for the disposal of low-level radioactive waste (LLW), certain radioactively contaminated infectious waste, asbestos-contaminated material, and polychlorinated biphenyls (PCBs). It was also used for the retrievable storage of transuranic (TRU) waste. MDA G is contained within a 63-acre fenced area known as Area G and consists of 32 pits, 194 shafts, and 4 trenches. The major contaminant releases at the site are tritium and a subsurface organic-compound vapor-phase plume. A number of naturally occurring and fallout radionuclides were also sporadically detected (some above background values [BVs]) in soil and rock samples from beneath MDA G. Trace levels of organic chemicals (including several dioxin and furan congeners) and inorganic chemicals were detected but without discernable trends. Area G is currently used for LLW disposal and TRU and mixed TRU waste storage.

The site characterization for MDA G has been completed. An investigation report was submitted to the New Mexico Environment Department (NMED) on September 8, 2005 (LANL 2005, 090513) and an addendum to the investigation report on May 16, 2007 (LANL 2007, 096110). NMED approved the investigation report for MDA G (NMED 2007, 096716). This CME plan describes the evaluation and decision approaches to be used in determining the need for, and components of, corrective measures to protect human health and the environment. The CME will be conducted under the requirements of the Consent Order and documented in the CME report. The Laboratory’s Environmental Programs Directorate–Corrective Actions Project is implementing this CME for MDA G in accordance with requirements stipulated in the Consent Order. During the MDA G investigation, tritium was detected in moisture in subsurface pore gas and radionuclides were detected in tuff. These radionuclides are not subject to the Consent Order. Therefore, the alternative analysis in the CME goes beyond the traditional RCRA corrective action analysis associated with potential impacts from hazardous waste. An expanded analysis will ensure that the proposed corrective measure will protect human health and the environment against impacts from radioactive materials at the site. The regulatory basis for analyzing and addressing the impacts of radioactive materials is contained in DOE Orders 435.1, “Radioactive Waste Management,” and 5400.5, “Radiation Protection of the Public and the Environment.”

This plan will address the following CME tasks:

- define the overall objectives of the evaluation
- describe the history of site operations and the history of releases of contamination
- describe the current subsurface and substructure conditions of on- and off-site contamination in all affected media and contaminant migration pathways at MDA G
- describe the general approach to the CME and the selection of potential remedies
- identify and describe potential receptors
- identify specific corrective measures to be evaluated that will be effective in minimizing future releases from the site
- describe a process for detailed evaluation of corrective measure alternatives to ensure compliance with cleanup levels and other applicable regulatory criteria
- identify additional data needs

- propose a schedule for conducting the CME
- propose the format for the CME report

Closure of active units in Area G will be coordinated with the remedy selected for MDA G. No bench- or pilot-scale studies are anticipated to be necessary in support of the CME.

1.1 Statement of Problem

NMED directed the Laboratory to prepare and submit a CME work plan for MDA G no later than July 13, 2007, and a CME report no later than September 12, 2008. Two considerations involved in this determination are as follows:

1. Since 1985, the Laboratory has performed pore-gas monitoring under several characterization programs. During the Phase I RFI, the quarterly pore-gas monitoring, and the 2005 MDA G field investigation, the Laboratory found evidence that concentrations of several organic and inorganic chemicals have been released to the subsurface tuff beneath MDA G. Analytical results indicate the presence of a subsurface VOC vapor-phase plume beneath MDA G. The present-day risk assessment indicates that current risk to human health and the environment is acceptable under existing conditions at MDA G according to U.S. Environmental Protection Agency (EPA) and NMED criteria. The future risk has not been evaluated and will be assessed in the CME report.
2. The Phase I RFI and 2005/2007 site investigation for MDA G indicated a release of tritium and other radionuclides. Using EPA and DOE standards, the impact of the tritium and other radionuclide releases was found to be small. The present-day assessment indicates that current risk/dose to human health and the environment is acceptable under existing conditions at MDA G, according to EPA and DOE criteria. The future risk/dose has not been evaluated and will be assessed as part of the CME. Therefore, regarding the radionuclides at MDA G, the determination to proceed with a CME is based on a potential for future adverse human health or environmental impacts, in accordance with DOE Orders 435.1, “Radioactive Waste Management,” and 5400.5, “Radiation Protection of the Public and the Environment.”

Assessments of cover designs at MDA G indicate that the primary future risk/dose to cover performance is the potential for plant, animal, or human intrusion into subsurface disposal units (Day et al. 2005, 090536). This CME will be conducted to evaluate and recommend a corrective measure alternative in the CME report that will mitigate this potential future risk/dose at MDA G, as defined in Section 3.

Existing regulated (active) mixed waste storage at MDA G will likely be impacted by the selection and implementation of a remedy for the inactive subsurface units of MDA G. Closure of the impacted units must be coordinated with the CME and remedy implementation process.

1.2 CME Purpose and Scope

The purposes of the CME are (1) to identify and evaluate corrective measure alternatives that address potential unacceptable future risk/dose and (2) to recommend one or more of those alternatives for implementation. Many of the alternatives to be considered include a monitoring component to confirm if the corrective measure is effective. Actions to be taken if the corrective measure becomes ineffective will be proposed in the CME report.

The scope and focus of the CME are defined by the site information summarized in Section 2. Where data are insufficient to evaluate a corrective measure alternative fully, additional data will be collected as part of the CME.

At its conclusion, the CME will be fully documented in a CME report that includes, at a minimum, the enumerated items in Section VII.D.2 and follows the outline provided in Section XI.F of the Consent Order. The Laboratory and DOE will involve the public in corrective measure selection and implementation to ensure that the proposed remedy described in the CME report addresses public concerns about the site. The Public Involvement Plan for the MDA G CME report (Appendix B) includes public meetings to provide data and enumerate the alternatives to be evaluated in the CME.

1.3 Regulatory Context

The Consent Order schedule for MDA G requires the following activities and associated deadlines, which may be adjusted based on actual document approval dates:

1. Investigation report (submitted on September 8, 2005, and May 16, 2007, and approved by NMED on June 8, 2007).
2. CME work plan (no later than July 13, 2007)
3. CME report (no later than September 12, 2008)
4. Corrective measure implementation (CMI) plan (within 90 days of NMED's selection of a final remedy)
5. Remedy completion report (December 6, 2015)

This CME will be conducted in accordance with the requirements of the Consent Order and will also be designed to meet the intent of DOE Order 5400.5, "Radiation Protection of the Public and the Environment." The CME will be developed in a manner that permits coordination with closure and postclosure requirements for RCRA-regulated units at Area G.

Area G has been used for a variety of waste management operations. Since 1957, it has been used to dispose of radioactive waste and is currently the only active LLW disposal facility at the Laboratory. Current operations at Area G include storage and characterization of TRU and mixed TRU waste destined for offsite disposal at the DOE Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico. Current Area G operations also include storage of mixed LLW (MLLW) destined for off-site treatment and/or disposal.

LLW has been disposed of in subsurface pits and shafts. These units are regulated as LLW disposal units and are subject to the requirements of DOE Order 435.1, "Radioactive Waste Management." This order also applies to inactive LLW units that received LLW after September 26, 1988, which was the effective date of the DOE Order 5820.2A, "Radioactive Waste Management," the order preceding DOE Order 435.1. The pits and shafts that received LLW, possibly containing hazardous constituents, are also identified as corrective action disposal units (included in the scope of MDA G) and, as such, are subject to the requirements of the Consent Order. Additionally, some of the LLW and/or corrective action disposal units are authorized for disposal of low-level Toxic Substances Control Act (TSCA) waste (i.e., PCBs) that is radioactively contaminated.

TRU and mixed-TRU wastes awaiting characterization, certification, and shipment to the WIPP are stored in surface and subsurface units. TRU waste is retrievably stored in subsurface pits, trenches, and shafts. Some of these subsurface units are identified as corrective action units (within the scope of MDA G) and are subject to the requirements of the Consent Order. TRU and mixed-TRU wastes are also stored aboveground and in container storage units (CSUs). The CSUs are subject to RCRA permit and/or interim status requirements for releases of hazardous constituents.

MLLW is currently stored in surface CSUs before shipment off-site for treatment and/or disposal; the CSUs are subject to RCRA permit and/or interim status requirements. Additionally, some MLLW was disposed in one subsurface pit and one shaft after the effective date of RCRA hazardous waste management regulations and is therefore subject to RCRA disposal unit closure requirements. These two subsurface RCRA disposal units were previously identified as corrective action units; however, they are not subject to the corrective action requirements of the Consent Order.

Because several types of waste management operations have occurred over time at the site, the waste management units (inactive and active) are subject to the requirements of several different regulatory programs. Figure 1.3-1 shows Area G and MDA G, including the inactive subsurface disposal units and surface CSUs. The waste management units at Area G are placed into five categories: LLW disposal units, TRU waste storage units, RCRA disposal units, corrective action units, and CSUs. These units are summarized in Table 1.3-1 and described in the following sections. Table 1.3-2 provides a summary of the nine solid waste management units (SWMUs) that comprise MDA G.

1.3.1 LLW Disposal Units

The LLW disposal units in Area G (Area G Landfill) include Pits 15, 38, and 39 and Shafts C11, C14, 21, 23, 97, 137, 141–144, 147–149, 161–177, 197, 300, 301, 307–309, 311, 313, 315, 317, 319, 321, 323, 325, 327, 329, 331, 333, 335, 337, 339, 341, 343, 345, 347, 349, 351, 353, 355, 357, 359–367, 369, and 370. These subsurface pits and shafts are regulated as LLW disposal units by DOE Order 435.1, “Radioactive Waste Management.” These units were not identified as corrective-action units under Module VIII of the Laboratory’s Hazardous Waste Facility Permit and are not subject to the requirements of the Consent Order. Because these LLW disposal units are physically interspersed with the corrective action disposal units discussed below, addressing closure requirements for the LLW and MDA G corrective action disposal units cannot be addressed independently of each other. The performance requirements for closure of the LLW disposal units under DOE Order 435.1 are expected also to meet corrective action objectives for protection of human health and the environment established under the Consent Order. Nevertheless, the CME will evaluate alternatives in a manner that integrates with existing evaluations for final closure of the LLW disposal units. This approach will result in a single, comprehensive closure approach that meets the requirements of DOE Order 435.1 and the Consent Order.

1.3.2 TRU Waste Storage Units

The TRU waste storage units in Area G include Shafts 235–243, 246–253, 262–266, and 302–306. TRU waste was placed into these shafts for retrievable storage for eventual disposal at a deep geologic repository (i.e., the WIPP). After the TRU waste has been retrieved, any remaining contamination within these units will be addressed with the LLW disposal units. However, some TRU waste may not be retrieved because of technical or safety concerns, and DOE may determine that these wastes will be left in place. If TRU waste is disposed of in place, the radionuclide inventory associated with the TRU waste will be included in the closure evaluations performed under DOE Order 435.1.

1.3.3 RCRA Disposal Units

The RCRA disposal units in Area G (referred to as the Area G landfill in the closure/postclosure plan for TA-54 [LANL 2007, 096796]) are Pit 29 (below the corrugated metal pipe storage layer) and Shaft 124. These subsurface units were used for disposal of hazardous wastes after the effective date of the RCRA hazardous waste management regulations and are subject to RCRA closure and postclosure-care requirements under 40 CFR 264 Subparts G and N, as incorporated by 20.4.1.500 NMAC. These units are physically interspersed with the corrective action disposal units that make up MDA G and the LLW disposal units. These disposal units are excluded from corrective action requirements under the terms of the Consent Order and are subject only to closure and postclosure care permit requirements. NMED has indicated that it will issue a RCRA closure/postclosure care permit for the RCRA-regulated disposal units (NMED 2005, 090169). This permit should contain specific closure requirements for the RCRA disposal units in Area G.

1.3.4 Corrective Action Units

The corrective action units of MDA G include both disposal units and TRU waste storage units, including Pits 1–10, 12, 13, 16–22, 24–33, 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, 196, 200–233, and Trenches A–D.

Some of the corrective action units are currently used for storing TRU waste. TRU waste was placed into these subsurface units in retrievable storage for later disposal at a deep geologic repository (i.e., the WIPP). While retrieval of TRU waste does not constitute a corrective action under the Consent Order, any potential releases of hazardous constituents during storage are subject to corrective action. However, some of this TRU waste may not be retrieved because of technical or safety concerns, and DOE may determine that these wastes will be left in place.

The corrective action disposal units are physically interspersed with the LLW and the RCRA-regulated disposal units. This physical layout makes it impractical to address the closure requirements of any of the subsurface units independent of one another. Closure of the subsurface RCRA-regulated disposal units may be proposed under alternative closure requirements and be addressed within the corrective action approach for MDA G, identified in the Consent Order. The design for the final cover of the LLW disposal units, which is being developed as part of the DOE 435.1 closure process, should be integrated with the requirements for the corrective action units. The cover design will be evaluated and further refined (as necessary) during the CME for the corrective action units (comprising MDA G). This design and development approach will meet the requirements of DOE Order 435.1 and the Consent Order.

1.3.5 Container Storage Units

The container storage units in Area G include Pad 1 (54-226 and 54-412); Pad 3 (54-8), and 54-33; 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, 54-232); Pad 10 (formerly Pads 2 and 4); Pad 11 (54-375), 54-8, and 54-33; and Shafts 145 and 146. These CSUs are used for storage of containerized MLLW and/or mixed TRU wastes. In general, the CSUs consist of asphalt pads and associated fabric domes and/or other structures. Two subsurface shafts are also included with these CSUs; they were used for MLLW storage for a brief period of time and are currently empty. All these CSUs were included in the TA-54 RCRA permit renewal application (LANL 2003, 091318) and should be included in the Laboratory’s revised Hazardous Waste Facility Permit when it is renewed by NMED. Although no immediate regulatory deadline to close these units has been stipulated, they are located on the surface above the subsurface units that must be closed. Therefore, these units will be closed under RCRA-permit requirements.

1.3.6 Regulatory Approach and Assumptions

The planning, design, and implementation of corrective measures for the corrective action disposal units will need to be integrated with closure of the RCRA disposal units and DOE-regulated LLW disposal units because of the close physical proximity and intermingled nature of these units. The preferred approach is to implement alternative closure requirements for the RCRA-regulated units in accordance with 40 CFR 264.110(c) (as incorporated by 20.4.1.500 New Mexico Administrative Code [NMAC]). RCRA closure/postclosure care requirements will be considered in the CME during the evaluation of corrective measure alternatives to ensure that closure and corrective measure activities are compatible and fully integrated.

The CME options to be considered at MDA G (as part of corrective action activities) include

1. partial or complete removal of the buried waste inventory through excavation and off-site disposal,
2. containment of the waste inventory by an engineered cover,
3. in situ stabilization,
4. treatment of the subsurface vapor plume by soil vapor extraction (SVE), and
5. some combination of these options.

1.4 Public Involvement Plan

In accordance with the EP Public Involvement Plan (LANL 2005, 089310), submitted to NMED under Section VII.E.4 of the Consent Order, the Laboratory has developed a project-specific public involvement plan for the MDA G CME (Appendix B). A public meeting was held on February 28, 2007, at the start of the CME planning process to present the results of the site investigation, the preliminary alternatives to be considered in the CME, and the results of technical evaluations that have been performed or that are underway (e.g., alternative capping technologies). This and subsequent meetings will provide the public with the opportunity to ask questions and provide comments. In addition, input will be solicited from neighboring pueblos, local governments, NMED, EPA Region 6, and other community organizations to address stakeholder concerns. The EP-CAP staff conducting the CME will provide written responses to public comments.

1.5 Plan Overview

This CME plan addresses the following tasks to meet the requirements of the Consent Order:

- characterizing current site conditions
- identifying and developing the corrective measure alternative or alternatives (a preliminary evaluation of technologies that can be applied to MDA G)
- establishing the process and criteria for evaluating corrective measure alternatives (public review and comments will be incorporated at various stages in the CME process)
- recommending the corrective measure or measures
- proposing the format of progress reports and the final CME report

2.0 BACKGROUND INFORMATION

The current conditions at MDA G are described in detail in the investigation work plan and the investigation report and addendum for MDA G (LANL 2004, 087833; LANL 2005, 090513; LANL 2007, 096110). These two documents describe the site and include disposal units, waste inventory, characterization activities that have been conducted, analytical results of sampling, and assessments of potential current-day risks to human health and the environment. The following paragraphs summarize information about the site.

2.1 SWMU Description

Subsurface disposal units at MDA G consist of 32 pits, 4 trenches, and 194 shafts (Figure 1.3-1). The site includes both corrective action units and RCRA disposal units, based on the date of operation. Table 1.3-1 categorizes these units according to their regulatory basis.

The pits, trenches, and shafts are constructed in unit 2 (caprock) and unit 1 (subsurface) of the Tshirege Member of the Bandelier Tuff, a consolidated tuff unit. The pits and trenches are shallow units in the surface layers of the mesa top, ranging from depths of 8 to 61 ft. The shafts are deeper units, ranging from depths of 25 to 65 ft and diameters of 1 ft to 8 ft. The regional aquifer is estimated to be at a depth of approximately 930 ft below ground surface, based on data from wells at the Laboratory and the predictions of the hydrogeologic conceptual model for the Pajarito Plateau (LANL 1998, 059599). The topography of Area G is relatively flat, and the site does not extend beyond the mesa top. The cover material placed over the disposal units has increased elevations across the site. Portions of the disposal units at MDA G are covered with concrete and/or asphalt to house ongoing waste-management activities conducted at Area G.

2.2 History and Background

Area G began operations in 1957. DOE initially authorized Area G for disposal of LLW, certain radioactively contaminated infectious waste, asbestos-contaminated material, and PCBs, and for the temporary placement of TRU waste. The inventories of the disposal units are provided in Appendix G of the approved investigation work plan (LANL 2004, 087833).

The disposal areas were excavated, filled, and covered sequentially from the east end of the mesa, progressing westward. Thus, the oldest portion of the inventory exists at the east end and the newest at the west end.

During operation (i.e., when waste was being received), the pits and trenches remained open to the atmosphere. When active, the shafts remained covered with steel lids for safety and security. When operations ceased, the remaining capacity of the pits, shafts, and trenches was backfilled with clean, compacted tuff and closed. The disposal shafts were then covered with a concrete plug (LANL 1992, 007669, p. 5-179).

MDA G Waste Inventory

Waste disposal records for MDA G are found in unnumbered disposal logbooks (LANL 2003, 076036) used to record information on the type, date, location, and volume of waste placed in MDA G. Records before 1974 are incomplete, and many logbook entries contain only brief descriptions of wastes disposed (i.e., waste types, volumes, and disposal locations are not always provided). An estimate of the types, activities, and quantities of waste disposed of at MDA G was compiled in the Operable Unit (OU) 1148 data report (IT Corporation 1992, 023247) and in the approved RFI work plan for OU 1148 (LANL 1992, 007669). Inventory before 1971 includes waste defined as mixed TRU. Inventory disposed after 1971 but before 1987 includes waste meeting the current definition of MLLW.

Complete records were not kept on the types or amounts of hazardous constituents contained in waste disposed before 1986 or the types or amounts of radioactive constituents of TRU waste disposed before 1971. Existing records describe the radioactive constituents of TRU waste generated and retrievably placed at MDA G since 1971. Records also describe the hazardous and radioactive constituents of MLLW and mixed TRU waste retrievably placed since 1986 (LANL 2004, 087833).

An estimate of waste volumes in inactive units of MDA G is provided in disposal unit information tables in the Appendix I of the approved MDA G work plan (LANL 2004, 087833).

2.3 Identification of Chemicals of Potential Concern

The report on channel sediment (LANL 1996, 054462) and the investigation report for MDA G (LANL 2005, 090513) present the analytical results for channel sediment, subsurface rock, ambient air, and pore-gas samples collected at the site. The inorganic chemical and radionuclide results were compared with Laboratory BVs or fallout values (FVs) to determine if elevated concentrations in the surrounding environmental media had been detected.

The MDA G investigation report and addendum identified a wide variety of chemicals of potential concern (COPCs) potentially released from MDA G based on borehole sampling performed for the investigation, past pore-gas monitoring, and the earlier Phase I RFI report (LANL 1996, 054462). COPCs were identified in subsurface cores beneath waste disposal units, in pore gas, in ambient air and surface flux near MDA G, and in channel sediments. COPCs include radionuclides, inorganic chemicals, and organic chemicals (PCBs, pesticides, dioxins, furans, VOCs, and semivolatile organic compounds [SVOCs]).

Data collected during the Phase I RFI at MDA G indicated releases of several organic and inorganic chemicals and radionuclides to subsurface tuff beneath the disposal units.

In sediment samples, americium-241, cesium-137, cobalt-60, plutonium-238, plutonium-239 and tritium were detected above BVs/FVs. Barium, cadmium, chromium, and iron were detected above BVs. The pesticide methoxychlor was the only organic chemical detected.

VOCs were detected in pore-gas samples collected from monitoring boreholes, surface flux, and ambient-air samples. Tritium was detected in surface flux samples and pore gas.

Results from the 2005/2007 MDA G investigation (LANL 2005, 090513; LANL 2007, 096110) confirmed the presence of a number of organic and inorganic chemicals and radionuclides and were consistent with the results obtained during the Phase I RFI (LANL 1992, 007669). The primary organic chemicals detected included chlorinated VOCs and trace levels of several dioxin/furan congeners. Inorganic chemicals detected above background levels did not show any discernable trends and, as such, the extent of contaminant releases has been defined. Data collected during the Phase I RFI, quarterly monitoring, and the 2005 investigation indicate that the highest VOC concentrations are beneath the eastern portion of the site in the vicinity of the shaft field west of Pits 2 and 4. The results of quarterly pore-gas monitoring show VOCs and tritium concentrations to be stable over time. Sampling results indicated that 1,1,1-trichloroethane (TCA) is the dominant component of the pore gas beneath MDA G.

The data review of COPCs presented in the MDA G investigation report and addendum (LANL 2005, 090513, Appendices F and G; LANL 2007, 096110) is summarized here as a function of the receptor scenario:

- for human health—industrial scenario: 8 inorganic chemicals, 1 organic chemical, and 6 radionuclides
- for human health—residential scenario: 9 inorganic chemicals, 12 organic chemicals, and 6 radionuclides
- for ecological assessment—8 inorganic chemicals, 1 organic chemical, and 6 radionuclides

2.4 Nature and Extent of Contamination

The MDA G investigation report and addendum describe the extent of contamination at MDA G and conclude that the nature and extent of contamination in surface and subsurface media has been defined (LANL 2005, 090513; LANL 2007, 096110). Pore-gas analytical results from the 2005/2007 boreholes detected tritium (in 35 boreholes) and VOCs (in 38 boreholes) in the vadose zone. Consistent with the ongoing quarterly pore-gas monitoring conducted since 1997, the maximum vapor concentrations were identified in the eastern portion of MDA G (in the vicinity of the shaft field west of Pits 2 and 4) limited at depth by the Cerros del Rio basalt layer (where no TCA was detected) with the dominant subsurface vapor contaminant being TCA. Varying concentrations of contaminants found together, such as tetrachloroethene and Freon-113 in the vadose zone, indicate releases from different sources at MDA G. Tritium concentrations decrease with distance and depth, possibly indicating separate release areas.

Soil and rock samples collected during the 2005 MDA G investigation confirmed the presence of a number of organic and inorganic chemicals and radionuclides beneath the former disposal units and were consistent with the results obtained during the Phase I RFI (LANL 2004, 087833). The only organic chemicals detected in core samples were trace levels of several dioxin and furan congeners.

Inorganic chemicals detected beneath MDA G were indicative of natural variability within the various stratigraphic layers (LANL 2005, 090513). All inorganic chemicals detected above BVs in the units adjacent to the base of the disposal pits, trenches, and shafts 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. All detections within the fractures were less than the soil BV, a more representative metric for comparison.

Naturally occurring and fallout radionuclides were detected above BVs in soil and rock samples from beneath MDA G (LANL 2005, 090513). Naturally occurring radionuclides were detected at concentrations within the natural variability of these chemicals in the subsurface. Fallout radionuclides detected in subsurface samples were americium-241, plutonium-238, plutonium-239, and strontium-90. These detections generally occurred sporadically across the site, with americium-241 detected in 10 of 38 boreholes, plutonium-238 in 3 of 38 boreholes, plutonium-239 in 8 of 38 boreholes, and strontium-90 in 6 of 38 boreholes.

Because the extent of radionuclide and chemical contamination has been determined and is very limited vertically below the disposal units, except for vapor-phase VOCs and tritium, the likelihood of migration to the aquifer is expected to be small over the next 1000 yr or more, provided infiltration rates are kept at current rates or lower. Although vapor-phase VOCs and tritium have been detected at depth, the concentrations measured in the deepest samples collected are predicted to not be high enough to be of concern with respect to groundwater contamination, as shown in Appendix F. The site conceptual model (section 2.7 and Appendix E) and the monitoring data do not indicate migration of contaminants to groundwater. The existing groundwater monitoring data, however, are not sufficient to confirm this.

2.5 Current-Day Risk

The COPCs discussed in Section 2.3 were evaluated to determine if they posed a potential risk/dose to human and ecological receptors under current site conditions. The maximum concentration of each COPC was compared with soil-screening levels for each chemical to determine impacts to human health. The conclusions of the risk assessment presented in Appendix G of the investigation report (LANL 2005, 090513) are listed below:

- The results of the present-day risk assessment for MDA G concluded that surface and subsurface contamination at the site posed no unacceptable risk to human health from exposure to ambient air or from movement of VOCs or tritium from the subsurface to the surface.
- Results of the human health risk assessment indicated carcinogenic and noncarcinogenic risks (1×10^{-8} and 0.07, respectively) for an industrial worker were less than NMED's target levels of a cancer risk of 10^{-5} and a hazard index (HI) of 1.0 (NMED 2005, 090802).
- The potential dose for an industrial worker at MDA G is approximately 1.5 mrem/yr, which is below the DOE's target dose of 15 mrem/yr (DOE 2000, 067489).
- Contamination in channel sediment poses no risk to ecological receptors. Methoxychlor[4,4'-] was detected in 14 sediment samples and had a hazard quotient (HQ) less than 0.3. Americium-241, cesium-137, cobalt-60, plutonium-238, plutonium-239, and tritium were detected in multiple sediment samples but had HQs less than 0.3. Inorganic chemicals of potential ecological concern (COPECs) were either not detected in channel sediment or had detected concentrations similar to BVs. Potential exposure to the inorganic COPECs is similar to background. The HI (0.09) from the inhalation ecological screening level comparison to pore-gas VOCs indicates no potential present-day risk to burrowing animals.
- The results of the present-day risk assessment indicate that no action is necessary to address exposure to on-site industrial workers to VOCs and tritium in ambient air or methoxychlor, inorganic chemicals, and radionuclides in sediment or tuff at MDA G.

2.6 Proximate SWMUs and AOCs

To evaluate the potential impact of MDA G and to make sound decisions regarding the need for and nature of effective remedies, the potential impact of nearby SWMUs and areas of concern (AOCs) on the area should be understood. With respect to contaminant inventory and physical size, the most significant SWMUs/AOCs near MDA G, are MDA L (SWMU 54-006) and MDA H (SWMU 54-004) (Figure 2.6-1).

MDA L is located in the central portion of Mesita del Buey, approximately 0.7 mi west-northwest of MDA G and is a 2.6-acre site previously used for disposal of nonradioactive liquid wastes. As with MDA G, the surface areas of MDA L (Area L) have been used for the Laboratory's waste operations. A vapor-phase VOC plume and a tritium plume exist below MDA L. As an operating hazardous waste storage unit, MDA L access is restricted to authorized personnel. The subsurface VOC plume is monitored quarterly.

MDA H is located 1.6 mi west-northwest of MDA G. This 0.3-acre site functioned as the Laboratory's primary disposal area for classified, solid-form waste from 1960 to August 1986. The corrective measures study for MDA H was submitted to NMED on May 31, 2003 (LANL 2003, 076039) and subsequently revised and submitted to NMED in June 2005 (LANL 2005, 089332).

2.7 Conceptual Site Model for MDA G

The conceptual site model for contaminant transport at MDA G and the location of the regional water table are shown in Figures 2.7-1 and 2.7-3, respectively. The conceptual site model is based on site characterization data, field and pilot tests, and unsaturated zone modeling to describe how contaminants may be released from the disposal units and transported by several environmental pathways.

The conceptual site model describes COPCs and/or radionuclides and potential release modes, transport pathways, and receptors. The known sources of environmental contamination, documented in the MDA G investigation report (LANL 2005, 090513, Appendix G, pp. G-27–G-30) are

- vapor-phase releases of tritium and VOCs from subsurface SWMUs;
- inorganic chemicals, radionuclides, and organic chemicals in drainage channel sediment; and
- metals and radionuclides present in pore water in the tuff located below the disposal units.

The conceptual site model includes the following modes of contaminant release:

- leaching (dissolution) by water either within the waste or infiltrating from the surface through the covers and into the waste volume;
- volatilization or vaporization and diffusion of certain contaminants within the waste;
- incorporation into plants whose roots grow into the waste;
- excavation by animals burrowing into the waste; and
- exposure of wastes because of erosional processes (wind, water, and mass wasting).

Contaminants released from the disposed waste may be redistributed within and beyond the site by the following primary transport pathways:

- vapor-phase transport of volatile chemicals (VOCs and tritiated water vapor) into the surrounding unsaturated zone with potential for transport to the regional aquifer;
- vapor-phase transport of volatile chemicals (VOCs and tritiated water vapor) into the atmosphere;
- surface-water transport of contaminated surface soils as eroded sediment into adjacent canyons by runoff;
- airborne transport of small particulates brought to the surface by biointrusion or erosion;
- unsaturated transport of contaminants with infiltrating water through the thick (900 to 1000 ft) unsaturated zone;
- saturated zone transport of contaminants if contaminants reach the regional aquifer; and
- biointrusion transport through plant roots and burrowing animals.

With respect to the transport pathways, the pathway through the unsaturated zone is of concern because contaminants may eventually reach the regional water-supply aquifer. Unsaturated zone monitoring will address the effectiveness of the corrective measures and verify infiltration rates. Current site characterization data indicate that the tuff beneath MDA G is unsaturated. Simulated travel times for liquid phase unsaturated zone transport are approximately 10,000 yr for peak concentrations of nonadsorbing species to reach the water table. However, the first arrival of extremely low concentrations by this method is simulated to occur in about 100 yr. Percent saturations increase slightly above the Cerros del Rio basalt, especially in the Guaje Pumice Bed. The contrast in hydrologic properties between the pumice and basalt may cause some laterally spreading along the paleotopography of the Cerros del Rio basalt, which slopes to the south towards Pajarito Canyon. Greater percolation rates likely exist beneath the canyon because of channelized runoff and perched alluvial water. If contaminants are laterally diverted atop the basalt to beneath the canyon, faster transport rates toward the aquifer would likely occur. The conceptual site model for contaminant migration through the unsaturated zone is presented in more detail in Appendix E.

In addition to the unsaturated zone monitoring discussed above, groundwater monitoring near MDA G will be used to sample for contamination in the regional aquifer and any perched intermediate zones in accordance with the Laboratory's Interim Facility-Wide Groundwater Monitoring Plan (LANL 2007, 096665). Regional aquifer samples are currently collected at wells R-20, R-21, R-22, R-23 and R-32, and perched-intermediate zone water from Pajarito Canyon is collected in well R-23i. In addition, 5 new regional monitoring wells and 2 new perched-intermediate monitoring wells in Pajarito Canyon are proposed for the TA-54 area to further bolster the monitoring network (LANL 2007, 098548). The locations of existing and planned wells for the enhanced monitoring network are shown in Figures 2.7-2 and 2.7-3. The combined monitoring network, including unsaturated zone monitoring, will supply data to determine whether any corrective measures that are implemented are effective at reducing infiltration and preventing migration of contaminants to the regional aquifer. The intermediate-depth monitoring wells will provide additional information on contamination in perched intermediate water, if it is present, beneath Pajarito Canyon.

The existence of VOCs and tritium in pore gas at the base of the Bandelier Tuff is primarily from vapor-phase transport. Several activities and studies are proposed to address uncertainties associated with vapor-phase transport and its potential impact on the regional aquifer. A pilot test will be performed to address the radius and depth of pressure influence of SVE wells, the rate of extraction of VOCs, and the rebound time. A vapor-phase tracer test and air permeability tests will be used to assess and provide site-specific data for numerical transport models. Vapor sampling of VOCs and tritium and 3-dimensional mapping will identify multiple source areas and changes in concentration with time. The proposed SVE at MDA G will help to reduce potential negative effects of VOCs at the site because the SVE system will remove the vapor-phase VOC source from within the mesa. The enhanced groundwater monitoring network around MDA G will allow sampling of the water table and any potential perched intermediate zones intercepted in Pajarito Canyon to determine if VOCs from MDA G have reached the water table or a possible intermediate perched zone in the canyon. Appendix F contains analytical calculations demonstrating that groundwater screening criteria in the regional aquifer will not be exceeded for all VOCs and tritium with cover fluxes of 1 mm/yr.

Receptors potentially exposed to contamination from MDA G include site workers at Area G and TA-54 and biota at the site. Human receptors also include those living downwind or downgradient from the site and may also include inadvertent intruders. MDA G is managed in a way that limits nonhuman receptors to invasive plants, small mammals, birds, and invertebrates. The mesa top is fenced off from the surrounding hillsides and is managed intensively to limit access to the area by large animals (e.g., deer, elk, and mountain lions); some limitations may also apply to foxes, coyotes, raccoons, bobcat, or other medium-size mammals.

3.0 CME OBJECTIVES AND SCOPE

3.1 CME Objectives

A range of corrective measures alternatives will be evaluated in the CME to determine whether, and if so, what corrective action is required at MDA G to ensure the protection of human health and the environment in the future. For this evaluation, the capability to control the release of potentially harmful quantities of contaminants from the site will be assessed in accordance with NMED, EPA, and DOE risk- and dose-assessment guidance. A range of alternatives, including no further action (i.e., monitoring only), source removal, containment, and contaminant extraction will be assessed. The containment alternatives will be evaluated to ensure that contaminant concentrations do not exceed cleanup levels at points of compliance if the material in the subsurface disposal units is left in place. The benefits, costs, and implementation risks of all technologies will be compared with the no-further-action alternative and to alternatives for excavation of the material in the subsurface disposal units and contaminant extraction.

Target Corrective Action Objectives

Each corrective measure alternative will be evaluated in terms of how well it meets the following site-specific corrective action objectives:

- *Protect human health*. For RCRA hazardous constituents, the selected corrective measure will provide reasonable assurance that (1) the excess incremental cancer risk estimated according to EPA's reasonable maximum exposure (RME) approach does not exceed NMED's target of 10^{-5} for the design life of the selected corrective measure and (2) the noncancer hazard does not exceed NMED's target of an HI of 1.0. For radionuclides, the selected corrective measure will provide reasonable assurance that the total calculated RME dose does not exceed DOE's target dose limit of 15 mrem/yr for the design life of the measure.
- *Protect the environment*. The selected corrective measure alternative will provide reasonable assurance of the protection of the environment as determined by ecological assessment guidance available at the time of the selection of the alternative.
- *Attain media cleanup levels*. The selected corrective measure alternative will provide reasonable assurance that migration of contaminants during the design life of the corrective measure will not result in contaminant concentrations above cleanup levels at the point(s) of compliance.
- *Provide source control to reduce or eliminate releases that may pose a threat*. The selected corrective measure alternative will be designed to provide reasonable assurance that future releases will be minimized and that the impact of any potential release is within the risk/dose levels specified above.
- *Waste management compliance*. The corrective measure alternative will comply with standards for management of wastes generated by implementation of the corrective measure.

3.2 Scope of the CME

The CME will evaluate the potential for future adverse human health and environmental impacts at MDA G. Consistent with the conceptual site model presented in Section 2 of this plan, impacts may result from the release of potentially harmful amounts of specific contaminants and access to those contaminants by human or ecological receptors and/or direct contact by humans, plants, or animals as a result of intrusion into the disposal units.

3.2.1 Establishing Cleanup Levels

Cleanup and screening levels are constituent- and medium-specific concentrations that are indicators of potential harm to human health and the environment. Screening levels for chemicals in soil, sediment and tuff are NMED soil screening levels (SSLs) as presented in the "Technical Background Document for Development of Soil Screening Levels" (NMED 2005, 090802, or the most current version). In accordance with this guidance, if an NMED SSL is not available for a chemical, the EPA Region 6 human health media-specific screening level is used as the SSL (adjusted to 10^{-5} risk for carcinogens) (EPA 2005, 091002, or the most current version). Screening levels for radionuclides in soil, sediment, and tuff are screening action levels (SALs) based on 15 mrem/yr exposure and are derived using RESRAD, Version 6.21 (LANL 2005, 088493).

Although potential MDA G risk and dose do not currently exceed cleanup goals (i.e., 10^{-5} cancer risk), a CME will be performed for MDA G to address potential future risk and dose. Under the Consent Order, SSLs are used as soil cleanup levels for the alternative involving excavation, unless a site-specific, risk-based cleanup level is established

3.2.2 Points of Compliance

The point of compliance for MDA G is the point where compliance with the cleanup levels set for the corrective measure must be demonstrated. It is the point at which exposure to a human or ecological receptor is probable under the site-specific current and reasonably foreseeable future land use.

The Consent Order does not define points of compliance. Points of compliance are medium-specific and depend on factors such as the potential for exposure of human or ecological receptors, contaminant migration, impact to sensitive ecosystems, and overall accessibility. Because no corrective action regulations specify points of compliance, they are developed on a site-specific basis. A point of compliance could also be defined as an area with the potential for exposure to receptors.

The CME will use the conceptual site model for MDA G to propose performance-monitoring locations to demonstrate compliance with cleanup levels. Points of compliance in the vadose zone beneath MDA G and dose at the MDA G boundary will be evaluated in the CME.

3.2.2.1 Vadose Zone

The vadose zone will be monitored to determine if the concentration of a hazardous constituent or a radionuclide meets or exceeds the specified cleanup levels, based on performance/long-term monitoring. Performance monitoring and sampling will be evaluated in the CME for the containment, extraction and partial excavation alternatives.

3.2.2.2 Groundwater Monitoring

DOE and the Laboratory submited a well evaluation and network recommendations report for TA-54 to NMED on October 5, 2007. The report identified regional groundwater monitoring objectives and monitoring requirements and proposed installing new regional wells to meet the monitoring objectives. An implementation schedule was provided in this report. The upgraded monitoring network will provide data needed to confirm and refine the conceptual model concerning migration of contaminants to groundwater. The network will also be used to determine the effectiveness of the corrective measure by monitoring for releases to regional groundwater.

3.2.3 Applicable Regulations and Requirements Evaluations

This section presents an overview of laws and regulations that may apply to the implementation of the corrective measure under the Consent Order. The medium (e.g., surface water, groundwater, air, or soil) that each relevant regulation applies to, if applicable, is also discussed.

Generator and Transporter Requirements. Any action resulting in the generation of hazardous and solid waste during the corrective measures implementation (CMI) will comply with the following regulations for hazardous waste management:

- 40 CFR Part 260, “Hazardous Waste Management System: General” (incorporated by 20.4.1.100 NMAC)
- 40 CFR Part 261, “Identification and Listing of Hazardous Waste” (incorporated by 20.4.1.200 NMAC)
- 40 CFR Part 262, “Standards Applicable to Generators of Hazardous Waste” (incorporated by 20.4.1.300 NMAC)
- 40 CFR Part 263, “Standards Applicable to Transporters of Hazardous Waste” (incorporated by 20.4.1.400 NMAC)

Land Disposal Restrictions. All MDA G activities that generate hazardous waste as part of the corrective measure will comply with the land-disposal restriction requirements of 40 CFR Part 268, “Land Disposal Restrictions” (incorporated by 20.4.1.800 NMAC).

Public Participation and Community Relations. Section VII.E.4 of the Consent Order requires that the public be afforded the opportunity to be involved in all corrective measures selections and implementations. Section 7004 of RCRA also encourages public participation in the development, revision, implementation, and enforcement of any regulation, guideline, information, or program activity. The MDA G Public Involvement Plan (Appendix B) employs a variety of ways to contact and involve members of the community.

The MDA G Public Involvement Plan includes meetings with stakeholders such as the Northern New Mexico pueblos, Los Alamos County, the Northern New Mexico Citizens’ Advisory Board, officials of the community, and members of the public. The MDA G Public Involvement Plan complies with DOE public participation policy outlined in DOE Policy 1210.1, “Public Participation,” and the installation work plan (LANL 2000, 066802).

The National Environmental Policy Act. Section 102(2)(c) of the National Environmental Policy Act (NEPA) requires that all federal agencies prepare an environmental impact statement for all federal actions significantly affecting the quality of the human environment. The DOE has established a procedure for compliance with NEPA; it is defined in the following documents:

- 10 CFR Part 1021, “National Environmental Policy Act Implementing Procedures”
- 40 CFR Part 1500, “Purpose, Policy, and Mandate”
- 40 CFR Part 1501, “NEPA and Agency Planning”
- 40 CFR Part 1502, “Environmental Impact Statement”
- 40 CFR Part 1503, “Commenting”
- 40 CFR Part 1504, “Predecision Referrals to the Council of Proposed Federal Actions Determined to be Environmentally Unsatisfactory”

- 40 CFR Part 1505, “NEPA and Agency Decisionmaking”
- 40 CFR Part 1506, “Other Requirements of NEPA”
- 40 CFR Part 1507, “Agency Compliance”
- 40 CFR Part 1508, “Terminology and Index”

Impacts from corrective measures at MDAs, including MDA G, are being assessed as part of the revised Site-wide Environmental Impact Assessment currently under development. Before the corrective measure is implemented, all NEPA procedures will be completed. The Environment, Safety, and Health questionnaire will be completed and reviewed by the Laboratory’s NEPA team.

The Clean Water Act. The Clean Water Act requirements apply to the CME if implementing the corrective measure impacts surface water.

The Clean Air Act. The Clean Air Act requirements may apply to the corrective measure if implementing the corrective measure impacts air quality. Dust will be mitigated for health and safety reasons during field activities, and the air will be continuously monitored with miniature instantaneous readout aerosol monitor (Mini-RAM) personal air monitors.

The Toxic Substances Control Act. TSCA may be applicable to the corrective measure if TSCA-regulated constituents are released or removed from any soil or water.

Solid Waste Management. This regulation (20.9.1 NMAC) applies to all solid waste to be processed or disposed of under the selected remedy for MDA G by means of, but not limited to, recycling, composting, transformation, or landfilling. The cover design and alternative cover design for MDA G are governed by this regulation.

3.3 Institutional Considerations

3.3.1 Land Use

MDA G is located on DOE property that has historically been used for industrial purposes, specifically, the management of Laboratory wastes. Continued operations are planned for surface waste management areas at Area G. As a result, the area within the administrative boundary of TA-54, which includes MDA G, is subject to continued controlled access. This area will remain under DOE institutional control for as long as the Laboratory is operational (LANL 1995, 057224).

3.3.2 Decision Approach

The conceptual approach to conducting the CME and reaching a remedy decision for MDA G is consistent with Section VII.D and the evaluation criteria identified in the Consent Order. DOE Order 5400.1, “General Environmental Protection Program,” is also used to address radiological constituents. The technical approach draws from NMED, EPA, and DOE guidance on risk assessment of exposures to hazardous waste and dose assessment of exposures to radioactive chemicals, respectively (EPA 1989, 008021; NMED 2005, 090802, DOE Orders 435.1, “Radioactive Waste Management,” and 5400.5, “Radiation Protection of the Public and the Environment”).

DOE Order 435.1 provides performance requirements for LLW disposal facilities for waste disposed of after September 26, 1988:

1. Dose to representative members of the public shall not exceed 25 mrem total annual effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air;
2. Dose to representative members of the public via the air pathway shall not exceed 10 mrem in 1 yr total effective dose equivalent, excluding the dose from radon and its progeny; and
3. 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 air may be applied at the boundary of the facility.

DOE Order 435.1 requires preparing a performance assessment for DOE low-level waste disposed of after September 26, 1988. The performance assessment includes calculations for a 1000-yr period after closure of potential doses to representative future members of the public and potential releases from the facility to provide a reasonable expectation that the performance objectives identified are not exceeded as a result of operation and closure of the facility. The Area G performance assessment (Hollis et al. 1997, 063131) was issued in 1997 and will be updated in 2007.

Because the CME is being conducted to address concerns about the potential for future exposures and adverse impacts, computational models simulating the natural processes that transport released contaminants will be used to support the risk and dose assessments (together referred to as *impact assessments*) and used in the evaluation criteria for the no-further-action and containment alternatives. Evaluation of future risk/dose assessments must allow for some level of uncertainty. The approach to be implemented for the CME will address uncertainties in an explicit and quantitative manner that describes the nature of uncertainties, how they are treated in the alternatives assessments, and how they affect the results (and interpretation of results) of the assessments.

4.0 SCREENING OF TECHNOLOGIES AND IDENTIFICATION OF CORRECTIVE MEASURE ALTERNATIVES

The inventory and characterization data in the approved MDA G investigation work plan (LANL 2004, 087833) and the investigation report (LANL 2005, 090513) will be reviewed and a list of technologies will be developed in the CME to identify potential corrective measures for source, pathway, and receptor controls. An initial set of corrective measures intended to address a full range of options for source, pathway, and receptor controls includes the following:

- no further action (monitoring only)
- maintenance and monitoring of existing cover
- engineering controls/containment
- contaminant extraction from media
- source removal
- combinations of alternatives

The technologies will be screened in the CME to eliminate those that do not prove feasible to implement, that rely on technologies unlikely to perform satisfactorily or reliably over time, or that do not achieve the target corrective measure objectives within a reasonable time period. A list of corrective measure alternatives will be developed and the alternatives will be evaluated further.

Based on specific information on site conditions at MDA G, including the contaminant inventory, the design of the disposal units, and the environmental setting, the following preliminary list of corrective measure alternatives was developed. This list of alternatives represents a workable number of options that meet the corrective action objectives. This list may expand or contract based on further technology screening and regulatory and public input.

No-further-action/continued-institutional-controls alternatives:

- Alternative 1A, Monitoring only, no further action
- Alternative 1B, Maintenance of existing covers and monitoring

Containment alternatives:

- Alternative 2, Engineered cover
- Alternative 3, Subsurface barriers
- Alternative 4A, Near-surface waste stabilization
- Alternative 4B, Complete waste stabilization

Source-removal alternatives:

- Alternative 5A, Partial waste source excavation
- Alternative 5B, Complete waste source excavation
- Alternative 5C, Excavation and consolidation of waste

Contaminant-extraction alternatives:

- Alternative 6, Contaminant extraction from media

Combination of alternatives:

- Alternative 7, Combination of alternatives

4.1 Identification and Description of Corrective Measure Alternatives

Because no potential unacceptable present-day risk or dose exists at MDA G, the need for corrective action is based on the potential for releases in the future that may pose an unacceptable risk or dose to human and/or ecological receptors. Thus, the alternatives emphasize controlling the sources that may contribute to releases, if waste is left in place, and providing continuing containment that will limit the magnitude of future releases at acceptable risk and dose levels.

Since MDA G contains both intact buried wastes and potentially mobile contaminants in the environmental media, the list of alternatives was developed to address the options for both.

4.1.1 Alternative 1A, Monitoring Only

The no-further-action alternative (hereafter called the monitoring-only alternative) will provide the basis for comparative evaluation for all other alternatives, serving as the benchmark. This baseline alternative includes continued monitoring of the subsurface vapor-phase VOC and tritium plumes and moisture monitoring. Monitoring of the existing cover is required to verify attainment of the performance objectives under DOE Order 435.1

Continued monitoring may indicate that the existing cover design will be sufficient to attain the performance objectives under DOE Order 435.1. For this alternative, it is assumed that no effort will be made to maintain the containment systems or to control any releases that occur. The control of site access and Laboratory administrative requirements for the site will remain as they are, continuing institutional controls for the area for as long as the Laboratory is operational.

4.1.2 Alternative 1B, Maintenance of Existing Covers and Monitoring

This alternative is similar to the monitoring-only alternative with the addition that existing containment features will be maintained for evaluation periods of 100 yr and 1000 yr. Maintenance activities can extend the containment effectiveness and operational lifetime for the existing covers at MDA G. This alternative incorporates the monitoring for Alternative 1A and provides for upkeep of the existing containment systems. Any releases identified by site monitoring will also be addressed through maintenance activities, including small-scale improvements to the existing containment systems. The control of site access and Laboratory administrative requirements will continue for as long as the Laboratory is operational.

4.1.3 Alternative 2, Engineered Containment

Engineered covers represent one of the primary containment alternatives for subsurface waste disposal units. Covers reduce water infiltration and provide a barrier to erosion and intrusion. An engineered cover alternative will be assessed to identify additional benefits over current covers.

Because of the generally arid environment, MDA G is a good candidate for a site-specific RCRA-alternative cover. An effectively designed RCRA alternative cover will reduce moisture infiltration, protect against soil erosion, deter plant and animal intrusion, and inhibit human intrusion (ITRC 2003, 091330). Several cover designs will be evaluated for performance over a 1000-yr evaluation period. These designs may include erosion protection with gravel surface treatments, varying depths of enriched soil to enhance plant growth, varying depths of the main crushed tuff layer, and biointrusion barriers such as chainlink fencing, a pea-gravel layer, or a large cobble layer.

To evaluate cover design alternatives, the Laboratory developed a conceptual cover design for the performance assessment for Area G (Day et al. 2005, 090536). The performance assessment evaluates whether the performance objectives of DOE Order 435.1 will be met. The conceptual cover design involves an 8.2 ft minimum cover over the existing operational cover.

4.1.4 Alternative 3, Subsurface Barriers and Alternative 4, Waste Stabilization

Construction of subsurface barriers or waste stabilization activities, such as in situ vitrification or jet grouting, may be desirable components of a containment system for MDA G. Although complete stabilization of wastes may be impractical, when considering the depth of waste disposal shafts in MDA G, stabilization of shallower waste burial configurations at MDA G may be practical and/or necessary to achieve future risk/dose goals. Higher radiation content wastes in Pits 1–5 (LANL 2006, 091691) in the eastern portions of MDA G appear to be candidates for stabilization because stabilization of these wastes reduces the dose to a receptor on the surface and may result in a substantial reduction in the depth of the final cover. If the post-1970 TRU waste is removed, then approximately 4% of the original TRU activity remains in these five pits. An analysis of this alternative, particularly in combination with other alternatives for MDA G, will be performed in the CME.

4.1.5 Alternative 5A/5B/5C, Partial or Complete Waste Excavation

Future potential risk/dose concerns at MDA G can be mitigated or entirely eliminated by either partial or complete excavation of wastes or by excavation, reburial, and consolidation of waste. Under a complete waste excavation approach, all waste would be removed, treated, and disposed of at an off-site facility. Increased short-term risks to workers, the environment, and the community will be evaluated, along with the risk/dose to members of the public along transport routes and at the final disposal location. This alternative offers the potential for clean closure of the site and would eliminate the need for long-term institutional controls.

The partial excavation alternative will evaluate the effect of removing the post-1970 TRU waste (LANL 2006, 091691) and the pre-1970 TRU waste in Pits 1–5. Upon retrieval of TRU waste, these units may be used for LLW disposal. In addition, excavation of near-surface wastes will be evaluated. Limited excavation would result in the potential to establish a thicker buffer between buried wastes and potential receptors without requiring large abovegrade structures.

Recycling of waste materials will also be reviewed as part of the excavation scenarios.

4.1.6 Alternative 6, Contaminant Extraction from Media

Contaminant extraction technologies applicable to remediation of the existing vapor-phase VOC plume at MDA L were evaluated in Appendix H of the approved MDA L work plan (LANL 2004, 087624), and this evaluation is applicable to the plume at MDA G. SVE was identified as the recommended technology.

4.1.7 Alternative 7, Combination of Alternatives

Combinations of Alternatives 1 through 6 will be evaluated.

4.2 Initial Screening of Alternatives

An initial screening of alternatives will be conducted in the CME to reduce the number of alternatives to be evaluated in detail. This screening will be qualitative and will eliminate those alternatives that may not prove feasible to implement, that rely on technologies unlikely to perform satisfactorily or reliably, or that do not achieve the target corrective measure objectives within a reasonable period of time. This screening process will eliminate technologies that have severe limitations for a given set of waste and site-specific conditions. The screening process will examine the following:

- *Site Characteristics.* Site data will be reviewed to identify conditions that may limit or promote the use of certain technologies; those limited technologies will be eliminated from further consideration.
- *Waste Characteristics.* Waste characteristics may limit the effectiveness or feasibility of technologies, that is, the waste characteristics may particularly affect the feasibility of in situ methods, direct treatment methods, and off-site land disposal.
- *Technology Limitations.* The level of technological development, the performance record, and the construction, operation, and maintenance problems will be identified for each technology considered. Technologies that are unreliable, perform poorly, or are not fully demonstrated will be eliminated in the screening process.

5.0 PROCESS AND CRITERIA FOR EVALUATION OF ALTERNATIVES

5.1 Technical Approach

Preliminary engineering designs for the alternatives that passed the initial screening will be developed to support evaluation of performance. Preliminary designs will address the following:

- *Covers*. Covers will be evaluated for the containment alternatives to assess the thickness, slope, and materials.
- *Excavation requirements and waste acceptance criteria*. A preliminary cut-and-fill design will be prepared to assess excavation requirements and waste acceptance criteria for off-site disposal. Requirements will be defined for placing a structure over the excavation to control vapor emissions during excavation activities.
- *Waste stabilization and subsurface barriers*. An assessment of reduction in surface dose and the related reduction in cover thickness will be evaluated.
- *Requirements and costs*. Technology vendors will be consulted to establish requirements and costs for stabilization and removal technologies.

After the preconceptual engineering designs are completed and reviewed, the potential future impacts for the containment corrective measure alternatives will be evaluated. Models similar to the mathematical models used in the update to the MDA G performance assessment (Day et al. 2005, 090536) will be used to simulate processes that may result in the release of contamination from the subsurface at MDA G. The models will simulate

- surface erosion—erosion of surface materials covering the waste,
- cover infiltration—dissolution of contaminants into water percolating through the waste,
- vapor transport—diffusion and extraction of vapor-phase contaminants in vadose zone,
- biotic intrusion,
- dissolution of contaminants into water percolating through the waste, and
- downward migration of solutes through the rock beneath the site.

A diagram of the model relationships is shown in Figure 5.1-1.

Input variables include quantitative and qualitative site-specific data described in the MDA G investigation report (LANL 2005, 090513) or will be developed as part of CME activities and will include parameters such as the following:

- rooting and burrowing depths of plants and animals
- shaft dimensions
- cover design
- COPC concentrations
- porosity of tuff
- residual moisture of tuff

- topography
- tuff hydrologic properties (porosity, permeability, diffusivity, in situ moisture content, etc.)

Contaminant concentrations potentially released from the inventory will be calculated as a function of time in the surface soil, runoff water, air, vadose zone and groundwater.

Simulation of erosion of surface materials covering the waste will be performed using Siberia, a landscape evolution model (Wilson et al. 2005, 092034), or a similar model. Simulation of erosion over the 1000-yr evaluation period will be used to determine the cover thickness necessary to prevent excessive infiltration and meet dose criteria at the site boundary. The minimum thickness to prevent excessive infiltration will be performed using UNSAT-H (Fayer 2000, 072734), HYDRUS (Newman and Schofield 2005, 092068), or Siberia (Wilson et al. 2005, 092034). If adverse impacts are identified in the analysis, then corrective measures that may reduce either the impact or the likelihood of those adverse conditions will be identified. For example, if the assessment identifies that erosion of the cover over the waste at MDA G has the potential to create unacceptable impacts by exposing the waste, then erosion-resistant cover designs will be evaluated.

Dissolution of contaminants into water percolating through the cover and waste will be simulated using a model code such as UNSAT-H or HYDRUS. The Hydrologic Evaluation of Landfill Performance (HELP) model (EPA 1994, 070239) will manage climate data.

After the cut-and-fill design has been completed and reviewed for the excavation alternatives, waste disposal alternatives will be identified for each of the waste streams, and waste-disposal sites will be identified. Worker and transportation risk will be assessed for excavation and off-site transportation of MDA G material. If no facilities will accept these wastes, the excavation and off-site disposal alternative will be removed from further consideration.

The information developed will be used in the comparative evaluation of alternatives specified in the Consent Order and reviewed in Sections 5.2 and 5.3.

5.2 Evaluation Criteria

A description of each alternative will be prepared that includes preliminary process flow sheets, preliminary sizing, the type of construction for buildings and structures, and rough quantities of utilities required. Each alternative will be evaluated against the following criteria: applicability, technical practicability, effectiveness, implementability, impacts to human health and the environment, and cost of each alternative. A table summarizing the alternatives and the criteria will be provided.

5.2.1 Applicability

Each alternative will be evaluated for its overall suitability for containment or remediation of the contaminants in the subject medium for protection of human health and the environment.

5.2.2 Technical Practicability

Each alternative will be evaluated for the uncertainty in designing, constructing, and operating a specific remedial alternative, including an evaluation of historical applications of the alternative, performance, reliability, and minimization of hazards.

5.2.3 Effectiveness

Each alternative will be evaluated for its ability to mitigate the measured or potential impact of contamination in a medium under current and projected site conditions over a 1000-yr time frame, if appropriate. The assessment shall include the anticipated duration for the technology to attain regulatory compliance. Each alternative will be evaluated for both short- and long-term effectiveness.

5.2.4 Implementability

During the corrective measure assessment of implementability, the relative ease of construction and the total time required to achieve a given level of response will be evaluated. The following types of information will be included:

- administrative activities needed to implement the corrective measure
- constructability, time for implementation, and time for benefit results
- availability of off-site treatment, storage, and disposal services
- availability of prospective technologies for each alternative
- operation and maintenance requirements for each alternative

5.2.5 Human Health and Ecological Protectiveness

The human health assessment will focus on the extent to which each alternative mitigates short- and long-term potential exposure to residual contamination and the extent to which it protects human health both during and after it is implemented. Known levels of COPCs on-site, potential exposure routes, and potentially affected populations will be included in the assessment. Each alternative will be evaluated to determine the level of exposure to COPCs and the reduction of that exposure over time. The relative reduction of exposure will be determined by comparing residual levels for each alternative with applicable criteria, standards, or regulations. The increased worker and transportation risks for the excavation and off-site disposal alternative(s) will be assessed versus the long-term risk of leaving material in place for the containment and no-further-action alternatives.

The environmental assessment for each alternative will focus on facility conditions and pathways of COPC exposure addressed by each alternative. An evaluation of the short- and long-term adverse effects of the alternative, any adverse effects on environmentally sensitive areas, and an analysis of measures to mitigate adverse impacts will be included as part of evaluating ecological risk associated with each alternative. The applicability of an alternative will assess the overall suitability for the alternative for containment or remediation of the contaminants in the subject medium for protection of human health and the environment.

5.2.6 Cost

The cost of each alternative will be calculated on a net present value basis. The cost estimate will include capital, operational, and maintenance costs. Capital costs consist of direct (construction) and indirect (nonconstruction and overhead) costs. Operational and maintenance costs are postconstruction costs required to ensure continued effectiveness of a corrective measure. In addition to the total cost of the corrective measure, the cost per year and cumulative cost per year will also be estimated.

Remedial Action Cost Engineering and Requirements System (RACER), a cost-estimating program developed for Department of Defense environmental remediation projects, will be used to develop conceptual cost estimates for evaluating corrective measure alternatives. RACER cost data are updated annually.

5.3 Long-Term Monitoring

A long-term monitoring program developed as part of the CME will evaluate moisture monitoring associated with the performance of the corrective measure and VOC monitoring in the vadose zone to evaluate the effectiveness of SVE. An interim monitoring plan is proposed in Appendix D.

5.4 Pilot Studies

An SVE pilot test will be conducted at MDA G to evaluate the effectiveness of SVE as a method for removing organic vapor from the subsurface and provide data to design a remediation system. The SVE pilot test will leverage equipment designs that were approved and deployed in accordance with the Laboratory's engineering design, hazard analysis, and Integrated Work Management procedures during the SVE pilot test conducted at MDA L in 2006. Data collected during the MDA L pilot test will be used to develop a work plan for the pilot test at MDA G. During planning for the test, effluent treatment options will be evaluated including, granular activated carbon (GAC), catalytic oxidation (CATOX), and a CATOX-Scrubber combination to minimize treatment and waste disposal costs related to use of the GAC.

Three plume areas have been identified at MDA G. The SVE pilot test will be located within the northeastern plume area (Figure 5.4-1). Major TRU waste operations are ongoing in the area of the other two plumes.

The extraction phase of the SVE pilot test will be operated for up to 30 d. Rebound monitoring on the extraction borehole and monitoring boreholes will be conducted to provide information on the source term and to characterize the behavior of the source region. The increased understanding of source dynamics gained from simulations of the rebound tests will provide additional certainty in understanding the response of the plume to SVE and will assist in developing extraction strategies (i.e., assessing optimal pumping-rebound timing).

6.0 PROCESS AND CRITERIA FOR JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE

Based on the analyses described in Section 5.0, a corrective measure alternative will be selected and recommended for MDA G.

The relative performance of each alternative will be presented, and a cost-benefit analysis will be performed. Tradeoffs between the evaluation criteria will be stated explicitly and will be presented in summary tables. The recommended alternative will be justified based upon its ability 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 CME will include a schedule for the closure of MDA G based on the recommended alternative, including a schedule for closure and the decontamination and decommissioning of structures and retrieval of TRU waste.

7.0 REPORTS

The CME report will comply with Section XI.F of the Consent Order and will include the following:

1. a description of the location, status, and current use of the site
2. a description of the history of the site operations and the history of releases of contaminants
3. a description of the site surface conditions
4. a description of the site subsurface conditions
5. a description of on- and off-site contamination in all affected media
6. identification and description of all sources of contaminants
7. identification and description of contaminant migration pathways
8. identification and description of potential receptors
9. a description of cleanup standards or other applicable regulatory criteria
10. identification and description of a range of remedy alternatives
11. remedial alternative pilot or bench-scale testing results
12. a detailed evaluation and rating of each of the remedy alternatives, applying the criteria set forth in Section VII.D.4 of the Consent Order
13. identification of a proposed remedy
14. a design criteria of the proposed remedy
15. a proposed schedule for implementation of the preferred remedy

The CME report will be submitted to NMED no later than September 12, 2008. Approval of the CME report by NMED is scheduled on or before January 31, 2009.

8.0 REFERENCES

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

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

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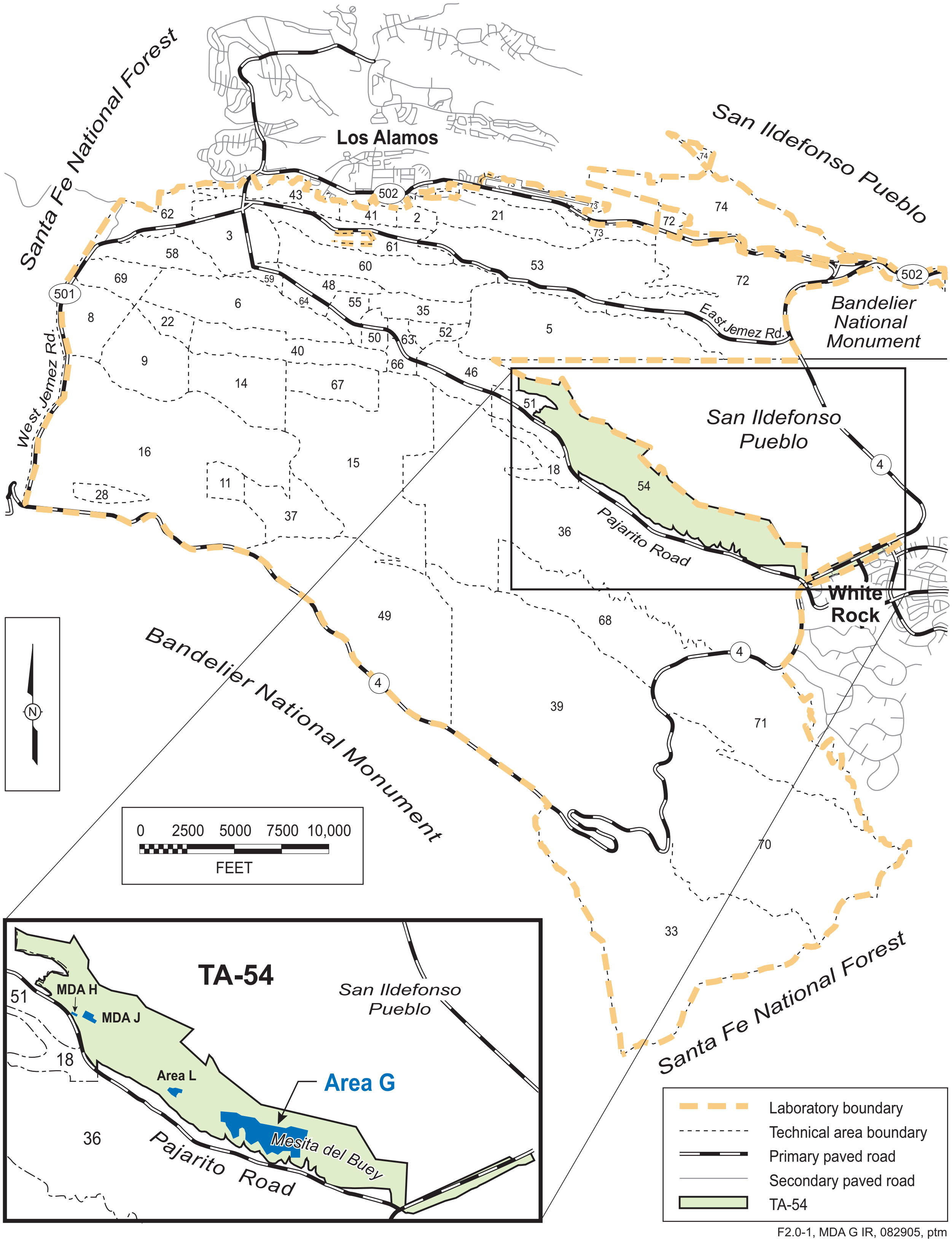
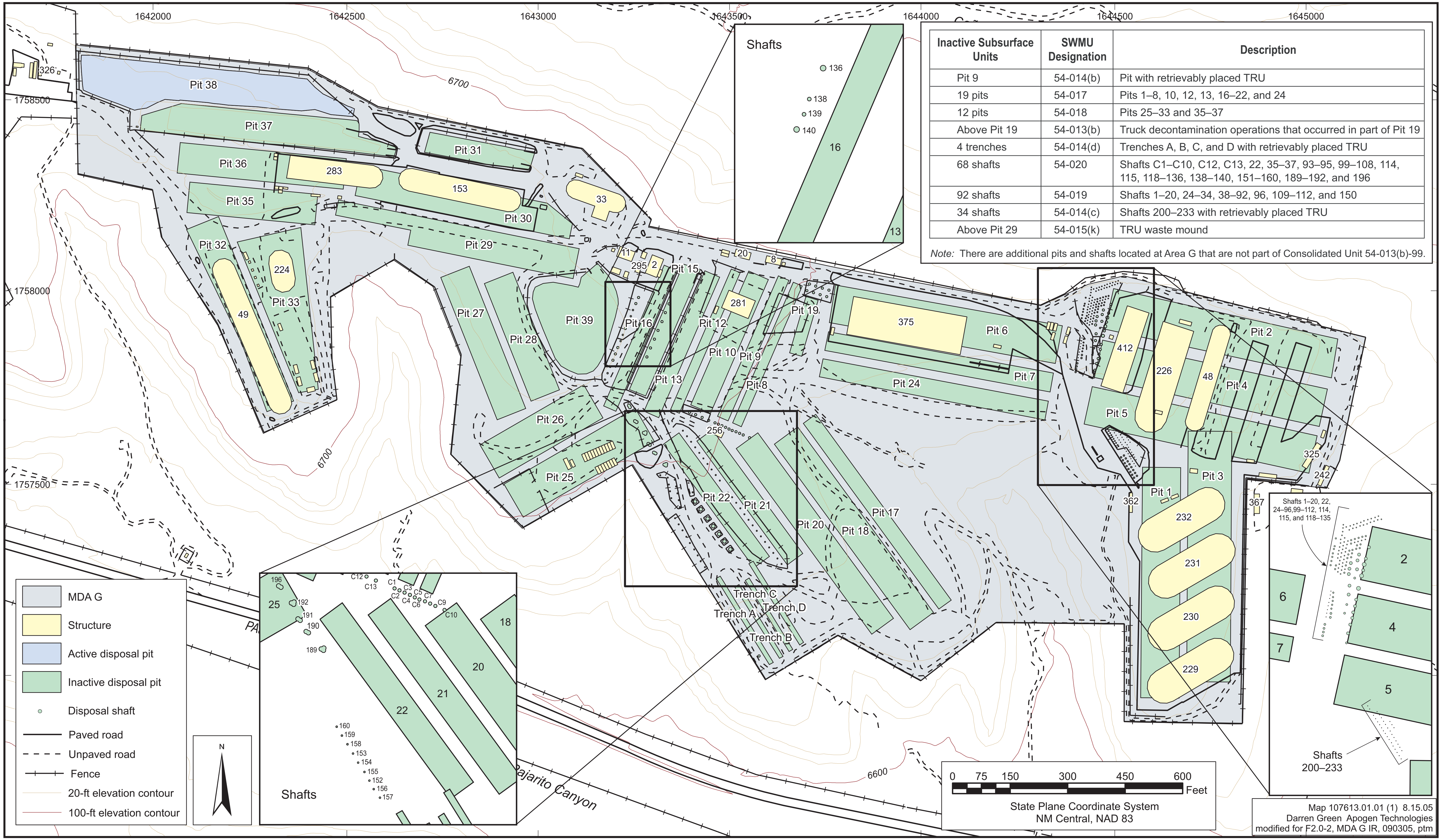


Figure 1.0-1 Location of Area G in TA-54 with respect to Laboratory technical areas

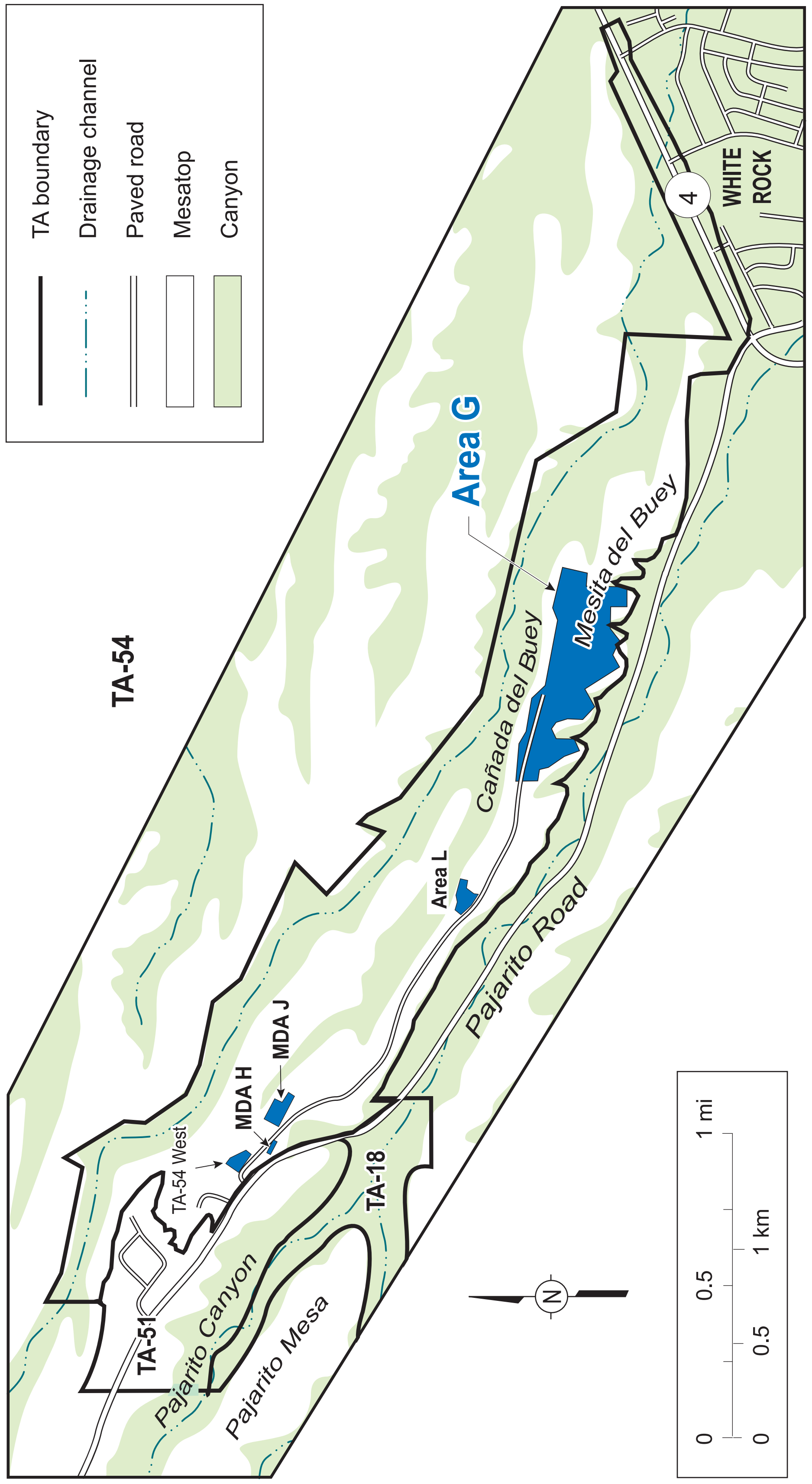


Inactive Subsurface Units	SWMU Designation	Description
Pit 9	54-014(b)	Pit with retrievably placed TRU
19 pits	54-017	Pits 1–8, 10, 12, 13, 16–22, and 24
12 pits	54-018	Pits 25–33 and 35–37
Above Pit 19	54-013(b)	Truck decontamination operations that occurred in part of Pit 19
4 trenches	54-014(d)	Trenches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

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

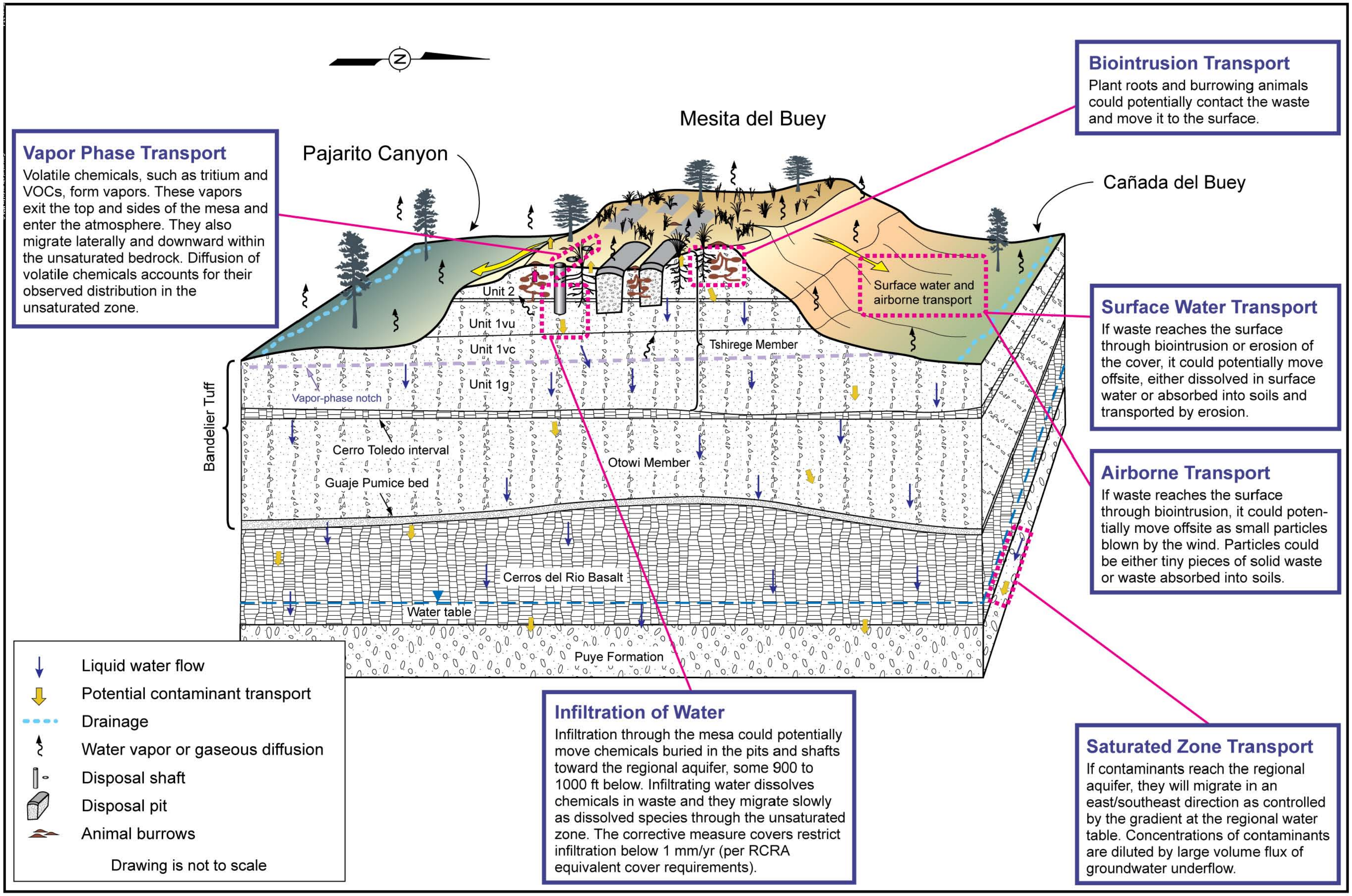
Map 107613.01.01 (1) 8.15.05
Darren Green Apogen Technologies
modified for F2.0-2, MDA G IR, 090305, ptm

Figure 1.3-1 MDA G subsurface waste disposal units



Source: A. Kron_MDA L RFI Rpt., 120302, modified for F2.1-1, MDAG IR, 082605, ptm

Figure 2.6-1 Location of Area G in TA-54



Vapor Phase Transport

Volatile chemicals, such as tritium and VOCs, form vapors. These vapors exit the top and sides of the mesa and enter the atmosphere. They also migrate laterally and downward within the unsaturated bedrock. Diffusion of volatile chemicals accounts for their observed distribution in the unsaturated zone.

Biointrusion Transport

Plant roots and burrowing animals could potentially contact the waste and move it to the surface.

Surface Water Transport

If waste reaches the surface through biointrusion or erosion of the cover, it could potentially move offsite, either dissolved in surface water or absorbed into soils and transported by erosion.

Airborne Transport

If waste reaches the surface through biointrusion, it could potentially move offsite as small particles blown by the wind. Particles could be either tiny pieces of solid waste or waste absorbed into soils.

Infiltration of Water

Infiltration through the mesa could potentially move chemicals buried in the pits and shafts toward the regional aquifer, some 900 to 1000 ft below. Infiltrating water dissolves chemicals in waste and they migrate slowly as dissolved species through the unsaturated zone. The corrective measure covers restrict infiltration below 1 mm/yr (per RCRA equivalent cover requirements).

Saturated Zone Transport

If contaminants reach the regional aquifer, they will migrate in an east/southeast direction as controlled by the gradient at the regional water table. Concentrations of contaminants are diluted by large volume flux of groundwater underflow.

J. Tauxe, 062101 after A. Kron_Rev. for F2.3-1, MDA H RS, 122001, RLM_Rev. for MDA H CMS Rpt., 051403, cf; modified 101507, ptm

Figure 2.7-1 Conceptual site model of contaminant transport mechanisms for MDA G

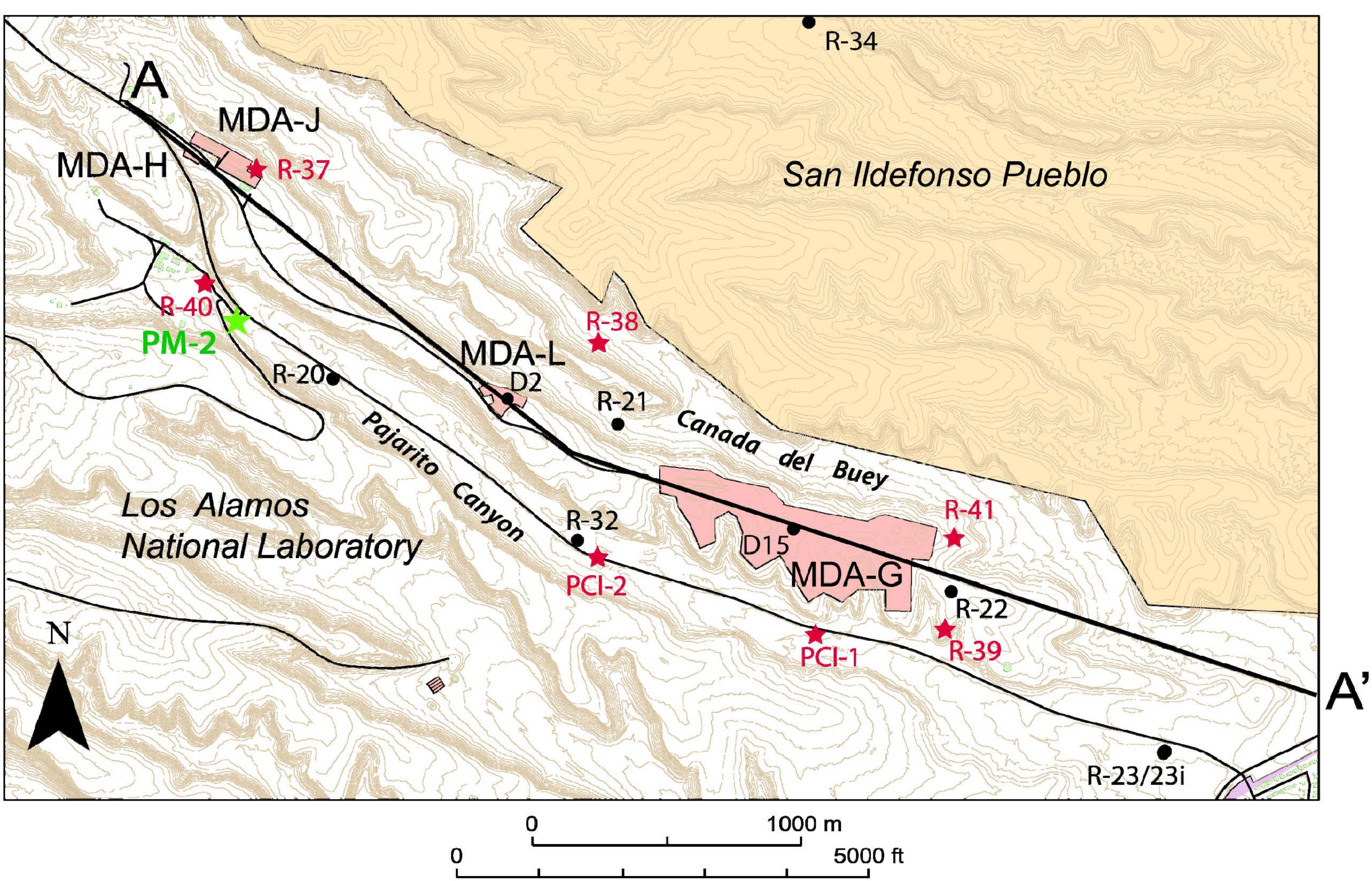


Figure 2.7-2 Plan view of existing (black label) and proposed (red label) monitoring wells in the TA-54 area. R-wells extend to the regional aquifer. R-23i and the PCI-wells extend to intermediate perched zones in Pajarito Canyon (if they are present).

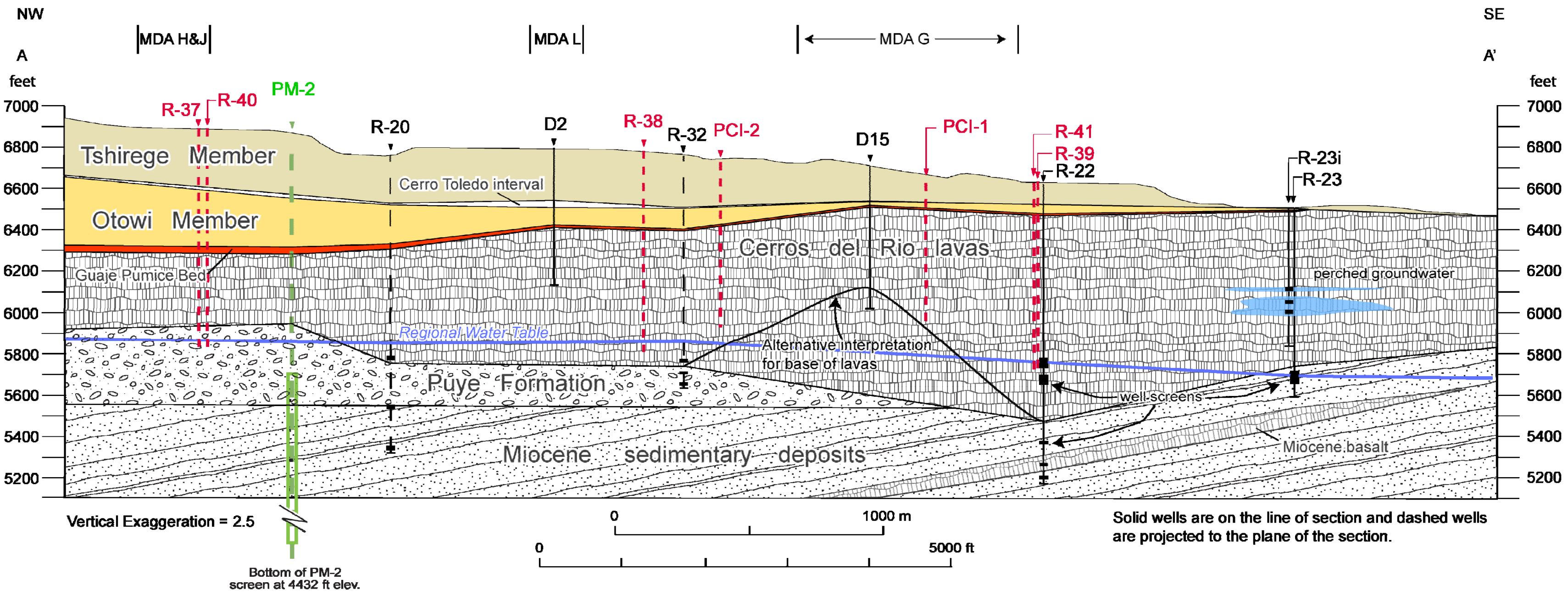


Figure 2.7-3 Cross-section view along A–A' of existing (black label) and proposed (red label) monitoring wells in TA-54 area

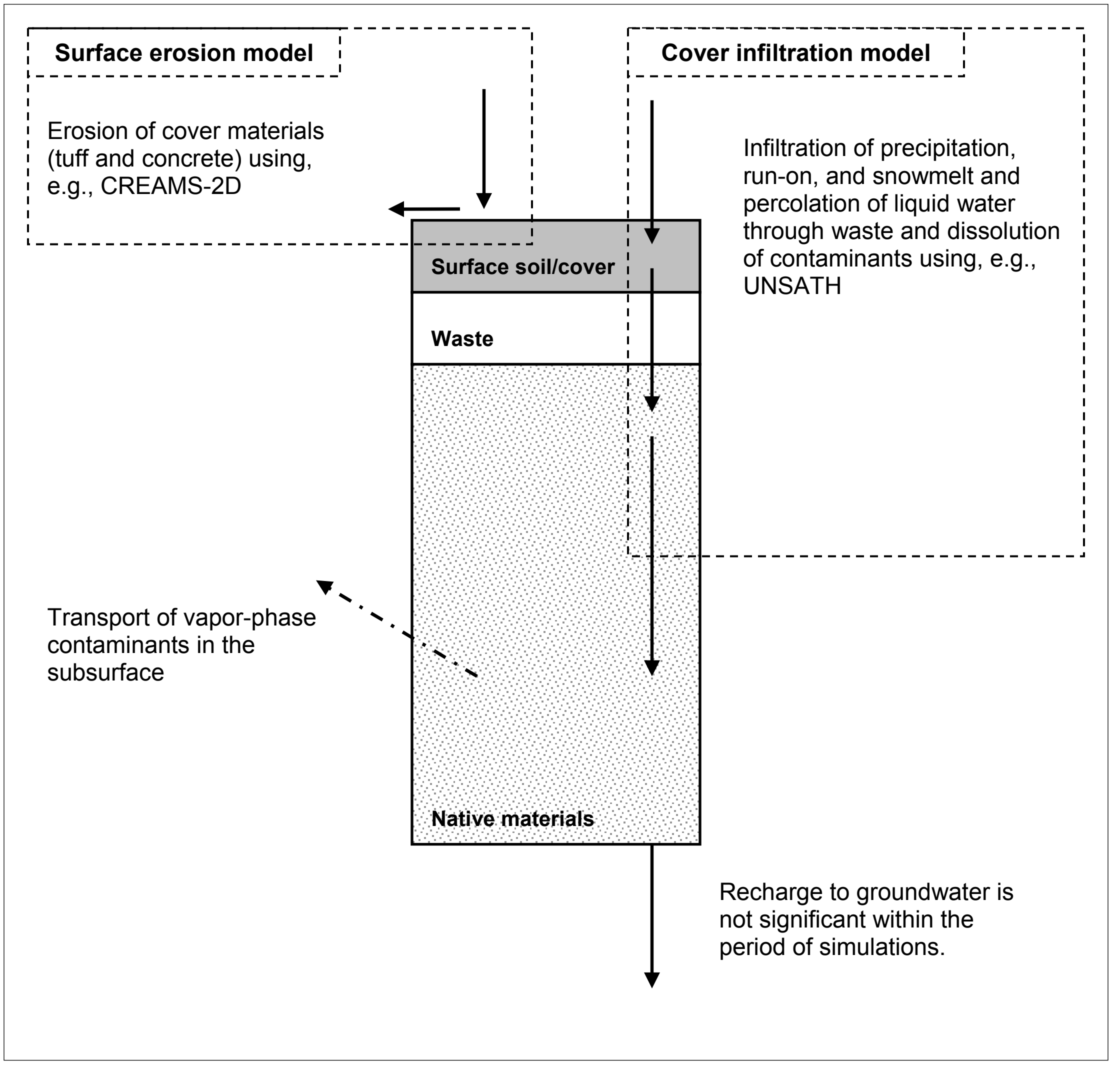


Figure 5.1-1 Diagram of model relationships

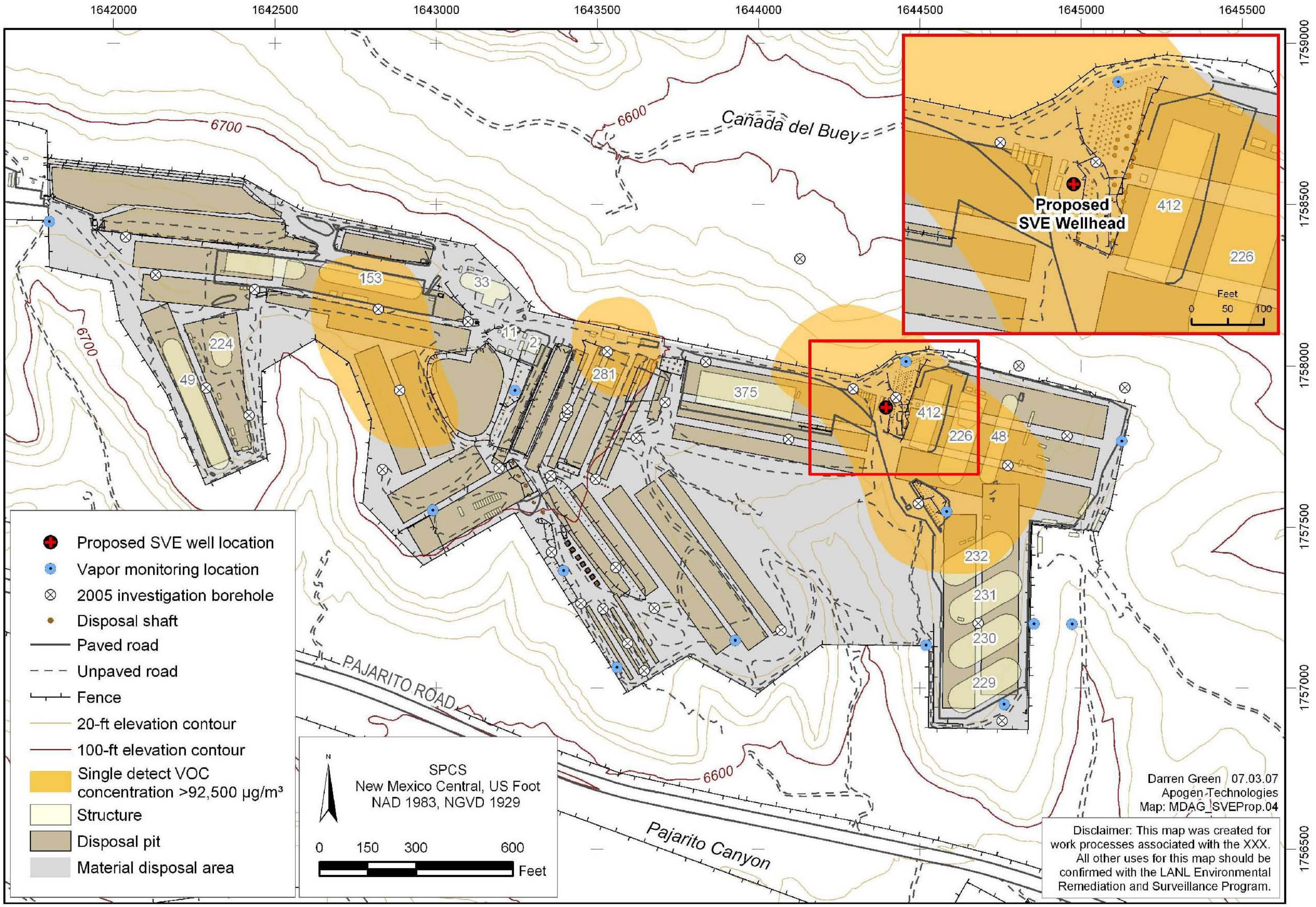


Figure 5.4-1 Proposed location of MDA G SVE pilot study

Table 1.3-1
Summary of Waste Management Units at Area G

Disposal Units - Closure Requirements Defined in DOE Order 435.1					Container Storage Units - Closure Requirements Defined by Operating Permit
		Closure Requirements Defined by Operating Permit	Closure Requirements Defined under Corrective Action		
LLW Disposal Units	TRU Waste Storage Units	RCRA Disposal Units	Corrective Action Disposal Units	TRU Waste Storage Units[a]	
Pit 15	Shafts 235–243, 246–253, 262–266, 302–306	Pit 29 (below layer of stored TRU corrugated metal pipes)	Pits 1-10, 12, 13, 16–22, 24–30, 32–33, 35–37	TRU waste in corrugated metal pipes stored atop LLW in Pit 29	Pad 1 (54-226, 54-412)
Pits 38, 39		Shaft 124	Pit 31	Pit 9	Pad 3 (54-48)
Shafts 21, 23, 97, 137, 141–144, 147–149, 161–177, 197, 300, 301, 307, 308, 360–367, 369, 370			Shafts C1–C10, C12, C13, 1–20, 22, 24–96, 99–112, 114, 115, 118–123, 125–136, 138–140, 150–160, 189–192, 196	Trenches A–D	Pads 5, 7, 8 (54-49, 54-224, 54-144, 54-145, 54-146, 54-177, 54-1027, 54-1028, 54-1030, 54-1041)
Shafts C11, C14, 321, 323, 325, 327, 329, 331, 333, 335, 339, 341, 343, 345, 347, 349, 351, 355, 357				Shafts 200–232	Pad 6 (54-153, 54-283)
Shafts[b] 309, 311, 313, 315, 317, 319, 337, 353, 359				Shaft 233[b]	Pad 9 (54-229, 54-230, 54-231, 54-232) Pad 10 (formerly Pads 2 and 4) Pad 11 (54-375)[c] 54-8 54-33 Shafts[d] 145, 146

[a] Upon retrieval of TRU waste, unit(s) may be utilized for LLW disposal.

[b] Unused/empty. Unit(s) may be utilized for LLW disposal.

[c] Included in RCRA Permit application renewal.

[d] Unit(s) may be utilized for LLW disposal.

Table 1.3-2
Summary of SWMUs in MDA G

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

Note*:* Additional pits and shafts located at Area G are not part of Consolidated Unit 54-013(b)-99.

Appendix A

Acronyms, Glossary, and Metric Conversion Table

A-1.0 ACRONYMS

AOC	area of concern
BV	background value
CATOX	catalytic oxidation
CME	corrective measures evaluation
CMI	corrective measures implementation
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CMP	corrugated metal pipe
CSU	container storage unit
DOE	Department of Energy
EPA	U.S. Environmental Protection Agency
EP-CAP	Environmental Programs Directorate–Corrective Actions Project
ET	evapotranspiration
FV	fallout value
FWO	Facility Waste Operations
GAC	granular activated carbon
HELP	Hydrologic Evaluation of Landfill Performance
HI	hazard index
HQ	hazard quotient
HWB	Hazardous Waste Bureau
LANL	Los Alamos National Laboratory
LLW	low-level waste
MCL	maximum contaminant level
MDA	material disposal area
MLLW	mixed low-level waste
NEPA	National Environmental Policy Act
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
OU	operable unit
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (also hexahydro-1,3,5-trinitro-1,3,5-triazine)

RFI	RCRA facility investigation
RME	reasonable maximum exposure
SAL	screening action level
SAP	sampling and analysis plan
SSL	soil screening level
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TA	technical area
TCA	1,1,1-trichloroethane
TNT	2,4,6-trinitrotoluene
TRU	transuranic
TSCA	Toxic Substances Control Act
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Plant

A-2.0 GLOSSARY

action level—(1) A numerical value that has been established by statistical analysis or has been set according to regulatory limits and is used as a criterion for action. Contamination found in a particular medium below an appropriate action level is not generally subject to remediation or further study. (2) A health- and environment-based concentration derived using chemical-specific toxicity information and standardized exposure assumptions. An action level can be developed on a facility-specific basis or can be taken from standardized lists.

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

alluvial—Pertaining to geologic deposits or features formed by running water.

assessment—(1) The act of reviewing, inspecting, testing, checking, conducting surveillance, auditing, or otherwise determining and documenting whether items, processes, or services meet specified requirements. (2) An evaluation process used to measure the performance or effectiveness of a system and its elements. In this glossary, assessment is an all-inclusive term used to denote any one of the following: audit, performance evaluation, management system review, peer review, inspection, or surveillance.

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

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

corrective measures study—A formal process for identifying and evaluating alternative remedies for releases at a facility.

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

disposal—The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into, or on, any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwaters.

ecological screening levels—Soil, sediment, or water concentrations that are used to screen for potential ecological effects. The concentrations are based on a chemical's no-observed-adverse-effect level for a receptor, below which no risk is indicated.

environmental impact statement (EIS)—A document required of federal agencies by the National Environmental Policy Act when those agencies are considering major projects or legislative proposals that could significantly affect the environment. Designed as a decision-making tool, an EIS describes the positive and negative effects of an undertaking and cites alternative actions.

evapotranspiration—(1) The discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces and by transpiration from plants. (2) The loss of water from the soil by evaporation and/or by transpiration from the plants growing in the soil.

hazard index—The sum of hazard quotients for multiple contaminants to which a receptor may have been exposed.

HSWA module—See Module VIII.

"Hydrogeologic Workplan"—The document that describes the activities planned by Los Alamos National Laboratory (the Laboratory) to characterize the hydrologic setting beneath the Laboratory and to enhance the Laboratory's groundwater monitoring program.

mixed waste—Waste containing both hazardous and source, special nuclear, or byproduct materials subject to the Atomic Energy Act of 1954.

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

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

RCRA facility assessment (RFA)—Usually the first step in the Resource Conservation and Recovery Act (RCRA) corrective action process. The RFA includes the identification of potential and actual releases from solid waste management units and preliminary determinations about releases and the need for corrective action and stabilization measures.

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

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

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

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

risk—A measure of the probability that damage to life, health, property, and/or the environment will occur as a result of a given hazard.

screening action level (SAL)—A radionuclide's medium-specific concentration level; it is calculated by using conservative criteria below which it is generally assumed that no potential exists for a dose that is unacceptable to human health. The derivation of a SAL is based on conservative exposure and on land-use assumptions. However, if an applicable regulatory standard exists that is less than the value derived, it is used in place of the SAL.

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

solid waste management unit (SWMU)—(1) Any discernible site at which solid wastes have been placed at any time, whether or not the site use was intended to be the management of solid or hazardous waste. SWMUs include any site at a facility at which solid wastes have been routinely and systematically released. This definition includes regulated sites (i.e., landfills, surface impoundments, waste piles, and land treatment sites), but does not include passive leakage or one-time spills from production areas and sites in which wastes have not been managed (e.g., product storage areas). (2) According to the March 1, 2005, Compliance Order on Consent (Consent Order), any discernible site at which solid waste has been placed at any time, and from which the New Mexico Environment Department determines there may be a risk of a release of hazardous waste or hazardous waste constituents (hazardous constituents), whether or not the site use was intended to be the management of solid or hazardous waste. Such sites include any area in Los Alamos National Laboratory at which solid wastes have been routinely and systematically released; they do not include one-time spills.

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

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

A-3.0 METRIC TO ENGLISH CONVERSIONS

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

Appendix B

Public Involvement Plan for Material Disposal Area G Corrective Measures Evaluation Report, Revision 2

Public Involvement Plan for Material Disposal Area G Corrective Measures Evaluation Report, Revision 2

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

CONTENTS

1.0 INTRODUCTION AND PURPOSE

The Environmental Programs Directorate–Corrective Actions Project (EP-CAP) of Los Alamos National Laboratory (the Laboratory) has developed this Public Involvement Plan to seek input from and to provide information to the community about the steps that will be taken to conduct a corrective measures evaluation (CME) at Material Disposal Area (MDA) G at Technical Area (TA) 54. The EP-CAP will consider community concerns when it evaluates and recommends key actions necessary to remediate the site.

The principal objectives of this public involvement plan are to communicate the purpose of the MDA G CME and to afford the public an opportunity to make its preferences known. The objectives of the MDA G CME include

1. identifying and evaluating corrective measure alternatives that address potential unacceptable future risk and dose at MDA G, and
2. recommending one or more of those alternatives for implementation.

This plan, developed according to the U.S. Environmental Protection Agency's (EPA's) Resource Conservation and Recovery Act (RCRA) public participation requirements (EPA 1998, 092078), is consistent with the EP-CAP's Public Involvement Plan (LANL 2005, 089310) and the requirements of the March 1, 2005, Compliance Order on Consent (the Consent Order), signed by the New Mexico Environment Department (NMED), the U.S. Department of Energy (DOE), and the Regents of the University of California.

2.0 PRINCIPLES

Fundamental to all of the Laboratory remediation project strategies and actions is the view that the public has the right to know about issues affecting its health and welfare and also to participate in the planning process for activities involving remediation of Laboratory sites. This public involvement plan has been developed in accordance with the following principles:

1. **Access to information:** A record of all public meetings will be kept. Technical documents will be placed in locations available to the community.
2. **Clarity:** Scientific information and regulatory procedures will be presented in terms understandable to the public.
3. **Responsiveness:** All questions by the public will be answered in a timely manner.
4. **Multilevel communication:** A variety of methods will be used to contact and inform the public, including newsletters, direct mail, community meetings, website postings, and articles in the printed media.
5. **Timeliness:** The public will receive adequate notice of meetings and meetings will be scheduled at a time and place that is convenient and comfortable. Adequate time to review materials will also be provided.
6. **Coordination:** Good communication among all concerned agencies and community organizations will be critical to the success of the process.
7. **Accessibility of personnel:** Both the Laboratory and DOE personnel will be accessible to the public.
8. **Educate:** The public will receive briefings on the investigation and the corrective action processes and will have the opportunity to provide input to the process.

3.0 DESCRIPTION OF FACILITY

3.1 Background

Consolidated Unit 54-013(b)-99, a consolidation of nine solid waste management units (SWMUs), also known as MDA G, is located within a 63-acre waste management area located on Mesita del Buey at the Laboratory, approximately 1 mi northwest of White Rock, New Mexico (See Figure 1). The MDA G waste disposal units are constructed in the Tshirege Member of the Bandelier Tuff, a consolidated tuff unit. The regional aquifer is estimated to be at a depth of approximately 930 ft. The topography of MDA G is relatively flat, and it does not extend beyond the mesa top.

MDA G was used for the disposal of low-level radioactive waste (LLW), certain radioactively contaminated infectious waste, asbestos-contaminated material, and polychlorinated biphenyls (PCBs). It was also used for the retrievable storage of transuranic (TRU) waste. The disposal site has been used for a variety of waste management functions since 1957. Disposal and retrievable storage units include 32 pits, 194 shafts, 4 trenches with depths ranging from 10 ft to 65 ft below the original ground surface. The contaminant releases at MDA G include vapor-phase tritium and volatile organic compounds (VOCs) from subsurface SWMUs; inorganic chemicals, radionuclides, and organic chemicals in drainage channel sediment; and inorganic chemicals and radionuclides dissolved in liquid solvents into tuff below the subsurface SWMUs.

3.2 Regulatory Status

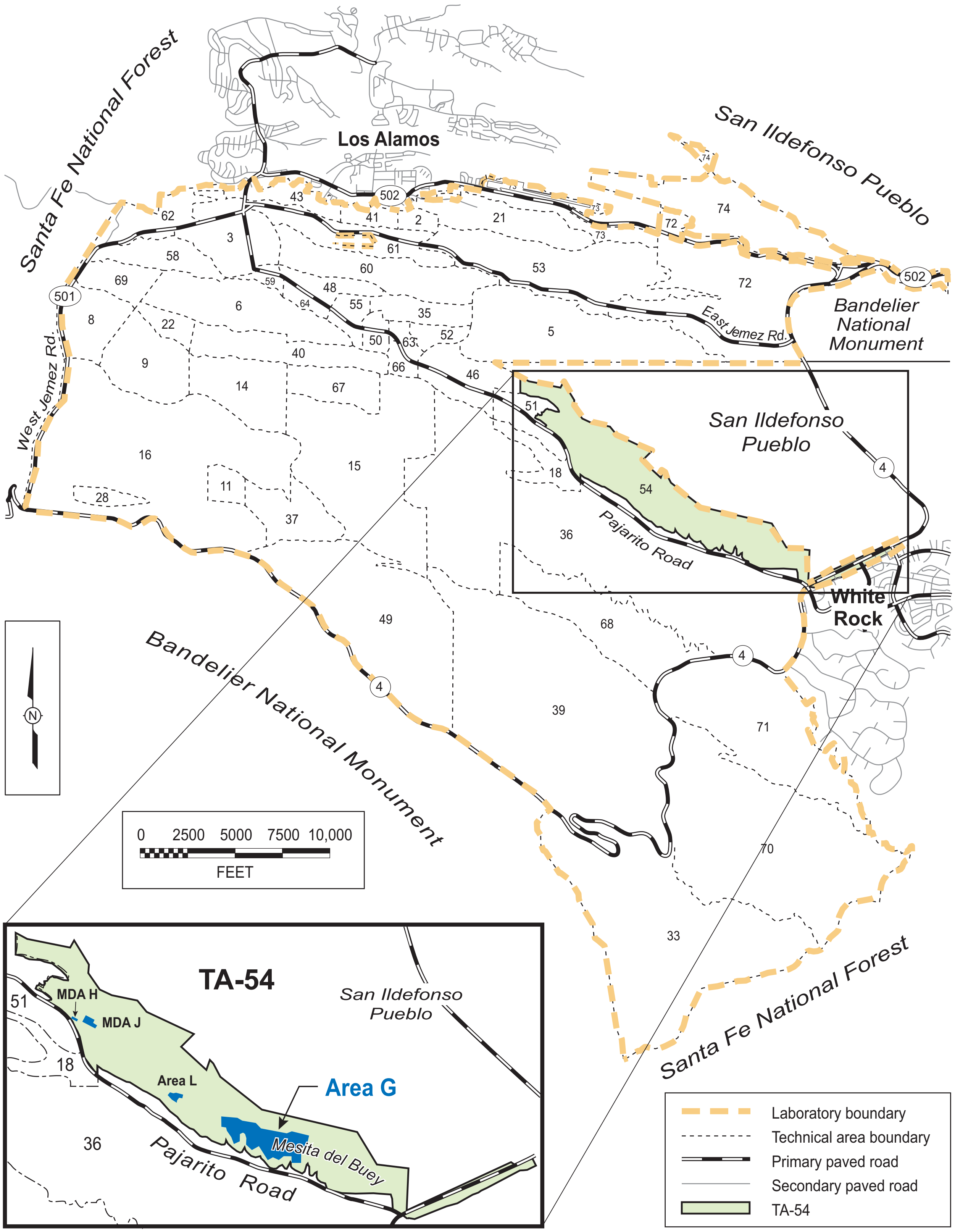
The inactive MDA G units are regulated under two separate authorities, the Consent Order and RCRA, depending on the dates the units operated. Under the Consent Order authority, the investigation report for MDA G was submitted to NMED on September 8, 2005 (LANL 2005, 090513) and an addendum was submitted in May 2007 (LANL 2007, 096110). The New Mexico Environment Department (NMED) approved the investigation report in June 2007 (NMED 2007, 096716). The CME report, the product of evaluations performed under the CME work plan for MDA G, is scheduled to be finalized no later than September 12, 2008. The remedy completion report is scheduled to be finalized on or by December 31, 2015. Units regulated under RCRA are interspersed among the corrective action units governed by the Consent Order.

3.3 Current Status

All pits, trenches, and shafts are covered with varying amounts of fill, concrete and asphalt.

TRU and mixed-TRU wastes awaiting characterization, certification, and shipment to the Waste Isolation Pilot Project (WIPP) are stored in subsurface units and surface units. TRU waste is retrievably stored in subsurface pits, trenches, and shafts. Some of these subsurface units are identified as corrective action units (within the scope of MDA G) and are subject to the requirements of the Consent Order. TRU and mixed-TRU wastes are also stored aboveground in surface storage areas and container storage units (CSUs), respectively. The CSUs are subject to RCRA permit and/or interim status requirements.

Mixed LLW (MLLW) is currently stored in surface CSUs before it is shipped off-site for treatment and/or disposal; the CSUs are subject to RCRA-permit and/or interim-status requirements. Additionally, some MLLW was disposed of in two subsurface pits after the effective date of RCRA hazardous waste management regulations and therefore are subject to RCRA disposal unit requirements. These two subsurface RCRA disposal units were previously identified as corrective action units; however, they are not subject to the requirements of the Consent Order.



F2.0-1, MDA G IR, 082905, ptm

Figure 1 Location of Area G in TA-54 with respect to Laboratory technical areas

4.0 PUBLIC INVOLVEMENT OPPORTUNITIES

4.1 Public Meetings

The EP-CAP will organize and conduct public meetings for the MDA G CME to give the community an opportunity to learn about the status of the project and provide input. Public meetings will also be conducted if the project reaches a critical step and when it is necessary to provide new information. These sessions will be facilitated by Laboratory and DOE staff who will address specific questions. Notices regarding these sessions will be announced in advance.

4.2 Document Review

Project documents will be created and maintained at the Laboratory's Public Reading Room, located at TA-03, the Study Center (505-665-4400). The project's website, erproject.lanl.gov, will also post project documents. However, the large file size of maps and graphics may prevent complete versions of technical documents to be posted on the website.

4.3 Printed Materials

The staff will prepare and mail updates periodically describing the activities taking place on the project.

4.4 Project Website

A website, erproject.lanl.gov, exists to provide information and the latest developments on the project.

4.5 Mailing List

A mailing list of interested parties will be created to disseminate information. These parties include, but are not limited to, individuals and organizations that have expressed an interest in receiving information, such as government officials, the Los Alamos Public Schools, and the Los Alamos County commissioners.

4.6 Community Advisory Group and/or Community Facilitator

Through the public involvement process, a community advisory group will be constituted and/or a community facilitator will be selected, if necessary.

5.0 ROLES AND RESPONSIBILITIES

5.1 Department of Energy

The DOE role is oversight of EP-CAP and, as such, is responsible for reviewing all investigation plans and reports and for determining that the investigation is adequate. It is also responsible for ensuring that the public and the environment are protected. Finally, DOE is responsible for ensuring that the public is informed about the investigation and that its concerns are identified and addressed before plans and reports are approved.

5.2 The EP-CAP

The EP-CAP will be responsible for the following:

- managing the public involvement process
- executing this plan
- organizing and holding the public meetings
- preparing summary documents and project updates
- providing a facilitator for the community advisory group, if necessary
- maintaining a mailing list of all interested members of the community
- maintaining the public information repositories
- creating and maintaining a website for EP-CAP projects
- assisting in developing educational outreach opportunities for the public regarding ongoing work on the MDA G CME
- providing adequate notice of all public meetings
- responding to all written comments and working with the responsible parties and their technical consultants to answer technical questions

6.0 KEY CONTACTS

Name	Organization	Phone	E-mail	Role
Primary Contacts				
John Hopkins	EP-CAP	667-9551	johnhopkins@lanl.gov	Project Leader
Gabriela Lopez Escobedo	ADEP	665-7352	gabriela@lanl.gov	Program Manager
Gordon Dover	EP-CAP	667-0819	mcinroy@lanl.gov	Deputy Project Director
Lorrie Bonds Lopez	EP-DO	667-0216	lorriel@lanl.gov	Outreach Project Leader
Frank Bosiljevac	DOE-AL	845-5746	fbosiljevac@doeal.gov	Federal Project Manager
David Gregory	DOE-LASO	667-5808	dgregory@doeal.gov	Federal Project Director
Secondary Contacts				
Richard Bohn	County of Los Alamos	662-8120		Los Alamos County Community Development Director
J. Kyle Zimmerman	County of Los Alamos	662-8150		Los Alamos County Public Works Director
Gerald T. E. Gonzalez	County of Santa Fe	986-6200		Santa Fe County Manager
Debbie Hays	County of Sandoval	867-7500		Sandoval County Administrator
Martin Aguilar	San Ildefonso Pueblo	455-2273		Governor, Pueblo of San Ildefonso
David Cobrain	NMED	476-6055		
Hai Shen	NMED	476-6039		

7.0 STAKEHOLDER IDENTIFICATION

Target Stakeholders	Possible Stakeholder Questions and Issues
Internal/Regulatory/Partnering Stakeholders	
DOE	Constructability
NMED	Integrated closure of sites and units
Potential External Stakeholder	
White Rock Residents and Business Owners	Health risks
Local Pueblo Leaders	Impact to area cultural resources
Land Owners	Impact to property values
Los Alamos/Santa Fe/Sandoval County	Changes to utility service
Los Alamos Public Schools	Impact to enrollment
Commuters/Drivers on Pajarito Road	Impact to road traffic
Residents of the State of New Mexico	Impacts to environment and road traffic

8.0 KEY MILESTONES

Milestone	Completion Date
1. Create MDA G fact sheet	October 31, 2006
2. Mail notification of public meeting	December 15, 2006
3. Announce public notice in news media	December 15, 2006
4. Meet with public on CME	January 31, 2007
5. Mail and distribute feedback cards	February 15, 2007
6. Submit CME plan, rev. 2, to NMED	October 15, 2007
7. Submit CME report to NMED	September 12, 2008

9.0 MEETING PLANS AND RESOURCES

9.1 Public Meetings

Public Meeting 1 Details

Date and Time: February 28, 2007

Venue: Fuller Lodge

Event: Project Kickoff—description of site setting, screening process, possible alternatives

Moderator: Public Participation Coordinator

Speaker: EP-CAP Program staff

Other Meetings: To be determined and announced

9.2 Resources/Posters/Handouts/Mailings

- MDA G fact sheet
- Posters of possible alternatives and site setting
- Mail notice 30 days prior to meeting

10.0 REFERENCES

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

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

EPA (U.S. Environmental Protection Agency), May 1998. "Public Participation," section 7 in *RCRA Orientation Manual*, EPA530-R-98-004, Office of Solid Waste and Emergency Response, Washington, D.C. (EPA 1998, 092078)

LANL (Los Alamos National Laboratory), May 2005. "Environmental Stewardship–Environmental Remediation and Surveillance Program Public Involvement Plan," Los Alamos National Laboratory document LA-UR-05-3951, Los Alamos, New Mexico. (LANL 2005, 089310)

LANL (Los Alamos National Laboratory), September 2005. "Investigation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99, at Technical Area 54," Los Alamos National Laboratory document LA-UR-05-6398, Los Alamos, New Mexico. (LANL 2005, 090513)

LANL (Los Alamos National Laboratory), May 2007. "Addendum to the Investigation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99, at Technical Area 54," Los Alamos National Laboratory document LA-UR-07-2582, Los Alamos, New Mexico. (LANL 2007, 096110)

NMED (New Mexico Environment Department), June 8, 2007. "Approval for the 'Investigation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99, at Technical Area 54'," New Mexico Environment Department letter to D. Gregory (DOE LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED HWB), Santa Fe, New Mexico. (NMED 2007, 096716)

Appendix C

Schedule for Corrective Measures Evaluation/Corrective Measures Implementation at Material Disposal Area G

The schedules for the corrective measures evaluation (CME) and corrective measures implementation (CMI) for Material Disposal Area (MDA) G at Los Alamos National Laboratory are detailed in Table C-1.

Table C-1
Schedule for the MDA G CME/CMI

Activity	Date
MDA G investigation report submitted to New Mexico Environment Department (NMED)	09/08/05*
Addendum to the Investigation report submitted to NMED	5/07
Approval of investigation report	06/08/07
Submit MDA G CME Plan to NMED	06/05/06*
Submit Revision 2 of the MDA G CME Plan to NMED	10/15/07
Submit MDA G CME report to NMED	No later than 9/12/08
NMED approves the MDA G CME report	1/31/09
NMED initiates public comment period	TBD
NMED selects final remedy	TBD
Complete MDA G CMI report	TBD
Implement construction of final MDA G corrective measure	TBD
Deliver MDA G remedy completion report	12/31/15

*As specified in the revised the Compliance Order on Consent schedule (February 27, 2006).

Appendix D

Interim Subsurface Vapor-Monitoring Plan for Material Disposal Area G at Technical Area 54

D-1.0 INTRODUCTION

The following plan describes proposed subsurface vapor monitoring activities and the frequencies at which they will be conducted within the vadose zone beneath Material Disposal Area (MDA) G. The objective of the monitoring is to evaluate trends in volatile organic compound (VOC) and tritium concentrations over time.

D-2.0 HISTORICAL DATA REVIEW

Routine monitoring of VOCs in subsurface pore gas has been ongoing at Area G from 1992 to the present. Data were last reported in the “Periodic Monitoring Report for Vapor Sampling Activities at Technical Area 54 Material Disposal Area G” (LANL 2006, 093269). Monitoring since 1992 has been conducted in 32 boreholes, including 4 boreholes drilled for the MDA G Phase I Resource Conservation and Recovery Act facility investigation (RFI) and 9 boreholes installed by Facility Waste Operations (FWO) at Area G. Most monitoring events consisted of collecting two pore-gas samples from each borehole using SUMMA canisters from selected depths and screening all ports for VOCs in pore gas using the Brüel and Kjaer (B&K) multigas monitor.

Results from routine monitoring indicate that trichloroethane[1,1,1-] (TCA) is the dominant contaminant present as a vapor beneath MDA G. Maximum concentrations are closely associated with the location of the earliest MDA G disposal in the eastern portion of the area. TCE is the predominant VOC detected in the western areas of MDA G. The highest TCE concentrations are detected in 54-24394 at a depth of 45 ft below ground surface (bgs) in the vicinity of Pits 32 and 33.

Following completion of the 38 boreholes in 2005, all ports were screened using the B&K multigas monitor and pore-gas samples were collected from each borehole at the base depth of the nearest adjacent disposal unit and at total depth of the borehole. Samples were collected using a downhole straddle-packer system to isolate the desired sampling interval. Samples were collected in SUMMA canisters for VOC analyses and in silica gel columns for tritium analysis. Purge gas was screened during the sampling process for percent oxygen and carbon dioxide.

Results from the 2005 investigation confirm the presence of VOCs in subsurface pore gas at MDA G. Thirty VOCs were detected, the dominant contaminant is TCA. Concentrations of TCA generally decreased from east to west across the site. The highest concentration of TCA was detected at location 54-24378. TCA concentrations in nearby locations 54-24388, 54-24379, 54-24386, and 54-24385 are also elevated compared to the rest of the site indicating the greatest release of TCA is at the east end of MDA G near Pits 1 through 5 and the adjacent shaft fields.

The highest levels of TCA in the central and western portions of MDA G were detected in samples collected from locations 54-24390 and 54-24394, respectively. Although TCA is still the dominant contaminant in these areas, the relatively higher concentrations of other VOCs, including trichloroethene (TCE) and tetrachloroethene (PCE), in these samples indicate releases from different sources. However, levels of VOCs in the subsurface vapor in these portions of MDA G are an order of magnitude less than in the eastern portion.

The concentrations of VOCs in subsurface vapor measured during 2006 are similar to or less than the concentrations measured in 1997 (LANL 2004, 087624, Appendix B). Concentrations of VOCs in pore-gas are not large enough to pose an immediate threat of groundwater contamination by the VOC plume (LANL 2006, 093269)

Boreholes 54-01110 and 54-01111 are located adjacent to the active and inactive tritium disposal shafts in the south-central portion of MDA G. Core, subsurface vapor, and flux samples collected at MDA G all indicate this is the region with the highest levels of tritium (LANL 2004, 089304). Analysis of vapor samples collected in 2003 from locations 54-01110 and 54-01111 indicated that tritium levels increase with depth to 90 ft and 139 ft, respectively. The results from the 2005 field investigation confirm tritium is elevated in the south-central portion; however, the maximum tritium concentrations were detected in samples from locations 54-24386 and 54-24378, located in the eastern portion. Tritium concentrations generally decrease with distance and depth from these two portions of MDA G.

During 2007, borehole BH-37 (location 54-24397) near boreholes 54-01110 and 54-01111 was extended into the basalt at 239.75 ft bgs. Tritium concentrations at this borehole were consistent with earlier investigations and show an overall decrease with depth to the basalt. The concentration of tritium detected from pore-gas moisture collected from the basalt at borehole 54-24397 was 1750 pCi/L. This value is less than 10% of the maximum contaminant level for drinking water.

D-3.0 MONITORING METHODS

Monitoring methods were selected to provide both precise and accurate data on the concentrations of tritium and VOCs in subsurface vapor beneath MDA G to determine trends through time. The method for monitoring pore gas at MDA G includes purging the sampling port and field-screening purge gas and collecting samples in SUMMA canisters and silica gel columns from prescribed locations for off-site laboratory analysis. The proposed frequency of sampling and the locations to be sampled are defined in Section 4.0, Proposed Monitoring Distribution and Frequency. Field screening of subsurface vapor at MDA G will include measuring the percent carbon dioxide, percent oxygen, static subsurface pressure, and organic vapors. Vapor samples for laboratory analysis will be collected using SUMMA canisters and silica gel columns. SUMMA canister samples will be analyzed for VOC concentrations by the Environmental Protection Agency (EPA) Method TO-15. Silica gel column samples will be analyzed for tritium by EPA Method 906.0.

Monitoring of pore gas at MDA G will be conducted in accordance with the current version of Environmental Programs Directorate Standard Operating Procedure 06.31, Sampling Sub-Atmospheric Air. In accordance with this procedure, field screening will be performed before analytical samples are collected. Each port will be purged and monitored with a Landtec GEM2000 instrument or equivalent, until the percent carbon dioxide and oxygen levels have stabilized at values representative of subsurface pore-gas conditions and are consistent with previously recorded measurements. The vapor will then be screened for VOCs using a B&K multigas analyzer, Type 1302, which measures four VOCs: TCA, TCE, PCE, and Freon-11. The B&K analyzer also measures percent carbon dioxide to 0.01%. Once purge and field screening are completed, vapor samples will be collected using SUMMA canisters and silica gel columns, as prescribed in Section 4.0.

During each sampling event, three types of field quality assurance (QA) samples will be collected and analyzed for VOCs using SUMMA canisters: a field duplicate sample, 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, and a performance evaluation sample/calibration gas sample taken from a tank of a certified gas mixture. Analytical laboratory QA for EPA Method TO-15 includes internal standards, surrogates, replicates, blanks, laboratory control samples, and reference standards. A field duplicate silica gel column QA sample will be collected and analyzed for tritium.

D-4.0 PROPOSED MONITORING DISTRIBUTION AND FREQUENCY

The pore-gas monitoring locations are shown in Figure D-1 and listed in Table D-1. Four boreholes drilled in 2005 and one drilled in 2007 are equipped with sampling ports for pore-gas monitoring. The 12 older monitoring locations and 5 newer investigation locations will allow monitoring within and adjacent to areas of maximum VOC and tritium concentrations at MDA G. Locations 54-27436, 54-24370, and 54 24394 will monitor the areas of maximum VOC levels. Location 54-24386 will be one of the monitoring locations within the eastern portion of MDA G where the maximum levels of tritium and VOCs have been detected. A table of port depths for these boreholes is listed in Table D-1. The remainder of the boreholes listed in Table D-2 will be abandoned to minimize potential contaminant pathways to the subsurface.

Location 54-25105, the open borehole within the Puye Formation, will remain available for packer sampling from the end of the casing at 485 ft to the total depth at 701 ft. Because of the instability and irregular diameter of the open portion of the borehole, installing a membrane or deploying a straddle packer below the casing is not feasible. This location will allow for continued monitoring at depth beneath MDA G.

Every port in the pore-gas monitoring locations listed in Table D-1 will be monitored annually by field measurement of percent carbon dioxide, percent oxygen, and organic vapors using the methods described in Section 3.0. These data will be compared to the historic record to evaluate spatial extent and trends of the dominant VOCs released from MDA G.

Vapor samples will be collected annually using SUMMA canisters for VOCs and silica gel columns for tritium from the port nearest the lowest base elevation of the adjacent disposal unit, and at the total depth of the locations listed in Table D-1 with two exceptions: location 54-25105 will be sampled across the open portion using a single packer, and location 54-22116 will be sampled from the two ports containing the highest level of TCA, as measured by the B&K analyzer. Annual subsurface vapor monitoring will include collection of a minimum of 20 vapor samples from subsurface monitoring locations at MDA G. Additionally two duplicates, two equipment blanks, and one performance evaluation sample will be collected during each event using SUMMA canisters. One duplicate sample will be collected during each event using a silica gel column. During the second year, vapor samples will be collected semiannually.

Annual monitoring will continue until a final remedy for MDA G is selected. Final long-term monitoring requirements will be determined as part of the corrective measures implementation (CMI) process based on the remedy selected. The frequency of annual monitoring is based on the following:

- The concentrations of VOCs and tritium in the deepest samples collected are not high enough to pose an immediate threat of groundwater contamination based on screening evaluations,
- Historical monitoring data have shown little change in plume concentrations over time, and
- Annual monitoring would provide sufficient lead time to implement corrective measures (e.g., SVE) if concentrations in deep samples did increase to levels posing a potential threat to groundwater.

Pore-gas monitoring data will be reported annually until the CMI. Monitoring data will be reported in a periodic monitoring report according to the requirements of the March 1, 2005, Compliance Order on Consent, Section XI.D. This report may include recommendations for future monitoring and remedial actions based on data results and trends.

D-5.0 REFERENCES

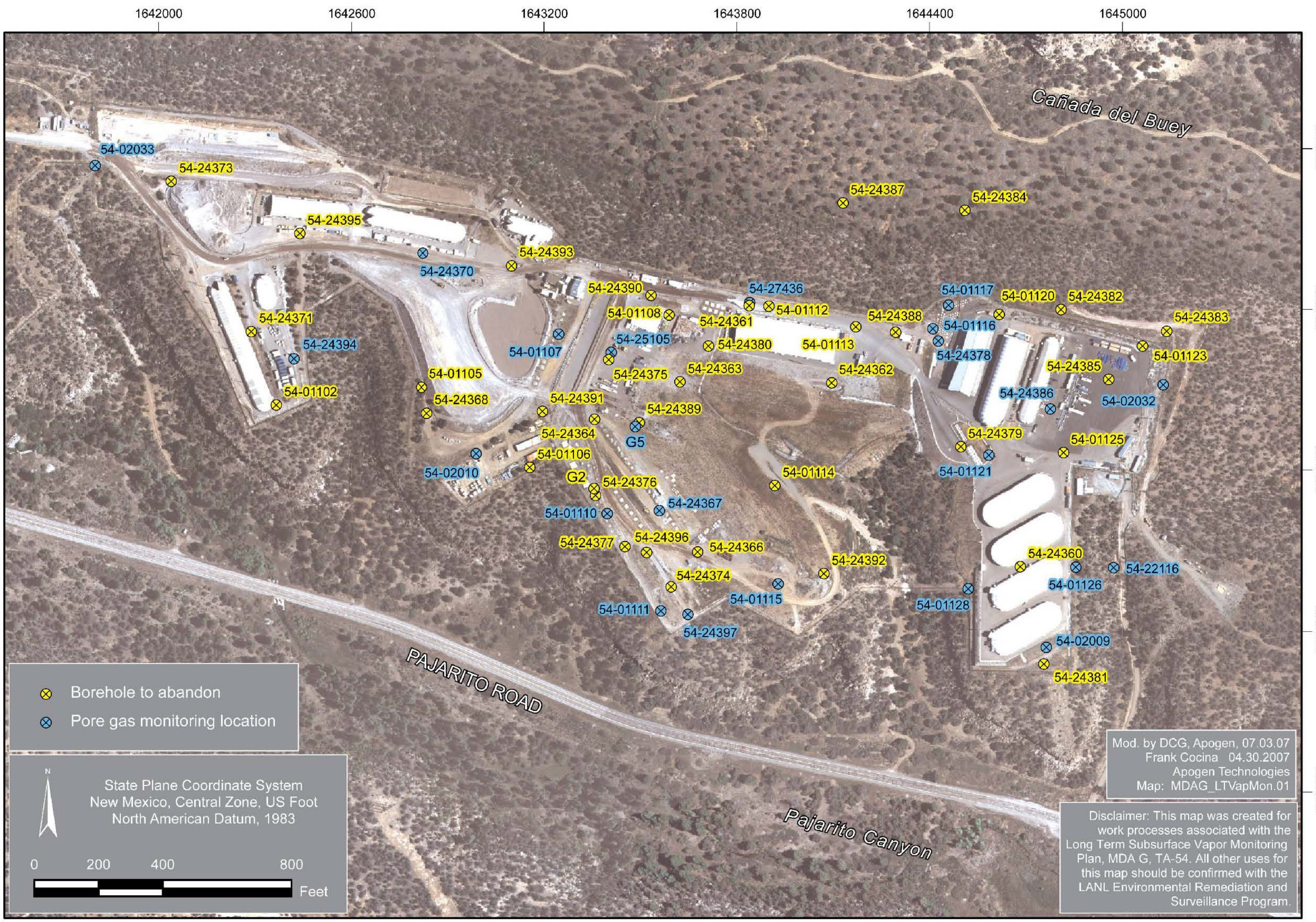
The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the Environmental Programs Directorate's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

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

LANL (Los Alamos National Laboratory), November 2004. "Investigation Work Plan for Material Disposal Area L, Solid Waste Management Unit 54-006 at Technical Area 54, Revision 2," Los Alamos National Laboratory document LA-UR-04-8245, Los Alamos, New Mexico. (LANL 2004, 087624)

LANL (Los Alamos National Laboratory), November 2004. "Quarterly Technical Report, July–September 2004," Los Alamos National Laboratory document LA-UR-04-7387, Los Alamos, New Mexico. (LANL 2004, 089304)

LANL (Los Alamos National Laboratory), July 2006. "Periodic Monitoring Report, Vapor Sampling Activities at Technical Area 54 Material Disposal Area G for First and Second Quarters of Fiscal Year 2006," Los Alamos National Laboratory document LA-UR-06-3708, Los Alamos, New Mexico. (LANL 2006, 093269)



Mod. by DCG, Apogen, 07.03.07
Frank Cocina 04.30.2007
Apogen Technologies
Map: MDAG_LTVapMon.01

Disclaimer: This map was created for work processes associated with the Long Term Subsurface Vapor Monitoring Plan, MDA G, TA-54. All other uses for this map should be confirmed with the LANL Environmental Remediation and Surveillance Program.

Figure D-1 Locations of boreholes for interim pore-gas monitoring

Table D-1
MDA G Pore-Gas Monitoring Locations

Well ID	Depths of Ports (ft)
54-01107	20, 44.5, 56.5, 74, 91, 100
54-01110	20, 48, 60, 70, 85, 90
54-01111	20, 39.5, 50, 70, 78, 100, 139
54-01115	7, 26, 40, 53, 63, 68
54-01116	None, blank FLUTe membrane
54-01117	20, 31.5, 55, 73, 82, 85
54-01121	20, 26, 61.5, 70, 76, 98, 121
54-01126	7, 17, 28, 35, 42, 49
54-01128	7.5, 15, 20, 30, 39
54-02009	37, 62, 79, 92
54-02010	30,53, 95,
54-02032	20, 60, 100, 130, 156
54-02033	20, 60, 100, 200, 220,260, 277
54-22116	28, 46, 64, 82, 100, 118 136, 154, 172, 190, 208, 226, 244, 262, 280
54-24370	40, 72, 120, 174, 200, 243
54-24386	40, 83,117, 135, 195
54-24394	50, 100, 150, 192, 245, 300
54-25397	50, 90, 130, 165, 188, 239
54-25105	Open borehole
54-27436	45, 70, 115, 163, 185
G-5	None, blank FLUTe membrane

Table D-2
MDA G Boreholes
To Be Abandoned

Well ID	
54-01102	54-24375
54-01105	54-24376
54-01106	54-24377
54-01108	54-24379
54-01112	54-24380
54-01113	54-24381
54-01114	54-24382
54-01120	54-24383
54-01123	54-24384
54-01124	54-24385
54-01125	54-24387
54-24360	54-24388
54-24361	54-24389
54-24362	54-24390
54-24363	54-24391
54-24364	54-24392
54-24366	54-24393
54-24368	54-24395
54-24371	54-24396
54-24373	54-24523
54-24374	G2

Appendix E

Conceptual Model of Subsurface Contaminant Migration at Technical Area 54

E-1.0 INTRODUCTION

This document is an overview of the current Los Alamos National Laboratory (LANL or the Laboratory) conceptual model for migration of contaminants in the subsurface at Technical Area (TA) 54. The conceptual model presented here focuses on subsurface contaminant transport in the unsaturated zone beneath TA-54. It is based on data collected and analyzed over more than two decades, combined with the basic tenets of reactive transport through porous rock. However, conceptual models continue to change and evolve as new data become available; therefore, this document concludes with a brief discussion of uncertainty in the various conceptual model components.

E-2.0 MATERIAL DISPOSAL AREAS AT TA-54

Data collected during many investigations at TA-54 have allowed the Laboratory to gain an understanding of the nature and extent of subsurface contamination. Four Material Disposal Areas (MDAs) G, H, J, and L are located at TA-54, and each has a unique history, inventory, and potential impacts on the regional groundwater. The primary chemicals of potential concern (COPCs) that have migrated in the vapor phase in the subsurface at TA-54 are volatile organic compounds (VOCs) and tritium (radioactive hydrogen with a half-life of 12.3 yr) (LANL 2001, 070158; LANL 2005, 090513; LANL 2005, 092591).

MDA G, the largest MDA at TA-54, is located at Area G, a 63-acre site where ongoing low-level waste operations are conducted. MDA G consists of 32 pits, 4 trenches, and 194 shafts that were used to dispose of Laboratory waste from the 1950s to the late 1990s. MDA G was used for disposal of low-level and transuranic (TRU) radioactive waste, certain radioactively contaminated infectious waste, asbestos-contaminated material, and polychlorinated biphenyls, as well as for the temporary placement of TRU waste. Additionally, there are dozens of shafts at the site, some of which received large inventories of tritium. Currently, the only significant subsurface contaminant migration at MDA G has been of vapor-phase VOCs and tritium. Tritium concentrations decrease rapidly with distance from the surface and reach values below screening levels at depths greater than 200 ft (LANL 2005, 090513, pp. 16–23).

MDA H is a 0.3 acre classified waste MDA consisting of nine 60-ft-deep shafts. Some tritium and very low pore-gas concentrations of VOCs have been detected beneath the shafts. The predominant inventory at MDA H is uranium and plutonium in both metallic and oxide forms. The site also contains a limited inventory of the more mobile compounds RDX (research department explosive [also hexahydro-1,3,5-trinitro-1,3,5-triazine]), cyanuric acid, and TNT (2,4,6-trinitrotoluene) (LANL 2005, 089332, pp. 4–9).

MDA L is an approximately 2.5 acre liquid-waste disposal facility that has a large inventory of VOCs buried in a collection of 34 shafts to depths of 60 ft. Additionally, a pit and two impoundments were used to dispose of and treat metal-contaminated waste. VOCs are of greatest concern at MDA L where concentrations and inventory are larger than at the other TA-54 MDAs. VOCs have been detected in pore gas at depths of greater than 300 ft. Tritium has been measured in pore water in the subsurface at MDA L at concentrations below the Environmental Protection Agency (EPA) maximum contaminant level (MCL), equivalent to 20,000 pCi/L in water, while significant detections of metals below the impoundments are limited to a few meters (LANL 2005, 092591, pp. 34, 71).

MDA J was a surface disposal area used for administratively controlled solid wastes and for the storage and disposal of special wastes. MDA J was closed in 2002, and NMED approved the closure/postclosure plan in 2003.

E-3.0 GENERAL CONCEPTUAL MODEL

Data gathered during field investigations, such as rock physical properties, subsurface stratigraphy, and moisture and contaminant distributions, have assisted in creating the current understanding of subsurface transport at TA-54 (Hollis et al. 1997, 063131; Broxton and Vaniman 2005, 090038; Springer 2005, 098534). TA-54 is located on Mesita del Buey, a dry finger-mesa. The hydrologic conditions on the surface and within this dry mesa lead to slow unsaturated water flow and transport (Birdsell et al. 2005, 092048, p. 760). Dry mesas shed precipitation as surface runoff to the surrounding canyons such that most deep infiltration occurs episodically following snowmelt. Much of the water that does enter the soil zone is lost through evapotranspiration (ET). In fact, potential ET was estimated to exceed precipitation at the TA-54 climate station by a ratio of 6:1 (LANL 2005, 089332, p. 10). As a result, annual net infiltration rates at TA-54 are estimated to be on the order of 1 mm/yr or less (Kwicklis et al. 2005, 090069, p. 672). Because the mesa consists of nonwelded to moderately welded tuffs with low water content, unsaturated-zone water flow is matrix-dominated in the tuffs (Soll and Birdsell 1998, 070011, p. 193; Birdsell et al. 2005, 092048, p. 620; LANL 2005, 089332, pp. O-17–O-18). However, flow may be fracture-dominated in the basalt that underlies the tuff (Stauffer and Stone 2005, 090037). Finally, transport of vapor-phase contaminants in the subsurface at TA-54 is dominated by simple diffusion from areas of high concentration to areas of low concentration and includes partitioning of vapor species into pore water (Stauffer et al. 2005, 090537, p. 760).

In terms of subsurface transport rates at TA-54, vapor-phase VOCs migrate the most rapidly. Tritium, moving as water vapor, moves somewhat slower, aqueous-phase nonsorbing contaminants migrate slower still, and aqueous-phase adsorbing contaminants transport the most slowly. Assuming a long-term infiltration rate of 1 mm/yr or less, as would be expected from a properly functioning cover, travel times for aqueous-phase nonsorbing contaminants migrating through dry mesas to the regional aquifer are expected to be on the order of thousands of years (Newman 1996, 059118, p. 1; Newman et al. 1997, 059371, p. 19; Birdsell et al. 1999, 069792, p. 73; Collins et al. 2005, 092028, pp. 2-85–2-94). However, within a dry mesa, the transport of volatile contaminants in the vapor phase is much more rapid than for waterborne contaminants (Stauffer et al. 2005, 090537, p. 760).

E-3.1 Liquid-phase Transport

In addition to the low volume of water that infiltrates into the mesa, stratigraphy is an important control over liquid-phase contaminant transport beneath TA-54. Numerical simulations performed for the MDA G performance assessment and the MDA H corrective measures study (Birdsell et al. 1999, 069792, pp. 41–49; LANL 2005, 089332, Appendix I) show that liquid-phase travel times to the regional aquifer are proportional to the thickness of the Bandelier Tuff beneath a given disposal area. Stratigraphic data show that the Bandelier Tuff is substantially thicker on the western side of MDA G than on the eastern side, and the resultant travel times are approximately 50% greater for the western side (Birdsell et al. 1999, 069792, p. 32; Stauffer et al. 2005, 097432, p. 35). The Bandelier Tuff is thicker at MDAs H and L than at MDA G (Figure 2.7-3).

In addition to data gathered specifically for the TA-54 area, data from other Laboratory facilities are relevant and provide input to guide the conceptual model of unsaturated subsurface contaminant migration at TA-54. Such data include an unsaturated-zone water injection test and subsequent modeling that showed limited fracture flow with the majority of flow occurring in the matrix of the porous rocks of the Bandelier Tuff (Purtymun et al. 1989, 006889; Robinson et al. 2005, 091682). Other studies support the conclusion that in the absence of anthropogenic ponding on the mesas, the long-term rates of infiltration are quite low and preclude first arrival of waterborne contaminants to the regional aquifer to less than

100 yr and peak arrival in several hundred to thousands of years (Birdsell et al. 2005, 092048, p. 620; Birdsell et al. 1999, 069792, pp. 70–72; Newman 1996, 059118, p. 1).

The Cerros del Rio basalt, which lies beneath the Bandelier Tuff layers, also exerts strong controls over travel times and direction for liquid transport. Data from a tracer test through the Cerros del Rio basalt beneath the low-head weir site in Los Alamos Canyon indicate that high rates of gravity-driven flow and liquid-phase transport can occur through the basalt in low porosity fracture networks under wet (ponded) conditions (Stauffer and Stone 2005, 090037, p. 727). The model of rapid fracture flow of liquid in the Cerros del Rio basalt has been used as a conservative assumption for transport predictions at TA-54. Areas with a relatively thicker sequence of basalt and a relatively thinner sequence of overlying Bandelier Tuff are expected to have more rapid liquid-phase travel times beneath the MDAs. However, ponding on top of the basalts is not expected to occur beneath the dry mesa at TA-54, and data collected from depth beneath Mesita del Buey to date support this assumption. The Guaje Pumice Bed, which is often present atop the Cerros del Rio basalt at TA-54, has higher (but not saturated) moisture contents than overlying tuff units because its pore structure causes high suction (i.e., the pores tend to trap water). No perched intermediate groundwater was found directly beneath MDA G to 700 ft, beneath MDA L to 660 ft, or in R-22 to 883 ft (Ball et al. 2002, 071471, p. ix). Also, no seeps or springs are known to occur along the mesa sides. Therefore, although unsaturated flow in the basalts may occur through fractures, flow is not expected to be saturated, and total mass flux of contaminants will be controlled by the limited amount of water that percolates through the mesa.

Data and analyses from wet canyons such as Los Alamos and Mortandad Canyons show that perched alluvial aquifers in the bottom of wet canyons lead to more rapid vertical transport toward the regional aquifer than from mesa sites (Birdsell et al. 2005, 092048, p. 62). Recent borehole data show that the Cerros del Rio basalt has a strong southward dip of between 4 and 5 degrees beneath MDA G, while at MDA L and MDA H the dip is much gentler towards the west. This geologic unit may play a role in contaminant transport because it potentially causes water to flow laterally rather than vertically downward. However, flow rates along this dipping surface are likely to be quite low at the measured in-situ saturation because of the unsaturated permeability relationships that describe the rate at which water can move through partially saturated rock.

E-3.2 Vapor-phase Transport

Vapor-phase transport accounts for the observed migration to depth of VOCs and tritium in pore gas within the Bandelier Tuff. Extensive analyses of the VOC contamination in pore gas beneath MDA L have shown that vapor-phase transport accounts for the migration of VOCs, for which vapor-phase concentrations are in equilibrium with water concentrations as determined by Henry’s Law partitioning. Vapor migration of VOCs in the subsurface can be fully described by diffusive behavior that is unaffected by preferential air flow or barometric pumping within the mesa (Stauffer et al. 2005, 090537, p. 760). Diffusion theoretically spreads contamination in a spherical direction along concentration gradients. However, topography plays an important role in vapor transport at TA-54. With low vapor concentrations occurring at the top and sides of the mesas, the steepest concentration gradients are toward the surface. These steep gradients preferentially lead to vapor transport toward these external boundaries rather than downward toward the regional aquifer.

Stratigraphy is a less important control for vapor-phase transport than for liquid-phase transport because of the tendency for the plume to spread in all directions rather than being gravity driven. Rapid transport by advective vapor flow is not a likely transport mechanism within the fractured Cerros del Rio basalt because vapor-phase densities are low enough that gravity-driven downward flow in fractures should not occur. Additionally, if vapor-phase transport of VOCs were to reach the regional aquifer by diffusing through the fractured Cerros del Rio basalt, the Henry's Law partitioning would result in extremely low groundwater concentrations based on current observed vapor concentrations (LANL 2005, 092591, pp. 23-25; LANL 2007, 096409, p. v). In the event that VOC transport causes low concentrations to reach the regional aquifer, the area of migration would be centered directly below a given site rather than stratigraphically controlled.

Tritium is transported in the subsurface at TA-54 through a multiphase coupled process. Primarily, it is transported by the diffusion of water vapor. However, as tritiated water vapor diffuses away from a source area, it readily equilibrates with tritium-free pore water. The relatively rapid process of vapor-phase diffusion (in the case of tritium, the vapor is water vapor) is effectively slowed down by the presence of pore water, which acts as a reservoir for tritium activity that partitions from the vapor. This interaction with pore water results in a lower effective water-vapor diffusion coefficient than would be observed if no liquid pore water were present. This conceptual model is based on observations of tritium in the subsurface at both MDA G and TA-53 (Vold and Eklund 1996, 070156, p. 1; Stauffer 2003, 080930, p. 1). Data and modeling results indicate that the effective vapor-phase diffusion coefficient for tritium is 25 times lower than for the more volatile vapor-phase VOCs at TA-54, primarily because those VOCs do not partition as readily into pore water. Diffusion of tritium toward the surface occurs because concentration gradients toward the surface are steep, leading to some surface flux of tritium to the atmosphere in water vapor. Diffusion of significant amounts of tritium toward the regional aquifer is unlikely unless the source concentration is large. In addition, radioactive decay of tritium (half-life of 12.3 yr) decreases tritium mass as it migrates through the unsaturated zone. If some tritium reaches the water table by water-vapor diffusion, it should be centered directly below the disposal site because this is the shortest diffusive pathway, and the tritium would then significantly partition into the groundwater. Modeling done in support of the MDA H corrective measures study report, showed that even with highly conservative assumptions, tritium poses no risk to groundwater at MDA H (LANL 2005, 089332, Appendix I).

It is possible that a vapor plume of either VOC or tritium could reach the Guaje Pumice Bed, which is generally present atop the Cerros del Rio basalt at TA-54. Because this unit has higher moisture contents than overlying tuff units, vapor diffusion may be slower thought the pumice. VOC or tritium vapors that reach the Guaje Pumice Bed will partition into the pore water. If lateral flow occurs in the Guaje Pumice Bed atop a dipping basalt unit, this flow could reach Pajarito Canyon where enhanced liquid-phase flow might occur. However, as noted above, flow rates along this dipping surface are likely to be quite low because of unsaturated permeability relationships.

E-4.0 MODELING THEORY

The components supporting the conceptual model of contaminant transport at TA-54 are the principles of chemistry and physics that underlie the theory of contaminant transport through porous media. Numerical models and analysis used at the Laboratory are based on widely accepted equations that describe the movement of chemicals in the subsurface (Zyvoloski et al. 1997, 070147). These models include transport of chemical constituents dissolved in water and chemical constituents that move predominantly in the vapor phase. The models also can replicate transformation of chemicals because of reactions while in the subsurface. Extensive quality assurance and model validation ensure that the numerical simulations replicate both analytical solutions and more complicated controlled laboratory experimental results. Combining this information with knowledge of the nature and extent of contaminant migration and an understanding of the processes that affect flow and transport allows formulation of conceptual models for contaminant transport toward the regional aquifer for each of the relevant MDAs at TA-54.

E-5.0 CONCEPTUAL MODELS OF SUBSURFACE CONTAMINANT TRANSPORT AT MDAs H, L, AND G

E-5.1 MDA H

Based on the data and analysis described above, MDA H poses the lowest potential to impact regional groundwater at TA-54. The site has the thickest section of Bandelier Tuff, and subsequently travel times for liquid transport to the regional aquifer should be the longest for a given infiltration rate. The site also has relatively little surface disturbance, with the shafts being much smaller than the pits at MDA G. Thus, the potential for ponding in subsidence craters and/or moisture introduced while the shafts were open to the environment is limited. Furthermore, there was no liquid waste input to the shafts. With little potential for water to infiltrate the waste, the rate at which the chemical inventory can migrate will be limited. The inventory at MDA H is primarily composed of metallic uranium and its oxides, which move more slowly than pore water because they preferentially adsorb to solid surfaces. Liquid-phase modeling performed for the MDA H corrective measures study (LANL 2005, 089332, pp. J-9–J-12) predicts that the nonadsorbing or very weakly adsorbing species RDX, cyanuric acid, and TNT could be carried with infiltrating water to the regional aquifer over 1000 yr. However, contaminant concentrations of these species are predicted not to reach levels exceeding risk thresholds, even under the assumption that these species are released continuously at their solubility limit.

In the absence of significant liquid-phase transport, the two remaining COPC types, tritium and VOCs, may continue to move by vapor diffusion. Because of the very low concentrations of VOCs, the expected rate of movement is quite low, as diffusion is driven by concentration gradients. Additionally, if very low concentrations of VOCs were to reach the regional aquifer in the vapor phase, the Henry's Law partitioning would result in extremely low groundwater concentrations. Tritium diffusion is limited by the rate at which the water vapor can diffuse relative to the decay of the tritium. Because of the short half-life, diffusion of significant amounts of tritium to the regional aquifer is unlikely. However, if some tritium does reach the aquifer, it should be centered directly below the site, as this is the shortest diffusive pathway.

At MDA H, the most accurate model of the basalt surface shows a gentle dip to the west, implying that first arrival of waterborne contaminants would be to the west of the site. Therefore, a groundwater well placed east of the site would be likely to intercept any COPCs that enter the regional aquifer by liquid transport because the water table gradient flows from west to east in this area.

E-5.2 MDA L

The primary COPCs at MDA L are tritium and VOCs. The subsurface moisture profile at this site does not show signs of increased infiltration of water compared to less disturbed areas, and the Bandelier Tuff is quite thick across the site; thus, unsaturated-zone travel times for liquid-borne species should be long, on the order of hundreds to thousands of years. Additionally, the proposed cover and maintenance should ensure limited infiltration for the next 100 yr. The tritium plume in the unsaturated zone is similar in nature to that found at MDA H, and the same transport mechanisms described above apply to tritium transport at MDA L. The migration of tritium toward the regional aquifer is expected to be slow relative to the decay rate of tritium such that impacts at the regional aquifer will be well below the EPA MCL of 20,000 pCi/L. If tritium reaches the regional aquifer at low concentrations, the footprint of impact should lie centered directly beneath the source region, as this is the shortest pathway for diffusion. If high tritium concentrations reach the higher percent saturations in either in the Otowi Member or the Guaje Pumice Bed at the base of the Bandelier Tuff section and fractionate into the liquid water, the tritium could migrate with the liquid phase following faster flow paths in the fractures of the basalt. Such a pathway may explain the measured tritium at MDA L in the basalt at depths of 550–608 ft. in boreholes 15-2 and 15-3 (LANL 2005, 092591, p. 87).

VOCs at MDA L are of more concern than at either MDA G or MDA H because of the larger inventory and historic liquid disposal practices. An unknown mass of VOCs is currently thought to be slowly leaking from aging containers disposed of at MDA L, resulting in a VOC plume that behaves diffusively and can be simulated by numerical modeling (Stauffer et al. 2005, 090537, p. 760). The plume, by volume, is primarily composed of 1,1,1-trichloroethane (TCA) 70%, trichloroethylene (TCE) 12%, and 1,1,2-trichlorotrifluoroethane (Freon-113) 11%. Simulations of catastrophic drum failure suggest that VOCs could reach the regional aquifer in less than 100 yr, albeit at low concentrations due to the diffusive dilution of the plume as it migrates through the large volume of the subsurface (Stauffer et al. 2007, 097871, pp. 13–15). The diffusive footprint at the water table from such an event is predicted to be centered on the source regions at the surface, as described above. The primary mechanism for vapor transport through the basalt is likely to be vapor diffusion in the very small volume fraction of the basalt that makes up the fracture network. Diffusion within fractures with open apertures could approach the free air diffusion rate. However, the total mass flux to depth would remain low because mass flux is directly proportional to the volume fraction in which the diffusion occurs. Additionally, diffusion is not preferentially downward and would tend to spread the vapor constituents laterally as well as vertically, including upwards to the surface. VOCs transported by vapor diffusion at concentrations at or less than 10 parts per million by volume (in the vapor phase) would result in very low water concentrations at the top of the regional aquifer because VOCs preferentially fractionate into the vapor phase. Because of the expected low concentrations and dilution in the regional aquifer, a detection monitoring well at the water table would be most effective if placed close to the eastern boundary of MDA L.

E-5.3 MDA G

MDA G has the largest inventory of the MDAs at TA-54 containing many of the radionuclides associated with nuclear weapons production, including several nonsorbing species such as technetium-99 and carbon-14. However, the only COPCs that have migrated a significant distance are VOCs and tritium, both of which travel in the vapor phase because liquid-phase migration is expected to be quite slow at MDA G and will limit the ability of the majority of inventory constituents to migrate.

The VOC inventory at MDA G is much lower than at MDA L, and the maximum VOC concentrations in the subsurface are also approximately an order of magnitude lower than at MDA L (LANL 2005, 090513). Transport of VOCs at MDA G should be quite similar to that at MDA L; however, the Bandelier Tuff is much thinner at MDA G. With a shorter section of tuff to diffuse through, the VOCs could potentially reach the regional aquifer more quickly than simulations at MDA L predict, although concentrations would be lower because of the lower source strength. The regional aquifer would potentially be affected along the shortest diffusive pathway beneath MDA G. Concentrations measured in the regional aquifer would be expected to be low because they would be controlled by fractionation from the vapor phase into liquid water at the top of the water table.

Tritium at MDA G is also a COPC because of the large waste inventory (>2 million Curies) at this site. The vapor-phase transport mechanisms are expected to be the same as those discussed for MDAs H and L, but because of the thinner Bandelier Tuff and thicker section of basalt, travel time to depth could be shorter at MDA G. The thinner tuff layer at MDA G allows tritium vapor to diffuse to the bottom of the tuff more quickly than at MDA H.

Although there is some potential for migration, there also is potential significant dilution of VOCs and tritium if they migrate to the aquifer because of groundwater underflow beneath MDA G, based on analysis of transport of water in equilibrium with VOC vapors from the top of the basalt into the regional aquifer (Appendix F). In the analytical calculation presented in Appendix F, the ratio of the highest measured pore-gas concentrations of VOCs and tritium at the top of the Cerros del Rio basalt and the groundwater screening criteria were used to calculate dilution ratios necessary to achieve compliance with groundwater screening criteria. These values were compared to dilution ratios obtained from dividing the volume flux of infiltration through the disposal area cover by the volume flux of horizontal groundwater underflow beneath the site. If the groundwater dilution ratios are greater than the concentration ratios required to meet screening criteria, concentrations in groundwater will be below the screening criteria. The results indicate that the groundwater screening criteria in the regional aquifer will not be exceeded for all VOCs and tritium with proposed corrective measure covers that limit infiltration to fluxes of 1 mm/yr. Dilution ratios are 10 to 100 times those needed to meet screening criteria for aquifer conductivities ranging from 1E-3 and 1E-2 cm/s, respectively. Maintenance of the cover will ensure that the cover flux is never greater than 1 mm/yr for the performance period.

E-6.0 UNCERTAINTY IN THE CONCEPTUAL MODEL

Uncertainties associated with the conceptual model include modeling parameters, the paleotopography of the top of the basalt, and the lack of field vapor-phase tracer tests.

The VOC modeling for MDA L discussed above used a porosity of 0.1 and an effective diffusion coefficient of 3.0E-06 m^2/s for the basalt. Evidence exists for a distant connection to the atmosphere (White Rock Canyon) in the high permeability basalt, which may increase the effective diffusion coefficient. Also, the effective porosity in the basalt may be lower than that used in the simulations. The net effect of these two uncertain processes would be to increase the speed at which VOCs reach the regional aquifer by vapor diffusion. However, the lower porosity would reduce the mass flow rate (i.e., kg/yr) of VOCs that could reach the regional aquifer.

Vapor transport in the basalt is not well constrained by current measurements, leading to uncertainty in this conceptual model. This uncertainty could be partially alleviated by performing a vapor phase tracer test using a diffusive species between two existing wells, such as 54-1015 and 54-1016. A single well could also be used with one vapor port as the source and ports above and below serving as monitoring points for tracer breakthrough. Reduction of uncertainty in the conceptual model for vapor-phase transport in the basalt would help to constrain estimates of travel time and mass flux of both VOC and tritium to the regional aquifer.

Another major source of uncertainty in the conceptual model for TA-54 is the understanding of the paleotopography of the top of the basalt. The geometry at the top of the basalt may control lateral diversion of chemical constituents by unsaturated flow. Lateral diversion could in turn lead to waste arriving at the regional aquifer in a location that is not well predicted. Five recent boreholes have altered the understanding of the geometry of this surface and changed the direction of predicted dip from nearly due west at MDA G to due south. This change in understanding has been incorporated into the selection of locations for perched intermediate monitoring wells PCI-1 and PCI-2 near MDA G (LANL 2007, 098548).

Uncertainties will also be addressed by unsaturated zone monitoring of waste disposal areas. In addition the “Technical Area 54 Well Evaluation and Network Recommendations, Revision 1” report was submitted to NMED on October 5, 2007 (LANL 2007, 098548). That document recommends adding five additional regional monitoring wells and two additional intermediate-zone monitoring wells (in Pajarito Canyon) for monitoringTA-54, including MDAs G, L, and H. These additional monitoring wells will bolster the Laboratory’s ability to detect any contaminants that might migrate from MDA G.

E-7.0 REFERENCES

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

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Appendix F

Calculated Dilution Ratios in Groundwater Beneath MDA G

F-1.0 QUALITY CONTROL FORM

Project: MDA G CME Plan NOD and Response to Comments	**Calculation No. 1**	**Sheet 1 of 1**
Calculation Title: Calculation of Volatile Organic Compounds and Tritium Concentrations in Groundwater Resulting from Potential Migration from Material Disposal Area G	Discipline: Hydrology	
Computer Program No.: Excel Spread Sheet	Version/Release No.: Not applicable	

Purpose and Objective:

To calculate VOC concentrations in groundwater at a point of compliance downgradient from the MDA G Disposal Area at TA-54 in Los Alamos, New Mexico. Highest measured pore gas VOC and tritium concentrations at the top of the Cerro del Rio basalt (Tb 4) and the groundwater screening criteria will be used to calculate dilution ratios necessary to achieve compliance with groundwater cleanup levels. A range of infiltration rates from 1 mm/yr to 10 mm/yr through the MDA G ET Cover will be used to calculate vertical volume fluxes for the 63 acres of MDA G disposal area that will reach the water table. This will be used to calculate a groundwater dilution ratio when divided by the volume flux of horizontal groundwater underflow through a cross sectional area of the MDA G site perpendicular to groundwater flow assuming a mixing zone of 25 ft below the water table. Groundwater dilution ratios will be calculated for a range of hydraulic conductivities and compared to screening concentration dilution ratios to determine compliance with screening criteria.

Results:

Groundwater cleanup levels will not be exceeded for all VOCs and tritium with cover fluxes of 1 mm/year. Dilution ratios are 10 to 100 times those needed to meet screening criteria for aquifer conductivities ranging from 1E-3 and 1E-2 cm/sec, respectively. Screening criteria for VOCs and tritium in the regional aquifer will not be exceeded for improbable 10 mm/year cover fluxes if subsurface hydraulic conductivity ranges between 1E-2 and 1 E-3 cm/sec. Maintenance of the cover will assure that the cover flux is never greater than 1 mm/yr for the performance period (Tables F-1.0-1, F-1.0-2, and F-1.0-3).

Revision(s)

Rev. No.	Revision Description

Approval(s)

Rev. No.	Originator (Print) Sign/Date	Checking Method	Checker (Print) Sign/Date	Approval (Print) Sign/Date
1	Kent Bostick 9/2707		Rebecca Hollis 9/28/07	Phil Stauffer 10/02/07

Form C6-13-B, Rev. 1, 03/31/03

F-2.0 ASSUMPTIONS

Area of disposal area cover is 63 acres.

Horizontal groundwater mixing zone is the square root of the cover area by 25 ft deep.

Hydraulic gradient is 1/100 ft (Stone et al. 1999, 064039; Keating et al. 2001, 095399)

Horizontal hydraulic conductivity of basalt ranges are from 1E-2 to 1E-4 cm/s (Stauffer et al. 2007, 097871).

Vertical cover fluxes range from 1 mm/yr (most probable) to 10 mm/yr (least probable).

VOC concentrations expressed in $\mu g/m^3$ were converted from groundwater cleanup levels in water using Henry's Law (LANL 2007, 096110).

Concentrations at the top of the Cerro del Rio basalt conservatively represent future concentrations entering the water table. This is reasonable because vapor-phase transport has occurred for more than 40 yr, and there is no longer any measured free-phase liquid VOCs in the subsurface soil to create a continuing source.

The highest concentrations of VOCs and tritium are evenly distributed over the area of the cover projected down to the water table (highly conservative).

Upgradient sources of contamination are negligible.

F-3.0 REFERENCES

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

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Table F-1.0-1
Calculated Dilution Ratios in Groundwater Beneath MDA G

Description	1-1 DCA	PCE	TCA	TCE	Tritium (pCi/L)
VOC screening level as µg/m^3	5750	3770	42300	2100	20000
Highest concentration at top of Tb 4 µg/m^3	17000	3400	240000	21000	102800
Concentration dilution ratio at water table needed to meet groundwater cleanup levels	0.34	1.11	0.18	0.10	0.19

Source: LANL 2007, 096110.

Table F-1.0-2
Calculated Dilution Ratio of Vertical Flux Through Cover and Groundwater Underflow

Description	RCRA Equivalent Cover Flux			Extreme Infiltration Conditions Cover Flux		
Vertical flux through MDA-G Cover (mm/yr)	1.0E+00	1.0E+00	1.0E+00	1.0E+01	1.0E+01	1.0E+01
Vertical volume flux over 6.3E+01 acres (mm^3/yr)	2.55E+11	2.55E+11	2.55E+11	2.55E+12	2.55E+12	2.55E+12
Hydraulic conductivity (cm/sec) (K)	1.00E-04	1.00E-03	1.00E-02	1.00E-04	1.00E-03	1.00E-02
Underflow area (1.66E+03 ft x 2.5E+01 ft) (A)	4.14E+04	4.14E+04	4.14E+04	4.14E+04	4.14E+04	4.14E+04
Hydraulic gradient 1/100 (ratio) (I)	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02
Groundwater volume flux underflow (mm^3/yr) (Q=KIA)	1.21E+12	1.21E+13	1.21E+14	1.21E+12	1.21E+13	1.21E+14
Dilution Ratio	2.10E-01[a]	2.10E-02[b]	2.10E-03[b]	2.10E+00[c]	2.10E-01[a]	2.10E-02[b]

Sources: Stauffer 2007, 097871; Stone et al. 1999, 064039

[a] VOCs/tritium approach/exceed screening criteria at water table.

[b] VOCs/tritium are 10 to 100 times less than the screening criteria at water table.

[c] VOCs/tritium exceed screening criteria at water table.

Table F-1.0-3
Conversions for Calculations

Original Value	Converted Value
6.3E+01 acres (Cover Area)	2.55E+11 mm^2
1.00E-04 cm/sec (K)	3.15E+04 mm/yr
1.00E-03 cm/sec (K)	3.15E+05 mm/yr
1.00E-02 cm/sec (K)	3.15E+06 mm/yr
4.14E+04 ft^2 (A)	3.85E+09 mm^2
6.3E+01 acres (Cover Area)	2.74E+06 ft^2 (square root: 1.65E+03 ft)