EMID-701735

DEPARTMENT OF ENERGY
Environmental Management Los Alamos Field Office (EM-LA)
Los Alamos, New Mexico 87544

EMLA-2021-BF156-02-001

October 28, 2021

Mr. Ricardo Maestas
Acting Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6313

Subject: Submittal of the Addendum to the Investigation Report for Chaquehui Canyon Aggregate Area for Material Disposal Area K, at Technical Area 33

Dear Mr. Maestas:

Enclosed please find two hard copies with electronic files of the "Addendum to the Investigation Report for Chaquehui Canyon Aggregate Area for Material Disposal Area K, at Technical Area 33." The "Investigation Report for Chaquehui Canyon Aggregate Area" evaluated the nature and extent of contamination and potential human health and ecological risks for Solid Waste Management Units (SWMUs) 33-002(a), 33-002(b), 33-002(c), 33-002(d), 33-002(e), and 33-010(f) associated with Material Disposal Area (MDA) K located in Technical Area 33 at Los Alamos National Laboratory. This addendum to the 2020 investigation report evaluates the nature and extent of the vapor-phase contamination at MDA K.

Characterization data presented in this addendum consist of results from three boreholes drilled in 2020–2021. Nature and extent of contamination were evaluated for tritium detected in tuff samples and for volatile organic compounds and tritium detected in pore-gas samples at MDA K.

Based on the results of data evaluations presented herein, the U.S. Department of Energy Environmental Management Los Alamos Field Office (EM-LA) and Newport News Nuclear BWXT-Los Alamos, LLC (N3B) recommend drilling three additional boreholes and installing dedicated pore-gas monitoring systems to extend the investigation area and to further define the nature and extent of contamination at MDA K. The locations, number of samples, and analytical suites will be included in a Phase III work plan for the Chaquehui Canyon Aggregate Area.

A pre-submission meeting between the New Mexico Environment Department (NMED), EM-LA, and N3B was held on September 23, 2021, to present a summary of the information provided in this addendum.

If you have any questions, please contact Brenda Bowlby at (360) 930-4353 (brenda.bowlby@em-la.doe.gov) or Cheryl Rodriguez at (505) 414-0450 (cheryl.rodriguez@em.doe.gov).

Sincerely,

ARTURO DURAN

Digitally signed by ARTURO DURAN
Date: 2021.10.15 10:58:51 -06'00'

Arturo Q. Duran
Compliance and Permitting Manager
Environmental Management
Los Alamos Field Office

Enclosure(s):

1. Two hard copies with electronic files:
   Addendum to the Investigation Report for Chaquehui Canyon Aggregate Area for Material Disposal Area K, at Technical Area 33 (EM2021-0464)

cc (letter with hard-copy enclosure[s]):
Brenda Bowlby, N3B
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October 2021
EM2021-0464

Addendum to the Investigation Report for Chaquehui Canyon Aggregate Area for Material Disposal Area K, at Technical Area 33

Addendum to the Investigation Report for Chaquehui Canyon Aggregate Area for Material Disposal Area K, at Technical Area 33

October 2021

Responsible program director:

Michael O. Erickson		Program Director	RCRA Remediation Program	10/5/2021
Printed Name	Signature	Title	Organization	Date

Responsible N3B representative:

Troy Thomson		Acting Program Manager	N3B Environmental Remediation Program	10/5/2021
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Responsible DOE EM-LA representative:

Arturo Q. Duran	ARTURO DURAN Digitally signed by ARTURO DURAN Date: 2021.10.15 11:09:05 -06'00'	Compliance and Permitting Manager	Office of Quality and Regulatory Compliance	
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EXECUTIVE SUMMARY

The 2020 “Investigation Report for Chaquehui Canyon Aggregate Area” evaluated the nature and extent of contamination and potential human health and ecological risks for Solid Waste Management Units (SWMUs) 33-002(a), 33-002(b), 33-002(c), 33-002(d), 33-002(e), and 33-010(f) associated with Material Disposal Area (MDA) K located in Technical Area 33 at Los Alamos National Laboratory located in Technical Area 33. This addendum to the 2020 investigation report evaluates the nature and extent of vapor-phase contamination at MDA K.

The approved “Investigation Work Plan for Chaquehui Canyon Aggregate Area, Revision 1” proposed drilling seven boreholes and collecting soil, tuff, and vapor samples from each borehole and analyzing for tritium in pore gas. Characterization data for the vapor contamination associated with MDA K consist of results from three boreholes drilled in 2020–2021. Nature and extent of contamination were evaluated for tritium detected in tuff samples and for volatile organic compounds (VOCs) and tritium detected in pore-gas samples at MDA K.

Based on the results of data evaluations presented in this addendum, the U.S. Department of Energy Environmental Management Los Alamos Field Office and Newport News Nuclear BWXT-Los Alamos, LLC, recommend drilling three additional boreholes and installing dedicated pore-gas monitoring systems to define the nature and extent of contamination at MDA K. One new borehole is proposed to be located near the outfall of SWMU 33-002(d), a second borehole located just south of the seepage pit for SWMU 33-002(b), and a third borehole located to the southeast of MDA K. A vapor-monitoring system is proposed to be installed in each borehole, and one round of pore-gas sampling collected and submitted for VOCs and tritium analysis. The locations, number of samples, and analytical suites will be included in a Phase III investigation work plan for Chaquehui Canyon Aggregate Area.

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1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE). The Laboratory is located in north-central New Mexico, approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers approximately 36 mi^2 of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons that contain perennial and intermittent streams running from west to east. Mesa tops range in elevation from approximately 6200 ft to 7800 ft above mean sea level.

The DOE Environmental Management Los Alamos Field Office's (EM-LA's) mission is to safely, efficiently, and transparently complete the cleanup of legacy contamination and waste resulting from nuclear weapons development and government-sponsored nuclear research before 1999 at the Laboratory. EM-LA's cleanup scope under the 2016 Compliance Order on Consent (Consent Order) with the New Mexico Environment Department (NMED) includes waste, soil, and groundwater remediation. The cleanup sites are designated as either solid waste management units (SWMUs) or areas of concern (AOCs). EM-LA's cleanup contractor, Newport News Nuclear BWXT-Los Alamos, LLC (N3B), implements the Los Alamos Legacy Cleanup Contract.

This investigation report addendum addresses potentially contaminated sites within the Chaquehui Canyon Aggregate Area at the Laboratory, associated with Material Disposal Area (MDA) K. These sites are potentially contaminated with hazardous chemicals and radionuclides. Corrective actions at the Laboratory are subject to the Consent Order. The Consent Order was issued pursuant to the New Mexico Hazardous Waste Act, New Mexico Statutes Annotated (NMSA) 1978 Section 74-4-10, and the New Mexico Solid Waste Act, NMSA 1978, Section 74 9 36(D). NMED, pursuant to the New Mexico Hazardous Waste Act, regulates cleanup of hazardous wastes and hazardous constituents. DOE regulates cleanup of radioactive contamination, pursuant to DOE Order 458.1, Administrative Change 4, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management." Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to NMED in accordance with DOE policy.

1.1 General Site Information

The Chaquehui Canyon Aggregate Area is located in Technical Area 33 (TA-33) at the Laboratory (Figure 1.1-1) and consists of 51 SWMUs and AOCs, 7 of which were investigated and/or remediated by the Laboratory and were approved for no further action (NFA) before the effective date of the March 2005 Consent Order and 1 of which was remediated and received a certificate of completion under the 2005 Consent Order (NMED 2006, 093526). The remaining 43 SWMUs and AOCs underwent sampling activities in 2019–2020 and Phase II investigation sampling activities in 2020–2021. Details of previous Phase I investigation, including the results of the 2019–2020 sampling activities, are provided in the 2020 investigation report for Chaquehui Canyon Aggregate Area (N3B 2020, 701046). Six sites associated with MDA K are addressed in this addendum. These sites include SWMUs 33-002(a), 33-002(b), 33-002(c), 33-002(d), 33-002(e), and 33-010(f). Table 1.1-1 lists the 6 sites, with a brief description, summary of previous investigations, and the current status for each site.

1.2 Purpose of the Investigation Report Addendum

The approved investigation work plan for Chaquehui Canyon Aggregate Area (LANL 2010, 111298.9; NMED 2011, 201242) proposed drilling seven boreholes and collecting soil, tuff, and vapor samples from each borehole and analyzing for tritium in core and pore gas. Drilling these seven boreholes was delayed during the 2019–2020 investigation. The investigation report stated that a phased approach would be implemented to determine the presence and concentrations of tritium and to define the lateral and vertical extent of a subsurface tritium contamination at MDA K. This addendum addresses the drilling of three boreholes (locations 33-60938, 33-60939, and 33-60940), collection of tuff samples at the base of each geologic unit, installation of a dedicated vapor-monitoring system, and collection of one round of vapor samples.

All analytical data collected from the 2020–2021 MDA K investigation are presented and evaluated in this addendum. All analytical data collected previously for SWMUs 33-002(a), 33-002(b), 33-002(c), 33-002(d), 33-002(e), and 33-010(f) are reported and evaluated in the Phase I investigation report (N3B 2020, 701046).

1.3 Document Organization

This report is organized in 7 sections, including this introduction, with multiple supporting appendices. Section 2 provides details on the aggregate area site conditions (surface and subsurface). Section 3 provides an overview of the scope of activities performed at the site. Section 4 describes the regulatory criteria used to evaluate potential risk/dose to ecological and human health receptors. Section 5 provides an overview of the operational history of the site, historical releases, summaries of previous investigations, results of the field activities performed during the 2020–2021 investigation, site contamination, and evaluation of the nature and extent of contamination. Section 6 presents the conclusions of the nature and extent of contamination investigation and discusses recommendations. Section 7 includes a list of references cited and the map data sources used in all the figures.

The appendices include acronyms, a metric conversion table, and definitions of data qualifiers used in this report (Appendix A); field methods (Appendix B); analytical suites and results, including sample collection logs (Appendix C [on CD included with this document]); and borehole logs (Appendix D).

2.0 SITE CONDITIONS

2.1 Surface Conditions

2.1.1 Soil

Soil on the Pajarito Plateau was initially mapped and described by Nyhan et al. (1978, 005702). The soil on the slopes between the mesa tops and canyon floors was mapped as mostly steep rock outcrops consisting of approximately 90% bedrock with patches of shallow, weakly developed colluvial soil. South-facing canyon walls generally are steep and usually have shallow soil in limited, isolated patches between rock outcrops. In contrast, the north-facing canyon walls generally have more extensive areas of shallow dark-colored soil under thicker forest vegetation. The canyon floors generally contain poorly developed, deep, well-drained soil on floodplain terraces or small alluvial fans (Nyhan et al. 1978, 005702).

Soil at TA-33 Main Site and the surrounding mesa top is classified as Hackroy Rock Complex (Nyhan et al. 1978, 005702). Field logs from sampling conducted at MDA K indicate that soil ranges in depth from 0 to 8 ft (LANL 1997, 071478, p. 9). Soil may be sandy and contain pumice pebbles ranging up to 0.5 in. in size. Clay lenses may be intermixed with pulverized tuff. Soil in the drainages is sandy, with some clay and many small pebbles. Bedrock is exposed at many areas on the lower (eastern) part of the site, including the drainage east of the septic system [SMWU 33-004(a)].

Soil at TA-33 South Site is classified as Hackroy Rock Complex (Nyhan et al. 1978, 005702). Parent Hackroy soil is shallow, well-drained soil that forms on mesa tops from weathered tuff. The surface layer is a brown, sandy loam approximately 4 in. thick. Hackroy subsoil is a reddish-brown clay mixed with gravel or loam approximately 8 in. deep. The Hackroy Rock outcrop complex contains 20% Hackroy soil, 10% Nyjack soil, and 70% rock outcrop. Nyjack soil is similar to Hackroy but deeper and more loamy (LANL 1997, 071478, p. 9). Much of the soil at South Site was scraped to bedrock to build the berms near the firing sites.

The soil in the Chaquehui Canyon Aggregate Area belongs to the Carjo, Frijoles, Hackroy, Nyjack, Pogna, Seaby, Tocal, Totavi, and the fine Typic Eutoboralfs series, and the Sanjue-Arriba complex (LANL 1993, 015313, pp. 3-17–3-21; LANL 1993, 020946). Soil descriptions are summarized below (Nyhan et al. 1978, 005702).

- The Carjo series is typical of mesa tops and consists of moderately deep, well-drained, and moderately developed soil with an A-B-C horizon sequence. The parent material of the soil may range from Bandelier Tuff to sequences of alluvium/colluvium interstratified with moderately developed to well-developed buried soil. The soil textures of the Carjo series can be very fine sandy loams.
- The Frijoles series is characteristic of deep, well-drained soil formed from pumice on level to moderately sloping mesa tops. The soil is developed with an A-B-C horizon sequence, with textures grading from a brown sandy loam through a clay layer, to a gravelly clay loam.
- Hackroy soil consists of very shallow to shallow, well-drained, and moderately developed soil with an A-B horizon sequence. Soil textures can range from sandy loams to clay loams derived from tuff.
- Nyjack soil consists of moderately deep, well-drained, and moderately developed soil with an A-B-C horizon sequence. Soil textures can range from fine sandy loams to clay loams. The parent material of the soil may range from Bandelier Tuff to sequences of alluvium/colluvium interstratified with moderately developed to well-developed buried soil.
- The Pogna series is a shallow well-drained soil with an A-C horizon sequence. Typically, the soil is a fine sandy loam or sandy loam formed over tuff bedrock on gently to strongly sloping mesa tops.
- The Seaby series consists of shallow to moderately deep, well-drained soil with an A-B-C horizon sequence formed on weathered tuff on gently to moderately sloping mesas. The soil texture grades from a sandy loam to a strong brown gravelly clay loam.
- The Tocal series consists of very shallow to shallow, well-drained soil formed in material weathered from tuff on gently to moderately sloping mesa tops. The soil is developed with an A-B-C horizon sequence and grades from a very fine sandy loam through a clay loam to a silt loam.
- The Totavi series consists of deep, well-drained soil with an A horizon sequence that formed in alluvium in canyon bottoms. Soil textures are a gravelly loamy sand or sandy loam.
- The fine Typic Eutoboralfs consist of moderately deep, well-drained soil that formed in colluvium and material weathered from tuff. Textures include very fine sandy loam, or sandy loam, developed with an A-B horizon sequence, on gentle to moderate slopes and are usually located downgradient of fault zones.
- The Sanjue-Arriba complex includes deep, well-drained soil with an A-C horizon sequence that weathered in materials derived from pumice and found on moderately steep to very steep slopes. Soil textures range from a gravelly sandy loam to a loamy sand.

2.1.2 Surface Water

Most surface water in the Los Alamos area occurs as ephemeral, intermittent, or interrupted streams in canyons cut into the Pajarito Plateau. Springs on the flanks of the Jemez Mountains, west of the Laboratory's western boundary, supply flow to the upper reaches of Cañon de Valle and to Guaje, Los Alamos, Pajarito, and Water Canyons (Purtymun 1975, 011787; Stoker 1993, 056021). These springs discharge water perched in the Bandelier Tuff and Tschicoma Formation at rates from 2 to 135 gallons per minute (gpm) (Abeele et al. 1981, 006273). The volume of flow from the springs maintains natural perennial reaches of varying lengths in each of the canyons. The Rio Grande flows through White Rock Canyon immediately to the southeast of TA-33.

The hydrogeology of the canyon systems is thoroughly discussed in section 2.1.3 of the Laboratory's hydrogeologic work plan (LANL 1998, 059599). The surface water infiltration pathways within the aggregate area include native or disturbed soil, unconsolidated alluvium, Bandelier Tuff, Puye Formation, and basalt; faults and fracture systems; and cooling joints (LANL 1999, 064617, p. 3-25).

At TA-33, ephemeral surface water flow from the mesa top to the surrounding canyons may be expected during spring snowmelt and summer thunderstorms. Surface water does not collect on the mesa top at any of the SWMUs or AOCs in the Chaquehui Canyon Aggregate Area. Chaquehui Canyon has a total drainage area of approximately 1.6 mi^2 with a drainage channel length of 3.4 mi, which runs across approximately 2 mi of TA-33. Three springs are located near the confluence of Chaquehui Canyon with the Rio Grande: Doe Spring is located 0.5 mi upstream of the confluence, and Springs 9 and 9A are located 0.25 mi upstream of the Rio Grande. All three springs support perennial flow at the end of Chaquehui Canyon to the Rio Grande (LANL 1998, 059599).

2.2 Subsurface Conditions

2.2.1 Stratigraphic Units

This section summarizes the stratigraphy of the Chaquehui Canyon Aggregate Area. Additional information on the geologic setting of the area and information on the Pajarito Plateau can be found in the hydrogeologic work plan (LANL 1998, 059599).

The stratigraphy of the Chaquehui Canyon Aggregate Area is summarized in this section. Additional information on the geologic setting of the area and information on the Pajarito Plateau can be found in the Laboratory's hydrogeologic synthesis report (Collins et al. 2005, 092028).

The geology of the area near TA-33, including White Rock Canyon, has been described as part of an evaluation of potential landslides and mass movements (Reneau et al. 1995, 054405). Descriptions of the geologic units in that evaluation are summarized below. Principal units, from oldest to youngest, include sedimentary rocks of the Santa Fe Group; volcanoclastic and quartzite-rich gravels of the Puye Formation; older alluvial deposits, basaltic flows, and phreatomagmatic deposits of the Cerros del Rio volcanic field; and the lower and upper Bandelier Tuff (Griggs and Hem 1964, 092516; Dethier 1997, 049843). The stratigraphy and selected characteristics of these units are summarized below.

2.2.1.1 Santa Fe Group

The Miocene Santa Fe Group exposed in White Rock Canyon is composed primarily of pinkish-grey to buff-colored, poorly to moderately lithified silty sandstone and pebbly sand with an arkosic matrix (Griggs and Hem 1964, 092516; Galusha and Blick 1971, 021526; Dethier 1997, 049843). Thin beds of altered dacitic tephra are locally abundant. These rocks record mainly fluvial deposition on the distal margins of alluvial fans constructed when the Española basin was internally drained. The sandstone, locally cemented with sparry calcite, crops out extensively near the site of the former Buckman village east of the Rio Grande but is poorly exposed west of the Rio Grande. The southernmost exposure in northern White Rock Canyon is at the confluence with Ancho Canyon, to the north of TA-33.

2.2.1.2 The Puye Formation

The Puye Formation is principally a Pliocene volcanogenic alluvial fan sequence derived from the Jemez Mountains (Turbeville et al. 1989, 021587), but it includes ancestral Rio Grande gravels and lacustrine deposits, particularly along and west of White Rock Canyon. The Puye Formation is informally divided into a fanglomerate facies and an axial Rio Grande facies (Dethier 1997, 049843). Along White Rock Canyon and tributary canyons south of Otowi Bridge, these facies are interfingered laterally and in vertical sequences. The fanglomerate facies is mainly pinkish-grey to grey, locally cemented, weakly lithified pebble-to-boulder size gravel, boulder-rich debris flows, and sand. Highly weathered dacitic pumice-rich layers also occur, which have weathered to clay. The ancestral Rio Grande facies is mainly grey, poorly to moderately lithified, locally cemented quartzite-rich pebble-to-cobble gravel, but it includes beds of silt and silty sand. In Ancho Canyon, to the north of TA-33, the Puye Formation is at least 200 ft thick, including 80 ft of Rio Grande gravels underlain by at least 115 ft of fanglomerate.

2.2.1.3 Pliocene Fluvial and Lacustrine Deposits

Unlithified and generally uncemented Pliocene sedimentary deposits interlayered with basalt flows and phreatomagmatic deposits are exposed within a few miles of the Rio Grande. These rocks include buff to brownish-yellow sand and pebbly sand, silt, silty sand, and beds of cinders and debris flows. They are the temporal equivalent, in part, of the ancestral Rio Grande facies of the Puye Formation, but the presence of granitic clasts indicates they were derived from the southern Sangre de Cristo Range (Dethier 1997, 049843). They correlate with the older alluvium of Griggs and Hem (1964, 092516) and, in part, with the Ancha Formation of Spiegel and Baldwin (1963, 054259). Fine-grained units are locally rich in swelling clays that were probably produced from the alteration of basaltic glass derived from Cerros del Rio volcanism. Lacustrine deposits record a Rio Grande dammed south of Water Canyon contemporaneous with eruptions from maars and emplacement of basaltic flows.

2.2.1.4 Cerros del Rio Volcanic Field

Mafic Lavas

Lava flows of basalt, hawaiite, basaltic andesite, andesite, and related intrusive rocks of the Pliocene Cerros del Rio volcanic field form surface exposures along White Rock Canyon and east of the Rio Grande from Otowi Bridge to Cochiti Dam. Volcanic landforms include maars, shields, fissure vents, cinder cones near the Rio Grande, and a cinder cone at TA-33 Area 6. Near Otowi Bridge, mesa-capping flows are about 130 ft thick, whereas south of Water Canyon the flow sequence is greater than 260 ft thick, and near Chaquehui Canyon massive flows are greater than 400 ft thick. East of the Rio Grande, the sequence of basaltic flows also thickens to the south. The thickest flows appear to fill paleovalleys or craters greater than 200 ft deep, whereas some of the thinner flows apparently spread out over surfaces of little relief. Flow bases are smooth to rubble-rich; locally a few tens of inches to a few feet of alluvium separate the flows.

Ages of 2.3 to 2.7 Ma (millions of years) have been obtained from rock dating of the Cerros del Rio volcanic field near northern White Rock Canyon, including argon-40/argon-39 ages of 2.4 to 2.6 Ma from basalt flows and dikes at the TA-33 cinder cone (Laughlin et al. 1993, 054424; Dethier 1997, 049843). A topographically low flow in lower Water Canyon yielded a similar age of about 2.47 Ma, indicating a relatively short period of intense volcanism and over 650 ft of local aggradation occurred at about 2.4 to 2.6 Ma.

Phreatomagmatic Deposits

Thin-bedded to massive matrix-supported flow and fall deposits crop out at La Mesita, along Chino Mesa, between Chaquehui Canyon and Water Canyon, and in several other zones south to Cochiti Dam, mainly along the Rio Grande. These deposits were produced at maar volcanoes that formed when rising magmas reacted with groundwater along the Pliocene course of the Rio Grande (Aubele 1978, 054426; Heiken et al. 1989, 054425; Dethier 1997, 049843). At several of these volcanic centers, lava flows are interlayered with the upper portions of the phreatomagmatic sequences, and some maars probably were the source of thick flows of basaltic andesite (Dethier 1997, 049843). For instance, 100 ft of phreatomagmatic deposits along the southwest side of Chaquehui Canyon near the Rio Grande are overlain by a 200-ft-thick volcanic section that includes seven flows and interlayered phreatomagmatic deposits; these rocks are in turn capped by a package of flows 400 ft thick that may reflect a single cooling unit.

"Pajarito Plateau" Tholeiitic Basalt

Thin flows of tholeiitic basalt typically form the western rim of White Rock Canyon in the TA-33 area, extending north to Los Alamos Canyon. The flows were derived from vents to the west and northwest of White Rock, and one of these vents is exposed south of Pajarito Canyon, southwest of the intersection of Pajarito Road and NM 4. In late Pliocene time, the basalts entered a lake dammed in White Rock Canyon at an elevation of about 6200 ft. Deltas of pillow basalt and palagonitic breccia formed at the edge of the paleolake and are best exposed in Los Alamos and Mortandad Canyons. Available data indicate these tholeiitic flows can be distinguished from other Cerros del Rio lavas by their chemistry (Laughlin et al. 1993, 054424; Dethier 1997, 049843) in addition to their higher stratigraphic position and flow direction. Ages of 1.8 to 2.5 Ma have been obtained from these basalts (Laughlin et al. 1993, 054424; Dethier 1997, 049843; WoldeGabriel et al. 2001, 092523), including argon-40/argon-39 ages of 2.46 to 2.49 Ma near TA-33.

2.2.1.5 Early Quaternary Alluvium

Early Quaternary alluvium is locally exposed near TA-33 below the Tshirege Member of the Bandelier Tuff. Volcanic fallout units of the Cerro Toledo rhyolite, which fill this stratigraphic interval to the northwest (Heiken et al. 1986, 048638), are apparently sparse in the vicinity of White Rock Canyon. In Ancho Canyon near NM 4, about 20 ft of dacite-rich bouldery stream gravels derived from a stream draining the Sierra de los Valles occurs between the Otowi and Tshirege Members. In lower Water Canyon and a northeastern tributary to lower Ancho Canyon, alluvial deposits composed largely of quartzite-rich gravels and river-polished basalt boulders occur beneath the Tshirege Member and indicate that the early Quaternary position of the Rio Grande was at an elevation of about 5700 to 5800 ft above sea level.

2.2.1.6 Tshirege Member Bandelier Tuff

The Tshirege Member of the Bandelier Tuff at TA-33 consists of light-grey nonwelded to slightly welded pumiceous pyroclastic flows and a thin basal pumiceous fall unit, the Tsankawi Pumice Bed (Bailey et al. 1969, 021498). These rocks were erupted from the Jemez Mountains about 1.22 Ma (Izett and Obradovich 1994, 048817). The Tshirege Member is the uppermost rock unit at TA-33 and underlies the SWMUs and AOCs within Chaquehui Canyon Aggregate Area. This unit is typically about 200 to 250 ft thick at TA-33 but pinches out over paleotopographic highs, such as the TA-33 cinder cone, and reaches a thickness of about 750 ft where it fills the early Quaternary paleocanyon.

The Tshirege Member can be divided into mapping units that reflect distinct flow units or cooling units and variations in alteration. Four mapping units modified from the units of Baltz et al. (1963, 008402) and Vaniman and Wohletz (1990, 009995.2) in other parts of the Pajarito Plateau are described below.

The lowest unit, unit 1g, consists of nonwelded ignimbrite with glassy pumice (Vaniman and Wohletz 1990, 009995.2). The second lowest unit, unit 1v, consists of nonwelded vapor-phase-altered ignimbrite (Vaniman and Wohletz 1990, 009995.2). Unit 2 is the primary cliff-former at TA-33, consisting of slightly welded ignimbrite with discontinuous surge beds at the base. The contact of unit 2 with the overlying nonwelded to slightly welded ignimbrites of unit 3 is poorly defined and is here considered to be the approximate break in slope at the base of the upper, relatively steep tuff step.

2.2.2 Hydrogeology

The hydrogeology of the Pajarito Plateau is separable in terms of mesas and canyons forming the plateau. Mesas are generally devoid of water, both on the surface and within the rock forming the mesa. Canyons range from wet to relatively dry; the wettest canyons contain continuous streams and contain perennial groundwater in the canyon-bottom alluvium. Dry canyons have only occasional stream flow and may lack alluvial groundwater. Intermediate perched groundwater has been found at certain locations on the plateau at depths ranging between 100 and 700 ft below ground surface (bgs). The regional aquifer is found at depths of about 600 to 1200 ft bgs.

Hydrogeologic conceptual site models for each watershed at the Laboratory are presented in watershed investigation reports (e.g., LANL 2009, 106939). These conceptual models show that, under natural conditions, relatively small volumes of water move beneath mesa tops because of low rainfall, high evaporation, and efficient water use by vegetation. Atmospheric evaporation may extend into mesas, further inhibiting downward flow.

2.2.2.1 Groundwater

In the Los Alamos area, groundwater occurs as (1) water in shallow alluvium in some of the larger canyons, (2) intermediate perched groundwater (a perched groundwater body lies above a less permeable layer and is separated from the underlying aquifer by an unsaturated zone), and (3) the regional aquifer.

No groundwater wells are located in or near TA-33. Drilling to a depth of 315 ft during the investigation of MDA K in 1993 did not encounter perched water. Groundwater discharges from four springs (Springs 8A, 9, 9A, and Doe Spring) located in lower Chaquehui Canyon east of South Site above the Rio Grande. At South Site (elevation 6400 ft above sea level), the depth to groundwater is assumed to be 800 ft, based on the elevation of Doe Spring (5600 ft above sea level).

2.2.2.2 Vadose Zone

The unsaturated zone from the mesa surface to the top of the regional aquifer is referred to as the vadose zone. The source of moisture for the vadose zone is precipitation, but much of it runs off, evaporates, or is absorbed by plants. The subsurface vertical movement of water is influenced by properties and conditions of the materials that make up the vadose zone.

Although water moves slowly through the unsaturated tuff matrix, it can move rapidly through fractures if saturated conditions exist (Hollis et al. 1997, 063131). Fractures may provide conduits for fluid flow but probably only in discrete, disconnected intervals of the subsurface. Because they are open to the passage of both air and water, fractures can have both wetting and drying effects, depending on the relative abundance of water in the fractures and the tuff matrix.

The Bandelier Tuff is very dry and does not readily transmit moisture. Most of the pore spaces in the tuff are of capillary size and have a strong tendency to hold water against gravity by surface-tension forces. Vegetation is very effective at removing moisture near the surface. During the summer rainy season, when rainfall is highest, near-surface moisture content is variable because of higher rates of evaporation and of transpiration by vegetation, which flourishes during this time.

The various units of the Bandelier Tuff tend to have relatively high porosities. Porosity ranges between 30% and 60% by volume, generally decreasing for more highly welded tuff. Permeability varies for each cooling unit of the Bandelier Tuff. The moisture content of native tuff is low, generally less than 5% by volume throughout the profile (Kearl et al. 1986, 015368; Purtymun and Stoker 1990, 007508).

3.0 SCOPE OF ACTIVITIES

This section presents an overview of field activities performed during the implementation of the drilling investigation activities at MDA K. Field investigation results and observations are presented in detail in section 3 and in the appendices. The scope of activities for the 2020–2021 investigation included premobilization activities; geodetic surveys; borehole drilling, sampling, and installation of the vapor-monitoring system; health and safety monitoring; and waste management activities.

3.1 Site Access and Premobilization Activities

The Chaquehui Canyon Aggregate Area is closed to the public and is accessible only to Laboratory employees, and some areas are accessible only with a clearance or under supervision of an escort. Before field mobilization, efforts were made to provide a secure and safe work area and to reduce impacts to workers, cultural resources, and the environment.

Premobilization activities included completing the permit requirements identification form, completing excavation permits, and requesting sampling paperwork from the N3B Sample Management Office (SMO). Additional premobilization activities included staging waste containers.

3.2 Field Activities

This section describes the field activities conducted during the 2020–2021 investigation. Additional details regarding the field methods and procedures used to perform these field activities are presented in Appendix B.

3.2.1 Geodetic Surveys

Geodetic surveys were conducted during the MDA K drilling activities to identify borehole locations. The planned borehole locations for the 2020–2021 investigation were chosen based on the locations in the approved investigation work plan (LANL 2010, 111298; NMED 2011, 201242), then adjusted for drill rig accessibility. An initial geodetic survey was performed to establish and mark the planned drilling locations in the field.

Geodetic surveys were conducted by a licensed State of New Mexico surveyor, using a differential global positioning system (GPS) unit. Horizontal accuracy of the GPS unit is within 0.1 ft. During drilling, if the planned location could not be sampled because of surface or subsurface obstruction or other unanticipated field conditions, the relocated sampling location was resurveyed.

The surveyed coordinates for the three new borehole locations are presented in Table 3.2-1. All coordinates are expressed as State Plane Coordinate System 83, New Mexico Central, U.S. All surveyed coordinates for sampling locations were uploaded to the Environmental Information Management (EIM) database.

3.2.2 Field Screening

Core samples and cuttings were screened for gross-alpha and -beta radioactivity by an N3B radiological control technician (RCT) using appropriately calibrated instruments. Field Response checks of radiological instruments were performed and documented by the RCTs. Radiological screening was performed using an alpha/beta particle sensitive scintillation detector and an ionization chamber for dose rate measurements. All radiation detection instrumentation is calibrated on an annual basis through an agreement with Triad RP-SVS. Screening for tritium was not conducted.

After field-screening measurements were established, appropriate precautions were taken before samples were collected. Samples from the core material were collected and logged. The RCT collected and recorded background level measurements for gross-alpha and -beta radioactivity daily.

All samples were screened for gross-alpha, -beta, and -gamma radioactivity by on-site RCTs before transport to the SMO. Results were recorded on each sample collection log (SCL)/chain-of-custody (COC) form.

Field-screening results were recorded on borehole logs and/or corresponding SCLs/COC forms. Borehole logs are presented in Appendix D, and SCLs/COC forms are included in Appendix C (on CD included with this document). The screening results are presented in Table 3.2-2.

3.2.3 Subsurface Investigation

3.2.3.1 Borehole Drilling and Subsurface Sampling

Samples were collected using a split-barrel sampler in accordance with N3B-SOP-ER-2001, “Soil, Tuff, and Sediment Sampling,” at depth intervals based on the lithology.

For the 2020–2021 investigation, three boreholes were drilled to depths ranging from 215.9 to 290.0 ft below ground surface (bgs), and tuff and vapor samples were collected to characterize the site. The tuff samples were extracted from the core barrels, placed in stainless-steel bowls with stainless-steel spoons, and then transferred to sterile sample collection jars. Samples were then submitted to the SMO under COC for laboratory analyses as specified by the approved investigation work plan (LANL 2010, 111298; NMED 2011, 201242). Borehole logs are included in Appendix D.

3.2.3.2 Vapor Monitoring Installation

Stainless-steel vapor-monitoring systems were installed at MDA K in accordance with actual field conditions and geological logging performed during the drilling operation. The following general guidelines were used to construct each well.

- Boreholes were drilled to total depth (TD) using 4.5-in.-inside diameter (I.D.) augers and continuously cored using either a 2.5-ft or 5-ft core barrel assembly. Boreholes were logged by a geologist to identify geologic contacts.
- Boreholes were over-drilled to TD using 6.5-in.-I.D. augers to facilitate installation of the vapor-monitoring systems. The vapor-monitoring systems were constructed inside the larger diameter augers.
- Each vapor port was measured and banded every 20 ft to a 1-in. stainless-steel drop pipe and installed inside the 6.5-in. augers following the methods below:
    - ❖ Connect the 0.25-in.- × 6-in.-long cylindrical stainless-steel screen to 0.25-in. stainless-steel tubing.
    - ❖ Place the 0.25-in.- × 6-in.-long cylindrical stainless-steel screen at the appropriate depth and secure using stainless-steel banding to the drop pipe.
    - ❖ Lower the sample system into borehole and continue to add drop pipe and sample ports until all sample ports are installed.
    - ❖ Maintain the well under tension in the center of the augers while annular fill materials are added.
- Five feet of sand was placed in the borehole to surround the screen.
- Bentonite was placed above the 5-ft sand interval and hydrated.
- Augers were extracted as well installation progressed.
- The above steps were repeated for installing additional vapor-monitoring ports based upon geological logging.

Port depths were chosen to be at the base of each formation beginning with Qbt 3 at location 33-60938 and Qbt 2 at locations 33-60639 and 33-60940. At location 33-60938, the pore depths are located at 19.0 ft, 82.0 ft, 100.0 ft, 170.0 ft, 220.0 ft, and 241.35 ft bgs. At location 33-60939, the pore depths are located at 56.0 ft, 100.0 ft, 148.0 ft, 193.5 ft, 203.4 ft, and 213.4 ft bgs. At location 33-60940, the pore depths are located at 30.0 ft, 68.0 ft, 100.0 ft, 166.0 ft, 217.5 ft, and 228.2 ft bgs.

3.2.3.3 Equipment Decontamination

Between collection of each sample and between sampling locations, all field equipment with the potential to contact sample material (e.g., hand augers, sampling scoops, bowls, and core barrel sections) was decontaminated to prevent cross-contamination of samples and locations. Dry decontamination was performed in accordance with N3B-SOP-ER-2002, “Field Decontamination of Equipment.” The dry decontamination methods used are described in Appendix B. Rinsate blanks were used to check the effectiveness of decontamination.

An RCT field-screened the drilling equipment for gross-alpha and -beta radioactivity after each borehole was drilled. An RCT also surveyed the drill rig before it was brought on site and before it was released back to the drilling contractor.

3.2.4 Health and Safety Measures

All 2020–2021 investigation activities were conducted in accordance with a site-specific environmental safety and health plan and an integrated work control document that detailed work steps, potential hazards, hazard controls, and required training to conduct work. These health and safety measures generally included the use of modified level-D personal protective equipment (PPE) and field monitoring for noise and dust using portable monitoring systems. Organic vapor monitoring was performed for health and safety purposes only (section 3.2.2).

3.2.5 Waste Management

All waste generated during the MDA K investigation was managed in accordance with the waste management plan in the approved investigation work plan (LANL 2010, 111298, Appendix B; NMED 2011, 201242) and the N3B-approved project waste characterization strategy form (WCSF) [Appendix F of the investigation report (N3B 2020, 701046)]. These documents incorporate the requirements of all applicable U.S. Environmental Protection Agency (EPA) and NMED regulations and DOE orders. Characterization and management of waste was performed in accordance with N3B-P409-0, "N3B Waste Management."

The waste streams associated with the investigation included contact investigation-derived waste, municipal solid waste, and environmental media.

Drill cuttings and discarded core from boreholes were collected and containerized in 3.5-yd^3 or 5-yd^3 Type IP-1 bags and placed on pallets in a waste staging area pending shipment. This waste stream was characterized in accordance with the N3B-approved WCSF [Appendix F of the investigation report (N3B 2020, 701046)]. The drill cuttings and discarded core waste stream were classified as low-level waste based on historical site investigation data.

Contact investigation-derived waste included PPE such as gloves, disposable sampling supplies, decontamination towels, and other solid waste that may have come in contact with potentially contaminated environmental media. Contact waste was stored in a 55-gal. drum on a pallet in the waste staging area pending shipment. As described in the WCSF, the contact waste was characterized using samples collected during the investigation.

Each waste stream was containerized and managed in storage areas appropriate to the type of waste. The management of waste is described in greater detail in Appendix F of the investigation report (N3B 2020, 701046). All available waste documentation, including WCSFs, WCSF amendments, and waste profile forms, is provided in Appendix F of the investigation report.

3.3 Sample Analyses

The SMO shipped all investigation samples to off-site contract analytical laboratories for the requested analyses. The analyses requested were specified in the approved investigation work plan (LANL 2010, 111298; NMED 2011, 201242) and were analyzed for all or a subset of the following: volatile organic compounds (VOCs), tritium, and pH.

Field duplicates of investigation samples were analyzed for the same analytical suites as the corresponding investigation samples. Field trip blanks were analyzed only for VOCs.

3.4 Deviations

Deviations from the scope of activities defined in the approved investigation work plan (LANL 2010, 111298; NMED 2011, 201242) occurred during the implementation of the MDA K investigation. A phased approach to the drilling was conducted to determine the presence and concentrations of tritium and VOCs in pore gas. Figure 2.4-1 shows the investigation work plan–approved locations, with borehole numbers added, and the actual locations drilled in 2020–2021. Locations were moved because of the presence of a cultural site and site accessibility issues using a drill rig. The approved investigation work plan proposed collecting soil, tuff, and vapor samples at 10-ft intervals. Tuff and pore-gas samples were collected at the base of geologic formations instead of every 10 ft. Specific deviations are described in greater detail in section B-8.0 of Appendix B.

4.0 REGULATORY CRITERIA

This section describes the criteria used for evaluating potential risk to human receptors and the potential for contamination of groundwater by VOCs and tritium in soil vapor. Regulatory criteria identified by medium in the Consent Order include cleanup standards, risk-based screening levels (SLs), and risk-based cleanup goals.

4.1 Current and Future Land Use

The specific SLs used in the risk evaluation and corrective-action decision process at a site depend on the current and reasonably foreseeable future land use(s). The current and reasonably foreseeable future land use(s) for a site determines the receptors and exposure scenarios used to select screening and cleanup levels. The land use within and surrounding the Chaquehui Canyon Aggregate Area is currently industrial and is expected to remain industrial for the reasonably foreseeable future.

4.2 Vapor Intrusion Screening Levels

VOCs present in releases from sites associated with MDA K [SWMUs 33-002(a), 33-002(b), 33-002(c), 33-002(d), 33-002(e), and 33-010(f)] may vaporize and be released into subsurface media (e.g., soil, tuff, fractured rock). These vapor-phase contaminants may potentially be transported through the subsurface to the water table. Once in contact with the water table, vapor-phase VOCs might condense into the water. Thus, vapor-phase contaminants are a potential source of groundwater contamination. For MDA K, monitoring of subsurface vapors is being performed to evaluate the potential for groundwater contamination or, if necessary, to evaluate the need for corrective actions to prevent possible groundwater contamination.

Under the Consent Order, results of environmental investigations and monitoring are compared with SLs, which are media-specific contaminant concentrations that indicate the potential for unacceptable risk. The Consent Order specifies that SLs for soil and groundwater developed by NMED be used to evaluate soil and groundwater contamination. NMED has developed vapor intrusion screening levels (VISLs) for evaluating the potential for vapor intrusion into buildings and subsequent exposure through inhalation. However, NMED's VISLs do not address potential migration of vapors to groundwater. Because the Consent Order does not identify SLs for subsurface vapor, N3B developed Tier I SLs to evaluate monitoring results.

The Tier I approach evaluates whether pore gas containing a VOC at the concentration detected in the vapor sample could contaminate groundwater above the groundwater SL. The approach assumes that pore gas containing VOCs at the concentrations detected in the pore-gas sample is in hypothetical contact with the water table in sufficient quantity to condense into groundwater in accordance with Henry's law. If Tier I SLs are not exceeded, VOCs cannot contaminate groundwater above cleanup levels even if the vapor contamination is in direct contact with groundwater, and no further screening is necessary.

4.3 Tier I Soil-Vapor Screening

The Tier I screening analysis evaluates the potential for contamination of groundwater by VOCs in soil vapor using groundwater SLs equal to groundwater cleanup levels in the Consent Order. The analysis predicts the groundwater concentration that might be in equilibrium with the maximum soil-vapor concentrations of VOCs detected if the soil-vapor concentrations were in contact and equilibrium with groundwater. The analysis is performed using VOC concentrations in the pore gas in calculations according to Henry's law partitioning. If the predicted concentration of a particular VOC in groundwater is less than the groundwater SL, then no potential exists for exceedances of groundwater cleanup levels.

Because there are no SLs for soil vapor that address the potential for groundwater contamination, the screening evaluation is based on Consent Order groundwater cleanup levels and the Henry's law constant that describes the equilibrium between vapor and water concentrations. The source of Henry's law constants is the NMED "Risk Assessment Guidance for Site Investigations and Remediation Volume 1, Soil Screening Guidance for Human Health Risk Assessments," (NMED 2019, 700550) or the EPA regional screening tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables). The following dimensionless form of Henry's law constant is used:

$$H' = \frac{C_{air}}{C_{water}}$$ **Equation 3.1-1**

Where, H' = the dimensionless Henry's law constant,

C_{water} = the volumetric concentration of the contaminant in water, and

C_{air} = the volumetric concentration of the contaminant in air (or soil vapor).

Equation 3.1-1 can be used to calculate the Tier I pore-gas SL (SL_{pgI}) as follows:

$$SL_{pgI} = H' \times SL_{gw} \times 1000$$ **Equation 3.1-2**

Where, SL_{pgI} = the Tier I pore-gas SL (μg/m^3),

SL_{gw} = the groundwater SL (μg/L), and

1000 = a conversion factor (to convert L to m^3).

In accordance with Section IX of the Consent Order, the groundwater SLs used in Equation 3.1-2 are determined as follows.

For each individual substance, the lower concentration of the New Mexico Water Quality Control Commission (NMWQCC) groundwater standard or EPA maximum contaminant level (MCL) is used as the screening value. If an NMWQCC groundwater standard or an MCL has not been established for a specific substance for which toxicological information is published, the NMED SL for tap water is used as the groundwater screening value. NMED SLs are established for either a cancer- or noncancerous-risk type; for the cancer-risk type, SLs are based on a 10^{-5} excess cancer risk. This report was prepared using the 2019 "NMED Risk Assessment Guidance for Site Investigations and Remediation Volume 1, Soil Screening Guidance for Human Health Risk Assessments" (NMED 2019, 700550). If an NMED SL for tap water has not been established for a specific substance for which toxicological information is published, the EPA regional SL for tap water (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables) is used as the groundwater screening value. The EPA SLs are established for either a cancer- or noncancerous-risk type. For the cancer-risk type, the Consent Order specifies screening at a 10^{-5} excess cancer risk. The EPA SLs for tap water are at 10^{-6} excess cancer risk; therefore, 10 times the EPA 10^{-6} SLs are used in the screening process.

If the hypothetical concentration of a VOC in groundwater (calculated using Equation 3.1-2) and the measured VOC concentration in a pore-gas sample is less than the groundwater SL, the concentration of the VOC in soil vapor will not exceed the groundwater SL, even if the VOC contamination were to be in direct contact with groundwater. An analysis of the MDA K data is presented in section 5.0.

Table 4.6-1 presents the calculated concentrations of contaminants in soil vapor corresponding to groundwater SLs (hereafter, Tier I SLs) for the Tier I screening. Table 4.6-2 presents the results of the Tier I screening for the soil-vapor data. No VOCs were identified that exceeded the Tier I SL.

4.4 VISLs for Potential Human Exposure

NMED has developed VISLs for chemicals associated with environmental releases within the state (NMED 2019, 700550).

NMED guidance on evaluating a vapor intrusion pathway does not specify a sample depth that needs to be evaluated against the VISLs. The guidance does specify that evaluation is required if a pathway for exposure is complete or potentially complete, e.g., detected VOC concentrations near buildings with occupants. Therefore, the concentrations of VOC contaminants in pore-gas samples located closest to buildings with occupants are the relevant locations for comparison with the VISLs for soil gas (µg/m^3). The focus should be on VOC contaminants in the first 30 ft of subsurface based on the potential movement of the VOC vapor contaminants through the subsurface and into the building.

5.0 DATA REVIEW METHODOLOGY

The purpose of the data review is to define the nature and extent of contaminant releases for each SWMU or AOC in the Chaquehui Canyon Aggregate Area. The nature of a contaminant release refers to the specific contaminants that are present, the affected media, and associated concentrations. The nature of contamination is defined through identification of chemicals of potential concern (COPCs), which is discussed in section 5.1. The identification of a chemical or radionuclide as a COPC does not mean the constituent(s) is (are) related to the site as a result of site operations. A COPC is identified because it is present at a site based on the criteria discussed below, but it might be present because of adjacent and/or upgradient operations and/or infrastructure typical of industrial and metropolitan development. If such origins are evident, the constituents might be excluded from the data analyses and risk assessments. The extent of contamination refers to the spatial distribution of COPCs, with an emphasis on the distribution of COPCs potentially posing a risk or requiring corrective action. The process for determining the extent of contamination and for concluding no further sampling for extent is warranted is discussed in section 5.2.

5.1 Identification of COPCs

COPCs are chemicals and radionuclides that may be present as a result of releases from SWMUs or AOCs. Inorganic chemicals and some radionuclides occur naturally, and inorganic chemicals and radionuclides detected because of natural background are not considered COPCs. Similarly, some radionuclides may be present as a result of fallout from historic nuclear weapons testing, and these radionuclides are also not considered COPCs. The Laboratory collected data on background concentrations of many inorganic chemicals, naturally occurring radionuclides, and fallout radionuclides. These data have been used to develop media-specific background values (BVs) and fallout values (FVs) (LANL 1998, 059730). For inorganic chemicals and radionuclides for which BVs or FVs exist, identification of COPCs involves background comparisons, which are described in sections 5.1.1 and 5.1.2. If no BVs or FVs are available or if samples are collected where FVs are not appropriate (i.e., greater than 1-ft depth or in rock), COPCs are identified based on detection status (i.e., if the inorganic chemical or radionuclide is detected, it is identified as a COPC unless there is information indicating it is not present as a result of a release from the SWMU or AOC).

Organic chemicals may also be present as a result of anthropogenic activities unrelated to the SWMU or AOC or, to a lesser extent, from natural sources. Because there are no background data for organic chemicals, background comparisons cannot be performed in the same manner as for inorganic chemicals or radionuclides. Therefore, organic COPCs are identified based on detection status (i.e., the organic chemical is detected). When the nature of contamination is assessed, the history of site operations may be evaluated to determine whether an organic COPC is present because of a release from a SWMU or AOC or is present from a non-site-related source. Organic chemicals that are clearly present from sources other than releases from a SWMU or AOC may be eliminated as COPCs and not evaluated further.

5.1.1 Inorganic Chemical and Radionuclide Background Comparisons

The COPCs are identified for inorganic chemicals and radionuclides in accordance with N3B-SOP-ER-2004, “Background Comparisons for Inorganic Chemicals,” and N3B-SOP-ER-2005, “Background Comparisons for Radionuclides.” Inorganic COPCs are identified by comparing site data with BVs, statistical comparisons, and other lines of evidence, as applicable (LANL 1998, 059730). The upper end of the background data set may be used for comparison if one or more of the following conditions exist:

- Statistically determined BV is significantly greater than the maximum background concentration.
- Statistical tests cannot be performed because of insufficient data (fewer than eight samples and/or five detections per medium) or a high percentage of nondetections.
- Sufficient numbers of samples have been collected to determine nature and extent, but results are predominately nondetections.
- Site history does not indicate the constituent is directly related to site activities or to a dominant waste stream.
- Spatial analyses do not show a pattern or trend indicating contamination.
- The maximum detected concentration is statistically determined to be an outlier. (Note: A sufficient number of samples must be collected to show a point is an outlier and is not indicative of a hot spot.)

Radionuclides are identified as COPCs based on background comparisons and statistical methods if BVs or FVs are available, based on detection status if BVs or FVs have not been established, or based on other lines of evidence, as applicable.

Background data are generally available for inorganic chemicals in soil, sediment, and tuff (LANL 1998, 059730). However, some analytes (e.g., nitrate, perchlorate, and hexavalent chromium) have no BVs. A BV may be either a calculated value from the background data set (upper tolerance limit [UTL] or the 95% upper confidence bound on the 95th quantile) or a detection limit (DL). When a BV is based on a DL, there is no corresponding background data set for that analyte/media combination.

For inorganic chemicals, data are evaluated by sample media to facilitate the comparison with media-specific background data. To identify inorganic COPCs, the first step is to compare the sampling result with BVs. If sampling results are above the BV and sufficient data are available (eight or more sampling results and five or more detections), statistical tests are used to compare the site sample data with the background data set for the appropriate media. If statistical tests cannot be performed because of insufficient data or a high percentage of nondetections, the sampling results are compared with the BV and the upper end of background concentration for the appropriate media. If concentrations are above the BV but no results are greater than the upper end of the background data set, lines of evidence are presented to determine whether the inorganic chemical is or is not a COPC. If at least one sampling result is above the BV and the upper end of the background data set, the inorganic chemical is identified as a COPC. The same evaluation is performed using DLs when an inorganic chemical is not detected but has a DL above the BV. If no BV is available, detected inorganic chemicals are identified as COPCs.

Radionuclides are identified as COPCs based on comparisons with BVs for naturally occurring radionuclides or with FVs for fallout radionuclides. Thorium-228, thorium-230, thorium-232, uranium-234, uranium-235/236, and uranium-238 are naturally occurring radionuclides. Americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, and tritium are fallout radionuclides.

Naturally occurring radionuclides detected at activities above their respective BVs are identified as COPCs. If there is no associated BV or FV and the radionuclide is detected, it is retained as a COPC.

The FVs for the fallout radionuclides apply to the top 0.0 to 1.0 ft of soil and fill and to sediment regardless of depth. If a fallout radionuclide is detected in soil or fill samples collected below 1.0 ft or in tuff samples, the radionuclide is identified as a COPC. For soil and fill samples from 1.0 ft bgs or less, if the activity of a fallout radionuclide is greater than the FV, comparisons of the top 0.0-to-1.0-ft sample data are made with the fallout data set. The radionuclide is eliminated as a COPC if activities are similar to fallout activities or lines of evidence can be presented to establish the radionuclide is not a COPC. Sediment results are evaluated in the same manner, although all data are included, not just the data from 0.0 to 1.0 ft bgs.

The FV for tritium in surface soil (LANL 1998, 059730) is in units of pCi/mL. This FV requires using sample percent moisture to convert sample tritium data from pCi/g (as provided by analytical laboratories) to the corresponding values in units of pCi/mL. Sample percent moisture historically has been determined using a variety of methods, often undocumented. In accordance with N3B-SOP-ER-2005, “Background Comparisons for Radionuclides,” identification of tritium as a COPC in soil is based on detection status.

Sample media encountered during investigations at Chaquehui Canyon Aggregate Area include soil (all soil horizons, designated by the media code ALLH or SOIL), fill material (media code FILL), alluvial sediment (media code SED), and Bandelier Tuff (media codes Qbt 1v, Qbt 1g, Qbt 2, Qbt 3, and Qbt 4). Because no separate BVs are available for fill material, fill samples are evaluated by comparison with soil BVs (LANL 1998, 059730). In this addendum, the discussions of site contamination in soil include fill samples along with soil samples in sample counts and comparisons with background. Fill samples are not discussed separately from soil. The units of the Upper Bandelier Tuff (Qbt 2, Qbt 3, and Qbt 4) are likewise evaluated together with respect to background, as are the units of the Lower Bandelier Tuff (Qbo, Qct, and Qbt 1g) (LANL 1998, 059730).

5.2 Extent of Contamination

Spatial concentration trends are initially used to determine whether the extent of contamination is defined. Evaluation of spatial concentration data considers the conceptual site model of the release and subsequent migration. Specifically, the conceptual site model should define where the highest concentrations would be expected if a release had occurred and how these concentrations should vary with distance and depth. If the results are different from the conceptual site model, it could indicate that no release has occurred or there are other sources of contamination.

In general, both laterally and vertically decreasing concentrations are used to define extent. If concentrations are increasing or not changing, other factors are considered to determine whether extent is defined or if additional extent sampling is warranted. These factors include

- the magnitude of concentrations and rate of increase compared with soil screening levels (SSLs)/screening action levels (SALs),
- the magnitude of concentrations of inorganic chemicals or radionuclides compared with the maximum background concentrations for the medium,
- concentrations of organic chemicals compared with estimated quantitation limits (EQLs), and
- results from nearby sampling locations.

The primary focus for defining the extent of contamination is characterizing contamination that potentially poses a potential unacceptable risk and might require additional corrective actions. As such, comparison with SSLs/SALs is used as an additional step following a determination of whether extent is defined by decreasing concentrations with depth and distance and whether concentrations are below EQLs or DLs. The initial SSL/SAL comparison uses the residential SSL/SAL (regardless of whether the current and reasonably foreseeable future land use is residential) because this value is typically the most protective. If the current and reasonably foreseeable future land use is not residential, and if the residential SSL/SAL is exceeded by or is similar to COPC concentrations, comparison with the relevant SSL/SAL may also be conducted. For all SWMUs and AOCs in the Chaquehui Canyon Aggregate Area, the current and reasonably foreseeable future land use is industrial (section 4.1).

The SSL/SAL comparison is not necessary if all COPC concentrations are decreasing with depth and distance. If, however, concentrations increase with depth and distance or do not display any obvious trends, the SSLs/SALs are used to determine whether additional sampling for extent is warranted. If the COPC concentrations are sufficiently below the SSL/SAL (e.g., the residential and/or industrial SSL/SAL is 10 times [an order of magnitude]) or more than all concentrations), the COPC does not pose a potential unacceptable risk and no further sampling for extent is warranted. The validity of the assumption that the COPC does not pose a risk is confirmed with the results of the risk-screening assessment. The calculation of risk also assists in determining whether additional sampling is warranted to define the extent of contamination needing additional corrective actions.

Calcium, magnesium, potassium, and sodium may be COPCs for some sites. These constituents are essential nutrients, and their maximum concentrations are compared with NMED's essential nutrient screening levels (NMED 2019, 700550). If the maximum concentration is less than the SL(s), no additional sampling for extent is warranted and the inorganic chemical is eliminated from further evaluation in the risk assessment.

6.0 TA-33 BACKGROUND AND FIELD INVESTIGATION RESULTS

6.1 Background of TA-33

6.1.1 Operational History

TA-33, also known as Hot Point (HP) Site, is located on the Lower Pajarito Plateau in the southeastern corner of the Laboratory (Figure 1.1-1). TA-33 was initially developed in 1947 as a test site for implosion-type initiator experiments using conventional high explosives (HE), depleted uranium (DU), and beryllium. Polonium-210 was prepared off-site and used as the radiation source for the experiments. The experiments were performed in underground chambers, on surface firing pads, and at firing sites equipped with large guns that fired projectiles into earthen berms. Initiator testing at TA-33 ceased in 1972. After 1972, TA-33 has been used for offices, laboratories, and storage in support of electronics design and fabrication and experiments formerly conducted at the Hot Dry Rock Program. An antenna for the National Radio Astronomy Observatory Very Long Baseline Array radio telescope was sited at TA-33 in 1985 and is operational. The high-pressure tritium facility (former building 33-86) was constructed in 1955 and operated until 1990. The tritium facility was decommissioned and demolished in the mid-1990s (LANL 2010, 111298).

6.1.2 Summary of Releases

Potential contaminants at TA-33 may have been released into the environment through operational releases at and downgradient of former firing sites and associated facilities, subsurface disposal pits, a former burn area, inactive incinerator, septic systems, inactive seepage pits and sump, surface disposal areas, former storage areas, former transformer, and drainlines and outfalls.

6.1.3 Current Site Usage and Status

TA-33 is currently used for experimental research activities that support the creation, delivery, and maintenance of innovative detection and energy-projection systems for remote applications in space and around the world and is expected to remain active for the foreseeable future. TA-33 is not accessible to the public.

6.2 MDA K

MDA K consists of a septic system and two seepage pits with drainlines and outfalls that served the former tritium facility (building 33-86) and a former surface disposal area. MDA K is located in the southeast area of Main Site at TA-33. Six SWMUs are associated with MDA K; SWMU 33-002(a); 33-002(b); 33-002(c); 33-002(d); 33-002(e); and 33-010(f). The results of the 2019–2020 investigation at these sites are included in the investigation report (N3B 2020, 701046).

6.2.1 Site Description and Operational History

6.2.1.1 SWMU 33-002(a) – Septic System (MDA K)

SWMU 33-002(a) is the former location of a septic system that served the former Tritium Facility (former building 33-86) and a nearby guard station (former building 33-90) at Main Site (Figure 6.2-1). The septic system was installed in 1954 east of former building 33-86 and consisted of an 860-gal. septic tank (former structure 33-93), inlet and outlet drainlines, a siphon tank, and an approximately 50-ft × 100-ft drain field. The septic system operated until 1990 when discharges of effluent from the Tritium Facility ceased; however, the septic system continued to receive effluent from the guard station until the mid-1990s. The principal waste stream received by the septic system was sanitary wastewater from former buildings 33-86 and 33-90. The system also received tritium- and uranium-contaminated liquids associated with operations and other releases from former building 33-86, including two releases of plutonium-contaminated liquid in 1961 (LANL 1992, 007671, p. 3-19). The SWMU 33-002(a) septic system was removed during the 2005 voluntary corrective action (VCA) implemented at the site (LANL 2010, 110352).

6.2.1.2 SWMU 33-002(b) – Sump (MDA K)

SWMU 33-002(b) is the location of a former seepage pit (former structure 33-134) and former inlet drainline that connected sinks and floor drains in former building 33-86 (former Tritium Facility) to the former seepage pit at Main Site (Figure 6.2-1). The seepage pit was an unlined, rubble-filled pit that measured 6 ft in diameter and 8 ft deep, with a 3-in.-thick concrete lid. Discharges to the seepage pit began in 1955 when building 33-86 became operational and ceased in 1959 when the seepage pit was backfilled. Wastes discharged to the SWMU 33-002(b) seepage pit between 1955 and 1959 contained organic solvents, including ethanol, methanol, trichloroethene (TCE), benzene, and acetone. Some of these solvents were contaminated with tritium. The SWMU 33-002(b) seepage pit also may have received beryllium, mercury, and DU. The SWMU 33-002(b) seepage pit and inlet drainline were removed during the 2005 VCA implemented at the site (LANL 2010, 110352).

When the SWMU 33-002(b) seepage pit was deactivated and disconnected from the building 33-86 waste inlet, the building 33-86 roof drain was connected to the inactive SWMU 33-002(b) inlet drainline, and a new 2-in., 90-ft-long vitrified clay pipe (VCP) outlet drainline connected to the east end of the SWMU 33-002(b) inlet drainline within the backfilled seepage pit (former structure 33-134) to discharge storm water from the building 33-86 roof to an outfall northeast of the building [SWMU 33-002(e)] (LANL 2003, 107491). Operations in building 33-86 ceased in 1990 and the building underwent decontamination and decommissioning (D&D) and was demolished in the mid-1990s.

6.2.1.3 SWMU 33-002(c) – Sump (MDA K)

SWMU 33-002(c) is the location of a former seepage pit (former structure 33-133) and associated inlet drainline constructed in 1955 that received discharges from sinks and floor drains in former building 33-86 (former Tritium Facility) at Main Site (Figure 6.2-1). The seepage pit was an unlined, rubble-filled pit that was 6 ft in diameter and 8 ft deep with a 3-in.-thick concrete lid. Discharges to the seepage pit ceased in 1959. When the SWMU 33-002(c) seepage pit was deactivated, an outlet drainline for noncontact cooling water from former building 33-86 was extended through the pit and routed approximately 90 ft downslope to create an outfall [SWMU 33-002(d)]. Wastes discharged to the SWMU 33-002(c) seepage pit contained tritium and organic chemical solvents, including TCE, methanol, ethanol, acetone, and propanol (LANL 1992, 007671, p. 3-19). The SWMU 33-002(c) seepage pit and inlet drainline were removed during the 2005 VCA implemented at the site (LANL 2010, 110352).

When the SWMU 33-002(c) seepage pit was deactivated and disconnected from the building 33-86 waste inlet, the drainline to the seepage pit (former structure 33-133) was extended 90 ft to the east to create an outfall northwest of the building for the discharge of noncontact cooling water from former building 33-86 [SWMU 33-002(d)] (LANL 2003, 107491). Operations in building 33-86 ceased in 1990 and the building underwent D&D and was demolished in the mid-1990s.

6.2.1.4 SWMU 33-002(d) – Drainline and Outfall from Former Building 33-86 (MDA K)

SWMU 33-002(d) is a former outfall and associated 90-ft outlet drainline that discharged noncontact cooling water from former building 33-86 (Figure 6.2-1). This outfall was created when the SWMU 33-002(c) seepage pit was deactivated and disconnected from the building 33-86 inlet drainline to the sump in 1959 (LANL 1990, 007513). At that time, a 4-in. VCP outlet drainline was attached to the inactive cast iron inlet to former sump 33-133 [SWMU 33-002(c)] and was extended 90 ft to the east of former sump 33-133 to create an outfall for the discharge of noncontact cooling water from former building 33-86 (LANL 2003, 107491). The outfall operated under the Laboratory's National Pollutant Discharge Elimination System permit (Outfall 04A147) until July 11, 1995, when it was removed from the permit. Tritium and metals were potential contaminants in the noncontact cooling water. The 90-ft outlet drainline that discharged to the outfall was removed during the 2005 VCA implemented at the site (LANL 2010, 110352).

6.2.1.5 SWMU 33-002(e) – Drainline and Outfall from Former Building 33-86 (MDA K)

SWMU 33-002(e) consists of a former roof drain, drainline, and outfall that served former building 33-86 (the former Tritium Facility) (Figure 6.2-1). A 90-ft-long VCP outlet drainline connected to the east end of the SWMU 33-002(b) inlet drainline within the backfilled seepage pit (former structure 33-134) to discharge storm water from the building 33-86 roof to an outfall northeast of the building (LANL 2003, 107491). This outfall was created when the SWMU 33-002(b) seepage pit was deactivated, backfilled, and disconnected from the building 33-86 drainline. At that time, the drainline to the seepage pit was extended 90 ft to the east to create an outfall for the discharge of storm water from roof drains on former building 33-86 (LANL 2003, 107491). Storm water discharges from building 33-86 roof drains potentially contained tritium associated with releases from the former building 33-86 air-emission stacks. The drainline was removed during the 2005 VCA implemented at the site (LANL 2010, 110352).

6.2.1.6 SWMU 33-010(f) – Surface Disposal Site (MDA K)

SWMU 33-010(f) is a reported surface disposal area consisting of two small surface disposal areas located 300 ft southeast of former building 33-86 and approximately 50 ft apart at Main Site (Figure 6.2-1). The history of the site and the origins of the wastes are not known. The 1990 SWMU report states the SWMU was identified during a 1987 ER Project reconnaissance and describes the site as concrete, cans, and metal pieces that littered the area east of the former Tritium Facility (former building 33-86) (LANL 1990, 007513). The 1995 Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) report describes this SWMU as consisting of two small surface disposal areas located 300 ft southeast of former building 33-86 and approximately 50 ft apart (LANL 1995, 071262). One of the areas is described as approximately 15 ft^2 and the other as approximately 10 ft × 20 ft. Materials at the site included pieces of concrete; piles of tuff and cured asphalt; rusted metal cans, rebar, and strapping bands; and other miscellaneous construction debris. Although the source of these materials is not known, some were believed to be associated with roadwork activities. During the 2005 VCA conducted at SWMUs 33-002(a-e) directly north and east of SWMU 33-010(f), only small piles of soil and a few pieces of concrete were observed to be present at the site.

6.2.2 Site Contamination

6.2.2.1 Soil, Rock, and Sediment Sampling

Based on previous investigation results, further characterization was required to define the vertical and lateral extent of vapor contamination associated with MDA K. As a result, the following activities were completed as part of the 2020–2021 investigation of MDA K.

- A total of 15 tuff samples were collected from the 3 borehole locations. At location 33-60938, tuff samples were collected from 18.1 to 19.1 ft bgs, 81.5 to 82.5 ft bgs, 169.15 to 170.15 ft bgs, 217.15 to 218.15 ft bgs, 228.70 to 230.15 ft bgs, and 286.65 to 287.65 ft bgs. At location 33-60939, tuff samples were collected from 55.0 to 56.0 ft bgs, 146.2 to 147.2 ft bgs, 200.0 to 201.0 ft bgs, 211.2 to 212.0 ft bgs, and 214.9 to 215.9 ft bgs. At location 33-60940, tuff samples were collected from 66.95 to 67.95 ft bgs, 165.0 to 166.0 ft bgs, 218.5 to 219.5 ft bgs, and 229.5 to 230.7 ft bgs. All samples were analyzed at off-site fixed laboratories for pH, temperature, and tritium.
- A total of 18 pore-gas samples were collected from the 3 borehole locations. At location 33-60938, samples were collected from 19.0 ft, 82 ft, 100.0 ft, 170.0 ft, 220.0 ft, and 241.35 ft bgs. At location 33-60939, samples were collected from 56.0 ft, 100.0 ft, 148.0 ft, 193.5 ft, 203.4 ft, and 213.4 ft bgs. At location 33-60940, samples were collected from 30.0 ft, 68.0 ft, 100.0 ft, 166.0 ft, 217.5 ft, and 228.2 ft bgs. All samples were analyzed at off-site fixed laboratories for VOCs and tritium.

The 2020–2021 sampling locations at MDA K are shown in Figure 6.2-1. Table 6.2-1 presents the samples collected and analyses requested for MDA K. The geodetic coordinates of sample locations are presented in Table 3.2-1.

6.2.2.2 Soil, Rock, and Sediment Field-Screening Results

During headspace screening for organic vapors, a maximum concentration of 0.4 ppm was detected at location 33-60938 from 217.15 to 218.15 ft bgs. For the radiological-screening results, five samples exceeded twice the maximum site background levels for alpha-emitting radionuclides and three samples exceeded twice the maximum site background levels for beta/gamma-emitting radionuclides. No changes were made to sampling or other activities based on field-screening results. Field-screening results are presented in Table 3.2-2.

6.2.2.3 Rock and Vapor Sampling Analytical Results

Decision-level data associated with the tritium contamination at MDA K consist of results from 33 samples (15 tuff and 18 pore gas) collected from 3 locations.

Inorganic Chemicals

No samples were analyzed for inorganic chemicals per the approved investigation work plan (LANL 2010, 111298; NMED 2011, 201242).

Organic Chemicals

A total of 18 pore-gas samples were collected and analyzed for VOCs. Table 6.2-2 presents the detected organic chemicals. Figure 6.2-2 shows the spatial distribution of detected organic chemicals.

Organic chemicals detected in the boreholes at MDA K include acetone; bromodichloromethane; chloroform; ethanol; 2-propanol; toluene; 1,1,2-trichloro-1,1,2-trifluoroethane; and trichloroethene. The detected organic chemicals listed are retained as COPCs.

Radionuclides

A total of 15 tuff samples and 18 pore-gas samples were collected and analyzed for tritium. Tables 6.2-3 and 6.2-4 present the radionuclides detected or detected above BVs/FVs. Figures 6.2-3 and 6.2-4 show the spatial distribution of radionuclides detected or detected above BVs/FVs.

Tritium was detected in one Qct sample at an activity of 7.84 pCi/g. Tritium was detected in 14 pore-gas samples with a maximum activity of 17,627.2 pCi/L. Tritium is retained as a COPC.

Tier I Screening

Analytical results compared with Tier I screening values are shown in Tables 4.6-1 and 4.6-2.

6.2.2.4 Nature and Extent of Soil and Rock Contamination

The nature and extent of organic and radionuclide COPCs in the boreholes at MDA K are discussed below. The spatial distribution of COPCs was evaluated using the data presented in Tables 6.2-2, 6.2-3, and 6.2-4, and Figures 6.2-2, 6.2-3, and 6.2-4.

Organic Chemicals

Organic COPCs in the boreholes at MDA K include acetone; bromodichloromethane; chloroform; ethanol; 2-propanol; toluene; 1,1,2-trichloro-1,1,2-trifluoroethane; and trichloroethene.

Acetone was detected in one sample with a concentration of 50 μg/m^3. Concentrations decreased with depth at location 33-60939 and were not detected in the boreholes to the south and southwest. The Tier I pore-gas screening concentration (20,300 μg/m^3) was approximately 406 times the detected concentration. The vertical extent of acetone is defined, and further sampling for lateral extent is not warranted.

Bromodichloromethane was detected in one sample with a concentration of 21 μg/m^3. Concentrations increased with depth at location 33-60938 and decreased laterally to the east and north. The Tier I pore-gas screening concentration (116 μg/m^3) was approximately 5.5 times the detected concentration. The lateral extent of bromodichloromethane is defined, and further sampling for vertical extent is not warranted.

Chloroform was detected in four samples with a maximum concentration of 23 μg/m^3. Concentrations increased to 220 ft at location 33-60938, and did not change substantially to 241 ft bgs. Chloroform was not detected in the boreholes to the east and north. The Tier I pore-gas screening concentration (12,000 μg/m^3) was approximately 521 times the maximum concentration. The lateral extent of chloroform is defined, and further sampling for vertical extent is not warranted.

Ethanol was detected in one sample with a concentration of 58 μg/m^3. Concentrations decreased with depth at location 33-60939 and increased laterally. The vertical extent of ethanol is defined, and further sampling for vertical extent is not warranted.

Propanol[2-] was detected in one sample with a concentration of 34 μg/m^3. Concentrations decreased with depth at location 33-60939 and was not detected in the boreholes to the south and southwest. The

Tier I pore-gas screening concentration (136 µg/m^3) was approximately 4 times the detected concentration. The vertical extent of 2-propanol is defined, and further sampling for lateral extent is not warranted.

Toluene was detected in one sample with a concentration of 6.8 µg/m^3. Concentrations decreased with depth at location 33-60940 and increased laterally to the east. The Tier I pore-gas screening concentration (272,000 µg/m^3) was approximately 40,000 times the detected concentration. The vertical extent of toluene is defined, and further sampling for lateral extent is not warranted.

Trichloro-1,2,2-trifluoroethane[1,1,2-] was detected in nine samples with a maximum concentration of 57 µg/m^3. Concentrations decreased with depth at locations 33-60938 and 33-60939 and increased with depth at location 33-60940 and increased laterally to the east. The Tier I pore-gas screening concentration (1,190,000,000 µg/m^3) was approximately 20,880,000 times the maximum concentration. Further sampling for vertical extent and lateral extent of 1,1,2-trichloro-1,2,2-trifluoroethane is not warranted.

Trichloroethene was detected in five samples with a maximum concentration of 18 µg/m^3. Concentrations decreased with depth at locations 33-60938 and 33-60939 and decreased laterally to the east. The Tier I pore-gas screening concentration (2020 µg/m^3) was approximately 112 times the maximum concentration. The vertical extent of trichloroethene is defined, and further sampling for lateral extent is not warranted.

Radionuclides

The radionuclide COPC in the boreholes at MDA K is tritium.

Tritium was detected in 14 gas samples at a maximum activity of 17,627.2 pCi/L. At location 33-60939, the activity did not change significantly from 17,627.2 pCi/L at 203.4 ft bgs to 16,407.9 pCi/L at 213.4 ft bgs. Activities decreased with depth at the other two locations and increased laterally to the northeast.

Tritium was detected in one tuff sample at an activity of 7.84 pCi/g at location 33-60939 in the deepest sample (214.9–215.9 ft bgs). Activities increased with depth at location 33-60939 and increased laterally northeast from the tritium facility and associated septic system, seepage pits, and drainlines. The vertical and lateral extent of tritium in tuff is not defined.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Nature and Extent of Contamination

Based on the evaluation of the data, the nature and extent of the VOC contamination in pore gas has been defined for the three boreholes drilled. However, the extent of VOC contamination in pore gas has not been defined in the central part of MDA K, adjacent to areas where releases occurred.

Based on the evaluation of the data, the extent of the tritium contamination in tuff has not been defined. Tritium activities in the tuff samples show the highest activity at location 33-60939, which is north and northeast of the other two locations. Additional information is required to understand and delineate the tritium contamination.

Based on the evaluation of the data, the extent of the tritium contamination in pore gas has not been defined. Tritium activities in the pore-gas samples show the highest activity at location 33-60939, which is north and northeast of the other two locations. Additional information is required to understand and delineate the tritium contamination in pore gas associated with MDA K.

7.2 Recommendations

The recommendations are based on soil/fill, tuff, and pore-gas data for MDA K.

Drilling three additional boreholes is recommended to define the extent of the VOC and tritium contamination in pore gas associated with MDA K (Figure 7.2-1). Boreholes BH-1, BH-2, and BH-3 are recommended to be drilled, core samples collected, and pore-gas monitoring systems installed. Another round of pore-gas samples from locations 33-60938, 33-60939, and 33-60940 is recommended for collection of VOC and tritium samples.

The proposed location for borehole BH-1 is proposed to be downgradient of the outfall for SWMU 33-002(d) and slightly south of one of the original planned boreholes. The proposed location for borehole BH-2 was chosen to define the activity of the tritium south of the SWMU 33-002(b) seepage pit. The proposed location for borehole BH-3 is downgradient and south of the outfall associated with SWMU 33-002(e) and slightly north of one of the original planned boreholes.

The locations, depths, number of samples, and analytical suites will be included in a Phase III investigation work plan for Chaquehui Canyon Aggregate Area.

8 0 REFERENCES AND MAP DATA SOURCES

8.1 References

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID, ESHID, or EMID. This information is also included in text citations. ERIDs were assigned by the Laboratory's Associate Directorate for Environmental Management (IDs through 599999); ESHIDs were assigned by the Laboratory's Associate Directorate for Environment, Safety, and Health (IDs 600000 through 699999); and EMIDs are assigned by N3B (IDs 700000 and above). IDs are used to locate documents in N3B's Records Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and N3B maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

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8.2 Map Data Sources

Data sources for all figures are provided below, unless otherwise indicated on the figures themselves.

Sampling location- er_location_ids_pnt; Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2010-0035; 21 January 2010.

SWMU or AOC: er_prs_all_reg, Potential Release Sites; Los Alamos National Laboratory, Waste and Environmental Services Division, Environmental Data and Analysis Group, EP2009-0633; 1:2,500 Scale Data; 25 January 2010.

Structure or Building: ksl_structures_ply; Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Fence: ksl_fences_arc; Security and Industrial Fences and Gates; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Paved road: ksl_paved_rds_arc; Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Dirt road: ksl_dirt_rds_arc; Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Storm drain: ksl_stormdrn_arc; Storm Drain Line Distribution System; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Contours: lanl_contour1991_; Hypsography, 2, 10, 20, 100 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

Communication: ksl_comm_arc; Communication Lines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 08 August 2002; as published 28 May 2009.

Electric: ksl_electric_arc; Primary Electric Grid; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Gas: ksl_gas_arc; Primary Gas Distribution Lines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Industrial waste: wfm_indstrl_waste_arc; Primary Industrial Waste Lines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 January 2009.

Sewer: ksl_sewer_arc; Sewer Line System; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Steam: ksl_steam_arc; Steam Line Distribution System; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Water: ksl_water_arc; Water Lines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

LANL Boundary: plan_ownerclip_reg; Ownership Boundaries Around LANL Area; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; 19 September 2007; as published 04 December 2008.

Roads: lac_streets_arc; Streets; County of Los Alamos, Information Services; as published 16 May 2006.

Landscape: ksl_landscape_arc; Primary Landscape Features; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Former structures: frmr_structures_ply; Former Structures of the Los Alamos Site; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2008-0441; 1:2,500 Scale Data; 08 August 2008.

Technical area boundary: plan_tecareas_ply; Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 04 December 2008.

Inactive Outfall: wqh_inact_outfalls_pnt; WQH Inactive Outfalls; Los Alamos National Laboratory, ENV Water Quality and Hydrology Group; Edition 2002.01; 01 September 2003.

NPDES Outfalls: wqh_npdes_outfalls_pnt: WQH NPDES Outfalls; Los Alamos National Laboratory, ENV Water Quality and Hydrology Group; Edition 2002.01; 01 September 2003.

Outfalls: er_outfalls_pnt: Outfalls; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; Unknown publication date.

Monitoring wells: Environmental Surveillance at Los Alamos During 2006, Groundwater monitoring; LANL Report LA-14341-ENV, September 2007.

Supply Wells: Locations of Monitoring and Supply Wells at Los Alamos National Laboratory, Table A-2, 2009 General Facility Information; LANL Report LA-UR-09-1341; March 2009.

Drainage: wqh_drainage_arc: WQH Drainage_arc; Los Alamos National Laboratory, ENV Water Quality and Hydrology Group; 1:24,000 Scale Data; 03 June 2003.

Aggregate Area: er_agg_areas_ply: Aggregate Areas; Los Alamos National Laboratory, ENV Environmental Remediation & Surveillance Program, ER2005-0496; 1:2,500 Scale Data; 22 September 2005.

Canyon Reaches: er_reaches_ply: Canyon Reaches; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program, ER2002-0592; 1:24,000 Scale Data; Unknown publication date.

Springs: er_springs_pnt: Locations of Springs; Los Alamos National Laboratory, Waste and Environmental Services Division in cooperation with the New Mexico Environment Department, Department of Energy Oversight Bureau, EP2008-0138; 1:2,500 Scale Data; 17 March 2008.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating, and Mapping Section; 06 January 2004; Development Edition of 05 January 2005.

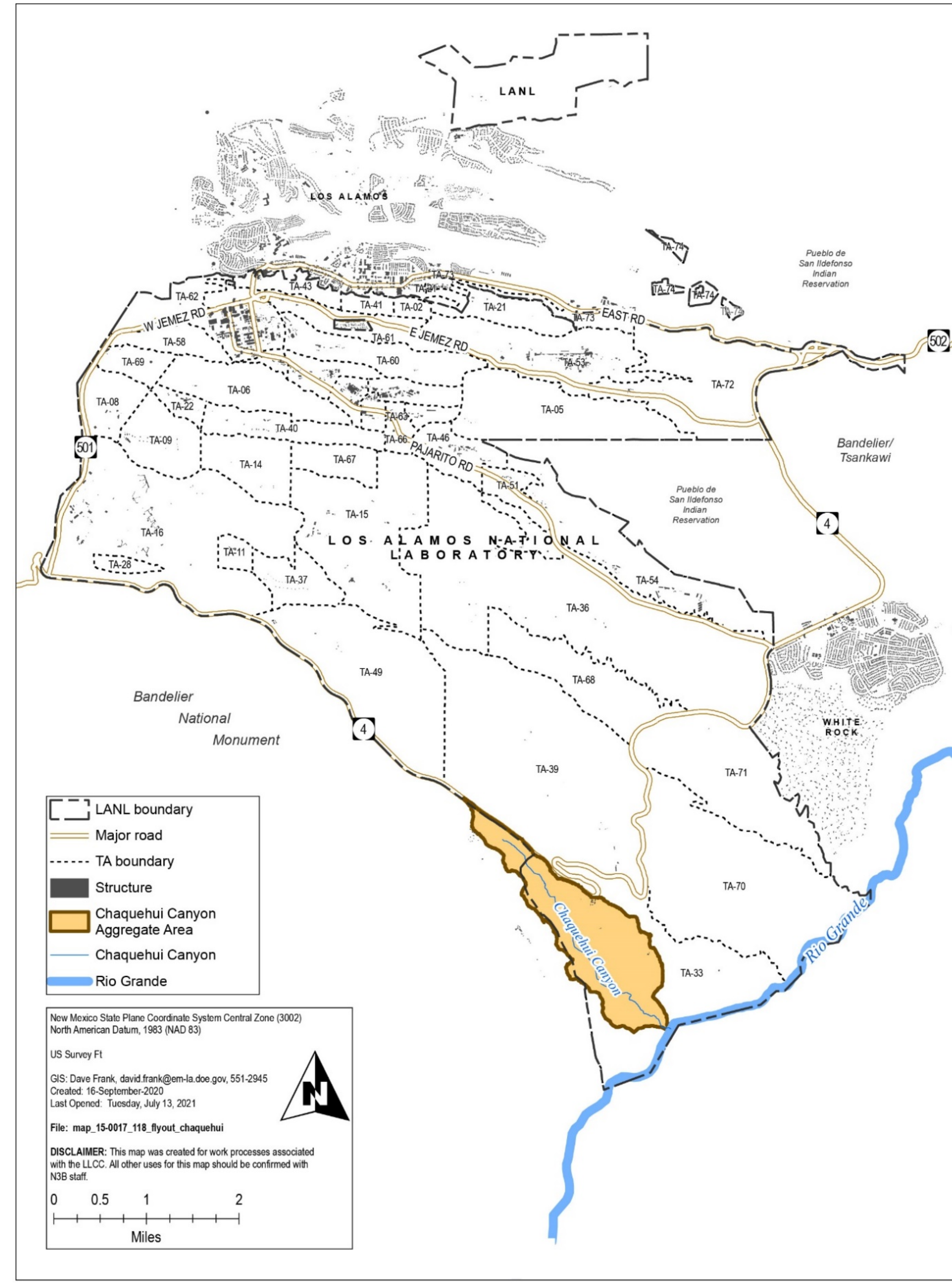


Figure 1.1-1 Location of Chaquehui Canyon Aggregate Area with respect to Laboratory technical areas

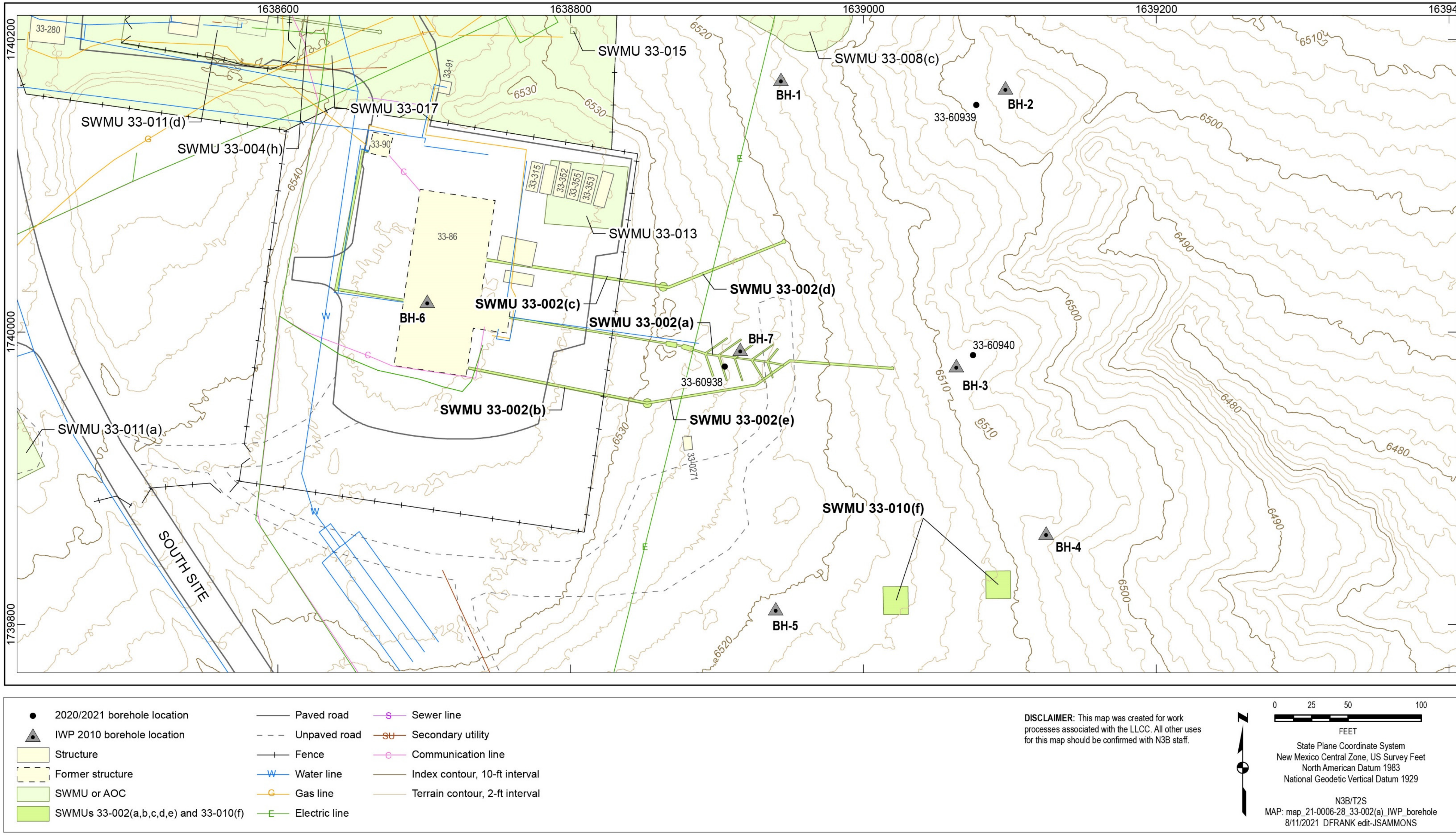


Figure 2.4-1 Investigation work plan–approved borehole locations and actual boreholes drilled in 2020–2021

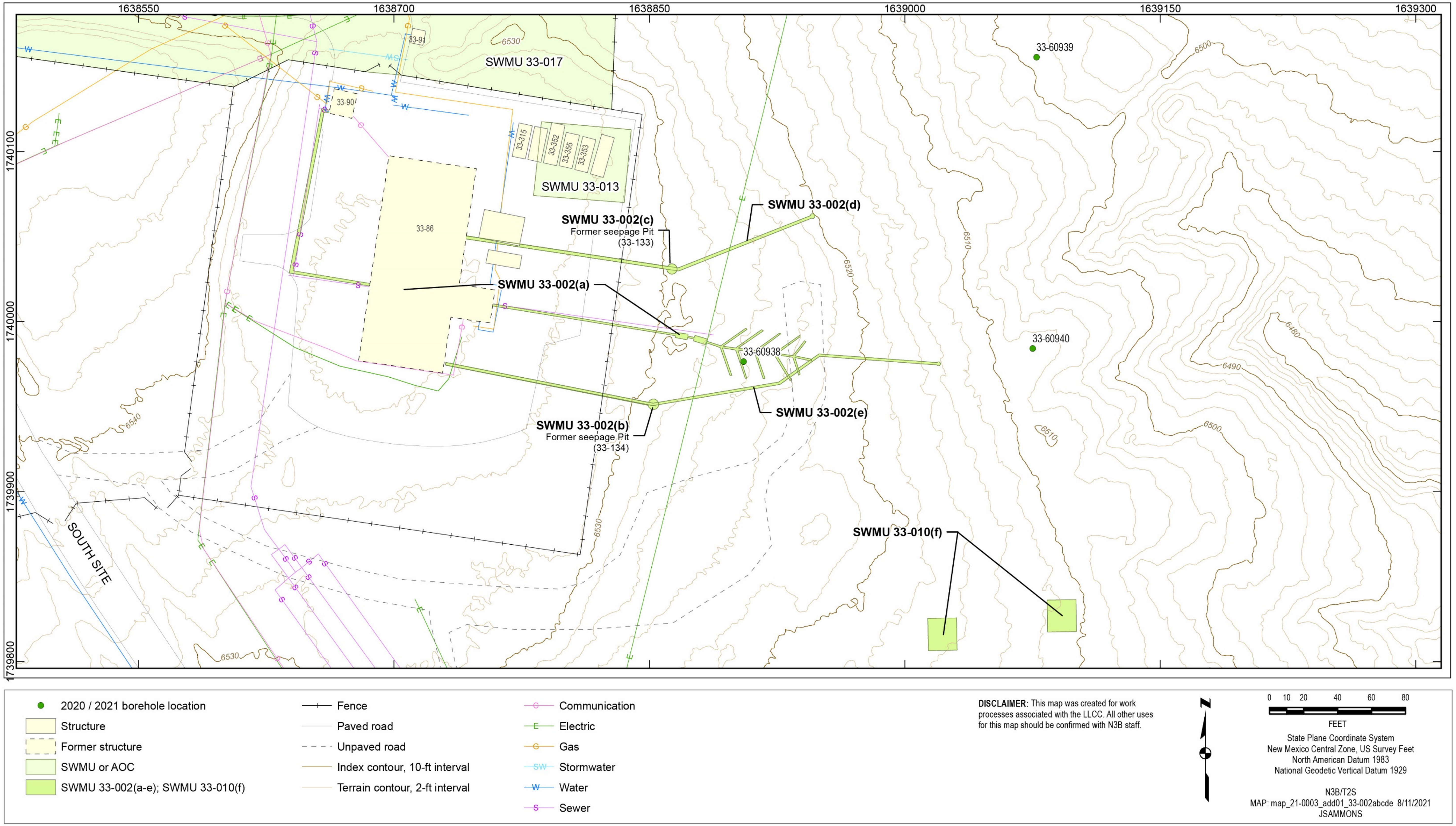


Figure 6.2-1 MDA K borehole locations

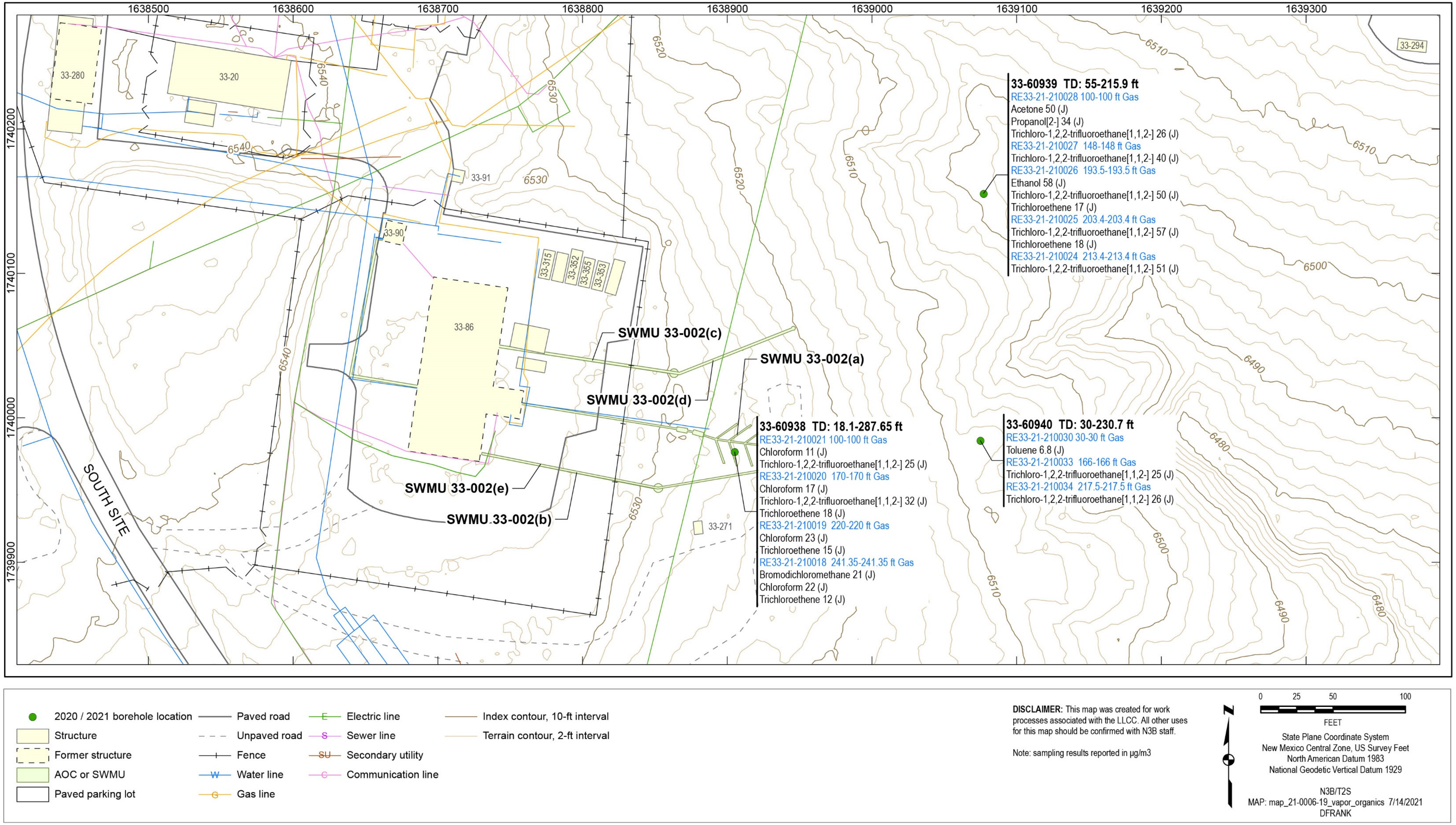


Figure 6.2-2 Organic chemicals detected in pore gas in boreholes at MDA K

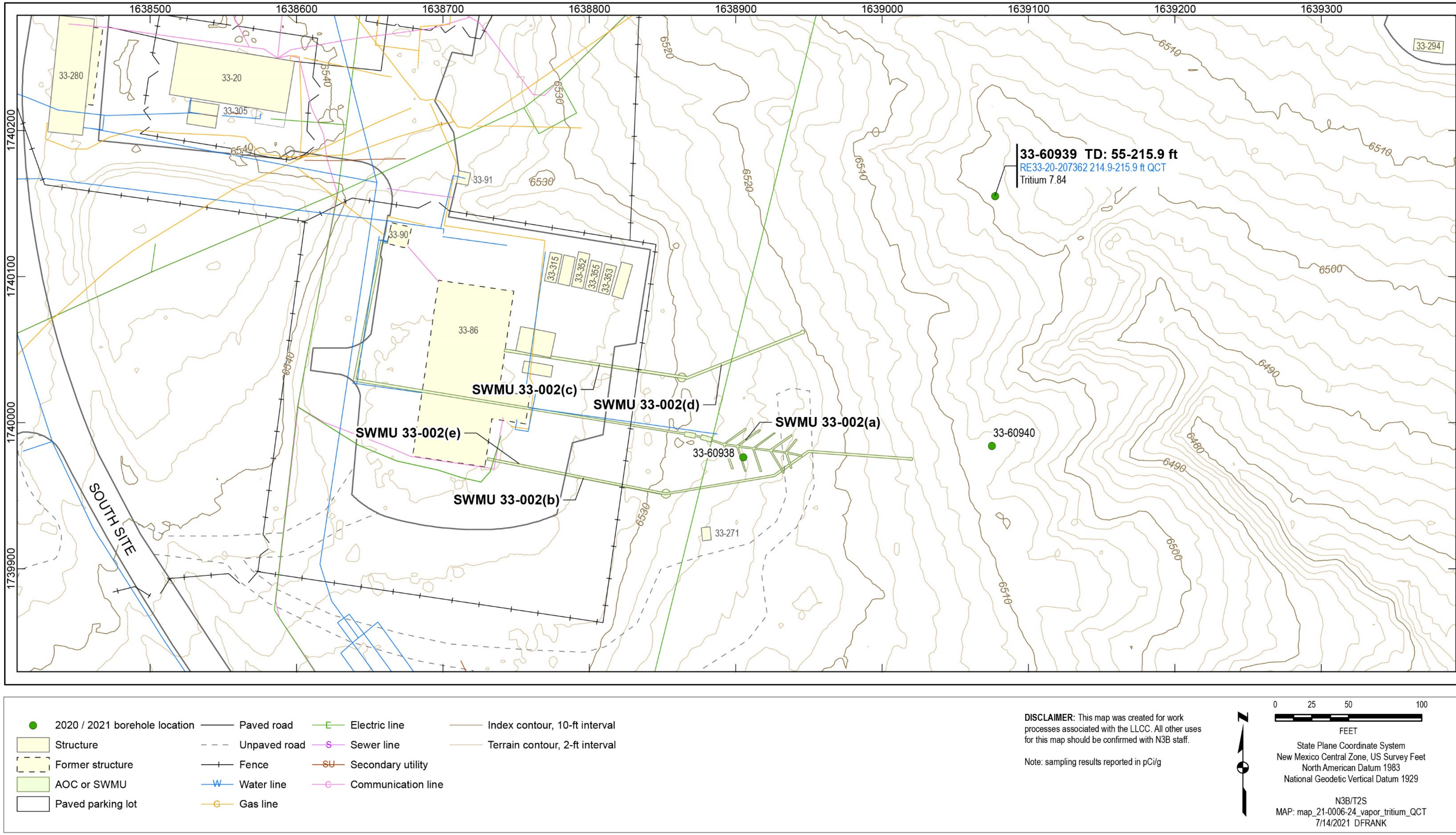


Figure 6.2-3 Tritium detected or detected above BVs/FVs in tuff in boreholes at MDA K

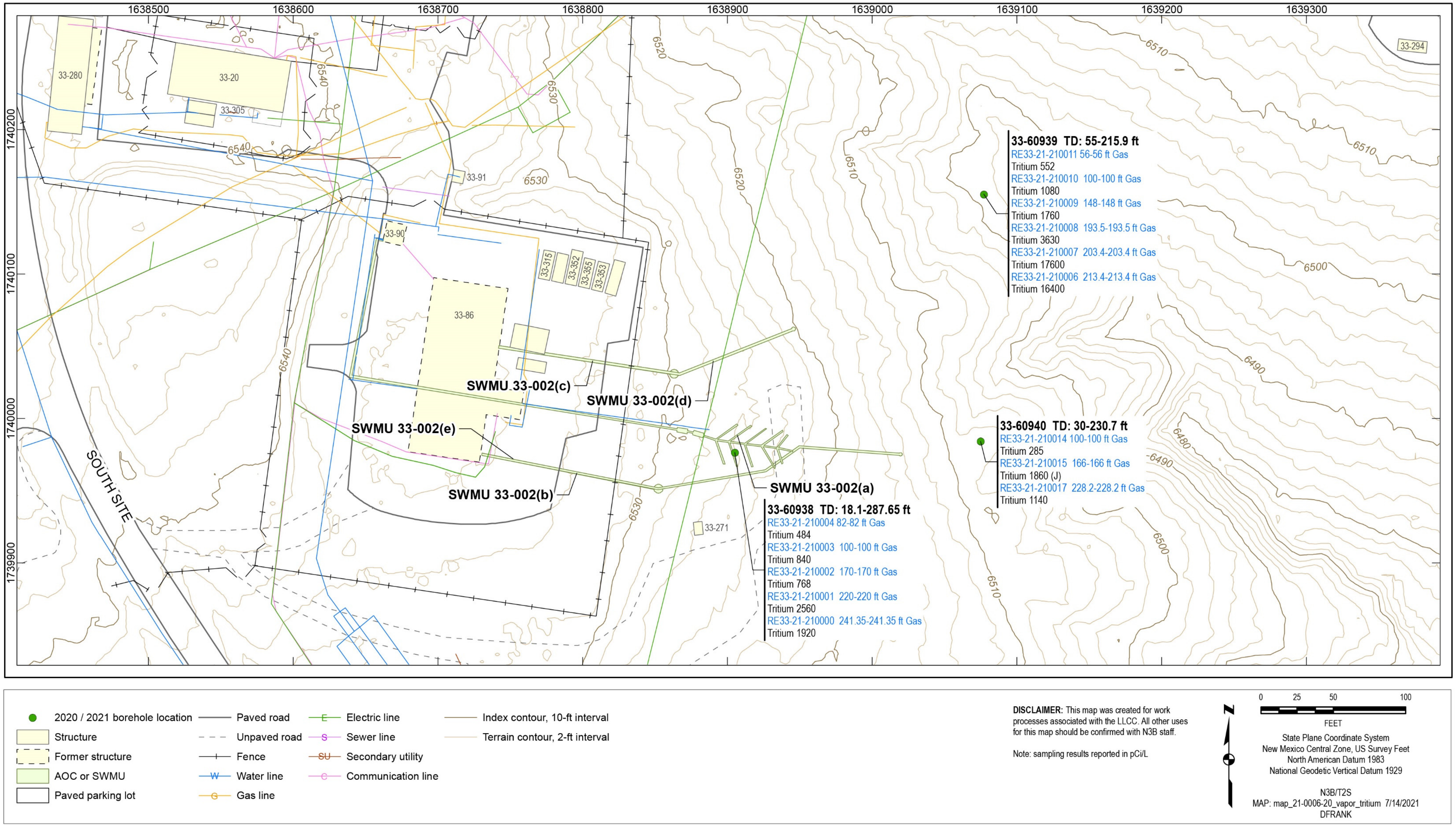


Figure 6.2-4 Tritium detected in pore gas in boreholes at MDA K

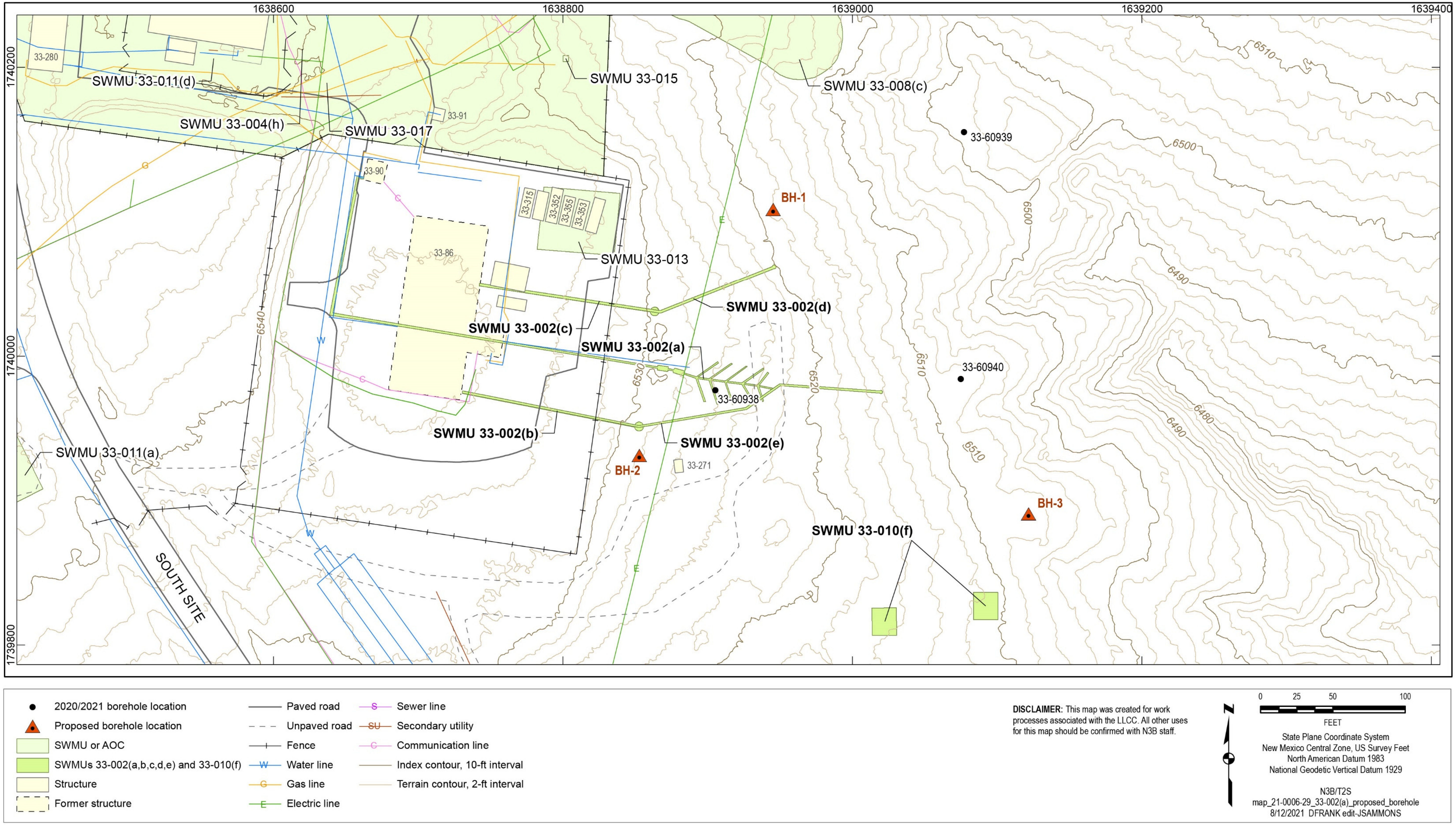


Figure 7.2-1 Proposed MDA K boreholes

Table 1.1-1
Sites under Investigation in the Addendum for Chaquehui Canyon Aggregate Area

SWMU/AOC	Brief Description	2019–2020 Investigation	Current Status
SWMU 33-002(a)	Septic System (MDA K)	Sampled	Investigation report (section 6.7)
SWMU 33-002(b)	Sump (MDA K)	Sampled	Investigation report (section 6.8)
SWMU 33-002(c)	Sump (MDA K)	Sampled	Investigation report (section 6.9)
SWMU 33-002(d)	Drainline and Outfall from Former Building 33-86 (MDA K)	Sampled	Investigation report (section 6.10)
SWMU 33-002(e)	Drainline and Outfall from Former Building 33-86 (MDA K)	Sampled	Investigation report (section 6.11)
SWMU 33-010(f)	Surface Disposal Site (MDA K)	Sampled	Investigation report (section 6.30)

Table 3.2-1
Surveyed Coordinates for MDA K Borehole Locations

SWMU/AOC	Location ID	Easting (ft)	Northing (ft)
MDA K borehole	33-60938	1638905.23	1739976.362
	33-60939	1639077.27	1740155.455
	33-60940	1639075.00	1739984.153

Table 3.2-2
Field-Screening Results for Tuff Samples Collected at MDA K Boreholes

Location ID	Sample ID	Start Depth (ft)	End Depth (ft)	Alpha Reading (dpm[a]/100 cm^2)	Beta/Gamma Reading (dpm/100 cm^2)	PID[b] Ambient Reading	PID Reading	Background Alpha (dpm/100 cm^2)	Background Beta/Gamma (dpm/100 cm^2)
33-60938	RE33-20-207352	18.1	19.1	26.7	1868	0.0	0.3	10.1	971
33-60938	RE33-20-207353	81.5	82.5	17	2189	0.0	0.0	17	1222
33-60938	RE33-20-207354	169.15	172.15	20.4	1707	0.0	0.1	5.4	961
33-60938	RE33-20-207355	217.15	218.15	56.2	2028	0.0	0.4	10.2	901
33-60938	RE33-20-207356	228.7	230.15	10.2	1112	0.0	0.1	10.2	901
33-60938	RE33-20-207357	286.65	287.65	20.4	1232	0.0	0.0	15.3	913
33-60939	RE33-20-207358	55.0	56.0	5.2	1866	0.0	0.1	15.8	1729
33-60939	RE33-20-207359	146.2	147.2	47.3	1963	0.0	0.0	21	1902
33-60939	RE33-20-207360	200.0	201.0	21	1489	0.0	0.0	15	943
33-60939	RE33-20-207361	211.2	212.0	27	1650	0.0	0.0	15	943
33-60939	RE33-20-207362	214.9	215.9	14	943	0.0	0.0	15	943
33-60940	RE33-20-207363	66.95	67.95	58.9	1682	0.0	0.0	10	816
33-60940	RE33-20-207364	165.0	166.0	32.2	1489	0.0	0.0	36.8	1116
33-60940	RE33-20-207365	218.5	219.5	21	1824	0.0	0.0	27	747
33-60940	RE33-20-207366	229.5	230.7	37	1108	0.0	0.0	27	747

[a] dpm = Disintegrations per minute.

[b] PID = Photoionization detector.

Table 4.6-1
Tier I Pore-Gas Screening Calculations

VOC	Henry's Law Constant[a] (dimensionless)	Groundwater SL (µg/L)	Source of Groundwater SL	Tier I Pore-Gas Concentrations Corresponding to Groundwater Standard (µg/m^3)
Acetone	0.00144	14,100	NMED Tap Water[b]	20,300
Bromodichloromethane	0.0869	1.34	NMED Tap Water	116
Chloroform	0.15	80	EPA MCL[c]	12,000
Ethanol	na[d]	na	na	na
Propanol[2-]	0.000331	410	EPA Tap Water	136
Toluene	0.272	1000	NMWQCC[e]	272,000
Trichloro-1,2,2-trifluoroethane[1,1,2-]	21.6	55,000	NMED Tap Water	1,190,000,000
Trichloroethene (TCE)	0.404	5	NMWQCC	2020

[a] The source of Henry's law constants is the "NMED Risk Assessment Guidance for Site Investigations and Remediation Volume 1, Soil Screening Guidance for Human Health Risk Assessments" (NMED 2019, 700550) or the EPA regional screening tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables).

[b] NMED 2019, 700550.

[c] MCL = Maximum contaminant level; 20.6.2.3103 New Mexico Administrative Code.

[d] na = Not available.

[e] NMWQCC = New Mexico Water Quality Control Commission; https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables.

Table 4.6-2
VOC Tier 1 Screening at MDA K

VOC	Maximum Pore Gas Concentration (µg/m^3)	Tier 1 Screening Level Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard (µg/m^3)	Tier 1 Potential for Groundwater Impact[a]
Acetone	50 (J)[b]	20,300	No
Bromodichloromethane	21 (J)	116	No
Chloroform	23 (J)	12,000	No
Propanol[2-]	34 (J)	136	No
Toluene	6.8 (J)	272,000	No
Trichloro-1,2,2-trifluoroethane[1,1,2-]	57 (J)	1,190,000,000	No
Trichloroethene (TCE)	18 (J)	2020	No

Notes: Tier 1 screening concentration is the calculated concentration in pore gas exceeding groundwater standard derived from Equation 3.1-2. Shaded cells indicate VOCs that did not pass the Tier 1 screen.

[a] If concentration of a VOC measured in a pore-gas sample is less than the pore-gas SL, the concentration of the VOC in soil vapor will not exceed the groundwater SL, even if the VOC plume is in direct contact with groundwater.

[b] (J) = The analyte was positively identified and the associated numerical value is estimated to be more uncertain than would normally be expected for that result.

Table 6.2-1
Samples Collected and Analyses Requested for MDA K

Sample ID	Location ID	Depth (ft)	Media	Tritium	VOCs
RE33-20-207352	33-60938	18.1–19.1	QBT3	N3B-2021-15	—*
RE33-21-210005	33-60938	19.0	Pore gas	N3B-2021-648	—
RE33-21-210023	33-60938	19.0	Pore gas	—	N3B-2021-647
RE33-20-207353	33-60938	81.5–82.5	QBT2	N3B-2021-15	—
RE33-21-210004	33-60938	82.0	Pore gas	N3B-2021-648	—
RE33-21-210022	33-60938	82.0	Pore gas	—	N3B-2021-647
RE33-21-210003	33-60938	100.0	Pore gas	N3B-2021-648	—
RE33-21-210021	33-60938	100.0	Pore gas	—	N3B-2021-647
RE33-20-207354	33-60938	169.15–170.15	QBT1V	N3B-2021-42	—
RE33-21-210002	33-60938	170.0	Pore gas	N3B-2021-648	—
RE33-21-210020	33-60938	170.0	Pore gas	—	N3B-2021-647
RE33-20-207355	33-60938	217.15–218.15	QBT1G	N3B-2021-56	—
RE33-21-210001	33-60938	220.0	Pore gas	N3B-2021-648	—
RE33-21-210019	33-60938	220.0	Pore gas	—	N3B-2021-647
RE33-20-207356	33-60938	228.7–230.15	QCT	N3B-2021-56	—
RE33-21-210000	33-60938	241.35	Pore gas	N3B-2021-648	—
RE33-21-210018	33-60938	241.35	Pore gas	—	N3B-2021-647
RE33-20-207357	33-60938	286.65–287.65	TCB	N3B-2021-58	—
RE33-20-207358	33-60939	55.0–56.0	QBT2	N3B-2021-543	—
RE33-21-210011	33-60939	56.0	Pore gas	N3B-2021-816	—
RE33-21-210029	33-60939	56.0	Pore gas	—	N3B-2021-801
RE33-21-210010	33-60939	100.0	Pore gas	N3B-2021-816	
RE33-21-210028	33-60939	100.0	Pore gas	—	N3B-2021-801
RE33-20-207359	33-60939	146.2–147.2	QBT1V	N3B-2021-543	—
RE33-21-210009	33-60939	148.0	Pore gas	N3B-2021-816	—
RE33-21-210027	33-60939	148.0	Pore gas	—	N3B-2021-801
RE33-21-210008	33-60939	193.5	Pore gas	N3B-2021-816	—
RE33-21-210026	33-60939	193.5	Pore gas	—	N3B-2021-801
RE33-20-207360	33-60939	200.0–201.0	QBT1G	N3B-2021-543	—
RE33-21-210007	33-60939	203.4	Pore gas	N3B-2021-816	—
RE33-21-210025	33-60939	203.4	Pore gas	—	N3B-2021-801
RE33-20-207361	33-60939	211.2–212	QBTT	N3B-2021-543	—
RE33-21-210006	33-60939	213.4	Pore gas	N3B-2021-816	—

Table 6.2-1 (continued)

Sample ID	Location ID	Depth (ft)	Media	Tritium	VOCs
RE33-21-210024	33-60939	213.4	Pore gas	—	N3B-2021-801
RE33-20-207362	33-60939	214.9–215.9	QCT	N3B-2021-543	—
RE33-21-210012	33-60940	30.0	Pore gas	N3B-2021-826	—
RE33-21-210030	33-60940	30.0	Pore gas	—	N3B-2021-815
RE33-20-207363	33-60940	66.95–67.95	QBT2	N3B-2021-695	—
RE33-21-210013	33-60940	68.0	Pore gas	N3B-2021-826	—
RE33-21-210031	33-60940	68.0	Pore gas	—	N3B-2021-815
RE33-21-210014	33-60940	100.0	Pore gas	N3B-2021-826	—
RE33-21-210032	33-60940	100.0	Pore gas	—	N3B-2021-815
RE33-20-207364	33-60940	165.0–166.0	QBT1V	N3B-2021-696	—
RE33-21-210015	33-60940	166.0	Pore gas	N3B-2021-826	—
RE33-21-210033	33-60940	166.0	Pore gas	—	N3B-2021-815
RE33-21-210016	33-60940	217.5	Pore gas	N3B-2021-826	—
RE33-21-210034	33-60940	217.5	Pore gas	—	N3B-2021-815
RE33-20-207365	33-60940	218.5–219.5	QBT1G	N3B-2021-709	—
RE33-21-210017	33-60940	228.2	Pore gas	N3B-2021-826	—
RE33-21-210035	33-60940	228.2	Pore gas	—	N3B-2021-815
RE33-20-207366	33-60940	229.5–230.7	TP	N3B-2021-709	—

Note: Numbers in analyte columns are request numbers.

*— = Analysis not requested.

Table 6.2-2
Organic Chemicals Detected in Pore Gas at MDA K

Sample ID	Location ID	Depth (ft)	Media	Acetone	Bromodichlormethane	Chloroform	Ethanol	Propanol[2-]	Toluene	Trichloro-1,2,2-trifluoroethane[1,1,2-]	Trichloroethene
Tier I Pore-Gas Screening Concentrations				**20,300**	**116**	**12,000**	**na[a]**	**136**	**272,000**	**1,190,000,000**	**2020**
RE33-21-210021	33-60938	100.0–100.0	Gas	—[b]	—	11 (J)	—	—	—	25 (J)	—
RE33-21-210020	33-60938	170.0–170.0	Gas	—	—	17 (J)	—	—	—	32 (J)	18 (J)
RE33-21-210019	33-60938	220.0–220.0	Gas	—	—	23 (J)	—	—	—	—	15 (J)
RE33-21-210018	33-60938	241.35–241.35	Gas	—	21 (J)	22 (J)	—	—	—	—	12 (J)
RE33-21-210028	33-60939	100.0–100.0	Gas	50 (J)	—	—	—	34 (J)	—	26 (J)	—
RE33-21-210027	33-60939	148.0–148.0	Gas	—	—	—	—	—	—	40 (J)	—
RE33-21-210026	33-60939	193.5–193.5	Gas	—	—	—	58 (J)	—	—	50 (J)	17 (J)
RE33-21-210025	33-60939	203.4–203.4	Gas	—	—	—	—	—	—	57 (J)	18 (J)
RE33-21-210024	33-60939	213.4–213.4	Gas	—	—	—	—	—	—	51 (J)	—
RE33-21-210030	33-60940	30.0–30.0	Gas	—	—	—	—	—	6.8 (J)	—	—
RE33-21-210033	33-60940	166.0–166.0	Gas	—	—	—	—	—	—	25 (J)	—
RE33-21-210034	33-60940	217.5–217.5	Gas	—	—	—	—	—	—	26 (J)	—

Notes: Results are in $\mu g/m^3$. Data qualifiers are presented in Appendix A.

[a] na = Not available.

[b] — = Not detected.

Table 6.2-3
Radionuclides Detected above BVs/FVs in Tuff at MDA K

Sample ID	Location ID	Depth (ft)	Media	Tritium
Qct Background Value[a]				**0.3**
Construction Worker SAL[b]				**1,600,000**
Industrial SAL[b]				**2,400,000**
Residential SAL[b]				**1700**
RE33-20-207362	33-60939	214.9–215.9	QCT	7.84

Note: Results are in pCi/g.
[a] BVs from LANL (1998, 059730).
[b] Screening action levels (SALs) from LANL (2015, 600929).

Table 6.2-4
Radionuclides Detected in Pore Gas at MDA K

Sample ID	Location ID	Depth (ft)	Media	Tritium
Tier I Pore-Gas Maximum Contaminant Level*				**20,000**
RE33-21-210004	33-60938	82.0–82.0	Gas	484.024
RE33-21-210003	33-60938	100.0–100.0	Gas	839.911
RE33-21-210002	33-60938	170.0–170.0	Gas	768.004
RE33-21-210001	33-60938	220.0–220.0	Gas	2563.48
RE33-21-210000	33-60938	241.35–241.35	Gas	1915.01
RE33-21-210011	33-60939	56.0–56.0	Gas	551.886
RE33-21-210010	33-60939	100.0–100.0	Gas	1078.65
RE33-21-210009	33-60939	148.0–148.0	Gas	1757.64
RE33-21-210008	33-60939	193.5–193.5	Gas	3631.89
RE33-21-210007	33-60939	203.4–203.4	Gas	17,627.2
RE33-21-210006	33-60939	213.4–213.4	Gas	16,407.9
RE33-21-210014	33-60940	100.0–100.0	Gas	284.735
RE33-21-210015	33-60940	166.0–166.0	Gas	1864.57 (J)
RE33-21-210017	33-60940	228.2–228.2	Gas	1142.82

Note: Results are in pCi/L.
*Maximum contaminant level from the Clean Water Act.

Appendix A

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

A-1.0 ACRONYMS AND ABBREVIATIONS

AOC	area of concern
bgs	below ground surface
BV	background value
COC	chain of custody
Consent Order	Compliance Order on Consent
COPC	chemical of potential concern
D&D	decontamination and decommissioning
DL	detection limit
DOE	Department of Energy (U.S.)
dpm	disintegrations per minute
DU	depleted uranium
EIM	Environmental Information Management (database)
EPA	Environmental Protection Agency (U.S.)
EQL	estimated quantitation limit
FV	fallout value
gpm	gallons per minute
GPS	global positioning system
HE	high explosives
HP	Hot Point (Site)
ID	identification
I.D.	inside diameter
IDW	investigation-derived waste
LANL	Los Alamos National Laboratory
Ma	millions of years
MCL	maximum contaminant level (EPA)
MDA	material disposal area
N3B	Newport News Nuclear BWXT-Los Alamos, LLC
NFA	no further action
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
NPDES	National Pollutant Discharge Elimination System
NRAO	National Radio Astronomy Observatory

O.D.	outside diameter
PID	photoionization detector
PPE	personal protective equipment
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RCT	radiological control technician
RFI	RCRA facility investigation
SAL	screening action level
SCL	sample collection log
SL	screening level
SL_{gw}	groundwater screening level
SL_{pgl}	Tier I pore-gas screening level
SMO	Sample Management Office
SOP	standard operating procedure
SSL	soil screening level
SWMU	solid waste management unit
TA	technical area
TCE	trichloroethene
TD	total depth
Triad	Triad National Security, LLC
UTL	upper tolerance limit
VCA	voluntary corrective action
VCP	vitrified clay pipe
VISL	vapor intrusion screening level
VOC	volatile organic compound
WCSF	waste characterization strategy form

A-2.0 METRIC CONVERSION TABLE

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

A-3.0 DATA QUALIFIER DEFINITIONS

Data Qualifier	Definition
U	The analyte was analyzed for but not detected above the reported estimated quantitation limit.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample but likely to have a high bias.
J-	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample but likely to have a low bias.
UJ	The analyte was analyzed for but not detected. The associated value is an estimate.
R	The data are unusable. Note: Analyte may or may not be present.

Appendix B

Field Methods

B-1.0 INTRODUCTION

This appendix summarizes the field methods used during the 2020–2021 investigation of the Chaquehui Canyon Aggregate Area at Los Alamos National Laboratory (LANL or the Laboratory). Table B-1.0-1 presents a summary of the field methods used, and the following sections provide more detailed descriptions of these methods. All activities were conducted in accordance with standard operating procedures (SOPs) listed in Table B-1.0-2.

B-2.0 EXPLORATORY DRILLING CHARACTERIZATION

No exploratory drilling characterization was conducted. All drilling was conducted for the purpose of collecting investigation samples and installing a permanent vapor-monitoring well system to each borehole.

For the 2020–2021 investigation, three boreholes were drilled to depths ranging from 215.9 to 290 ft below ground surface (bgs), and vapor samples were collected to characterize the site. The tuff samples were extracted from the core barrels, placed in stainless-steel bowls with stainless-steel spoons, and then transferred to sterile sample collection jars. Samples were then submitted to the Sample Management Office (SMO) under COC for laboratory analyses as specified by the approved investigation work plan (LANL 2010, 111298; NMED 2011, 201242). Borehole logs are included in Appendix D.

While removing the hollow stem augers after drilling borehole 7 (renamed BH-7a), 130 ft of augers became stuck in the borehole. The borehole was abandoned in accordance with N3B-SOP-ER-6005, “Monitoring Well and Borehole Abandonment.” A new borehole, location 33-60938, was drilled.

At BH-3 (location 33-60940) the augers parted at 41.5 ft bgs during the installation of the vapor-monitoring equipment. The installation continued as planned. The augers remain in the borehole from 41.5 to 63.8 ft bgs and do not affect the vapor monitoring because there is no port in that depth range.

B-3.0 FIELD-SCREENING METHODS

This section summarizes the field-screening methods used during the investigation activities. Field screening for radioactivity and volatile organic compounds (VOCs) was performed on each sample collected. Field-screening results are presented in Table 3.2-2 of the addendum.

B-3.1 Field Screening for Organic Vapors

Field screening for organic vapors was conducted using an Ion Science Tiger VOC ppm photoionization detector (PID) equipped with an 11.7-electron volt lamp. Screening was performed in accordance with the manufacturer’s specifications. Screening was performed on each sample collected, and screening measurements were recorded on the field sample collection logs (SCLs) and chain-of-custody (COC) forms provided on CD in Appendix C. The field-screening results are presented in Table 3.2-2 of the addendum.

B-3.2 Field Screening for Subsurface Vapor

Subsurface vapor was screened before each vapor sample was collected. A LANDTEC GEM-500 gas extraction meter was connected to the formation airflow. During the purge, percent methane, percent carbon dioxide, and percent oxygen readings were recorded every several minutes. Screening measurements were recorded in each vapor-sample screening log. Additionally, before sampling began, a Newport News Nuclear BWXT-Los Alamos, LLC (N3B) radiological control technician (RCT) screened the port openings using an Overhoff 394-C tritium monitor.

B-3.3 Field Screening for Radioactivity

During sampling of tuff, each sample was screened for radioactivity shortly after it was collected, targeting alpha and beta/gamma emitters. Screening was performed using an Eberline E600 with a 380AB or RadEye SX with a L43-93 detector, and Eberline RO-20 dose rate meter. Screening measurements were recorded on the SCLs and COC forms and are provided in Appendix C on CD. These screening results are presented in Table 3.2-2 of the addendum.

B-4.0 FIELD INSTRUMENT CALIBRATION

All instruments were calibrated before use. Triad National Security, LLC (Triad) conducts the calibration of the Eberline E-600 and RadEye SX on an annual cycle. All calibrations were performed according to the manufacturer's specifications and requirements.

B-4.1 Eberline E-600 Calibration and RadEye SX Calibration and Response Check

An N3B RCT conducts a daily response check of the Eberline E-600 and RadEye SX before use to measure levels for radioactivity. All response checks were performed according to approved operating procedures. Response checks were recorded in daily functional check logs. Triad calibrated the instrument using americium-241 and chloride-36 sources for alpha and beta emissions, respectively. Calibration records are maintained by Triad.

B-4.2 Photoionization Detector Calibration

A qualified N3B Environment, Safety and Health representative conducted the calibration of the Ion Science Tiger VOC ppm PID. All calibrations were performed according to the manufacturer's specifications and requirements. The Ion Science Tiger VOC ppm PID was zeroed using ambient-air and bump-checked daily using 100-ppm isobutylene reference gas and evaluated within 5% of the stated value. If the bump check was outside the 5% tolerance, then a complete calibration was conducted to the 100-ppm isobutylene reference gas. Calibration records were maintained on-site using field instrumentation environmental monitoring forms.

B-5.0 SUBSURFACE SAMPLING

This section summarizes the methods used to collect subsurface samples of tuff and pore gas in accordance with the approved investigation work plan (LANL 2010, 111298.9; NMED 2011, 201242).

B-5.1 Borehole Logging

Borehole logs were completed for boreholes drilled with a hollow-stem auger drill rig. Information recorded on field-boring logs included footage, lithology, stratigraphy, and depths of bedding contacts. The borehole logs are presented in Appendix D.

B-5.2 Subsurface Sampling Methods

Subsurface samples were collected using a Central Mine Equipment 750 Hollow-stem Auger Rig with stainless-steel split-spoon core-barrel sampler. The samples were collected in accordance with an approved subcontractor procedure technically equivalent to N3B-SOP-ER-2001, "Soil Tuff and Sediment Sampling."

The material from the split-spoon core barrel was field screened for radioactivity, visually inspected, and logged. The sample material was placed in a stainless-steel bowl and was broken, if necessary, with a decontaminated rock hammer or stainless-steel spoon to fit the material into the sample containers.

A stainless-steel scoop and bowl were used to transfer samples to sterile sample collection jars for transport to N3B's SMO. The sample collection tools were decontaminated immediately before each sample was collected (see section B-5.5) in accordance with a subcontractor procedure technically equivalent to N3B-SOP-ER-2002, "Field Decontamination of Equipment."

B-5.3 Pore-Gas Sampling Methods

Vapor sampling was conducted using a stainless-steel tubing system. The stainless-steel tubing system uses continuous lengths of 0.25-in.-outside diameter (O.D.) stainless-steel tubing with a single port installed at the target depth of each tube. Bentonite is used above and below each sampling port to seal off the interval to be sampled. The 5-ft space between the bentonite seals at each sampling interval is filled with sand. Sampling is performed by extracting the formation air through the sand layer and into the stainless-steel tubing.

After the vapor-sampling system was installed, the system was purged to ensure formation air was extracted. During the purge, percent oxygen, percent carbon dioxide, and percent methane readings from the sample train exhaust were collected every several minutes using a LANDTEC GEM-500 gas-extraction meter. At the end of every purge cycle, a PID reading was collected from the airflow in the sample train apparatus. Vapor samples for VOC analysis were collected in SUMMA canisters, one sample per canister. A silica gel sampler was used to collect the tritium sample after the SUMMA canister sample was collected. Samples were submitted to the SMO for shipment to contract analytical laboratories for VOC analysis by U.S. Environmental Protection Agency (EPA) Method TO-15 and for tritium analysis by EPA Method 906.0

B-5.4 Quality Assurance/Quality Control Samples

Quality assurance/quality control (QA/QC) samples were collected in accordance with an approved subcontractor procedure technically equivalent to N3B-SOP-SDM-1100, "Sample Containers, Preservation, and Field Quality Control." The QC samples included field duplicates and field trip blanks.

Field duplicate samples were collected from the same material as the regular investigation samples and submitted for the same analyses. Field-duplicate samples were collected at a frequency of at least 1 per 10 samples (10%).

Field trip blanks were collected at a frequency of one per sampling team per day to determine contamination during storage and transport when samples were being collected for VOC analysis. Field trip blanks were containers of certified clean sand, unopened and kept with the sample containers during sampling and transport.

B-5.4 Sample Documentation and Handling

Field personnel completed a SCL/COC form for each sample. Sample containers were sealed with signed custody seals and placed in coolers at approximately 4°C. Samples were handled in accordance with N3B-SOP-SDM-1101, “Sample Control and Field Documentation”; and N3B-SOP-SDM-1100, “Sample Containers, Preservation, and Field Quality Control.” Samples were transported to the SMO in sealed coolers containing ice packs and shipped from the SMO to the analytical laboratories. The SMO personnel reviewed and approved the SCL/COC forms before taking custody of the samples. The SCL/COC forms are provided in Appendix C (on CD).

B-5.5 Decontamination of Sampling Equipment

All sampling equipment, including split-spoon core barrels, was decontaminated immediately before each sample was collected to avoid outside contamination and cross-contamination between samples. The drilling equipment was decontaminated before mobilization of the hollow-stem auger rig to the next borehole to avoid cross-contamination between samples and borehole locations. Decontamination included cleaning the equipment with wire brushes, scrapers, Fantastik, and clean paper towels.

B-6.0 WASTE STORAGE AND DISPOSAL

This section summarizes the investigation-derived waste (IDW) generated during the Material Disposal Area (MDA) K drilling activities. All waste was managed in accordance with an approved subcontractor procedure technically equivalent to N3B-P409-0, “N3B Waste Management.”

B-6.1 Waste Loading and Staging

Waste streams include contact IDW, municipal solid waste, and environmental media. All project waste was managed in accordance with the “Waste Characterization Strategy Form (WCSF) for Chaquehui Canyon Aggregate Area” (N3B 2019, 700299) and staged in designated waste storage areas. Project waste was separated by form (e.g., soils, debris), type, and potential disposition pathway (e.g. industrial, hazardous, low-level waste soils and debris, mixed waste). When appropriate, compatible waste forms with different densities were packaged together to minimize void space and maximize load-out efficiency while maintaining package weights below the road weight limit of 39,000 lb.

Drill cuttings and discarded core were packaged in N3B-supplied IP-1 rated containers. All waste containers were closed and secured in accordance with the manufacturer’s procedures and made ready for transport according to N3B waste packaging and shipping procedures and the Energy Solutions waste acceptance criteria. Containers and their contents were concurrently tracked and managed using a container identification (ID) system and waste accumulation log. Project waste was stored in designated waste storage areas pending characterization.

B-6.2 Investigation-Derived Waste Storage and Disposal

All IDW generated during the field investigation was managed in accordance with the project WCSF (N3B 2019, 700299) and an approved subcontractor procedure technically equivalent to N3B-P409-0, “N3B Waste Management.” These procedures incorporate the requirements of all applicable EPA and New Mexico Environment Department (NMED) regulations, U.S. Department of Energy orders, and Laboratory implementation requirements.

B-7.0 GEODETIC SURVEYING

Geodetic surveys of sampling locations were performed by a licensed State of New Mexico surveyor. Horizontal accuracy of the global positioning system unit is within 0.1 ft. During sampling, if the planned location could not be sampled because of surface or subsurface obstruction or other unanticipated field conditions, the relocated sampling location was resurveyed. The surveyed sample location coordinates are presented in Table 3.2-1 of the investigation report.

B-8.0 DEVIATIONS FROM WORK PLAN

Proposed sampling locations identified in the approved investigation work plan for Chaquehui Canyon Aggregate Area (LANL 2010, 111298.9; NMED 2011, 201242) were moved as a result of site conditions encountered during the fieldwork activities. These locations were moved because they were sited next to a cultural resource or the proposed locations were inaccessible. When locations were moved, the new locations were sited as close as possible to the original locations.

Deviations to sampling locations and to the work plan scope are discussed below:

Solid Waste Management Units (SWMUs) 33-002(a,b,c,d,e) and 33-010(f) – MDA K: The approved investigation work plan included the scope to drill seven boreholes and collect soil, tuff, and vapor samples at 10-ft intervals from each borehole and analyze for tritium in tuff and VOCs and tritium in pore gas (LANL 2010, 111298.9; NMED 2011, 201242). This approach was reviewed by the project team and determined to be somewhat impractical from a field implementation perspective and the resultant tritium sample data may not provide the best information for determining the need to install a permanent vapor-monitoring well. The time required to purge and collect a tritium vapor sample ranges between 6–12 hr after set-up depending upon the porosity of the geologic formation and meteorological conditions. Collection of tritium vapor samples every 10 ft would require drilling 10 ft with an auger rig equipped with a continuous coring system, stopping, reconfiguring the rig with drop pipe and a packer system (or mobilizing a second rig over the hole), and collecting a vapor sample. This technique would result in a drilling productivity of only 10 ft per day and extensive standby time. This approach would require a minimum of approximately 25 to 27 working days to complete each boring to top of basalt (this assumes the crew could drill 10 ft and collect a tritium sample in one shift, which is unlikely). This approach also only provides a snap shot in time of tritium concentrations (collected using a packer system method rather than the preferred stainless-steel well system) and does not offer the opportunity to evaluate seasonality or changes/movement of the plume.

Drilling these seven boreholes was delayed during the 2019–2020 investigation. Therefore, a phased approach was implemented to determine the presence and concentrations of tritium and to define the lateral and vertical extent of a subsurface tritium plume. During the first phase, three boreholes were drilled and tuff samples collected from the base of the lithologic units. The project team determined that it was a reasonable assumption that vapors would likely accumulate at the base/top of each geological formation. The project team decided to collect tuff samples at the base of each formation and to install a permanent stainless-steel vapor-monitoring system at the base of each geologic unit. The stratigraphy of each boring was evaluated before the selection of the port depths. The ports were installed (1) at the base of each geologic formation, (2) at other intervals of geologic interest, (3) at 100 ft bgs, which was the highest tritium activity in the previous boreholes, and (4) at the total depth of the borehole. Vapor samples were collected from geologic intervals from six ports in each monitoring well and analyzed for tritium and VOCs. Vapor samples were collected several weeks after installation of the permanent monitoring system, which allowed the formation to stabilize before collecting vapor samples. Data collection of VOCs was not identified in the investigation work plan but was part of the first phase investigation.

B-9.0 REFERENCES

The following reference list includes documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ERID, ESHID, or EMID. This information is also included in text citations. ERIDs were assigned by the Laboratory's Associate Directorate for Environmental Management (IDs through 599999); ESHIDs were assigned by the Laboratory's Associate Directorate for Environment, Safety, and Health (IDs 600000 through 699999); and EMIDs are assigned by N3B (IDs 700000 and above). IDs are used to locate documents in N3B's Records Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and N3B maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

LANL (Los Alamos National Laboratory), November 2010. "Investigation Work Plan for Chaquehui Canyon Aggregate Area, Revision 1," Los Alamos National Laboratory document LA-UR-10-7226, Los Alamos, New Mexico. (LANL 2010, 111298.9)

N3B (Newport News Nuclear BWXT-Los Alamos, LLC), February 25, 2019. "Waste Characterization Strategy Form (WCSF) for Chaquehui Canyon Aggregate Area," Newport News Nuclear BWXT-Los Alamos, LLC, document EM2019-0045, Los Alamos, New Mexico. (N3B 2019, 700299)

NMED (New Mexico Environment Department), March 3, 2011. "Approval with Modifications for the Investigation Work Plan for Chaquehui Canyon Aggregate Area, Revision 1," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2011, 201242)

Table B-1.0-1
Summary of Field Investigation Methods

Method	Summary
Field-screening and Instrument Calibration	Field screening for radioactivity and VOCs was performed on each sample collected. Field screening for high explosives was performed at one SWMU where firing site debris was observed and subsequently removed. The response check and calibration of instruments used to screen for radioactivity and VOCs was conducted by a qualified representative. All response checks and calibrations were performed daily according to the manufacturers' specifications and requirements with approved operating procedures and recorded on the appropriate forms. N3B RCTs performed and documented a free release survey of the exterior of the sample containers, and then a U.S. Department of Transportation shipping survey was performed and documented before transportation to the SMO.
Split-Spoon Core-Barrel Sampling	A stainless-steel core barrel (typically 4 in. inside diameter (I.D.) and 2.5 ft long) was advanced using a powered drilling rig. The core barrel extracts a continuous length of soil and/or rock that can be examined as a unit. The split-spoon core barrel is a cylindrical barrel split lengthwise so the two halves can be separated to expose the core sample. Once the core barrel was extracted and opened, a sample for VOC analysis was transferred immediately to a sample container. If necessary, pieces small enough to fit into the sample container were removed from the core using a decontaminated rock hammer or stainless-steel spoon. Containers for VOC analysis were filled as completely as possible and sealed with Teflon-lined caps. The section of core in the core barrel was then screened for radioactivity and organic vapors and described in a geologic log. A portion of the core was then collected as a discrete sample from the desired depth for remaining analyses.
Handling, Packaging, and Shipping of Samples	Field team members sealed and labeled samples before packing to ensure the sample and the transport containers were free of external contamination. They packaged all samples to minimize the possibility of breakage during transport. After all environmental samples were collected, packaged, and preserved, a field team member transported them to the SMO, which arranged to ship the samples to the analytical laboratories.
Sample Control and Field Documentation	The collection, screening, and transport of samples were documented on standard forms generated by the SMO. These included SCLs, COC forms, and sample container labels. SCLs were completed at the time of sample collection, and the logs were signed by the sampler and a reviewer who verified the logs for completeness and accuracy. Corresponding labels were initialed and applied to each sample container, and custody seals were placed around each sample container. COC forms were completed and signed to verify that the samples had not been left unattended.
Field Quality Control Samples	Field QC samples were collected as follows: Field Duplicates – collected at a frequency of 10% at the same time as a regular sample and submitted for the same analyses. Trip Blanks: required for all field events that included the collection of samples for VOC analysis. Trip-blank containers of certified clean sand were unopened and kept with the other sample containers during the sampling process.
Field Decontamination of Drilling and Sampling Equipment	Dry decontamination was used to minimize the generation of liquid waste. Dry decontamination consisted of using a wire brush or other tool to remove soil or other material adhering to the sampling equipment, followed by use of a commercial cleaning agent (nonacid, waxless cleaners) and paper wipes.
Containers and Preservation of Samples	Specific requirements/processes for sample containers, preservation techniques, and holding times are based on EPA guidance for environmental sampling, preservation, and QA. Specific requirements for each sample were printed on the SCL provided by the SMO (size and type of container, e.g., glass, amber glass, or polyethylene). All samples were preserved by placing in insulated containers with ice to maintain a temperature of 4ºC.

Table B-1.0-1 (continued)

Method	Summary
Management of Environmental Restoration Project Waste, Waste Characterization	IDW was managed, characterized, and stored in accordance with an approved WCSF that documents site history, field activities, and characterization approach for each waste stream managed. During the investigation, waste characterization complied with on- or off-site waste acceptance criteria. All stored IDW was marked with appropriate signage and labels. Drummed IDW was stored on pallets to prevent deterioration of containers. A waste storage area was established before waste was generated. Waste storage areas were located in controlled areas of the Laboratory and were monitored as needed to prevent inadvertent addition to or management of wastes by unauthorized personnel. Each container of waste generated was individually labeled with waste classification, item identification number, and radioactivity (if applicable) immediately following containerization. All waste was segregated by classification and compatibility to prevent cross-contamination.
Coordinating and Evaluating Geodetic Surveys	Geodetic surveys focused on obtaining survey data of acceptable quality to use during project investigations. Geodetic surveys were performed by a Licensed State of New Mexico Surveyor. All coordinates were expressed as State Plane Coordinate System 83, NM Central, U.S. feet. All elevation data were reported relative to the National Geodetic Vertical Datum of 1983.

Table B-1.0-2
Standard Operating Procedures Used for the
Investigation Activities at Chaquehui Canyon Aggregate Area

N3B-AP-TRU-2150	Waste Characterization Strategy Form
N3B-SOP-ER-6005, R0	Monitoring Well and Borehole Abandonment
N3B-AP-ER-1002, R0	Environmental Remediation (ER) Field Work Requirements
N3B-SOP-SDM-1101, R1	Sample Control and Field Documentation
N3B-SOP-SDM-1100, R0	Sample Containers, Preservation and Field Quality Control
N3B-GDE-ER-5015, R0	Storm Water Best Management Practices Manual
N3B-SOP-ER-2001, R0	Soil Tuff and Sediment Sampling
N3B-SOP-ER-2002, R0	Field Decontamination of Equipment

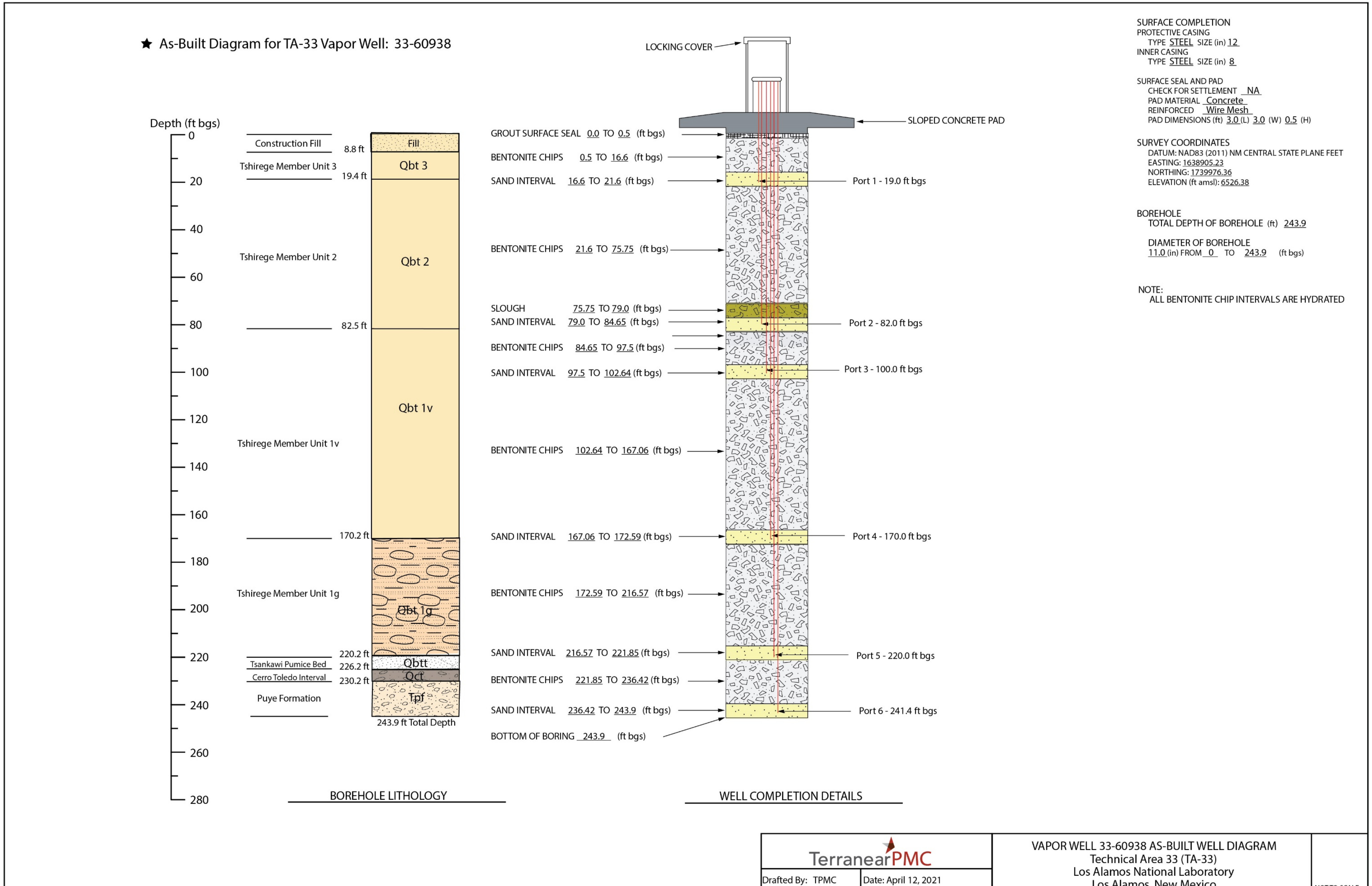
Note: Procedures used were approved subcontractor procedures that were technically equivalent to the procedures listed.

Appendix C

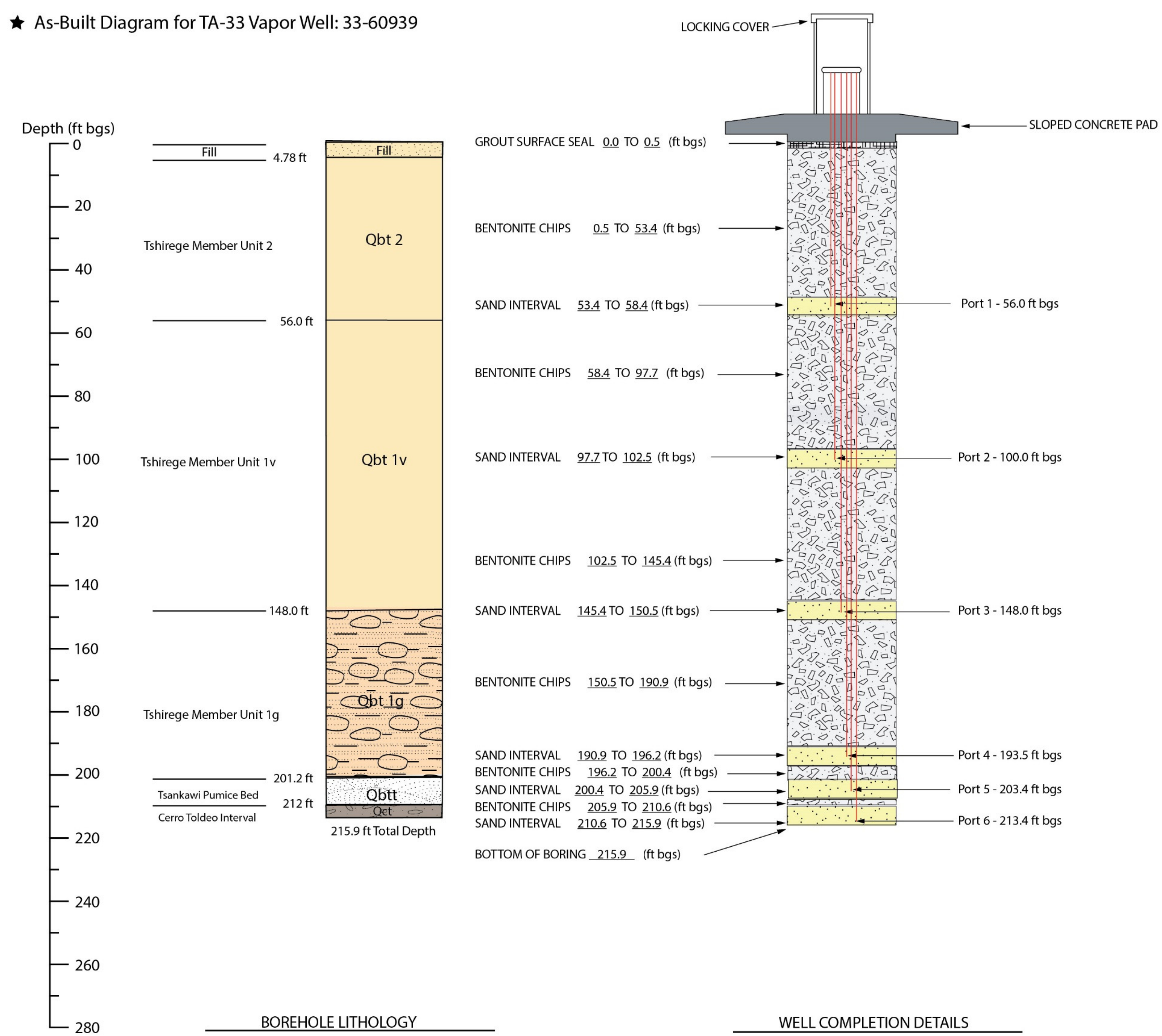
Analytical Suites and Results and Analytical Reports
(on CD included with this document)

Appendix D

Borehole Logs and Well Construction



★ As-Built Diagram for TA-33 Vapor Well: 33-60938
Depth (ft bgs)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Construction Fill
Tshirege Member Unit 3
Tshirege Member Unit 2
Tshirege Member Unit 1v
Tshirege Member Unit 1g
Tsankawi Pumice Bed
Cerro Toledo Interval
Puye Formation
8.8 ft
19.4 ft
82.5 ft
170.2 ft
220.2 ft
226.2 ft
230.2 ft
Fill
Qbt 3
Qbt 2
Qbt 1v
Qbt 1g
Qbtt
Qct
Tpf
243.9 ft Total Depth
BOREHOLE LITHOLOGY
LOCKING COVER
SLOPED CONCRETE PAD
GROUT SURFACE SEAL 0.0 TO 0.5 (ft bgs)
BENTONITE CHIPS 0.5 TO 16.6 (ft bgs)
SAND INTERVAL 16.6 TO 21.6 (ft bgs)
BENTONITE CHIPS 21.6 TO 75.75 (ft bgs)
SLOUGH 75.75 TO 79.0 (ft bgs)
SAND INTERVAL 79.0 TO 84.65 (ft bgs)
BENTONITE CHIPS 84.65 TO 97.5 (ft bgs)
SAND INTERVAL 97.5 TO 102.64 (ft bgs)
BENTONITE CHIPS 102.64 TO 167.06 (ft bgs)
SAND INTERVAL 167.06 TO 172.59 (ft bgs)
BENTONITE CHIPS 172.59 TO 216.57 (ft bgs)
SAND INTERVAL 216.57 TO 221.85 (ft bgs)
BENTONITE CHIPS 221.85 TO 236.42 (ft bgs)
SAND INTERVAL 236.42 TO 243.9 (ft bgs)
BOTTOM OF BORING 243.9 (ft bgs)
Port 1 - 19.0 ft bgs
Port 2 - 82.0 ft bgs
Port 3 - 100.0 ft bgs
Port 4 - 170.0 ft bgs
Port 5 - 220.0 ft bgs
Port 6 - 241.4 ft bgs
WELL COMPLETION DETAILS
SURFACE COMPLETION
PROTECTIVE CASING
TYPE STEEL SIZE (in) 12
INNER CASING
TYPE STEEL SIZE (in) 8
SURFACE SEAL AND PAD
CHECK FOR SETTLEMENT NA
PAD MATERIAL Concrete
REINFORCED Wire Mesh
PAD DIMENSIONS (ft) 3.0 (L) 3.0 (W) 0.5 (H)
SURVEY COORDINATES
DATUM: NAD83 (2011) NM CENTRAL STATE PLANE FEET
EASTING: 1638905.23
NORTHING: 1739976.36
ELEVATION (ft amsl): 6526.38
BOREHOLE
TOTAL DEPTH OF BOREHOLE (ft) 243.9
DIAMETER OF BOREHOLE
11.0 (in) FROM 0 TO 243.9 (ft bgs)
NOTE:
ALL BENTONITE CHIP INTERVALS ARE HYDRATED
TerranearPMC
Drafted By: TPMC
Date: April 12, 2021
VAPOR WELL 33-60938 AS-BUILT WELL DIAGRAM
Technical Area 33 (TA-33)
Los Alamos National Laboratory
Los Alamos, New Mexico
NOT TO SCALE



SURFACE COMPLETION
PROTECTIVE CASING
TYPE STEEL SIZE (in) 12
INNER CASING
TYPE STEEL SIZE (in) 8

SURFACE SEAL AND PAD
CHECK FOR SETTLEMENT NA
PAD MATERIAL Concrete
REINFORCED Wire Mesh
PAD DIMENSIONS (ft) 3.0 (L) 3.0 (W) 0.5 (H)

SURVEY COORDINATES
DATUM: NAD83 (2011) NM CENTRAL STATE PLANE FEET
EASTING: 1639077.27
NORTHING: 1740155.45
ELEVATION (ft amsl): 6499.43

BOREHOLE
TOTAL DEPTH OF BOREHOLE (ft) 215.9

DIAMETER OF BOREHOLE
11.0 (in) FROM 0 TO 215.9 (ft bgs)

NOTE:
ALL BENTONITE CHIP INTERVALS ARE HYDRATED

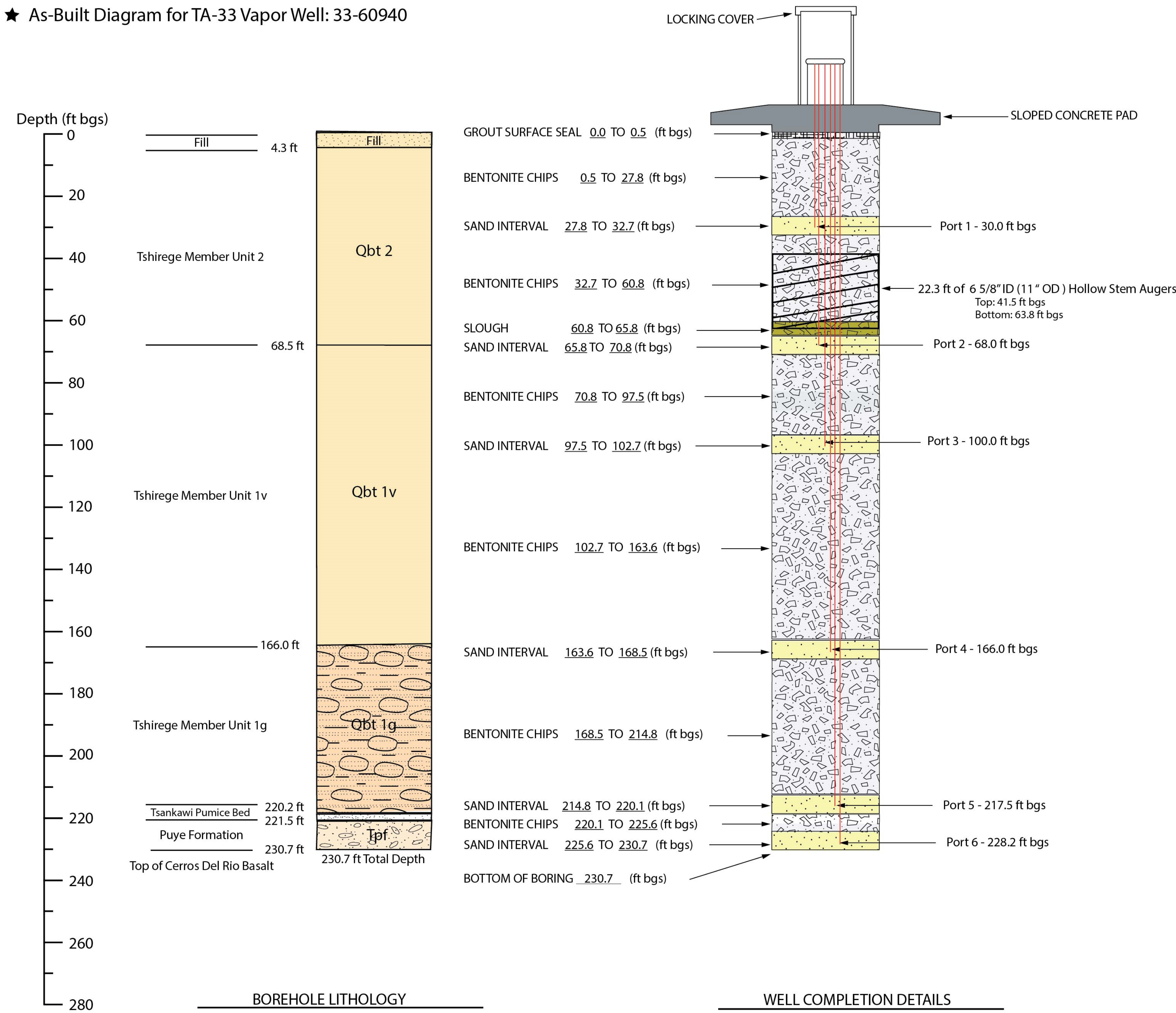
TerranearPMC

Drafted By: TPMC | Date: April 12, 2021

VAPOR WELL 33-60939 AS-BUILT WELL DIAGRAM
Technical Area 33 (TA-33)
Los Alamos National Laboratory
Los Alamos, New Mexico

NOT TO SCALE

★ As-Built Diagram for TA-33 Vapor Well: 33-60940



SURFACE COMPLETION
PROTECTIVE CASING
TYPE STEEL SIZE (in) 12
INNER CASING
TYPE STEEL SIZE (in) 8

SURFACE SEAL AND PAD
CHECK FOR SETTLEMENT NA
PAD MATERIAL Concrete
REINFORCED Wire Mesh
PAD DIMENSIONS (ft) 3.0 (L) 3.0 (W) 0.5 (H)

SURVEY COORDINATES
DATUM: NAD83 (2011) NM CENTRAL STATE PLANE FEET
EASTING: 1639075.0
NORTHING: 1739984.15
ELEVATION (ft amsl): 6509.65

BOREHOLE
TOTAL DEPTH OF BOREHOLE (ft) 230.7

DIAMETER OF BOREHOLE
11.0 (in) FROM 0 TO 230.7 (ft bgs)

NOTE:
ALL BENTONITE CHIP INTERVALS ARE HYDRATED

TerranearPMC	VAPOR WELL 33-60940 AS-BUILT WELL DIAGRAM Technical Area 33 (TA-33) Los Alamos National Laboratory Los Alamos, New Mexico	NOT TO SCALE
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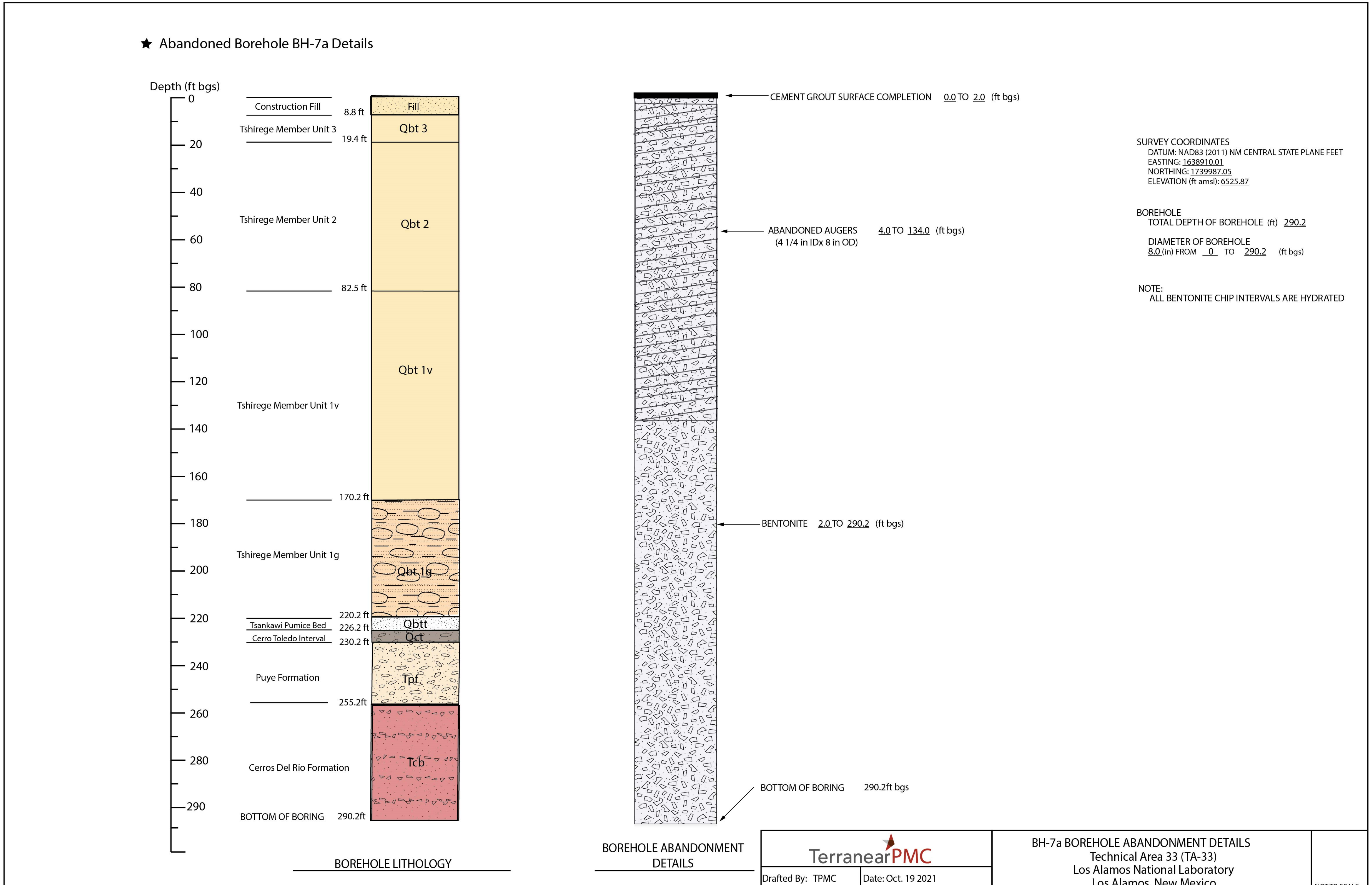
★ Abandoned Borehole BH-7a Details
Depth (ft bgs)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
290
Construction Fill
Fill
8.8 ft
Tshirege Member Unit 3
Qbt 3
19.4 ft
Tshirege Member Unit 2
Qbt 2
82.5 ft
Qbt 1v
Tshirege Member Unit 1v
170.2 ft
Tshirege Member Unit 1g
Qbt 1g
220.2 ft
Tsankawi Pumice Bed
Qbtt
226.2 ft
Cerro Toledo Interval
Qct
230.2 ft
Puye Formation
Tpf
255.2ft
Cerros Del Rio Formation
Tcb
BOTTOM OF BORING
290.2ft
BOREHOLE LITHOLOGY
CEMENT GROUT SURFACE COMPLETION 0.0 TO 2.0 (ft bgs)
ABANDONED AUGERS 4.0 TO 134.0 (ft bgs)
(4 1/4 in IDx 8 in OD)
BENTONITE 2.0 TO 290.2 (ft bgs)
BOTTOM OF BORING 290.2ft bgs
BOREHOLE ABANDONMENT DETAILS
SURVEY COORDINATES
DATUM: NAD83 (2011) NM CENTRAL STATE PLANE FEET
EASTING: 1638910.01
NORTHING: 1739987.05
ELEVATION (ft amsl): 6525.87
BOREHOLE
TOTAL DEPTH OF BOREHOLE (ft) 290.2
DIAMETER OF BOREHOLE
8.0 (in) FROM 0 TO 290.2 (ft bgs)
NOTE:
ALL BENTONITE CHIP INTERVALS ARE HYDRATED
TerranearPMC
Drafted By: TPMC
Date: Oct. 19 2021
BH-7a BOREHOLE ABANDONMENT DETAILS
Technical Area 33 (TA-33)
Los Alamos National Laboratory
Los Alamos, New Mexico
NOT TO SCALE