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Subject: **Remedy Completion Report for Corrective Measures Implementation at Consolidated Unit 16-021(c)-99**

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Remedy Completion Report for Corrective Measures Implementation at Consolidated Unit 16-021(c)-99. This report documents completion of the activities conducted for the surface corrective measures implementation (CMI) at Consolidated Unit 16-021(c)-99 at Los Alamos National Laboratory. The report is intended to close out all remaining corrective actions for the surface CMI and includes a long-term monitoring plan that will be implemented to evaluate the long-term fate and transport of residual contamination and the performance of the corrective actions.

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Enclosures: Two hard copies with electronic files – Remedy Completion Report for Corrective Measures Implementation at Consolidated Unit 16-021(c)-99 (EP2017-0080)

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Remedy Completion Report for Corrective Measures Implementation at Consolidated Unit 16-021(c)-99

Los Alamos
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Prepared by the Associate Directorate for Environmental Management

EP2017-0080

Remedy Completion Report for Corrective Measures Implementation at Consolidated Unit 16-021(c)-99

September 2017

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EXECUTIVE SUMMARY

This report documents completion of the activities for the surface corrective measures implementation (CMI) at Consolidated Unit 16-021(c)-99 (the 260 Outfall) located in Technical Area 16 at Los Alamos National Laboratory (LANL or the Laboratory). The report documents the closeout of all remaining corrective actions for the surface CMI and includes a long-term monitoring and maintenance plan that will be implemented to evaluate the long-term fate and transport of residual contamination and the effectiveness of the corrective actions.

The CMI was performed to implement the remedy selected by the New Mexico Environment Department in 2006. The remedy included (1) removal of contaminated soil from the 260 Outfall source area and disposal off-site; (2) immobilization of contaminants in a contaminated surge bed using pressure grouting and (3) installation of a pilot permeable reactive barrier (PRB) and spring treatment units to treat alluvial groundwater for RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) and barium, the primary contaminants in shallow groundwater in Cañon de Valle.

The available inventory of RDX in near-surface soils at the 260 Outfall was significantly reduced during the 2000–2001 interim measures and the 2009–2010 CMI, and RDX concentrations in downgradient alluvial wells show long-term declines to levels near the New Mexico tap water screening level. As part of the CMI closure process, the Laboratory removed the pilot PRB (damaged during flooding in 2011); plugged and abandoned the PRB wells in Cañon de Valle; replaced an alluvial monitoring well in Cañon de Valle; and removed the spring treatment boxes at SWSC, Burning Ground, and Martin Springs. This report documents these activities and presents a conceptual model of the fate and transport of RDX and barium. The need for additional PRBs to remove RDX and barium from shallow groundwater was also evaluated. The evaluation concluded that low concentrations and declining trends of RDX and the limited mobility of barium in groundwater precludes the need for PRBs to protect intermediate and regional groundwater.

The Laboratory proposes long-term monitoring of springs, base flow, and alluvial groundwater to monitor trends in RDX and barium in Cañon de Valle and Martin Spring Canyons. In addition, the low-permeability cap above the former settling pond at the 260 Outfall will be inspected and maintained as necessary, and water levels in a surge bed monitoring well will be monitored to ensure the cap remains protective of the underlying surge bed.

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Acronyms and Abbreviations

ADEM	Associate Directorate for Environmental Management
bgs	below ground surface
CME	corrective measures evaluation
CMI	corrective measures implementation
CMS	corrective measures study
DNX	hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine
DOE	Department of Energy (U.S.)
EPA	Environmental Protection Agency (U.S.)
GAC	granular activated carbon
HE	high explosives
HI	hazard index
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazocine
IM	interim measure
LANL	Los Alamos National Laboratory
LTMMP	long-term monitoring and maintenance plan
MCL	maximum contaminant level
MNX	hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine
NMAC	New Mexico Administrative Code
NMED	New Mexico Environmental Department
NPDES	National Pollutant Discharge Elimination System
PRB	permeable reactive barrier
PVC	polyvinyl chloride
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
SWSC	Sanitation Wastewater Systems Consolidation
TA	technical area
TNT	2,4,6-trinitrotoluene
TNX	hexahydro-1,3,5-trinitroso-1,3,5-triazine
UTL	upper tolerance limit
WQCC	Water Quality Control Commission

1.0 INTRODUCTION

This report documents completion of the activities for the surface corrective measures implementation (CMI) at Consolidated Unit 16-021(c)-99 located in Technical Area 16 (TA-16) at Los Alamos National Laboratory (LANL or the Laboratory). The CMI was performed to implement the remedy selected by the New Mexico Environment Department (NMED) in 2006 (NMED 2006, 095631).

In September 2016, the Laboratory submitted a report entitled “Evaluation Report for Surface Corrective Measures Implementation Closure, Consolidated Unit 16-021(c)-99” (LANL 2016, 601837). The report was approved by NMED in October 2016 (NMED 2016, 601914), and the Laboratory completed the remaining tasks identified in the CMI evaluation report, including removal of the damaged pilot permeable reactive barrier (PRB) and plugging and abandoning the PRB wells in Cañon de Valle; installation of a replacement alluvial monitoring well in Cañon de Valle; and removal of the carbon-filter systems and site restoration at Sanitation Wastewater Systems Consolidation (SWSC), Burning Ground, and Martin Springs.

This report summarizes the activities conducted to close out the CMI. In addition, this report provides an overview of the CMI activities conducted in 2009–2010 at Consolidated Unit 16-021(c)-99 (the 260 Outfall). This report also presents a conceptual model of the fate and transport of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) and barium, the primary contaminants in shallow groundwater in Cañon de Valle. Furthermore, this report summarizes the performance of the pilot PRB during its brief operational period from 2010 to 2011 and evaluates whether additional PRBs are necessary to remove residual RDX and barium from shallow groundwater in Cañon de Valle and Martin Spring Canyons.

Completion of these activities fulfills the requirements of the CMI work plan for Consolidated Unit 16-021(c)-99 (LANL 2007, 098192) and the evaluation report for the surface CMI closure (LANL 2016, 601837). Because the Laboratory considers the CMI remedy to be complete, it recommends that monitoring related to Consolidated Unit 16-021(c)-99, including monitoring of alluvial groundwater, base flow, and springs, transition to long-term monitoring. Appendix A includes a long-term monitoring and maintenance plan (LTMMP).

With completion of the CMI for Consolidated Unit 16-021(c)-99, which focused on surface and shallow subsurface soils and alluvial groundwater, future activities related to the 260 Outfall will focus on deep perched-intermediate groundwater and regional groundwater at TA-09 and TA-16.

Figure 1.0-1 shows the location of TA-16 with respect to Laboratory TAs and surrounding landholdings. Figure 1.0-2 shows the location of the Consolidated Unit 16-021(c)-99 and the 260 Outfall as well as the Cañon de Valle channel and nearby SWSC, Burning Ground, and Martin Springs. Figure 1.0-3 shows the alluvial monitoring well network in Cañon de Valle and Martin Spring Canyon. Figure 1.0-4 shows the deep perched-intermediate and regional monitoring well network in the vicinity of Consolidated Unit 16-021(c)-99 and water table contours for the intermediate zone and regional aquifer.

1.1 Site Location and Description

TA-16, located in the southwest corner the Laboratory (Figure 1.0-1), is surrounded by a security fence and covers approximately 2410 acres (3.8 mi^2). TA-16 is bordered by Bandelier National Monument along NM 4 to the south and by the Santa Fe National Forest along NM 501 to the west. Water Canyon, a 200-ft-deep canyon with steep walls, separates NM 4 from active sites at TA-16, and Cañon de Valle forms the northern boundary of TA-16.

TA-16 was established to develop explosive formulations, cast and machine explosive charges, and assemble and test explosive components for the U.S. nuclear weapons program. Consolidated Unit 16-021(c)-99 consists of the high explosives– (HE-) machining building (16-260) and associated sumps, drainlines, and troughs that discharged into the 260 Outfall drainage channel. The 260 Outfall drainage channel consists of the outfall, a former settling pond, and the lower portion of the drainage channel leading to Cañon de Valle.

Building 16-260 had been used since 1951 to process and machine HE. Water was used during HE machining; wastewater from machining operations contained dissolved HE and entrained HE cuttings. Wastewater was routed to 13 settling sumps to recover entrained cuttings. From 1951 to 1996, the water from these sumps was discharged to the 260 Outfall, with millions of gallons discharged per year. The discharge volumes were probably higher during the 1950s when HE-production output from building 16-260 was substantially greater than it was in the 1990s (LANL 1994, 076858). Barium, a constituent of certain HE formulations, was also present in the outfall discharge.

Water contaminated with HE and barium flowed from the sumps into the settling pond to capture entrained HE cuttings in the concrete trough and ultimately to the 260 Outfall, located 200 ft east of building 16-260. The outfall discharged into Cañon de Valle, providing a pathway for contaminants to enter the alluvial groundwater, vadose zone, and deeper groundwater (LANL 2003, 077965).

The HE compounds RDX and HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and barium, associated with the 260 Outfall have been detected in alluvial groundwater and springs. RDX and HMX have also been detected in perched-intermediate groundwater (LANL 2003, 077965) and in the regional aquifer (LANL 2016, 601779), but elevated barium concentrations have not been detected in deeper groundwater. Concentrations of RDX in alluvial groundwater are declining to levels at or below the NMED tap water screening level (NMED 2017, 602273).

Other contaminants associated with the 260 Outfall include TNT (2,4,6-trinitrotoluene), which is more sorptive (and therefore less mobile) than RDX and HMX, but TNT has not been detected in groundwater in recent years. A wide range of other contaminants, including low levels of volatile organic compounds, metals, and HE byproducts and degradation products are also associated with 260 Outfall discharges.

From the late 1970s to 1996, the 260 Outfall was permitted by the U.S. Environmental Protection Agency (EPA) to operate under the Laboratory’s National Pollutant Discharge Elimination System (NPDES) permit (EPA 1990, 012454). The 260 Outfall was deactivated in November 1996, and discharge into Cañon de Valle no longer occurs.

1.2 Report Objectives

The objectives of this report are as follows:

- Summarize work completed under the “Corrective Measures Implementation Plan for Consolidated Unit 16-021(c)-99, Revision 1” and subsequent campaigns (LANL 2007, 098192; LANL 2010, 108868; LANL 2010, 110508).
- Document completion of the recommendations presented in the “Evaluation Report for Surface Corrective Measures Implementation Closure, Consolidated Unit 16-02l(c)-99” (LANL 2016, 601837).
- Document that corrective actions related to the surface CMI are protective of the regional aquifer, and no further actions are needed related to the CMI, other than long-term monitoring.

- Provide a LTMMP to include long-term monitoring of base flow, alluvial groundwater, and springs and inspection and maintenance of the low-permeability cap. The LTMMP will provide data verifying that the surface CMI activities implemented in 2009 and 2010 remain protective, and no other conditions have changed at Consolidated Unit 16-021(c)-99 that could require further corrective action.

2.0 CHRONOLOGY OF CORRECTIVE ACTIONS AT CONSOLIDATED UNIT 16-021(c)-99

This section summarizes the chronology leading up to the surface CMI at Consolidated Unit 16-021(c)-99 and the work completed for the CMI.

2.1 Interim Measure Excavation (1999–2001)

An interim measure (IM) remedial excavation was conducted in the outfall drainage channel and settling basin from 1999 to 2001. Highly contaminated soil and tuff in the 260 Outfall drainage channel were excavated. More than 1300 yd^3 of contaminated soil containing approximately 8500 kg of HE was removed from the settling pond and channel, constituting approximately 90% of the HE in the 260 Outfall source area (LANL 2002, 073706). A low-permeability cap was constructed over the former settling pond area.

2.2 Corrective Measures Study (2003)

A corrective measures study (CMS) for Consolidated Unit 16-021(c)-99 was conducted, and a CMS report was submitted to NMED in 2003 (LANL 2003, 085531). The report proposed corrective measures alternatives to address contamination in surface and subsurface soils within the outfall source area and an underlying surge bed, as well as alluvial sediment, springs, surface water, and groundwater located within Cañon de Valle and Martin Spring Canyon.

The 2003 CMS report proposed corrective measures at the 260 Outfall, including excavation of contaminated soils, grouting of the surge bed beneath the outfall to immobilize residual HE and barium, and maintenance of the low-permeability cap installed over the settling pond in 2001.

For the Cañon de Valle and Martin Spring Canyon alluvial groundwater, the CMS proposed natural flushing of alluvial sediments and PRB treatment of groundwater and surface water. Three PRBs for Cañon de Valle and one PRB for Martin Spring Canyon were proposed, along with carbon-filter treatment units at SWSC and Burning Ground Springs, to treat HE-contaminated discharge.

Alternatives to address contaminated deep groundwater were not identified or evaluated because a second CMS had been planned to address contamination in intermediate and regional groundwater (LANL 2007, 098734).

2.3 Remedy Selection by NMED

NMED selected the final remedy for SWMU 16-021(c) in 2006 (NMED 2006, 095631), incorporating certain recommendations from the 2003 CMS report. The remedy selected included the following:

- Soil removal and off-site treatment and disposal of contaminated soil and tuff at the outfall source area;

- Pressure injection of a clay-based grout into boreholes that intersect the surge bed and extension of the existing cap in the pond area; and
- Installation of PRB and spring treatment units to treat the sediment, surface water, and alluvial groundwater. NMED requested the installation of a pilot PRB to determine its effectiveness before the remaining PRBs were installed.

2.4 CMI Plan (2007)

Following NMED's selection of the final remedy, the Laboratory prepared a CMI plan for Consolidated Unit 16-021(c)-99 (LANL 2007, 098192). The CMI plan presented the designs to remediate HE and other contaminants present in the Consolidated Unit 16-021(c)-99 outfall drainage channel and in the alluvial groundwater systems of Cañon de Valle and Martin Spring Canyons. The proposed corrective actions included plans to remove the concrete outfall trough, excavate soils at several locations within the outfall channel, grout a contaminated surge bed, install a pilot PRB in Cañon de Valle to remediate HE and barium in alluvial groundwater, and install carbon filter treatment systems at two springs to remediate HE. Additional details regarding these activities are provided below.

2.5 CMI (2009–2010)

The CMI was conducted in 2009–2010 with a primary objective of remediating HE and other contaminants at the 260 Outfall channel and remediating RDX and barium in alluvial groundwater, and RDX in discharge from SWSC, Burning Ground, and Martin Springs. The CMI was conducted in accordance with the CMI work plan (LANL 2007, 098192) and NMED's approval with modifications (NMED 2009, 107307).

The 2009–2010 CMI activities included (1) removing the concrete trough outfall adjacent to building 16-260 at the 260 Outfall channel; (2) removing soil and sediment within the former settling pond within the 260 Outfall drainage channel; (3) replacing a low-permeability cap on the former settling pond; (4) removing soil and tuff from the 260 Outfall drainage channel; (5) sampling soil in the SWSC cut of Cañon de Valle; (6) installing surge bed injection grouting within the former settling pond at the 260 Outfall channel; (7) installing carbon-filter treatment systems of spring waters at SWSC and Burning Ground Springs in Cañon de Valle and modifying the existing carbon filter at Martin Spring in Martin Spring Canyon; and (8) installing a pilot PRB for treatment of HE and barium in Cañon de Valle.

Corrective actions conducted during the 2009–2010 CMI are discussed in the "Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99" (LANL 2010, 108868) and in the "Addendum to the Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99" (LANL 2010, 110508).

A "Long-Term Monitoring and Maintenance Plan for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99" was submitted to NMED on April 30, 2010 (LANL 2010, 109252). The plan included monitoring and maintenance requirements for the 260 Outfall former settling pond and surge bed, the spring carbon filters at SWSC, Burning Ground, and Martin Springs, and the PRB in Cañon de Valle. The plan has been superseded by the LTMMP presented in Appendix A of this report.

2.6 Corrective Measures Remedial Actions

2.6.1 260 Outfall Drainage Channel

The remedial actions implemented for the 260 Outfall drainage channel were to (1) remove the east-west concrete trough and any contaminated soil below the trough, (2) remove isolated pockets of soil from the former settling pond area that exceeded risk-based screening levels following the 2000–2001 IM, (3) remove isolated pockets of soil from the outfall drainage channel that exceeded risk-based screening levels following the 2000–2001 IM, and (4) maintain or replace the low-permeability cap on the former settling pond (LANL 2007, 098192). These actions were documented in the “Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99” (LANL 2010, 108868) and in the “Addendum to the Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99” (LANL 2010, 110508). A summary of these corrective actions is presented below.

2.6.2 Former Settling Pond Surge Bed

Previous investigations identified the presence of surge beds with high concentrations of RDX, HMX, and TNT beneath the former settling pond at the 260 Outfall (LANL 1998, 059891). During the 2000 IM, soils from the former settling pond within the outfall drainage channel were removed, but the residual contaminants in the surge bed remained (LANL 2002, 073706).

The remedial action for the surge bed during the 2009–2010 CMI was to prevent porewater from coming in contact with the contaminated surge bed by isolating the surge bed using pressure-grouting (LANL 2007, 098192). This was achieved by drilling injection boreholes into the surge bed and injecting the grout through the boreholes and into the surge bed to immobilize contaminants by plugging porosity. Thousands of gallons of grout were injected into 16 boreholes.

To evaluate the effectiveness of this corrective action, a shallow monitoring well screened to a depth of 15.0 to 19.0 ft was installed within the surge bed. To date, the well has been dry but will continue to be monitored using a dedicated pressure transducer. The well will be sampled if sufficient water is present (Appendix A).

2.6.3 Carbon Filter Installation at SWSC, Burning Ground, and Martin Springs

The CMS report (LANL 2003, 085531) identified carbon filters as the preferred option for cleanup of RDX in discharge from SWSC, Burning Ground, and Martin Springs. Figure 1.0-2 shows the locations of SWSC, Burning Ground, and Martin Springs.

Carbon filters were installed at Martin Spring in 2001 as a pilot and at SWSC and Burning Ground Springs in 2009 as part of the CMI (LANL 2010, 108868). The Martin Spring carbon filter system was upgraded during the CMI with the installation of a second spring collection box at a seep next to the original spring outlet (LANL 2010, 108868). Figure 2.6-1 shows as-built details for the filter system installed at Burning Ground Spring.

The initial intent was to operate the carbon filters to treat RDX near the source of each of the springs, pending NPDES permit approval. However, since that time, it has been determined that treatment would not be required because the concentrations of RDX in the springs manifests as very low concentrations in the receiving surface water and alluvial groundwater in Cañon de Valle and Martin Spring Canyon. These concentrations are protective of the regional aquifer.

2.6.4 Pilot PRB Installation in Cañon de Valle

NMED selected PRBs as the remedy to treat sediment, surface water, and alluvial groundwater (NMED 2006, 095631). Three PRBs were proposed for Cañon de Valle and one for Martin Spring Canyon. The remedial objective of the pilot Cañon de Valle PRB was to reduce RDX and barium concentrations in alluvial groundwater to below their respective groundwater standards, which, in turn, would reduce the concentrations of contaminants in groundwater infiltrating perched-intermediate and regional groundwater zones (LANL 2007, 096003).

Locations for the PRBs were selected in reaches of Cañon de Valle identified by geophysical field investigations as areas with high recharge potential to these underlying zones. In addition, a PRB proposed for the eastern edge of the perennial stream in Cañon de Valle was designated to be equipped with an infiltration gallery to allow surface water storm surges to infiltrate the PRB for treatment.

During the remedy selection process (NMED 2006, 095631), NMED required that the Laboratory install one PRB in Cañon de Valle as a pilot project to investigate its effectiveness before other PRBs were installed. The pilot PRB was installed in an area believed to be a potential recharge zone for deeper groundwater. Figure 1.0-2 shows the location of the pilot PRB, and Figure 2.6-2 shows the locations of the former monitoring wells installed at the PRB to monitor its performance. A key goal of the pilot PRB in Cañon de Valle was to demonstrate a significant decrease (>90%) in RDX concentrations in alluvial groundwater.

2.7 Pilot PRB Operations

Installation of the PRB was completed in January 2010. Figure 2.7-1 presents the as-built drawing for the PRB along with the PRB treatment vessel, groundwater transfer line, and high-permeability infiltration zone. During installation, 20 monitoring points (16 alluvial wells and 4 piezometers) were installed to measure water levels and groundwater chemistry of the barrier's inflow and outflow (Figure 2.6-2). PRB wells were monitored for HE compounds, HE-degradation products, and barium to evaluate PRB performance.

During the initial operational period from April to July 2010, treatment was not successful because of mineral precipitation and subsequent plugging of the reactive media. In September 2010, the sequencing of the media was rearranged, and under the new configuration, the PRB successfully treated approximately 140,000 gal. of water from September 2010 to February 2011. Concentrations of RDX were reduced from 16 µg/L to below detection limits, and barium concentrations were reduced from approximately 4000 µg/L to approximately 1000 µg/L.

The performance goal of the PRB was to be a passive, low-maintenance treatment system. However, because the zero valent iron in the original configuration had a limited operational period of 4 mo, the medium was replaced with granular activated carbon (GAC) in July 2011. GAC is very effective in removing HE from groundwater (LANL 2014, 600004; LANL 2017, 602288). To further reduce the barium concentration so post-treatment concentrations of barium would be less than the 1000 µg/L tap water standard, a greater volume of zeolite was added to the vessel. However, the performance of the PRB after this modification was never assessed because shortly after it was added the PRB was significantly damaged by flooding.

One week after the GAC filter media was installed, flash flooding in Cañon de Valle damaged alluvial wells and sampling ports associated with the PRB. More severe flash flooding occurred in late August, destroying or severely damaging the PRB cutoff wall, inflow plumbing, and several additional alluvial wells in Cañon de Valle (LANL 2011, 206408).

The August 2011 flooding resulted from hydrologic perturbations to the Cañon de Valle watershed caused by the Las Conchas wildfire that began on June 26, 2011. The Cañon de Valle watershed and large areas upgradient of the PRB and 260 Outfall sustained moderate to severe fire damage during the Las Conchas fire. While Laboratory property and the PRB and the 260 Outfall area were not burned during the Las Conchas fire, the burn scar left the watershed vulnerable to flash flooding.

The August flooding in Cañon de Valle significantly damaged many parts of the PRB, rendering the treatment unit inoperable. Floodwater, sediment, and ash infiltrated the PRB vessel chambers, significant erosion occurred in the Cañon de Valle channel immediately east of the PRB cutoff wall, and piping and sampling components of the PRB sustained considerable damage. The flooding eroded backfill around the PRB cutoff wall down to bedrock, with an incision approximately 10 ft wide and about 5 ft deep. The cutoff wall was broken and splayed open downstream. The PRB monitoring tubes and plumbing around the treatment vessel were either transported downstream or buried, and the plumbing connecting the cutoff wall to the vessel was ripped out of the vessel and the cutoff wall. Debris from the PRB was found approximately 1 mi downstream. The August 2011 floods also destroyed or damaged 8 of the 20 PRB monitoring wells and piezometers (LANL 2011, 206408), and 2 alluvial monitoring wells, CdV-16-02657 and CdV-16-02658 (Figure 2.0-1).

On April 15, 2016, NMED and Laboratory personnel conducted a site visit to Cañon de Valle to assess the remnants of the PRB and to evaluate the adequacy of the alluvial monitoring well network for long-term monitoring. After reviewing the condition of the PRB, it was determined the PRB debris should be removed, but the buried portions of the cutoff wall should be left in place to minimize impacts by heavy equipment to the area and avoid further destabilization and erosion of fill material around the cutoff wall. In additional, Cañon de Valle provides core habitat for both the Jemez Mountains salamander and the Mexican spotted owl, both federally listed endangered species under the Endangered Species Act. The selected approach would minimize the potential for negative impacts to threatened and endangered species.

2.8 Evaluation Report for Surface CMI Closure (2016)

An “Evaluation Report for Surface Corrective Measures Implementation Closure, Consolidated Unit 16-021(c)-99” was submitted to the NMED on September 29, 2016 (LANL 2016, 601837). The evaluation report was developed in response to NMED’s approval with modifications for the “Semiannual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99” (NMED 2016, 601213). In its approval, NMED directed the Laboratory to submit an evaluation report to NMED by September 30, 2016.

The evaluation report evaluated current and unresolved issues relevant to the CMI and proposed an approach to resolve the remaining requirements. The report included the following:

- Recommendations for removal of the damaged PRB and associated debris in Cañon de Valle.
- Plans to plug and abandon damaged PRB wells or wells not being used.
- Evaluation of the alluvial groundwater monitoring network in Cañon de Valle alluvium to be used for long-term monitoring, including the addition of the PRB alluvial seep and a replacement alluvial monitoring well (CdV-16-02657r).
- In-depth review of RDX trends in Cañon de Valle and Martin Spring Canyon springs and alluvium and recommendations for removing the treatment units and restoring the sites because of declining trends in RDX concentrations in alluvial wells.

Completion of these activities was to be documented in a CMI remedy completion report for Consolidated Unit 16-021(c)-99. This report documents completion of these activities.

2.9 Implementation of Evaluation Report Recommendations

The NMED approved the CMI evaluation report in October 21, 2016 (NMED 2016, 601914), and the Laboratory implemented the recommendations from the report during the period from November 2016 to June 2017. The damaged PRB and debris were removed; the PRB monitoring wells were plugged and abandoned; the carbon-filtration units at SWSC, Burning Ground, and Martin Springs were removed and the springs restored; and replacement alluvial monitoring well CdV-16-02657r was installed. Additional details are presented below.

2.9.1 Removal of the PRB

The PRB was removed during the period from November 30, 2016, to January 6, 2017, and damaged or unused monitoring wells were plugged and abandoned (section 2.4.2).

During PRB removal, the following tasks were completed:

- The PRB treatment vessel was removed and the filtration media (zeolite and GAC) from the treatment box were containerized.
- The corrugated steel culverts and piping immediately above and below the PRB, including the piping between the culverts and the PRB, were removed.
- The exposed portions of the cutoff wall and the infiltration gallery were removed, and associated PRB debris up to 1500 ft downcanyon was collected and disposed of.
- The infiltration gallery downstream of the treatment unit was excavated and removed for disposal.
- All wastes were processed and are currently awaiting disposition. Waste from the PRB removal activities was managed in accordance with the approved waste characterization strategy form.
- Debris that had washed down the canyon during the 2011 flooding was recovered from the canyon.

To reduce impacts to the watershed and to protect habitat for threatened and endangered species, care was taken to minimize disturbances to the stream and banks. Piping between the treatment unit and the PRB buried under considerable soil within the north bank was left in place, except where it was exposed. Most of the buried cutoff wall was also left in place.

Documentation for the removal of the PRB components in Cañon de Valle is provided in Appendix B (on CD included with this report), including the “Certification of Compliance for Removal of the PRB and Components in Cañon de Valle.” This certification of compliance was submitted to the U.S. Army Corps of Engineers to demonstrate compliance with Nation-Wide Permit #27. Photographs documenting the removal are included in Appendix C.

2.9.2 Plugging and Abandonment of PRB Monitoring Wells

The PRB monitoring well network suffered considerable damage during the August 2011 flooding, with 8 of the 20 PRB monitoring wells destroyed or damaged (LANL 2011, 206408). Table 2.9-1 summarizes the PRB well and piezometer completion depths, the damage sustained during the flooding of 2011, and the final disposition of each well (retained or plugged and abandoned). The wells were constructed of

Schedule 40 2-in.–inside diameter polyvinyl chloride (PVC) and were completed to depths of 8.0 to 13.1 ft (LANL 2010, 108868). Figure 2.6-2 shows the locations of the former monitoring wells and piezometers at the PRB.

The Laboratory submitted a well plugging plan of operations to the New Mexico Office of State Engineer September 27, 2016, with plans indicating 10 PRB wells and piezometers were to be plugged and abandoned in accordance with the requirements of 19.27.4 New Mexico Administrative Code (NMAC). The Office of the State Engineer approved the plan on December 12, 2016. The approved “Well Plugging Plan of Operations” is provided in Appendix D (on CD included with this report). This plan includes schematic diagrams of the plugged and abandoned wells, and cross-references the original PRB monitoring well names with the Office of the State Engineer well numbers. The plan also provides details regarding the proposed plugging approach for each well, the plugging and sealing materials, and the wells themselves.

Ten PRB wells were plugged and abandoned on December 20 and 21, 2016. Wells CdV-16-611923 and CdV-16-611937 were retained for long-term monitoring purposes. During the plugging and abandonment process, the surface pads and protective casings were removed, the inner casings were pulled, and the boreholes were backfilled with cement grout to ground surface (LANL 2016, 601837, section 3.0). If the PVC casings could not be extracted, they were cut off at 6 in. below ground surface (bgs), and the boreholes and casing were filled with cement grout to ground surface. After the wells were plugged and abandoned, plugging records were submitted to the Office of the State Engineer documenting the plugging and abandonment activities per 19.27.4 NMAC.

Following plugging and abandonment of the alluvial monitoring wells and completion of all PRB removal activities, the site was graded and restored and a diversion berm was installed to protect the restored area. The area was reseeded using a standard reclamation seed mix. All project-derived waste was characterized and managed in accordance with the Laboratory’s standard operating procedure for waste management, EP-DIR-SOP-10021, “Characterization and Management of Environmental Programs Waste.”

2.9.3 Removal of the Spring Carbon Filter Units

The evaluation report for surface CMI closure (LANL 2016, 601837) recommended removing the spring treatment units at SWSC, Burning Ground, and Martin Springs based on declining RDX concentrations in alluvial wells within Cañon de Valle and Martin Spring Canyon (section 3.1.1). The spring treatment units at SWSC, Burning Ground, and Martin Springs were removed between March 28 and June 30, 2017. Documentation for the removal of the spring treatment units is provided in Appendix B (on CD included with this report), which includes the certificates of compliance for removal of the carbon filter units from the three springs. These certificates were submitted to the U.S. Army Corps of Engineers to demonstrate compliance with Nation-Wide Permit #18. Photographs documenting the removal are included with the certificates. Appendix C presents photographs documenting removal of the filter units and the restored spring sites.

2.9.4 Alluvial Well Installation

Flooding in August 2011 caused erosion that destroyed monitoring well 16-02657, located near the 260 Outfall in Cañon de Valle. Replacement of this well was proposed in the evaluation report (LANL 2016, 601837), and the well was replaced in 2017.

On April 21, 2017, a location suitable for replacement well CdV-16-02657r was identified near the original well location. The first four attempts were terminated when a layer of cobbles was encountered between 1.0 and 1.7 ft bgs and the hand auger could not be advanced. The fifth attempt reached a total depth of 3.8 ft bgs within the cobble layer and encountered groundwater standing at 2.9 ft bgs. Two more attempts were made, both of which encountered auger refusal at 1.0 ft bgs.

On May 5, 2017, a two-person crew from the Laboratory returned to the location of the fifth hand-auger hole, cleaned the hole back down to 3.7 ft bgs, and completed the well. As-built details of well CdV-16-02657r are shown in Figure 2.9-1. A 3-ft × 3-ft by 4-in. concrete pad and protective casing were subsequently installed. On May 19, 2017, the Laboratory attempted to develop the well, but water levels have declined since the well was installed and the well was dry.

3.0 CONCEPTUAL MODEL FOR CONTAMINANT TRANSPORT OF RDX AND BARIUM

RDX and barium were the primary contaminants targeted in alluvial groundwater during the 2009–2010 surface CMI (LANL 2007, 098192). This section discusses the fate and transport of RDX and barium and the basis for why the present-day concentrations detected in springs and alluvial groundwater in the area are protective of the regional aquifer.

3.1 RDX Fate and Transport

RDX is the most significant contaminant within the Water Canyon and Cañon de Valle watershed. RDX was used as a key component in a range of nuclear weapons systems, and it was processed in large quantities estimated at greater than 500,000 lb at TA-16 (LANL 1994, 039440, Appendix D). RDX is a possible human carcinogen (Class C) and has a low NMED tap water screening level of 7.02 µg/L based on a 10^{-5} carcinogenic risk level.

RDX is a mobile contaminant that does not sorb strongly to environmental media and is readily transported in water. RDX breaks down more slowly in oxidizing conditions than do many of the other major HE used at TA-16, and it is moderately soluble (with a solubility limit of approximately 40 ppm) (Layton et al. 1987, 014703; LANL 1994, 039440, Appendix D; LANL 2007, 098734, p. 10). RDX degradation pathways are complex (Halasz et al. 2010, 205249, and references therein); key degradation products include MNX (hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine); DNX (hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine); and TNX (hexahydro-1,3,5-trinitroso-1,3,5-triazine).

RDX dissolved in groundwater partitions between dissolved RDX and adsorbed RDX. RDX adsorbs minimally to tuff and sediment, with greater adsorption if organic carbon is present. Laboratory batch and column experiments on core samples from the Otowi Member of the Bandelier Tuff and the Puye Formation show low partitioning coefficients for RDX sorption to tuff and sediment core materials, with K_d values ranging from 0.0 to 0.70 L/kg and retardation factors varying from 1.0 to 1.8, indicating the underlying tuff and Puye have a relatively low adsorption capacity for RDX (Heerspink et al. 2017, 602560).

RDX biodegrades aerobically and anaerobically (Card and Autenrieth 1998, 104081; Bradley and Dinicola 2005, 095588)). Anaerobic degradation rates are typically much more rapid than aerobic rates (Wani et al. 2002, 097588). RDX can also break down inorganically through direct reduction, such as under highly reducing conditions (LANL 2007, 098734) or under strongly oxidizing conditions (BWXT Pantex and SAIC 2006, 096990). RDX also degrades chemically through direct hydrolysis, particularly at elevated pHs (Layton et al. 1987, 014703, p. 194).

3.1.1 RDX Trends

Concentrations of RDX in alluvial monitoring wells in Cañon de Valle show long-term declines over the last 15 yr. Figure 3.1-1 presents RDX concentrations in Cañon de Valle alluvial wells from 2000 to present. Before the CMI in 2009–2010, RDX concentrations frequently exceeded the NMED tap water screening level of 7.02 µg/L, indicated by the red line in the figure. RDX concentrations in most alluvial wells currently are near or below the NMED tap water screening level of 7.02 µg/L (Figure 3.1-1).

Well CdV-16-611923 is currently being monitored in lieu of CdV-16-02658, which was destroyed during the flooding (LANL 2016, 601837). Monitoring well CdV-16-02657, located near the 260 Outfall, historically showed high RDX concentrations but was destroyed in 2011 by flooding. This well was replaced with well CdV-16-02657r (section 2.9.4).

Figure 3.1-2 shows RDX concentrations in discharge from SWSC, Burning Ground, and Martin Springs from 2000 to present. RDX concentrations in discharge from all three springs continue to exceed the NMED tap water screening level of 7.02 µg/L, although concentrations in Martin Spring have declined significantly over the last 15 yr and are roughly half of what they were in the early 2000s. Concentrations in SWSC and Burning Ground Springs also indicate an apparent decline in recent years since implementation of the surface CMI in 2009–2010. These declines in RDX concentrations at SWSC and Burning Ground Springs may reflect the reduction of RDX source at the 260 Outfall after the 2001 IM and 2009–2010 CMI.

Figure 3.1-3 shows RDX concentrations in groundwater samples collected from Martin Spring Canyon locations, including concentrations in Martin Spring and in downgradient alluvial wells. Concentrations in alluvial wells within Martin Spring Canyon are well below the NMED tap water screening level of 7.02 µg/L.

The long-term declines in RDX concentrations in Cañon de Valle are likely from a number of factors, including the deactivation of the 260 Outfall in 1996, the implementation of surface cleanup measures at the 260 Outfall through several campaigns [including a 2000–2001 IM cleanup (LANL 2002, 073706) and the 2009–2010 CMI campaign (LANL 2010, 108868)]. Approximately 90% of the HE in the Consolidated Unit 16 021(c)-99 source area was removed during the 2000 and 2001 IM (LANL 2002, 073706). Changes in surface hydrology within Cañon de Valle after the Las Conchas fire likely played a role, as did ongoing natural attenuation processes.

The long-term declines in RDX concentrations in Martin Spring may reflect cessation of discharges to the outfalls in the area and ongoing natural attenuation processes.

3.2 Barium Fate and Transport

Barium was targeted for removal, along with RDX, during the design of the PRB. Barium was processed and discharged to the environment at TA-16 in large quantities as a component of the HE Baratol, an explosive containing TNT and barium nitrate. Baratol was processed and/or tested extensively at TA-11, TA-14, TA-15, and TA-16 in the Water Canyon/Cañon de Valle watershed from 1945 to the 1950s (LANL 2011, 207069). Discharge from the 260 Outfall was the most significant source of barium for the area (LANL 2011, 207069). An estimated 500,000 lb of barium nitrate was used over the past 50 yr (LANL 1994, 039440).

With the cessation of discharge from the 260 Outfall, barium is no longer discharged to Cañon to Valle. The barium inventory at the 260 Outfall has been significantly reduced with the IM (LANL 2002, 073706), but elevated barium concentrations in Cañon to Valle alluvial groundwater and surface water persist.

Barium exceeds the NMED Water Quality Control Commission (WQCC) groundwater standard of 1000 µg/L in alluvial wells within Cañon de Valle but has not migrated to deep perched-intermediate groundwater or the regional aquifer (section 3.3.4). The persistence of barium in the shallow groundwater and the absence of barium in deeper groundwater reflect barium's sorptive geochemical properties, which are summarized below and discussed in more detail in a Laboratory report (LANL 2011, 206408).

Barium nitrate dissociates in water to the barium cation and nitrate anion. The degree of saturation of barium minerals in water can lead to precipitation or dissolution of barium minerals. In the Cañon de Valle alluvium, barium exists in both dissolved and solid phases; the latter includes barite ($BaSO_4$) and witherite ($BaCO_3$) (LANL 1998, 059891). The two solid-phase compounds differ in solubility. Once precipitated, barite remains insoluble under natural conditions, while witherite dissolves under wet conditions (LANL 2003, 077965).

Barium adsorbs on clays, oxides, and hydrous oxides, with literature values for equilibrium sorption coefficients in soil ranging from 66 mL/g to 2800 mL/g (Myers 2003, 076188). Barium sorption on clay is minimally reversible under natural conditions. Once sorbed, barium is partially immobilized on the clay surface (Myers 2003, 076188), retarding its movement in the environment. Laboratory studies done as part of the CMI (LANL 2007, 098192) show K_ds for water/tuff of 72 mL/g to 79 mL/g, indicating natural retardation of barium is significant.

The relative sorption potential of barium versus RDX is reflected in their distributions in intermediate and regional groundwater. RDX is more mobile, with minimal adsorption, while barium sorbs onto both tuff and alluvial sediment. RDX is present in intermediate and regional groundwater, while elevated barium is not present in intermediate and regional groundwater.

Barium exceeds the standards only in the surface and alluvial systems, and barium's mobility is limited by conditions in near-surface soils and alluvial groundwater. In addition to flushing dissolved barium from porewater and desorbing any reversibly sorbed barium, rising alluvial groundwater levels can dissolve barium minerals, primarily witherite, present in the unsaturated zone (Reid et al. 2005, 093660). Alternatively, declining alluvial groundwater levels will precipitate barium minerals. The presence of barium minerals partially buffers barium concentrations in surface waters and significantly buffers barium concentration in alluvial waters (Reid et al. 2005, 093660).

3.2.1 Barium Trends

Barium mobility is controlled by sorption and by the dynamics of surface and alluvial hydrology, and continues to be mobilized by fluctuating water levels in the alluvium. Barium is also irreversibly removed from groundwater when barite precipitates. However, because witherite is also present and dissolves when wet, barium concentrations in alluvial groundwater remain elevated, buffered by the geochemical processes described above.

With time, the mobile fraction of barium is gradually being reduced. However, the inventory of barium in shallow sediments within Cañon de Valle is significant (LANL 2011, 207069), and elevated barium concentrations in alluvial groundwater will persist for many years. Barium's sorptive properties limits its migration downward and it is unlikely it will reach deeper groundwater in perched-intermediate zones and in the regional aquifer.

Barium concentrations in alluvial groundwater within Cañon de Valle continue to exceed the NMED WQCC standard of 1000 µg/L. Figure 3.2-1 shows (filtered) barium concentrations in Cañon de Valle alluvial monitoring wells and in discharge from SWSC and Burning Ground Springs. Concentrations in spring discharge are ~150 µg/L to 300 µg/L, while concentrations in the alluvial wells range from ~7000 µg/L to 49,000 µg/L.

Figure 3.2-1 shows a long-term decline for barium in CdV-16-02658, located upgradient of the location of the former PRB, suggesting gradual removal. However, well CdV-16-611923, upstream of the PRB cutoff wall, shows a significant spike in barium concentrations after the PRB was installed in 2010. After the cutoff wall was installed, water levels in the alluvium above the cutoff wall rose, saturating sediments that likely contained the mobile fraction of barium, witherite. The barium dissolved, spiking concentrations in groundwater. The elevated barium eventually dissipated after flooding breached the cutoff wall in 2011.

Barium concentrations in spring discharge are an order of magnitude (or more) lower than barium concentrations in the alluvium, well below the NMED WQCC standard of 1000 µg/L (Figure 3.2-2). These springs represent discharge of shallow (less than 200-ft depth) perched water in the vadose zone (LANL 2011, 207069). Connectivity between the springs and mesa top is rapid (less than 6 mo), based on a tracer study (LANL 2003, 077965; LANL 2011, 207069).

Figure 3.2-3 shows filtered barium concentrations in Martin Spring discharge and in Martin Spring Canyon alluvial wells. Barium concentrations in shallow groundwater within Martin Spring Canyon are significantly lower than in Cañon de Valle, ranging from 100 µg/L to 300 µg/L, well below the NMED WQCC standard of 1000 µg/L. Barium concentrations in discharge from Martin Spring show a gradual decline with time, perhaps reflecting a long-term reduction of the mobile fraction of barium from the system.

Elevated barium concentrations are not observed in deep perched-intermediate and regional groundwater, with the exception of recent concentrations measured in R-25b (see below). Figure 3.2-4 shows barium trends in deep perched-intermediate groundwater, and Figure 3.2-5 shows barium trends in regional groundwater within the TA-16 area. Barium concentrations detected in deeper groundwater are at background levels. The background upper tolerance limit (UTL) for barium in intermediate groundwater is 13.5 µg/L, and the background UTL for barium in regional groundwater is 38.1 µg/L (LANL 2016, 601920).

Note that the elevated barium concentrations detected in R-25b during the last three sampling events reflect the influence of the 6000 gal. of tracer/potable water deployed in this well during the tracer testing activities in November 2015 (LANL 2017, 602161). The source for the potable water was the regional aquifer, which contains higher levels of nonanthropogenic barium than perched-intermediate groundwater (LANL 2016, 601920). Analytical data indicate the tracer/potable water mix has not fully dispersed beyond the vicinity of the well screen in R-25b (LANL 2017, 602161).

The removal of barium from the alluvial system to protect regional groundwater was a primary remedial objective for the PRB. However, no evidence indicates barium is migrating to deeper groundwater, and deeper groundwater is protected from barium by the sorptive characteristics of barium and the fine-grained characteristics of the underlying sediments. Thus, from a remedy perspective, additional PRBs are not needed in either Cañon de Valle or Martin Spring Canyon to remove barium to protect regional groundwater.

3.3 Conceptual Model Summary

The CMI performance objectives were to reduce concentrations of barium and RDX in alluvial groundwater to prevent their migration to deeper groundwater. The media cleanup standards were to remediate contaminant concentrations in alluvial groundwater to below the applicable cleanup levels of 6.1 µg/L for RDX and 1000 µg/L for barium (LANL 2007, 098192). The 2003 CMS (LANL 2003, 085531) proposed the points of compliance at the five existing alluvial wells in Cañon de Valle, three existing alluvial wells in Martin Spring Canyon, two surface water sampling points along the perennial surface water reach of Cañon de Valle, one surface water sampling point in Martin Spring Canyon, and water from the springs. RDX concentrations in the alluvial wells are generally at or below the current NMED tap water screening level of 7.02 µg/L.

The decrease in RDX concentrations in shallow water reflects multiple factors, including the elimination of the original outfall source of contamination with cessation of NPDES discharges into Cañon de Valle, surface removal activities conducted in 2001 and during the surface CMI in 2009 and 2010, and long-term reduction of RDX from the system from natural degradation processes.

Barium is more persistent in shallow groundwater within Cañon de Valle and, to a lesser extent, in Martin Spring Canyon. However, barium is not likely to migrate to perched-intermediate groundwater or the regional aquifer given its sorptive characteristics, making it considerably less mobile than RDX in oxidizing groundwater. Although it is well buffered in the near-surface system, natural adsorptive processes slowly remove barium from the system.

3.4 Evaluation of Need for Additional PRBs

Based on the conceptual model for the transport of RDX and barium, the need for additional PRBs in Cañon de Valle and Martin Spring Canyon was assessed. The CMI plan proposed the original PRB as a pilot study, with a goal of removing RDX and barium from alluvial groundwater to below groundwater screening levels, thereby decreasing contaminant migration to underlying intermediate and regional groundwater zones. The pilot PRB demonstrated that RDX could be removed to below the tap water screening level (which was 6.1 µg/L at the time of PRB installation) (LANL 2009, 108010). The pilot PRB also demonstrated that barium concentrations in alluvial groundwater could be reduced from 4000 µg/L to approximately 1000 µg/L (section 2.7 above).

RDX concentrations in alluvial groundwater within Cañon de Valle and Martin Spring Canyon are already at or near the current tap water screening level of 7.02 µg/L. Factors resulting in long-term declines in RDX concentrations since the original 2003 CMS include the mitigative effects of surface cleanup actions at the 260 Outfall in 2000 and 2001 and 2009 and 2010 for the CMI, which significantly reduced the mobile inventory of RDX in the vicinity of the 260 Outfall. Furthermore, natural attenuative processes continue to reduce RDX concentrations in shallow groundwater in Cañon de Valle. In Martin Spring Canyon, RDX concentrations in alluvial groundwater are below the NMED tap water screening level.

The other objective of the PRBs was to remove barium from the alluvial groundwater to protect deeper groundwater in the perched-intermediate system and the regional aquifer. However, because of the geochemical properties of barium, including its sorptive characteristics, barium is not likely to reach deep perch groundwater or the regional aquifer. Data from deep wells at TA-16 and TA-09 show barium concentrations at background levels, even after 50 yr of discharge down Cañon de Valle (section 3.2.1). Barium will continue to persist in alluvial groundwater within Cañon de Valle for many years but does not threaten the regional aquifer.

Thus, given RDX concentrations in alluvial groundwater are at or near the groundwater screening levels and given the elevated barium concentrations do not threaten deeper groundwater because of barium’s sorptive geochemical characteristics, the Laboratory believes additional PRBs are not needed in either Cañon de Valle or Martin Spring Canyon.

4.0 GROUNDWATER CLEANUP LEVELS PER THE CONSENT ORDER

The surface CMI was implemented under the March 2005 Compliance Order on Consent (Consent Order) utilizing the groundwater cleanup levels specified in that Consent Order. The 2005 Consent Order has been superseded by the June 2016 Consent Order, which applies a different approach for using groundwater standards.

The 2005 Consent Order specified groundwater cleanup levels as the WQCC groundwater standards, including alternative abatement standards (20.6.2.4103 NMAC), and the drinking water maximum contaminant levels (MCLs), adopted by EPA under the federal Safe Drinking Water Act (42 United States Code §§ 300f to 300j-26). If both a WQCC standard and an MCL had been established for an individual substance, then the lower of the two levels was considered the groundwater cleanup level. If no WQCC groundwater standard or MCL was established, then the 2005 Consent Order required use of target excess cancer risk level of 10^{-5} and/or hazard index (HI) of 1 as the basis for proposing a cleanup levels. The Consent Order allowed for the most recent version of the EPA Region VI human health medium-specific screening level for tap water as the screening level if either a WQCC standard or an MCL has not been established for a specific substance. The 2005 Consent Order established the primary point of compliance at all monitoring locations within the aquifer and did not specify whether the standards applied in all groundwater zones.

The 2016 Consent Order requires groundwater cleanup levels to be based on the maximum beneficial use of the groundwater to ensure protection of human health. For protection of human health and the environment, groundwater cleanup levels are based on existing standards (e.g., drinking water standards) when they are available and when using them is protective of current and reasonably expected exposures. The 2016 Consent Order states that applicable standards for use as screening levels for protection of human health are the WQCC groundwater standards, including alternative abatement standards (20.6.2.4103 NMAC), and the EPA drinking water MCLs. If both a WQCC standard and an MCL have been established for an individual substance, then the lower of the two levels will be considered the screening level for that substance. If no WQCC groundwater standard or MCL has been established for a contaminant for which toxicological information is published, the U.S. Department of Energy shall use a target risk level of 10^{-5} lifetime excess cancer risk for carcinogenic contaminants and/or noncarcinogenic HI of 1 as the basis for developing a screening level.

The 2016 Consent Order allows the use of alternative cleanup objectives if attainment of the established cleanup objectives is demonstrated to be technically unfeasible. The 2016 Consent Order defines “groundwater” as “interstitial water that occurs in saturated earth material and is capable of entering a well in sufficient amounts to be utilized as a water supply.”

The Laboratory proposes to use the 2016 Consent Order methodology to establish groundwater cleanup levels for the regional aquifer for Consolidated Unit 16-021(c)-99 should corrective action be necessary. Under this approach, groundwater cleanup levels based on WQCC standards or MCLs would not apply to alluvial groundwater or perched-intermediate groundwater because these waters are not a potential sources of drinking water under current and reasonably foreseeable future land use. Groundwater cleanup standards based on WQCC standards or MCLs would apply to the regional aquifer where the aquifer could potentially be used as a drinking water source. Therefore, groundwater cleanup standards based on protection of drinking water supplies would not be applied to spring discharges or alluvial groundwater on Laboratory property, as originally proposed in the 2003 CMS (LANL 2003, 085531) and in the 2007 CMI plan (LANL 2007, 098192).

The basis for the proposed point of compliance for protection of drinking water supplies to the regional aquifer is that groundwater within the alluvium in Cañon de Valle is limited and would not be used as a “water supply” and therefore does not meet the definition of “groundwater” per the 2016 Consent Order. Similarly, the limited extent and yield of perched-intermediate groundwater zones is relatively low (LANL 2011, 203711; LANL 2014, 600004; LANL 2017, 602288).

Current and reasonably foreseeable future land use at TA-16 is designated as HE research, development, and testing, according to the Laboratory’s comprehensive site plan of 2000 and the 2001 update (Barnes et al. 1990, 070209; LANL 2000, 076100).

5.0 CONCLUSIONS AND RECOMMENDATIONS

The surface CMI at the 260 Outfall (LANL 2007 098192) is complete, and remedial actions for cleanup of HE and other contaminants in the 260 Outfall channel have been successfully implemented. The available inventory of RDX and barium in near-surface soils at the 260 Outfall has been significantly reduced as a result of the 2000–2001 IM and the 2009–2010 CMI. This significant reduction in contaminant source at Consolidated Unit 16-021(c)-99 appears to be a factor in the long-term declines in RDX concentrations observed in downgradient alluvial groundwater.

Low concentrations and declining trends of RDX and immobility of barium in alluvial groundwater preclude the need to use PRBs and the springs treatment units for further remediation of contamination in the springs and alluvial groundwater because the current condition is considered protective of the regional aquifer.

5.1 Long-Term Monitoring and Maintenance at Consolidated Unit 16-021(c)-99

At this time, the Laboratory proposes long-term monitoring of springs, base flow, and alluvial groundwater and inspections of the low-permeability cap above the former settling pond. If inspections indicate maintenance of the cap is required, it will be conducted to ensure the cap remains protective of the underlying contaminated surge bed and it continues to prevent water from migrating into the subsurface. Long-term monitoring will also be conducted at the surge-bed monitoring well using a pressure transducer. If sufficient water is found to be present, it will be sampled.

Sampling activities will be presented annually in the Interim Facility-Wide Groundwater Monitoring Plan but will transition to a long-term monitoring mode. Data will continue to be reported in monthly groundwater data reviews and in periodic monitoring reports.

5.1.1 Long-Term Monitoring and Maintenance Plan

A “Long-Term Monitoring and Maintenance Plan for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99,” submitted to NMED in 2010 (LANL 2010, 109252), has been updated in this report to address removal of the PRB and spring treatment options. The updated LTMMP is included in Appendix A.

Sampling of groundwater, base flow, and springs for the TA-16 260 monitoring group is conducted semiannually (LANL 2017, 602406). In Appendix A, the sampling analytes and frequencies proposed in the monitoring year 2018 Interim Facility-Wide Groundwater Monitoring Plan (LANL 2017, 602406) for alluvial groundwater, base flow, and springs for the TA-16 260 monitoring group have been adapted as the long-term monitoring requirements for Consolidated Unit 16-021(c)-99 (Appendix A), and no changes to the monitoring approach are planned for the 2018 monitoring year.

5.1.2 Annual Long-Term Monitoring and Maintenance Report

A long-term monitoring and maintenance report summarizing the data collected under the LTMMP will be submitted annually to NMED on September 30. This report will include data plots and analysis of the results. The report will also discuss any maintenance and repair of the low-permeability cap. The report will provide recommendations to NMED regarding potential changes or refinements to future monitoring and maintenance activities.

The Laboratory also proposes that the current annual corrective measures evaluation (CME)/CMI progress reports that are submitted to NMED in November of each year be terminated because this remedy completion report closes out the surface CMI activities related to Consolidated Unit 16-021(c)-99. Instead, the proposed annual long-term monitoring and maintenance reports would be submitted in lieu of the annual CME/CMI progress reports. Pending NMED approval of this approach, no annual CME/CMI progress report will be submitted in November 2017.

6.0 REFERENCES AND MAP DATA SOURCES

6.1 References

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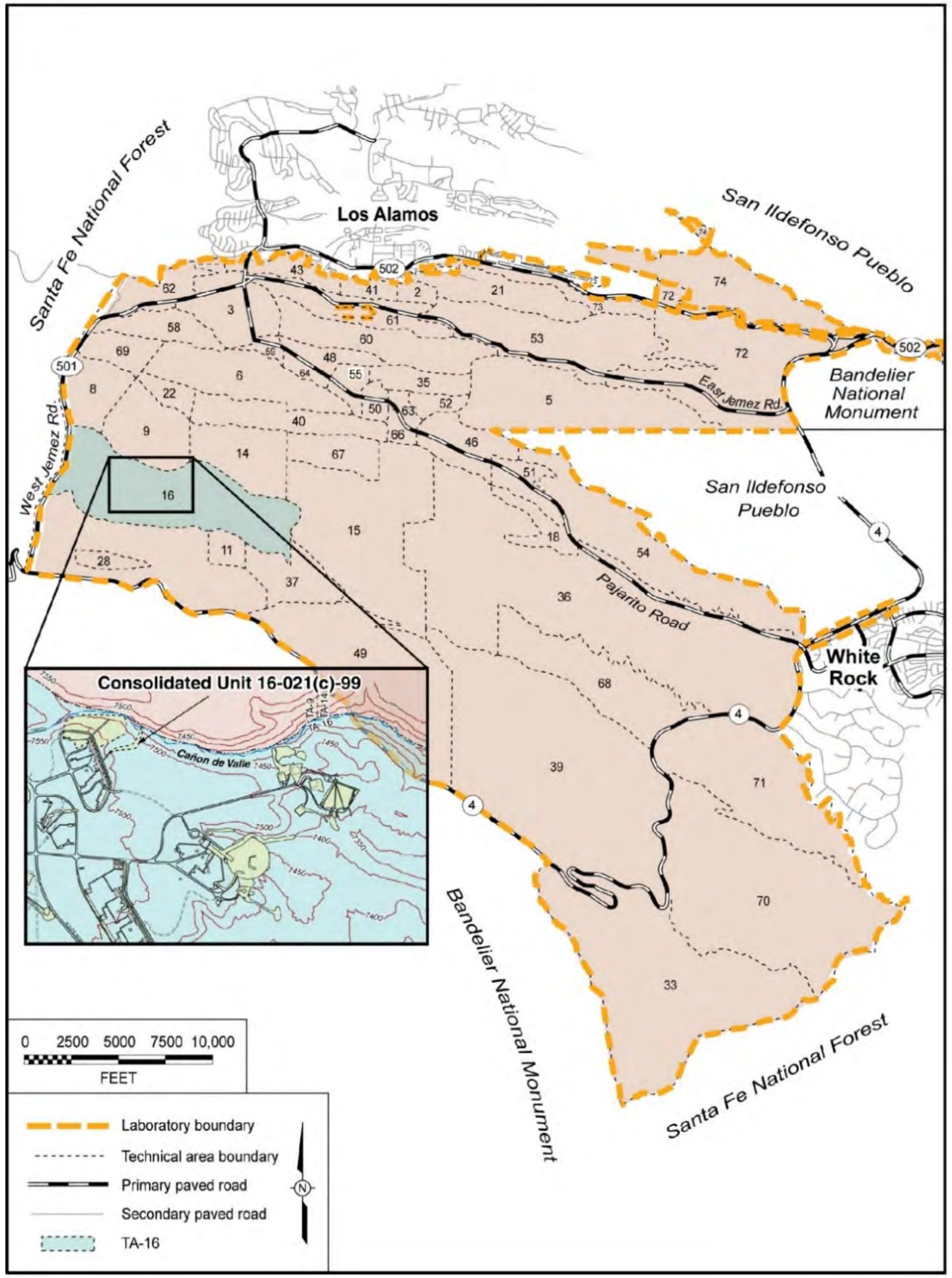

Figure 1.0-1 **Location of TA-16 with respect to Laboratory TAs and surrounding landholdings. Consolidated Unit 16-02(c)-99 is also shown.**

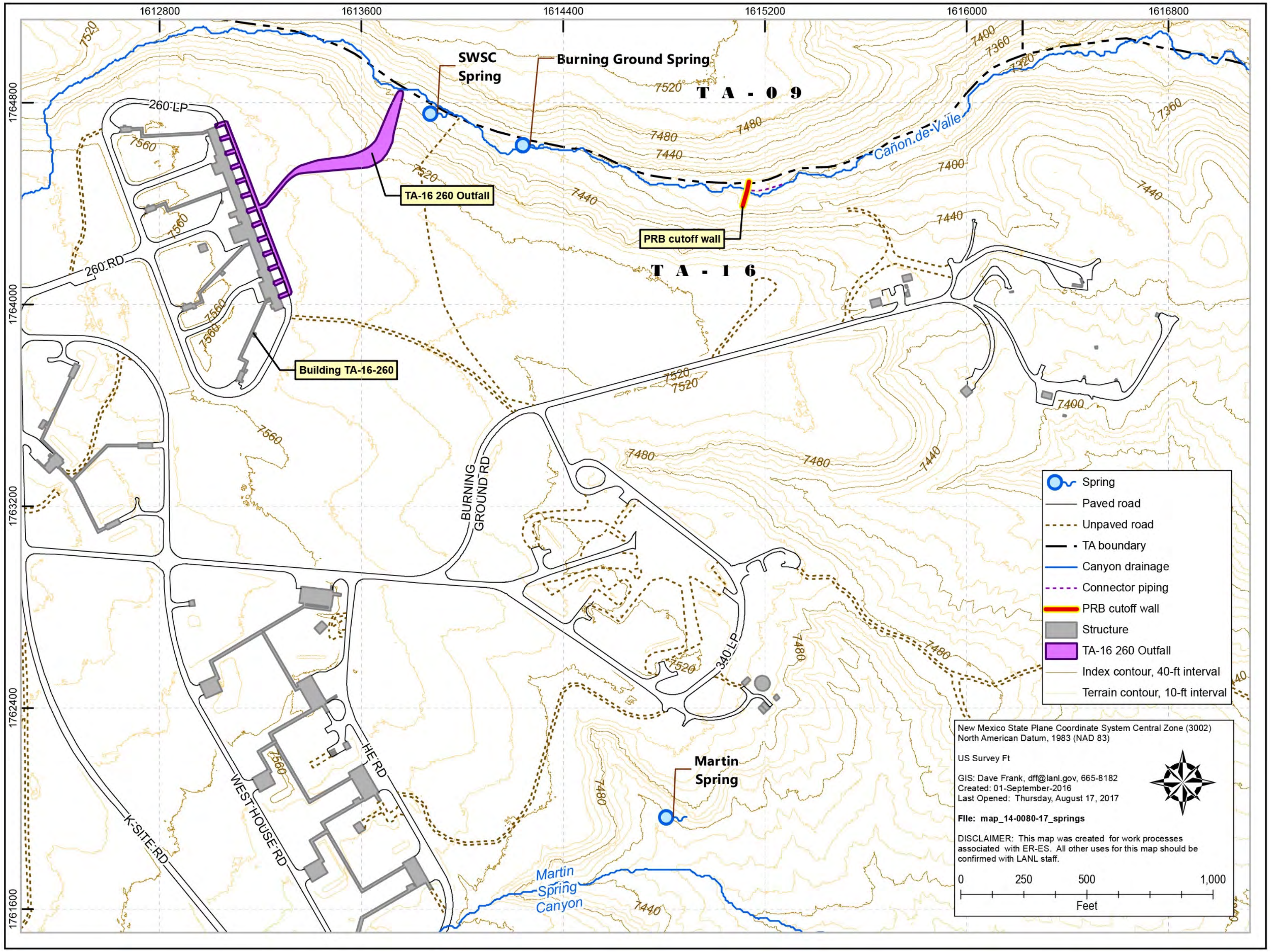

Figure 1.0-2 Locations of SWSC, Burning Ground, and Martin Springs and the PRB cutoff wall

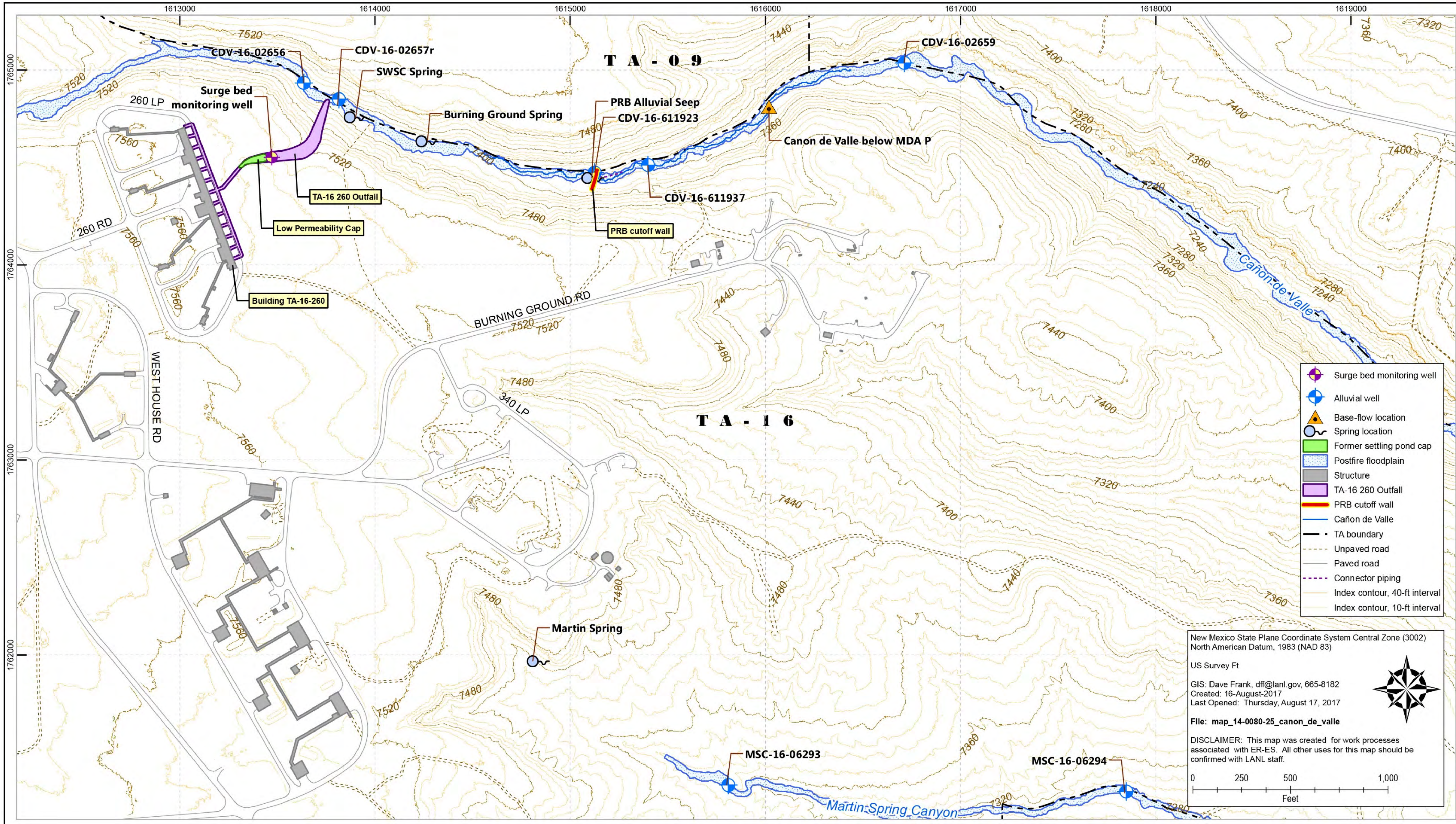

Figure 1.0-3 Shallow monitoring well network in Cañon de Valle and Martin Spring Canyon, including alluvial monitoring wells, surge bed well, and springs

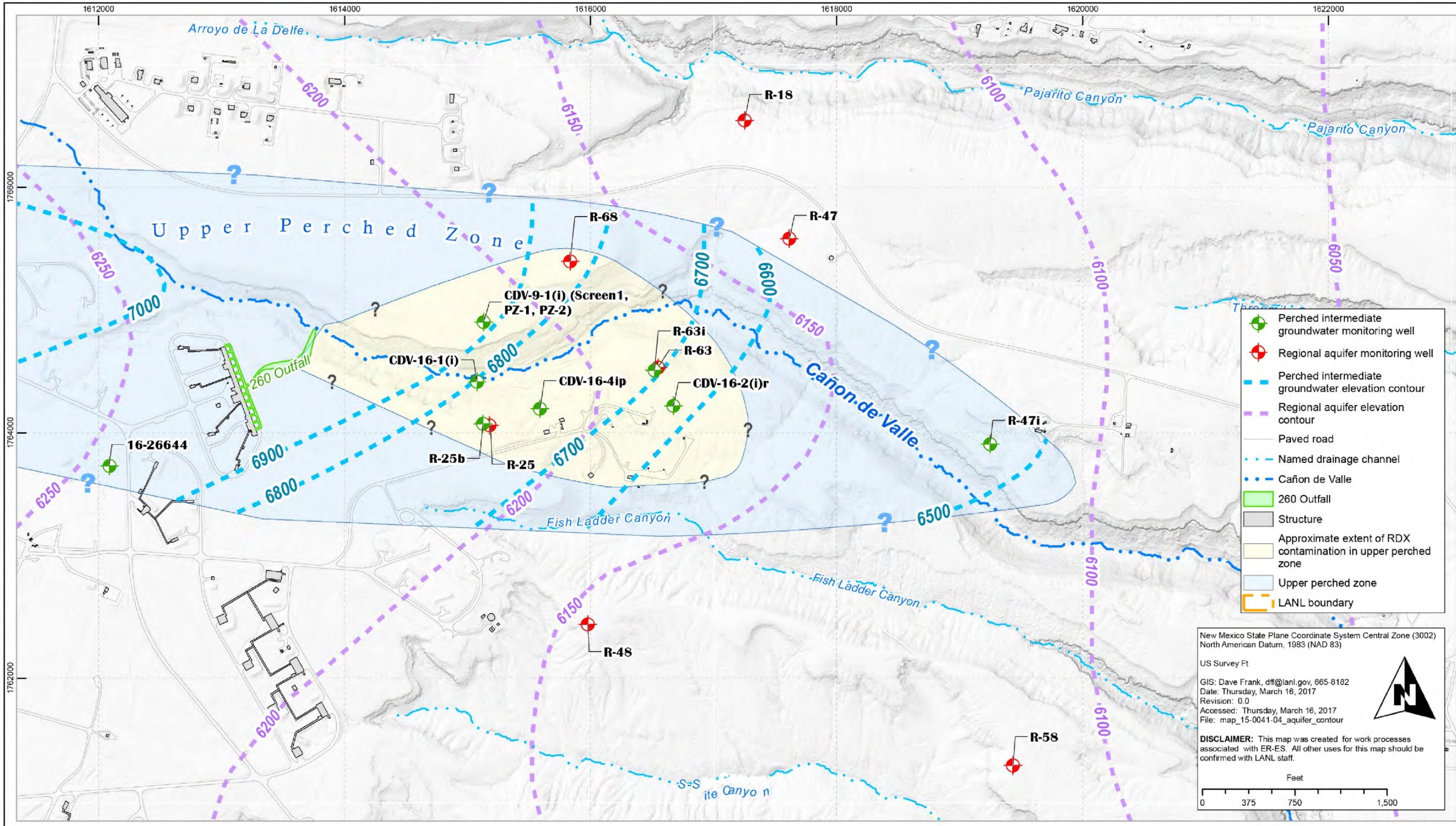

Figure 1.0-4 Perched-intermediate and regional groundwater wells in the vicinity of the 260 Outfall, and water table contours for intermediate (blue dashed lines) and regional groundwater (purple dashed lines)

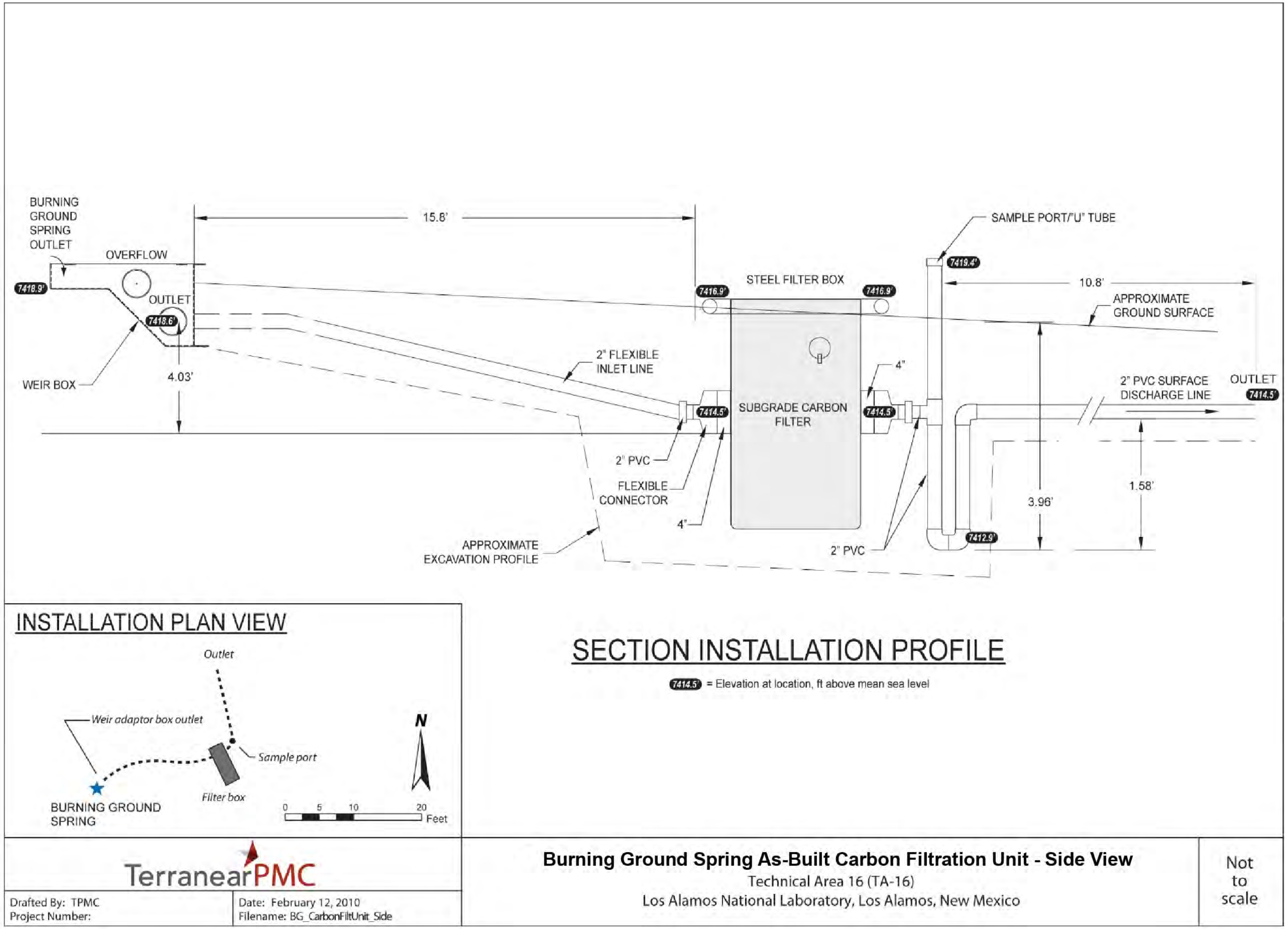

Figure 2.6-1 As-built diagram of Burning Ground Spring carbon filter system

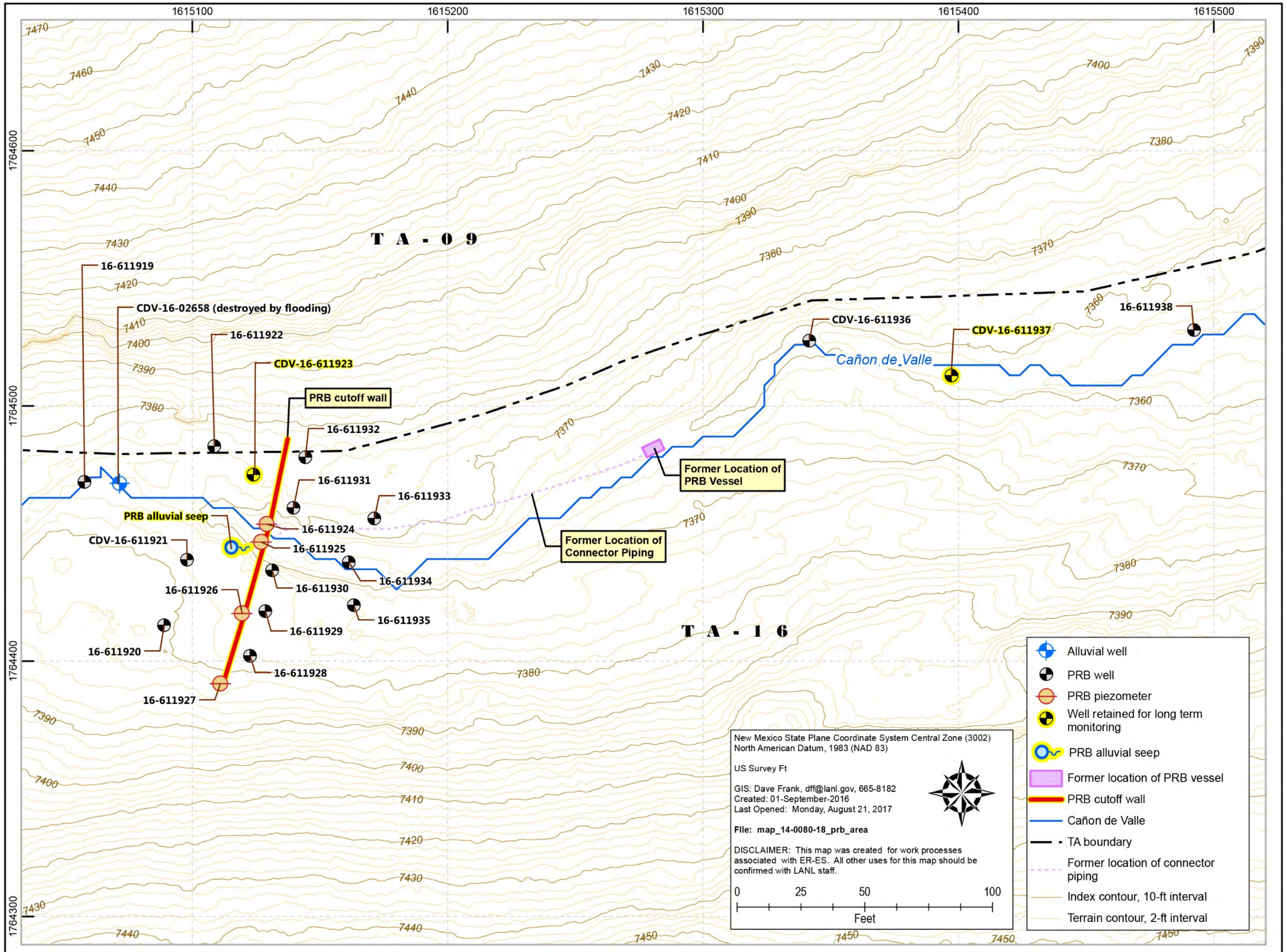

Figure 2.6-2 Locations of the former monitoring wells and piezometers at the PRB. Long-term monitoring locations are highlighted.

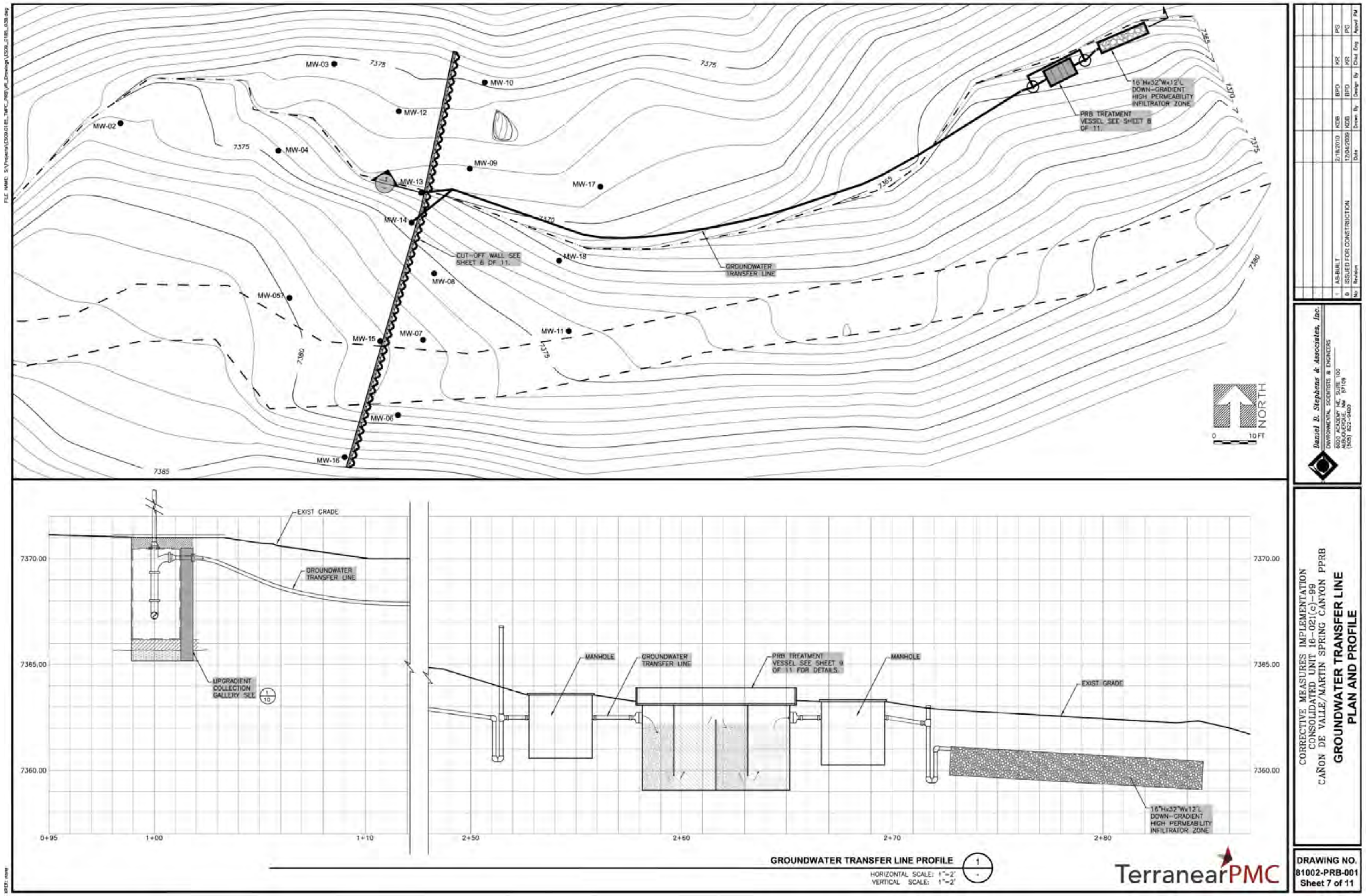

Figure 2.7-1 As-built drawing for the PRB showing the PRB treatment vessel, groundwater transfer line, and high-permeability infiltration zone

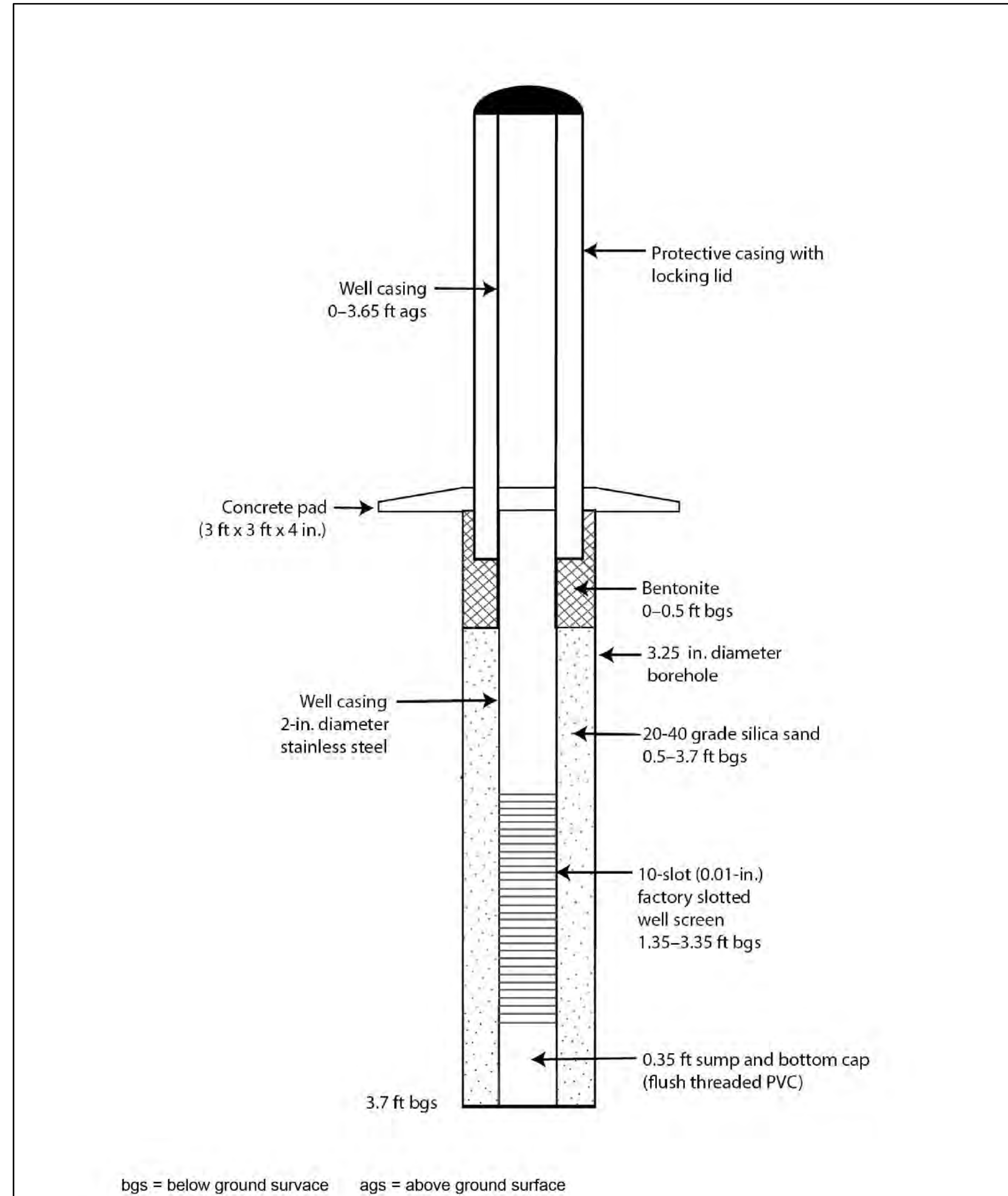

Figure 2.9-1 As-built diagram for alluvial monitoring well CdV-16-02657r

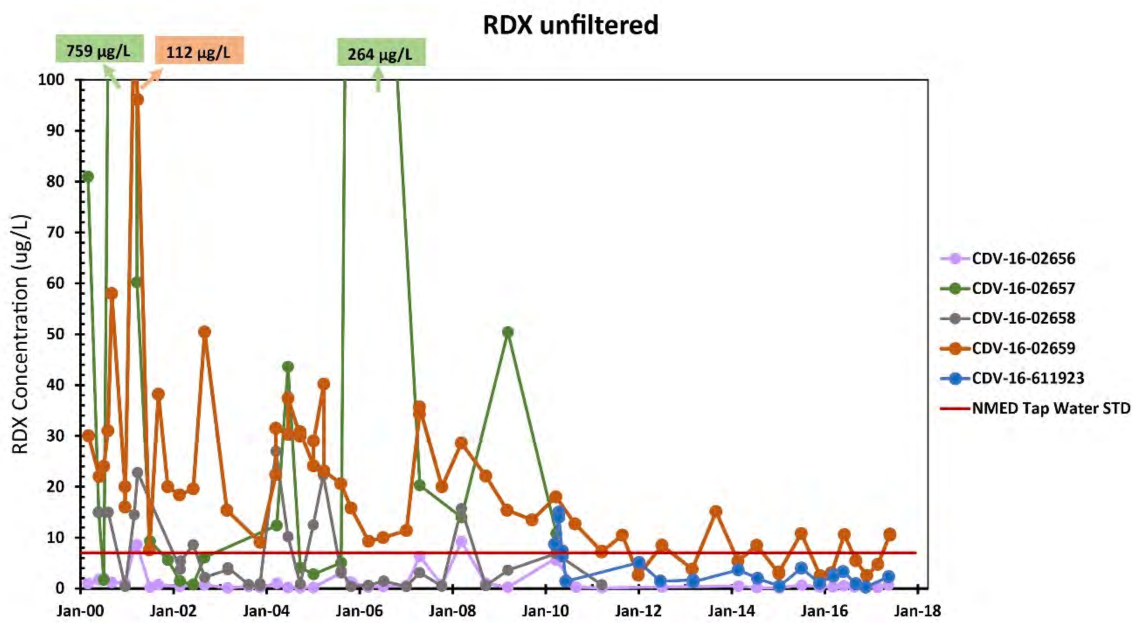

Figure 3.1-1 RDX concentrations in alluvial monitoring wells in Cañon de Valle from 2000 to present. Well CdV-16-02658 was destroyed by flooding in 2011.

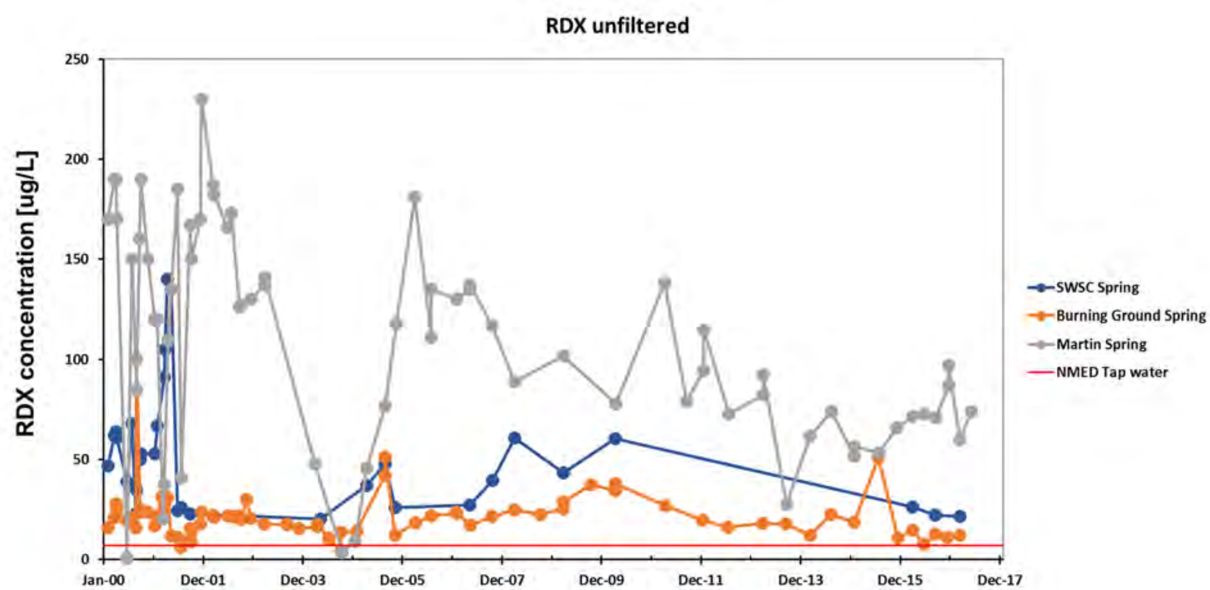

Figure 3.1-2 RDX concentrations in discharge from SWSC, Burning Ground, and Martin Springs from 2000 to present

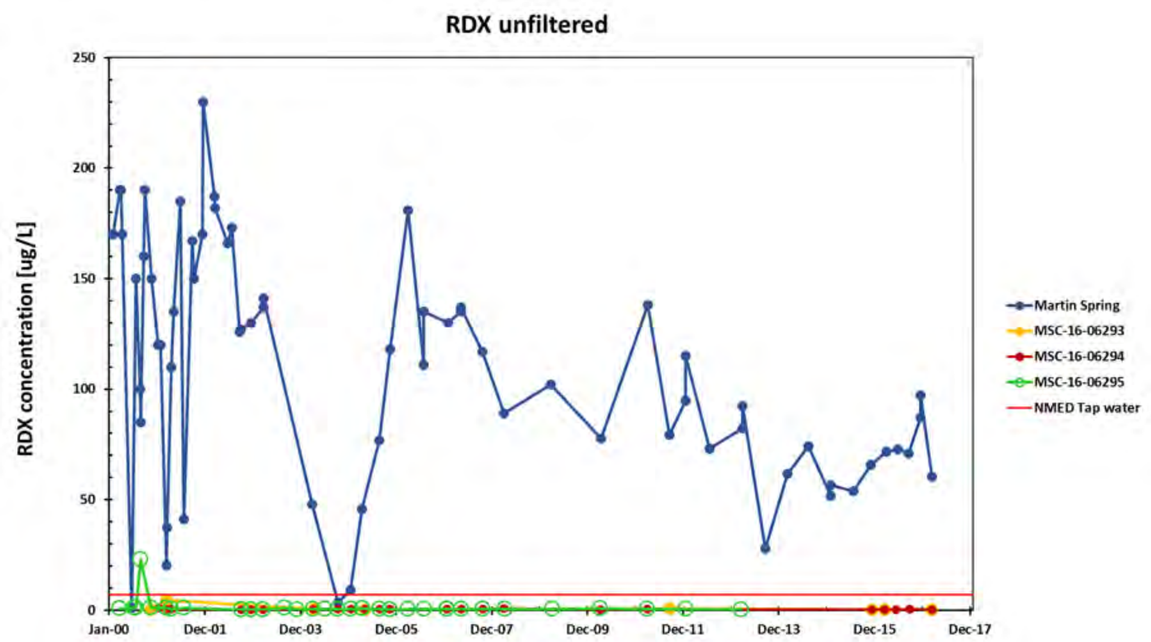

Figure 3.1-3 RDX concentrations in groundwater samples collected from Martin Spring Canyon locations, including concentrations in Martin Spring and in downgradient alluvial wells. Well MSC-16-06295 was destroyed by flooding in 2011.

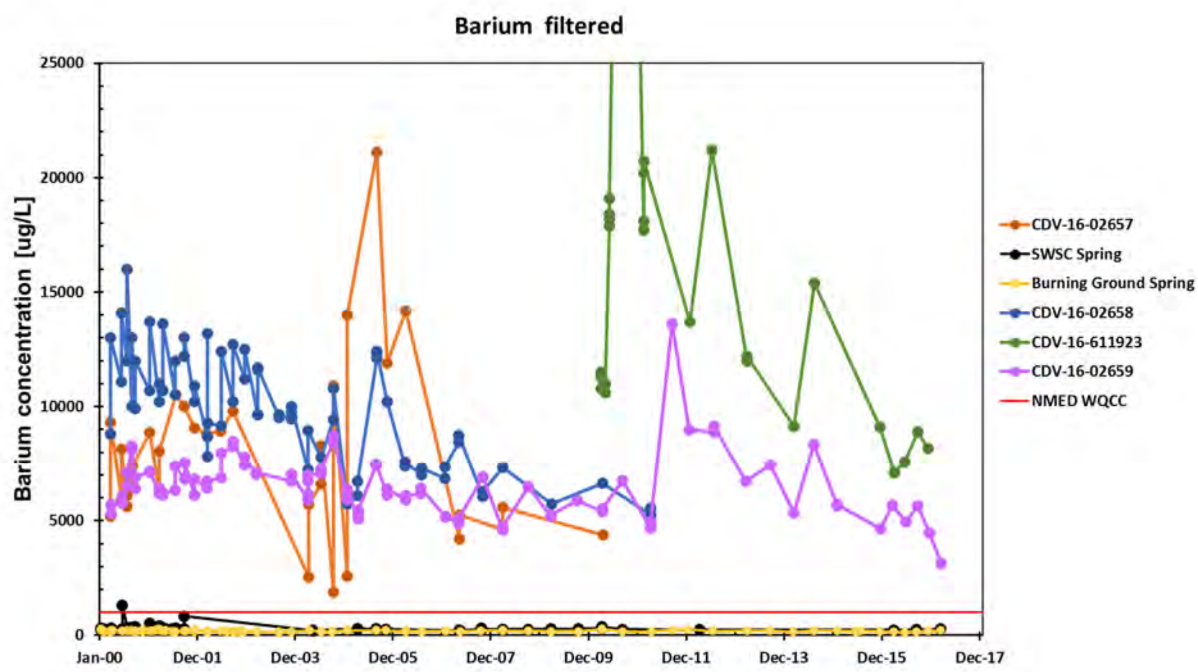

Figure 3.2-1 Barium concentrations in Cañon de Valle alluvial monitoring wells and in discharge from SWSC and Burning Ground Springs. Well CdV-16-02548 was destroyed by flooding in 2011.

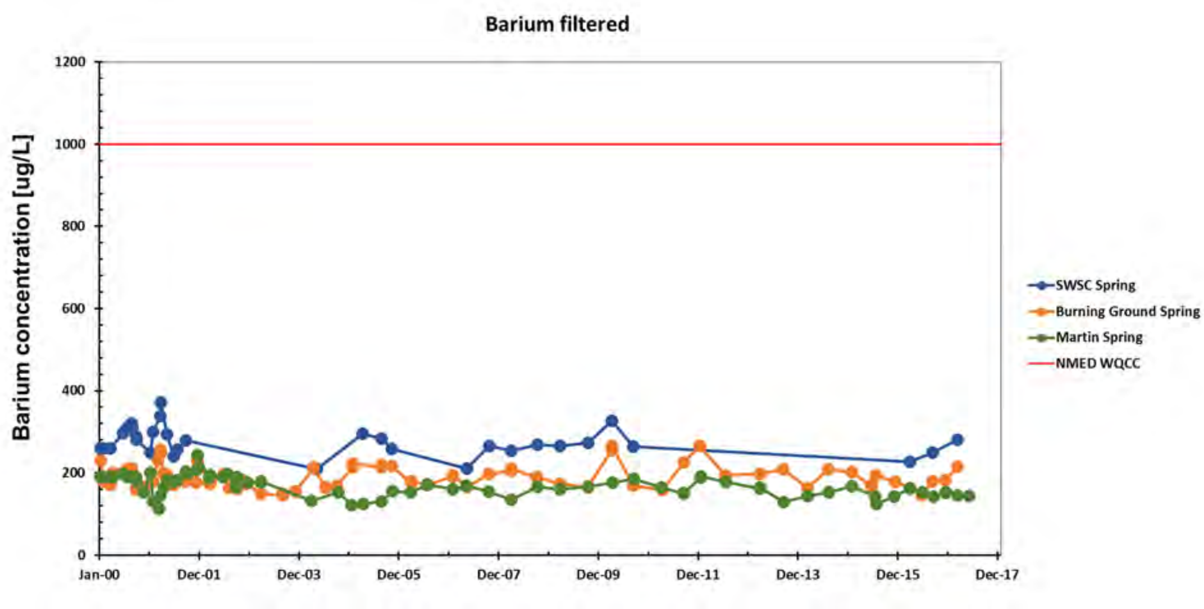

Figure 3.2-2 Barium concentrations in discharge from SWSC, Burning Ground, and Martin Springs from 2000 to present

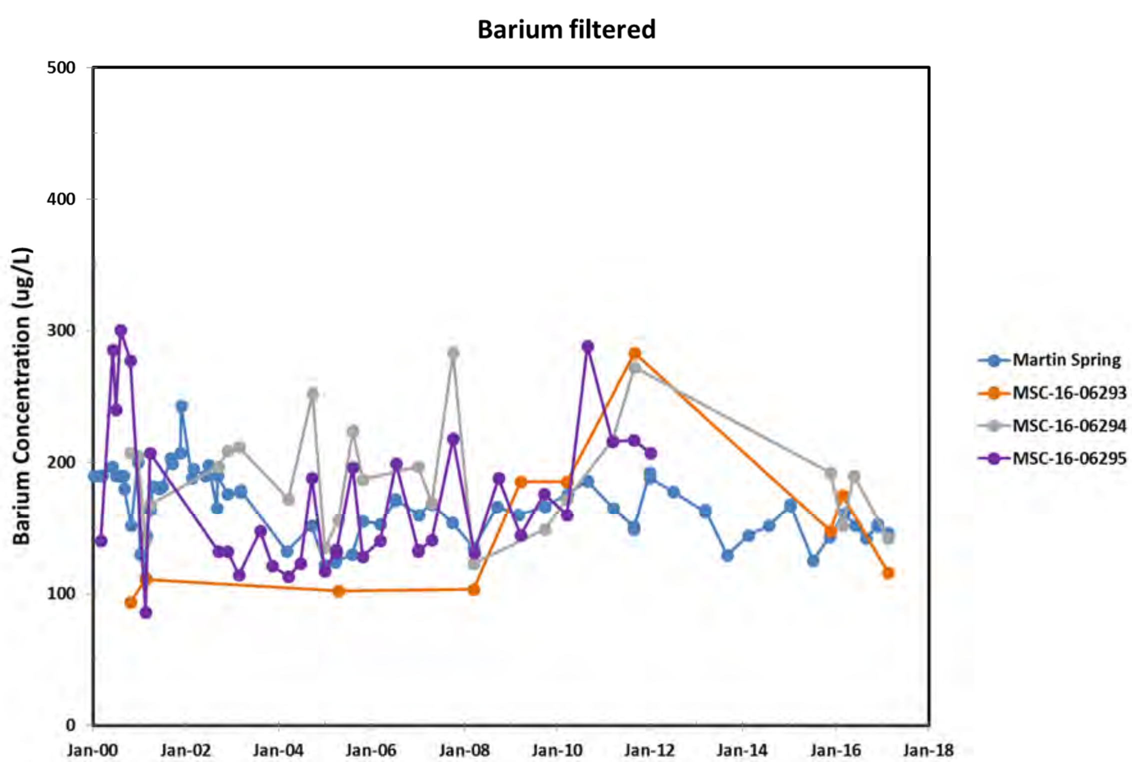

Figure 3.2-3 Barium concentrations in Martin Spring discharge and in Martin Spring Canyon alluvial wells. Well MSC-16-06295 was destroyed by flooding in 2011.

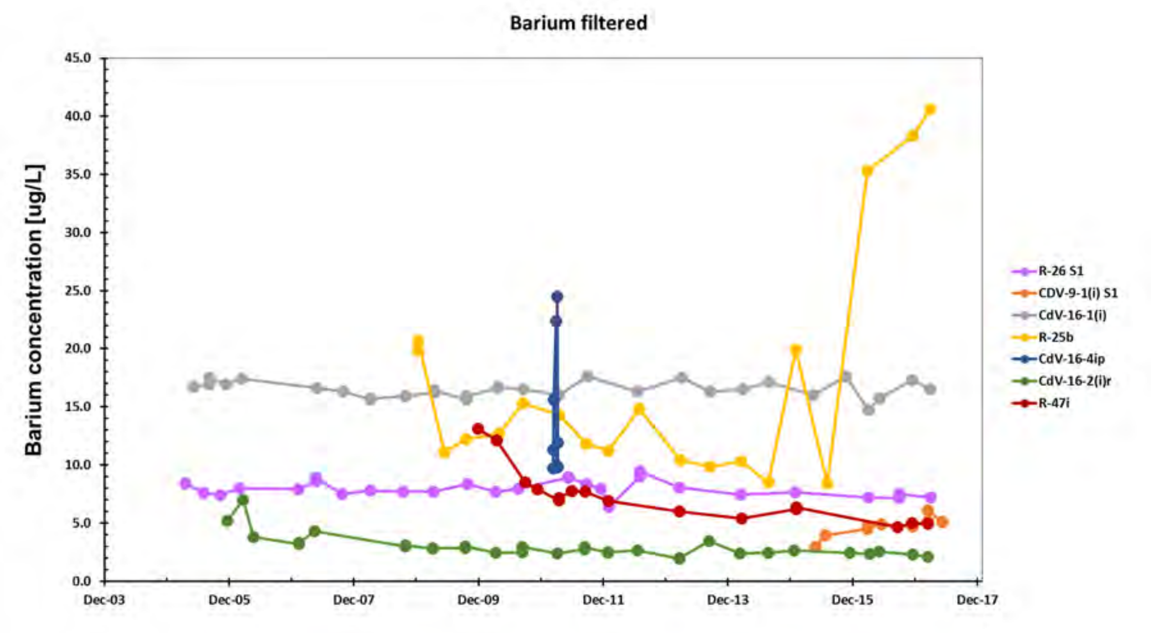

Figure 3.2-4 Barium concentrations in deep perched-intermediate groundwater in the vicinity of TA-16. The UTL is 13.5 µg/L (LANL 2016, 601920).

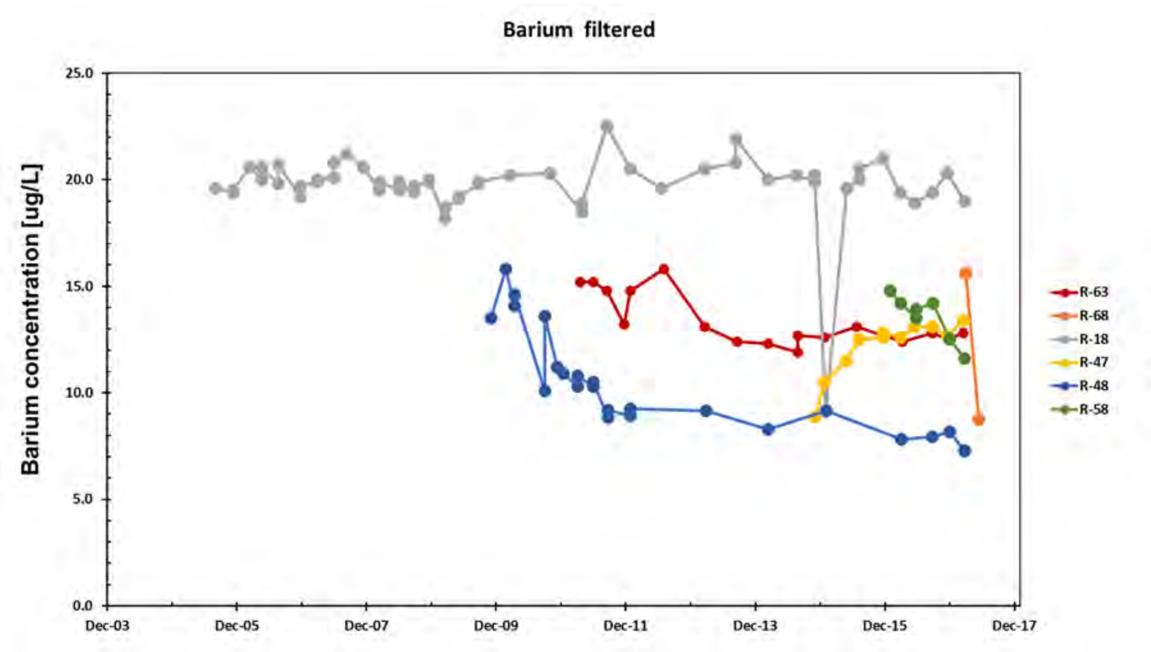

Figure 3.2-5 Barium concentrations in regional groundwater in the vicinity of TA-16. The UTL is 38.1 µg/L ((LANL 2016, 601920).

Table 2.9-1
Summary of PRB Monitoring Wells and Their Final Disposition

Location	Alternate Name	Total Depth (ft bgs)	Final Disposition	Notes
Upgradient Alluvial Wells				
CdV-16-611919	MW-2	8.0	No longer exists	Washed away during August 21, 2011, flood.
CdV-16-611920	MW-5	12.5	Plugged and abandoned	
CdV-16-611921	MW-4	14.4	Plugged and abandoned	
CdV-16-611922	MW-3	13.3	Plugged and abandoned	
CdV-16-611923	MW-12	8.7	Retained for long-term monitoring	Monitoring Year 2018 Interim Facility-Wide Groundwater Monitoring Plan location. Retained for long-term monitoring.
Upgradient Piezometers				
16-611924	MW-13, PZ-13	~ 10 to 15	Plugged and abandoned	Piezometer damaged by August 3, 2011, floodwater and debris.
16-611925	MW-14, PZ-14	~ 10 to 15	Plugged and abandoned	
16-611926	MW-15, PZ-15	~ 10 to 15	Plugged and abandoned	
16-611927	MW-16, PZ-16	~ 10 to 15	Plugged and abandoned	
Downgradient Alluvial Wells				
CdV-16-611928	MW-6	13.0	Plugged and abandoned	
CdV-16-611929	MW-7	13.1	Plugged and abandoned remaining portion of piezometer	Well broken off during August 21, 2011, flood.
CdV-16-611930	MW-8	13.0	Plugged and abandoned remaining portion of piezometer	Well broken off during August 21, 2011, flood.
CdV-16-611931	MW-9	12.0	Plugged and abandoned	Surface completion and well housing destroyed during August 21, 2011, flood, leaving only PVC well casing.
CdV-16-611932	MW-10	13.0	Plugged and abandoned	
CdV-16-611933	MW-17	9.0	Plugged and abandoned	
CdV-16-611934	MW-18	8.0	No longer exists	Alluvial well washed away during August 21, 2011, flood.
CdV-16-611935	MW-11	12.0	Plugged and abandoned	
CdV-16-611936	MW-19	7.5	No longer exists	Alluvial well washed away during August 21, 2011, flood.
CdV-16-611937	MW-20	8.5	Retained for long-term monitoring	Monitoring year 2018 Interim Facility-Wide Groundwater Monitoring Plan monitoring location. Retained for long-term monitoring.
CdV-16-611938	MW-1	8.5	No longer exists	Alluvial well washed away during August 21, 2011, flood.

Note: Blank cells indicate additional information is not available.

Appendix A

Long-Term Monitoring and Maintenance Plan for Corrective Measures Implementation at Consolidated Unit 16-021(c)-99

A-1.0 INTRODUCTION

This appendix presents the long-term monitoring and maintenance plan (LTMMP) for the corrective measures implementation (CMI) at Consolidated Unit 16-021(c)-99 within Technical Area 16 (TA-16) at Los Alamos National Laboratory (LANL or the Laboratory) (Figure 1.0-1 of the report). The LTMMP follows from the remedy completion report for corrective measures at Consolidated Unit 16-012(c)-99.

Consolidated Unit 16-021(c)-99 consists of the high explosives (HE) machining building (16-260) and associated sumps, drainlines, and troughs that discharged into the 260 Outfall drainage channel. The 260 Outfall drainage channel consists of the outfall, a former settling pond, and the lower portion of the drainage channel leading to Cañon de Valle (Figure A-1.0-1). HE-contaminated water from the outfall entered the former settling pond and drained into the 260 Outfall drainage channel.

The CMI at Consolidated Unit 16-021(c)-99 included installing four treatment systems: (1) a low-permeability cap on the former settling pond, (2) injection grouting of the surge bed underlying the former settling pond, (3) carbon filter treatment systems of spring waters at SWSC and Burning Ground Springs in Cañon de Valle and at Martin Spring in Martin Spring Canyon, and (4) a pilot permeable reactive barrier (PRB) treatment system in Cañon de Valle (section 2.5).

This LTMMP discusses monitoring and maintenance of the 260 Outfall former settling pond cap and monitoring of the surge bed; monitoring of discharge at SWSC, Burning Ground, and Martin Springs; and monitoring of groundwater and base-flow monitoring at select locations within Cañon de Valle and Martin Spring Canyon.

A-1.1 Purpose

The LTMMP describes monitoring activities that will be conducted to assess the long-term effectiveness of the CMI for Consolidated Unit 16-021(c)-99 and to support continuous evaluation of the conceptual model for the fate and transport of residual contamination in nearby springs, surface water, and alluvial groundwater. The LTMMP also includes an inspection approach for the low-permeability cap at Consolidated Unit 16-021(c)-99 and provisions for maintaining the cap, as necessary.

A-1.2 Reporting

The Laboratory will submit to the New Mexico Environment Department (NMED) an annual long-term monitoring and maintenance report summarizing monitoring data for base flow and alluvial groundwater in Cañon de Valle and Martin Spring Canyon. The report will be submitted to NMED on September 30.

The long-term monitoring and maintenance report will include an evaluation of data from the reporting year in the context of the long-term data trends, corrective measures implemented, and other potential factors, including interannual hydrologic variability, to ensure that CMI actions taken remain protective. The report will also discuss any maintenance and repair activities conducted on the low-permeability cap. The report may also include recommendations to NMED regarding potential changes or refinements to future monitoring activities, if necessary.

The report will be provided in lieu of the annual corrective measures evaluation (CME)/CMI progress reports that have been submitted to NMED annually in November and will document all Consolidated Unit 16-021(c)-99 monitoring, inspection, and maintenance activities for the previous year.

A-1.3 Regulatory Context

LTMMP activities follow from the remedy completion report for corrective measures at Consolidated Unit 16-012(c)-99. The LTMMP complements and integrates with the Interim Facility-Wide Groundwater Monitoring Plan (IFGMP) for groundwater and surface water monitoring. The Laboratory implements the IFGMP in accordance with Section XII of the 2016 Compliance Order on Consent (the Consent Order). Section XII requires an annual update of the IFGMP and anticipates that monitoring plans for specific areas will change as groundwater investigation objectives are met.

Monitoring of groundwater from springs (including SWSC, Burning Ground, and Martin); alluvial wells; and intermediate and regional wells in the vicinity and downgradient of the 260 Outfall has historically been conducted as part of the TA-16 260 monitoring group activities conducted under the IFGMP. With the completion of surface CMI activities at Consolidated Unit 16-021(c)-99, the U.S. Department of Energy has incorporated changes to the TA-16 260 monitoring group portion of the IFGMP to reflect this LTMMP.

A-1.4 Monitoring Objectives

Key objectives of the LTMMP include:

- Monitoring effectiveness of the low-permeability cap and surge-bed grouting to ensure infiltrating water does not encounter and mobilize residual contamination in the outfall area and underlying shallow vadose zone.
- Monitoring the long-term trend in contaminant concentrations (primarily HE and barium) in springs, surface water, and alluvial groundwater to ensure historically declining and/or stable concentrations persist.

A-2.0 260 OUTFALL FORMER SETTLING POND AND SURGE BED

Sections A-3.1 and A-3.2 discuss the inspection and monitoring and maintenance approach for the low-permeability cap on the former settling pond and the surge bed monitoring well that was installed to monitor the effectiveness of the injection grouting.

A-2.1 Low-Permeability Cap

The objective of the low-permeability cap on top of the former settling pond is to prevent surface water from infiltrating underlying potentially contaminated tuff. Storm water run-on and runoff controls are in place to prevent erosion of the cap and to prevent runoff and sediment from moving farther down the 260 Outfall drainage channel. The low-permeability cap will be inspected semiannually for evidence of settling or cracking, erosion, water ponding, and animal intrusion. Inspections will be conducted in March or April to check for damage that may be associated with winter and snowmelt conditions and in September to monitor for damage from summer rainfall runoff. Should the inspections reveal damage to the low-permeability cap that may prevent the cap from meeting its objective, maintenance activities will be conducted as necessary. The inspection results and a summary of maintenance activities conducted on the low-permeability cap will be reported to NMED in the annual long-term monitoring and maintenance report. Table A-2.1-1 summarizes the inspection and monitoring requirements for the low-permeability cap and the surge bed monitoring well discussed in section A-2.2.

Monitoring and maintenance of the storm water control structures at Consolidated Unit 16-021(c)-99 continues under the Laboratory's Individual Permit Program, issued by the U.S. Environmental Protection Agency, Region 6, on September 30, 2010, to Los Alamos National Security, LLC, and the U.S. Department of Energy under National Pollutant Discharge Elimination System (NPDES) Permit No. NM0030759. Storm water controls installed at the site under the Individual Permit currently include vegetation, earthen berms, curbing, riprap, a rock check dam, and a rock cap. These controls are inspected and maintained as required by the permit. Inspection requirements and details are included in the "2016 Update to the Site Discharge Pollution Prevention Plan, Revision 1, NPDES Permit No. NM0030759, Water/Cañon de Valle Watershed, Receiving Waters: Cañon de Valle, Potrillo Canyon, Water Canyon, and Fence Canyon, Volume 4" (LANL 2017, 602284). This plan provides additional details regarding control measures, storm water monitoring, inspections and maintenance, and compliance status for the storm water management area CDV-SMA-2, which includes the 260 Outfall.

A-2.2 Surge Bed Monitoring Well

CMI activities included injecting grout into the subsurface surge bed material underlying the former settling pond (where contamination was previously identified). A total of 9080 gal. of grout was injected into 16 boreholes installed within the former settling pond area in the 260 Outfall drainage channel to stabilize the surge bed (LANL 2010, 108868). To evaluate the effectiveness of the injection grouting and of the low-permeability cap, a well was installed next to the former settling pond and completed in a surge bed to monitor for the appearance of water in the surge bed (LANL 2007, 098192, p. 16). The location of the surge bed monitoring well is shown in Figure A-1.0-1. The well was drilled to a depth of 25 ft and screened across the surge bed horizon. No water was observed during drilling and construction of the well.

Going forth, the presence of water will be monitored using a pressure transducer linked to a telemetry system. If sufficient water is detected within the well, it will be sampled up to twice a year for off-site analyses of explosive compounds. Any water-level and monitoring data collected will be reported to NMED in the annual long-term monitoring and maintenance report.

To date, no water has been observed in the surge-bed monitoring well, although the well has not been continuously monitored in the past using pressure transducers. Installation of a pressure transducer on telemetry should help to verify that measurable water is not moving through the low-permeability cover or in the surge beds.

A-3.0 GROUNDWATER MONITORING AT SWSC, BURNING GROUND, AND MARTIN SPRINGS

Concentration trends for HE compounds have been variable but are generally declining or stable for an extended period of time. As described in the remedy completion report, the current concentrations of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) detected in the springs is considered protective of nearby surface water and alluvial groundwater because the concentrations decrease dramatically away from the source. The objective of the long-term monitoring at each of the springs is to ensure concentrations remain low or stable with time.

Discharge from SWSC, Burning Ground, and Martin Springs has been actively monitored and will continue to be monitored under the LTMMP. The data collected will be used as input for groundwater and contaminant transport modeling activities. Monitoring parameters and sampling frequencies for the springs are summarized in Table A-3.0-1. Monitoring data from the springs will be reported in the annual long-term monitoring and maintenance report.

A-4.0 ALLUVIAL GROUNDWATER MONITORING AND BASE-FLOW MONITORING IN CAÑON DE VALLE AND MARTIN SPRING CANYON

Base-flow and alluvial groundwater are mixes of spring discharges and water from upgradient locations and sources. Contaminant concentrations at surface water and alluvial monitoring locations have been steadily declining and are currently low and stable with some seasonally driven variability.

Monitoring of alluvial groundwater and base flow in Cañon de Valle and alluvial groundwater in Martin Spring Canyon have been actively monitored and will continue to be monitored under the LTMMP to assess long-term trends in contaminant concentrations and to ensure CMI activities conducted in 2009 and 2010 remain protective (LANL 2010, 108868; LANL 2010, 110508). Monitoring parameters and sampling frequencies for alluvial wells, springs, and base flow are summarized in Table A-4.0-1. All monitoring data will be reported in the long-term monitoring and maintenance report. Figure A-4.0-1 shows monitoring year 2018 IFGMP sampling locations in the vicinity of the 260 Outfall, with long-term monitoring locations highlighted in yellow. All IFGMP monitoring wells are inspected annually and maintained under the Laboratory's Well Maintenance Program.

It is anticipated that monitoring data from the alluvial wells and base flow will continue to show declines or stable concentrations of RDX and barium in alluvial groundwater. These data will be evaluated during development of the long-term monitoring and maintenance report. If the data show significant increases in contaminant concentrations over time, the conditions in the vicinity of Consolidated Unit 16-021(c)-99 will be reassessed to identify the cause for the increases in contaminant concentrations and to evaluate whether additional corrective action is necessary.

A-5.0 REFERENCES AND MAP DATA SOURCES

A-5.1 References

The following reference list includes documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ERID or ESHID. This information is also included in text citations. ERIDs were assigned by the Associate Directorate for Environmental Management's (ADEM's) Records Processing Facility (IDs through 599999), and ESHIDs are assigned by the Environment, Safety, and Health Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and ADEM 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), July 2007. "Corrective Measures Implementation Plan for Consolidated Unit 16-021(c)-99, Revision 1," Los Alamos National Laboratory document LA-UR-07-4715, Los Alamos, New Mexico. (LANL 2007, 098192)

LANL (Los Alamos National Laboratory), March 2010. "Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-10-0947, Los Alamos, New Mexico. (LANL 2010, 108868)

LANL (Los Alamos National Laboratory), August 2010. "Addendum to the Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-10-5576, Los Alamos, New Mexico. (LANL 2010, 110508)

LANL (Los Alamos National Laboratory), May 1, 2017. “2016 Update to the Site Discharge Pollution Prevention Plan, Revision 1, NPDES Permit No. NM0030759, Water/Cañon de Valle Watershed, Receiving Waters: Cañon de Valle, Potrillo Canyon, Water Canyon, and Fence Canyon, Volume 4,” Los Alamos National Laboratory document LA-UR-17-23039, Los Alamos, New Mexico. (LANL 2017, 602284)

A-5.2 Map Data Sources

Paved Road Arcs; Los Alamos National Laboratory, FWO Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 13 August 2010.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

SWMU or AOC boundary: Potential Release Sites; Los Alamos National Laboratory, ESH&Q Waste & Environmental Services Division, Environmental Data and Analysis Group.

LANL Areas Used and Occupied; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; 19 September 2007; as published 21 June 2017.

Wells; Los Alamos National Laboratory, Waste and Environmental Services, Division; Locus EIM database pull.

Road centerline; Road Centerlines for the County of Los Alamos; County of Los Alamos, Information Services; as published 04 March 2009.

Drainage; Watercourse; Los Alamos National Laboratory, ENV Water Quality & Hydrology Group; 05 April 2005.

Hillshade; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\Data\HYP\LiDAR\2014\Bare_Earth\BareEarth_DEM_Mosaic.gdb; 2014

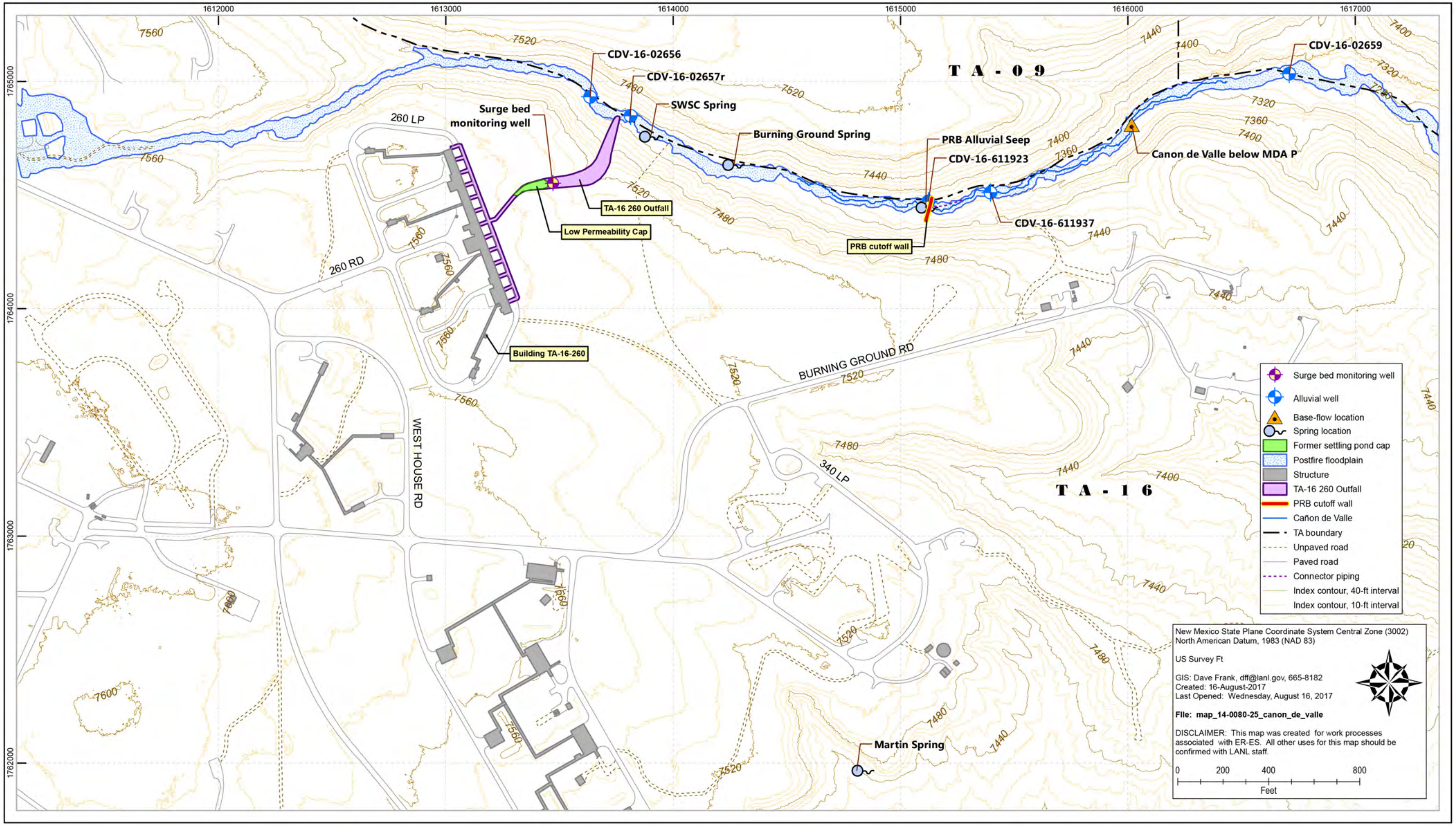

Figure A-1.0-1 Location of the 260 Outfall drainage channel showing the low-permeability cap and surge bed monitoring well in Cañon de Valle. Nearby springs and alluvial monitoring wells are also shown.

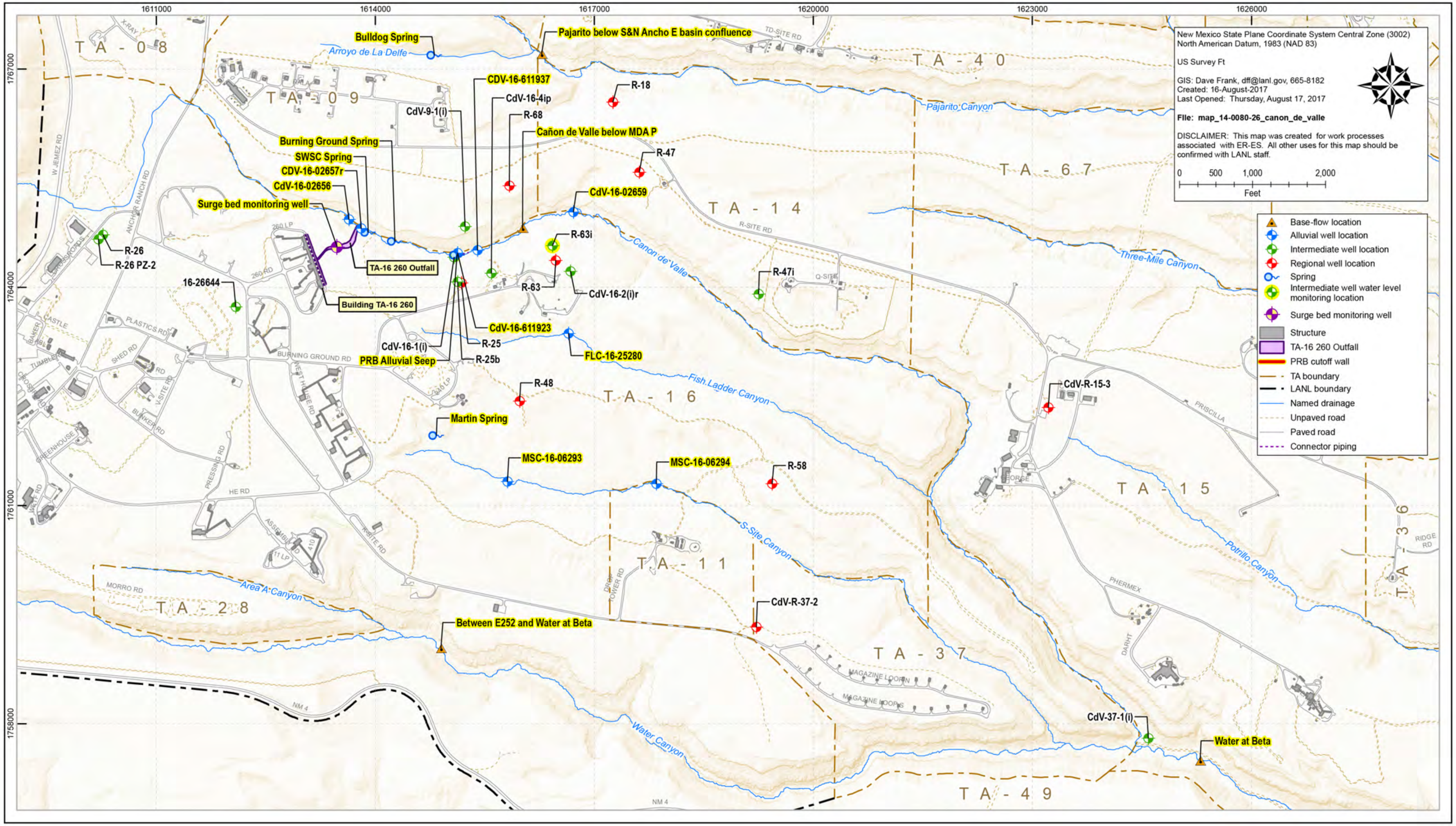

Figure A-4.0-1 IFGMP sampling locations in the vicinity of the 260 Outfall, with long-term monitoring locations highlighted

Table A-2.1-1
Inspection and Monitoring Requirements for the Low-Permeability Cap and Surge Bed Monitoring Well

Location	Objective	Monitoring Event Frequency	Comments
Low-Permeability Cap	Stability	March/April September	Inspections of the low-permeability cap will follow spring snowmelt and summer rains. Any problems with the integrity of the cap that could prevent it from meeting its design objective of preventing surface water infiltration will be repaired in a timely manner. Inspections and maintenance of the runoff/run-on controls in the vicinity of the low-permeability cap are conducted separately under the Laboratory's Individual Permit Program (LANL 2017, 602284).
Surge Bed Monitoring Well	Chemical analysis	Twice yearly if water is present	Water levels will be monitored with pressure transducers using telemetry. If water is observed and sufficient water is present, samples will be collected for analysis of HE and other constituents per Table A-4.0-1.

Table A-3.0-1
Monitoring Plan for Base Flow, Springs, and Alluvial Monitoring Locations in TA-16

Location	Watershed	Monitoring Group	Surface Water Body or Source Aquifer	Metals	Volatile Organic Compounds	Semivolatile Organic Compounds	Polychlorinated Biphenyls	HEXMOD	Dioxins/Furans	Radionuclides	Tritium	Low-Level Tritium	General Inorganics	Naphthalene Sulfonates	Sodium Bromide Tracer	$^{15}N/^{18}O$ Isotopes in Nitrate
Canon de Valle below MDA P	Water	TA-16 260	Base flow	S	S	B (2018)[a]	V (2020)[b]	S	V (2020)	B (2018)	—[c]	—	S	—	—	—
Between E252 and Water at Beta	Water	TA-16 260	Base flow	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
Water at Beta	Water	TA-16 260	Base flow	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
Pajarito below S&N Ancho E Basin Confluence	Pajarito	TA-16 260	Base flow	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
Bulldog Spring	Pajarito	TA-16 260	Spring	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	A
SWSC Spring	Water	TA-16 260	Spring	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	A
Burning Ground Spring	Water	TA-16 260	Spring	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	A	S	—	—	A
Martin Spring	Water	TA-16 260	Spring	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	A	S	—	—	A
FLC-16-25280	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
CdV-16-02656	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
CdV-16-02657r	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
CdV-16-02659	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
CdV-16-611923	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
MSC-16-06293	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
MSC-16-06294	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
PRB Alluvial Seep	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
CdV-16-611937	Water	TA-16 260	Alluvial	S	S	B (2018)	V (2020)	S	V (2020)	B (2018)	—	—	S	—	—	—
Surge Bed Monitor Well	Water	TA-16 260	Surge Bed (Intermediate)	S	S	S	—	S	—	—	—	—	S	—	—	—

Notes: Sampling frequencies: S = semiannual (2 times/yr); A = annual (1 time/yr); B = biennial (1 time/2 yr); V = quinquennial (1 time/5 yr).

[a] 2018 = Samples scheduled to be collected during implementation of monitoring year 2018 IFGMP.

[b] 2020 = Samples scheduled to be collected during implementation of monitoring year 2020 IFGMP.

[c] — = This analytical suite is not scheduled to be collected for this type of water at locations assigned to this monitoring group.

Appendix B

Documentation for the Army Corps of Engineering
(on CD included with this document)

Appendix C

Photographs of Permeable Reactive Barrier Removal Activities and Restored Sites at SWSC, Burning Ground, and Martin Springs

1.0 PERMEABLE REACTIVE BARRIER (PRB)

Figure 1.0-1 View of PRB area before restoration, showing damaged cutoff wall and undercut well

Figure 1.0-2 PRB treatment vessel before removal

Figure 1.0-3 Excavation area after removal of PRB treatment vessel

Figure 1.0-4 PRB treatment vessel after removal

Figure 1.0-5 Granular activated carbon (left side) and zeolite (right side) in PRB treatment vessel, after removal

Figure 1.0-6 Former location of PRB treatment vessel after removal and site restoration, looking east

Figure 1.0-7 Former location of PRB treatment vessel after removal and site restoration, looking west

Figure 1.0-8 Restored PRB site after removal of exposed portion of cutoff wall

2.0 SWCS SPRING

Figure 2.0-1 SWSC Spring area after removal of treatment box and site restoration

3.0 BURNING GROUND SPRING

Figure 3.0-1 Burning Ground Spring area after removal of treatment box and site restoration

4.0 MARTIN SPRING

Figure 4.0-1 Martin Spring area after removal of treatment box and site restoration

Figure 4.0-2 Martin Spring channel after removal of treatment box and site restoration. Straw wattle protects channel from sediment.

Figure 4.0-3 Martin Spring treatment box after removal

Appendix D

Well Plugging Plans of Operations
(on CD included with this document)